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3D design exploration before print

By Julien Happich

3D printing is taking over the world, it seems, but so far non-CAD users are only left with catalogue parts to choose from. Modifying an existing 3D digital file can be painstaking for the non-initiated, and even for experts, the tedious process could turn a good product design into a non-printable part or something that would lack the structural integrity of the original design. Hence, typical 3D printing houses and file repositories only offer proven printable products with very little room for customization.

Yes, you can probably tick some boxes to choose the material or the colour, sometimes there is room to carve out some text, but any other modification would in essence mean a redesign and performing a battery of 3D-printability checks, at your own risks.

Researchers at MIT and the Interdisciplinary Center Herzliya in Israel have come up with a browser-based user interface that lets anyone modify and quickly visualize a whole new design space around an original 3D part, while doing all the necessary checks (printability, structural analysis) in the background.

In a paper titled “Fab Forms: Customizable Objects for Fabrication with Validity and Geometry Caching”, MIT graduate student in computer science and engineering Masha Shugrina details how she leverages cloud computing to pre-qualify parameter design variations for manufacturability based on adaptive sampling of the design space.

For each original 3D design, the authors perform a precomputation of the modified object by varying the general design parameters and then prune off the non-printable or structurally non-viable results from the exploration space.

For practical purposes, only a few parameters are left visible to the online users who can interactively sweep a small set of parameters through different values using virtual sliders (the other hidden parameters will be swept based on their geometric ties with the visible parameters).

The precomputation stage means that the results are displayed in real time rather than minutes or even hours, rendering the 3D object as a valid proposition regardless of the slider’s position, ready to print.

In their examples, the team distributed the precomputations over 10 to 40 custom cores on Amazon Web Services, and distributed sampling took less than a day for most models. Adaptive sampling was required to generate more samples where geometry is changing the most, so that end-users get the impression of continuously changing the parameters as they manipulate the sliders.

So would commercial companies or CAD library companies have to deliver a particular file format for the MIT Fab Forms algorithms to elaborate all the possible (and printable) sample variations, and how would a CAD part provider chose which parameters are marked as end-user visible?

“In principle, this approach is applicable to any CAD file”, Shugrina told EE Times Europe, “but the customizable design parameters would have to be chosen at the start of the design process, by the designer”.

By thinking “customization” early-on in the design process, designers and brands could somehow give an orientation to the design exploration space they put forward.

Although it could certainly be possible to design a special tool to figure out which set of parameters should be made end-user visible, Shugrina does not envisage existing CAD part libraries to be automatically converted to offer the new customization service. Instead, the algorithms could be implemented as a standalone feature in CAD tools to perform fast design exploration and CAD modelling in the cloud.

Regarding intellectual property rights, the issues are circumvented by preventing the user from downloading the actual modified CAD files, explained Shugrina. A modified design could be made available only for direct 3D printing. The 3D printing company would charge for its services, and the designer would get a royalty for every new print implementation from within the exploration space of his/her original design.
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Autonomous driving not a question of technology, managers say

By Christoph Hammerschmidt

Drivers who summon their vehicles out of the underground garage with their smartphone and then continue their ride in a laid-back manner while the silicon chauffeur directs the car through the traffic: this scenario could be reality in a few years, shows a representative survey among top managers in the automotive industry carried out by German IT industry association Bitkom in the run-up of the IAA motor show. However, the biggest roadblock preventing that autonomous driving will become reality is not technology, the managers said.

According to the survey, 48 percent of the respondents expect that autonomous vehicles will prevail within the next 15 years. 2 percent event think that this will be the case earlier. Only 6 percent expressed scepticism in that they said this way of driving will “never” become commonplace.

The survey shows that digitisation will fundamentally change individual mobility and lead to new, hitherto unseen ways of travelling. For instance, the car and the smartphone will merge in terms of functionality. The link between car and smartphone makes it possible, for instance, to lock doors remotely or read out status data from the car, such as fuel level. Cars will become integral part of the digital lifestyle. “The car is no longer just a means of transportation – it will become a mobile data centre that assumes many tasks for us”, says Bitkom president Thorsten Dirks.

The vehicle of the future will also be integrated into an intelligent traffic networks infrastructure that enables them to communicate within milliseconds with fellow cars – for instance if a vehicle ahead crashes. Thus, the receiving vehicle can brake automatically, significantly reducing reaction time. This technology will make traffic flowing more efficiently and help reduce accidents and traffic stalls. 86 percent of the respondents expressed their belief that in ten years interconnected traffic safety systems will lead to significantly fewer accidents.

A prerequisite of a smart traffic infrastructure however will be that the vehicles will be capable of transmitting data, for example their exact location, direction and speed. 85 percent of the respondents said they would advocate a legal obligation of vehicles to provide such data, with the majority said that such an obligation should be effective for anonymised data.

The transition to connected and autonomous driving is also changing car buyers selection criteria. All respondents agreed that internet connection for cars is becoming a buying criterion. 96 percent said they see that consumers increasingly make sure that the HMI in the car cockpit is compatible with the smartphone’s GUI. Other findings were that the vast majority of respondents regard a connected infotainment system as an important buying criterion. Parking assistance systems, environmental properties, car-to-car based services and integrated navigation services will also gain importance.

Most of the enterprises regard the shift as positive; 97 percent see digitisation as a chance while only 3 percent believe that the risks outweigh the chances.

The most important roadblock for autonomous driving is not a missing technology component. 83 percent of the managers polled said the lack of legislation regarding liability issues is preventing innovation towards autonomous driving. “Liability is indeed the most controversial issue” commented Dirks. For instance, it is unclear if a software vendor can be held responsible in the case of an accident. “In this point, it is absolutely necessary to provide clarity”, the Bitkom president said.

**Chip scale optics for GaN-on-Si LEDs**

Plessey has developed a patented technology for Chip Scale Optics (CSO) based on its GaN-on-Silicon MaGIC LEDs. Chip Scale Optics permits design of light emission angles down to ten degrees direct from the LED. Having the primary optics on-chip eliminates the cost of primary optics typically found in packaged LEDs and chip-on-board modules. Furthermore, it significantly lowers the cost and provides for far greater design freedom for secondary optics within a luminaire. The first off applications include retail spot lighting, hospitality lighting, high and low bays, street lighting and stadium lighting. It is estimated that Plessey’s chip scale optics will halve the cost of these lighting applications. “The CSO technology was originally designed as an on-chip phosphor dam. We realised that the original growth silicon, normally sacrificed during LED production, could be shaped and used to form mechanically robust, MEMS-type features on the emitting surface of a vertical LED. The degree of collimation is controlled in part by the mechanical dimensions of these on chip structures and we have demonstrated emission angles as low as 10 degrees”, explained Plessey’s CTO, Dr. Keith Strickland.

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LED lighting in home automation: ready, aim, ...

By Josh Israelsohn, Mouser Electronics

Examples of commercial home automation equipment date back to at least 1975 with the launch of Pico Electronics’ X10 project in Scotland. Although engineers of the day could not have imagined many of today’s implementation technologies, the architectures and use models that they did imagine inform system designs to this day. Among the first applications for early home-automation systems were lighting and appliance controls, both of which home-automation providers implemented as simple on-off mains-power switches. Conveniently for installation, the network physical media was the power line as well, operating with high-speed bursts during the AC zero crossings and communicating one bit per crossing. Accounting for communication overhead and message duplication built into the protocol, early systems realized a communication rate of about 20 baud. With 12-bit control messages (8-bit address and 4-bit command), latencies for simple commands in the 600 to 750 ms range could be said to have pushed the limits of good taste… or market tolerance. Beyond that, the challenges to power-line communication are legend and the reliability of home-automation systems fell short of market expectations for many years.

...Then technology caught up

Today, home-automation systems are enjoying resurgence and, for the first time in their four-decade history, appear poised for broad-market adoption. As many have seen in other segments, this turn derives from a confluence of several technology advances, none necessarily driven by home-automation applications per se, but which combine to serve such uses far better than any set of technologies previously available for the purpose. For residential lighting in the context of home automation, three specific areas of technological innovation have contributed to making systems more attractive to the broad residential market: Communication, control, and the lighting devices themselves. At the heart of many home-automation implementations is a wireless network, which solves many of the problems suffered by power-line communication schemes including difficulty communicating across phases of split 240/120-V systems, adjacent-dwelling interference, and glacial data rates. Currently, wireless devices conforming to IEEE 802.15.4 are most common, particularly those conforming to ZigBee Alliance specifications popular in IoT applications. ZigBee provides 250 kbps data rates in the 2.4 GHz ISM band; lower rates to 20 kbps in geo-specific sub-GHz spectrum. Unlike WiFi, which forms star networks extendible only by adding dedicated hardware repeaters, ZigBee nodes form mesh networks, which extend automatically with each additional node.

Dedicated home-automation control hardware has given way to software applications that run on the universal wireless HMI device—the mobile phone. Gateway hardware solves the connectivity problem created by mobiles’ lack of compatible radios and serves as the bidirectional interface between the 802.15.4 ZigBee wireless home-automation network and nearly ubiquitous 802.11x WiFi data communication LANs, as shown in figure 1.

Because the HMI and system-control functions are not always present, timing, sequencing, and grouping functions must reside within the individual client devices. Moving these functions to the client devices also provides for multiple HMI interfaces to coexist on the same network through a single gateway. Basic setups such as lighting groupings and scenes reside within the light controls.

Commercial leads the way

Fluorescent fixtures have long dominated commercial lighting where their diffuse light output, high colour temperature, and efficiency have provided benefits in office spaces where lighting installations can cover floor space seemingly by the acre. Historically, simple switches controlled fluorescent lighting troffers. Lighting for large cubical-farms might switch troffers in clusters or wire multi-tube devices with each tube position ganged to a separate circuit, allowing stepwise dimming by switching off one or more tubes in each troffer. Overall, however, traditional fluorescent lighting devices did not invite control by dimmers and systems rarely included occupancy detection. Meanwhile, LED lighting and new lighting-controls are allowing companies to realize cost reductions in excess of those that simple lumen-per-watt comparisons suggest.

In residential lighting, incandescent bulbs compatible with standard threaded Edison sockets, such as A, BR, and PAR series bulbs, dominate.

Dimming, enlightened

Automated or not, a traditional dimmer blanks its output during the leading portion of each half power cycle and, once activated, remains on until a power-line zero crossing. Incandescent light bulbs—roughly 98% efficient as heaters, are in effect thermal low-pass filters with long time constants relative to the line-power period. An LED, by contrast, is essentially an electrons-in-photons-out DC current-driven device. LEDs are not natively compatible with AC voltage sources and traditional dimmers that chop up the AC voltage...
waveform only compound the incompatibility. LED ballasts provide the fundamental rectification and V-I conversion necessary to operate from AC voltage sources and, in dimmable devices, essentially map the duty cycle onto an output current range.

In its recent Solid-State Lighting Spot Check, JAS Technical Media measured the illumination produced by various LED bulbs operating on a number of dimmers, using an incandescent bulb as reference. Data from one trial, typical of the spot check’s overall results, appear in figures 2 and 3. The plots normalize each bulb’s dimming curve to its own output with the dimmer bypassed. The graph’s horizontal axis is the power dissipation of a 100-W incandescent bulb reference, measured with the dimmer bypassed and at each test point along the dimmer’s travel.

Better bulbs

Sales of early generation LED light bulbs for residential service were sluggish for several reasons. Bulbs were only available with one or two options of lumen output. Pricing for early generation bulbs—typically $25 to $50—produced sufficient sticker shock to keep many homeowners on the sidelines. The market log jam broke a couple of years ago when Cree marketed 2700 K, 900 lumen bulbs for under $10 with street prices in the area of $8.50 in some home-improvement stores. Since then, LED bulbs have become available at reasonable cost in a wider range of lumen ratings and bulb shapes, making the technology more attractive to the full range of residential lighting applications.

More recently, Osram Sylvania released a series of smart bulbs that integrate an 802.15.4 radio, processor, dimmable current drive, and the LEDs in standard A19 envelopes. These bulbs are compatible with Osram Sylvania’s gateway, allowing grouping, scene programming, and dimming without wall dimmers. Smart bulbs take a hefty premium at the cash register, but if you factor in the cost of a smart dimmer and the greater-than 11 year projected bulb life, they may be attractive, particularly for homeowners that do not want to get involved with installing new smart dimmers.

Where home-automation might truly shine in residential lighting is in lighting arrangements not possible by other means. For example, in conjunction with automated controls, colour-tunable LED lamps can produce a range of effects. On the fanciful end of that spectrum, one can set the colour of, say, accent lighting in a living room to a deep blue to create an ambience reminiscent of a theatre for movie night or shift the light colour in a dining room toward red for a romantic dinner. More pragmatic, home-automation systems can program lights in a bedroom to fade up in time for waking with colour to match a sunrise culminating, if desired, with the high colour temperature of a cloudless sky. Although such systems remain untested in clinical settings, they may be particularly attractive to people in northern latitudes who suffer from seasonal affective disorder by simulating daylight—something incandescent bulbs cannot do.

Ready, aim...

… watch your feet. A good number of home automation systems have entered the market in the last year or so, but interoperability, or the lack thereof, may stunt residential-market adoption rates in the near term. Taking WiFi equipment as an example, you can buy a wireless router from Netgear, a range-extender from Linksys, a printer from HP, and a camera from Canon and not care who makes WiFi silicon for any of those devices, not to mention your laptop, pad computer, or mobile phone. Interoperability is a given.

If present at all, interoperability is far from obvious in the home automation market. Vendors’ marketing-collateral materials are essentially mum on the topic. So it appears that if you buy a gateway for one branded system, you are locked into that brand for all of your networked nodes and for your application software. Although technology aplenty is readily available, clouds on the horizon could be those of a coming market shakeout. The market is far from mature and there is plenty of opportunity and technical support for an upstart to jump in.

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MEMS platforms are way to go, says Bosch’s Finkbeiner

By Peter Clarke

In the two years since we last interviewed Stefan Finkbeiner, CEO of Bosch Sensortec, the company has taken over from ST-Microelectronics as the leading global supplier of MEMS components. Here he explains how the company is going conquer the Internet of Things.

Part of Bosch Sensortec’s success has come from an approach that has leveraged the company’s position in automotive to address smartphone applications. And Finkbeiner told EE Times Europe that a multi-use platform approach with MEMS sensors made application-specific through software will be one way to address the numerous vertical markets for the Internet of Things.

“We have a good balance. Being in both markets is important. That way you can often develop a common platform and then two separate products,” said Finkbeiner who we met at the European MEMS Summit, organized by SEMI and held in Milan, Sept. 17 and 18.

Asked whether Bosch Sensortec needed to add novel technologies and sensor types to its current position in inertial sensors Finkbeiner said: “We have a lot of growth with the current technology into IoT,” he answered. “Today it is use cases, not technology, that is driving business.”

Bosch Sensortec has access to corporate research performed by parent company Robert Bosch GmbH. They are looking into new measurement technologies, optical MEMS, microfluidics and so on, Finkbeiner said.

“But choosing the right time to deploy such technologies is key. If you already have an existing technology, the new technology has to have a significant advantage over the existing one. And you also have to look at the performance of the complete sensor, which could include local software and the impact of packaging. Often a change in software or in packaging can produce a more significant benefit than overthrowing the base technology,” he said.

Nonetheless Bosch Sensortec is introducing gas and chemical sensors, humidity sensors for an environmental cluster on smartphones. But mainly Bosch Sensortec is looking to tweak what it has got to address a panorama of new market opportunities. “We are looking to diversify out of automotive and smartphones into IoT and industry 4.0”

As the market leader Bosch Sensortec would be one of the first companies that could benefit from moving to a larger wafer size for production.

Bosch has its own 200mm wafer fab opened in 2010 in Reutlingen, Germany, built alongside a 6-inch wafer fab that has been in operation since 1995. ICs produced on the site are used in electronic control units (ECUs), in automobile engines, electronic stabilizers and ride control, airbag, night-vision and driver assistance systems and in consumer electronics applications such as smartphones.

When the 200mm fab was commissioned back in 2010 Bosch said it would take up until 2016 for it to be fully facilitated. It could be argued that one way for Bosch to put off the expense of a next wafer fab would be for the company to start converting its lines to 300mm wafers, but Finkbeiner says there is no near-term benefit for doing this.

“From the technical side; you can do it. But from the commercial side does it make sense?” Finkbeiner asked rhetorically. He pointed out that despite the fact that the physical structures in MEMS do not scale as easily or predictably as transistors have, companies have made progress in shrinking structures and MEMS die sizes. “You can get 30,000 MEMS die on an 8-inch wafer. That means a single lot of 25 wafers gets you 750,000 pieces. With a few wafers you can get millions of parts.”

Finkbeiner added that the fragmentary nature of MEMS and the one product, one process limitations meant that there was almost no product that justified production on 300mm wafers. And building a 300mm MEMS wafer fab would not be feasible any time soon. “Reutlingen is not yet full. When we get closer [to being full] we will think again about what should be next."

Partnership with other companies on a More-than-Moore 200mm/300mm wafer fab might be one option.

**IoT and wearables**

From its strong base in automotive and smartphones Bosch Sensortec – like most other MEMS suppliers – wants to expand by servicing the Internet of Things. “To make money in IoT you have to look at the application,” Finkbeiner said.

When asked whether he saw wearable equipment as a real market that can add on to the smartphone sector Finkbeiner said the threshold for success in wearables would be high, in terms of functionality, reliability and energy efficiency but there were opportunities. “The volume in wearables is considerably lower than in smartphones. But there are definite use cases such as sports and healthiness, locating and monitoring children and the elderly,” he said.

In his talk at the European MEMS Summit Finkbeiner said that Bosch Sensortec would be introducing application-specific sensor nodes (ASSNs) – combinations of multi-axis sensors, microcontrollers and software – and stripped down hubs for IoT applications soon. “Software will become an essential success factor for MEMS in the future.”
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Dialog to acquire Atmel for USD4.6bn in IoT push

By Paul Buckley

U.S.-based Dialog Semiconductor PLC is to buy Atmel Corp. in a $4.6 billion cash-and-stock deal in a move to try and capture a larger slice of the Internet of Things (IoT) market. Dialog sells chips used to manage power in high-end smartphones from Apple Inc. and others. Atmel, based in San Jose, Calif., focuses on microcontrollers that provide computing power for many kinds of consumer and business hardware.

Jalal Bagherli, Dialog’s chief executive, said the deal will help the company reduce its dependence on a few smartphone makers and acquiring Atmel’s customer base and line of products will make Dialog a major player in chips for connected cars, wearable devices and other networked IoT devices.

“We won the second round of bidding,” said Bagherli.

The transaction continues a string of combinations in the semiconductor business, where stock prices have been held down by slowing growth and companies see advantages in merging product lines and sales forces.

In May Avago Technologies Ltd. agreed to buy Broadcom Corp. for $37 billion with Intel Corp. declaring a $16.7 billion deal to buy Altera Corp.

Dialog, based near London in Reading, traces its lineage to 1981 and the European operations of a U.S. company called International Microelectronic Products Inc. Those operations were acquired by auto maker Daimler-Benz AG and later spun out, with Dialog going public on the Frankfurt exchange in 1999.

Atmel, founded in 1984, achieves about 70% of the company’s revenue from microcontrollers which are used in applications that include smartwatches, fitness devices and Arduino circuit boards. Atmel also sells chips to help manage sensors and touch screens in smartphones and tablets.

Bagherli pointed out that Atmel has also developed technology to provide security for Internet of Things applications. “That is very, very key for IoT,” said Bagherli.

The combined company would have $2.7 billion in annual sales, Dialog said. Atmel actually has more employees than its acquirer - 5,000 to about 1,500, because Atmel operates factories to manufacture some of its chips. Until now Dialog had relied entirely on external manufacturing services.

Dialog expects the transaction to result in annual savings of $150 million within two years. The company will fund the takeover with existing cash, new debt and shares. Both companies’ boards of directors have approved the transaction, which is expected to close in the first quarter of 2016.

Imec laminates stretchable LED display onto garments

By Julien Happich

R esearchers from Holst Centre (set up by TNO and imec), imec and CMST, imec’s associated lab at Ghent University, have demonstrated what they claim to be the world’s first stretchable and conformable thin-film transistor (TFT) driven LED display, laminated into textiles.

Marking a step forward in wearable electronics, the conformable display is very thin and mechanically stretchable as it relies on imec’s patented stretch technology (flexible meander interconnects) connecting standard silicon LEDs as many small hard islands.

A fine-grain version of the proven meander interconnect technology was developed by the CMST lab at Ghent University and Holst Centre, demonstrating LED displays with a LED pitch of 1mm, with 0.5mm meanders and 0.5mm LED islands.

“The current limit is in the size of available LEDs”, conceded Hanne Degans, talking on behalf of imec, adding “stretchability is compromised by a lower LED pitch and larger LED islands.

Switching to smaller, bare-die LEDs extends the usability of the meander technology”.

The LED displays are fabricated on a polyimide substrate and encapsulated in rubber, allowing the displays to be laminated in to textiles that can be washed. Importantly, the technology uses fabrication steps that are known to the manufacturing industry, enabling rapid industrialization.

So, is imec working on displacing these silicon LEDs with fully printed OLED islands or couldn’t it withstand the heat from the lamination process? We asked.

“The integration of OLEDs with textiles and stretchable displays based on OLED technology are being pursued as parallel paths at Holst Centre and imec. The integration of OLED devices in textiles is not limited by the heat from the lamination process”, answered Degans.
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GaN soon on 8-inch silicon wafers, hopes MACOM

By Julien Happich

As M/A-COM Technology Solutions Inc. (MACOM) announced its 4th generation 100W GaN on Silicon wideband transistor at the European Microwave show in Paris, the company is confident it is set to play a major role in the GaN supply chain.

Built using the company’s proprietary 4th generation GaN on Silicon (GaN on Si) process, the 100W part (MAGX-100027-1000CP) is optimized for DC to 2.7GHz operation and is aimed at defense communications, land mobile radio, avionics, wireless infrastructure, ISM applications and VHF/UHF/L/S-band radar. It supports CW, pulsed, and linear operation with output power levels up to 100W (50 dBm). Operating from 50V, the device supports continuous wave operation with a 18.3dB gain at 2.45GHz, and 70% drain efficiency.

According to the company, such parts deliver a performance that rivals expensive GaN on Silicon Carbide at a projected volume production cost structure below that of incumbent LDMOS technology, and thus its Gen4 GaN technology could finally bring GaN to the mainstream market, on silicon, while enabling a power density more than four times that of LDMOS.

