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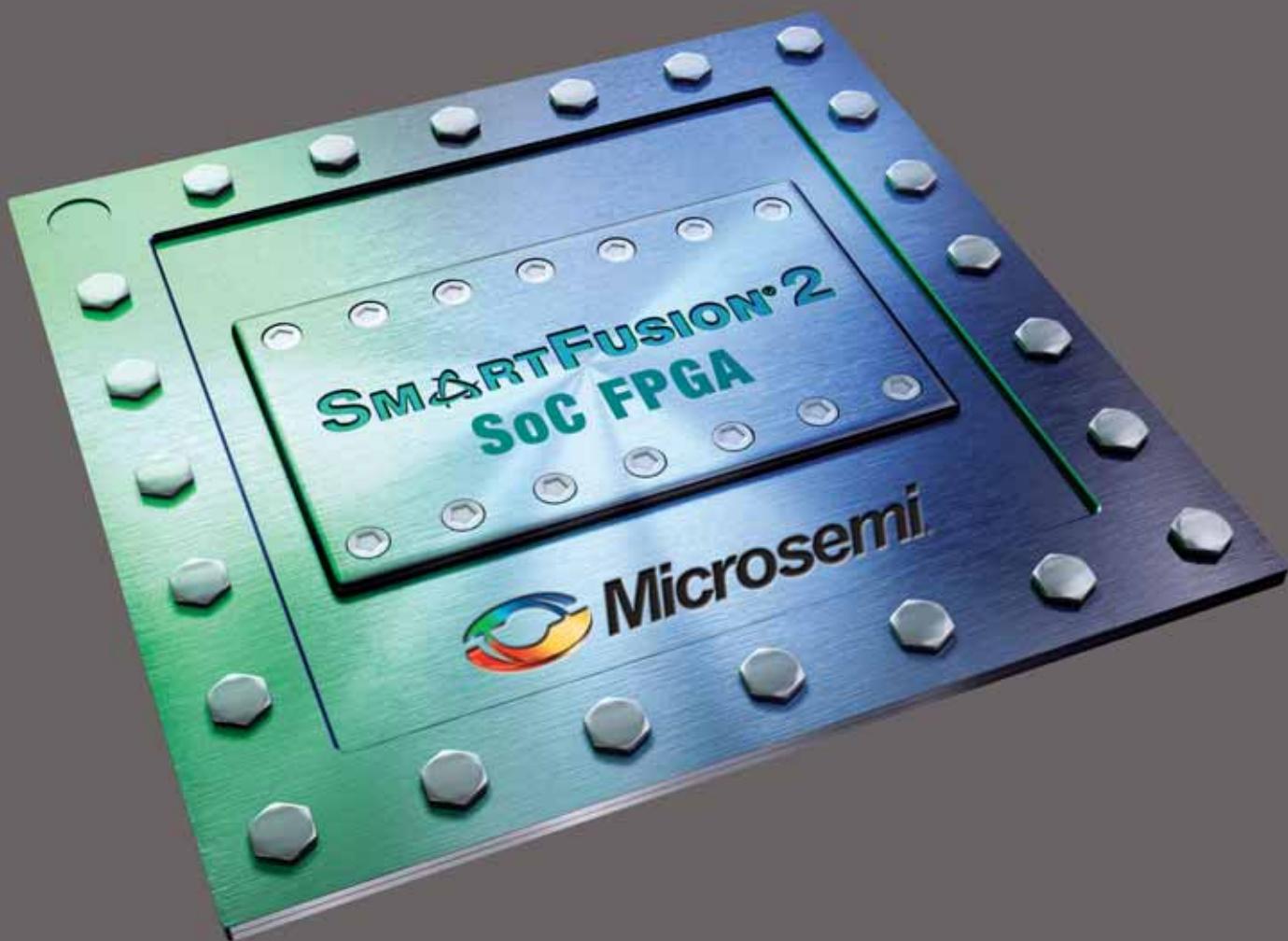
**Technology**
New hope for eye loss victims

**Special report 1**
Automotive electronics

**Special Report 2**
Connectors for all needs

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Cover prepared by **MICROSEMI**
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# TRENDS IN
# SOLDERS
# TECHNOLOGIES

In autumn 2012, in an international online survey of solder producers and users, Soldertec collected data from 145 respondents on key technologies, market and legislative issues faced by the industry over the next five years to ten years. This was a repeat of a survey carried out in 2010, trying to assess how opinions in the industry have changed in the intervening two years.

A total of 354 issues were highlighted; 50% of them related to technology, slightly down from 53% in 2010. Issues related to the market were also down from 33% to 11%. The major change was the substantial rise in concern over legislation, up from 15% to 39%.

Soldertec, a global network within ITRI, the world's foremost authority on tin, undertakes this exercise on behalf of tin producers, users and supply chain companies. Over 50% of tin produced is currently used in solder. ITRI was one of the first independent research organisations to look at lead-free solders and recommend the SAC 305/405 alloys. This led to the organisation being appointed to co-ordinate the Elfnet (European Lead Free Network) collaboration in 2007. It was our work in this area that led to the formation of Soldertec, the global network for solder producers, solder users and electronics manufacturers.

The 145 respondents were a sample from around 4,000 of Soldertec's own database of solder and electronics industry members and customers. Generally these were technical staff focused on interconnection technology, although some were in product development and marketing, and some were industry consultants or from research organisations. Their responses produced an outline roadmap for the solder industry (see **www.soldertec.com** for more information).

Looking at the survey contributions as a whole, it became clear that the underlying theme for the industry is reliability. Whether the actual issues raised were about new solder alloys, legislation, or tin whiskers, it is apparent that the concern was how this would affect reliability.

In terms of legislation, REACH (Registration, Evaluation, Authorisation & restriction of CHemicals) was cited as the primary cause for concern – especially in flux materials, closely followed by RoHS, which is understandable given the recent coming RoHS2 legislation.

> **Although there are still calls in some quarters to return to SnPb, this seems unlikely**

The amount of legislation relevant to the industry has risen sharply. However, there does appear to be some sensible thinking on the horizon, as the EU is trying to tie all the various bits of legislation together and is encouraging legislators globally to conform to the same principles.

Although there are still calls in some quarters to return to SnPb, this seems unlikely. Instead there will be a greater focus on low – or no – silver solders in general to save costs. In a solder with a content of 3% silver, around 50% of the metal cost is due to the silver content. All of the major solder manufacturers have alloys in this area, and work will continue to improve performance. However, low silver alloys already have the advantage of better drop shock properties, which is desirable for use in the growing market of portable and handheld electronic devices.

A trend for low melting point solders is starting to emerge, mainly based around the SnBi eutectic which melts at 138°C. One of the biggest costs associated with soldering is the energy bill, mainly coming from the reflow ovens. Solder which has a lower melting point and, so, a lower reflow temperature, has a potential to incur energy savings. Eutectic SnBi is very hard and brittle, so the alloy needs elemental additions to increase ductility. Again, most major solder manufacturers already have a solution in this market, with work ongoing.

Miniaturisation will continue apace, but doubts are surfacing over how long for. The average component size just five years ago was 4mm, whereas today it is in the order of 0.4mm, with many components significantly smaller than that. The smaller size creates problems with manufacturing and with placement. It can also constitute a health hazard as due to potential inhalation. It seems likely that to progress an alternative solution needs to be found and these are starting to emerge with the advent of embedded electronics and similar technologies.

Although the industry is experiencing tough times in the face of the current economic climate, the signs are good. There is still a healthy culture of innovation and progress, without loss of the desire to build a better, more reliable product.

# NEW INVENTION AIMS TO BOOST CONFIDENCE OF EYE LOSS VICTIMS

*Dr Philip Breedon showing the prototype artificial eye with a pupil that responds to light*

Researchers at Nottingham Trent University have created an artificial eye with a cosmetic pupil that can dilate and contract in response to light. Using smart materials, the prototype aims to solve the longstanding problem of eye loss victims having two different sized pupils at night or in bright sunshine. Although artificial eyes today often appear lifelike, none on the open market feature a pupil which can change in size like a real eye.

The intention is to increase confidence in people who use prosthetic eyes by making their artificial eye as lifelike as possible.

The research – overseen by Dr Philip Breedon, a reader in smart technologies at the university – was carried out for Nottingham-based firm John Pacey-Lowrie Ocular Prosthetics and took 18 months. Now the prototype has been successfully developed, the university will undertake further research to miniaturise it to the size of a human eye.

"Many people who have a prosthetic eye are very conscious of how realistic it looks. Young to middle-aged people are especially conscious of being out at night as they are aware that one pupil can often be bigger than the other, and it bothers them," said Pacey-Lowrie, who has worked in ocular prosthetics for 35 years. "This research is a real breakthrough that promises to end this longstanding problem. The aim is to help people have increased confidence."

Made from acrylic resin, the prosthetic eye features a pupil made from carbon paste and, in conjunction with a smart material, it increases in size when an electric current is passed through it. Powered by a tiny battery, a light sensor in the prosthetic eye communicates with a controller. The controller calculates how much power is needed by the carbon paste to achieve the appropriate size pupil and then sends a charge to the carbon paste along two wires. The artificial pupil then dilates and contracts accordingly.

"I think that the chances of going to the commercial market with this are strong," said Pacey-Lowrie, who trained as an ocularist at Moorfields Eye Hospital in London. "It's not on the market anywhere else in the world. I am very confident that we will be able to miniaturise the technology in the very near future and get it on the open market."

The second phase of the research – to miniaturise the prototype – has now begun and is expected to run for about 18 months.

"It will no doubt be a real challenge to miniaturise the prototype to the smaller size needed, but it is something that we believe can be achieved," said Dr Breedon.

# European Project Drives the Future of Power Microelectronics

The Large Area silicon-carbide Substrates and heTeroepitaxial GaN for POWER device application project, or LAST POWER, is a European Union-sponsored program aimed at developing a cost-effective and reliable technology for power electronics. It recently announced its three-year program achievements, which guarantee to place Europe at the forefront of research and commercialization of energy-efficient devices for industrial and automotive applications, consumer electronics, renewable-energy conversion systems and telecommunications.

The main achievements in SiC-related efforts were based on the demonstration by SiCrystal AG of Nuremberg of large-area 4H-SiC substrates, 150mm in diameter, with a cut-off angle 2°-off axis. The material quality, both in crystal structure and surface roughness, is comparable to the standard 100mm 4°-off material available at the beginning of the project. These substrates have been used at LPE/ETC for epitaxial growth of moderately doped epi-layers suitable for the fabrication of 600-1200V JBS (Junction Barrier Schottky) diodes and MOSFETs,

owing to the development of a novel chemical vapour deposition reactor for the growth of large-area (150mm) 4H-SiC.

The quality of the epitaxial layer enabled the fabrication of JBS diodes by STMicroelectronics (ST). Characterization of the first lots showed electrical performance comparable with state-of-the-art 4°-off material. In this context, the fundamental technological step was the chemical mechanical polishing process – StepSiC reclamation and planarization – implemented at NOVASiC, which is a key issue both for the preparation of the substrates before epitaxial growth and for the sub-nanometric control of the surface roughness of the device active layers. Within the project, the same company also developed epitaxial growth capability for both MOSFET and JFET devices.

Additional research activities in SiO2/SiC interfaces were carried out in collaboration with ST and IMM-CNR to improve the channel mobility in 4H-SiC MOSFETs.

Finally, novel technological modules for high-temperature 4H-SiC JFETs and

MOSFETs were developed in collaboration between Acreo and FORTH, with the support of CCR for the study of molding compounds and "lead-free" die-attach materials for reliable packaging solutions.

The LAST POWER project also researched the use of GaN-based devices in power-electronics applications. In particular, ST successfully obtained the development of AlGaN/GaN HEMTs epitaxial structures grown on 150mm Si substrates, reaching a target of 3mm thickness and 200V breakdown. LAST POWER worked with

IMM-CNR, Unipress and ST to develop the technological steps for normally-off AlGaN/GaN HEMTs with a "gold-free" approach. The process modules are fully compatible with the device-fabrication flow-chart set in the ST production line and are being integrated for HEMTs fabrication. The fruitful interaction between the project partners working on material growth and device technology has enabled important steps towards monolithic integration of GaN-based and SiC-based devices, as both technologies have been successfully proven on 2°-off axis 4H-SiC substrates.

## LAST POWER

Launched in April 2010 by the European Nanoelectronics Initiative Advisory Council (ENIAC) Joint Undertaking (JU), a public-private partnership in nanoelectronics, LAST POWER links private companies, universities and public research centres working in the field of wide-bandgap semiconductors (SiC and GaN). The consortium members are STMicroelectronics (Italy), project coordinator; LPE/ETC (Italy); Institute for Microelectronics and Microsystems of the National Research Council – IMM-CNR (Italy); Foundation for Research & Technology-Hellas – FORTH (Greece); NOVASiC (France); Consorzio Catania Ricerche – CCR (Italy); Institute of High Pressure Physics – Unipress (Poland); Università della Calabria (Italy); SiCrystal (Germany); SEPS Technologies (Sweden); SenSiC (Sweden); Acreo (Sweden); and Aristotle University of Thessaloniki – AUTH (Greece).

# Acoustic Time Delay Device Could Reduce the Size and Cost of Phased Array Systems

Radar systems today depend increasingly on phased-array antennas, an advanced design in which extensive grids of solid state components direct signal beams electronically. Phased array technology is replacing traditional electro-mechanical radar antennas – the familiar rotating dish that goes back many decades – because stationary solid state electronics are faster, more precise and more reliable than moving mechanical parts.

Yet phased array antennas, which require bulky supporting electronics, can be as large as the older systems. To address this issue, a research team from the Georgia Institute of Technology has developed a novel device – the ultra-compact passive true time delay. This component could help reduce the size, complexity, power requirements and cost of phased array designs, with applications in other defense and communication areas as well.

The patent-pending ultra-compact device takes advantage

of the difference in speed between light and sound, explained Ryan Westafer, a Georgia Tech Research Institute (GTRI) research engineer who is leading the project. The ultra-compact device uses acoustic technology to produce a type of signal delay that's essential to phased-array performance; existing phased-array antennas use cumbersome electrical technology to create this type of signal delay.

"Most true time delay equipment currently uses long, meandering electromagnetic delay lines – comparable to coaxial cable – that take up a lot of space," said Westafer. "In addition, there are some time delay designs that utilize photonic technology, but they currently have size and functionality drawbacks as well."

The ultra-compact delay device uses acoustic delay lines that are embedded entirely within thin-film materials. The component can be made thousands of times smaller than an electrical delay-line design, and it can be readily

integrated on top of semiconductor substrates commonly used in radar systems.

In a phased array radar system, true time delays are necessary to assure proper performance of the many signal-beam-producing elements that make up the array. As the elements scan back and forth electronically at very high speeds, their timing requires extremely fine coordination.

"The individual antenna elements of a phased array appear to scan together, but in fact each element's signal has to leave up to a few nanoseconds later than its neighbour or the steered beam will be spoiled," explained Kyle Davis, a GTRI research engineer who is a team member.

Traditional phased array systems use one foot of electrical delay line for each nanosecond of delay. By contrast, the Georgia Tech team's time-delay design consists of a thin-film acoustic component that's only 40 microns square. The tiny device can be readily integrated into the silicon

substrate of a radar component, yet it provides the same delay as many feet of cable.



*Georgia Tech Research Institute (GTRI) research engineers Kyle Davis and Ryan Westafer, with professor William Hunt of the School of Electrical and Computer Engineering (l-r), examine a 3"-diameter silicon wafer on which they have fabricated thousands of bulk acoustic-wave devices capable of delaying electromagnetic waves (Credit: Gary Meek)*

# IT'S EASIER THAN YOU THINK TO PROTECT
# YOUR EMBEDDED SYSTEM DESIGN FROM THEFT

If you have invested years and millions of dollars in the design of an embedded system (and in the creation of the Intellectual Property, or IP, that goes along with the design) it can be of critical importance to protect that system from unauthorized duplication or theft. The protection of an embedded system that uses FPGAs is particularly relevant since FPGAs have become the platforms of choice for innovation.

Design Security is the assurance that the Intellectual Property (the FPGA Design) programmed into a device is secure and operates as intended for the life of the product. The most important elements in creating robust Design Security for an FPGA are a secure FPGA fabric, a secure configuration bitstream and a secure key storage system. If these elements work together correctly they become inherent capabilities of the FPGA and are almost invisible to the designer.

## THE KEYS TO IMPROVED SYSTEM SECURITY

In order to construct a robust security system it is important to have a way to 'lock' the system from unauthorized intrusion and to insure that only valid commands and data are recognized. Typically security systems utilize special keys, just like the key to the front door of your house, to authorize system access. These keys are stored within the system and must also be protected for unauthorized access. The most secure keys use either Non-Volatile Memory (NVM) or SRAM Physically Unclonable Function (SRAM-PUF) based keys. SRAM-PUF keys use a novel key storage mechanism that combines the passive zeroization feature of volatile memory (the key goes away when power is removed) with tamper-resistant nonvolatile key storage.

## DESIGN SECURITY BEGINS WITH YOUR TARGET DEVICE

When you look at selecting a target device is it enough for the device to have an AES (as an example) core? The answer is no. The device you're trusting must be hardened against side channel attacks. Figure 1 shows a classic example of a side channel attack.

Figure 1 shows a safe cracker using his fingertips to feel tumblers falling while also listening to the same. Through this process he can extract information about the combination using these, alternative, side channels. In electronics devices, circuitry performing a cryptographic operation can leak information about its state unknowingly. If the associated circuitry wasn't designed properly the device can be vulnerable to electronic side channel attacks. Figure 2 illustrates a side channel analysis setup.

One of the most popular side channels to "listen to" is power supply consumption. In Figure 2 the input data is an encrypted bitstream for an FPGA and the output data is the configuration data for the FPGA. In addition there is some built-in cryptographic circuitry, typically AES, handling the decryption of the bitstream. The decryption key can be extracted from the power supply side channel using Differential Power Analysis (DPA) techniques. DPA uses data gathered by observing how the power consumption of the electronic system changes during cryptographic processing. With the use of some simple statistical techniques such as correlation, and access to both the cipher text and power consumption information for each cipher text, an adversary can perform DPA and extract the value of the secret key. Once the key is found the plaintext bitstream can be determined and then reverse engineered. So not only is it important



Figure 1: A Classic Side Channel Attack
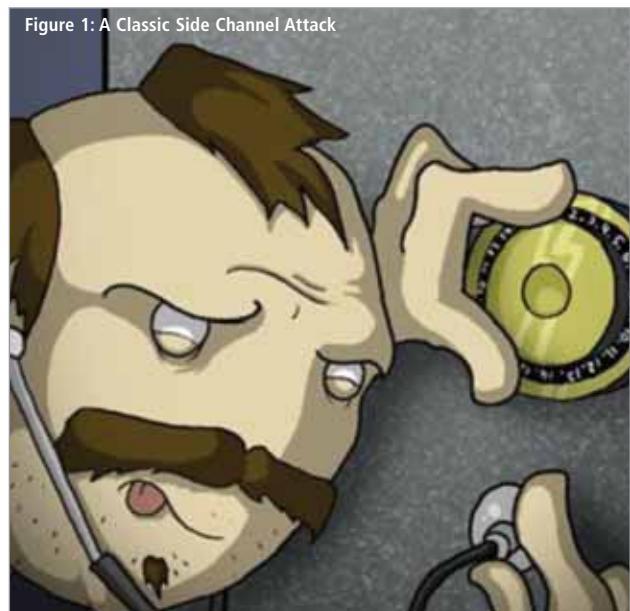
to have good security algorithms and protocols they also need to be implemented with side channel attack prevention in mind.

## IMPLEMENTING DESIGN SECURITY EASILY

A secure FPGA fabric, a secure bit stream and a safe security key storage systems are the fundamental features required for robust design security. If the designer needed to implement these features on an FPGA the extra FPGA fabric effort and cost required would be very difficult to justify. What is needed is an FPGA with these security features that are built-in to the device so the designer need not implement them or even understand the details of how they work. Design security should just be easy. Let's look at the approach to implementing a secure design when targeting a device in an FPGA family with 'built-in' design security features.

## SMARTFUSION2 AND IGLOO2 DEVICES

Microsemi IGLOO2 and SmartFusion2 devices both provide several of the most robust security capabilities in the industry along with traditional FPGA capabilities. Microsemi SmartFusion2 SoC FPGAs combine a wealth of programmable fabric, a High-Performance Memory System (that includes blocks of SRAM and Non-Volatile storage, advanced DMA capabilities, DDR3/DDR2/LPDDR Memory controllers, Fabric Interface Controllers (to easily connect to fabric implemented peripherals and processing accelerators), 5Gbps Multi-Protocol SerDes (with PCIe and XAUI/XGXS hardware protocol support), a System Security block and an AHB Bus Matrix to connect everything together efficiently. SmartFusion2 devices also include a dedicated ARM® Cortex-M3™ processor and advanced peripherals.