The company is sampling its 100W parts now, with 200W and 3000W devices soon to be announced, but that’s not all.

It has big plans to ramp up its production, from today’s 4” wafers to 6” or 8” silicon wafers.

Over the past few years, MACOM has been growing through a number of strategic acquisitions, including several optoelectronic chip companies such as Optomai Inc. back in 2011, or Photonic Controls LLC and BinOptics Corporation in 2014, but also Mindspeed Technologies for its foothold in wireless basestation infrastructures, and more importantly Nitronex, LLC (acquired in 2014 for its GaN-on-Silicon products and patents portfolio, including a unique process).

“MACOM now truly offers solutions across the entire wireless communication chain, from RF to optical communication links”, emphasized the company’s EMEA sales director, Markus Schaefer, “In fact our company has evolved so much over the past five years that internally, we like to call ourselves the new MACOM” he added.

In particular, the Nitronex acquisition means the company holds key patents for RF devices built using GaN-on-Silicon, so in effect, other companies considering using GaN-on-Silicon instead of GaN-on-Silicon Carbide would have to license the IP.

In order to further lower the cost of GaN-on-Silicon and also to ensure double sourcing for a broader adoption of its technology, MACOM is looking for fab partners willing to share some of their capacity on 8-inch silicon wafers.

“We’ll be making an announcement soon” promised Mike Ziehl, Vice President of Marketing for the RF and Microwave business unit at MACOM.

“If you consider an average selling price of $20 for GaN RF transistors, 50 million of them shipping yearly just for base stations, and possibly another 50 million transistors for the RF energy market (including microwave ovens), that makes up a two billion dollars addressable market opening its doors to our technology”, Ziehl added.

“We are a 500 million dollars company today, we could well double in size within the next five years”, he added optimistically.

The company is confident that thanks to its IP portfolio and with strategic licensing agreements, it could lay the foundation for a new GaN supply chain model whereby it could become the preeminent supplier of compound semiconductors for RF and microwave applications.

Li-Fi interconnect aims to replace plugs and cables

By Paul Buckley

Scientists at the Fraunhofer Institute for Photonic Micro-systems IPMS in Dresden are aiming to use Li-Fi communication modules to replace wired fieldbus systems or HF connectors that are subject to wear. The scientists claim that for moving or movable plant components the Li-Fi interconnect technology offers greater reliability and security.

Optical technology makes it possible to transmit data in both half and full duplex modes at speeds of up to 12.5 gigabits per second over short distances. The transceiver replaces cable or plug connections and operates up to ten times faster than currently available wireless solutions. Other advantages include negligible bit error rates (<10^-11), and low energy consumption. The unique transceiver is especially suitable for industrial applications in which large amounts of data need to be transmitted very quickly and where plug connections no longer meet requirements or provide the necessary level of reliability.

“With our know-how in the field of optical design, high-frequency electronics, packaging as well as high-frequency and optical measurement and test, we are able to flexibly react to the needs of our customers,” explained Project Manager Frank Deicke. “So we can, for example, optimize the size of existing prototypes or customize application-specific range and alignment”. The Fraunhofer IPMS technology can already be tested and the institute currently offers evaluation kits for data rates of 1, 5 and 10 Gbps.
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During the annual press day that ams AG organized at its headquarters last month, in Graz, Austria, CEO Kirk Laney was upbeat about the company’s future. The fab lite company recorded about 170 million euros of revenues during Q2 2015, a 60% increase over the same quarter last year, with gross margins in the 54% region (including acquisition-related costs).

“Because we do the tough stuff, specialty analog designs, we can drive high margins even in the competitive consumer market”, commented Laney.

The sensors and analog circuits company’s current capacity in its 200mm in-house fab is 180 to 190k wafer equivalent per annum, designing CMOS and specialty analog down to 180nm. But it has maxed out its capacity and ams is having a new fab custom-built by agencies of the State of New York that it will rent as a fully operational wafer fab for the next 20 years. The new fab is expected to add up in excess of 150k 200mm-wafer equivalent per year, while being 130nm capable. Production ramp is expected early 2018.

“This is very critical for our company, because we use a fab-lite business model, so we can garner premium margins” explained Laney. “Adding that capacity will allow us to bring the costs down, we looked at certain places in Asia but we needed a dollar-based operation for the sake of currency stability, and this opportunity was just too good to pass up”.

Although the company outsources some of its production to TSMC, UMC, or GloFo for its non-critical consumer and communication products (making up 71% of its revenues), it wants to keep the industrial, medical and automotive products under close control on its own fabs.

“That’s because when we operate with our in-house processes, we can tweak the transistors, and we have much better simulation models too, so we can achieve better design optimization.

For the small volumes we outsource to them, the large foundries won’t bother tuning their process for us, hence some of our key IP would not be transferable to them”, told us Laney.

The company also reserves about 10% of its in-house capacity for external customers, so the new fab will allow an extension of this capacity too. Laney expects the extension to be modular, as a gradual increase to balance its outsourcing demand. As for staffing the new facility, there are plenty of high tech businesses from whom to poach engineers, and ams is confident it will also be able to groom new graduates into successful ams engineers.

Would this fab be MEMS-capable?

“We won’t be touching gyros or accelerometers unless we can add our own capabilities to them” answered Laney who doesn’t want to see his margins shrink through commoditization.

Laney briefly commented on the next CEO transition, with Alexander Everke to become the new CEO of ams in March 2016. As the former General Manager of Multimarket Semiconductors Business Unit and Executive Vice President of NXP, Everke came on board when ams acquired the environmental CMOS sensor business from NXP last summer.

“We’ll be doing some road shows and working together over the 3rd and 4th quarters of this year, then he will take over during the first quarter of 2016 to lead ams to become a 1 billion Euros company within the next 3 to 4 years”.

ams wants to be seen as the largest focused sensor semiconductor company, and it hopes to leverage the smartphone-based IoT sensors frenzy to grow significantly.

Executive Vice President of Marketing and Strategy, Thomas Rienir surfing the IoT wave for which ams seems well prepared.
He described IoT as the 3rd growth wave in semiconductors, reaching across all vertical markets.

“Strategy is about finding where you are good and finding the market fit”, he said, comparing ams to a good surfer ready to take on the new sensor-driven market wave.

“If you consider health-monitoring applications and their related sensors moving to smart phones, you could be monitoring 10 million people every hour” Riener emphasized. Data analysis on such a large scale could enable predictive medicine. Say you’ve figured out that statistically, when two data lines cross, you know there is a risk of a heart attack and your doctor gives you a call to alter the trend with medication or a change of habits.

ams already provides many basic sensor elements for integration, but also fully integrated modules, ranging from temperature, humidity or pressure, to light detection with its own sensor fusion recipes to yield context awareness information. But the company is keen to expand its offering by acquiring innovative startups with other promising sensing solutions. Multi-spectral sensing and photonics are areas to watch, admitted Riener, confessing that the company was developing dual spectral sensors for the coming years.

Insurance companies call the shots
Talking about multi-spectral sensing and photonics, both ams COO Thomas Stockmeier and Sajol Ghoshal, Senior Director for emerging sensing strategies shared their view on the central role that LED lighting and associated sensors could take in our lives.

Smart lighting is no longer just about digital dimming or automatic lumen and colour maintenance, but parts such as the company’s AS7221 smart lighting manager (with an embedded true-color Tri-Stimulus RGB sensor) could be used to perform colour tuning to complement daylight intensity and directly impact our circadian clock.

In fact, such unobtrusive wavelength modulation (mostly going unnoticed) can affect our moods and productivity, and this is an early area of research that could find many applications, told us Stockmeier. This may be for optimal health and relaxation at home or on the contrary to increase your alertness level at the work place. This sort of light-based manipulation is akin to forced medication, but if it’s good for productivity and means fewer sickies, sure more than one company will love it.

Ghoshal sees a bigger picture for LED lighting, “lighting is a natural sensing hub” he said, with lighting sockets and power readily available in every building. So ams wants to create the sensing solutions to fill the future market needs, and according to Ghoshal, this means a move from today's dumb LEDs to complete spectrally-cognitive sensor platforms, LED lights doubling as multi-sensor hubs to increase context awareness and accelerate IoT deployment along a trend he calls the Internet of Awareness (trade marked on his slide).

Implemented as self-learning luminaires, such IoT sensor hubs could serve for occupancy and motion detection, navigation, space utilization monitoring, safety and security (smoke/fire detection), air quality monitoring or circadian compensation. Pushing their data to the cloud for analytics, these context-aware sensors would enable new cloud driven services and solutions, going beyond local controls to support self-learning connected cloud services.

Here again, multi-spectral sensing is on the agenda at ams, for the detection and identification of environmental biometrics.
Another well-being related product, the AS7000 launched during the event is the company’s first product in its bio-sensor family, a total solution for 24/7 heart rate measurement for wearables.

The AS7000 platform solution includes an integrated optical sensor module accompanied together with software to deliver what the company says are the industry-leading, highest accuracy optical heart rate measurements (HRM) and heart rate variation (HRV) readings.

Designed within a 6.1x4.1x1.0mm opto-mechanical package, the AS7000 relies on photoplethysmography (PPG) to derive the pulse rate by sampling light modulated by the blood vessels, which expand and contract as blood pulses through them.

Through treadmill exercises, ams engineers have benchmarked the solution against existing electro-cardiogram (ECG) based fitness and health monitoring applications, they claim equivalent accuracy, but for a much better wearability (wrist rather than chest-strapped) which would make the module suitable for a fit-and-forget type of wrist band to support continuous monitoring.

The device also enables skin temperature and skin resistivity measurements by providing interfaces to external sensors.

It could be paired with an external accelerometer so the embedded algorithms could filter out motion artefacts attributable to the beating of the heart which interfere with PPG readings, irrespective of the wearer’s own motion.

By wearing such bands for several days (in between battery changes), users would provide their doctor a more complete view of their vital parameters, including trends and historical information. This could be an enormous market, providing such health monitoring becomes mainstream.

In fact, when designing such sensor solutions, ams is in discussion with insurance companies, not just designers or doctors, let alone consumers who may not feel compelled enough to wear that thing.

“By talking to insurance companies, we want to know what they would expect from this technology”, justified Ronald Tingl, Senior Marketing Manager for the biosensors line.

Some would want to tie the data to medication, to see how pharmaceuticals and exercise recommendations can work together. Actually, it seems that most companies in the health&fitness sensor market try hard to convince law makers and insurance companies that they would all benefit from making such bands compulsory, or at least cost-prohibitive not to use (due to increased insurance premiums). After the point system for driving licenses, maybe the future holds a point system for unhealthy behaviours (lack of exercise among other things)?

A complete HRM/HRV wristband demonstration kit is available together with a heart rate app allowing for real time logging of all the data.

Future generations will include reflective \text{SpO}_2, skin temperature GSR and blood pressure, we were told.
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Turning the world into a digital user interface: SuriCog

By Julien Happich

What would strike you at first when looking at the glass-free spectacles demonstrated by French startup SuriCog at the enova exhibition, is the lack of screen for the projection of digital information in some sort of superimposed augmented reality scenario. But SuriCog is here to demonstrate some unique eye-tracking technology which could turn your surroundings into a custom user interface, naturally.

A small camera mounted inwards detects the reflection of two IR LEDs illuminating the right eye ball, then video image processing determines the actual axis of vision of the wearer. Also integrated on the right side of the spectacle is a special telemetry system which gives the distance of the wearer to the nearest physical object in his/her line of sight. If you intersect that data with a 3D digital model of your environment, then you are able to not only tell where the wearer is looking but also where he or she is situated in this environment.

“We can track the user's location to within millimetres”, told us Arthur Carrier, business engineer at SuriCog, though he was shy about the actual technology used to perform the distance measurement.

From looking at the WEETSY design (that's how they call the wearable device), one could suspect a dark slanted optical window on the slightly bulging right spectacle arm. This could be hosting some sort of IR laser, but again Carrier didn’t want to comment. Of course, we are not talking about absolute geolocation but relative user positions within a given environment.

“For now, we are looking for early adopters of our technology to identify the potential killer apps and help us refine our offering” he said, “So we perform feasibility studies and provide a demonstrator together with a software development kit” he added.

The company started generating some revenues in 2014 from applications in ergonomic studies and assisted training in aeronautics, when the instructor needs to check if the trainee is looking at the right place.

The vision health market is another promising market, precisely for orthopsy, where the WEETSY spectacles could help with the detection of oculomotor disturbances. Dedicated monitoring applications could help the wearer re-educate their eyes through specific motion exercises.

What makes SuriCog’s eye-tracking different from other products on the market is that it is not limited to one screen, but encompasses the whole space.

Also, multiple users can have access to different information depending on where they look, in the same room. In fact, the company is experimenting with the Louvre museum in Paris to provide audio guides to its visitors. The experiment is to take place in front of a wall-sized painting, with triggered audio comments corresponding to elements of the painting being looked at.

SuriCog has just raised a round of funds from private investors to further its product development. Among other things, the startup would like to reduce the signal processing hardware from its current chewing-gum box sized format to maybe a USB stick or even to an ASIC. The demonstrator was tethered and tied to a little processing box, but in the future, it could operate wirelessly using a Bluetooth connection, hopes Carrier.

First, SuriCog will focus on B2B projects, with companies who already have a digital model of their environment or at least who have the resources to recreate their workspace in 3D. But as 3D scanning technologies become more affordable or even mainstream, then the company could chase the consumer market, either with its own standalone product or maybe by licensing its unique eye-tracking technology to other AR or VR headset manufacturers.

Initiatives such as Google’s Tango project or Parrot’s recent 3D mapping drone demonstrator could enable consumers to easily model their environment, hence creating a surrounding user interface where the mere look at something could trigger an event. The real world would become a remotely accessible digital interface, a suitable API could let users define the codes of interaction.
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The Open Interconnect Consortium (OIC), led by such industry heavyweights as Intel, Cisco, Samsung, General Electric and Samsung, has made public its long-awaited Internet of Things specification 1.0. The OIC move is expected to add weight to the IoT debates brewing over several incompatible specs promoted by different groups.

The newly released OIC 1.0 is technically still a “candidate spec,” because the OIC is currently going through a 60-day formal IPR process, explained Mike Richmond, executive director at the Open Interconnect Consortium. “By the third week of October, we expect it to become the formal spec.”

During an interview with EE Times, Richmond stressed that “we all need to understand that the big unresolved problem with IoT is not about ‘things.’ But it’s about the network.”

He laid out two key points which he believes will set OIC apart from rival offerings.

First, the OIC offers “cloud-native architecture.” Second, it provides a better Intellectual Property Rights policy.

To be more specific, OIC is based on “the industry’s first cloud-native architecture designed for IoT” documented in a formal specification, according to Richmond.

“You hear about cloud-native architecture – as it’s being used by web services. It’s a concept more familiar to the enterprise market.”

But how does the cloud-native design matter to the IoT world?

“We’ve adapted the cloud architecture to IoT, because it allows us to scale. Our goal [in connectivity] is to go beyond a single home, or a single machine,” Richmond said.

OIC’s approach leverages cloud techniques to enable smooth integration between local and cloud (e.g., local-to-local and local-to-cloud) use cases.

“Cloud-native architecture means that even if developers start with a local-only approach they don’t have to re-architect it to scale,” explained the consortium.

Chris Rommel, executive vice president at VDC Research Group, Inc., told EE Times that the benefit of OIC’s ‘cloud-native approach’ is architecture that allows devices to intelligently self-organize and communicate locally if the cloud is not directly accessible.”

In other words, “The OIC is using the combination of XMPP, 6LowPAN, and RESTful APIs help to provide this flexibility.”

Rommel noted that OIC is using the approach based on Representational State Transfer (REST), a software architecture style for building scalable web services.

In contrast, Qualcomm-led AllSeen, one of OIC’s competitors, is using Remote Procedure Call (RPC). RPC allows a computer program to cause a subroutine or procedure to execute in another address space – often on another device on a shared network – without the programmer explicitly coding the details for this remote interaction. Asked to compare the two approaches, Rommel said, “The REST-based approach of OIC can sometimes lead to better interoperability compared to the RPC approach used in AllSeen since REST is semantically/contextually consistent.” Rommel, however, added, “But both frameworks ultimately have a goal of supporting broad-based interoperability.”

IPR policy

Although many engineers roll their eyes over talk about differences in IPR policy, the distinctions are important, OIC’s Richmond noted.

Under OIC, two legally separate entities exist. One develops specifications/certification programs, and another, called IoTivity, is specifically designed to be an open source project. The key here is that OIC and the associated IoTivity open source project both grant royalty free licenses, but they depend on separate patent policies. The OIC spec is covered by RAND-Z (Reasonable & Non-Discriminatory Zero royalty) patent licensing, while IoTivity code is covered by Apache v2.0.

Why is this so important?

Richmond sees this approach as the best patent coverage available in any OSI-approved open-source license. For instance, under IoTivity, covered by Apache 2.0, anyone, whether an OIC member or not, can download, use, modify or contribute back to IoTivity and will get the full benefit of Apache 2.0 patent provisions.

Under OIC, covered by RAND-Z patent licensing, members are granted a royalty-free license to any necessary claims. They must implement OIC Specifications for the “compliant portion” of their product, regardless of whether the member was involved in developing the relevant portion of the spec.

Some AllSeen members, however, believe that building a wall between software developers working on open source code (i.e. IoTivity) and developers of specs/certification (OIC) is a bad idea. They say it’s critical to give developers access to both code and spec.

Richmond disagrees. His claim is that OIC offers software developers freedom “not to become an OIC member.” He said, “It’s not required for software developers to be an OIC member. It’s not fair to ask them to pay a membership fee in order to develop codes, which creates a conflict for those working in the open-source community.”

VDC Research Group’s Rommel said that in contrast to OIC, “AllSeen is mired in some ambiguity based on the ownership of certain IP patents by a holding company (Qualcomm) while, technically, it is a subsidiary of Qualcomm that is a member of AllJoyn.”

Rommel is concerned that this might lead to IP contamination by an organization or if there were a change in policy at the holding company (as opposed to the member subsidiary).
in which it could technically allow Qualcomm to take action to protect its IP. Rommel added, “However, they and AllSeen are on record saying they do not plan for this to ever happen.”

Rommel called OIC “a young group.” It’s a year old. But he described the group as “technically very ambitious.”

While the OIC has maintained a low profile while “senior architects [sent from its board member companies] literally pounded away at the spec.” Richmond - an Intel employee at that time - was “just a lurker at the OIC meeting until last March,” he said. “But I was blown away” by OIC participants’ intensive work. After the OIC all-member meeting, he decided to take the job as the group’s executive director in May.

Richmond, who has lived through various networking technology debates (i.e. token ring vs. Ethernet), said, “It’s so easy to get caught up in a day-to-day marketing battle.” While it’s a “great game,” he cautioned that “IoT is a marathon. We have just reached the first post on a long road.”

More specifically, Richmond said, “Our concern is not getting there first, but getting it right.” Otherwise, the industry will pay for its haste five years from now, he warned.

Although there are differences in IoT industry specs, Richmond takes the long view. “The industry has its own way of sorting out differences, just like we have seen what happened with the networking technology debates.”

Asked about what’s ahead, he acknowledged that many things are still undone – including the launch of the OIC certification program. The group has already done three plug fests, he said, “which we see as onramp to certification.” He also noted that the OIC has no intention to do “soft certification” – a simple protocol in which companies self-certify their products.

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Asked how the OIC is planning to define “things” – each connected device’s functions and use cases on the application level, Richmond said, “We have liaison agreements with other [industry] groups” who have spent years working on definitions.

While declining to name the groups the OIC is working with (he said he isn’t sure which ones are public), he explained that lots of detailed work has been done in areas such as industrial, health/fitness and automotive. The OIC has no plans to duplicate their work.

Similar to Qualcomm-led AllSeen, OIC is focused on the application layer sitting above the network stack. OIC’s Richmond said, “We run on top of Thread network. We see ourselves a perfect fit.”

However, devils lurk in the details. VDC’s Rommel pointed out, “All IoT middleware/framework alliances and consortiums have slightly different points of focus and goals, whether it is on a particular vertical market, proximity radio, or on a slightly different part of the software/system stack.”

Rommel summed it up: “Thread, for example, sits below OIC/IoTivity and is focused on an IP specification for low power devices over wide area networks, but does not provide full end-to-end interoperability.

Allseen, like OIC, targets the development of a higher level communication framework but is initially targeted at consumer/home applications. OIC is intended to ultimately have a broader target across more vertical markets than is Allseen.
Flooding young minds through digital immersion

By Julien Happich

In his introduction keynote of the IMMERSION 2015 event taking place at the Sorbonne University in Paris, Immersive Education Initiative Director Aaron E. Walsh gave attendees an overview of existing virtual and augmented reality technologies as they are used today.

Whether it be for entertainment (mostly gaming and advertising), training and education or to explore yet to be built computer-generated machineries and architectural spaces, the solutions range from the full digital confinement offered by Oculus-type devices or 3D digital domes that englobe users within virtual reality streams, to more open augmented reality implemented as clever graphics superimpositions on mobile devices screens (including smart glasses).

Although virtual reality is not new, the acquisition of Oculus by Facebook last year gave a strong signal to content providers and game designers, as a technology due to take centre stage in social networking, enabling virtual avatars to connect within digital wonderlands.

Software industry heavyweights Microsoft and Google are into the game too, backing up fancy augmented reality projects such as Hololens or Magic Leap with the promise to have our lives digitally enhanced wherever we look.

Of course, the 5th European Immersive Education Summit (EiED 2015) had its focus on using AR and VR for better or augmented education, that is, offering pupils and students a richer education environment for a meaningful learning experience. Something that engages them more and that leaves a lasting impression for a better assimilation of the topics being taught.

“Learning is enhanced when intangible concepts are reinforced by tangible objects” said Walsh, taking as an example a Physics lesson where pupils could manipulate volumes and view complex shapes from within. “Virtual reality and augmented reality engage students at a deeper level than lecturing them on a blackboard, it grabs and keeps their attention like the best video games" he highlighted, “It gives learners a sense of presence, of being there”.

Other keynote speakers such as Melissa A. Carrillo, Director of New Media and Technology at the Smithsonian Latino Center, or Dr. Bryan Carter, Assistant Professor of Africana Studies at the University of Arizona, shared their experience using virtual reality sets to convey cultural heritage, helping their pupils recreate cultural events or immerse themselves into past sceneries of historical significance. Carrillo presented excerpts of her work on the “Día de los Muertos” while Carter gave us an overview of the “Virtual Harlem” project.