## SECURITY MODEL OVERVIEW

Figure 3 depicts the simplified security model used in both SmartFusion2 SoC FPGAs and IGLOO2 FPGAs. The System Controller is the heart of the security system and manages all programming, verification, design security key-management, and
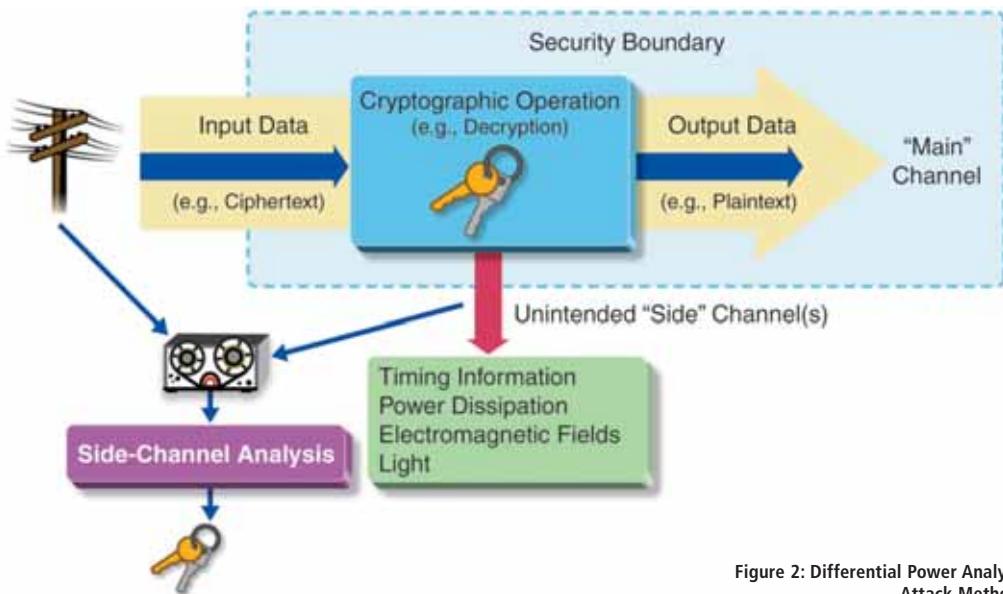
Figure 2: Differential Power Analysis Side-Channel Attack Methodology Example

related operations. It interfaces with the Security Keys, the embedded Non-Volatile Memory array, and the Flash FPGA fabric configuration memory. During normal operation it can also provide optional cryptographic user services.

## SECURE FPGA FABRIC

Microsemi Flash-based FPGA configuration memory cells are located within the FPGA fabric and directly control the routing switches and look-up tables used to implement user logic. Security is greatly enhanced, since configuration data is not stored off-chip, and therefore does not need to be loaded and decrypted on each power-up, exposing the associated keys to side channel analysis during their use.

## SECURE CONFIGURATION BIT STREAM

IGLOO2 and SmartFusion2 devices only accept encrypted bitstreams. Researchers claim, and history confirms, that plaintext bitstreams can and will be reverse engineered. Using only encrypted bitstreams makes it more difficult for the bitstream format to be reverse engineered by researchers, malicious users, or adversaries.

## PROTECTED SECURITY KEYS

The heart of the security system is the safe storage of security keys. SmartFusion2 and IGLOO2 device families use a DPA resistant design. Microsemi is the only FPGA supplier to license the Cryptography Research Incorporated (now Rambus) DPA patent portfolio. Microsemi FPGAs with DPA features have bitstream and keys that are hardened against DPA analysis. The DPA protection offered by Microsemi FPGAs doesn't require additional design effort from the user. These capabilities create an additional 'layer' of protection around any security keys stored in the device. The designer simply accesses the keys and uses the associate security algorithms with the knowledge that these actions are resistant to side-channel attacks. For even more security, the Permanent FlashLock®



Figure 3: Simplified Security Model for SmartFusion2 and IGLOO2
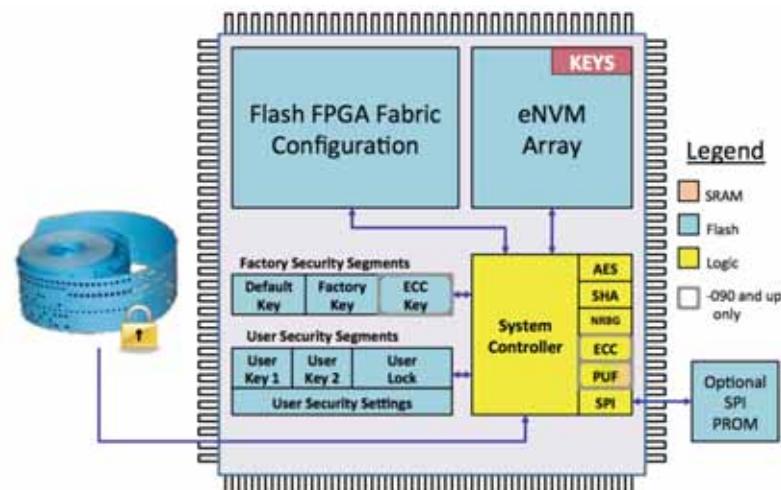
Mode can be used to turn a SmartFusion2 or IGLOO2 device into an OTP device. This mode is considered quite secure because it disables most programming, verification and debug operations.

## EASY DESIGN SECURITY WITH IGLOO2 FPGAS AND SMARTFUSION2 SOC FPGAS

The SmartFusion2 and IGLOO2 families make it easy to implement robust key storage via a secure FPGA fabric, protected bitstream and robust Flash-based key. The designer need not spend additional time implementing security functions with Microsemi FPGAs; they can be included as part of the overall design and manufacturing flow with minimal overhead for the designer. It's easy to create a secure manufacturing, deployment and end of life processes that can be critical to creating a protected embedded system.

**Author: Tim Morin, Microsemi**
**http://www.microsemi.com/fpga-soc/fpga-and-soc**

# Recirculation

**MYK DORMER** IS A SENIOR RF DESIGN ENGINEER AT RADIOMETRIX LTD
**WWW.RADIOMETRIX.COM**

**M**ost of the time, low power wireless modules behave in fairly sensible, easily explicable ways. Provide them the right power and control signals, feed in the right baseband signal or data stream, connect the aerial, and you have a link – just like it says in the data sheet.

And then, just sometimes, things go totally crazy. The data link just doesn't work – or worse: it's intermittent. You check every interface pin and waveform for a glitch. You ensure you are in range. Nothing seems amiss …. Until you look at the receiver AF output, or an on-channel monitor receiver output, and the modulation waveform looks nothing like the well behaved, familiar "square waves with rounded off edges", which communications theory tells you should be there.

You see extreme distortion of a type you've never seen before. Apparently random DC offsets, added to wave-shapes that suggest both excessive high and low pass filtering, in different places. Ringing or overshoot is apparent (impossibly) on the trailing edges. Nothing in the circuit (or any circuit for that matter) could be

responsible for such odd effects, and they don't even seem constant. They change as you move around the lab, maybe as connecting cables are moved,

> **Distortions are much more noticeable on real data packets, compared to test tones**

and as anything goes near the transmitter end antenna.

What I am describing here is an effect known as "recirculation". While mathematically complex, it is in essence very simple. It is what happens to a transmitter when some of its output energy is coupled back into the frequency defining circuits (the PLL and VCO and/or the modulator) and has an effect on the modulation waveform, but not so much as to cause "ordinary" instability.

It can happen to any transmitter type, but low loop bandwidth frequency synthesized designs with the VCO operating on the output frequency, in other words conventional narrowband multichannel designs, are particularly

prone, while wider bandwidth loops (including fractional-N types), mixer-in-loop designs and multiplier chain transmitters are more or less resistant. Lower power output transmitters suffer proportionally less, while insufficient shielding and aerials mounted close to the circuitry should be warning signs.

Diagnosing recirculation is actually relatively simple, if you can either monitor the analogue AF output of the link receiver or set up a monitor receiver on the channel. A digital output doesn't help much, as only "bit errors" and not the waveform corruptions responsible will be seen.

● Modulation waveform distortions change with changes in the aerial match and radiation pattern (i.e. as you wave your hand around it). The distortions will vanish, or get far less pronounced, if the aerial is replaced with a dummy load and/or the transmitter power is reduced.

● Distortions are much more noticeable on real data packets, compared to test tones. They may not even be present on a sine-wave test signal at all. Nothing can be seen on an unmodulated carrier (this is distinct from an RF instability, where unmodulated signals may also manifest aberrant behaviours).

● Distortion gets worse when the transmitter housing is open and when test probes are attached to critical parts of the circuitry.

Unfortunately, curing the problems can be considerably harder. Expect to conduct a protracted series of tests before you have enough results. Do not expect a magic cure in ten minutes, and if you get one be suspicious.

● Try to determine how the RF is coupling back into the transmitter. This may be direct pickup on signal or control lines leading to the module, or it could be RF power reflected from a mismatched aerial. Moving the aerial away from the transmitter can frequently effect a (temporary and impractical) cure, while threading ferrite rings or beads onto the aerial coax can prevent braid currents from a mismatched aerial reaching the module.

● Systematically add decoupling to all lines entering the radio, right at the pin if possible. Carefully record the result. You will probably find a particular signal or control path that is especially sensitive. If lucky, simply isolating this pin will be a cure.

● Where possible, shield and/or shorten connecting cables wires and tracks. Sometimes this will require a re-layout of the PCB where the module is located. Adding a good ground-plane at this point can reap benefits. If all else fails, consider adding extra screening cans.

● Carefully inspect the support and ancillary circuits around the module. These can also be a source of pickup (for some reason buffers and inverters in the data/modulation path are particularly vulnerable) and may require extra RF suppression parts to be added.

Diligent work will often identify – and cure – a specific recirculation vulnerability, but it is unfortunately sometimes necessary to admit defeat if the problem is sufficiently recalcitrant.

In these cases the only recourse will be to change the radio, to something of a sufficiently different architecture. Talk to your module supplier: they have probably seen this before. ●

# AUTOMOTIVE HYBRID
# INSTRUMENT CLUSTER

AS CARS CONTINUE TO EVOLVE AND BECOME MORE COMPLEX, SO DO THEIR INSTRUMENT CLUSTERS. BY **TIMM HINRICHS**, SENIOR PRODUCT MARKETING ENGINEER AT FUJITSU SEMICONDUCTOR EUROPE



**Figure 1:** A typical hybrid instrument cluster with a TFT (480 x 272) in the middle

**T**he instrument cluster is the most important data source for the driver of a car. It provides vital information on the speed, fill level of the fuel tank and the status of the engine among others. If there's a malfunction, it will be indicated on the instrument cluster.

Back in the early days, the instrument cluster was quite simple: two spindles from the gear box and the motor controlled two analogue gauges that displayed the speed (speedometer) and the rotation speed of the engine (tachometer). In addition, the instrument cluster usually included a fuel gauge and a water temperature gauge. Every car also had an odometer, showing the distance travelled by the vehicle, and several lamps that displayed the status of the hand brake, the direction indicators and other warning lights like low oil pressure.

Today, the instrument cluster receives all this information via automotive bus systems like CAN (Controller Area Network). The CAN bus allows for communication between electronic control units (ECUs) inside a vehicle and does not require a host system. Today, each car often has over 50 ECUs.

This unified communication system allows for all kinds of information to be displayed on the instrument cluster. However, much of it cannot be displayed all that easily by gauges and indicator lamps, so most instrument clusters now also include a display. Simple displays are the dot-matrix type, and mid-range

cars already feature TFT displays in the instrument cluster. Many cars are also equipped with an onboard computer that provides advanced and useful information on how far the fuel in the tank will last, the average vehicle speed, driving time, average/current fuel consumption and outside temperature among others. This combination of gauges and a display is called a hybrid instrument cluster.

### Hybrid Instrument Clusters

Figure 1 shows a typical hybrid instrument cluster with four gauges, a TFT display and several indicator lamps. The TFT display in the middle has a resolution of 480 x 272 pixels in portrait format, and 24-bit colour depth. In this example, the speedometer, tachometer, the fuel tank's fill-level and the water temperature are displayed by gauges, the direction indication by lamps (or LEDs) and all of the other information is shown on the TFT display.

Possible content of the TFT display includes:
- Information from the onboard computer, such as fuel consumption or the weather;
- Navigation information that features a direction arrow, distance and traffic signs;
- Radio meta-data that displays the name of the channel and other information provided by RDS (Radio Data System);
- Media playback information that shows the title of a song

that's being listened to and the cover of its album;
● Advanced driver assistance information, like parking distance control or an open-door warning;
● Pop-up messages like broken lights, nearly empty fuel tank, traffic jam or current speed limits.

Figure 2 shows three examples of the content commonly shown on a TFT display.

## Safety and Security

Operational safety and security against attacks are two important factors in car electronics. The goal of operational safety is to prevent or reduce dangers that can occur if individual components fail. This goal is typically achieved by using redundancy or fault detection mechanisms, with a fall-back to basic functionality.

The goal of attack-resistant systems is to protect devices from outside interference and tampering. Here it is particularly important to prevent attackers from being able to gain unauthorized access to information – not to mention control – over a system. Control system manufacturers must be able to protect their intellectual property, which could be software in the equipment's MCU for example, against read access from the outside world. Otherwise, counterfeit equipment can be sold at much lower prices, which will be financially harmful.

Cryptographic procedures not only allow for electronic anti-theft devices to be implemented, but also prevent attackers from modifying the brake system's control software or hacking into the driver assistance systems. In addition, cryptography helps

distinguish original control systems from counterfeit equipment, which may contain components not certified for in-vehicle use. Secure, attack-resistant systems are therefore an ally in ensuring operational safety.

A software initiative called HIS (Herstellerinitiative Software) was founded by car manufacturers including Audi, BMW, Daimler, Porsche and Volkswagen. This consortium defined the secure hardware extension, or SHE, which can be implemented as a self-contained secure area on a microcontroller. It contains a random number generator and a separate storage area that acts as a secure repository for cryptographic keys, plus dedicated logic for the encryption of data in accordance with the highly secure AES standard with its 128-bit key length.

## Graphic Engine/Display Controller

The MCU, which provides the interface to the TFT, is responsible for generating all graphic data. To boost performance and reduce the load on its processor, a 2D graphic engine has been installed in the controller for hybrid instrument clusters.

All bitmaps to be shown on the display are transferred from flash memory into VRAM (video memory). The graphics engine then combines the bitmaps to create the final scene, which is then sent to the display. It also does the pre-processing, scaling and rotation, blending and mixing of different input layers.

The display controller interfaces with the TFT and includes a few additional features that reduce the load on the internal CPU and graphics engine, and reduces memory and internal bus load.

**Figure 2:** These screenshots show possible content that can be displayed on the TFT

**Figure 3:** Block diagram of Fujitsu's single-chip solution for hybrid instrument clusters MB9EF226, also known as 'Titan'



It is also important that the display controller includes a mechanism that ensures the content is displayed correctly. This unit checks the content at the display output and generates an error message in case of a mismatch.

The graphics engine and the display controller should also include memory-saving and bus-load-reducing features by offering compression and support for colour palettes (index colour) that are supported by them both.

A more sophisticated solution also supports the reduction of motion blur (reduces stroboscopic artefacts during fast movements), rounds corners in the graphics and offers anti-aliasing of edges. An included graphics library allows customers to easily develop their own graphics application.

### Software

Nowadays, most car manufactures prefer to run AUTOSAR (AUTomotive Open System ARchitecture) on the vehicle's ECUs. AUTOSAR is a standardized architecture for automotive software and provides a basic infrastructure for assisting with the development of software, user interfaces and managing all application domains.

As mentioned earlier, the developer also requires a graphics library that can feature a standardized API (Application Programming Interface) like OpenVG.

When it comes to the design of the HMI (human machine interface), an HMI design tool can help reduce the time to market and allow for one HMI design to be run on different platforms.

### Outlook

Resolution of the TFT display in hybrid instrument clusters will undoubtedly continue to improve in the future. Today, displays that offer QVGA resolution (320 x 240 pixels) are quite common in the mid-range car segment. Higher resolution will deliver higher quality graphics and more processing power from the instrument cluster controller. We are already seeing the first high-end cars with two high-resolution 8:3 displays included in the dashboard that do away with classic gauges. These systems are called virtual clusters.

Head-Up Displays (HUD) are already common in high-end cars. The HUD presents information in the main viewing direction of the driver, in most cases by having a small projector display graphical content on the windshield. In the future, such content will most likely vary to an even greater extent. It's likely that the user will be able to define his own display view (sporty or classic, for instance). ●

## TITAN: A SINGLE-CHIP SOLUTION FOR HYBRID INSTRUMENT CLUSTERS

MB9EF226 – named Titan (see its block diagram in Figure 3) – is the newest member of Fujitsu's FCR4 family, which is based on the well-established ARM Cortex-R4 core. The MCU provides intelligent support for up to six traditional gauges, plus the 2D graphics engine IRIS, to enable it to drive a colour display in the same cluster. By including a Secure Hardware Extension (SHE) module, it also offers customers first-class security, since the module is completely integrated into the hardware.

Titan offers driver information systems an enhanced function set capable of running more sophisticated software solutions and supporting the AUTOSAR specification. Titan has also been optimized to perform in accordance with key industry benchmarks for safety, security and power consumption.

Developed at Fujitsu's MCU Competence Centre in Langen, near Frankfurt, the MCU is designed to operate as a single-chip solution for hybrid instrument clusters featuring graphics and gauges. As with all of the devices in Fujitsu's cluster line-up, Titan is supported by CGI Studio, Fujitsu's unique software development platform for 2D and 3D graphical interfaces.

With a core that operates at up to 128MHz, Titan offers more than 200DMIPS of processing power, plus 2MB of flash memory and 208kB of RAM. Apart from the standard interfaces like CAN, I2C and LIN_USART, Titan also offers a MediaLB interface that supports applications such as transfer of graphics data from an electronic control unit (such as the satnav, for example) via the MOST bus to Titan.

As realized in Titan, Fujitsu's 2D graphics engine IRIS consists of a display output with TCON that supports four display layers and allows for pixel clocks of up to 40MHz, a command sequencer that permits the CPU and IRIS to run in parallel, a signature unit that offers support for security aspects and the 2D graphics core itself. The engine is optimized for low memory usage. As one example, a typical sequence of operations would be the parallel scaling, rotation and decompression of different bitmaps as the first step, and then blending of these bitmaps into a single output entity as the second step, thus avoiding the need for intermediate storage. Titan also offers additional device security, including secure handling of the trace and JTAG ports, plus flash memory features.

The hardware-implemented SHE module embedded in Titan allows Tier 1 automotive suppliers and car manufacturers to set up a guard against software manipulation of electronic control units or their theft. Initial applications that use this cryptographic unit include immobilizers, keyless entry systems, feature activation and remote services such as remote diagnostics or software updates.

CSR

Push every boundary.™

# Technology-platform innovator chooses XJTAG boundary scan for speed and flexibility

**"CSR's platform technology solutions are used by consumer electronics OEMs to add functionality like Bluetooth®, Wi-Fi® or GPS/GNSS to their products. By integrating XJTAG boundary scan into automated test equipment, CSR has reduced test and programming times and increased coverage; one board, which used to take two hours, now takes only four minutes."**

CSR, based in Cambridge, UK, is a pioneering designer and developer of platform technology solutions that provide advanced functionality for end products used by millions of gadget-loving consumers across the world. CSR deploys its portfolio of technologies in location, audio, video and connectivity to create innovative solutions for leading brands serving market segments such as voice & music, automotive infotainment, imaging and location-based services.

CSR is using XJTAG boundary scan within integrated test solutions that contain conventional and custom-designed instruments and interfaces used for parametric measurements and functional tests. XJTAG boundary scan tests are invoked by custom test software. "XJTAG provides Application Program Interfaces (APIs) that enable integration with our bespoke test software," says Hardware Test Manager Brendan Townsend. "These APIs make it possible for us to employ boundary scan in the way we want."

The XJTAG system is helping CSR test its own electronic assemblies for use in company-wide test and development applications. XJTAG programs can test devices connected to the boundary scan chain as well as non-JTAG devices on the same nets. The system is also used to perform tasks such as programming devices and verifying PCBs according to the netlist. "We can test both for connectivity and short circuits on hundreds of connections

in a single test pass," says Brendan Townsend. "Some of our boards contain CPLDs designed-in expressly to allow us to test board-to-board connectors using XJTAG."

According to Brendan Townsend, time savings are among the most valuable benefits the XJTAG system has delivered. "Test and programming times are greatly reduced when compared to an otherwise manually-driven process.

To highlight one example, we have cut the overall programming and test time of one of our boards from two hours to four minutes while at the same time considerably increasing test coverage. Fault diagnosis is also faster, and we are benefiting at the operational level through reduced operator training and by eliminating the need to author extended work instructions, which can take days."

With XJTAG, CSR's test strategies are also more flexible and adaptable. "XJTAG has allowed our test engineering activity to transition from bespoke hardware towards the more flexible software domain. We are able to reuse and update project files efficiently, since XJTAG tests are device-centric rather than board-centric," comments Brendan

Townsend. "We are also able to deploy proven tests in a variety of scenarios, such as for early build verification when working with contract assemblers."

Brendan Townsend adds that reliable and knowledgeable support from the XJTAG technical team has contributed to CSR's success using boundary scan. "XJTAG's support engineers have excellent credentials, and are communicative and accessible. With their help, taking advantage of the features and flexibility of the XJTAG system, we have established consistent test processes that are not dependent on the skills of individual users. Overall, XJTAG has enabled us to achieve exactly what we wanted from boundary scan."

## opinion

Brendan Townsend
Manager
Hardware Test
CSR

**"We have cut the overall programming and test time of one of our boards from two hours to four minutes while at the same time considerably increasing test coverage. Fault diagnosis is also faster, and we are benefiting at the operational level through reduced operator training and by eliminating the need to author extended work instructions, which can take days."**

**"XJTAG's support engineers have excellent credentials. With their help, we have established consistent test processes that are not dependent on the skills of individual users. XJTAG has enabled us to achieve exactly what we wanted from boundary scan."**

## Data Bank — CSR

| | |
|---|---|
| Company | CSR plc |
| Nature of business | Platform technology solutions for the consumer electronics market |
| Main products | CSR μEnergy®, BlueCore®, SiRFstar®, COACH®, Quatro®, aptX®, DDFA®, MAPX™ |
| Customers | Automotive Infotainment, Voice & Music, Imaging, Bluetooth Smart and Indoors Location markets |
| Locations | Cambridge (HQ) and 26 offices across the UK, Germany, Israel, Asia, Japan, USA |
| Revenues | USD $1.025 billion (2012) |
| Web site | www.csr.com |

# DRIVING FULL THROTTLE
# TOWARDS NEW DRIVE CONCEPTS

**ANDREAS MANGLER**, DIRECTOR OF STRATEGIC MARKETING MANAGER AT RUTRONIK ELEKTRONISCHE BAUELEMENTE GMBH, BREAKS DOWN THE BASIC ELEMENTS NEEDED TO SUPPORT ELECTROMOBILITY

**A**gainst the background of dwindling resources and the imperative to reduce environmental pollution, there is no getting away from electromobility. Nevertheless, it continues to present new challenges to automotive manufacturers, OEMs and suppliers, as well as the manufacturers of the necessary components. Resolving these challenges will determine how quickly electromobility will gather pace.

### In the Fast Lane

When it comes to assessing the status quo of electromobility, a general consensus cannot always be taken for granted. Drawing on an international comparison, the latest McKinsey EVI electromobility index puts Germany into the fast lane and, more recently, ahead of China. The index measures progress in the development of alternative drive systems and the maturity of electromobility markets. Using a scale of 0 to 5, the report states that Germany has improved from 1.3 to 2.0 points since June 2010, while China has only registered a slight increase from 1.4 to 1.5 points.

"The largely unanimous view held by decision-makers in China is that pure electric cars have simply not reached mass-production maturity and that the necessary supplier base is also lacking," said McKinsey's Axel Krieger.

Development of the charging infrastructure also presents an obstacle: Out of a total of 400,000 charging stations, just 16,000 have been installed to date – and not in accordance with a uniform standard. Despite these obstacles, there is currently no alternative to switching to electromobility in the long term. And yet, if vehicle ownership in China is to approach the levels of the US, it will need more oil than the rest of the world put together, notes Krieger.

### No U-Turn

For Europe as well, there is no possibility of making a U-turn on the road to electromobility. Many countries have introduced funding measures aimed at driving the development of this technology forward, some of which are part of the "European Green Cars Initiative". With this private-public partnership, the European Commission intends to support research and development projects that focus on environmentally-friendly vehicle technologies and the creation of the necessary infrastructure. Funding of some €1.6bn for this purpose is available until the end of 2013, with the industry contributing a matching amount. The VDA (German Association of the Automotive Industry) states that



**Figure 1: There's no U-turn when it comes to electromobility: the only way is forward**

**Figure 2: Hybrids in combinations with both petrol and diesel engines will become increasingly important**

the German automotive industry alone plans to invest up to €12bn over the next three-to-four years in the development of alternative drive systems. This is 40% of the entire budget for driveline technology.

As an intermediate step on the way to the purely electric vehicle, automotive suppliers and OEMs are currently prioritizing hybrid vehicles and regenerative braking as well as start/stop systems. The A.T. Kearney study *"Antrieb 2025"* (*'Powertrain 2025'*) also predicts only a niche role for pure electric vehicles. It cites high purchase cost as the primary factor that will limit new vehicle registrations to 12%.

"Hybrids will become increasingly important across all segments, in combination with both petrol and diesel engines," says Dr Götz Klink of A.T. Kearney.

But regardless of the drive system being electric or hybrid, the most important requirements are the same. Both revolve around an (additional) electrical drive system, as well as energy storage.

The area of distribution is attracting a growing number of customers who have targeted these technologies as a new business area in the supplier sector and are gradually accumulating expertise and experience in this field. This is because it is not just about redesigning existing traditional technology, but vehicles will need to be redesigned from the ground up. For this reason they need a partner who not only possesses in-depth technological expertise, but who also understands the automotive market, the applicable standards, regulations and requirements, as well as customer needs and expectations.

### The Key Area Of Power Electronics

Power electronics is one key area for electromobility. This includes the inverter drive itself and the battery management system in conjunction with the inverter technology and the management of very high currents and voltages. Increasing the efficiency of the overall system and improving its longevity present the greatest challenges in this respect. These factors are frequently in conflict, as higher switching frequencies in inverters are also associated with higher junction temperatures and, hence, under certain circumstances, reduced lifetime of the power semiconductors.

This situation can be addressed by using components with low switching losses, such as silicon carbide (SiC) IGBTs, which allow for greater power densities and more compact designs with lower thermal management requirements. For example, Rohm now offers the first series SiC IGBT and the corresponding diodes. It has switching losses that are reduced by a massive 85% compared to silicon IGBTs using recovery diodes. The reduced heat generation, despite the

higher power density, increases the durability of the components and system as a whole. This is a crucial quality criterion for electric vehicles. After all, end customers are not interested in driving electric or hybrid vehicles if it means sacrificing features and comforts to which they have grown accustomed. An engine that has to be completely replaced after a maximum of ten years would be unacceptable to them.

The requirements associated with electromobility are also forcing manufacturers to adopt completely new approaches with regard to packaging. Accordingly, Bosch Semiconductor has developed the first IGBT for which high current contacts can be welded on rather than screwed. In addition, the contact connections to the chips are made without the use of wirebond wires. This makes the IGBT significantly more resistant to the type of vibrations almost constantly present in vehicles. It also offers greater reliability since the torque load of the screw connection is removed.

The welded connections can dissipate the generated heat more efficiently through the main connection, thereby further enhancing the reliability and longevity of the system and allowing faster clock timing. At the same time, they permit a more compact design than standard screw types. And since the contacts can be applied on an industrial scale, the entire system can be manufactured more efficiently.

> **As an intermediate step on the way to the purely electric vehicle, automotive suppliers and OEMs are currently prioritizing hybrid vehicles, regenerative braking as well as start/stop systems**

### Energy Storage Is The Sticking Point

The battery management system guarantees a stable supply of energy to the motor. The accurate cell-state recording with reference to the performance, charge status and age of the

battery, along with aspects such as cell monitoring, performance prediction, operating strategy, thermal management, cell balancing, cell aging and the high-voltage charging management, are decisive factors that determine both the yield and lifetime of a battery and as such the range of the vehicle as well as the quality, or service life, of the overall system.

> " Bosch Semiconductor has developed the first IGBT for which high current contacts can be welded on rather than screwed

Thus far confined to laboratory use, electrochemical impedance spectroscopy (EIS) can now also be used in mass products for state-of-health and on-line battery monitoring in vehicles. The networking of entire electric fleets will inevitably become standard practice. The OEMs are already working on systems that can perform centralized monitoring based on empirical and measured values for the entire electric fleet. They will also be able to use findings from all vehicles to provide reliable information regarding the status of each battery. This is because monitoring battery impedance as a function of numerous other physical parameters is an ideal criterion for monitoring battery aging.

High packing density, combined with optimum thermal management and low weight, are the development targets for new energy-storage systems. Lithium-ion batteries are currently the most interesting option among the available storage technologies that will feature in the next generation of hybrid vehicles.

An interesting alternative to using batteries or fuel cells on their own is to combine them with double-layer capacitors, such as those offered by Maxwell. These are far superior to batteries in virtually every respect, with the sole exception of energy density. Here, the double-layer capacitors are worse by a factor of ten than batteries and therefore, are unsuitable for use as the sole means of storing motive power. As a result, they are frequently not even considered during the development of electric and hybrid vehicles.

This is unfair because they offer the great advantage of being able to store or release large amounts of energy quickly. This makes them the perfect complement to batteries: In driving mode, the battery or the combustion engine delivers a constant average amount of energy. During acceleration the energy requirement of the electric motor briefly rises sharply, while braking briefly releases a large amount of energy.

These high power peaks can be absorbed and released very quickly by the capacitors. They improve the overall efficiency of electric or hybrid vehicles and enable them to accelerate from 0 to 100km/h very quickly. What's more, the batteries are subjected to smaller charging cycles and much fewer peak currents, all of which extends their service life.

## Distributors Provide The Jump-Start

The examples prove it: the shift to electric or hybrid drives is currently one of the biggest technology drivers in the electronics industry. It encourages new technologies and entirely new approaches to development. In order to evaluate them, it is important to keep an eye on the overall solution at all times, for even if new developments are frequently touted as a panacea, the optimal solution is never achieved by just one component but is always the result of fine-tuning all components.

In most cases it's not only the semiconductor but also the passive and electromechanical components that play an important role. They can often be just as important for the overall circuit and account for a high share of added value. In addition, all cost and benefit factors for the particular application should be incorporated into the design. Distributors with a complete portfolio of components, backed up by corresponding technological expertise and a strong position in the automotive market, are highly recommended as strong partners in the race for electromobility. ●

## SINGLE-CHIP ANALYTICAL DEVICE FROM RUTRONIK AND INFINEON

**A SMART ENERGY-MANAGEMENT SYSTEM THAT IS SUITABLE FOR ALL BATTERY TECHNOLOGIES REQUIRES, AMONG OTHER THINGS, THAT LOCALLY RECORDED DATA FROM THE BATTERY IS FIRST SENT TO A CENTRAL BATTERY MANAGEMENT SYSTEM IN THE CONTROL UNIT OF THE VEHICLE AND THEN, IF NECESSARY, TO AN ON-LINE SERVICE PROVIDER THAT GATHERS AND EVALUATES ALL DATA.**

To meet this requirement profile, Rutronik has worked exclusively with Infineon to develop a highly integrated chip-solution. The Single Chip Analytical Device MD8710 features an ARM Cortex-R4 processor as a central unit, a full Memory Protection Unit, an interrupt controller, a DMA controller and a watchdog timer. The analogue front-end of the module allows for signal processing at a dynamic range of 16 bits. Freely programmable synthesis of all analogue signals, along with signal analysis for electrochemical impedance spectroscopy (EIS), are already on the chip. As a result, battery manufacturers and automotive OEMs are merely faced with the challenge of carrying out mathematical modelling and simulating cells, stacks and/or complete batteries.

# IMPROVING IN-VEHICLE AIR CONDITIONING

## THERE ARE SIMPLE WAYS OF IMPROVING VEHICLE AIR-CONDITIONING PERFORMANCE WITH ADVANCED INFRARED SENSING TECHNOLOGY, SAYS **RIK MOENS** OF MELEXIS

Concerns about the price of petrol, along with the growing need to conserve rapidly-depleting oil resources and simultaneously lower the level of carbon emissions now impinge on every aspect of automotive design. With ever-increasing pressure on car manufacturers to maximize fuel-efficiency, their engineering teams face difficult challenges to reduce in-cabin power consumption while still delivering a high degree of comfort that car users have come to expect. Air conditioning systems represent a major drain on the vehicle's available power – drawing a considerable amount of current from the battery.

At present, automotive industry type-approval does not call for any form of test that would show what influence running the air conditioning will have on a vehicle's operational effectiveness. Likewise, the manufacturer is not under any legal obligation to disclose figures pertaining to how use of the air conditioning system will decrease the vehicle's fuel economy. This will soon change however, as the European Commission (EC) is in the process of developing test procedures that take into account the increased energy consumption caused by use of air conditioning systems.

Research recently carried out on behalf of the largest automotive association in Germany, Allgemeiner Deutscher Automobil Club (ADAC), looked at the power spend of a variety of different air-conditioning systems currently on the market. The data shows a large discrepancy in the efficiency of systems currently used within car models. In some cases turning on the air conditioning can directly result in an increase of 15% in the vehicle's total fuel consumption.

### Automotive Air-Conditioning Systems

The air conditioning infrastructure seen in vehicles today can be basically categorized into three types: manual, semi-automatic and fully automatic.

For manually-operated control systems, vehicle occupants set the temperature and intensity of the air flow directly through the blowers themselves. This requires ongoing readjustment as conditions change over time.

With semi-automatic air-conditioning systems, cabin temperature can be kept at a set level, defined by the vehicle occupants, but the air-flow intensity still has to be manually adjusted.



**Figure 1: Fuel consumption increase when air conditioning is active**
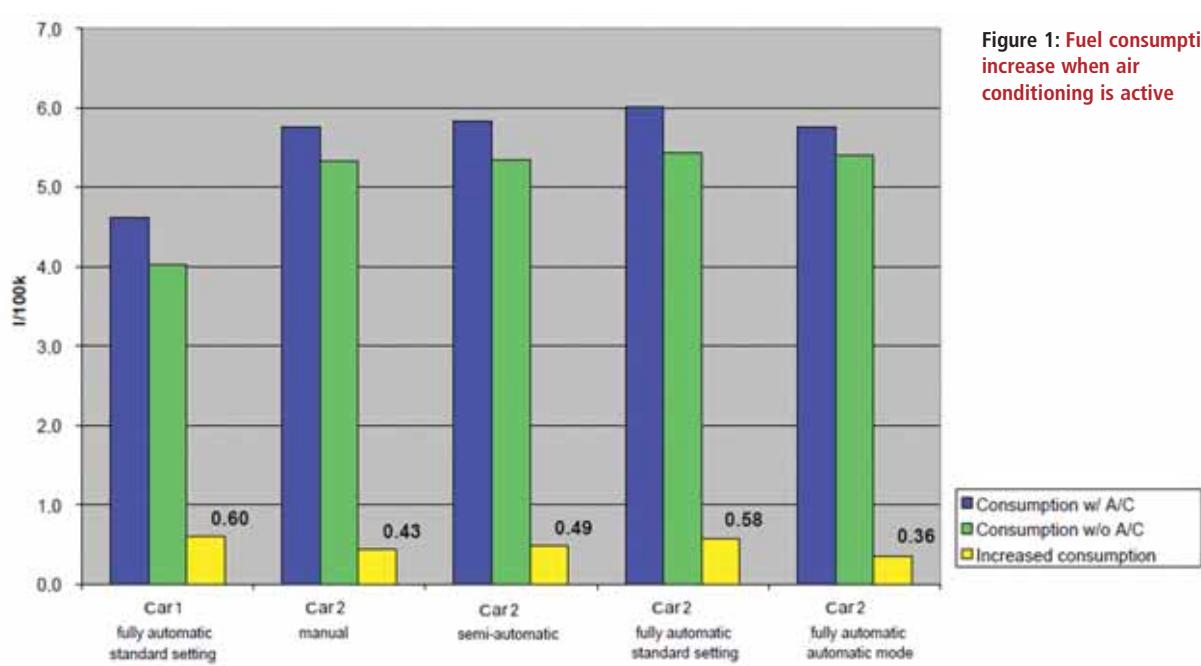
**Figure 2: Effect of air conditioning on fuel consumption when the vehicle is in idle (%)**
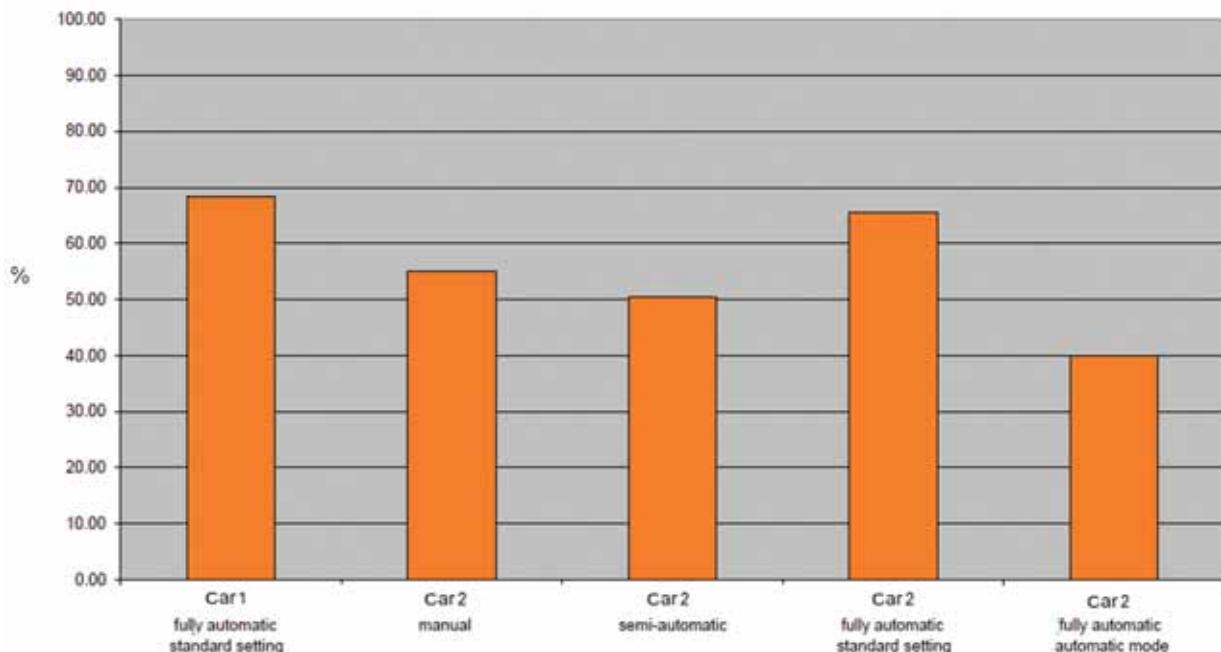


Modern, fully-automatic systems employ a variety of different sensors to allow optimal cabin conditions to be achieved, based on a pre-defined temperature chosen by the vehicle's occupants. In order to maintain this temperature, the system moderates the air flow and air volume passing through the blowers, as well as the air flow temperature.

Over the course of its research ADAC found that, if correctly used, fully automatic air-conditioning systems will consume markedly less fuel than conventional manual systems. However, if operated manually, their control mechanisms will not be of benefit and so no improvement in fuel economy will be seen.

The report also gives details of how the proportion of fuel consumption due to the air conditioning system is at its highest when vehicles are in heavy urban traffic. In such situations, when the car is slow-moving, the air conditioning will represent far more of a drain than any other power-consuming accessory in the vehicle, equating to nearly 70% in some cases.

ADAC concluded that vehicles using fully-automatic air-conditioning controls, in this particular case passive semiconductor technology (thermistors), were considerably more fuel-efficient than conventional manual or semi-automatic controls. Further independent studies have shown that even greater savings

> In some cases turning on the air conditioning can directly result in an increase of 15% in the vehicle's total fuel consumption

can be made to fuel consumption by utilizing more advanced semiconductor technology, featuring infrared (IR) sensors.

Along with air conditioning, the effect of the vehicle glazing on its fuel consumption should also be taken into account. In some vehicles, the total area of the windows can be as much as two square metres. On particularly sunny days this means the cabin will heat up considerably, with the air conditioning system having to work harder and consume more electricity. Some vehicles are now being introduced with optional thermal insulation. Through the absorption or reflection of the incident sunlight, it is possible to prevent the cabin from overheating. This thereby reduces the air-conditioning system's workload and lowers the fuel intake that must be allocated to this task.