Both emphasized that pupils who had opted for the immersive teaching environment had retained more about the lessons, gaining a fuller view of the topic. Maybe because they had been more proactive, wandering around the virtual spaces set up for them, looking for information and working collectively with other avatars.

Indeed, several of the papers presented at EiED 2015 highlighted the increased attention levels and test scores obtained amongst students when using virtual reality. One put forward by virtual reality software and systems provider EON Reality reports test scores increased by 35%. Another paper presented by startup company Playto claims its EEG-monitored video games and training courses help kids and students strengthen their focus and understand how they can concentrate for other tasks in their everyday life.

The dream put forward by virtual reality in education is that one professor could teach in the real world, say in a classroom, but assisted by a plethora of virtual tools and 3D representations. All this accessible by pupils from all around the world, as avatars sitting in a larger, fancier or even customized amphitheatre, all being able to manipulate and interact individually with the objects being presented to them.

In fact, virtual professors could step up the game as a paper “Virtual Agents’ Support For Practical Laboratory Activities” suggested. In it, Brazilian researchers discuss the use of virtual agents (in the shape of...
autonomous avatars) to expand educational capabilities beyond existing academics to one tutor per student, offering specific support in practical laboratory activities.

Virtual reality environments and augmented reality are certainly incredible tools, and although their specifications still need to mature, industry has already found many great applications. But isn’t it a risky bet to commoditize them through education?

Sure, pupils may have better scores in Maths, Literature, Engineering and what else... but if this immersion scenario is to become mainstream through education, then one augmented lesson after next, pupils will spend their days into fake environments, connecting only with avatars rather than humans.

Blend in all the “social” avatar networking that could be nurtured by internet giants, advertising companies and all the fantastic digital life scenarios put forward by content and game creators, there may not be much time left for real life, let alone a meaningful one. College connexions used to be the most durable and impervious to time, but those may now be lost for unrecognizable avatars.

Walsh is well aware that digital addiction is lurking in this environment, where users are much more captive at a way deeper and exclusive attention level than with today’s already addictive mobile screens.

So what about digital addiction by the millions?

At the end of his keynote, Walsh mentioned addiction, citing the case back in 2010 of a Korean couple who had left their 3-month old baby starve to death as they cared for a virtual child in a computer game. “I have lost some friends to VR addiction”, testified Walsh, “they couldn’t go to sleep, they couldn’t stop to eat, and that was in the mid-nineties when the graphics and the immersive experience of video games was much less compelling” he recalled.

He then called the research community for more studies on the effect of immersion on the brain and how it can impact the psychological state of frequent users.

“Maybe in the future, virtual reality systems should integrate physiological sensors to detect addictive uses and issue warnings” he suggested.

So yes, it would be time to look at the moral and ethical issues around VR before drowning young minds within untested digital territories. Although a boon for hardware and software makers, rushing VR into education would leave little choice to entire generations of future consumers, but that of being flooded with data wherever they look, pretty much the same way most of us feel compelled to stare at screens day in, day out, whether it be for work or leisure.

Is this really enhanced life?
A provider of proprietary materials for the design of organic flexible thin film transistors, Polyera is opening a new branch of business and hoping to create its own technology market pull. It is implementing its technology into the Wove band, a truly flexible display wristband expected to reach consumers by the middle of next year.

The Wove band sports a grayscale E-ink display, 1040x200 pixels across a 30x156mm capacitive multi-touch flexible foil, all controlled through Polyera’s flexible active matrix organic TFT backplane. With about five times the surface of a smart watch, the unit can not only deliver persistent ambient information (the E-ink is bi-stable at zero power), but it can also be used to run graphical compositions matching the wearer’s mood or clothing.

Prior to final commercial launch, the company is looking for experienced graphical designers familiar with Java for Android, HTML5/CSS3/JS or other graphics tools to explore new use cases and develop new applications and content (or compositions as the company calls it) under its Wove 0.1 prototype program.

Under the hood, the bracelet hosts a Freescale i.MX7 Dual-Core ARM cortex-A7 processor, 4GB of storage and 512MB of RAM, a 9 axis motion sensor for gesture-based interaction and a built-in eccentric rotating mass vibrating motor for haptic feedback (all running from a 230mAh battery). A Bluetooth 4.0 radio link supports communication with Android smartphones to download new compositions or get wrist notifications.

According to the company’s founder and CEO, Phil Inagaki, this will be the first commercial release of a truly flexible active matrix display that can actually be bent and flexed in the hands of consumers without breaking.

“Others like Sony use a matrix of amorphous silicon deposited on a plastic substrate, while Samsung uses polycrystalline silicon TFTs, but being silicon based, these display backplanes are too brittle and not robust enough to withstand multiple flexures” compares Inagaki, “so typically, even when marketed as flexible displays, the devices only have one fixed curvature encapsulated into a curved rigid design”.

So is this just a prototyping kit for others to embrace the underlying technology or will Polyera produce this consumer product as part of its portfolio?

The company’s initial business strategy was to find partners among display manufacturers to include its proprietary materials and processes into their existing display fabrication plants. But maybe the industry lacked of a good example in order to move ahead.

“It takes some time to bring to market these new flexible display technologies with reasonable yields and costs, and for companies who don’t have the know-how about the failure mechanisms of flexible displays and their integration with other electronic components, there is a big learning curve” explained Inagaki.

“So with the Wove Band, we’ve actually solved all the issues around designing with flexible displays. It will certainly be a milestone in the industry, and by showcasing our technology in this product, we hope to create momentum”.

Inagaki insists this is not just a demonstrator, the Wove will be a mass-produced consumer product sold by Polyera itself. “We’ve been quietly preparing this launch over the last three years. We’ve decided that is we were going to launch a product, we were going to be serious about it, so we are committed to fully develop and commercialize this product as an expansion of our business, with long term support”.

As a failsafe option for further product design exploration, the CEO does not dismiss the possibility to rely on crowd funding between now and commercial launch, to get as much consumer feedback as possible on what the band should provide. He may also open the company’s prototyping application program to thought leaders.

Asked about colour, Inagaki says his company is already actively developing next generation colour versions of the Wove, most likely with coloured E-ink. Although Polyera has already created fully functional prototypes of flexible colour OLED displays, flexible encapsulation of OLEDs is still a challenge. But more importantly, the CEO highlights that on a low power budget, an emissive technology such as OLED cannot compete with reflective E-ink displays, which makes the latter his preferred choice for always-on wearables.

The Wove Band can wrap its display around a wrist.

Inagaki leading by example: Polyera’s flexible displays

By Julien Happich

Various compositions showing different use cases.
16-bit Embedded Control Solutions

PIC24 Microcontrollers • dsPIC® Digital Signal Controllers
The top challenges facing today’s embedded system designer are attaining product specification and performance goals, achieving on-time market launch and meeting cost targets. Microchip’s 16-bit microcontroller and digital signal controller families deliver the performance, peripherals, software and hardware development tools to meet these objectives.

The 16-bit family is comprised of several subfamilies ranging from 4 KB to 512 KB of Flash in 14 to 144 pins, with packages as small as 4 × 4 mm. The PIC24F family offers a cost-effective, low-power step up in performance, memory and peripherals for many applications that are pushing the envelope of 8-bit microcontroller capabilities. The PIC24F family features devices with eXtreme Low Power (XLP) technology, 16 MIPS performance, rich analog integration and drivers for segmented or graphical displays. For more demanding applications, the PIC24E family offers up to 70 MIPS performance and includes a robust peripheral set including PWMs, timers, CAN and op amps.

The dsPIC® family of Digital Signal Controllers (DSCs) include a fully implemented Digital Signal Processor (DSP) engine, including a single-cycle 16 × 16 MAC and 40-bit accumulators, for enhanced math capabilities to execute and control high-speed precision digital control loops with the simplicity of a traditional microcontroller. Microchip’s dsPIC DSCs achieve up to 70 MIPS performance and include features for high-efficiency motor control, platinum-rated digital power supplies and other embedded control applications, including operation up to 150°C and support for both 3V and 5V applications. All 16-bit families have the same instruction set, basic peripherals and common pinouts and share the same development tool ecosystem for easy migration.

**Performance**
- PIC24 MCUs with XLP technology provide the lowest power and longest battery life
- dsPIC33 DSCs offer real-time response and highest performance
- Perform in harsh environment up to 150°C
- Deterministic interrupt response for real-time control
- Single-cycle bit manipulation and multiply
- High-endurance, flexible and secure Flash
- Fast DMA without cycle stealing

**Software**
- USB, graphics, crypto, smart card, file I/O and Wi-Fi® stacks
- Motor control software, models and tuning guides
- PMBus™ software and digital power compensator library
- DSP math function library and digital filter design tools
- Class B safety peripherals and library for IEC 60730
- Hundreds of code examples to setup peripherals and functions

**Peripherals**
- Rich analog integration – Analog-to-Digital Converters (ADCs), Digital-to-Analog Converters (DACs) and op amps
- Communications – UART, IrDA, SPI, I²C, USB, CAN, LIN and SENT
- Fast and flexible PWMs and timers
- Motor control PWM, precision ADC and QEI
- Digital power peripherals for low-latency control loops
- Optimized peripherals for real-time response
- Drivers for segmented or graphical displays
- Crypto engine for data security

**Tools**
- Supported by MPLAB® X IDE and XC16 compliers
- MPLAB Code Configurator for easy setup and configuration of peripherals and I/O
- Starter kits and low-cost Microstick boards
- Flexible Explorer 16 Development Board
- Reference designs for digital power conversion and lighting
Flexible Integrated Peripherals

Microchip offers a rich set of high-performance peripherals that integrate seamlessly with customer application and enable solution with reduced costs and time. The 16-bit family offers key communication and control peripherals like SPI, UART, CAN, PWM, Timers and I²C, as well as specialized peripherals for USB, graphics, motor control and digital power. With intelligent analog peripherals, you can integrate analog functions such as high-performance ADCs, DACs and op amps into your applications providing simple-to-use interfaces that ease analog design. In addition, core independent peripherals such as CLC, PTG and crypto enable higher levels of integration and flexibility.

### PIC24 and dsPIC33 Family Block Diagram

<table>
<thead>
<tr>
<th>Module</th>
<th>PIC24F 16 MIPS</th>
<th>dsPIC33F &amp; PIC24H 40 MIPS</th>
<th>dsPIC33E &amp; PIC24E 70 MIPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>16-bit Core</td>
<td></td>
<td></td>
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<tr>
<td>16-bit ALU</td>
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<td></td>
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<tr>
<td>16 × 16 Register</td>
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<td></td>
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<tr>
<td>17 × 17 MPY</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>JTAG &amp; EMU</td>
<td></td>
<td></td>
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<tr>
<td>Address Generation</td>
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<td></td>
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<tr>
<td>MEMOR Y BUS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 KB–512 KB Flash</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>512 B–96 KB RAM</td>
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<tr>
<td>4 Ch. DMA</td>
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<tr>
<td>ECC Flash</td>
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<tr>
<td>Live Update Flash</td>
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<tr>
<td>PERIPHERAL BUS</td>
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<tr>
<td>ADC: 10-bit, 12-bit and 16-bit options</td>
<td></td>
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<tr>
<td>DAC</td>
<td></td>
<td></td>
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<tr>
<td>Comparators</td>
<td></td>
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<tr>
<td>Op Amps</td>
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<tr>
<td>Charge Time Measurement Unit (CTMU)</td>
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<td></td>
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<tr>
<td>UART with LIN and IrDA®</td>
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<tr>
<td>SPI with I²S™</td>
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<tr>
<td>I²C™</td>
<td></td>
<td></td>
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<tr>
<td>USB: Device, Host, OTG</td>
<td></td>
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<tr>
<td>CAN</td>
<td></td>
<td></td>
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<tr>
<td>Peripheral Pin Select (PPS)</td>
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<tr>
<td>Parallel Master Port (PMP)</td>
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<tr>
<td>eXtreme Low Power (XLP) - Deep Sleep</td>
<td></td>
<td></td>
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<tr>
<td>ViAT</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Flexible Wake-Up Sources</td>
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<td></td>
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<tr>
<td>BOR, LVD, POR</td>
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<tr>
<td>WDT and Windowed WDT</td>
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<tr>
<td>Deadman Timer (DMT)</td>
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<tr>
<td>RTCC: Clock, Calendar, Alarm</td>
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<tr>
<td>CRC: Flash, RAM and Special Function Registers (SFR)</td>
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<tr>
<td>Class B Features: Illegal Opcode Detect, Error Trap Monitor, Reset Traceability, Oscillator Lock, Fail-Safe Clock Monitor, Frequency Check, PWM Lock</td>
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<tr>
<td>Crypto Engine with 256-bit AES and Random Number Generator (RNG)</td>
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<tr>
<td>Configurable Logic Cells (CLC)</td>
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<tr>
<td>Peripheral Trigger Generator (PTG)</td>
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<tr>
<td>16-bit and 32-bit Timers</td>
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<tr>
<td>Input Capture</td>
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<tr>
<td>Output Capture</td>
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<tr>
<td>16-bit PWM</td>
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<tr>
<td>Multiple-Output Capture Compare PWM (MCCP) and Single-Outputs CCP (SCCP)</td>
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<tr>
<td>PWM with Flexible Modes, Dead-Time, Edge or Center Alignment, Fault Inputs</td>
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<tr>
<td>ADC Triggered by PWM Modules</td>
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<tr>
<td>Quadrature Encoder Interface (QEI)</td>
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<tr>
<td>ADC 4 Msps with 6 Sample &amp; Holds</td>
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<tr>
<td>PWM with 1 ns Duty Cycle</td>
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<tr>
<td>Comparators with 25 ns speed</td>
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<tr>
<td>Segmented LCD Driver: Up to 480 Segments</td>
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<tr>
<td>Graphical Display Driver: with Hardware Acceleration</td>
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</tbody>
</table>

16-bit Embedded Control Solutions
16-bit Embedded Control Solutions

**eXtreme Low Power (XLP) Solutions**

Microchip’s XLP devices bring together the design and process technologies needed to address today’s low-power applications. With sleep currents down to 10 nA and industry-leading integration including USB, touch, crypto and LCD drivers, XLP products can help extend the life of your battery-powered application.

www.microchip.com/XLP

**Intelligent Analog Integration**

By integrating high-precision analog peripherals into the PIC® MCU, you can achieve simplified design cycles, board size reduction, faster throughput and improved signal integrity. Products include 16-bit Delta-Sigma ADC, 10 Msps ADC, DACs, and op amps to make it easy to interface to a wide variety of sensors including portable medical equipment and industrial sensors.

www.microchip.com/intelligentanalog

**Secure Data**

Embedded applications in the internet-connected world demand secure data and long battery life. PIC MCUs ensure data integrity without sacrificing power consumption through an integrated hardware crypto engine, random number generator for unique key creation and secure key storage for applications such as IoT sensor nodes and access control systems.

www.microchip.com/lowpowercrypto

**Driving Displays and Touch**

For applications that need compelling and intuitive user interfaces, our portfolio includes devices with integrated low-power segmented LCD drivers or colorful graphical display drivers with hardware acceleration. Additionally, Microchip offers a broad portfolio of touch solutions for resistive and projected capacitive applications that make it easy for you to integrate touch-sensing interfaces. These hardware peripherals are supported by free software libraries to quickly integrate the touch and display functions into your application with a single microcontroller.

www.microchip.com/graphics
www.microchip.com/LCD
www.microchip.com/touch

**Easy Connectivity**

Whether you are considering adding wired or wireless connectivity to your application, Microchip supports a wide variety of communication protocols. It’s easy to couple the PIC24 or dsPIC33 devices with Microchip’s certified Bluetooth® or Wi-Fi® modules. Peripherals for CAN, LIN, SENT and USB are integrated onto our 16-bit devices with supporting free software libraries.

www.microchip.com/connectivity

**Advanced Motor Control**

The dsPIC33 motor control families feature a high-performance core with specialized motor control peripherals. The devices are supported with free software libraries and motor control algorithms. Our flexible motor control development boards reduce development time.

www.microchip.com/motor

**Efficiency for Digital Power and Lighting**

The dsPIC33 “GS” DSC family is optimized for high performance on advanced algorithms for improved efficiency over widely varying load conditions. These devices feature dedicated peripherals such as fast ADCs and PWMs for digital power conversion and LED or HID lighting applications.

www.microchip.com/power

**System Level Integration**

PIC24 MCUs and dsPIC33 DSCs perform under pressure, with options that operate up to 5V for increased noise immunity and robustness. Additionally, many devices are rated for operation up to 125°C or 150°C ambient temperature for the most extreme automotive and industrial applications, including AEC-Q100 Grade 0 qualification. For safety-critical applications, the products include memory integrity check and error correction, backup oscillators and fault detection. The certified Class B software stack helps to simplify regulatory compliance.

www.microchip.com/hightemp
www.microchip.com/classb
eXtreme Low Power (XLP) Technology

Energy conservation is becoming essential for the growing number of electronic applications. Products with Microchip’s XLP technology offer the industry’s lowest sleep currents, where most applications spend 90–99% of their time. These devices are ideal for a variety of applications including portable medical devices, wearables/fitness monitors, remote controls, wireless sensors, asset tracking, thermostats, energy monitoring, security systems and IoT sensor nodes.

- Low sleep currents with flexible wake-up sources
  - Sleep current down to 9 nA
  - Brown-Out Reset (BOR) down to 45 nA
  - Real-time clock down to 400 nA
- Battery-friendly features
  - Enable battery lifetime greater than 20 years
  - Low-power supervisors for safe operation (BOR, WDT)
- VBAT battery back-up
  - Automatic switch-over upon loss of VDD
  - Maintains Real-Time Clock/Calendar (RTCC) and two user registers
  - Powered separately from 1.8–3.6V source (coin cell)
- Efficient instruction set; 90% single-cycle instruction
  - Active mode currents as low as 150 µA/MHz

XLP Battery Life Estimator

The XLP Battery Life Estimator is a free software utility to aid you in developing low-power applications. The tool estimates average current consumption and battery life. The utility allows you to select the target device, battery type, the application’s operating conditions (such as voltage and temperature) and model the active and power-down times for their application. The tool comes preloaded with specifications of Microchip’s PIC® microcontrollers featuring nanoWatt XLP technology and commonly used batteries in embedded applications.

Development Tools

16-bit XLP Development Board (DM240311)

This board is designed as true platform for low-power development with flexible power sources including AAA, CR2032, energy harvesting, USB or 9V power supply. It includes current measurement terminals and ships with PIC24FJ16KA102 and can be used with other 28-pin XLP devices.

LCD Explorer Development Board (DM240314)

This board showcases the PIC24FJ128GA310 family with segmented LCD driver. The board operates from two AAA batteries and includes circuitry for VBAT battery back-up from a coin cell battery.

MPLAB® Starter Kit for PIC24F Intelligent Integrated Analog (DM240015)

Featuring the PIC24FJ128GC010 family, this kit is ideal for designing low-power sensor networks. It includes on-board sensors for light, temperature and touch. The analog header makes it easy to add your custom sensors for a complete prototype.

MPLAB REAL ICE™ In-Circuit Emulator Power Monitor (AC244008)

This add-on board enables low-power monitoring and debugging. Breakpoints indicate when current exceeds a specified threshold and provides a graph of current, voltage and time versus code execution.

Application Notes

- AN1861: Bluetooth Smart Communication Using Microchip’s RN4020 Module and 16-bit PIC MCU
- AN1556: Blood Pressure Meter Design Using Microchip’s PIC24F Microcontroller and Analog Devices
- AN1416: Low Power Design Guide: A Single Source for Low Power Consumption from the Viewpoint of the MCU
- AN1267: nanoWatt XLP Technology: An Introduction to Microchip’s Low-Power Devices

Featured XLP Products

<table>
<thead>
<tr>
<th>Product</th>
<th>Flash (KB)</th>
<th>Pin Count</th>
<th>Sleep (nA)</th>
<th>Deep Sleep (nA)</th>
<th>WDT (nA)</th>
<th>32 kHz SOSC/RTCC (nA)</th>
<th>Active µA/MHz</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>PIC24FJ16KL402</td>
<td>4–16</td>
<td>14/20/28</td>
<td>30</td>
<td></td>
<td>210</td>
<td>690</td>
<td>150</td>
<td>MSSP</td>
</tr>
<tr>
<td>PIC24FJ64G8004</td>
<td>32–64</td>
<td>28/44</td>
<td>200</td>
<td></td>
<td>20</td>
<td>200</td>
<td>500</td>
<td>USB</td>
</tr>
<tr>
<td>PIC24FJ128GB204</td>
<td>64–128</td>
<td>28/44</td>
<td>380</td>
<td></td>
<td>18</td>
<td>340</td>
<td>300</td>
<td>Crypto, USB, VBAT</td>
</tr>
<tr>
<td>PIC24FJ128GA310</td>
<td>64–128</td>
<td>64/100</td>
<td>330</td>
<td></td>
<td>10</td>
<td>270</td>
<td>400</td>
<td>LCD, VBAT</td>
</tr>
<tr>
<td>PIC24FJ128GC010</td>
<td>64–128</td>
<td>64/100</td>
<td>330</td>
<td></td>
<td>10</td>
<td>270</td>
<td>400</td>
<td>Adv. Analog, LCD, USB, VBAT</td>
</tr>
</tbody>
</table>

www.microchip.com/xlp
**Intelligent Analog**

**PIC® MCUs with Intelligent Analog**

Analog design is difficult and consumes precious development time. Microchip’s intelligent PIC MCUs integrate analog functions such as high-performance ADCs, DACs and op amps, providing simple-to-use interfaces that ease analog design. This single-chip solution enables reduced system noise and provides higher throughput, while dramatically reducing design time and cost.

**Benefits of Analog Integration**

- Eliminates the complicated task of debugging the noise sources that reduce analog signal integrity
- Removes the bottleneck of communicating to the microcontroller from analog
- Provides consistent analog performance that can be leveraged from design to design, eliminating analog design rework
- Through intelligent connections made inside the chip, the analog is fully controlled by software
- Benefits include a simplified design cycle, board space savings, faster throughput and better signal integrity
- Intelligent analog leads to lower-cost designs that are brought to market faster

**Target Applications**

- Environmental quality sensors
- Portable medical equipment (glucose meters, portable ECGs, pulse oximeters, blood pressure meters)
- Industrial equipment (gas sensors, handheld multi-meters, lab instrumentation, e-meters, sensor arrays)

**Featuring the PIC24FJ128GC010 Family with Intelligent Analog**

The PIC24 “GC” family integrates a precision 16-bit ADC, high-speed 12-bit ADC, DAC and op amps with interconnect fabric providing the most analog integration available in a PIC MCU. With on-chip USB and segmented LCD driver, this family is ideal for portable devices with user interfaces.