### Move to Infrared Sensing Mechanisms

The sensor functionality deployed in many cars uses a simple temperature-dependent resistor to determine the air cabin temperature and, thus, regulate the air conditioning. But since heating via incident radiation from the sun is not factored in, this strategy often gives an inaccurate assessment of the temperature well-being of the passengers. This is leading to increased proliferation of more advanced sensing mechanisms based on some form of optoelectronics – in particular IR sensors. These are able to react far quicker to changes in temperature than other, more traditional sensor technologies. They can take into consideration the influence of sunlight on the temperature perceived by occupants and respond accordingly.

Going forward, factors like uneven distribution of sunlight throughout the cabin means that multi-zone air-conditioning systems capable of setting optimal conditions for each occupant will start to become more commonplace in both

**'FIRRAY'**

**THE MULTI-ELEMENT MLX90620 'FIRRAY', RECENTLY INTRODUCED BY MELEXIS, UTILISES THE COMPANY'S INNOVATIVE PROPRIETARY FIR (FAR INFRARED) TEMPERATURE MEASUREMENT TECHNOLOGY TO CREATE A HIGHLY COST-EFFECTIVE AND EASY-TO-IMPLEMENT THERMOGRAPHY SOLUTION.**

With a sensitivity range of 2um to 14um, it uses thermopile sensors to detect thermal radiation and measure temperatures, without needing to make contact with the object. Running from a 3V supply, this compact 16 x 4 element array is able to create a real-time profile of the emitted heat values for a given target. It can greatly simplify the thermal imaging system it is integrated into by immediately capturing imaging data from 64-pixel images in 2D, thus keeping the price-point suitable for high volume, low-cost applications. By integrating both an amplifier and analogue-to-digital converter (ADC) signal processing can be done directly, and the array offers an adjustable frame-rate from 0.5Hz to 64Hz.

Accuracy levels of ±1.5°C are maintained when operating in the 0°C to 50°C range. Two field of view (FoV) options are available (60º x 15º and 40º x 10º) to better fit specific application needs. A high speed I2C-compatible digital interface and a triggered mode for synchronisation with a control unit mean that this sensing array device can be used individually or combined with other devices to form an array with a larger imaging resolution.

The climate control system's external microcontroller can acquire the IR signal data from the array via the I2C bus and then, based on calibration data stored in the EEPROM memory, compensate for difference between sensors to build up an accurate thermal image, or calculate the temperature at each spot of the imaged scene. These constants can be used by the microcontroller for external post-processing of the thermal data, allowing pixel offset cancelling, pixel-to-pixel sensitivity difference compensation, object emissivity compensation and object temperature calculation. The result is an image with noise equivalent temperature difference (NETD) of better than 0.08KRMS at 1Hz refresh rate.
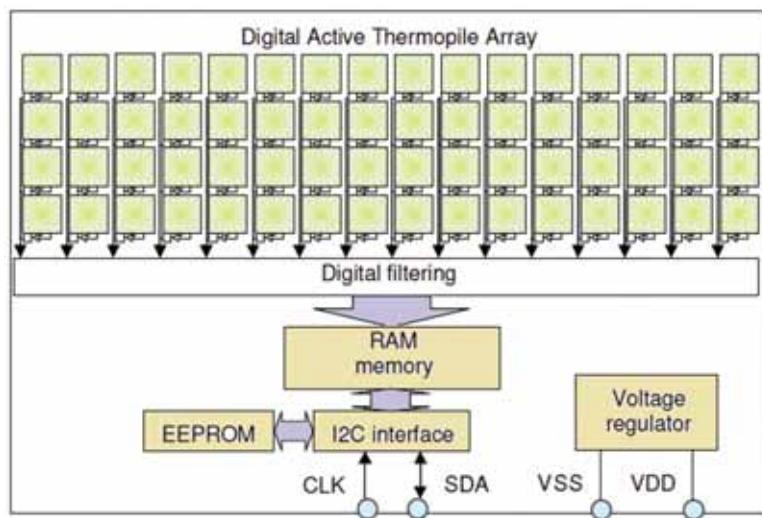


**Figure 3:** MLX90620 16x4 pixel FIR array with built-in EEPROM-stored calibration data and I2C digital interface

high-end and mid-range car models. Implementations of this nature call for multi-element IR sensor arrays that can produce an accurate profile of the variations in temperature throughout the cabin. These arrays offer a more sophisticated approach to addressing the changing heat-load, thus improving cabin temperature stability and enhancing the overall driving experience, while also being capable of reducing power consumption levels, lowering the system bill-of-materials and offering far easier implementation.

The use of multi-element far infrared (FIR) thermopile sensor arrays, covering the 20°C to 300°C temperature range, can produce a map of heat values for a given target area in real time, avoiding the need to scan the area with a single point sensor or employment of a costly micro-bolometer device. An array of this kind can measure the emitted IR energy from the driver/passenger and compensate for their

perceived temperature level, without being affected by variations in changes in cabin lighting conditions that could otherwise give erroneous results.

### Air-Conditioning Efficiency Issues in Electric Cars

Although the air-conditioning efficiency has to be considered for all new car model designs, more effective air-conditioning is particularly important in the hybrid/electrical vehicle sector. Electric vehicles, for example, have great difficulty when it comes to providing efficient cabin temperature control compared with vehicles based on internal combustion engines. The reason for this is that heat dissipated from the engine cooling system is not available to be utilized for cabin heating during winter. Furthermore, any drain on the battery of an electric vehicle will directly shorten its travelling range, resulting in more regular recharge periods and hampering performance.

The impact of automotive air-conditioning systems on vehicle fuel efficiency has been clearly quantified in the report published by ADAC, and car manufacturers need to act in order to diminish its magnitude. Deployment of innovative IR technology is now allowing next generation contactless in-cabin thermal sensor devices with multi-zone coverage to be brought to market. These promise to maintain driver/passenger comfort while significantly reducing power consumption levels and thereby improving fuel economy. ●

**REFERENCES**

[1] Automotive A/C Systems & their Impact on Fuel Efficiency, by Martin Poloczek, ADAC, July 2012

# VEHICLE STABILITY TESTING
## USING THE DEWETRON TEST SYSTEM

**ZHIBIN MIAO** AND **HONGTIAN ZHANG** FROM THE HEILONGJIANG INSTITUTE OF TECHNOLOGY IN CHINA PROPOSE A STABILITY CONTROL SYSTEM FOR VEHICLES, BASED ON CONTROLLING THE YAW MOTION. THE METHOD PROMISES TO DECREASE TRAFFIC ACCIDENTS AND REDUCE CASUALTIES AND VEHICLE DAMAGE

With the developments in vehicle technology and improvements in road traffic schemes, cars are becoming faster. As such, traffic accidents caused by high-speed instability are also on the rise.

Research carried out by car maker Audi states that around 40% of vehicles involved in traffic accidents at speeds of between 80km/h and 100km/h lose stability. When the vehicle exceeds 160km/h, almost all accidents are due to vehicle instability.

Related studies also indicate that in traffic accidents caused by loss of stability, 82% of vehicles will continue to travel a further 40 meters after loss of control. A Toyota study points out that almost all accidents caused by loss of control are due to not being able to control the vehicle's sideslip motion. As such, this subject matter is of critical importance to the automotive industry and drivers alike.

### Precision Measurement

Austrian firm Dewetron is a well-known manufacturer of portable data acquisition systems. It has always been known for its precision measurement equipment, but now it is also a main manufacturer of signal conditioning and open IPC platform test instruments.

In accordance with international vehicle road-test standards, we've used the DEWET 501-A test system in our project. With corresponding sensors, this system can acquire and process vehicle dynamic parameters such as vehicle speed, distance, steering angle, torque, wheel speed, and



**Figure 1**: Graphical interface of Dewetron testing system

lateral and longitudinal acceleration. It consists of a multi-channel data acquisition system, an analysis system and various sensors, which monitor the vehicle for coasting, fuel consumption, steep hill climbing, vehicle handling stability performance, maximum speed, acceleration, braking performance, operation stability, minimum stable speed, and measure the minimum turning diameter, brake pedal force, brake pedal stroke, brake line pressure, anti-lock braking system performance, temperature and so on.

> " Some 40% of vehicles involved in traffic accidents at speeds of between 80km/h and 100km/h lose stability; when the vehicle exceeds 160km/h, almost all accidents are due to vehicle instability

Not only can the system accurately complete automobile dynamic performance tests according to international standards, but it can also complete a dynamic and economic performance test, ride comfort test, handling and stability test and braking performance test.

The vehicle speed and distance sensors, which are based on global satellite positioning (GPS) technology, not only measure vehicle speed and distance, but also obtain the vehicle's test location and route data.

The system can provide important means for vehicle dynamic test and analysis. It can also capture video signals and access the CAN bus data acquisition module when it collects data. The graphical interface can be set up according to the test contents and personal preferences, as shown in Figure 1. Test data can then be saved and printed for further analysis.

### System Performance

The following are the overall system characteristics:
● **Test channel:** 32 analog channels (16 ICP/voltage input channels, 16 strain/voltage input channels); 8 counter input channels (for wheel speed sensor or engine speed frequency input); 8 digital I/O; 2 high-speed CAN-bus interfaces (for temperature module).
● **32 simultaneous sampling channels:** 100kS/s/ch and

**Figure 2:** Sensors of the Dewetron testing system

16-bit sampling frequency; A/D single channel, each channel can be individually set a sampling frequency.

● **Data storage:** 32G flash memory (expandable to 64G), which is very suitable for tests in a serious vibration environment.

● **The system can work in various ways:** independently or connected to a notebook computer.

● Its vibration characteristics meet the EN 60068-2-6 and EN 60721-3-2 2M2 standards. Electromagnetic interference resistance meets CE standards. So, it is fully applicable to the automobile road-test environment.

● **Signal conditioning:** its unique signal conditioning module is suitable for all kinds of sensors, which improves test accuracy and system reliability.

● **The software operating system:**
Windows XP; the data acquisition and analysis system is DEWESOFT-6-Prof and FLEXPRO-8-Prof DataView.

The connection diagram for testing system sensors is shown in Figure 2.

According to the specific requirements for vehicle performance test, the data acquisition and analysis system should have high impact resistance, vibration resistance, resistance to electromagnetic interference and other characteristics. The vehicle test data acquisition and analysis system is of compact-structure design. A signal conditioning module, the data acquisition board and arithmetic processing unit integrate into one system.

The DEWESoft software is an integration of multiple functions, including system parameter settings, a data recorder, X/Y oscilloscope, spectrum analyzer, octave analyzer, programmable operational virtual channel, video recorder and an integrated display.

System parameter settings include channel selection, range selection, filtering, sampling frequency, sensor parameter setting, sensor calibration, offset zero sensor and so on.

The data recorder function includes real-time display of measured values or mean square value and average value; simultaneously opening multiple display windows, with each window able to display from one to four channels.

The oscilloscope options can simultaneously open multiple display windows, and each window can be displayed in one to eight channels with the trigger mode.

X/Y recorder can display one or more channel for measurement test.

The spectrum analyzer has a variety of window functions (Henning, flat top, Haining, rectangular, index) with 256 to 64K spectral lines of resolution. It also has linear and logarithmic coordinates on the display, which shows the maximum RMS and frequency peak and can add dynamic marking frequency and amplitude.



**Figure 3:** Simulink diagram
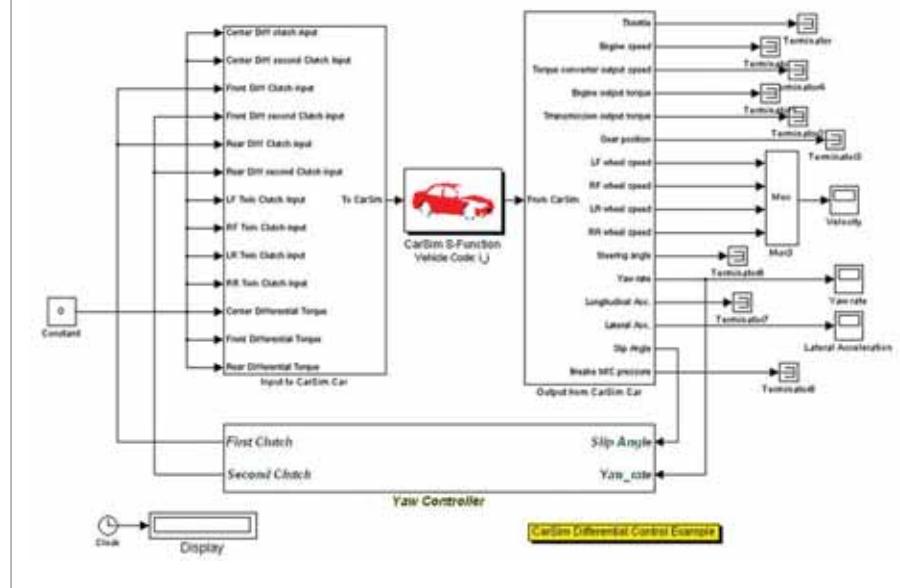
The octave analyzer has a 1/1, 1/3, 1/12, 1/24 octave online display, which shows the maximum RMS, frequency peak, linear and logarithmic coordinate.

The programmable operational virtual channel has a powerful online mathematical operations and filtering function, including triangle, differential, integral, logic and programmable digital filter function; virtual channels can be created arbitrarily.

The video recorder has synchronized video recording functions and supports four video inputs.

Flexible trigger features include optional level, time, triggering signal frequency, triggering condition, filtering edge trigger, slope trigger, pulse width, pulse width trigger and combination of multiple trigger modes.

Each channel can independently set a sampling frequency, which can automatically convert to high-speed sampling rate according to the trigger. It can connect GPS and complete

**Figure 4:** The test vehicle's route



**Figure 5:** The test vehicle with the Dewtron test system
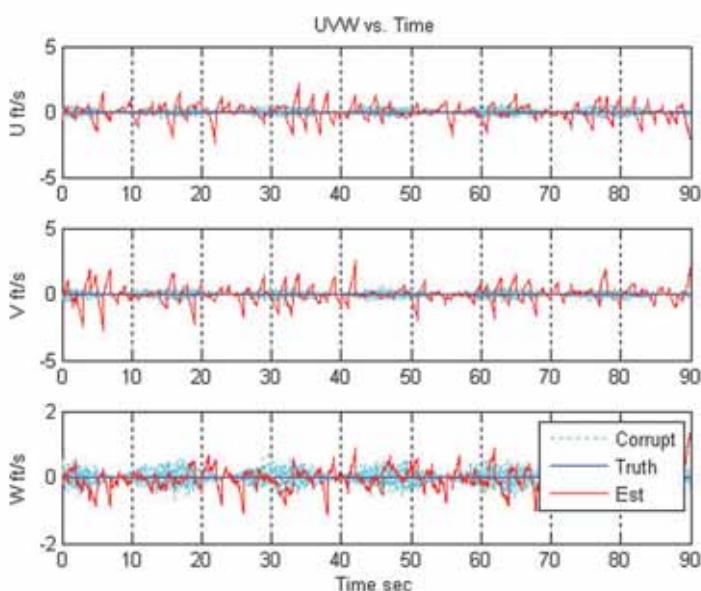


**Figure 6:** Linear velocities

synchronization with IRIG codes (Inter-range instrumentation group time codes). Band sensor database functions can connect a TEDS (Transducer Electronic Data Sheet) sensor and support multiple A/D cards.

Files can be output in a variety of formats including text, Excel, Flexpro, Matlab, I-DEAS, EScope and UFF58.

## Testing Application

To demonstrate the advantages of this system, we're checking a car's stability testing, based on a computer simulation. The part control structure of Simulink in Matlab is shown in Figure 3. Carsim is also used in this computer simulation.

The route of the vehicle is a square shape and the GPS signal is not stable or high precision. The GPS/INS integration navigation system can overcome the shortcomings of GPS in a city, however. Figure 4 shows the test track for the test. Figure 5 shows the test car and the Dewetron test system.

By evaluating the testing, three linear velocities, three angles and three position coordinates are calculated. The linear velocities calculations are shown in Figure 6. It can be seen that the errors are smaller than when not using the test system. ●

Figure 1: Miniature wire-to-wire connectors from Molex
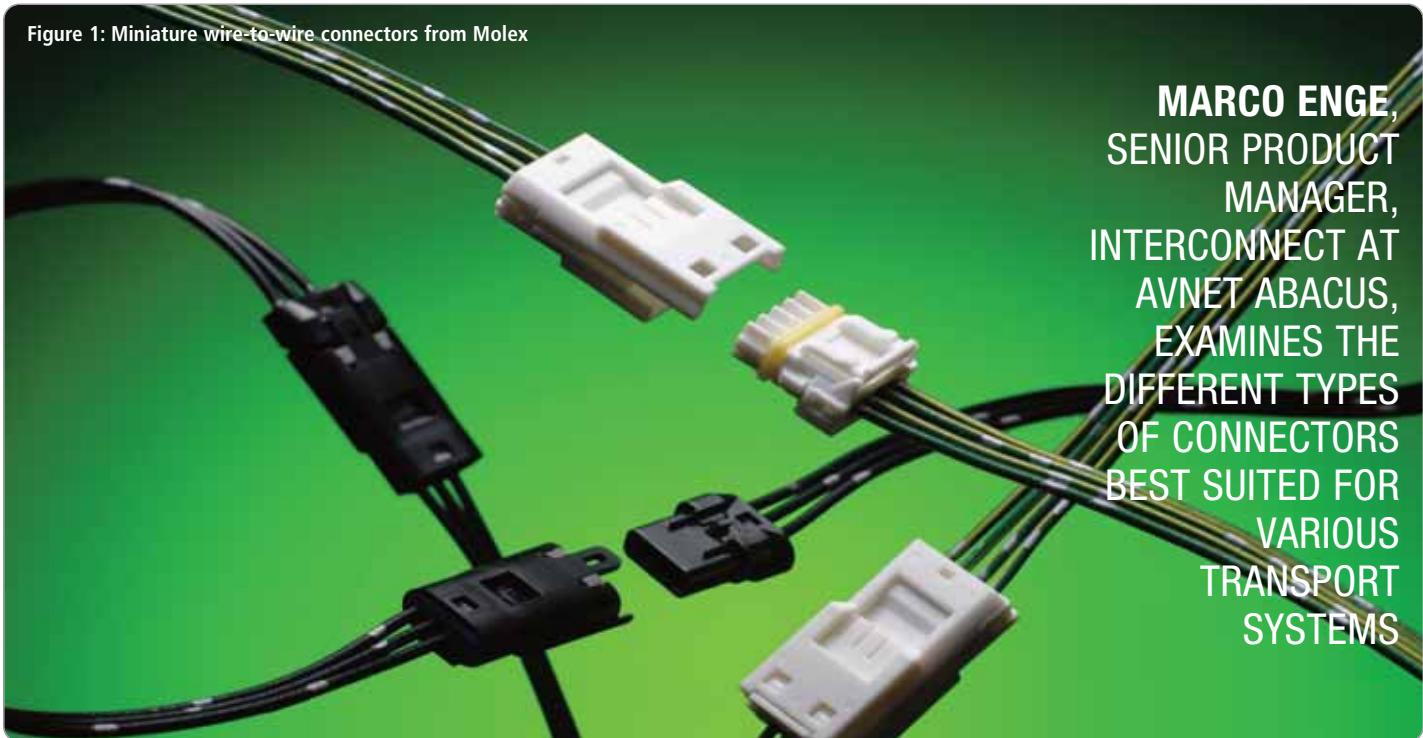
**MARCO ENGE**, SENIOR PRODUCT MANAGER, INTERCONNECT AT AVNET ABACUS, EXAMINES THE DIFFERENT TYPES OF CONNECTORS BEST SUITED FOR VARIOUS TRANSPORT SYSTEMS

# MULTIPLICITY OF CONNECTOR TYPES SUITABLE FOR TRANSPORTATION APPLICATIONS

**W**hat makes an electrical connector suitable for transportation applications? Not surprisingly, the answer to this question is going to depend on a number of considerations. This may range from the nature of the target application and how hostile or benign that environment is, through to how important the integrity of the connection is; for example does it provide a safety-critical function? The type of connector, whether for power, data or control signals, is clearly a primary selection criterion. Beyond this step, the decision process will be determined by whether the connector is required to mate a cable to another cable or to a socket or terminal on a circuit board assembly.

This article will look at the various types of connector typically used in transportation applications. Some are very

> While clearly designed as a heavy-duty connector, Amphenol's heavy|mate product is also an excellent example of a modular, hybrid connector solution

specific to certain applications, while others may be standard products that perhaps have higher specifications than their more commercial counterparts. Aspects of safety, reliability and environmental performance will all be considered by reviewing a number of different types of connector from various manufacturers.

## Connector Selection Criteria

The spectrum of transportation applications for electrical connectors ranges from relatively benign requirements, such as in-car entertainment systems, through to the ultra-rugged demands of construction, mining or agricultural vehicles. Add to this picture planes, boats and trains, and selecting a connector for use in a passenger or freight vehicle quickly becomes a multi-faceted consideration.

A connector's location has a significant bearing on its specification. An inline wire-to-wire connector used within a vehicle cabin is more likely to be defined by the number of contacts, and the contacts' current, voltage or other signal-handling characteristics, rather than the need for extreme mechanical ruggedness. That is not to say that such a connector does not need to offer good environmental performance, but quick and easy, low-force mating with

**Figure 2:** Molex SRC series multi-way wire-to-panel connector



**Figure 3:** Amphenol heavy|mate modular metal connector

positive orientation and locking will be key attributes. The SICMA series from Delphi (formerly FCI MVL) provides 2- to 6-way, mixed loading connectors that also meet the wider temperature range (-40oC to +125oC) and high sealing performance needed for use in engine compartments and other harsh environments.

Molex targets its similar Mizu-P25 series of miniature connectors at motorcycle applications where space is at a premium but also dust and moisture sealing is vital. These connectors feature the smallest mated diameter of any comparable type and were the first in their class to achieve IP67 sealing. They also feature colour-coded housings with polarization for correct mating, easy-to-use positive locks, a low-insertion-force terminal design, and are available in two families for low- or high-voltage operation (up to 125V or 250V respectively).

### Wire-To-Panel Connectors

Wire-to-panel connectors are more likely to focus on mechanical ruggedness and environmental performance. Such connectors may be located on the bulkhead between the engine compartment and cabin of a vehicle, often providing a means of isolating one from the other (referred to by

manufacturers as a firewall connector). This is illustrated in Figure 2 by Molex's SRC (sealed rectangular connector) series, targeted at commercial vehicles. Providing up to 84-way, mixed power or signal connections, this range features a sliding, cam-action latch enabling single-handed, blind mating in difficult situations, especially in agricultural machinery, mining and construction equipment, as well as rail and marine applications.

The SRC series provides full IP69K protection against dust and moisture (including water jet), together with a connector retention system that withstands forces greater than 200N, making this product particularly suited to harsh environments with high vibration levels. Assembly and labour costs are addressed by having the housing, seals, rear cover and terminal block shipped as a pre-assembled unit with a design that ensures crimped terminal leads are correctly located and locked into the connector. The rear cover provides protection and strain relief to the wire-seal interface.

Other manufacturers offer similar wire-to-panel connectors, or wire-to-board as they are sometimes described: Delphi's CMC series has compact, high-density connectors targeted at electronic engine control unit applications in cars, trucks and buses. The range includes 32, 48 and 64-way cable connectors and 32, 48, 64 and 112-pin headers, and supports operation from -40oC to +125oC with waterproof options of IP68 or IP69K. The APD series of circular connectors from ITT Cannon is also aimed at trucks and buses, as well as electric and other special vehicle applications. The series provides for high power and high voltage in a high-density design that supports connections up to 51-way. The circular body employs a bayonet coupling method that ensures vibration resistance, giving 100% reliability in harsh environments, and superior IP69K sealing is achieved using individual wire seals.

The connector types reviewed so far provide high performance electrical and environment specifications; featuring multi-way, high-current contacts and operation over a wide temperature range, commonly with full ingress protection from dust and water. However, all have been plastic-bodied designs, which while sufficiently robust for many automotive and similar vehicle applications, are not necessarily heavy duty enough for various industrial environments (including railways) or for use in vulnerable, exposed locations. For these applications, metal-bodied connectors such as Amphenol's heavy|mate brand range may be the answer.

### Heavy-Duty Connectors

While clearly designed as a heavy-duty connector, Amphenol's heavy|mate product, shown in Figure 3, is also an excellent example of a modular, hybrid connector solution. As such, it serves to illustrate many of the remaining considerations in selecting a connector for transport applications, so we will look at its features and

**Figure 4**: Radsok-technology for high power contacts



**Figure 5**: Amphenol's 'Wall-bushing' power feed through connector

specification in a little more detail.

First and foremost the heavy|mate connector is designed to be mechanically robust, vibration-proof, corrosion-resistant and impervious to the ingress of dust and moisture. It is targeted at industrial applications, including the more demanding end of the transportation market but also heavy machinery and the type of robotics equipment found in car assembly plants, giving some appreciation for the kind of use and conditions it needs to endure. The basic connector format is a wire-to-panel design but, unlike those above, it features a metal panel connector housing, a metal cable connector shroud and metal locking levers, all contributing to a highly robust design that provides secure, vibration resistant connector mating. Corrosion resistance is achieved with different case coatings to meet various performance specifications and, while competing parts exhibit surface peeling and rivet corrosion after 100-hour salt spray tests, Amphenol's highly-resistant coating can protect against much more extreme conditions.

Not all applications require the same level of environmental protection so, where not necessary, choosing a

lower specification may make sense. For example, the IP67 version of the heavy|mate connector saves cost with a more compact design that uses potted rivets and a collar to avoid sealing movement, while still maintaining a compatible panel cut. As well as sealing, the heavy|mate connector design also addresses electromagnetic compatibility requirements with a special EMC housing that incorporates shielding plates and collars.

The modular nature of the heavy|mate connector design provides frames that accommodate either 2, 3, 5 or 7 modules and allows for hybrid connectivity, supporting multiple-pin power or control connections at high voltage (up to 1000V) and high current (up to 240A), as well as signal interconnections including fibre optic, RJ45 and CAN-Bus type connectors.

Available contact technologies include machined contacts or lower-cost stamped contacts based on a vibration-proof, double-crimp design using a quality bronze material combined with partial plating to save money. Machine-crimping assembly can deliver further wiring cost savings at breakeven volumes around 60,000 compared to solder, screw or hand crimping. The insulated body of the connector guides the mating of stamped contacts, preventing contacts bouncing or being pushed out.

High-power contacts are provided by Amphenol's Radsok technology (as seen in Figure 4), which enables high current in a small diameter by providing a large contact surface. This low-insertion-force contact design absorbs vibration and provides a self-cleaning action. The same Radsok technology is also used in Amphenol's 'Wall bushing' power distribution connector, which provides a high-current, sealed connection through a bulkhead.

### Designed For Demanding Performance Requirements

Connector technology seems simple in principle but is complicated by demanding performance requirements and detailed technical specifications.

This article has attempted to unravel some of the issues concerning connectors for transport applications, but is by no means a definitive guide. Considerations that may need to be explored further include aspects of reliability and safety, such as how many mating cycles must be guaranteed, or if approval to VDE, UL or CSA standards are mandated by the target application. Hopefully though, an appreciation of some of the products serving the transport market will help guide the selection process. ●

# EMBEDDED BATTERIES?
## HAVE YOU GOT A SCREW LOOSE?

AN INTRIGUING BATTERY-RELATED STORY CAUGHT THE EYE OF **NEIL OLIVER**, TECHNICAL MARKETING MANAGER AT ACCUTRONICS

There was a worrying incident that took place last year: An Apple iPhone developed a fault and started emitting black smoke while the user was onboard a commercial aircraft. It ultimately had to be doused with a fire extinguisher.

Following the incident, the Australian Transport Safety Bureau published a full report. The fault turned out to be a rogue screw inside the phone that was left there following a screen repair made by an unauthorised repair centre. The screw was pressed into the soft packaging of the phone's embedded Lithium Ion polymer battery causing a short circuit that resulted in rapid increase in temperature, which quickly led to degradation of the battery itself. Luckily no-one was hurt on this occasion.

This story should act as a warning for original equipment manufacturers (OEMs) who are designing any type of electronic device with an embedded battery. You can control your own assembly operations or audit those of your subcontractor, but what happens down the road when someone else opens up your device and starts messing around with a screwdriver? How well is the battery protected? Can a foreign body be introduced that could create a short circuit? Furthermore, can you even stop someone from removing the approved battery and replacing it with one they bought for £5 on the Internet?

There was a time, in the not so distant past, when 'no user serviceable parts inside' meant you should leave your screwdriver in the drawer. However, in the age of the Internet, it is possible to Google a solution to any repair problem and then watch a HD video where a self-appointed YouTube 'expert' shows how to tear down, repair and rebuild almost anything with just a pen knife and soldering iron.

Where embedded batteries are concerned, this raises serious safety concerns as the OEM cannot control what an end user might attempt to do to the battery, to its protection circuitry or to the device charge circuitry. The device may simply stop working but the illegal repair could also start a fire, putting both property and lives at risk.

### Mechanical Disconnect

Manufacturers who are designing a device containing an embedded battery would be well advised to consider what should happen to the battery when someone opens the device.

I would advocate a mechanical disconnect so the battery is rendered useless if the device is opened. In this instance, the device would have to be returned to an authorised centre for a new battery to be fitted.

Manufacturers can further protect themselves by incorporating electronic authentication into their batteries and devices to protect against the use of illegal copies which can damage a company's reputation and aftermarket sales.

Of course embedded batteries are not the only solution for powering portable electronic devices. Removable batteries remain a viable option for all but the smallest of devices.

Removable batteries permit the use of multiple batteries per device and do not require the device to be opened when the battery needs replacing. In a product with an extended life cycle, the use of a removable battery makes far more sense, as the battery may be replaced many times during the life of the device.

### Suitable Applications

One sector where it is crucial that the battery – and unit as a whole – retain their integrity and not be tampered with by eager but ultimately misguided DIY enthusiasts is the medical industry.

For example, portable back-up power packs are used to power home-use medical ventilators, giving patients with respiratory illnesses confidence and security at home. Obviously, it's essential that such units are not tampered with,



Figure 1: When an Apple iPhone developed a fault and started emitting black smoke while the user was on-board a commercial aircraft, it was found that the problem was a loose screw resulting from an unqualified repair

**Figure 2:** Accutronics's CC2300 are good examples of batteries for professional electronic devices where a removeable solution is required

to transport this crucial equipment on their persons they simply can't afford to be overloaded. Moreover, where soldiers have to carry radio equipment, transmitters, lighting or vision systems, robustness becomes an additional imperative.

### Cell Nucleus

Many design engineers believe that, as a power source, the battery is the very heart of the product. However, one could go even deeper into the core of the battery and argue that the cell is the nucleus of the battery, determining the performance, lifecycle and durability of the application.

Some customers might be looking for high energy capacity, whilst others might need low-temperature performance, high availability, a longer lifecycle or a specific battery size. In other words, finding out exactly what is required of a battery for a piece of equipment is crucial to the success of the design. As a result, the first thing OEMs and battery developers should consider in each case is cell selection. There are always a number of stakeholders in any OEM device design and it is important for everyone to be involved early in the development cycle, if the optimal battery solution is to be chosen.

To select the most appropriate cell types, the design engineer first needs to determine the power consumption of the application, the runtime requirements and environmental operating conditions, feeding into this is the weight and volume budget and a requirement for the battery to meet specific cost targets.

The battery developer has a number of cell types available, including nickel cadmium (NiCad), nickel metal hydride (NiMH), Li-ion and Lithium ion polymer (LiP). In recent years Lithium ion chemistries have dominated product development due to their high energy density and excellent safety record, but the older nickel chemistries still offer superior performance in certain applications.

One fundamental guideline is to decide if the battery has to withstand extreme conditions such as freezing temperature, scorching heat, humidity or dirt. In these instances, the electronics need to be programmed differently to cope with the various environments, whilst the physical characteristics of the battery need to be robust enough for the given extremes.

### Alleviating Obsolescence

Intelligent cell selection can also help ensure future availability of the battery, which means the cell can be replaced if a superior version becomes available. This ensures a longer lifecycle for the battery and helps alleviate obsolescence-related issues.

The design of the electronics embedded within the system is another key issue for the OEM and its battery partner to address. The battery itself is an integral part of something that Accutronics refers to as the power management 'triangle'. This consists of the actual device on one side and the battery and the charger on each of the other two sides. One might define a good power management system as these three elements work together in harmony.

despite the temptation created by their use at home.

For X-ray machines, the development of powerful, lightweight batteries has enabled new portability, allowing X-rays to be carried out more quickly and cheaply than ever before, with the same quality. These kinds of devices help medical professionals rapidly and accurately assess the needs of casualty patients.

And whether it is a POS (Point of Sale) machine used in a restaurant or high-tech night-vision goggles, portable electronics have invaded every aspect of our personal and professional lives. Engineers, scientists, restaurant staff, delivery operatives and doctors all use portable electronic equipment that keeps the world turning. The common denominator in all of these devices is the requirement for a safe and reliable battery system. Other key requirements are ease-of-use, light weight and robustness. In the defence sector for instance, when military personnel on duty have

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**CREDIT-CARD-SIZED BATTERIES**

**THE ACCUTRONICS CC2300 AND CC3800 ARE GOOD EXAMPLES OF BATTERIES FOR PROFESSIONAL ELECTRONIC DEVICES WHERE A REMOVABLE SOLUTION IS REQUIRED.**

They meet all current transportation and IEC safety standards and have been designed without screws. Both are Lithium ion (Li-ion) credit-card-sized batteries for medical, industrial and portable electronic applications.

The credit card batteries were developed in response to OEM demand for a short lead-time, compact and rechargeable Lithium ion battery for their portable devices. They feature accurate impedance-tracking fuel gauges, an active protection system and a compact connector, all contained in a package with a footprint identical to that of a credit card.

These new smart batteries are ideal for applications such as telehealthcare, data recorders, point of sale terminals, handheld security scanners and numerous other portable electronic devices intended for professional use.

Every portable device in the consumer world, from satellite navigation units and laptops, to media players and mobile phones, has some sort of electronic power management system. The same applies in the specialist worlds of medical, military and industrial electronic device design, but here the operation of the battery is often mission-critical.

The best way to ensure that the power-management triangle principle is observed is to use a common communication system to determine the methods of communication between smart batteries, smart chargers and system devices. A battery designed this way controls how it is going to be charged by communicating with a smart charger and requesting the voltage and current it needs. This is the safest and most efficient way of charging the battery because it is always the battery itself that remains in control rather than a charging regime being imposed on it.

> One sector where it is crucial that the battery and unit as a whole retain their integrity and not be tampered with by eager but ultimately misguided DIY enthusiasts in the medical industry

The physical characteristics of a battery, such as its size, durability and weight, are also crucial in its design, as well as its performance characteristics such as efficiency, reliability and availability. For instance, portable medical devices might require a high tolerance to vibration, so they can be used while transporting patients by helicopter. Achieving this is a matter of managing the physical and performance characteristics simultaneously, which is no mean feat.

In military products, such as night vision goggles or rugged portable computers, which are often used in extreme environments, the battery needs to be able to cope with those conditions and also be small and lightweight for ease of carriage. For instance, it might must be watertight or feature sufficient ingress protection to keep out sand and dirt.

Material choice is crucial in ensuring these requirements are met. Magnesium, for instance, is very low weight, although expensive. If cost is a significant factor, which very often it is, a designer might instead work on the general shape and size of the battery and insulation techniques to help meet the client's expectations.

Another important factor to consider, and one that applies to the integration of all sub-assembled components, is the availability of parts and their potential obsolescence. For this reason, engineers should avoid designing in off-the-shelf consumer batteries. Experience has shown that these are poorly supported technically and very likely to become obsolete quickly.

For example, if you are manufacturing a portable satellite navigation system for military use, you may only make a couple of hundred units a year. If you opt for a battery intended for a consumer DVD player to help cut costs, you put yourself in very serious danger of receiving a last-order notice from your supplier sooner than you might expect.

## Long Product Lifecycle Issues

If the original battery manufacturer stops making the product, you will be faced with a situation in which the only way to get spare batteries is to reverse engineer your own. This is a particular issue for medical and military products, which usually have a long lifecycle, frequently more than a decade. Because of this, a good cell manufacturer will always work closely with the customer – and possibly the end user – to design cells that have a clear roadmap to guide the OEM through the future availability of the product.

This means that even if new technology renders the original plan obsolete, the manufacturer will still be able to provide the battery or an exact equivalent, and it will still work to the customer's specification. Simply choosing a customised industrial or professional battery, designed with your application in mind, guarantees you a lifetime of support.

Once a battery prototype has been developed, the final stage is to certify the product for use, from both safety and performance perspectives. So, even in highly professional applications, the OEM should protect the integrity of their device to ensure both the safety of the end user and their own legal position should anything go wrong. The alternative is to leave the embedded application open to abuse by the self-appointed YouTube experts and their legion of online 'likes'. ●

## ACCUTRONICS'S ATTENTION TO DETAIL

**THE RESEARCH AND DEVELOPMENT TEAM AT ACCUTRONICS IS DEDICATED TO DEVELOPING AND MANUFACTURING RECHARGEABLE BATTERIES THAT ALLOW PROFESSIONAL PEOPLE TO MEASURE, CALCULATE, INTERROGATE, SAMPLE, MONITOR OR COMMUNICATE IN THE WAY THEIR JOBS DEMAND.**

This is made possible by integrating fuel gauging electronics, active protection circuits and careful cell balancing into our batteries. Providing customers with state-of-the-art battery functionality is the focus of all efforts at Accutronics, as there is no such thing as a typical battery design project. This is partly because bespoke power sources are used everywhere from hospitals to manufacturing plants to military operations.

Once a battery prototype has been developed, the final stage is to certify the product for use, from both safety and performance perspectives. Accutronics normally manages the entire approval process on behalf of its customers. Each battery design undergoes the appropriate safety testing from, for example, the International Electrotechnical Commission (IEC) and Underwriters Laboratories (UL), as well as the International Air Transportation Authority (IATA) and military standards testing from MIL-STD-810F – The US Department of Defence Test Method Standard for Environmental Engineering Considerations and Laboratory Tests – if relevant.

# CLEANING IN ELECTRONICS MANUFACTURING
## IS KEY TO COMPONENTS RELIABILITY

THE GROWING NUMBER OF FAULTS IN ELECTRONIC COMPONENTS MANUFACTURED IN NO-CLEAN PROCESSES PUTS THE FOCUS BACK ON CLEANING IN ELECTRONICS MANUFACTURING. BY **DORIS SCHULZ**

Increasingly sophisticated components, their continuing miniaturization and growing reliability and lifetime requirements needs high level of cleanliness. The rising number of faults in electronic components manufactured in no-clean processes also puts the focus back on cleaning in electronics manufacturing. Adopting a cleaning strategy offers requirements-orientated cleanliness in an effective, reproducible and environmentally sound manner.

On the one hand particles, residua of flux materials and processing media can all severely damage electronic products. On the other hand, the need to clean components in electronics manufacturing has been 'diluted' by the development of no-clean fluxes and soldering pastes. For many components that are only used in non-critical atmospheric environments this is not a problem. However, if they are used in adverse environments, such as humid or fluctuating temperatures, the protective layer applied in a no-clean process can be gradually eroded, releasing ionizing substances that promote electro-migration and dendritic growth. This mostly occurs in narrow spaces, beneath components and between their connections or other contact surfaces. In addition, progressive miniaturization, wire bonding, protective coatings (conformal coatings) and increased use of high voltage components, all call for a high level of surface cleanliness. Added to these is the use of lead-free solders, containing a higher proportion of fluxes and more aggressive activators that can cause problems.

Cleaning of electronic components also involves removing potentially hazardous impurities such as fluxes, residues of soldering agents and adhesives, and such contaminants as dust and residue from previous manufacturing stages.

### Cleaning Agents

Wet chemical ultrasonic cleaning helps clean particles, flux material residua and other film-like contaminations from metal electronic components, printed circuit boards and wafers. Along with the cleaning medium, the frequency of the signals generated by the ultrasound generator is decisive for the cleaning effect, at which the oscillating system transmits these signals as sound waves into the liquid bath. Generally, the lower the frequency of the electrical signals, the higher the energy released by the sound waves. For cleaning tasks which require multiple frequencies, modular ultrasonic generators are available that can generate up to three different frequencies.

Selection criteria for suitable cleaning agents include the nature and quantity of the impurities to be removed and the subject material. Cleaning agents currently used in electronics manufacturing include solvents, water-based media containing alkaline surfactants, and water-based tenside-free cleaning agents.



**Figure 1:** Polished glass wafers are cleaned in an ultrasonic cleaning system with several immersion and rinsing baths before the conductive layers are evaporated on. Highly alkaline to neutral cleaning agents are used as medium
[Photo credit: UCM]

Solvents mainly in use contain non-halogenated hydrocarbons, modified alcohols or hydrofluorethers (HFEs). HFEs were developed as an alternative to the previously preferred chlorofluorocarbons (CFCs), after CFC manufacture was stopped about 20 years ago due to their high potential for breaking down ozone. Non-inflammable HFEs have similar properties to CFCs but pose no danger to the ozone, do not persist in the atmosphere and have low greenhouse effects. Additionally, they offer beneficial physical properties for cleaning of electronics, such as relatively high density, low viscosity and low surface tension. These solvents are used in monosolvent, cosolvent and bisolvent systems.