- 16-bit Delta-Sigma ADC
- 12-bit 10 MSPS Pipeline ADC
- 10-bit 1 MSPS DAC
- Dual op amps
- eXtreme Low Power: 18 nA deep sleep, 180 μA/MHz Run

**Development Tools**

**MPLAB® Starter Kit for PIC24F Intelligent Integrated Analog (DM240015)**

This kit includes an analog header for clean analog signals and plugs into breadboards. The board includes connections for microphone, headphones as well as on-board light and temperature sensors. The segmented display showcases custom icons and a scrolling banner. The board also includes cap touch buttons, USB connection and easy connection for RF modules.

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**Featured Intelligent Analog PIC MCU Families**

<table>
<thead>
<tr>
<th>Product Family</th>
<th>Pin Count</th>
<th>Flash (KB)</th>
<th>ADC</th>
<th>DAC</th>
<th>Op Amp</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>PIC24F16KM204</td>
<td>20–44</td>
<td>8–16</td>
<td>22 × 12-bit (100 ksp)</td>
<td>2 × 8-bit</td>
<td>2</td>
<td>Internal voltage reference, CLC, MCCP SCCP (16-bit PWM), CTMU, three comparators, 3V and 5V operation</td>
</tr>
<tr>
<td>PIC24FJ128G010</td>
<td>64–100</td>
<td>64–128</td>
<td>2 × 16-bit Delta-Sigma ADC 50 × 12-bit ADC (10 Msp)</td>
<td>2 × 10-bit</td>
<td>2</td>
<td>Analog interconnect switch matrix, internal voltage reference, CTMU, PWM, USB, LCD, mTouch® technology</td>
</tr>
<tr>
<td>dsPIC33EP64GS506</td>
<td>28–64</td>
<td>16–64</td>
<td>22 × 12-bit with 5 S/H (3.25 Msp)</td>
<td>2 × 12-bit</td>
<td>2</td>
<td>1.04 ns PWM resolution, four rail-to-rail comparators with dedicated DACs for each analog comparator, two oversampling filters for increased resolution</td>
</tr>
<tr>
<td>dsPIC33EP256G506</td>
<td>28–64</td>
<td>32–256</td>
<td>1.1 Msp 10-bit with 4 S/H or 500 ksp 12-bit with 1 S/H (configurable)</td>
<td>–</td>
<td>3</td>
<td>Flexible ADC trigger sources, CTMU for temperature or touch, CAN, Peripheral Trigger Generator (PTG), four comparators</td>
</tr>
</tbody>
</table>
Hardware Crypto Engine for Secure Data

Hardware Crypto Engine
With the Internet of Things growing at a rapid rate, protecting embedded data and extending battery life are not an option, but a necessity. Devices in Microchip's PIC24F “GB2” family are the first PIC® MCUs to offer an integrated hardware crypto engine along with eXtreme low power performance. This new family also features a True Random Number Generator (RNG) and One-Time-Programmable (OTP) key storage for protecting data in embedded applications. For connectivity, the “GB2” family integrates USB for device or host connections as well as a UART with ISO7816 support, which is helpful for smart card applications.

Key Features

Cryptographic Engine
- AES engine with 128, 192 or 256-bit key
- DES/Triple DES (TDES) engine
- Encryption, decryption and authentication
- True Random Number Generator (RNG)
- Achieve a higher level of data security with unique key
- One-Time-Programmable (OTP) memory for secure key storage
- Once written, keys cannot be read or overwritten by software
- Core Independent Peripheral – offloads CPU to save power and headroom

eXtreme Low Power Features
- 18 nA sleep, 180 µA/MHz Run
- Enables integrity of data without sacrificing power consumption
- VBAT allows the device to transition to a backup battery

Connection to USB or Wireless Protocols
- Integrated USB 2.0 device, host, OTG
- Easy connection to certified modules for Wi-Fi®, ZigBee®, Sub-GHz and Bluetooth® Low Energy

Alternatively, you can add crypto functions in software to any PIC24 or dsPIC33 device using the free software found in the Microchip Libraries for Applications (MLA) download at www.microchip.com/MLA.

Target Applications

Industrial
- Security door locks
- Access control systems
- Security cameras
- POS terminals
- Smart card readers
- Heat/gas meters
- IoT sensor nodes

Computer
- PC peripherals
- Printers
- Portable accessories

Medical/Fitness
- Pedometers
- Wearable fitness
- Handheld devices

Application Note
AN1861: Bluetooth Smart Communication Using Microchip's RN4020 Module and 16-bit PIC Microcontroller

Learn how low-power Bluetooth connectivity is an ideal match with the XLP PIC24 microcontrollers, especially those with integrated crypto engine for adding another layer of data protection for internet-connected applications. Bluetooth Low Energy or Bluetooth Smart has evolved to support applications that need simple command and control or quick status from a sensor. This low-power protocol is ideal for connecting local embedded applications to the cloud through a smartphone or tablet.

Development Tools
The PIC24FJ128GB204 Plug-In Module (MA240037) plugs into the Explorer 16 Development Board (DM240001). To add low-power Bluetooth Smart connection, simply add the RN4020 Bluetooth Low Energy PICtail™/PICtail Plus Daughter Card (RN-4020-PICTAIL). This flexible development system makes it easy to customize for various other wired or wireless connectivity options including USB, Wi-Fi or ZigBee.

Feature Products

<table>
<thead>
<tr>
<th>Product</th>
<th>Flash (KB)</th>
<th>Pins</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>PIC24FJ128GB204</td>
<td>128</td>
<td>44</td>
<td>TQFP, QFN</td>
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<tr>
<td>PIC24FJ128GB202</td>
<td>128</td>
<td>28</td>
<td>SOIC, SSOP, QFN, SPDIP</td>
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<td>SOIC, SSOP, QFN, SPDIP</td>
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</table>

www.microchip.com/lowpowercrypto

16-bit Embedded Control Solutions 7
Display and Touch

Many 16-bit designs incorporate modern user interfaces to increase the usability, functionality and look of end products. More sophisticated displays and touch interfaces create higher impact designs, yet they must be cost effective and easy to integrate. Microchip’s solutions allow for driving segmented or graphical displays with a single chip and offer integrated peripherals for touch buttons.

Segmented LCD Displays
The PIC24FJ128GA310 and PIC24FJ128GC010 families feature integrated segmented display drivers with up to 480 segments. Key advantages include:
- Direct drive of inexpensive, low-power displays
- Integrated analog for sensor applications like temperature sensing in thermostats
- Integrated touch sensing function for buttons or sliders

Graphical Displays
The PIC24FJ256DA210 family features integrated graphics acceleration and a display controller to directly drive displays up to 4.3” WQVGA with 480 × 272 resolution. This “DA” family includes:
- Dedicated graphics clock for a continuous, flicker-free display
- On-chip display controller provides direct interface to TFT, STN and OLED displays
- Easy to use graphics processing units for hardware acceleration allow for moving and copying rectangles, decompressing images and rendering text without CPU intervention
- Integrated color look-up table and 96 KB frame buffer support up to 8 bpp QVGA with internal memory

Touch Buttons: Keys and Sliders
Many PIC24 MCUs and dsPIC® DSC products include touch sensing capability for implementing keys or sliders as an alternative to traditional push button switches using CVD or CTMU technology. This enables more modern and stylish designs, lower manufacturing costs and increased reliability.
- Longer battery life with eXtreme Low Power MCUs
- Sensing through metal, plastic or glass
- High noise immunity and low emissions
- Free mTouch sensing solutions software library is available as part of MLA Software Legacy Version

Development Tools

LCD Explorer Development Board (DM240314)
The LCD Explorer Development Board provides an ideal platform to evaluate a MCU with a ×8 Common LCD Driver on a 38 segment ×8 common LCD display.

PIC24FJ256DA210 Development Kit (DV164039)
This kit bundles the PIC24FJ256DA210 Development Board (DM240312), a 3.2” Truly 240 × 320 TFT Display Board (AC164127-4), three Graphics Display Prototype Boards (AC164139), the MPLAB ICD 3 Debugger (DV164035) and also includes a USB Cable and accessories.

Remote Control Demo Board (DM240315-2)
This board integrates graphics, mTouch® technology, USB and RF4CE into a single demo. It features the PIC24FJ256DA210 MCU, a 3.5” Graphical TFT LCD with resistive touch screen, capacitive touch keys with plastic overlay, an MRF24J40 2.4 GHz transceiver and a ZENA™ wireless adapter.

Software and Application Notes

FREE Microchip Graphics Library
The Microchip Graphics Library is highly modular, easy to use and has an open documented interface for driver or controller support. The library supports the following features:
- Pre-made graphics objects
- Multiple fonts and languages
- User interface for mTouch sensing
- Buttons, charts, check boxes, scroll bars, list boxes, images and basic animation
- Download as part of the MLA software at www.microchip.com/MLA

Visual Graphics Display Designer by VirtualFab (SW500190)
Visual Graphics Display Designer (VGDD) is a powerful visual design tool that provides a quick and easy way of creating Graphic User Interface (GUI) screens for graphical interface applications on Microchip MCUs. This development environment, developed by our partner VirtualFab, fully utilizes the Microchip graphics library in MLA as well as Microchip’s graphics development boards.

Application Notes
- AN1428: Segmented LCD Biasing & Contrast Control Methods
- AN1368: Developing Graphics Applications Using an MCU with Integrated Graphics Controllers
- AN1478: mTouch Sensing Solutions Acquisition Methods Capacitive Voltage Divider
Connectivity

The PIC24 MCUs and dsPIC33 DSC products include a wide range of integrated connectivity peripherals as well as support for many wired and wireless communication protocols. Many of these communication libraries, such as USB and Wi-Fi, are integrated into the Microchip Libraries for Applications (MLA) which can be downloaded at www.microchip.com/MLA.

CAN, LIN and SENT

Many of the dsPIC® DSCs and PIC24 MCUs include an integrated CAN peripheral which is ideal for applications requiring robust communications with a high-speed, reliable industry standard protocol. Vector CANbedded™ and osCAN™ development solutions support PIC24 MCU and dsPIC DSC products with embedded CAN controllers. LIN support is integrated into many products for low-cost, single-wire serial communication for automotive applications.

The new dsPIC33EV family also includes SENT for automotive sensing. The dsPIC33EV 5V CAN-LIN Starter Kit (DM330018) contains data ports for CAN, LIN and SENT, a self-contained USB programming/debug interface, and an expansion footprint for flexibility in application hardware development.

A CAN/LIN PICtail™ Plus Daughter Board (AC164130-2) is available to plug into the Explorer 16 (DM240001) for developing embedded CAN or LIN applications. This must be used with a processor Plug-In Module (PIM) for a compatible PIC24 MCU or dsPIC DSC product.

IrDA®

The IrDA standard is an inexpensive method for providing wireless point-to-point communication. Through Application Note AN1071, Microchip’s free IrDA stack is available to support 16-bit MCUs with integrated IrDA support, enabling a cost-effective wireless connection with plenty of computing power left for other tasks.

PMBus

The PMBus protocol standard operations over an I²C physical layer and was developed to enable easy digital management of power supplies. The protocol allows for reading values from a power supply such as measured voltage and current parameters, temperatures and fan speeds as well as writing commands to control the operation of the power supply. The dsPIC “GS” family of DSCs supports the PMBus protocol along with many other dsPIC DSCs and PIC24 MCUs. A PMBus stack is available free from Microchip for use with the dsPIC “GS” family of DSCs.

Wireless

Microchip offers a wide range of wireless modules ranging from Wi-Fi®, Bluetooth, Bluetooth Smart and various Personal Area Networks. These fully certified surface-mount modules allow you to quickly and seamlessly add wireless connectivity to your applications. The wireless modules allow you to bypass costly and timely RF design, Bluetooth certification and governmental certifications to get your designs to market faster.

For wireless sensors and other battery-operated applications, the eXtreme Low Power PIC24 MCUs are ideal companions to Microchip’s RN4020 Bluetooth Low Energy Wireless Module, creating low-power wireless networks. Together these devices allow for connection to Bluetooth-enabled devices, making it easy to add internet connection to your embedded application for remote command and control. Application Note AN1861 describes the hardware and software needed to pair an XLP PIC24 to the RN4020 Bluetooth Low Energy Module.

USB

There are many PIC24 MCU and dsPIC DSC families with integrated USB which include support for device, host and On-The-Go (OTG) functionality. These products are supported by the dsPIC DSC USB Starter Kit (DM330012) as well as the Explorer 16 Development Board (DM240001) with USB PICtail Plus Daughter Card (AC164131) and one of the USB Processor Plug-In Modules (PIMs).

Microchip’s free USB framework includes USB software libraries as well as a comprehensive set of host and device drivers including Human Interface Device (HID) class for user interfaces, and Mass Storage Device (MSD) class for memory devices as well as CDC, PHDC, custom, audio, printer and demo code including thumb drive bootloader, and printer host. The USB libraries, drivers and demo code are all available with the Microchip Libraries for Applications download.
Motor Control

16-bit Motor Control Products

- High-performance dsPIC® DSC core with DSP instructions for precise control
  - Variable speed with constant torque using PI controllers
  - Field oriented control (FOC) for greater efficiency
- 5V 70 MIPS dsPIC DSC core for harsh environments
- High-performance on-chip op amps
- Intelligent, high-speed ADC
- Algorithms and application notes for
  - BLDC, PMSM, ACIM
  - Sensorless control
  - Field-oriented control
  - Certified class B safety software
- Dual motor control with FOC control for each motor
- Multiple package options, ranging from 28 to 144 pins
- Scalable motor control tools with low- and high-voltage options
- Motor control PWM: up to 14 outputs
  - Up to seven duty cycle generators
  - Independent or complementary mode
  - Programmable dead time settings
  - Edge- or center-aligned PWMs
  - Manual output override control, up to 10 fault inputs
  - ADC samples triggered by PWM module
- Quadrature encoder interface module
  - Up to two modules
  - Phase A, Phase B and index pulse input
- High current sink/source

Software and Application Notes

<table>
<thead>
<tr>
<th>Motor Type</th>
<th>Algorithm</th>
<th>App Note</th>
</tr>
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<tbody>
<tr>
<td>Stepper Motor</td>
<td>Closed-Loop Microstepping</td>
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<td>Sensored</td>
<td>AN957</td>
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<td>Sensored Sinusoidal</td>
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<td>Sensorless BEMF</td>
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<td>Sensorless Filtered BEMF with Majority Detect</td>
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<td>Sensorless Dual-Shunt FOC with SMO Estimator and Field Weakening</td>
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<td>Closed-Loop Vector Control</td>
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<td>Class B Safety Software (IEC 60730)</td>
<td>AN1106</td>
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<td>Motor Control Sensor Feedback Circuits</td>
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<td>MOSFET Driver Selection</td>
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<td>Current Sensing Circuit Concepts and Fundamentals</td>
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Other

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Featured Motor Control Products

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</table>
## Development Tools

### Motor Control Library for dsPIC33F/dsPIC33E

The Motor Control Library contains function blocks that are optimized for the dsPIC33F and dsPIC33E DSC families. All functions in this Motor Control Library have input(s) and output(s), but do not access any of the DSC peripherals. The library functions are designed to be used within an application framework for realizing an efficient and flexible way of implementing a motor control application.

### Motor Control Starter Kit (MCSK) (DM330015)

This starter kit with mTouch sensing is a complete, integrated development platform based on the dsPIC33FJ16MC102. It includes a USB interfaced debugger/programmer, a complete drive circuit, an on-board BLDC motor, a user-configurable switch and an mTouch sensing slider with LED indicators for speed control.

### dsPICDEM™ MCLV-2 Development Board (DM330021-2)

This low-voltage development board provides a cost-effective method of evaluating and developing sensored or sensorless Brushless DC (BLDC) motor and Permanent Magnet Synchronous Motor (PMSM) control applications. The board supports Microchip’s 100-pin PIM with dsPIC33E or dsPIC33F DSCs. This board supports the use of the internal, on-chip op amps found on certain dsPIC® DSCs or the external op amps found on the MCLV-2 board. A dsPIC33EP256MC506 Internal Op Amp PIM (MA330031) is included. The board is capable of controlling motors rated up to 48V and 15 A, with multiple communication channels such as USB, CAN, LIN and RS-232.

### dsPICDEM Motor Control Stepper Motor (MCSM) Development Board/Kit (DM330022/DV330021)

This board is targeted to control both unipolar and bipolar stepper motors in open-loop or closed-loop (current control) mode. The hardware is designed in such a way that no hardware changes are necessary for 8-, 6- or 4-wire stepper motors in either bipolar or unipolar configurations. Software to run motors in open-loop or closed-loop with full or variable micro-stepping is provided. A GUI for controlling step commands, motor parameter input, and operation modes is included. This flexible and cost-effective board can be configured in different ways for use with dsPIC33F motor control DSCs.

### Microchip Motor Control Library Blockset

The Microchip Motor Control Library Blockset contains a number of basic Simulink® blocks that can be used to jump start model-based design of motor control applications using Microchip’s dsPIC33F and dsPIC33E DSC families. These blocks include reference frame transforms, a proportional-integral controller and trigonometric functions, all of which can be used with Embedded Coder® to generate efficient code on the dsPIC DSC that utilizes the Microchip Motor Control Library.

### dsPICDEM MCHV-2 Development System (DM330023-2)

This high-voltage system is intended to aid the user in the rapid evaluation and development of a wide variety of motor control applications using a dsPIC DSC. This development system is targeted to control BLDC motors, PMSM and AC Induction Motors (ACIM) in sensor or sensorless operation. The rated continuous output current from the inverter is 6.5 A (RMS). This allows up to approximately 2 kVA output when running from a 208V to 230V single-phase input voltage.

### Low-Voltage Motor Control Development Bundle (Single Board and Drive Board) (DV330100)

Provides a cost-effective method of evaluating and developing dual/single motor control to drive BLDC motors or PMSMs concurrently or one of each. The dsPIC DSC Signal Board supports both 3.3V and 5V operated devices for various applications and frequently used human interface features along with the communication ports. The Motor Control 10–24V Driver Board (Dual/Single) supports currents up to 10 A.

### Motors

You can provide your own motor or purchase one of the motors used in our Application Notes which are guaranteed to run right out of the box:

- AC300024: 2-phase, 8-wire Stepper Motor
- AC300020: 24V BLDC Motor
- AC300022: 24V BLDC Motor with Shaft Encoder
- AC300023: 220V, AC Induction Motor

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www.microchip.com/motor
### 16-bit Digital Power and Lighting Products

- Streamlined interoperation between PWM, ADC and CPU
- High-performance core with DSP instructions
  - High-speed control loop execution for demanding power conversion applications
  - Fast and predictable interrupts
- High-resolution PWMs for digital power
  - 1 ns for duty cycle, phase shift, period and dead time
  - Flexibility to control numerous power topologies
- Live update features
  - Update all of the firmware in an operating power supply while maintaining continuous regulation

- Very fast ADCs optimized for digital power applications
- Complete reference designs and algorithms including:
  - AC/DC converter meeting platinum specification
  - LLC resonant DC/DC converter
  - Quarter brick DC/DC converter
  - Solar micro inverter
  - Interleaved power factor correction
  - Offline UPS
- Broad range of package sizes and types
  - 18–100 pins, as small as 4 x 4 mm
  - Robust packages to easy IPC-9592B qualification

### Software and Application Notes

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<thead>
<tr>
<th>Application Solution</th>
<th>AN #</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Factor Correction in Power Conversion Applications Using the dsPIC® DSC</td>
<td>AN1106</td>
<td>This application note focuses primarily on the study, design and implementation of Power Factor Correction (PFC) using a Digital Signal Controller (DSC).</td>
</tr>
<tr>
<td>Switch Mode Power Supply (SMPS) Topologies (Part I)</td>
<td>AN1114</td>
<td>This application note explains the basics of different types of SMPS topologies and their applications. The pros and cons of different SMPS topologies are also explained to guide the user to select an appropriate topology for a given application, while providing useful information regarding selection of components for a given SMPS design.</td>
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<tr>
<td>Switch Mode Power Supply (SMPS) Topologies (Part II)</td>
<td>AN1207</td>
<td>This application note is the second of a two-part series on Switch Mode Power Supply (SMPS) topologies. This series expands on the previous material in Part I, and presents the basic tools needed to design a power converter.</td>
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<td>Offline UPS Reference Design</td>
<td>AN1279</td>
<td>The application note describes the design of an Offline Uninterruptible Power Supply (UPS) using a Switch Mode Power Supply (SMPS) dsPIC Digital Signal Controller (DSC).</td>
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<tr>
<td>Digital Power Interleaved PFC Reference Design</td>
<td>AN1278</td>
<td>The application note describes the design of a Digital Power Interleaved PFC (IPFC) using a Switch Mode Power Supply (SMPS) dsPIC Digital Signal Controller (DSC).</td>
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<tr>
<td>Quarter Brick DC-DC Reference Design</td>
<td>AN1335</td>
<td>This application note describes the design of a Quarter Brick DC-DC Reference Design using a Switch Mode Power Supply (SMPS) dsPIC Digital Signal Controller (DSC).</td>
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<tr>
<td>DC-DC LLC Resonant Converter Reference Design</td>
<td>AN1336</td>
<td>This application note describes the design of DC-DC LLC Resonant Converter Reference Design using a Switch Mode Power Supply (SMPS) dsPIC Digital Signal Controller (DSC).</td>
</tr>
<tr>
<td>Grid Connected Solar Microinverter</td>
<td>AN1338</td>
<td>This application note describes the design of Grid Connected Solar Microinverter Reference Design using a Switch Mode Power Supply (SMPS) dsPIC Digital Signal Controller (DSC).</td>
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<tr>
<td>Platinum-rated AC/DC Reference Design Using the dsPIC DSC</td>
<td>AN1421</td>
<td>This application note presents a fully digital-controlled 720W AC-to-DC (AC/DC) power supply, which meets all CSCI Platinum Specifications, as well as provides a variety of additional, application-specific features and functions.</td>
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### Featured Digital Power Products

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<tr>
<th>Product</th>
<th>Pins</th>
<th>Flash (KB)</th>
<th>RAM (Bytes)</th>
<th>IC/OC</th>
<th>PS PWM</th>
<th>ADC</th>
<th>Analog Amps</th>
<th>Analog Compare</th>
<th>UART/ICC/SPI</th>
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<td>6</td>
<td>12 x 12-bit, 3 S/H</td>
<td>2</td>
<td>2</td>
<td>1/1/1</td>
<td>0</td>
</tr>
<tr>
<td>dsPIC33FJ06GS001</td>
<td>18/20</td>
<td>6</td>
<td>256</td>
<td>0/0</td>
<td>4</td>
<td>6 x 10-bit, 2 S/H</td>
<td>0</td>
<td>2</td>
<td>0/1/0</td>
<td>0</td>
</tr>
</tbody>
</table>
Digital Power and Lighting Reference Designs
and Development Boards

Reference Designs

**Platinum Rated 720 W AC/DC Reference Design**
This reference design demonstrates the flexibility of dsPIC DSCs in Switch Mode Power Supplies. This reference design has a peak efficiency of 94.1% and achieves the ENERGY STAR® CSCI Platinum Level. It features a 2-phase interleaved power factor correction boost converter followed by a 2-phase interleaved two-switch forward converter with synchronous rectification.