A monosolvent system usually uses a pure HFE. It is used to remove slight impurities such as light oils, halogen compounds, residue of easyclean solvent, particles and dust.

The cosolvent system consists of an HFE combined with a low-volatility organic solvent as solubility promoter. The solubility promoter removes impurities from the surface of the workpiece, and the HFE rinses away the solvent and the impurities from the components. Cleaning by cosolvent procedure is extremely versatile and gives good results with the most stubborn impurities such as heavy oils, grease, waxes, NC-flux residues, adhesives and hot-melt glues. Choice of a low-volatility organic solvent allows material compatibility to be tested.

> Cleaning by cosolvent procedure is extremely versatile and gives good results with the most stubborn impurities

Cosolvent and bisolvent systems differ mainly in that, for the cosolvent system, the solvent and the rinsing agent are mixed together, whilst in the bisolvent process they are kept separate.

## Process Optimization

To ensure efficient and reproducible cleaning, it is essential to match the cleaning agent to the machine technology. In selecting the type of cleaning equipment to use, key questions are: What throughput must be handled? What space is available in which to set up the equipment? How can the cleaning process be integrated into the manufacturing chain?

In addition to wet chemical procedures there's the cleaning technology that uses compressed carbon dioxide. This method complies with the requirements for environmentally-friendly, dry and residue-free techniques. Here, the $CO_2$ is liquefied by means of pressure. In this phase of $CO_2$, or supercritical $CO_2$, the medium is characterised by very good solvent characteristics when compared to numerous covalent contaminations, such as greases and oils.

Supercritical $CO_2$ is distinguished by low viscosity and low interfacial tension, which results in improved gap penetration capability. This allows to clean components with extremely complex geometries, as well as extremely small drill-holes and
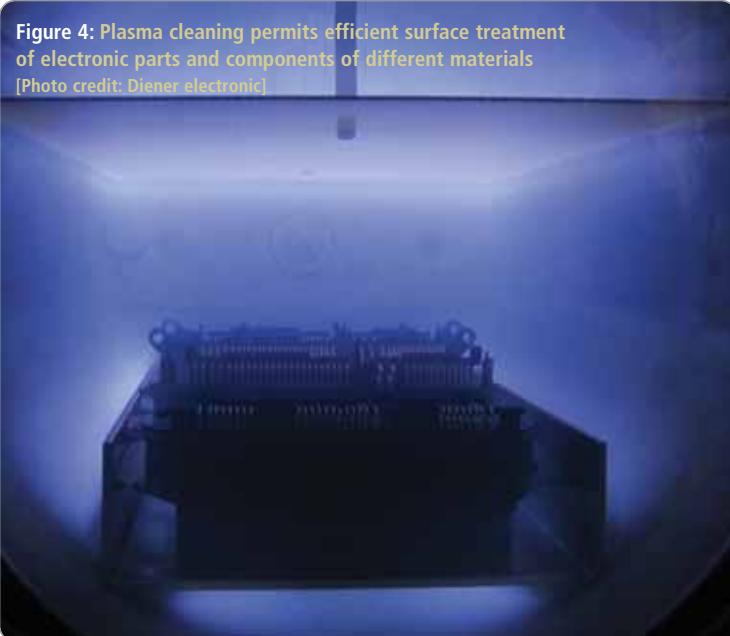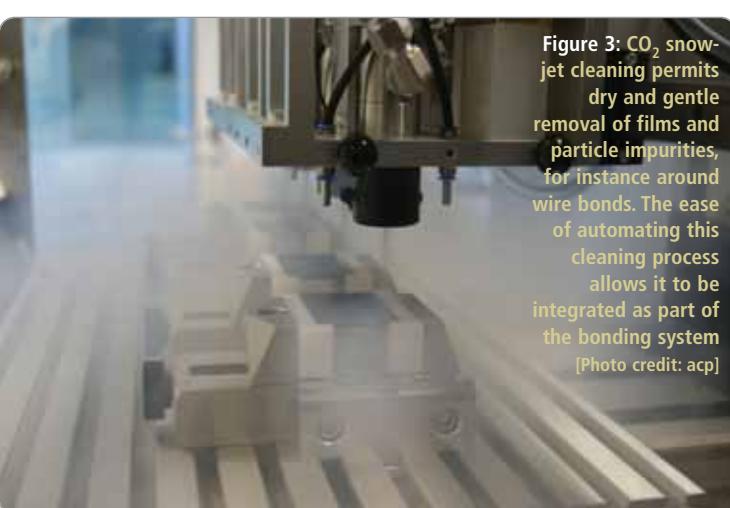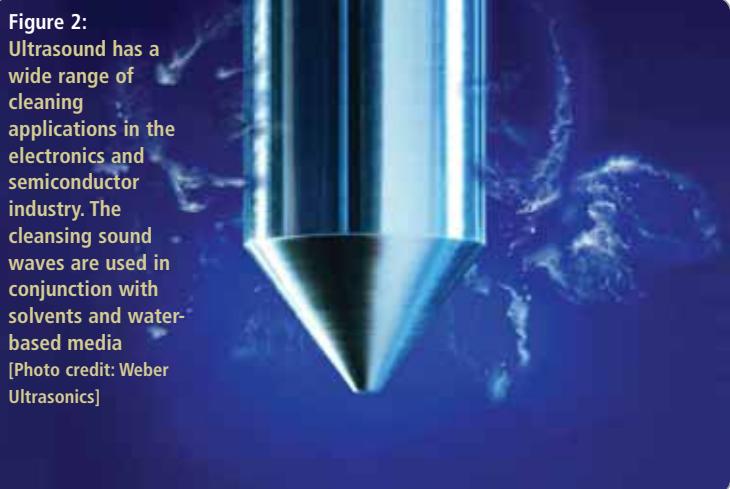


**Figure 2:** Ultrasound has a wide range of cleaning applications in the electronics and semiconductor industry. The cleansing sound waves are used in conjunction with solvents and water-based media [Photo credit: Weber Ultrasonics]



**Figure 3:** $CO_2$ snow-jet cleaning permits dry and gentle removal of films and particle impurities, for instance around wire bonds. The ease of automating this cleaning process allows it to be integrated as part of the bonding system [Photo credit: acp]



**Figure 4:** Plasma cleaning permits efficient surface treatment of electronic parts and components of different materials [Photo credit: Diener electronic]

very narrow gaps. In the field of electronics production, this technology has great potential as regards to cleaning complete printed circuit boards and assemblies, removing flux material residua, as well as removing oils and greases from metal
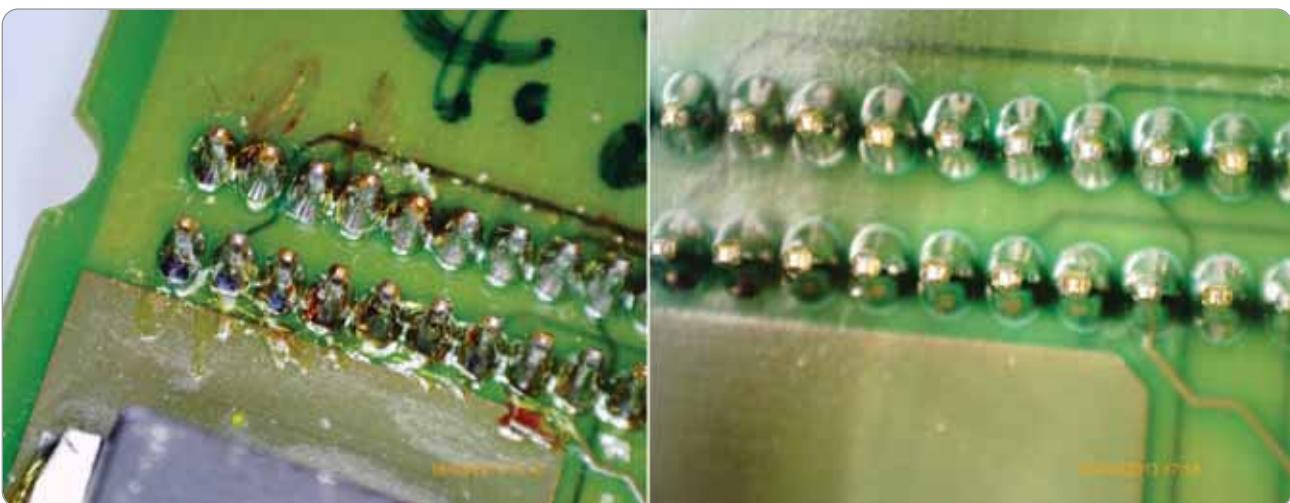
**Figure 5**: Non-inflammable HFEs allow for reliable removal of flux residues with good results
[Photo credit: Puretecs]
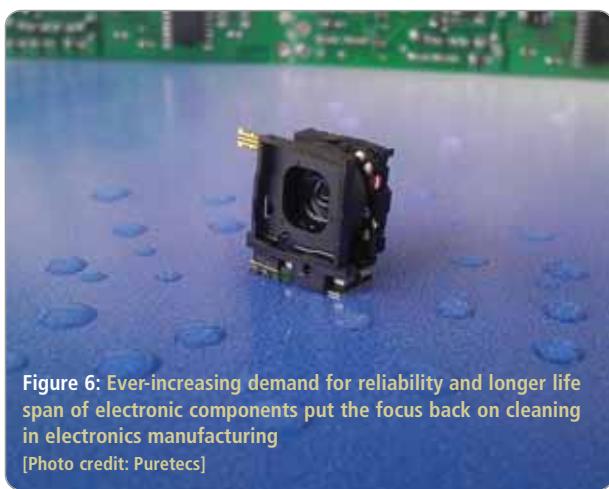


**Figure 6**: Ever-increasing demand for reliability and longer life span of electronic components put the focus back on cleaning in electronics manufacturing
[Photo credit: Puretecs]

components such as contacts.

Depending on the phase the environmentally-neutral carbon dioxide is used in, the process temperature is between 15 and 31 degrees Celsius. As such, the procedure is also suitable for the treatment of temperature-sensitive materials. As $CO_2$ will sublime immediately at ambient pressure, the components are completely dry upon completion of the cleaning procedure. Thanks to the direct transition to a gaseous phase, there will be no solvent residua remaining on the components and no secondary waste materials will be generated.

### CO2 Snow – An Ice-Cold Alternative

Liquid carbon dioxide is also used as a medium in CO2 snow-jet cleaning – in this case in the form of minute snow crystals. Due to the interaction of chemical, thermal and mechanical properties, the non-toxic and non-inflammable CO2 snow will remove film-like and particulate contaminations without leaving any residue, even selectively on functional areas such as contact points for example. As the cleaning procedure is of a dry nature, energy-intensive drying processes are not applicable here either.

The technology is employed for custom-tailored reliable manual- or fully-automated cleaning, in line with the requirements of different phases in electronics manufacture, such as preparation for bonding, equipping PCBs and foil-PCBs, and the manufacture of metal-insulator semiconductors (MISs).

### Plasma – Cleaning and Activation

Plasma, a gaseous mixture of atoms, molecules, ions and free electrons, allows for efficient surface treatment of electronic components and parts made of different materials. Here, organic contaminations such as oils and greases are cleaned and immediately the surface is activated. This double function is based on a physical and chemical reaction.

Depending on the case, low-pressure plasma or inline-compatible atmospheric pressure plasma is used. With the former it is possible to implement both oxidising and reducing processes. Within the oxidising plasma, organic contaminations such as greases, oils and adhesive residua can be removed before soldering or bonding. Reducing plasma processes are mainly used to optimise bond connections by means of reducing galvanically-applied metal layers.



**Figure 7**: Fluorescence measurements allow for inline cleanliness control for film-like residual contamination such as oil, grease which can impair downstream processes
[Photo Credit: SITA Messtechnik]

In the electronics industry, processes of surface cleaning and activation by means of atmospheric pressure plasmas are used before printing, before gluing or pouring electronic printed circuit boards and semiconductors, in the field of optoelectronic component production, as well as before wire bonding for example.

### Inline Cleanliness Control

For the inspection of cleaned parts and surfaces for residual contamination, which might impair the quality of downstream processes such as conformal coating and bonding, various methods are available including fluorescence measurement. The method utilizes the property of oils, grease, flux residues and surfactants to fluoresce when excited by ultraviolet light. The stronger the film layer, the stronger the emitted fluorescence. Calibration is conducted individually with the help of an ideally cleaned surface. Such systems can be integrated in a production line for inline measurement. ●

### PARTS2CLEAN

parts2clean is an international tradefair for industrial parts and surface cleaning. It aims to answer manufacturing questions such as: "What cleaning procedures will achieve the required degree of cleanliness repeatably and efficiently for a specific electronic product?", "What are the possibilities offered by special procedures for cleaning and activation?" and "Are there ways to carry out cleaning and conformal coating in a single process?" among others. The leading international tradefair for industrial parts and surface cleaning will be held from 22 to 24 October 2013 at the exhibition centre in Stuttgart, Germany, providing comprehensive details of cleaning systems, alternative cleaning technologies, cleaning media, quality assurance and test procedures, cleaning and transport containers, disposal and processing of process media, handling and automation, service provision, consulting, research and technical literature.
In addition, there will be simultaneous German-English/English-German translation of lectures at the parts2clean technical forums. For more information go to www.parts2clean.com.

**DAI HAIFENG** AND **ZHANG XIAOLONG** OF THE CLEAN
THE SCHOOL OF AUTOMOTIVE STUDIES AT TONGJI
A BATTERY MANAGEMENT AND STATE-OF-CHARGE

# Battery Management System For Electric Vehicles

**D**ue to energy saving and environmental considerations, and with the technological breakthroughs in battery life and performance, electric vehicles (EVs) have drawn more and more attention from automotive manufacturers all over the world. Although a lot of effort has gone into making battery-driven vehicles available, there are still many challenges left, one of the largest being how to guarantee that batteries work in a safe and efficient way.

Since batteries in EV applications work across a wide temperature range, and as they must furnish a broad range of current and power, a battery management system (BMS) that prevents them from being under- or over-charged, and calculates the energy left in the battery is the best way to guarantee their safe and efficient usage. One of the most important tasks of a BMS is to calculate the battery's state of charge (SOC).
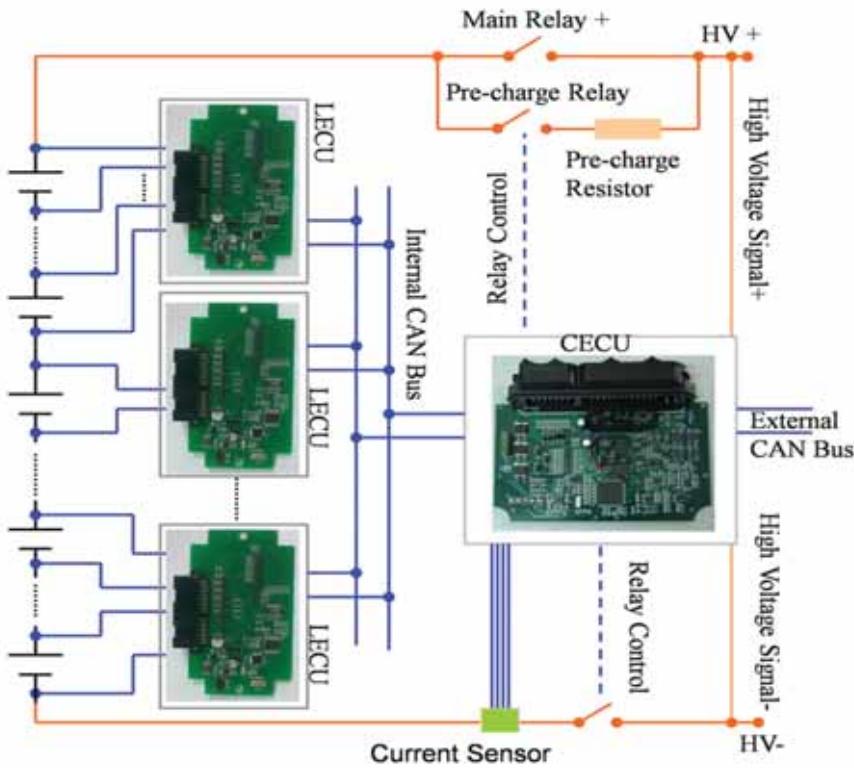
## Battery Management Systems

Generally, a BMS consists of several electronic control units (ECUs) – a central ECU (CECU) and several local ECUs (LECUs); see its typical structure in Figure 1. The LECUs take care of the battery cells directly, while the CECU makes decisions based on the battery state and predicts the available power/capacity of the battery using information from the voltage/current sensors and LECUs. Figure 2 illustrates the functionalities of a CECU, which include SOC estimation, state of health (SOH) estimation, maximum charge/discharge power and available-energy estimation, as well as fault diagnosis.

Since the battery pack is made up of hundreds of individual battery cells (often connected in series), the voltage of each individual cell has to be monitored for the purpose of protecting the cell from being over-charged or over-discharged.

For the purposes of cell voltage and temperature monitoring, the battery is usually divided into several modules, each consisting of a specific number of cells. Their voltages and temperatures are monitored by a LECU.

The LECU also has the task to balance the charge. State of the art today includes resistive charge balancing (generally referred to as 'passive balancing') and inductor- or capacitor-based energy-shift balancing, generally referred to as 'active balancing'. In passive balancing, cell voltages are adapted to each other by discharging highly charged cells. In active balancing, the cell voltages are matched to each other by shifting energy from the highly-charged cells to the lower-charged cells. Schematics of two typical balancing circuits are shown in Figure 3, where (a) is for passive balancing and (b) is for inductor-based active balancing.

## State of Charge

State of charge, or SOC, is the equivalent of a fuel gauge, which directly indicates the residual capacity of the battery, and therefore for the EV, and indicates the remaining driving range for the vehicle. As such, SOC estimation is often called Gas Gauge or Fuel Gauge, see Figure 4.

SOC can be defined as a fraction of the
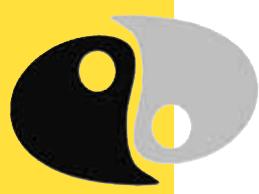
**Figure 1:** Typical structure of a battery management system (BMS)

**THIS REGULAR FEATURE COVERS ISSUES RELATED TO CHINESE RESEARCH AND DEVELOPMENT (R&D)**



**Figure 2:** Functionalities of a CECU
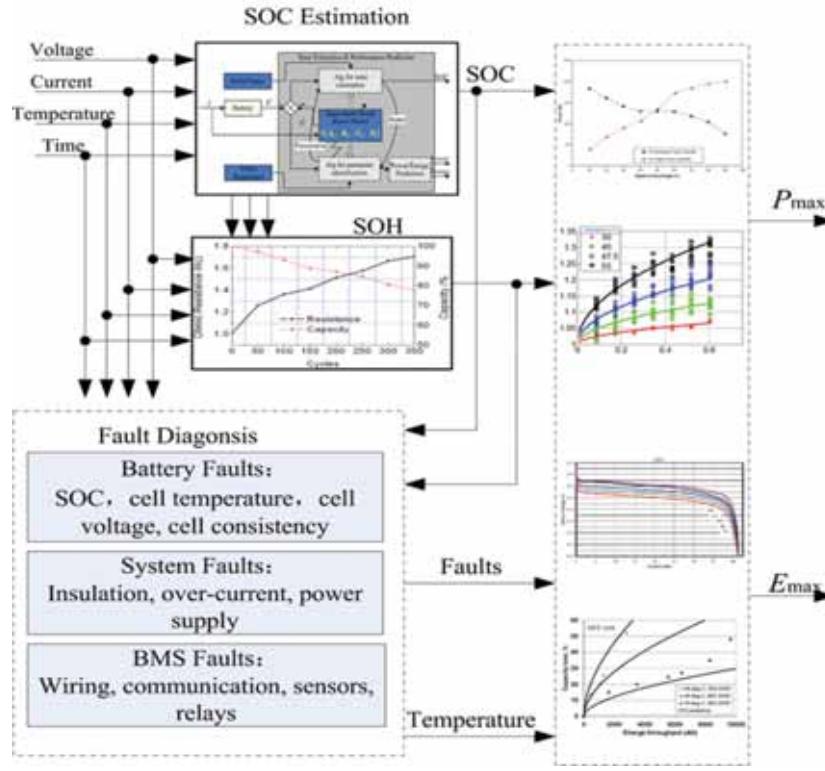
maximum possible charge remaining in each cell (%) available to do useful work. To use vehicular analogy, it is similar to the dashboard gas-gauge that reads "empty" (0%) to "full" (100%). Normally, the SOC is defined as the available capacity expressed as a percentage of some reference, sometimes its rated capacity but more likely its present capacity. Ideally it should be the rated capacity of a new cell, as with it aging its capacity gradually decreases. For example, towards the end of the cell's life its actual capacity will be approaching only 80% of its rated capacity and, in this case, even if the cell is fully charged its SOC would only be 80% of its rated capacity. Temperature and discharge rate effects reduce the effective capacity even further. This difference in reference points is important, since the user depends on the SOC estimation as he would a conventional gas gauge in a petrol-fuelled car.