**Quarter Brick DC/DC Converter Reference Design**
This reference design provides an easy method to evaluate the performance and features of SMPS DSCs in high-density quarter brick DC-DC converters.

**DC/DC LLC Resonant Converter Reference Design**
This reference design operates over a wide input voltage range (350–420V DC) with a nominal input of 400V, providing a 12V DC output while maintaining high-voltage isolation between the primary and secondary. This reference design is implemented using a single dsPIC33F “GS” digital power DSC that provides full digital control of the power conversion and system management functions.

**Digital Power Interleaved PFC Reference Design**
This reference design provides an easy method to evaluate the power and features of the SMPS dsPIC DSCs for IPFC applications. It features a universal input voltage range and produces a single high-voltage DC output up to 350 W with low Total Harmonic Distortion (THD) of the input current.

**Digital Pure Sine Wave Uninterruptible Power Supply (UPS) Reference Design**
This reference design demonstrates how digital power techniques applied to UPS applications enable easy modifications through software and allow for the use of smaller magnetics, higher efficiency and reduction in audible and electrical noise via a purer sine-wave output, USB communication and reduce cost.

**Grid Connected Solar Micro Inverter Reference Design**
This reference design demonstrates maximum power point tracking for PV panel voltages between 20–45V DC and has a maximum output power of 215 W. High efficiency is achieved by implementing a novel interleaved active-clamp flyback topology with Zero Voltage Switching (ZVS).

Development Boards

**MPLAB® Starter Kit for Digital Power (DM330017-2)**
This kit uses the dsPIC33EP64GS502 DSC to implement a buck converter and a boost converter. Each converter can drive its on-board MOSFET controlled resistive load or an external load. The board has an LCD display for voltage, current, temperature and fault conditions, and an integrated programmer/debugger, all powered by the included 9V power supply.

**Digital LED Lighting Development Kit (DM330014)**
The LED lighting development kit enables designers to quickly leverage the capabilities and performance of the dsPIC33 “GS” DSCs to create a 100% digitally controlled ballast function, while including advanced features such as dimming and color hue control. The dsPIC33 “GS” devices can support an entire system implementation for LED lighting products, including power-conversion circuits, such as AC-to-DC and DC-to-DC conversion, along with function such as Power Factor Corrections (PFC).

Tools and Libraries

**Digital Compensator Design Tool (DCDT)**
Use this free MPLAB® X IDE plug-in to calculate optimum compensator coefficients for maximum performance, with support for five common compensator types. Use this plug-in to analyze system response as well as stability.

**SMPS Compensator Library**
Optimized functions for the dsPIC33 family of DSCs implementing common compensator algorithms such as 2P2Z, 3P3Z and PID. These library functions are designed to be used within an application framework for realizing an efficient and flexible way of implementing the control of an SMPS application.

The above tools can be downloaded from www.microchip.com/dsPIC33EP-GS.

Additional information for all reference designs is available at www.microchip.com/power.

www.microchip.com/power
Easing System Level Integration

Robust 3V Operation
With operating voltages as low as 1.8V and up to 3.6V, PIC24 MCUs and dsPIC33 DSCs ensure robust operation such as:
- POR/BOR/Watchdog Timer (WDT)
- Support for temperatures up to 150°C
- AEC-Q100 Grade 0 qualification for automotive applications

Enhanced Robustness with 5V Operation
Microchip’s PIC24 MCU and dsPIC33 DSC portfolios include some families that operate up to 5V for increased noise immunity and robustness. Devices with 5V operation provide more dynamic range for signals and improved sensitivity. The 5V devices include additional features to ensure robust operation such as:
- Backup system oscillator
- Windowed watchdog timer (WWDT)
- PWM with fault detection
- Support for temperatures up to 150°C
- AEC-Q100 Grade 0 qualification for automotive applications

Safety Critical Applications and Class B Certification
PIC24 MCUs and dsPIC33 DSCs include integrated safety features to ease implementation of IEC 60830 compliance for Class B safety.

The CRC provides a memory integrity check and many devices also include memory error correction. For example, dsPIC33 devices with Error-Correcting Code (ECC) include 2-bit error detection and single-bit error correction for enhanced reliability, completely transparent and real-time implementation.

The memory also has read/write protection capability to protect sections of memory from code flow changes or interrupt vectors. You can establish zones that have different permissions, and you can define secure areas that should not be entered without the proper permissions.

Products include a backup system oscillator for system redundancy as well as clock-fail detection. Features such as a windowed watchdog timer will detect and reset the MCU in event of code execution error, with a dedicated clock source independent of the system clock. A Dead-Man Timer (DMT), clocked from the main system clock, detects out of sequence execution. The PWMs include fault detection features and the CPU includes trap instructions and illegal opcode detection.

The certified Class B software stack helps to simplify IEC 60830 regulatory compliance. This library routines integrate into the MCU application to test and verify the critical functionalities without affecting the end application. For more information, visit www.microchip.com/classb.

Robust Package Options for IPC-9592B
Some dsPIC33 “GS” devices are available with robust package options to help with operation in extremely noise environments. These packages make it easier to achieve IPC-9592B qualification. Options include a 28-pin μQFN (4 x 4 mm) or 28-pin μQFN (6 x 6 mm). These package options are designed to withstand temperature cycling as defined in IPC-9592B with over 700 cycles of −40°C/+125°C on thick high-layer count PCBs.

<table>
<thead>
<tr>
<th>Families with 5V Operation</th>
<th>Flash</th>
<th>Pins</th>
</tr>
</thead>
<tbody>
<tr>
<td>dsPIC33 “EV” DSC Family</td>
<td>32–256 KB</td>
<td>28–64</td>
</tr>
<tr>
<td>PIC24F “KM” and “KA” MCU Family</td>
<td>8–32 KB</td>
<td>20–44</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Temperature Ranges</th>
<th>Range</th>
<th>Part Number Suffix</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td>−40 to 85°C</td>
<td>-I</td>
</tr>
<tr>
<td>Extended</td>
<td>−40 to 125°C</td>
<td>-E</td>
</tr>
<tr>
<td>High</td>
<td>−40 to 150°C</td>
<td>-H</td>
</tr>
</tbody>
</table>

www.microchip.com/classb
www.microchip.com/hightemp
### Development and Evaluation Tools

A variety of hardware development boards are available for the PIC24 and dsPIC33 products, enabling you to shorten your design cycle and quickly develop prototypes. These boards are designed to allow easy connectivity to an MPLAB® ICD 3 In-Circuit Debugger, MPLAB REAL ICE™ In-Circuit Emulator or MPLAB PM3 device programmer. Many also include integrated debugger and programmers. When combined with the MPLAB X IDE and the MPLAB XC16 Compiler, these development boards and starter kits allow you to quickly gain knowledge and experience using Microchip’s 16-bit MCU and dsPIC® DSC products.

<table>
<thead>
<tr>
<th>Photo</th>
<th>Tool</th>
<th>Part Number</th>
<th>Description</th>
</tr>
</thead>
</table>
| ![Explorer 16 Development Board](image1) | Explorer 16 Development Board | DM240001 | This development board offers an easy way to evaluate the PIC24 MCU and dsPIC33 DSC families with modular PIMs to support various product families and a wide range of application daugther cards. Features on the Explorer 16 Board include:
- Processor PIMs
  - DM240001: Includes 100-pin PIMs PIC24FJ128GA010 and dsPIC33FJ256GP710
  - DM240002: Includes 44-pin PIMs PIC24FJ64GA004 and dsPIC33FJ32GP204
- Many other processor PIMs available for easy device evaluation
- PicTail Plus connector for expansion daughter boards
- Provide expansion for application-specific hardware
- Allow for the easy evaluation of software libraries
- Including USB, CAN, IrDA®, speech playback, graphics, Ethernet, ZigBee®, Wi-Fi®, and Bluetooth®
- Full documentation at [www.microchip.com/explorer16](http://www.microchip.com/explorer16) |
| ![Microsticks](image2) | Microsticks | DM330013-2 | Microsticks are USB-powered and include an on-board debugger/programmer. The boards are fully supported by MPLAB® X IDE and provide easy plug in to a standard breadboard with access to device signals for prototyping. The Microstick II works with all 28-pin PIC24FJ and dsPIC33EP families. Microstick for 3V PIC24F K-series works with the PIC24F “KK” and “KL” families. Microstick for 5V PIC24F K-series works with the PIC24F “KM” family. |
| ![Intelligent Analog PIC24 Starter Kit](image3) | Intelligent Analog PIC24 Starter Kit | DM240015 | This starter kit features the PIC24FJ128GA010 family with advanced analog peripherals. The board includes an analog header, allowing clean signals to be accessed for easy prototyping. The board also includes sensors for light, touch and temperature as well as USB, potentiometer, microphone and headphone interface. Comprehensive demos are included as well as integrated programmer and debugger. |
| ![XLP 16-bit Development Board](image4) | XLP 16-bit Development Board | DM240311 | This board is designed as a true platform for low power development, featuring the PIC24F16KA102, supporting other PIC24 XLP devices in 20- or 28-pin packages. It includes current measurement terminals for board or device level measurements and PicTail interface for expansion boards such as low-power wireless, SD/MMC, speech playback and more. The board is powered from AAA batteries, CR2032, energy harvesting, USB or a 9V supply. |
| ![LCD Explorer Development Board](image5) | LCD Explorer Development Board | DM240314 | This development board supports 100-pin PIC® MCUs with eight common segmented LCD drivers. It ships with the PIC24FJ128GA310 and other families can be evaluated with different processor PIMs. In addition to the display, the board includes a PicTail Plus connector for daughter cards. It can be powered from USB, battery or 9V power supply, and includes VBat battery back-up. |
| ![dsPIC33EV5V CAN-LIN Starter Kit](image6) | dsPIC33EV 5V CAN-LIN Starter Kit | DM330018 | This USB-powered starter kit features the dsPIC33EV256GM106 with connections for CAN, LIN and SENT, as well as integrated programmer and debugger. |
| ![dsPIC33E USB Starter Kit](image7) | dsPIC33E USB Starter Kit | DM330012 | This starter kit includes integrated programmer and debugger and expansion capability with the Multimedia Expansion Board or I/O Expansion Board. It comes with preloaded demonstration software to allow you to explore the features of the dsPIC33E DSC family including USB communication. |
| ![Motor Control Starter Kit](image8) | Motor Control Starter Kit | DM330015 | This board includes a small 3-phase BLDC motor driven by dsPIC33F16MC102 motor control device and integrated programmer and debugger, powered by 9V power supply. This is a low-cost way to evaluate the motor control features on the dsPIC33 family and comes with full source code based on Application Note AN1160: Sensorless BLDC Control with Back-EMF Filtering Using a Majority Function. |
| ![Digital Power Starter Kit](image9) | Digital Power Starter Kit | DM330017-2 | This board includes the dsPIC33EP64GS502 digital power conversion device to implement a DC/DC synchronous buck converter power stage and boost converter power stage. Each power stage includes a MOSFET controlled 5 W resistive load. The board includes a display for voltage, current, temperature and fault conditions and integrated programmer and debugger, all powered by 9V power supply. |
| ![Graphics PIC24FJ256DA210 Development Board](image10) | Graphics PIC24FJ256DA210 Development Board | DM240312 | This graphics development board is for developing colorful graphics displays with the PIC24FJ256DA210 family. The board includes touch pads, USB and a PicTail Plus connector for daughter cards. Match this board with your desired display size; it easily connects to the 3.2” Truly TFT Display (AC164127-4) or 4.3” Powertip TFT Display (AC164127-6) or Display Prototype Board (AC164139). |
Many software libraries, code examples and application notes are available to support the PIC24 MCUs and dsPIC33 DSCs. The table below includes some of the most popular software libraries and tools that help you jump start your application development.

<table>
<thead>
<tr>
<th>Software</th>
<th>Description</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Microchip Libraries for Applications (MLA)</strong></td>
<td>MLA includes source code, drivers, demos, documentation and utilities. All PIC24 MCUs and dsPIC33 DSCs are supported.</td>
<td><a href="http://www.microchip.com/mla">www.microchip.com/mla</a></td>
</tr>
<tr>
<td></td>
<td>■ USB – including device, host and OTG support</td>
<td></td>
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<tr>
<td></td>
<td>■ Graphics – including pre-made graphics objects, fonts, languages, images and display drivers</td>
<td></td>
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<tr>
<td></td>
<td>■ File I/O Memory Disk Drive – transfer portable memory devices between and embedded system and a personal computer</td>
<td></td>
</tr>
<tr>
<td></td>
<td>■ Crypto Software – including AES, DES, 3DES, SHA-1, SHA-2</td>
<td></td>
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<tr>
<td></td>
<td>■ Smart Card</td>
<td></td>
</tr>
<tr>
<td></td>
<td>■ MIWI™ Wireless Networking Protocol</td>
<td></td>
</tr>
<tr>
<td></td>
<td>■ TCP-IP for Wi-Fi®</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Legacy versions of MLA are achieved and also include support for TCP/IP with Ethernet, touch or accessory framework for Android™.</td>
<td></td>
</tr>
<tr>
<td></td>
<td><a href="http://www.microchip.com/mla">www.microchip.com/mla</a></td>
<td></td>
</tr>
<tr>
<td><strong>16-bit CPU Self-Test Library</strong></td>
<td>The 16-bit CPU Self-Test Library allows you to verify during run-time, that all CPU core features are functioning correctly.</td>
<td><a href="http://www.microchip.com/libraries">www.microchip.com/libraries</a></td>
</tr>
<tr>
<td><strong>Bootloaders</strong></td>
<td>Several application notes and code examples exist to help with your bootloader applications.</td>
<td>AN1094 AN1157 CE417</td>
</tr>
<tr>
<td></td>
<td>■ AN1094 describes UART-based bootloader with command line interface for dsPIC30F, dsPIC33F and PIC24FJ and PIC24H</td>
<td></td>
</tr>
<tr>
<td></td>
<td>■ AN1157 describes PIC24F family and includes a GUI for quick programming</td>
<td></td>
</tr>
<tr>
<td></td>
<td>■ CE417 code example for dsPIC33EP with aux Flash</td>
<td></td>
</tr>
<tr>
<td></td>
<td>■ USB bootloader included in the MLA USB stack</td>
<td></td>
</tr>
<tr>
<td><strong>Class B Safety Software Library</strong></td>
<td>Microchip has developed a library of lowlevel software routines that simplify meeting IEC 60730 requirements for Class B safety. Includes CPU register test, program counter test, variable memory test, Flash memory test and clock test. Certified by VBE.</td>
<td><a href="http://www.microchip.com/classB">www.microchip.com/classB</a> AN1778</td>
</tr>
<tr>
<td><strong>Code Examples</strong></td>
<td>Hundred of code examples are ready to help you set-up peripherals and functions, sorted by product family;</td>
<td><a href="http://www.microchip.com/codeexamples">www.microchip.com/codeexamples</a></td>
</tr>
<tr>
<td></td>
<td>■ PIC24E and dsPIC33E code examples = CE4XX</td>
<td></td>
</tr>
<tr>
<td></td>
<td>■ PIC24F code examples = CE3XX</td>
<td></td>
</tr>
<tr>
<td></td>
<td>■ PIC24H code examples = CE2XX</td>
<td></td>
</tr>
<tr>
<td></td>
<td>■ dsPIC33F code examples = CE1XX</td>
<td></td>
</tr>
<tr>
<td></td>
<td>■ dsPIC30 code examples = CE0XX</td>
<td></td>
</tr>
<tr>
<td><strong>Data EEPROM Emulation</strong></td>
<td>For devices that do not have on-chip EEPROM, this algorithm increases endurance when emulating EEPROM with an on-chip Flash memory.</td>
<td>AN1095</td>
</tr>
<tr>
<td><strong>Digital Filter Design</strong></td>
<td>The Digital Filter Design Tool makes designing and analyzing FIR and IIR filters easy. When the user enters frequency specifications, the tool automatically generates the filter code and coefficients. Graphical output windows provide the desired filter's characteristics.</td>
<td><a href="http://www.microchip.com/SW300001">www.microchip.com/SW300001</a></td>
</tr>
<tr>
<td><strong>Digital Power</strong></td>
<td>Several software libraries and tools are available for digital power applications.</td>
<td><a href="http://www.microchip.com/power">www.microchip.com/power</a></td>
</tr>
<tr>
<td></td>
<td>■ Includes Digital Power Compensator Libraries, optimized for use with dsPIC33 &quot;GS&quot; devices</td>
<td></td>
</tr>
<tr>
<td></td>
<td>■ Digital Compensator Design Tool helps calculate compensator coefficients for maximum performance</td>
<td></td>
</tr>
<tr>
<td></td>
<td>■ PMBus™ stack implements the PMBus protocol over I²C communication interface</td>
<td></td>
</tr>
<tr>
<td><strong>dsPICworks Data Analysis</strong></td>
<td>dsPICworks Data Analysis allows you to evaluate and analyze DSP algorithms in both time and frequency domains. Includes signal generation and DSP functions such as FFT or DCT.</td>
<td><a href="http://www.microchip.com/SW300021">www.microchip.com/SW300021</a></td>
</tr>
<tr>
<td><strong>Embedded Code Source</strong></td>
<td>Embedded Code Source is a collection of code, tools and utilities from Microchip and third party developers to help speed your design.</td>
<td><a href="http://www.embeddedcodesource.com">www.embeddedcodesource.com</a></td>
</tr>
<tr>
<td><strong>Fixed Point Math Library for PIC24 MCUs and dsPIC® DSCs</strong></td>
<td>This software library provides a set of speed-optimized functions for the most common digital signal processing applications. The I/Q math library includes over 65 general-purpose functions composed of 28 functions support Q15 math and 37 functions supporting Q16 math.</td>
<td><a href="http://www.microchip.com/libraries">www.microchip.com/libraries</a></td>
</tr>
<tr>
<td><strong>Floating Point Math Library for PIC24 MCUs and dsPIC DSCs</strong></td>
<td>The IEE-74-Compliant Floating Point Math Library is the compiled version of the math library that is distributed with the XC16 Compiler. It contains advanced single- and double-precision floating-point arithmetic and trigonometric functions from the standard C header file &lt;math.h&gt;.</td>
<td><a href="http://www.microchip.com/libraries">www.microchip.com/libraries</a></td>
</tr>
<tr>
<td><strong>Motor Control</strong></td>
<td>This library includes the Motor Control Library for 3-phase control as well as MATLAB Simulink® Blockset and motor models, tuning guides, application notes and code examples.</td>
<td><a href="http://www.microchip.com/motor">www.microchip.com/motor</a></td>
</tr>
<tr>
<td><strong>XLP Battery Life Estimator</strong></td>
<td>This library estimates average current consumption and battery life. The utility allows users to select the target device, battery type, the application's operating conditions (such as voltage and temperature) and model the active and power-down times for their applications.</td>
<td><a href="http://www.microchip.com/xlp">www.microchip.com/xlp</a></td>
</tr>
</tbody>
</table>
Microchip’s Development Ecosystem

MPLAB® X Integrated Development Environment (IDE)

MPLAB® X IDE
Windows® Mac OS® Linux®
SCALABILITY, MEET FLEXIBILITY

Universal and Integrated Tool Set
MPLAB X IDE is a single, universal graphical user interface for Microchip and third-party software and hardware development tools. It is the industry’s only IDE to support an entire portfolio of 8-bit, 16-bit and 32-bit PIC® MCUs, dsPIC® DSCs and memory devices.

Powerful Yet User-Friendly Interface
With complete project management, visual call graphs, a configurable watch window and a feature-rich editor that includes code-completion, context menus and a task navigator, MPLAB X IDE is flexible and friendly enough for new users.

Open-Source Platform
Based on the NetBeans™ Platform, MPLAB X IDE supports a host of free software components and plug-ins from the NetBeans community for high-performance application development customized to your needs.

Cross-Platform
Using MPLAB X IDE, users can run their favorite toolset and develop their next embedded application on Windows®, Linux® or Mac OS® X.

MPLAB XC16 Compiler for PIC24 MCUs and dsPIC DSCs
The MPLAB XC16 Compiler includes a complete ANSI C standard library, including string manipulation, dynamic memory allocation, data conversion, timekeeping and math libraries. The compiler has a powerful code optimizer. Other 16-bit MCU compilers generate as much as 165% larger code for the same application.

The assembler comes with the MPLAB XC Compiler and may be used with the compiler or as an assembler. It is a full-featured macro assembler. User defined macros, conditional assembly and a variety of assembler directives make the assembler a powerful code generation tool.

MPLAB Code Configurator (MCC)

MPLAB Code Configurator is a user-friendly plug-in that seamlessly integrates with your existing MPLAB X IDE to provide an easy setup and configuration experience with your chosen PIC MCU.

MPLAB Code Configurator offers a simple graphical representation of the selected PIC MCU and its on-chip peripherals and allows you to quickly arrange hardware peripherals into functional building blocks without an in-depth setup of registers or flags. The tool also displays package pins in both a graphical and tabular format, which makes pin and I/O configuration as easy as a mouse click.

MPLAB Code Configurator generates function and peripheral drivers in seamless, easy-to-understand C code for ultimate flexibility and portability. Its ease of use will help significantly reduce your software development time and get your product to market quicker.

Flexible
You can use it for simple configuration of your microcontroller in-system or to create complex functions with groups of integrated peripherals. Many PIC MCUs and their peripherals are supported, with new ones added regularly.

Intelligent
It can alert you of a potential pin or function conflict. It creates efficient code with a small memory footprint.

Easy to Use
Intuitive graphical user interface provides a visual representation of your selected PIC MCU, with an “aerial view” of the package. Pin selection and configuration is done via mouse click.