However, the real SOC measurement reference is often defined as the actual capacity of the cell instead of the rated capacity. In this case a fully charged cell, nearing end of life, could have a SOC of 100% but it would only have an effective capacity of 80% of its rated capacity and adjustment factors would have to be applied to the estimated capacity to compare it to its rated new capacity. Using actual capacity rather than rated capacity is usually a compromise to avoid the complexity of determining and allowing for age-related capacity adjustments, which tend to be conveniently ignored.

### Why Is SOC Needed?

Knowledge of the SOC is particularly important for large lithium batteries. Of all prevalent cell chemistries, lithium is the most chemically reactive and the only one which needs an electronic BMS to keep the battery within a safe operating window and to ensure a long life-cycle. Control of the SOC is a major objective of the BMS realized through accurate SOC

estimation. Furthermore, vehicle energy management needs a very precise control of SOC for efficient and safe management of energy flows.

In EV applications, the SOC is also used to determine range. It should be an absolute value based on the battery's capacity when new, and not a percentage of its present capacity which could result in an error of 20% or more, due to its aging. In EVs, especially in HEVs (hybrid electric vehicles), the SOC determines when the engine is switched on or off. SOC errors over 5% could seriously affect system fuel-efficiency.

Precise knowledge of the battery's SOC provides several benefits for vehicle management: first, an accurate SOC estimate is used to avoid harming cells by preventing over-charging and over-discharging conditions; second, with a good estimate, especially one with known error bounds, one can use the entire pack capacity more confidently; and third, a good SOC estimator is constant and dependable, enhancing the overall power-system reliability.

The central role of the SOC in a BMS can be seen in Figure 5. In vehicular applications, the only physical quantities which can be measured directly voltage, current and battery temperature.

**Figure 3:** Passive and active cell balancing:
(a) Passive cell balancing
(b) Inductor-based active cell balancing
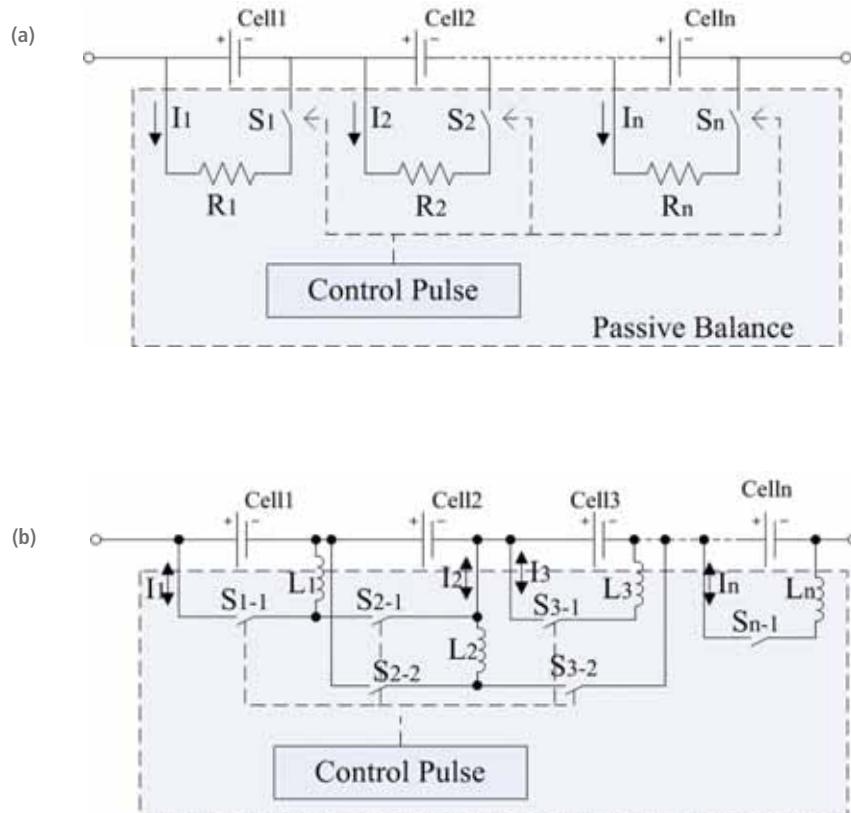
However, for energy management, the SOC, SOH, maximum available energy and power of the battery should also be known, which are not measurable and must be calculated. Other quantities including SOH, maximum available energy and power are functions of present SOC. Thus, an accurate SOC will help determine SOH, energy and power accurately.

### Getting Accurate SOC

A variety of SOC estimation methods have been introduced since the 1980s, which have been widely implemented in various academic research and industrial applications.

The most common and original method to estimate the SOC is current integration, or coulomb counting, requiring the measurement of battery current and an accurate timer, as well as a good knowledge of the initial SOC value. Derived from the definition of the SOC directly, this method is easy to implement and generally reliable and accurate within a short time period.

However, two main challenges exist within this method: first, an incorrect current measurement can introduce a large error; and second, not all energy supplied to the battery is consumed by charging, some is lost due to charge inefficiency.

The open circuit voltage (OCV) is often used to recalibrate the SOC estimated by using coulomb counting, since OCV varies over the whole range of SOC. Figure 6 illustrates the relationships between SOC and OCV of LiMnO2- and LiFePO4-based Li-ion batteries. Normally, to use this method, the battery should be kept under open-circuit condition for a long while, to ensure its equilibrium state. This limits the application of the OCV calibration method, because in real vehicular applications the open-circuit condition may not often exist.

### Different SOC Determining Methods

Some researchers apply intelligent algorithms such as fuzzy logic (FL), artificial neural networks (ANNs) and support vector machine (SVM) to estimate SOC. The FL-based method generally uses electro-chemical impedance spectroscopy (EIS) data, since the SOC measurement is dependent on EIS values, see Figure 7.

The ANNs used for SOC estimations generally have three layers:

**Figure 4:** Indication of the state of charge (SOC)
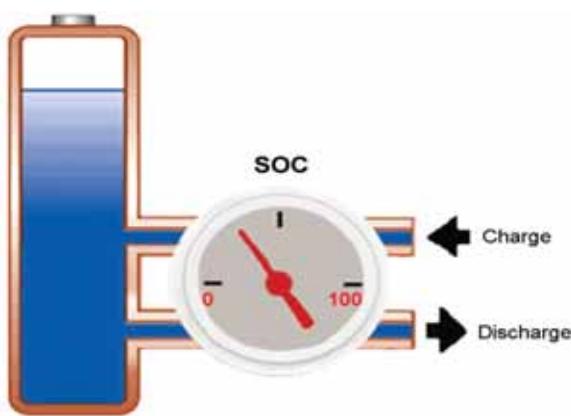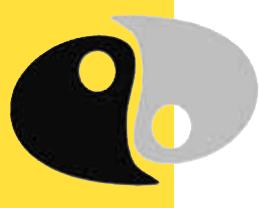
**Figure 5:** The role of SOC in battery management
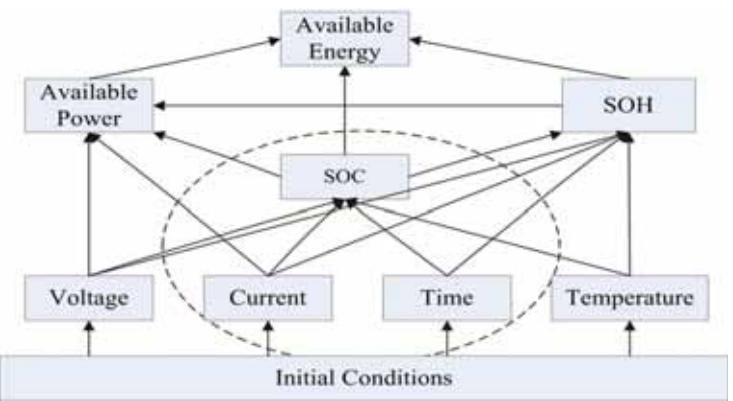


**Figure 6:** Relationship between SOC and OCV
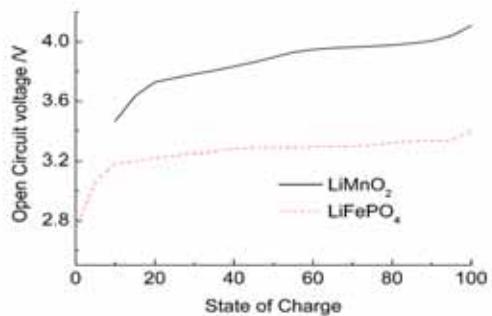


**Figure 7:** EIS measurements under different SOCs
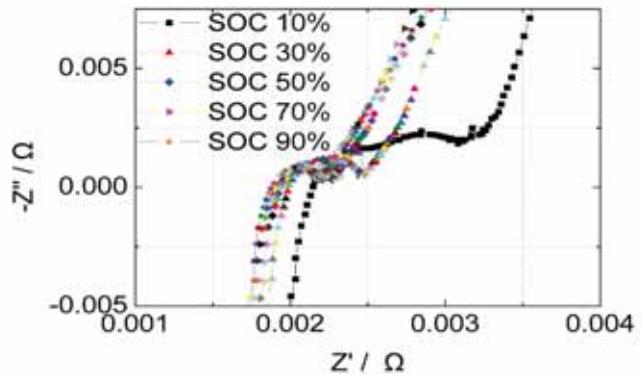


**Figure 8:** Equivalent circuit based battery model



**Figure 9:** Dual EKF based SOC estimator
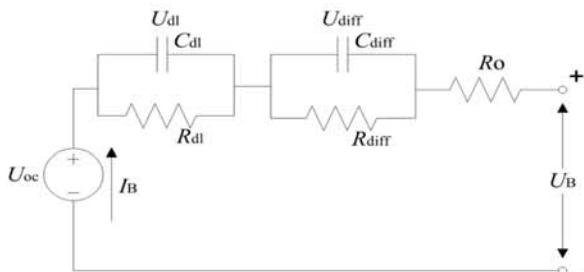


input layer, hidden layer and output layer. The input layer normally uses as variables battery internal parameters, e.g. charge transfer resistance, or external measurements including initial voltage, number of cycles, start of the discharge period etc.

The SVM is normally used to generate an empirical SOC estimation model, with current, voltage and SOC from the previous step and voltage change as input variables and SOC in the present step as output. However, those methods also face challenges. For fuzzy logic algorithms we need the EIS instrument, which adds to the cost and complexity, and for the ANN estimator, the training datasets are very difficult to get. As for the SVM estimators, tuning the empirical parameters can prove too complex.

Some adaptive filters are also designed to help estimate the SOC, for example the estimators based on Kalman filtering (KF), which gives the optimum estimation of a dynamic system with noise. Those

methods are generally implemented with a battery model.

Figure 8 shows a popular model composed of three resistors, two capacitors and one SOC-controlled voltage source $U_{OC}$. $R_O$ is used to describe the ohmic resistance, and the $R_{dl}C_{dl}$ and $R_{diff}C_{diff}$ networks are used to describe the polarization and diffusion characteristics.

With a recursive computation, the KF-based method is very easy to implement on a vehicular embedded system. Due to the non-linear characteristics of the battery, the linearization forms of the filtering, e.g. extended Kalman filter (EKF) and unscented Kalman filter (UKF) are often used. And due to the time-variant battery dynamics, dual Kalman filtering (DKF) can be used. Figure 9 illustrates the principle of the DKF-based estimator. ●

# IJTAG Standard Accelerates The Move To Embedded Instrumentation

BY **REG WALLER**, EUROPEAN DIRECTOR, ASSET INTERTECH INC

**M**ore than a decade ago, chip makers began routinely integrating test and measurement (T&M) functionality into many of their advanced high-end, high-speed devices. They were not necessarily motivated by some altruistic reasoning, like the betterment of the industry, rather it was done out of need. The semiconductor vendors found that embedding instrumentation into their products was the most effective, cost-efficient and, in some cases, the only way to characterise, validate and test not just their own devices, but later the circuit boards where their products were deployed.

Fast forward to the present day and many of what had been cutting-edge chips have entered the mainstream. As a result, a great wealth of embedded T&M intellectual property (IP) is available to be put to good use in a wide range of applications that includes circuit board validation, test and debug. That's the good news; the not-so-good news is there were a few hurdles to overcome. Every chip supplier had its own way of embedding instruments with their own vendor-specific user interfaces and tools. Using the embedded IP was difficult at best, impossible at times and, at the very least, frequently inefficient.

To rectify the situation, a working group of the IEEE set out to simplify and streamline the entire process by standardising the industry's approach to embedded instruments and to set up the on-chip infrastructure needed to support them. The resulting specification – the IEEE P1687 Internal JTAG (IJTAG) – does not dictate the functionality of embedded instrumentation; that's still up to the creativity and imagination of instrument developers. But by standardising the access method, IJTAG simplifies how instruments are managed and deployed, ensures the portability of instrument IP from chip to chip, and allows for the emergence of an embedded instrumentation ecosystem featuring third-party tools and other support facilities.

## IJTAG

The official name for the IJTAG specification, which is expected to be ratified by the IEEE later this year, is IEEE P1687 Standard for Access and Control of Instrumentation Embedded within a Semiconductor Device. It is commonly referred to as Internal JTAG because, in many ways, it borrows heavily from the IEEE 1149.1 Boundary-Scan Standard, which is known as JTAG after the committee that began its development, the Joint Test Action Group. IJTAG re-uses boundary scan's concepts of a Test Access Port (TAP) and embedded test controller. In addition, the IJTAG access network for embedded instruments incorporates a set of registers similar to the Test Data Registers (TDR) found in the boundary-scan standard and which typically comprise every onboard boundary-scan chain. From here, IJTAG takes off on its own.

From an on-chip architectural point of view, IJTAG is very flexible. Various IJTAG network configurations can be dynamically implemented to meet a wide range of requirements. Depending on the needs of the moment, segments of the on-chip IJTAG network of embedded instruments can be opened or closed, allowing engineers to manage the scan path, accessing instruments to turn them on or off, and even isolating an instrument while it runs. An IJTAG Segment Insertion Bit (SIB) connects or disconnects network segments to the main architecture. These architectures are described by IJTAG's Instrument Connectivity Language (ICL).

> *The semiconductor vendors found that embedding instrumentation into their products was the most effective, cost-efficient and, in some cases, the only way to characterise, validate and test their devices*

Another language defined in the IJTAG standard, the Procedural Description Language (PDL), represents the test vectors or operational procedures that are applied directly to instruments. PDL lets the engineer control and automate the operation and scheduling of embedded instruments independent

**Figure 1:** An FPGA with the functional test's file control table



of any IJTAG access network they may be connected to. Figure 1 shows a simple IJTAG on-chip architecture, featuring two instruments, a logic built-in-self-test (BIST) instrument and a memory BIST instrument. Such a network could grow to hundreds – if not thousands – of embedded instruments.

### The Emerging IJTAG Ecosystem

Historically, the development of open industry standards has quickly led to more cost-effective technologies and a vibrant ecosystem of products, support tools, integrators and technology providers. Although the IJTAG standard is still in its nascent stages, such an ecosystem is rapidly emerging. Chip-level electronic design automation (EDA) companies are developing or have already announced insertion, verification (simulation) and rules-checking tools. Chip suppliers like Avago, PLX Technologies and others are currently embedding IJTAG instruments into their products. My company ASSET InterTech has tools that manage and coordinate embedded instruments for board level validation, test and debug. And – the pièce de resistance – system manufacturers are actually beginning to
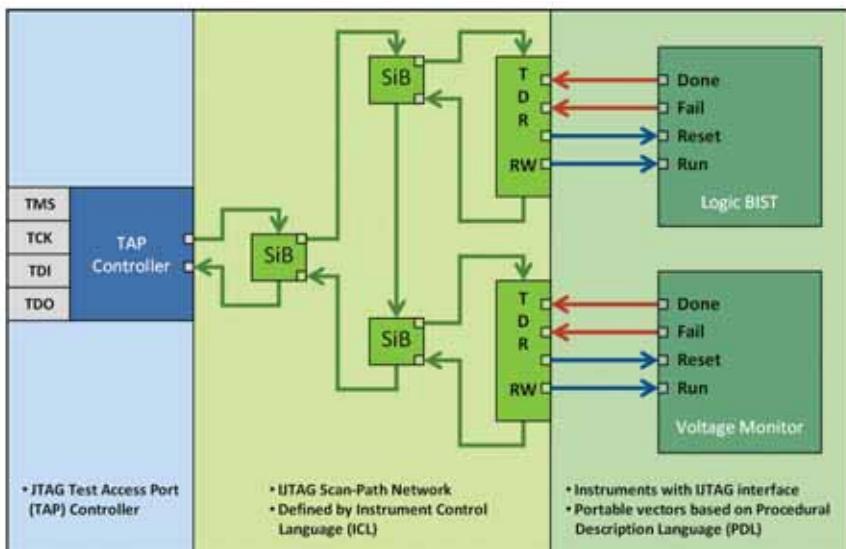
use IJTAG instruments. In addition, the wealth of educational material on the Internet has increased significantly. For example, an IJTAG tutorial is available at **http://www.asset-intertech.com/Products/IJTAG-Test/ IJTAG-Test-Software/IJTAG-Tutorial**. Because of its many benefits, the momentum is quickly growing behind embedded instrumentation. ●

# ECOC Exhibition
## 23 – 25 September 2013,
## London ExCeL, UK
### www.ecocexhibition.com

**The ECOC Exhibition is the largest European optical communications event and this year it comes to London. It will be held from the 23 – 25 September at the ICC London ExCeL. Once again it is expected to attract many exhibitors and visitors, with the promise to provide a platform for learning, exhibiting and networking.**

### Market Focus 2013
This year, one feature area not to be missed is the Market Focus theatre, sponsored by Oclaro. Now in its eighth year, the ECOC Market Focus has grown to become one of the focal points of the show and a popular platform to gain industry knowledge and insight into the latest technologies available.

The 2013 Market Focus will cover a broad selection of informative and on-trend optical communication topics including: optical integration and digital silicon photonics, mass-market broadband fibre access, datacenters, optics in cloud computing, packet-optical transport, service provider optical transmission, optical network agility and software-defined networks among others.

The content for the sessions is overseen by a panel of highly respected industry experts who are also the decision-making force behind the presentations.

### FTTx Centre
Returning to the show for 2013 is the FTTx Centre. This year it will feature 11 specialist zones, presenting cutting-edge technologies and interactive engineering demonstrations, including fibre optic network delivery methods, and OSP and ISP for FTTx vendor-independent products.

Run in conjunction with CTTS Group, with zone sponsors including Anritsu, FTTH Council Europe, ITW Chemtronics and Prysmian Group, the centre is worth a visit. CTTS technical experts will be on hand to give details about the products and technologies seen there.

### CTTS Training Centre
ECOC 2013 will also offer free training sessions led by CTTS. These hands-on, intensive sessions will provide essential insight into key techniques, including modern fusion splicing and passive optical network testing. Places for each session are limited, so be sure to register your interest and book a session early to avoid disappointment.
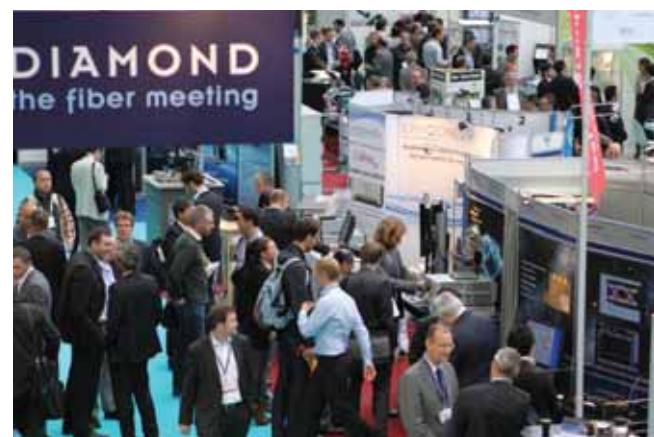
### ECOC TV
As every year, the ECOC TV camera crews will tour the exhibition, asking attendees for their views, news and opinions – so don't be shy to use the opportunity to promote your company news or industry views.

The ECOC exhibition and all its feature areas are free to attend and registration is now open. To find out more about the event and register, go to **www.ecocexhibition.com**

## Tektronix Will Show New and Enhanced Optical Test Solutions at ECOC 2013

Tektronix will be showing a wide-range of optical test and measurement products at ECOC 2013 (Stand 638, Hall N8-N10), which takes place from 23-25 September in London.