Saves Time
MPLAB Code Configurator generates simple, clearly documented APIs without the hassle of register-level setup. Its C code output can be easily modified for quick platform-level development. MCC is available as a plug-in for the free MPLAB X IDE. Learn more at www.microchip.com/MCC.
## Compare 16-bit Families

<table>
<thead>
<tr>
<th>Features</th>
<th>PIC24 Families</th>
<th>dsPIC® DSC Families</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>Low cost, lowest power, general purpose</td>
<td>High performance, general purpose</td>
</tr>
<tr>
<td></td>
<td><strong>System Level</strong></td>
<td></td>
</tr>
<tr>
<td>MIPS</td>
<td>16 MIPS</td>
<td>40 MIPS</td>
</tr>
<tr>
<td>Flash Memory (KB)</td>
<td>4–256</td>
<td>12–256</td>
</tr>
<tr>
<td>SRAM (KB)</td>
<td>0.5–96</td>
<td>1–16</td>
</tr>
<tr>
<td>DMA</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>BOR, LVD, POR, WDT</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Windowed WDT</td>
<td>–</td>
<td>✓</td>
</tr>
<tr>
<td>Deadman Timer (DMT)</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>RTCC - Clock, Calendar, Alarm</td>
<td>✓</td>
<td>–</td>
</tr>
<tr>
<td>CRC - Flash, RAM and SFR</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Class B Features</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td><strong>Timers/PWMs</strong></td>
<td></td>
</tr>
<tr>
<td>16-bit and 32-bit Timers</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Input Capture</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Output Compare</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>16-bit PWM</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Multiple-Output Capture Compare PWM (MCCP) and Single-Outputs CCP (SCCP)</td>
<td>✓</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td><strong>Intelligent Analog</strong></td>
<td></td>
</tr>
<tr>
<td>ADC</td>
<td>10-bit @ 500 ksps</td>
<td>10-bit @ 1100 ksps</td>
</tr>
<tr>
<td></td>
<td>12-bit @ 200 ksps</td>
<td>12-bit @ 500 ksps</td>
</tr>
<tr>
<td></td>
<td>12-bit @ 10 Mmps</td>
<td>10-bit @ 10 Mmps</td>
</tr>
<tr>
<td>DAC</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Comparators</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Op Amps</td>
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Not enough money in MEMS, own the data, says InvenSense CEO

By Peter Clarke

Behrooz Abdi, CEO of fabless MEMS company InvenSense Inc. (San Jose, Calif.), has said MEMS sensor component companies should offer complete IoT application solutions including data analytics.

What’s the reason for that?

Because the price of MEMS sensor components is likely to be eroded rapidly and largest part of the value is perceived to be in the services that can be based on the data acquired by those sensors.

“Yes the value is the data rather than the hardware,” said Abdi. “We do plan to bring end-to-end solutions to market in multiple vertical markets,” he told delegates at the European MEMS Summit, an event that was organized by SEMI on September 17 and 18 in Milan, Italy.

“It requires a lot of investment but we have to take this chance and try. Otherwise it’s a race to the bottom.”

Abdi portrayed the issue as “the good, the bad and the ugly” of MEMS. The good is that there are plenty of predictions of strong compound annual growth rates (CAGRs) for unit shipments. In 2016 this could produce 16 billion shipments of MEMS units with an average selling price of $1, Abdi said.

The bad, Abdi said, is severe price erosion in all the significant MEMS product categories including: inertial combos, microphones, gyroscopes, oscillators and RF MEMS.

The ugly is that while semiconductors overall and MEMS in particular are forecast to have a CAGR of between 30 and 60 percent.

“Our industry is creating such a lot of value but its all getting sucked up somewhere else,” Abdi told the delegates. Abdi flashed a slide showing that by 2020 a $1.4 trillion industry would be supported by a MEMS sensors market that would only register a few billion dollars.

Yole Developpement estimates the annual MEMS market will be worth $20 billion in 2020.

“Google is going to become a phone operator, laying down cable, selling phones. The Android phone is a collection of sensors. Android is a portal for making money on the data the service operator collects.”

Abdi added: “But ambient computing is necessary. You can’t clog up the bandwidth with raw data.” There needs to be local processing as well as processing on the edge of the network and in the cloud, Abdi said. “And that’s an opportunity.”

Fragmentation can hinder and help

Abdi said that fragmentation of the IoT market was also a double-edged sword. On the negative side because of the fragmentation and one product, one process, limitations of MEMS, it can take a long time to develop novel sensors.

“By the time you hit the market the price erosion is killing you. Hence startups going bust,” he said.

On the positive side the fragmentation means that there are many markets to go after with end-to-end solutions that could be based on the same MEMS technology platform, Abdi said. In InvenSense’s case this platform is based on its proprietary technology approach for MEMS manufacturing, algorithms and software.

InvenSense bought Movea in July 2014 to help it address sensor fusion and gesture recognition, a step on the way to Abdi’s vision of end-to-end IoT systems.

Abdi gave the example of a large set of IoT applications that are based on a knowledge of location, activity and context. “Drones are all about imaging and location. But you can’t send all the image data up to the cloud. It has to be processed locally. And even the drones market is fragmenting into different markets; security, farming, domestic, and so on,” Abdi said.

“So think about the end product or service and think about participating in the value,” he told the conference delegates.
Most differential field bus technologies, like CAN and RS485, specify a parameter called common-mode voltage. Common-mode voltage refers to the range of bus input voltages, with respect to the transceiver’s ground, within which the transceiver maintains consistent input receiver thresholds. In other words, when voltages present on the bus are within this range, the receiver maintains normal operation.

There are two frequent causes of common-mode voltage in industrial networks:

One source of common-mode voltage is the potential coupling of electromagnetic noise present in the vicinity of the network onto the bus wires. This noise could be generated from motors, fluorescent lights, relays, transformers, parallel cabling, and other RF sources. These noise sources only couple equally onto bus wires as a common-mode voltage, if twisted-pair cabling is used. In the event that non-twisted pair cabling is used, noise will not couple symmetrically and differential noise will be introduced into the system, reducing receiver margins.

Another frequent cause of common-mode voltage is the difference in ground potential that can occur between different nodes on the network. Substantial ground potential differences are common in industrial networks because electrical installations can often reach tens if not hundreds of meters. Figure 1 shows a simple two-node network with 50 meters of cabling between the two nodes, each of which draws 5 amps of current. Even with just 5m Ω of resistance per meter on standard 12 AWG cabling, this results in a 1.25V ground potential difference between the two nodes.

This difference in ground potential causes the receiving nodes on the network to “see” the voltages at their bus input terminals at a different voltage potential. Taking the example in Figure 1 and assuming an RS485 network where Node 2 transmitted a bit stream, Node 1 would receive that bit stream with a 1.25V higher DC offset (Figure 2).

It is easy to see how this ground potential difference could become even larger when additional loads are added to the network and the total length of cabling expands. Current from each additional load is superimposed on top of the existing current in the cable, and the effects of the cable resistance become proportionately worse. Imagine an elevator in a 50-story building with a node on every floor and five meters of cabling per floor. The ground potential difference could easily reach tens of volts, exceeding the common-mode range of most transceivers (for example, –7 to +12V). However, by implementing a resistor divider and biasing network on the front-end of the receiver block (Figure 3), differential transceivers are able to handle common-mode voltages. Resistors both attenuate the input signal seen on the bus pins and bias it towards \( V_{DC}/2 \) so that the comparator inputs are not saturated. By increasing the attenuation ratio of these resistors, larger voltages can be present on the bus pins before exceeding the input voltage range of the comparator.

The tradeoff is that a higher attenuation ratios result in smaller differential voltages seen by the comparator. This places a lot of burden on the comparator’s front-end in terms resolution, signal-to-noise ratio (SNR), DC gain, and bandwidth. Therefore, as long as the bus voltages remain within the allowable range for a given receiver design, common-mode voltages can be attenuated and adjusted, so that only the remaining differential voltage affects the output state of the comparator.

In summary, common-mode voltages occur frequently in industrial applications. By doing your due diligence and identifying what possible common-mode voltages may exist in your system, you can then choose an appropriate transceiver that is capable of handling the identified range. This allows you to alleviate potential communication failures caused by common-mode voltages before they even occur.

Join us next time when we will discuss some simple rules of thumb that facilitate low noise circuit design without having to do detailed analysis.

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**Fig. 1: Effects of wire resistance on long electrical installations.**

**Fig. 2: Ground potential differences to a receiving transceiver.**

**Fig. 3: Common differential receiver topology.**

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John P. Griffith is a systems engineer for the Interface group at TI – www.ti.com
A 100V DC energy monitor measures up

By Christopher Gobok

In today’s power conscious world of electronics, “energy monitoring” and “power monitoring” are often used interchangeably, but, in reality, have slightly different meanings, applications and benefits. Energy is often defined as the amount of power consumed over time, measured in joules (J) or kilowatt-hours (kWh), whereas power is a constant rate of energy usage, measured in watts (W). Thus, while a power rating is typically used to indicate how much electricity a device will consume at a snapshot in time, energy confirms in hindsight how much electricity was actually consumed during a defined time period. So, while the “green” goal of an energy and power monitor may ultimately be the same, an energy monitor may be more useful in most applications, since it goes a step further by accounting for shifts in power levels over time.

With AC loads aside, energy monitoring is becoming more popular and is already established in a handful of DC load applications. Handheld, rack-mounted and in-line energy meters are widely available and can be used by people such as facility managers to track and allocate energy used by equipment or departments among many things. This may also include load profiling, where expected energy consumption patterns are compared to present usage and areas of concern are flagged based on deviations from modeled energy patterns. By sizing loads, users can determine how many lights, computers, batteries, etc. can be connected to a system at any time.

Although a discrete energy monitoring solution can be built using a microprocessor and a handful of other components, this incurs system overhead from continuous data polling to perform the calculations and analyze the data. A respectable energy monitoring IC provides a simple solution that alleviates the host of these burdensome tasks, where the combination of measured parameters, which include voltage, current, power and energy levels, provide instant insight into a system’s health. Programmable threshold alerts may be all that is needed to provide early detection of a fault so preventative action can be taken before catastrophic events occur. Alternatively, systems can be optimized by simply understanding usage patterns; with this kind of information, valuable resources can be diverted accordingly, where over-utilized widgets can offload tasks to underutilized widgets.

The energy monitor role model

Energy monitors can be built in many different ways, which isn’t surprising considering that a variety of components are necessary to monitor energy usage in a system. To measure current, a sense resistor and amplifier are needed, and it is most convenient if the amplifier common-mode range extends to the positive supply rail and translates its output to ground. Precision resistive dividers are needed to measure voltage and, if there is more than one voltage to monitor, a multiplexer must also be added to the list. A multichannel analog-to-digital converter (ADC) comes next, with a precise reference and some means of interfacing to a microprocessor, while perhaps sharing I/O lines with neighboring ICs. ADC conversions would need to be synchronized to the time base of the microprocessor so that time can be tracked. The microprocessor must also multiply voltage and current to obtain power calculations, and sum these power values over the period for which energy is to be calculated. If detection of minimum and maximum values or alerts are required for any of the parameters, additional code needs to be written and constantly executed. Because of the overall complexity and difficulty of finding suitable components, energy monitoring easily lends itself to an integrated solution.

By integrating all of the necessary functional blocks in a small 4x3mm QFN or MSOP package, Linear Technology’s LTC2946 makes energy monitoring very practical for a wide variety of applications where a discrete solution is out of the question due to space, complexity or cost. The LTC2946 operates on as little as 2.7V, but can monitor the voltage and current of any 0V to 100V rail, as well as its own supply voltage and one additional voltage input. An on-board shunt regulator provides support for supplies greater than 100V. For flexibility, the sense resistor is external, allowing the LTC2946 to accurately monitor currents ranging from milliamps to tens of amps or more. The ADC has 12-bit resolution and a maximum total unadjusted error (TUE) of 0.4% for voltage and 0.6% for current. The additional ADC input (ADIN pin) TUE is also just 0.3% and can be used for monitoring auxiliary functions. The LTC2946 also inte-

Christopher Gobok is Product Marketing Engineer at Linear Technology Corporation – www.linear.com

Fig. 1: Simplified LTC2946 block diagram.

Fig. 2: LTC2946 high side energy meter.
grates a digital multiplier to calculate a 24-bit power result, as well as an accumulator and oscillator to calculate 32-bit energy and charge results. All values, measurements, status and user configuration data are stored in I2C accessible registers.

The LTC2946 finds its way into many complex, space-constrained, applications including RAID systems, telecommunications, transportation, solar monitoring systems, and industrial computer/control systems. Fortunately, only a few simple connections need to be made to this device. Figure 2 shows the LTC2946 monitoring the input voltage and current of a 3.3V microprocessor, while being powered by 12V. The only required external components are a sense resistor and three pull-up resistors.

Because of the wide rail-to-rail operating range, the LTC2946 is useful in many different low voltage and high voltage systems. Not only do 100V abs-max-rated supply and sense pins provide a lot of headroom, such as in 48V or -48V applications, but the zero volt sense monitoring capability is just as useful in monitoring current levels during short circuit or blackout situations. Fault current levels at zero volts can immediately indicate whether the power supply or load has gone bad without additional circuitry. The internal 12-bit Δ∑ADC inherently averages input noise over the measurement window, so operating in noisy environments is not a problem. In scan mode, the ADC continuously monitors the differential sense voltage, supply or positive sense voltage, and spare ADC input voltage sequentially with 25µV, 25mV and 0.5mV resolution respectively. Conversions have an effective refresh rate of up to 20Hz in continuous scan mode (depending on how often internal calibration is performed), although users can also enter a snapshot mode to take measurements of a single selectable input.

Energizing the energy monitor

The LTC2946 can derive its power from a wide range of supplies, which drastically simplifies the design process for any application. Figure 3a shows the LTC2946 being used to monitor a supply that ranges from 4V to 80V. No secondary bias supply is needed since the VCC supply pin can be connected directly to the monitored supply. If the LTC2946 is used to monitor a supply that goes as low as 0V, it can derive power from a wide range secondary supply connected to VCC as shown in Figure 3b. Similarly, if a low voltage supply as low as 2.7V is present, the LTC2946 can be configured as shown in Figure 3c to minimize power consumption.

For supplies greater than ±100V, the on-board linear regulator at the INTVCC pin can be used in both high and low side configurations to provide power to the LTC2946 through an external shunt resistor. Figure 4a shows a high side power monitor with an input monitoring range beyond 100V in a high-side shunt regulator configuration. The LTC2946 ground is separated from the circuit ground through RSHUNT and clamped at 6.3V below the input supply. Due to the different ground levels, the LTC2946’s I2C signals would need to be level shifted for communication with other ground referenced components; a current mirror would also be needed to measure the external voltage on the spare ADC input. Figure 4b shows the LTC2946 deriving power from a greater than -100V supply. Here, the low-side shunt regulator configuration allows operation by clamping the voltage at INTVCC to 6.3V above the input supply, which in this case is a negative rail. As shown in figure 4c, a shunt resistor is not required if the input supply and transients are limited to below -100V, where VCC measures the supply voltage at circuit ground with respect to the LTC2946 ground.

Digital convenience

Consistent with the flexible powering options, the LTC2946 includes a host of convenient digital features that simplifies de-
signs. The most apparent digital feature is the integration of a digital multiplier and accumulator which provide users with 24-bit power and 32-bit energy and charge values, alleviating the host of polling voltage and current data and performing extra computations. The chip calculates power by multiplying 12-bit measured current with 12-bit measured voltage. In continuous mode, the differential sense voltage is measured to obtain the load current data. However, the voltage data can be selected between the supply voltage, positive sense voltage, or spare ADC input voltage. A 24-bit power value is then calculated every time a current measurement is made. Lastly, energy and charge accumulators are incremented with power and current data and capable of storing several months’ worth of data at nominal current and power levels.

The LTC2946 has minimum and maximum registers for current, voltage, and power, which eliminate the need for continuous software polling and free the I²C bus and host to perform other tasks. In addition to detecting and storing min/max values, the circuit has min/max limit registers that can be used to issue an alert in the event any of the limits are exceeded, again, eliminating the need for the microprocessor to constantly poll the LTC2946 and analyze data. The LTC2946 can also be configured to generate an overflow alert after a specified amount of energy or charge has been delivered or when a preset amount of time has elapsed. For an energy monitor, an alert response can be equally as valuable as minimum and maximum registers. Figure 5 shows how the LTC2946 generates an alert signal via software and hardware. Measured data is compared against user defined thresholds; overvoltage, undervoltage, overcurrent, undercurrent, overpower, and underpower thresholds can all be defined and simultaneously monitored. Then, a status register informs the user which parametric thresholds have been exceeded, while actual fault values are logged in another register and can be interrogated at a later time. A separate alert register allows users to select which parameters will respond in accordance with the SMBus alert response protocol, where the Alert Response Address (ARA) is broadcasted and the /ALERT pin is pulled low to notify the host of an alert event.

The LTC2946 uses a standard I²C interface with very unique enhancements to communicate with the outside world. Nine I²C device addresses are available so multiple LTC2946s can be easily designed into the same system. All LTC2946 devices respond to a common address, which allows the bus master to write to several LTC2946s simultaneously, regardless of their individual address. A stuck-bus reset timer resets the internal I²C state machine to allow normal communication to resume in the event that I²C signals are held low for over 33ms (stuck bus condition). A split I²C data line conveniently eliminates the need to use I²C splitters or combiners for bidirectional transmission and receiving of data across an isolation boundary. Furthermore, the LTC2946-1 option has an inverted data output for use with inverting opto-isolator configurations.
IoT wireless sensors and the problem of short battery life

By Carlo Canziani

Wireless sensors provide great insight in applications like monitoring environmental conditions or industrial plants and machinery. Because they are simple to install, they can be deployed in a multitude of situations. In coming years, we will see an explosion of new uses for wireless sensors as the “Internet of Things,” or “IoT,” is widely deployed. But one of the factors that most limits the use of wireless sensors is their limited ability to do the job for a reasonable amount of time. When a wireless sensor’s operation is fully dependent on a battery, and the battery is depleted, it becomes just a piece of junk.

If you are designing battery-operated wireless sensors, you face numerous challenges in ensuring your devices operate for a reasonable amount of time. The typical approach is to use energy for just the required activity, then put the device in low-power-use mode. The operation of a wireless sensor can be segmented in a series of activities, each one requiring a certain level of power for a certain amount of time. The most common activities:

• Waking up, taking a measurement and processing data into a message
• Powering up the RF power amplifier, transmitting the message, and powering the RF PA down again
• In bidirectional sensors (transmit and receive): waking up, powering up the receiver, receiving, processing data, acting on a message, and powering back down

It is easy to see that multiple actions play a role in discharging the battery.

The simplest way to increase the battery life is to use a bigger battery, a battery with higher capacity. Nevertheless, your customers are likely to expect their sensors to be small and to offer high performance (so they can send lots of data and have local intelligence/data crunching capability). Clearly, your customer expectations are diametrically opposed to the easiest way to solve the issue of short battery life.

How do engineers estimate battery life?

As a design engineer, you need to start making compromises and find the balance between battery size and the wireless sensor’s functionality to get the best performance from a small battery with a sufficiently long time interval between battery replacements. The optimization process starts by understanding the energy requirements. Gathering data about energy usage is the first step to characterizing device performance.

A battery has a defined amount of energy, specified in Watt hours (Wh) and capacity, specified in amp hours (Ah). If you know how much power is required to operate your device, you can calculate the battery life.

Battery life (hours) = Battery capacity (Wh) / Average power drain (W)

Battery life (hours) = Battery capacity (Ah) / Average current drain (A)

Carlo Canziani is Business Development Manager EMEA at Keysight Technologies - www.keysight.com
SMART4HOUSE IS A FAMILY OF WIFI SENSORS AND SWITCHES FOR HOUSEHOLD PROTECTION AND CONTROL THROUGH THE SMARTPHONES WITH iOS or ANDROID OPERATING SYSTEMS

By Pavel Toman, Controltech s.r.o.

Water Leak Detector. The sensor is monitoring flooding of the detection probe with water. In case of flooding the sensor sends the message via "data service" to your smartphone or tablet and this way you are informed about the occurrence of the dangerous situation anywhere within the reach of the mobile signal.

Application area: Bathrooms, laundries, garages, cellars, technology rooms and sumps, etc.

Binary Sensor. Each module of Binary Sensor can be connected up to 4 sensors with contact outputs. In the case of status change of any of the sensors the Binary Sensor sends the message via "data service" to your smartphone or tablet. Hereby you are informed about any status change.

Application area: Securing of the entrance door with magnetic door contacts, window securing, level monitoring by floats with contact outputs, auxiliary contacts of circuit breakers, etc.

WiFi Relay. WiFi relay is designed for remote control of one or two independent devices equipped with potential free contacts. The module includes two relay's contact outputs which are controlled through the Smart4house application in your smartphone or tablet. Requirements for the switching on and off for each output are transmitted from your smartphone or tablet. The same path is used by the WiFi relay for sending information about implementation of the requirement. The relay outputs either may be operated in the on/off mode, or the switching pulse can be generated with duration of 1 second. The transmitted information is secured by encryption.

Application area: Remote control of entrance and garage gates, outdoor lighting control, remote switching of various heating or cooling modes, remote control of pumps, etc.

Temperature sensor. The temperature sensor is equipped with an internal sensor and an external probe with a 2 m cable. The sensor transmits the information about the current temperature based on a set interval to the smartphone or tablet. Our application allows you to pre-set the temperature levels. If the temperature is exceeding the limit a warning notification will be sent to your smartphone or tablet.

Application area: Indoor and outdoor temperature monitoring in remote objects (summer cottages, warehouses etc.), monitoring and data collecting on the status of cooling and freezer equipment, etc.

Smart4House follows the latest trends in technology & IT and ideologically supports IoT (Internet of Things).
However, when the device is in real operation, the battery life is typically shorter than the number you calculated. The most common comment is: “the battery quality is bad.” Representatives for big battery brands will offer detailed specifications and explain that among batteries of the same type, it is common to have capacity variations of 5 to 10 percent. But even using conservative battery capacity estimates, battery life typically falls short. The device dies before it is expected to. Why does this happen? Did we correctly estimate energy usage? Probably not. Let’s explore the problem.

The complexity of measuring dynamic current drain

In battery-powered devices like wireless sensors, to save energy the device sub-circuits are active only when required. Engineers design the device to spend most of its time in a sleep mode with minimum current drain. During sleep mode, only the real-time clock operates. The unit then wakes up periodically to perform measurements. The acquired data is then transmitted to a receiving node.

The different operating modes result in a current drain that spans a wide dynamic range from sub-µA to 100 mA, which is a ratio on the order of 1:1,000,000.

Traditional measurement techniques and their limitations

A well-known method for measuring current is to use the ammeter function of a DMM. The accuracy of current measurements made with modern digital DMMs looks good, but specifications are defined for fixed ranges and relatively static signal levels, which isn’t exactly the situation on a wireless sensor due to its dynamic current drain.

The DMM is connected in series between battery and device to measure the current. From time to time we see some reading instabilities due to the sensor’s active cycle or even the transmit mode. We know that DMMs have multiple ranges, and with auto range it should be able to select the most appropriate range and give the best accuracy. However, DMMs aren’t ideal. The auto range takes time to change range and settle the measurement results. Time to auto-range is often 10 to 100 ms, longer than transmission or active modes times. For this reason, the auto-range function needs to be disabled and the user needs to manually choose the most appropriate range.

The DMM makes measurements by inserting a shunt in the circuit and measuring the voltage drop across it. Normally to measure low current, you choose a low range based on a shunt with high resistance; to measure high current you choose a high range based on a low-resistance shunt. The voltage drop is also called burden voltage. Due to this voltage drop, not all the battery voltage reaches the wireless sensor. Most accurate low ranges for sleep current measurements have burden voltage during current peaks that may even cause the device to reset. Practically, we end up compromising and using a high current range that keeps the device operating during current peaks.

This compromise enables us to handle peak current and measure the sleep current, but at a high price. As the offset error is specified on range full scale, it heavily impacts measurements on low current levels. Its error contribution can be 0.005% error on 100 mA range = 5 µA, which is a 50% error on 10 µA or 500% error on a 1-µA current level. This current level is where the device spends most of its time, so this error has a huge impact on the battery life estimation.

After measuring the sensor’s low current level during sleep mode, we have to measure the active and transmission pulses. Measurements need to include both the current level and the time the sensor spends at that level. Oscilloscopes are excellent tools for measuring signals changing over time. However, we need to measure current in the 10’s of mA level, and current probes do not do a good job there due to their limited sensitivity and their drift. Good clamp probes have 2.5-mArms noise, and the zero compensation procedure needs to be repeated often. Current probes measure the electric field over a wire, so the trick to increase sensitivity is to pass the same wire multiple times so we multiply the magnetic field – this multiplies the current readout, enabling us to measure the current a bit better. With this approach, we can capture the current pulse of the activity and the transmission time. Even within the activity and transmission, the current changes levels: it looks like a train of
high and low levels. To properly calculate the average current the waveform needs to be exported and all the measured points need to be integrated to get the average value.

Oscilloscopes do a good job of capturing a single burst. However, the measurements are more complex if we want to verify how many times the sensor activates in a timeframe and how often it sends out a TX burst. Oscilloscopes can easily do a good job with measurements taken over the short term, but sensors may have operational cycles of minutes or hours, which can be complex to capture and measure.

Measurement innovations
The Keysight N6781A source/measure unit (SMU) for battery drain analysis overcomes the limitations of traditional measurements with two innovations: seamless current ranging and long-term gap-free data logging. The SMU is a module that can be used with the Keysight N6700 low-profile modular power system or N6705 DC power analyzer.

The seamless current ranging is a patented technology that enables the SMU to change the measurement range while keeping the output voltage stable without any dropout due to ranging. This feature enables you to measure the peaks with high current ranges and measure the sleep current with the 1-mA FS range, which has 100 nA of offset error. This low offset error (100-nA offset error is 10% at 1 µA or 1% at 10 µA), orders of magnitude better than a traditional DMM.

The seamless current ranging is combined with two digitizers to measure voltage and current with simultaneous sampling at 200 kSa/s (5-µs time resolution). Digitized measurements can be captured over 2 seconds and displayed with full time resolution and proportionally longer time with lower resolution. However, for long-term measurements, the internal data logger in the Keysight N6705B modular DC power analyzer integrates the 200-kSa/s measurements over a user-specified integration period (20 µs to 60 seconds) without losing any samples between the integration periods.

As the data logger is gap-free, all the samples fall in one integration period or in the next one -- no samples are lost. With the data logger, engineers can now measure the current and energy drain performance of a wireless sensor for up to 1000 hours of operation.

Measuring the sleep current is just a matter of placing the markers and directly reading out the values provided. The measurement in Figure 4 is made with a single acquisition over a long period of time; we get the complete picture of the current drain as well as an accurate measurement of the sleep current at 599 nA.

With pan and zoom capability, it’s possible to look at the current level and time spent at every power level. Details that traditional measurement tools do not see can now be identified and measured. A clear example is the trailing pulses identified by “???” in Figure 4. The software revealed this surprise: the device drain pulsed energy at ~90 µA peaks for 500 ms for an average current of 3.3 µA. When we add this current drain to the 599 nA sleep current, it moves to 730 nA, 22% higher current than we expected. This type of surprise can be one of the reasons for underestimating energy requirements and delivering a shorter battery life than anticipated.

In wireless sensor power optimization, engineers get great value by understanding the details. Knowing how much energy it takes to send out a single packet of information is very important when balancing user experience against battery drain and answering questions such as “should I send information once every second, every 5 seconds or every 10 seconds?” Engineers can accurately estimate the battery drain impact of any firmware change and validate it in a reasonable time with real measurements.

Joule measurements made easy
Joules are useful in battery life estimation, as every activity has a defined amount of energy. We can also compare device performance using Joules/transmitted bits. But engineers rarely use Joules because they need to be calculated from voltage, current and time.

With the Keysight 14585A control and analysis software, energy in Joules can be measured directly. For example, you might measure the energy consumed by transmitting a packet captured with a triggered measurement. This is one benefit of having two digitizers for voltage and current with simultaneous sampling that enable point-by-point power measurements. Joules can be easily read out as a value between the markers, and designers can go a step further by defining Joules/transmitted bit.
In situ testing of flexible electronics: an alternative to AFM

By Markus Fabich

The electronics industry is rapidly moving towards flexible, lightweight devices, and there are many factors to consider in designs that are both robust with a long life expectancy. Manufacturing electronic devices on deformable polymer substrates is the key characteristic of these technologies, and one approach to design is overlaying a thin layer of a conducting material on the polymer. Studying the electro-mechanical behaviour of thin films on polymer substrates for advanced flexible thin film electronic applications is a focus of Dr Megan Cordill’s work at the Erich Schmid Institute for Materials Science of the Austrian Academy of Sciences and the Department of Material Physics at the University of Leoben (Austria).

Focus on thin film behaviour

One research area of Dr Cordill’s group is the mechanical behaviour of ductile materials such as copper or gold under strain. Understanding the relationship of electrical and mechanical properties of thin film devices under strain provides unprecedented insights into their behaviour, and Dr Cordill’s approach of coupling a mechanical straining stage with high-resolution observation allows in situ analysis of both. “We want to study how the microstructure of ductile films affects their electrical and mechanical behaviour during mechanical loading, reflecting the strength and electrical resistance of the film, as well as its adhesion to the substrate,” she comments. “We are particularly interested in the different layers – how they interact when they are stretched or bent. Too many different layers degrades both the electrical and mechanical behaviour.”

Interestingly, observing the sample after unloading masks any cracks, as the polymer substrate relaxes to compress the overlaying film, and the sample may appear unaffected. Holding the sample for longer reveals any cracks, and therefore in situ testing is vital for visualizing deformation.

With the ability to measure delamination alongside electrical and mechanical properties in situ, CLSM with the Olympus LEXT OLS4100 provides a comprehensive picture of thin film behaviour under loading conditions.

Electromechanical testing of ductile films in situ

The mechanical straining stage device is controlled automatically for loading or unloading at a certain rate. Through coupling the device to the CLSM system, this allows the measurement of sample displacement and the electrical resistance in parallel, and is therefore termed the ‘in situ squared’ method by Dr Cordill’s group.

Cycles of straining replicate the fatigue the device would suffer outside of the laboratory. With the viscoelastic recovery of the polymer, after the sample is unloaded, it has a much lower resistance than it did at the maximum, and it is important to consider this alongside the maximum resistance - see figure 2. “Linking electrical and mechanical behaviour is something we are able to do a lot better now using CLSM and our testing device. We can stop at certain levels of strain, including a hold period of three minutes before acquiring the images.” This has proved beneficial in a range of studies.

Dr Cordill’s group has found CLSM provides information previously generated with the AFM, linking crack evolution as a function of strain. “With the AFM, we could only look at a small area – about 20-25 microns. Since the difference between a crack and a neck might only be five microns, you’re looking at 4-5 cracks per image, which doesn’t provide meaningful statistics.” There is also the consideration of speed, and the AFM is slower, with one experiment taking one or two days. “Compared to AFM I would say it takes half the time to learn how to run our CLSM system. Anyone can use an AFM, but to get high quality images, you need more experience, and it can be hard to inspect the same area each time. With CLSM it is much easier to get it right the first time, as image acquisition is straightforward and intuitive.”

Layers – less is more

From the research of Dr Cordill’s group, it is becoming increasingly clear that in certain film systems with certain microstructures, adhesion layers can prove detrimental to electromechani-

Markus Fabich is Product and Application Specialist for Materials Science Microscopy at Olympus SE & CO. KG – www.olympus-europa.com – He can be reached at Markus.Fabich@Olympus-Europa.com

Figure 1: ‘In situ squared’ straining system with CLSM. Load is applied automatically to a pre-determined value with known rate, and sample displacement and electrical resistance is measured. With the space of the Olympus LEXT OLS4100 stage, the standard 100x magnification working objectives can be used.

Figure 2: Linking electrical and mechanical behaviour.
In the rigid electronic industry, it was historically thought that gold and copper have low adhesion to polymers, and so additional layers were introduced. Dr Cordill explains: “Although this was not the case looking back to the literature of the 1980’s, it was assumed that the interlayer would still be needed in the flexible electronic industry. Our work is instead showing that these interlayers are actually damaging.”

For example, gold films can buckle and delaminate from the polymer substrate. On unloading the sample, these buckles form as the polymer springs back and the film becomes detached from the substrate. As higher loads are applied and removed, the buckles increase in size, or new buckles can form. Together with the film thickness, measuring the height and width with CLSM calculates the adhesion energy of the metal and polymer interface. Figure 3 shows how the gold film with a tantalum adhesion layer delaminates from the polymer substrate.

“Because we can see so many more buckles with the increased field of view compared with the AFM, I can make a lot of measurements just from one image. Actually, these buckles are too high for the AFM to measure.” Because of its higher range, the LEXT can be used to analyze a wider range of samples, and from these measurements, Dr Cordill’s research concludes that the adhesion of the gold layer is actually worsened in the presence of the tantalum adhesion layer.

Summary
Flexible electronic devices must withstand bending, stretching and twisting. The innovative work of Dr Cordill’s group has reinvented the design of flexible electronic devices, demonstrating how the inclusion of a tantalum adhesion layer is detrimental, leading to buckling and delamination of gold films. Shedding light on the behaviour of these devices in more detail than ever before, this discovery has been possible through coupling in situ testing with the fast and easy-to-use high-resolution imaging platform of the Olympus LEXT OLS4100. CLSM provides a fast means to generating new information, especially when compared to AFM, where a wider dynamic range means samples with varying feature heights can also be investigated.

“Manufacturers can now determine when cracks form, and respond to this information,” says Dr Cordill, who goes on to conclude: “Our approach is instrumental in guiding the optimization of materials and fabrication processes, leading us towards robust, market-ready devices.”

Figure 2: In situ testing links mechanical and electrical properties. During a cyclic experiment applying 2% maximum strain with 114 cycles, the electrical resistance (R/Ro) increased by 20% over time (A), but confusingly exhibited no crack damage (B). This is explained by the behaviour over a cycle of loading/unloading, where the polymer relaxes and hides the cracks that are otherwise visible when observed in situ (C).

Figure 3: Measuring adhesion energy between layers. Gold film with a tantalum adhesion layer on a polyimide substrate was strained to 6% and during unloading, buckles (delaminated areas) formed. Using the Olympus LEXT OLS4100 to generate a laser image for visualization (A), and height map of buckles (B) provided height and width information, plotted in graph C.
Pickering Interfaces’ eBIRST FAQ

By David Owen

Switching systems are an important part of many test systems; they allow test resources to access the key parts of the unit under test (UUT), share instrumentation resources, and create a test environment that is accurate and repeatable. However, the switching system is in a vulnerable place, and accidents may happen during development or when a connection is made to a faulty device. When those accidents happen you need a way to get the system up and running again with the minimum of effort and operator skills – because until the switching system is repaired the test system cannot be used. That is where the new eBIRST switching system test tools from Pickering Interfaces come in.

The eBIRST tools provide a means of quickly determining if your switching system has faults, identifies where that fault is located at relay level and allows you to take fast corrective action. This in turn saves on repair costs and minimizes downtime of your switching system. No other switching system manufacturer offers this level of support for their products.

Here are some answers to the most commonly asked questions about the eBIRST tools.

Q: What exactly do the eBIRST tools do and what are the benefits?

A: The eBIRST tools provide a means of quickly determining if a switching system has faults, identifies where that fault is located at relay level and allows the user to take fast corrective action. The tools greatly lower MTTR (Mean Time To Repair), saving users repair costs by allowing for fast local repair rather than return to factory, while allowing development to proceed or to minimize the downtime of manufacturing systems.

Q: What kind of switching systems do the eBIRST tools support?

A: The eBIRST tools support any of Pickering Interfaces PXI, PCI or LXI (Ethernet) controlled switching systems that have consistent path resistance at low signal levels. Through the use of three tools based on 200-way LFH, 78-way D-type and 50-way D-type connectors and a set of adaptors, a wide range of switching systems can be covered. These typically include all the highest density and complexity switching systems based on reed relays, low and medium power (typically 2A or less) EMR's and low frequency solid state relays.

Q: How do the eBIRST tools work?

A: They work by measuring the path resistance at the switching system’s connectors using four-wire tool measurements. This measurement quickly establishes if the path is good, has increased resistance or has failed.

Q: What is needed to make use of the eBIRST tools?

David Owen is Pickering Interfaces’ Business Development Manager - www.pickeringtest.com

A: The eBIRST tools are self-contained; all you will need is a USB2 port on a PC running Windows and the supplied application program to control them. The USB control port provides power for the tools. Adaptors used with the eBIRST tools are recognized and checked to make sure they are compatible with the switching system to be tested. The program uses a Test Definition File created for each switching system that defines how to test the system. Test Definition Files and the application program can be downloaded from the Pickering Interfaces website (pickeringtest.com/ebirst) free of charge to update the application program.

For some switching systems, there may be inputs on one connector and outputs on another, requiring a through path measurement between the two connectors to be carried out using two eBIRST tools. In order to make this connection, we offer a Master/Slave Cable that connects to the rear of the two tools allowing them to work together. The application program controls both tools to make a measurement between the two connectors; the connectors do not have to be the same type if the switching system requires them to be different. The Master/Slave Cable connection is generic across all of the tools.

Q: What can be tested with the eBIRST tools?

A: Almost any switching system that has a consistent path resistance at a current of 30mA or less, the test current used by the eBIRST tool. This includes RF switching systems that are DC coupled and use SMB connectors. The eBIRST tools do not cover switching systems based on high current relays as they are potentially subject to minimum switching capacity issues that can result in unpredictable path resistance and, therefore, false failure reports. The 30mA test current is considerably higher than that used in DMM based testing.

Q: Can eBIRST tools test other switching systems?

A: Pickering Interfaces eBIRST tools are designed to support...
the Pickering Interfaces family of switching systems only. At this time, there are no plans to broaden this scope.

**Q: How can eBIRST tools be made traceable and checked?**

**A:** Functionality and accuracy of the eBIRST tools can be checked with the aid of an external calibration fixture that allows users to either connect two tools together or measure a set of fixed value precision resistors. The two tools are controlled to perform a cross-check of their functional performance and the precision resistors on the fixture allow the tool to check for measurement accuracy. The resistors in the fixture can be checked using a user supplied calibrated DMM to ensure traceability.

**Q: What steps are necessary to run a test?**

**A:** Connect the eBIRST tool to the switching system, via an adapter if required. The switching system can be PXI, PCI or LXI based; it makes no difference as long as it uses a connector supported by the eBIRST tools. Then simply run the supplied application program.

**Q: Does the user need to configure the tool for a different switching system to be tested?**

**A:** For each switching system to be tested there is a Test Definition File that describes the tests to be performed and the limits to be applied. If the required Test Definition File is not present, a newer version of the eBIRST application program needs to be installed. Pickering Interfaces will continually expand the availability of Test Definition Files to cover all supported switching systems.

**Q: How do I find out where faulty relays are physically located?**

**A:** The eBIRST tools will quickly test the switching system, locate the faulty relay(s) and inform you what relays to replace via a graphical output. This output identifies the relays that need attention and where physically they are on the switching system. There is no need to refer to manuals to use lengthy cross reference tables that convert a functional position (e.g. X-Y co-ordinates on a matrix) to relays designation (e.g. RL123), then try to find it on the PCB layout. Instead, the eBIRST tools show you a layout of the PCB and exactly where the defective relays are on that layout. The eBIRST tools make fault location easy in order to simplify the repair task.

**Q: What if my switching system doesn’t look to be supported by eBIRST?**

**A:** Contact Pickering to request it – If there are no technical reasons why we can’t support the system (a minority of our switching systems cannot be supported for various technical reasons), we will add a Test Definition File to the application program.
While it can test relay paths in the matrix and report errors, it is less accurate and only works internally. For example, it does not test for connector issues. The eBIRST tools, however, will test most of the other switching in your system. Finally, one set of eBIRST tools can support an entire test floor, keeping your support costs low. I would recommend any test department manager to review their test system support strategy and to consider using Pickering Interfaces switching and eBIRST as part of their plan to maximize test system uptime.

So – the main question should be: Why choose Pickering products supported by the eBIRST switching system tools?

Users buy switching systems to test products. When the switching system develops a fault, it causes downtime, consumes an engineer’s time to diagnose the fault and delays projects. So when problems occur—instead of figuring out how to identify and rectify the fault, get your eBIRST tool, connect it to the system and run the test.

The eBIRST tools will quickly test the switching system, locate the faulty relay and inform you what relays to replace. Downtime is considerably reduced, and the problems of misdiagnosed faults causing ineffective repairs to be carried out are minimized.

So along with Pickering’s diagnostic test tools, standard three-year warranty and long-term product support, no other switching system manufacturer offers this level of support for their products. Pickering and eBIRST should be considered as part of your test system support strategy.

**Near-field probe pinpoints RF sources from 1 to 10GHz**

The SX probe heads’ high measurement resolution allows the developer to pinpoint RF sources of between 1 GHz and 10 GHz on densely packed printed circuit boards or on IC pins. The handy compact pin shape of the EMC near-field probes provides the developer with convenient working conditions on the respective PCB. High clock rates of 2 GHz, for example, may result in 5th order harmonics of up to 10 GHz. These harmonics are coupled out by RF sources on the PCB such as conductor sections, ICs and other components. They may stimulate other structural parts of the PCB to vibrate and generate emissions. In view of the high internal fundamental frequency of current PCBs, the measurement of harmonics of this frequency is an important step towards reliable EMC. The new SX1 near-field probe set contains three near-field probes with high resolution for measurements in the upper frequency range. The SX-E 03 is an E-field probe for frequencies between 1 GHz and 10 GHz with an electrode on the underside of the probe head sized approx. 4x4mm. This probe can be used to pinpoint small E-field sources such as conductors, individual components on a printed circuit board, etc. The head of the near-field probe is usually placed directly on the object of the measurement (high electric field strength). The SX-R 3-1 is an H-field probe for frequencies between 1 GHz and 10 GHz with a very small probe head to identify even the smallest components as a source of interference. This small probe head is also ideal for carrying out measurements in hard-to-reach locations such as in the vicinity of IC pins.

**Langer EMV-Technik GmbH**

www.langer-emv.de

**High flex PIM test lead optimised up to 4GHz**

Huber+Suhner has designed a PIM test lead for use with factory PIM analysers where there is a requirement to test antennas and components, as well as in the field with portable PIM analysers. The PIM test lead features a highly flexible, rugged and reliable construction and the company has designed the TL-P to be very durable with more than 2000 mating cycles achievable under normal working conditions. Optimised up to 4GHz, the TL-P PIM test lead is equally suitable for Return/Loss (RL) testing. Available in cable lengths of 1.5 or 3m, key values include a PIM figure greater than -117dBm (tested to IEC62037-2), return loss (up to L = 3m) of under 20dB at 4GHz and attenuation up to 0.90dB/m at 3GHz. The TL-P can handle power levels to 560W at 1GHz and has a shielding effectiveness greater than -120dB. All test lead assemblies are 100% tested for PIM, return loss and attenuation and come with a PIM test report and connector protection caps.

**Huber+Suhner**

www.hubersuhner.co.uk
Remote radio monitoring platform automates spectrum surveillance

Anritsu's newly launched remote spectrum monitor, MS27102A is a platform of modular and scalable products that helps operators generate a greater return on their multi-billion dollar spectrum investments while maximizing network capacity to meet consumer demand. Designed without a display or keyboard, the remote spectrum monitor automates the method of conducting radio surveillance, interference detection, and government spectrum policy enforcement while bringing greater flexibilities and cost efficiencies to network management. The bundled solution is flexible and expandable to evolve along with networks, it features two spectrum monitor modules at introduction, each with power of arrival (POA) algorithms to monitor for interference and approximate the position where the interfering signal is being generated. Designed to maximize network capacity by more efficiently solving issues associated with the presence of illegal or unlicensed signals that interfere with authorized transmissions, the MS27102A can be wall- or pole-mounted.

Anritsu
www.anritsu.com

Sound and vibration measurement system takes up to 256 channels

For acoustic, audio, and vibration testing on large structures such as airplane wings, turbines and trucks, Data Translation now offers the possibility to combine up to four VIBboxes to a complete system providing 256 channels for IEPE/ICP sensors or voltages. As every input has its own 24-bit A/D converter, the signals from sensors such as measurement microphones or accelerometers can be acquired simultaneously, synchronously and continuously at high sampling rates of up 51.2 kHz without time lapse or phase difference. In addition to the 256 analog inputs, the measurement system also provides 16 tachometer inputs, as well as a wide range of counter/timers and digital I/O channels. The current source for the IEPE/ICP sensors is individually programmable for each analog input in a supported range of ±10V or ±1V. 32 analog outputs with ultra-high 32-bit resolution can be used as signal source for any waveform stimulus.