The displayed products will address a wide range of applications, from multi-channel pattern generation and multi-channel BERT testing to coherent lightwave signal analysis and testing of the world's most complex components. Visitors to the Tektronix stand will be able to get hands-on demonstrations and technical advice to help them solve their individual test and measurement challenges. On hand will be the new AWG70000 series arbitrary waveform generator that offers the industry's best combination of high sample rate, long waveform memory and deep dynamic range.

"Tektronix has launched a number of exciting new technology measurement solutions that help our customers deal with new challenges in high-speed serial, optical, photonic and communication system designs," said Dean Miles, Technical Marketing Manager at Tektronix.

**www.tektronix.com**

## ETS-LINDGREN ANNOUNCES TEST SYSTEM FOR WIRELESS OVER-THE-AIR MEASUREMENTS

ETS-Lindgren has introduced a test system for wireless over-the-air (OTA) measurements employing reverberation technology. The new AMS-7000 performs accurate and repeatable wireless measurements on wireless devices such as mobile phones, laptops and machine-to-machine communication (M2M) enabled equipment.

As an alternative to anechoic chambers, ETS-Lindgren's new AMS-7000 test system uses reverberation technology for making a variety of accurate and repeatable wireless over-the-air (OTA) measurements. The results have shown correlation to CATL (CTIA Authorized Testing Laboratory) results. Tests that can be performed include SISO (Single In, Single Out), TRP (Total Radiated Power), TIS (Total Isotropic Sensitivity) and MIMO (Multiple In, Multiple Out) throughput measurements. The test system incorporates two Z-fold tuners, a DUT turntable and an antenna turret to improve isotropicity and homogeneity. The system operates over a frequency range of 700MHz to 18GHz.

The AMS-7000 is based on a combination of ETS-Lindgren's EMQuest Antenna Measurement Software and the company's longstanding line of SMART reverberation chambers.

**www.ets-lindgren.com**

## MICROSEMI BROADENS FPGA PRODUCT PORTFOLIO WITH HIGHLY-INTEGRATED IGLOO2

Microsemi has added a highly-integrated IGLOO2 to its FPGA product portfolio. IGLOO2 FPGAs offer lowest system cost, best-in-class integration, low power, reliability and security when compared to similar offerings on the market.

Microsemi's new non-volatile flash-based IGLOO2 FPGAs have the highest number of mainstream FPGA features including GPIOs, 5G SERDES interfaces and PCI Express endpoints of any similar device on the market today, and feature the industry's only high-performance memory subsystem. When compared to other 5G SERDES-based FPGAs under 150K logic elements (LEs), IGLOO2's high level of integration provides the lowest total system cost versus competitive FPGAs while improving reliability, significantly reducing power and systematically protecting valuable customers' design IPs.

**www.microsemi.com**

## BULGIN LAUNCHES NEW VERSIONS OF POPULAR IN-LINE CABLE CONNECTORS

Bulgin, an Elektron Technology connectivity brand, has launched 4-, 6- and 8-pole versions of its popular PX0777 environmentally-sealed in-line cable joiner, offering cost-effective water- and dust-proofing for a wide range of applications.

The original 3-pole version of the PX0777 has been part of the Bulgin Buccaneer range of environmentall-sealed connectors for over 15 years, taking advantage of the company's tried and tested technology to provide convenient IP68 rated connectivity for indoor and outdoor use. The recently released 4-, 6- and 8-pole cable joiners extends this robust environmental protection to a wider range of applications, offering rapid connection of multi¬core cables.

The new variants of the PX0777 uses a specially designed circular terminal block — rated at 10 A, 250 V per pole — allowing safe, secure connection of up to eight 1.5mm2 cores using the same compact moulded plastic body as the 3-pole version.

**www.bulgin.com**

## NEW LOW CXR PHOTOMOS WITH OPTIMIZED ON-RESISTANCE FOR CURRENTS OF UP TO 1A

The new CxR10 PhotoMOS relays belong to the successful Low CxR series PhotoMOS, with an optimized, i.e. low, product of C and R. Especially measurement applications require the smallest possible output capacitance C at the open contact and at the same time a low on-resistance R at the closed contact for high-frequency loads. Optimizing the capacitance and the resistance component in the transistors makes this possible. The most advanced MOSFET technology makes it possible to combine a very low contact resistance of 0.18 Ohms (typical) with a low output capacitance of 37.5pF (typical) at the same time.

The new types are available in the well proven ultra-miniature VSSOP and SSOP housing types. Furthermore, the new CxR10 PhotoMOS have a very short response time (0.2ms typical), a high I/O isolation (max. 1.5kVAC for SSOP), and a very low leakage current (< nA). The maximum switching voltage is 30V for both types, AC and/or DC.

**www.panasonic-electric-works.co.uk**

## RS Components Stocks Energy-Harvesting Kit From STMicroelectronics

RS Components (RS) is now offering the M24LR Discovery Kit from STMicroelectronics (ST), which is an easy-access development platform for contactless memories with unique energy-harvesting capabilities. It contains everything engineers need to start designing battery-free electronic applications that can exchange data with ISO/IEC15693-compatible NFC-enabled smartphones or RFID (Radio Frequency Identification) reader-writers.

The turn-key development platform helps accelerate the creation and integration of energy-autonomous data collection, asset tracking or diagnostics capabilities in a wide variety of applications, including phone and tablet accessories, computer peripherals, electronic shelf labels, home appliances, industrial automation, sensing and monitoring systems, and personal healthcare products.

With its unique combination of industry-standard serial-bus (I2C) and contactless RF interfaces, ST's M24LR dual interface EEPROM memory has the ability to communicate with the host system over-the-wire or over-the-air. Furthermore, the M24LR's RF interface can convert ambient radio waves emitted by RFID reader-writers and NFC devices into energy to power its circuits and enable complete battery-free operation.

**www.rs-components.com**

## New Clearsource LED Emitters Enable Precision Sensing And Detection

OMC, the pioneer in optoelectronics, including LED lighting, backlighting and industrial fibre optic transmission components, has introduced its ClearSource range of solid-state emitters that use a new die bonding technique to connect the LED chip electronically to the leadframe, eliminating 'dark spots' and improving beam precision.

Standard LED optical sensors use a top-mounting wire bond to connect the LED chip to the anode or cathode. The bond wire obstructs the light output, giving rise to dark spots and patches in the beam which makes precise sensing and detection more difficult. In the new ClearSource series, the wire is bonded to the side of the chip, leaving the output beam unobstructed. This produces a very well-defined light beam which enables high-accuracy sensing and detection. For even greater precision measurements that require near-parallel light emission, lenses can be incorporated. Additionally, this die-bond configuration reduces capacitive effects within the diode, enhancing switching speed and reliability.

**www.omc-uk.com**

## PRIZE-WINNING UNDERWATER ROBOT DEPENDS ON DATAMATE FROM HARWIN

Harwin, the leading hi-rel connector and SMT board hardware manufacturer, has announced that a prize-winning underwater robot project, designed and built for the international SAUC-E (Student Autonomous Underwater Challenge – Europe) program by students from the University of the West of England (UWE), depends on hi-rel Datamate connectors to deliver reliable power and signal transmission, even in challenging conditions.

SAUC-E challenges student engineers to design and build an Autonomous Underwater Vehicle (AUV) and then perform realistic missions in the underwater environment. Harwin's 2mm pitch Mix-Tek Datamate connector family proved to be highly-suitable for the project, combining both power and signal contacts in one space-saving shell. Contact design ensures that signal integrity is maintained ever under severe operating conditions of temperature, shock and vibration.

Harwin has sponsored UWE's work for a number of years, and the team performed well in the most recent SAUC-E challenge, winning the Smart Technology Award.

**www.harwin.co.uk**

## AVX INTRODUCES 25V RATING AND EXTENDED CAPACITANCE RANGE TO ITS MIL-PRF-49470 SMPS CAPACITORS

AVX Corporation, a leading manufacturer of advanced passive components and interconnect solutions, has expanded the voltage and capacitance range of its MIL-PRF-49470-qualified SMPS Series stacked MLC capacitors by adding a 25V capacitor to the original 50-500V offering. The new 25V SMPS capacitor currently features standard MIL-PRF-49470 Level "B" reliability; however, a parallel component with T-Level reliability for space applications is under qualification.

Designed for high-current, high-power and high-temperature applications, AVX's MIL-PRF-49470 SMPS capacitors exhibit very low ESR and ESL and can withstand temperatures ranging from -55°C to +125°C. Primarily used in the input/output filters of high-power and high-voltage power supplies, as well as in bus filters and DC snubbers for high-power inverters, the SMPS Series is also ideal for DC/DC converters, general and switched-mode power supplies, aerospace instrumentation panels, and a variety of hybrid power and military applications.

AVX's SMPS Series capacitors are available in six case sizes and with a variety of through-hole and surface-mount lead options.

**www.avx.com**

## ADVANCED POWER ELECTRONICS CORP ANNOUNCES MINIATURE ULTRA-LOW RDS(ON) DUAL LOAD SWITCH

Advanced Power Electronics Corp (USA), a leading Taiwanese manufacturer of MOS power semiconductors for DC-DC power conversion applications, has announced a miniature, ultra-low on-resistance 6A dual load switch. Comprising two N-channel MOSFETs with associated control circuitry, the APE8990-3 has an RDS(ON) of 20mΩ and controlled turn on functionality. The MOSFETs operate over an input voltage range of 0.8 to 5.5V and each support a maximum current of 6A. Each load switch is controlled by an ON/OFF input (ON), which is capable of interfacing directly with the low voltage control signals. Additional features include an on-chip 150Ω load resistor for quick output discharge when the switch is turned off. In order to avoid inrush current, the rise time is adjustable using an external ceramic capacitor on the CTx pin.

The APE8990-3 is available in an ultra small, space-saving 3x2mm 14-pin DFN package with a thermal pad.

**www.a-powerusa.com**

## Industry's Smallest MOSFET Package in Stock at Mouser

Mouser Electronics is now stocking the smallest MOSFET package on the market from ROHM Semiconductor which is optimized for thin, compact, portable devices.

ROHM Semiconductor ultra compact MOSFETs have the smallest package size on the market which is optimized for thin, compact, portable devices. The VML0806 case type measures just 0.8 × 0.6mm with a height of only 0.36mm. As portable devices, such as smartphones and digital cameras, get smaller and more sophisticated, thinner, more compact components are required. Until now, problems related to internal element miniaturization, bonding stability, package process accuracy, and surface mount technology limit the smallest conventional transistors to the 1006 size (1.0 × 0.6mm, t = 0.37mm). ROHM was able to overcome these challenges by utilizing a smaller element and high-precision package process technology, resulting in an unprecedentedly compact form-factor.

Mouser has 19 global support locations and stocks one of widest selection of the latest semiconductors and electronic components around.

**www.mouser.com**

## LATTICE INTRODUCES IMAGE SENSOR EXTENDER REFERENCE DESIGN

Lattice Semiconductor announced the SensorExtender reference design that offers a low-cost approach to remotely locate image sensors up to eight meters away from the image signal processor (ISP) and transmit and receive video signals at resolutions that range up to 720p60 and 1080p30.

The reference design uses inexpensive low-cost Cat5E cable to carry high-definition video and to send I2C sensor control signals from the ISP during the vertical blanking period. Three twisted pairs carry the video and commands, while a fourth pair provides power and ground to the remotely located sensors.

This solution serves applications that require image sensors to be separated from the image signal processor, which are often placed in tight spaces without room for adjacent ISPs to process the image. Typical applications include medical probes, large screen TVs with an integrated HD camera, surveillance domes, piping inspection ports and point-of-sale scanners.

**www.latticesemi.com**
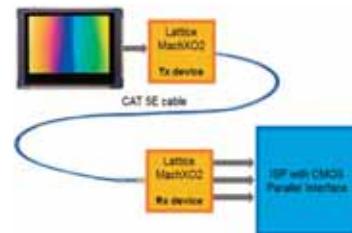
## LINEAR HALL-EFFECT SENSOR ICS ARE FACTORY-PROGRAMMED FOR OPTIMISED DESIGNS

The new A1388 and A1389 linear Hall-effect sensor ICs from Allegro MicroSystems Europe are factory one-time programmable devices which eliminate the need for customers to optimise or program the devices for their finished sensor assemblies.

The new sensor ICs are targeted at displacement and angular positioning sensing in the automotive, industrial and consumer market sectors. Their architecture allows them to support magnetic input sensitivity ranges of 2.0 to 4.0mV/G and 4.0 to 9.0mV/G respectively, but the devices initially being released are factory-programmed to specific magnetic input sensitivity levels.

The devices that are initially being released are the A1388LLHLX-2-T with 2.5 mV/G sensitivity, the A1389LLHLX-9-T with 9mV/G sensitivity and the A1389LLHLX-RP9-T with -9mV/G sensitivity.

The temperature coefficients for both sensitivity and the quiescent voltage output are programmed over temperature to maximise accuracy and minimise distribution tolerances. The A1388 and A1389 provide low output noise (15mV p-p at 9.0 mV/G sensitivity for the A1389) and reduced EMI susceptibility at various frequencies.

**www.allegromicro.com**

## ASPEN ELECTRONICS TO REPRESENT US-BASED ADSANTEC CORPORATION IN THE UK

ADSANTEC (Advanced Science And Novel Technology) Corporation has appointed Aspen Electronics as its representative in the UK. Best known as a high-speed mixed signal IC design house, the company has successfully been in business for over 10 years and specialises in providing cutting-edge custom-built ASICs for the test and measurement, telecommunication and computing markets.

Adsantec products are designed for applications up to 60GBps and include a portfolio of over 120 products, ranging from individual ICs to board level systems like PRBS generators. These products are ideal for production testing of Gigabit telecoms components and sub-systems, providing 18GBps, 34GBps and 44GBps PRBS signals at a fraction of the cost of a more conventional BERT tester.

**www.aspen-electronics.com**

## New Design Options For *har*-flex Connectors

Harting has introduced a number of new devices in its *har*-flex family of compact, versatile and rugged board-to-board and board-to-cable 1.27mm pitch connectors. Straight and angled connectors are now available as PCB models which, when combined with the connectors for flat ribbon connection, allow PCBs to be combined into complex systems perfectly adapted to their surroundings. All *har*-flex connectors are available with from six to 100 contacts, in increments of two. Fully assembled cables are also available.

The compact but rugged design of the *har*-flex connectors also guarantees reliable operation under adverse conditions. Two large holders ensure that the connectors are firmly held in place after soldering. A low-wear insertion and withdrawal procedure is achieved by a very smooth contact point between the male and female contacts. These connectors are delivered in packaging compatible with production machines, and can be processed in the SMT solder process.

**www.harting.com**

## VECTOR SOFTWARE WILL PROVIDE VECTORCAST TESTING PLATFORM TO VISTEON CORPORATION

Vector Software announced today that it will provide Visteon Electronics, a business unit of leading global automotive supplier Visteon Corporation, with the VectorCAST testing platform as a component of its software development strategy.

Visteon conducted a technology evaluation across multiple locations and development environments, and included testing on live hardware. VectorCAST was selected for its rich feature set, ease-of-use, TÜV SÜD ISO 26262 certification, and an existing world-wide customer base in automotive.

VectorCAST's open architecture allows integration with best-of-breed tools for requirements traceability, static analysis, and MISRA compliance. With VectorCAST, engineers can manage end-to-end traceability of development assets and are able to demonstrate that every requirement has been validated and every risk has been mitigated.

"VectorCAST helps automotive suppliers to cost-effectively comply with the  ISO 26262 functional safety standard and deliver high quality software products to the market with decreasing cycle times," said William McCaffrey, Vector Software's Chief Operating Officer.

**www.vectorcast.com**

## INTERCHANGEABLE (RT CURVE MATCHED) NTC THERMISTORS

ATC Semitec's SP interchangeable series is a range of NTC thermistors that offers very high precision (±0.2°C 0-70°C or better) at significantly lower pricing to that of existing interchangeable NTCs.

Readily available from stock, these new high accuracy NTCs mean that now a wider range of users can cost-effectively achieve more accurate temperature control and thus more energy-efficient and comfortable working environments.

The main features of the SP thermistor range include R25 values from 1kΩ to 100kΩ; accuracy of ±0.2K from 0-70°C; temperature range of -40°C/+150°C; fast response and 2.6mm bead size.

Insulated and SPMM micro-miniature (0.5mm diameter) sensors are also available.

Evaluation samples and ex-stock pricing can be supplied by the company directly.

**www.atcsemitec.co.uk**

# BBC LAUNCHES NEW APPRENTICESHIP TO ADDRESS SKILLS SHORTAGE IN THE BROADCAST SECTOR

**The BBC has launched the BBC Technology Apprenticeship, working with UK universities and major broadcasters, to address a critical skills shortage in the broadcast industry and help build the next generation of broadcast engineers.**

It plans to recruit 20 school-leavers annually, aiming to produce 100 highly skilled, experienced and employable graduate-level apprentices to meet growing industry demand.

Funded by BBC Technology and the government's Employer Ownership Skills Pilot, the scheme, with the participation of a number of industry partners, brings together some of the UK's biggest broadcasters (BBC, Channel 4 and ITV) and media infrastructure companies (Red Bee Media and Arqiva) to shape a common agenda, collaborating for the first time ever to solve a critical industry skills gap.

This combined industry involvement will help apprentices gain the knowledge, skills and experience to succeed, creating the next generation of engineering talent for the industry. Apprentices will also benefit from work placements within partner organisations as part of the practice-based learning programme.

The academic courses will cover key topics, including software development and managing IP networks, as well as the traditional engineering principles of electronics, electrics, video and audio systems. The BBC is working with the Universities of Salford and Birmingham City to develop best-in-class courses that give apprentices a world-class foundation in the theory of broadcast engineering.

**JAN DIDDEN**, **Audio Expert and Publisher of Linear Audio, The Netherlands:** This is an interesting development for several reasons. On the face of it, it is a welcome commitment from industry to invest in education for its own good. Although one could question whether educating 20 persons per year for what presumably are tens of thousands of vacancies is anything more than a token gesture. But everything counts.

The more serious issue here, however, is that apparently educational institutes are not able to shape curriculums toward industry needs. It seems the vast amounts of money spent here do not – or not sufficiently – provide industry with the employees they need. More than being jubilant for this excellent initiative, we would seriously need to ask ourselves what needs to be done to make it unnecessary.

**HAFIDH MECHERGUI**, **Associate Professor in Electrical Engineering and Instrumentation, University of Tunisia:** The BBC-initiated program, in collaboration with industrialists, constitutes an initiative to be encouraged. Indeed, this strategy fits within a framework of a policy designed to meet the business evolution impact on the broadcasting sector and which certainly should be supported by qualified personnel in the field.

This intelligent initiative is an opportunity for young people to be readied for the future to bring more to the broadcasting sector in rather tough and challenging conditions. The training program will help develop specific competences and, indeed, studies show that countries find it beneficial to specialize in fields they are competitive in.

I think the BBC by its glowing, world-famous status can only bring positive and useful results, not only for itself, but for the UK in general, which will allow it to remain the model to be followed by the broadcasting world.

**BARRY MCKEOWN**, **RF and Microwave Engineer in the Defence Industry, and Director of Datod Ltd, UK:** Can 20 apprenticeships a year make a difference? When does quality not quantity count? The answer depends on just what they are being trained to accomplish. Recently OFCOM completed the first phase of local TV licensing of 19 cities – from Cardiff to Belfast. Currently, the second phase licensing of a further 30 cities is under way. This endeavor will require new broadcast infrastructure to be built and maintained. Obviously, given the nature of an apprenticeship exercise, it cannot begin until these activities are underway. What is not obvious is that to pull together the necessary new skillsets to support this new diverse infrastructure requires a respected professional institution. This is where only an organization such as the BBC with its Charter Agreement obligation to undertake this support can make a difference.

**PROFESSOR DR DOGAN IBRAHIM**, **Near East University in Nicosia, Cyprus:** It's about time that the UK invests in the broadcast sector and, especially, in broadcast engineering. I remember years ago when the BBC was the only – and the greatest – source of reliable world news, and at the same one of the largest broadcasting companies in the world, equipped with modern technology and carrying out advanced research in the fields of communications and broadcasting techniques. The new apprenticeship scheme will certainly produce skilled graduate broadcast engineers with both theoretical and practical experience in the field. Funding from the government and the participation of other organisations will help to attract qualified students and, hopefully, remove the skills shortage to some degree at least.

> It's about time the UK invests in the broadcast sector and, especially, in broadcast engineering

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**If you are interested in becoming a member of our panel and comment on new developments and technologies within the electronics sector please register your interest with the Editor by writing to svetlanaj@sjpbusinessmedia.com**