Data Translation GmbH
www.datatranslation.eu

Board X-ray inspection boost with 3D algorithm

Goepel electronics claims its inline AXI system now offers an even faster high-end 3D inspection of complex assemblies thanks to the "X40 PLUS" upgrade, achieving an X-ray inspection speed increase of up to 18 percent versus the tool's prior capabilities. Optimization the imaging chain in combination with an improved axle system and faster execution of the test algorithms results in significant savings of cycle time depending on the maximum resolution and the board dimensions, says the company. As an example, a 216x164mm assembly with more than 8000 solder joints requires only about 40 seconds for complete 3D X-ray inspection. The X-Line 3D enables the safe inspection of double-sided boards. The three-dimensional X-ray inspection captures both top and bottom sides within a single pass. Based on a real time multi-angle image, recording a complete 3D inspection of the assembly is possible. Integrated reconstruction methods based on digital thomosynthesis enables the defined evaluation of individual layers of the circuit board under test. All the company's existing X40 Systems of the Series 200 can benefit from the upgrade.

Goepel electronics
www.goepel.com
Turning Bristol into a programmable city

By Bijan R. Rofoee, Mayur Channegowda, Shuping Peng, George Zervas and Dimitra Simeonidou

By 2050, the human population will have reached 9 billion people, with 75 percent of the world’s inhabitants living in cities. With already around 80 percent of the United Kingdom’s population living in urban areas, the U.K. needs to ensure that cities are fit for purpose in the digital age. Smart cities can help deliver efficiency, sustainability, a cleaner environment, a higher quality of life and a vibrant economy.

To this end, Bristol Is Open (BIO) is a joint venture between the University of Bristol and Bristol City, with collaborators from industry, universities, local communities, and local and national governments. Bristol Is Open (www.bristolisopen.com) is propelling this municipality of a half million people in southwest England to a unique status as the world’s first programmable city. Bristol will become an open testing ground for the burgeoning new market of the Industrial Internet of Things—that is, the components of the smart-city infrastructure. The Bristol Is Open project leverages Xilinx® Al Programmable FPGA devices in many areas of development and deployment.

The vision of the smart city

A smart city utilizes information and communications networks along with Internet technologies to address urban challenges, with the objective of dramatically improving livability and resource sustainability. It is predicted that the smart-cities industry will value more than $400 billion globally by 2020, with the U.K. expected to gain at least a 10 percent share, or $40 billion. The U.K. government investment in the smart-city sector includes around $150 million for research into smart cities funded by Research Councils U.K.; $79 million over five years earmarked for the new Future Cities Catapult center being established by the Technology Strategy Board in London; $52 million invested in future city demonstrators earlier this year; and $63 million recently allocated to Internet of Things (IoT) research and demonstrator projects.

Bristol Is Open is leading the way to building a city-scale research and innovation testbed. The aim is to drive digital innovation for the smart cities of the future: the open and programmable communities that will be the norm in the latter part of the 21st century.

The BIO testbed is equipped with leading-edge programmable networking technologies, enabled by a citywide operating system called NetOS, that allow smart-city applications to interact with city infrastructure—to program, virtualize and tailor network functions for optimum performance. Xilinx devices as high-performance generic platforms are utilized at many points in the city from the wired, wireless and IoT networking infrastructure to emulation facilities.

Let’s take a tour of this new type of urban community, starting with the overall vision for programmable cities. Then we will take a deeper look at how the Bristol project is utilizing Xilinx devices to build urban “white boxes” and to deliver various networking functions.

Future smart cities

More than 100 cities of 1 million people will be built in the next 10 years worldwide, while the continuous influx of people to cities will grow the number of urban residents by 60 million every year during that decade. The result is that more than 70 percent of the world’s population will be living in cities by 2050.

Considering also that cities occupy just 2 percent of the world’s landmass while consuming about three-quarters of its resources, the ongoing urbanization presents economic and societal challenges and a strain on the urban infrastructure. Growing cities will have to deal with a variety of challenges to maintain economic advancement, environmental sustainability and social resiliency. The solution is to make cities smarter. Although there is no absolute definition for smart cities, there are a number of key aspects widely recognized for a smart city’s operations. They include:

- Citizen-centric service delivery, which involves placing the citizen’s needs at the forefront.
- Transparency of outcomes/performance to enable citizens to compare and critique performance, establishment by establishment and borough by borough.
- An intelligent physical infrastructure, enabling service providers to manage service delivery, data gathering and data analyzing effectively.
- A modern digital, secure and open software infrastructure, to allow citizens to access the information they need, when they need it.

Technological enablers for smart cities are inspired by the Internet of Things, a market that, according to Gartner, will grow to 26 billion units installed as of 2020. That total represents an almost thirtyfold increase from 0.9 billion in 2009, with the revenue from technologies and services exceeding $300 billion. Smart cities deploy IoT technologies on a wide scale, enabling data gathering from sensors and things present in the ecosystem, pushing them for analysis and feeding back commands to actuators, which will control city functions.

From sensing and analysis, information passes back to actuators in the city infrastructure to control operations dynamically. This arrangement is an enabler for driverless cars using smart transport facilities; greater power efficiency thanks to smart lighting; the management of network resources for different times (daily and seasonal changes); the movement of resources depending on occasions such as sports events, which require

Bijan R. Rofoee is Senior Network Engineer at Bristol Is Open - Bijan.Rofoee@bristol.ac.uk
Mayur Channegowda is Chief Scientist, SDN at Zeetta Networks - www.zeetta.com
Shuping Peng is Research Fellow at the University of Bristol and Chief Scientist for Virtualization at Zeetta Networks
George Zervas is Professor of High-Performance Networks at the University of Bristol – www.bristol.ac.uk
Dimitra Simeonidou is CTO at Bristol Is Open and Professor of High-Performance Networks at the University of Bristol.
high-quality broadcast and coverage; and efficient handling of emergency situations (city evacuation).

**Programmable city vs. smart city**

Smart cities aim to improve and enhance public and private service offerings to citizens in a more efficient and cost-effective way by exploiting network, IT and, increasingly, cloud technologies. To achieve this goal, smart cities rely extensively on data collected from citizens, the environment, vehicles and basically all the “things” present in the city. The more data that becomes available, the more accurately city operations can be analyzed, which in turn will lead to the design and availability of smart-city services.

For the network infrastructure, citywide data retrieval and processing mean massive amounts of sensor data that needs to be collected, aggregated and transferred to computational facilities (data centers) for storage and possibly processing. The wide diversity of scenarios and applications presents major challenges regarding networking and computing infrastructure requirements in smart cities. Legacy information and communications technology (ICT) urban infrastructure can be a major bottleneck for smart-city operations, as it does not offer the capacity, flexibility and scalability desirable for the emerging, future-proof, resource-demanding and scalable smart-city applications.

Programmable networking technologies offer unique capabilities for raising the performance of smart-city operations. These technologies exploit open software and hardware platforms, which users can program to tailor network functions for different use case requirements. Improved control, monitoring and resource allocation in the network are the evident benefits of deploying programmable networks. More important, programmable technologies facilitate the integration of networks with IT facilities, which will result in greater application awareness.

Software-defined networking (SDN) is one of the main enablers for programmable networks. The SDN foundation is based on decoupling infrastructure control from the data plane, which greatly simplifies network management and application development while also allowing deployment of generic hardware in the network for delivering networking functions.

SDN-based scalable and facilitated network management also greatly empowers network virtualization. Network virtualization essentially enables multiple users to operate over shared physical resources, isolated from one another, reducing the need for installing supplementary physical hardware. Network function virtualization (NFV), a more recent innovation in virtualization technologies, offers software implementation of network functions in commodity hardware. Network functions such as firewall, deep packet inspection, load balancing and so on are deployed as pluggable software containers in generic machines, expediting network service deployments with great cost-efficiency.

In addition to software-driven networking, hardware and infrastructure programmability will progress beyond fixed-function hardware data planes. Adding high-level programmability and more sophisticated functionality to the data plane, accessed via standard software APIs, will make it possible to manage networking resources more intelligently and efficiently, increasing the rate of innovation.

**Bristol is Open: vision and architecture**

Launched in 2013, Bristol Is Open is a program funded by the local, national and European governments and also by the private sector. BIO is already delivering R&D initiatives that contribute to the advancement of smart cities and the Internet of Things.

BIO aims to serve as a living lab—an R&D testbed targeting city-driven digital innovation. It provides a managed multitenancy platform for the development and testing of new solutions for information and communication infrastructure, and thus forms the core ICT enabling platform for the Future Cities agenda. At the infrastructure level, BIO comprises five distinctive SDN-enabled infrastructures, as shown in Figure 1:

- **Active nodes** as optoelectronic-network white boxes using FPGA programmable platforms and heterogeneous optical and Layer 2/3 networking infrastructure
- **Heterogeneous wireless infrastructure comprising Wi-Fi, LTE, LTE-A and 60-GHz millimeter-wave technologies**
- **IoT sensor mesh infrastructure**
- **Network emulator comprising a server farm and an FPGA-SoC-network processor farm**
- **Blue Crystal high-performance computing (HPC) facility**

On the metro network, the infrastructure offers access to dynamic optical switching supporting multi-terabit/second data streams, multirate Layer 2 switching (1 to 100 GbE) and Layer 3 routing. The metro is also equipped with programmable hardware platforms and high-performance servers to allow open access to the infrastructure and a capability to create and experiment with new hardware and software solutions. This wired part of the infrastructure also connects to the Blue Crystal HPC facilities at Bristol in order to support experimentation with advanced cloud infrastructures.

The access network infrastructure includes overlapping and
seamless wireless connectivity solutions (macro and small-cell radio technologies) using a combination of cellular and Wi-Fi technologies enhanced with millimeter-wave backhaul and direct connections to the optical network. The facility also supports experimentation platforms for new 5G-and-beyond access technologies such as millimeter-wave-based access solutions with beam tracking, as well as new technology enablers such as massive MIMO for ultrahigh-density networks in the 2-GHz band.

In addition, BIO provides priority access to the infrastructure (for example, lampposts) for the additional installation of sensor nodes in the area, supported by suitable data aggregators, computing and storage resources. Optionally, these resources can directly interface into the wired and wireless network. BIO has also installed a low-energy wireless-sensor mesh network. This network will support IoT-based research, with initial sensors supporting environmental monitoring (temperature, air quality, pollution levels, lighting, noise and humidity) and smart streetlights.

BIO will also provide access, through suitable secure interfaces, to IoT assets already installed elsewhere in the city, including parking sensors, traffic lights, traffic flow sensors, surveillance (safety) cameras and public-vehicle sensors. Small sensors, including the smartphones and GPS devices of willing participants, will supply information about many aspects of city life, including energy, air quality and traffic flows. All the data generated will be rendered anonymous and made public through an “open data” portal.

The entire platform uses SDN control principles and, as such, is fully programmable by experimenters and end users. Internationally, the BIO experimental network will be the first of its kind and will generate new and exciting opportunities to pioneer the development of hardware and software for future communication technologies and cloud networking.

Software-defined networking for city infrastructures

The communications sector has seen a flowering of innovative solutions in recent years based on the concept of SDN, bringing advances in IT to the traditional hardware-driven telecommunications world. This decoupling of control and data through SDN enables innovative ways of controlling a network, while relying on a basic data-forwarding operation, common across all networking elements. The approach allows the integration of novel architecture concepts, such as information-centric networking (ICN), into such a software-driven network. SDN also enables continuous investment into smart infrastructure at the lowest layers of the ICT installations by driving the reduction of costs for physical components and pushing more of the operational aspects into the software.

As SDN is now reaching beyond ICT infrastructures into the IoT platforms, it creates the opportunity to realize a full circle of adaptability of computing and communication infrastructures, where sensory and real-world information drives the operation of the network. Network infrastructures in turn are utilized to provide the sensor information to applications and services in a meaningful and timely manner. At BIO, it is our vision for that programmability and adaptability across the various layers of the overall system to ultimately implement the notion of what we call a Living Network, where the Internet and things truly merge into a coherently managed and operated computing and communication environment.

Demonstrating SDN-based platforms on a citywide scale is crucial.

Virtualization for city infrastructure

A large number of highly diverse city applications need to be supported on top of the city infrastructures. For example, some applications will demand high capacity and very low latency. Others will consume very little bandwidth but will need to support a very large number of endpoints. Still others will have strict requirements on resiliency or security, privacy and so on. It is neither feasible nor cost-effective to establish dedicated infrastructures to support specific applications. Therefore, one of the key challenges for the city infrastructure operators is to offer customized, application-specific network solutions over a common ICT infrastructure. Virtualization, when integrated with an SDN-enabled control platform, is a key technical enabler for addressing this challenge. Virtualization is able to create multiple coexisting but isolated virtual infrastructures running in parallel, serving its tenant’s application requirements.

By thorough analysis of each tenant’s requirements in terms of social policy, security and resources, it’s possible to con-
struct a virtual infrastructure with a certain network topology, indicating the way that virtual nodes are interconnected with virtual links. Performance parameters (for example, latency) and resource requirements (such as network bandwidth, compute CPU/memory) are specified in the virtual nodes and links. Generally, virtual resources (nodes and links) are obtained by partitioning or aggregating physical resources. Therefore, a programmable hardware infrastructure is essential to support the composition of virtual infrastructures with high granularity and scalability.

In the city environment, the devices deployed in the urban infrastructure are heterogeneous, including wireless/mobile, wired, optical networks, data centers/cloud and functional appliances. In order to enable seamless service provisioning, it's mandatory to support converged virtual infrastructures enhanced with virtual network functions across the multitechnology, multidomain city infrastructure, so that each tenant can get its own slice of the city infrastructure. However, currently these technology domains are controlled and managed in silos. The NetOS with SDN capabilities at BIO provides a logically centralized control platform that can break through the management silos and bridge the different technology segments. The operating system is able to abstract the heterogeneous city devices, hide their complex technical details and expose the infrastructure in a uniform way.

The vision for the white box

Open network devices, or network white boxes, use unbranded, generic, modular and programmable hardware platforms. This type of equipment can load customized operating systems and enable on-demand redefining of network functions without the restrictions of vendor-locked devices. Network processors were the initial route to hardware programmability of the underlying network, leveraging the ease of defining functions through software APIs. Network processors are well-known hardware platforms that provide generic programmable features similar to general-purpose CPUs (with extended hardware resources), and can be programmed to perform various networking functions. The main advantage of processor-based architectures is rapid implementation of networking functions using high-level languages such as C, which is highly desirable for rapid prototyping. Network processors, however, are not optimized for parallel operations, which are essential for building high-performance data plane technologies supporting high-data-rate transport.

Field-programmable gate arrays (FPGAs) are high-performance and generic processing platforms utilizing programmability from transistor-level to IP-based function level. This makes them highly desirable platforms for designing and prototyping network technologies that must demonstrate high degrees of flexibility and programmability.

We are using Xilinx FPGAs that have evolved into system-on-chip (SoC) devices in multiple points within the BIO infrastructure: in active nodes - see figure 2 - as optoelectronic white boxes, emulation facilities, wireless LTE-A experimental equipment and IoT platforms. BIO uses programmable and customizable network white boxes that consist of programmable electrical (FPGA) and optical (switching, processing, etc.) parts. These boxes—which enable high-capacity data processing and transport, function programmability and virtualization—are deeply controllable through SDN interfaces. Figure 3 demonstrates the FPGA-based platform, which can host multiple functions in a programmable way, and is interfaced to a programmable photonic part.

FPGAs offer several advantages, including hardware repur-

Fig. 3: Bristol Is Open’s network white box is built around Xilinx FPGAs.

Zynq SoC-based Emulation Platform

To broaden the capabilities of BIO facilities in experimenting with larger and more-realistic scenarios, we have deployed a network emulator facility within BIO. This platform enables network emulation as well as resource virtualization and virtual-infrastructure composition techniques for advanced network, cloud and computational research. The emulation platform also utilizes local and remote laboratory-based facilities and distributed research infrastructures (networks and computing). Figure 4 demonstrates the multilayer, multipath emulation facilities at the core of the Bristol Is Open infrastructure.

The emulation facility offers a number of functions instrumental for enhanced network studies in conjunction with the BIO city network and other remote interconnected laboratories:

1. **Node and link emulation**: This platform can emulate network elements such as routers and switches from the wired and wireless domains, along with the interconnecting links with various physical attributes.

2. **Protocol emulation**: Whether centralized or distributed, network nodes rely on the protocols to communicate. The emulation facility with precise modeling of the network technologies allows the user/researcher to try out communication protocols and study their behavior on scale.

3. **Traffic emulation**: Depending on the emulation scenario (wireless networks, data center networks, etc.), traffic patterns with arbitrary intervals and operating from a few megabits to multiple terabits per second can be generated and applied to the target emulated or physical network.

4. **Topology emulations**: Any topological formation of the desired nodes and links is possible using the BIO emulation facility. This gives the user a chance to finely examine various aspects of the desired topology on the realistic network topologies before deployment and installation.

Unlike any other existing facilities that offer computer host-based emulation environments, BIO uniquely includes programmable hardware (FPGAs, network processors) as well as dynamic and flexible connectivity to multitechnology testbeds.
and a rich, dedicated connectivity infrastructure. The use of programmable hardware and external interconnectivity will allow users to accurately emulate the functionality and performance of network and computing technologies in scale and use them to synthesize representative complex systems. Exploiting the FPGA's parallel-processing capabilities and high-speed I/Os, BIO is equipped to emulate current or experimental network technologies and topologies, be they wired or wireless, precisely and at scale.

The network emulator uses a vast amount of advanced networking and IT technologies. An FPGA farm, server farm and L2/L3 programmable networking equipment are the main building blocks of the facility, enabling the users to build, experiment with and use various networking technologies in the data plane and control plane, such as virtualization, SDN and NFV, resource/workload allocation tools and algorithms, etc.

The emulator is connected to the BIO city network through 10-, 40- and 100-Gbps ports. The emulated networks can use standard data plane protocols such as Ethernet, OTN and Infini-band, or custom and proprietary protocols, to interconnect with other network domains.

The emulator uses Xilinx’s ARM®-based Zynq®-7000 All Programmable SoC platform, a single-chip implementation of processing and FPGA technologies. Algorithm acceleration is one of the target use cases for the Zynq SoC, where computationally intensive tasks for resource allocation, path calculation, load balancing and the like are offloaded to FPGA-based parallel processing. Hardware-assisted network function virtualization is another example of how we use Zynq SoC-based platforms in BIO for running performance-critical virtual network functions (VNFs) such as deep packet inspection, service control and security. Xen-based virtualization of ARM cores additionally facilitates running multiple operating systems on the same SoC chip. In this way, BIO can let multiple operators host their VNFs on the same device, and have shared and/or dedicated access to the parallel hardware computing resources to boost performance.

Experimentation as a service
The way cities work is changing. Using digital technologies, BIO is creating an open, programmable city that gives citizens more ways to participate in and contribute to the way their city works. We call it “City Experimentation as a Service.” Being open guides our procurement, our data management and the hardware and the software we use. Being open means the stakeholders in BIO proactively share what we learn with other cities, technology companies, universities and citizens.

Open source USB oscilloscopes
to grab: 3 units
This month, LabNation is giving away three of its SmartScope open source USB oscilloscopes, worth 229 Euros each, for EETimes Europe’s readers to win. Successfully funded through Kickstarter last year, the SmartScope is claimed to be the world’s first test equipment designed to run on multiple operating systems and platforms such as smartphones, tablets and PCs. It is powered directly from the host's USB interface making it suitable for many test and measurement applications far from the workbench. The instrument combines the multiple functions of an oscilloscope, logic analyser and a waveform generator in an aluminium case measuring just 110.0x64.0x24.2mm and weighing only 158 grams. The software provides the user interface and functionality, and can be downloaded from the SmartScope web site.

It is available for Android (Google Play Store or LabNation website), Apple Mac OS X, Apple iOS (jailbroken), Microsoft Windows 7, 8 and 10, and Ubuntu and Debian Linux distributions. The oscilloscope provides two analogue channels with a sample rate up to 100 MS/s that provides a -3dB bandwidth of 30 MHz. Input signal range is ±35 V with a 1 MΩ / 1pF impedance and has an 8 bit precision and a maximal resolution of 2.5mV. The logic analyser offers 8 input channel with a user selectable logic level of 3.3 or 5 VDC. The SmartScope application includes a number of standard protocol decoders such as for I2C and SPI in addition to allowing custom decoders to be created. The single channel waveform generator can create arbitrary waveforms with a data rate up to 50 MS/s and an output level from 0 to 3.3 V. A digital output generator provides 4 channels, up to a rate of 100 MS/s at either 3.3 or 5 V. The unit is supplied complete with a mini ‘B’ USB cable, 2 analogue probes, digital cable and probes.

Check the reader offer online at www.electronics-eetimes.com
Anybus CompactCom 40 industrial protocols on tiny FPGA

Microsemi Corporation and HMS Industrial Networks have joined forces to deliver the Anybus CompactCom 40-series products for industrial Ethernet solutions, based on Microsemi’s SmartFusion 2 SoC FPGA device. The highly secure device offers customers lower total cost of ownership and accelerated time-to-market with low power and secure industrial Ethernet protocol conversion solutions on a single SmartFusion2 FPGA platform. HMS’s Anybus CompactCom 40-series products offer hardware solutions specifically designed for factory automation applications including programmable logic controllers (PLCs), motor drives, motion drive control and safety modules, as well as other applications for industrial customers. HMS products are available in chip, brick and module product offerings, allowing customers to avoid designing ASSP/ASIC-specific boards for each industrial Ethernet standard. Customers can use HMS’s CompactCom 40-series and program Microsemi’s FPGA to the desired industrial Ethernet protocol standards with the intellectual property and software stack for the ARM Cortex-M3 microcontroller in SmartFusion2.

Microsemi
www.microsemi.com

SuperSpeed USB-to-FIFO bridge ICs easy evaluation

To encourage the widespread use of its FT600/1Q USB 3.0 SuperSpeed ICs, FTDI Chip has launched a new family of evaluation/development modules. Measuring 78.7x60mm, the UMFT600A and UMFT601A each have a high speed mezzanine card (HSMC) interface with 16-bit and 32-bit wide FIFO buses respectively. The UMFT600X and UMFT601X measure 70x60mm and incorporate field-programmable mezzanine card (FMC) connectors, again with 16-bit and 32-bit wide FIFO buses respectively. The HSMC interface is compatible with most Altera FPGA reference design boards, while the FMC connector delivers the same functionality in relation to Xilinx boards. Fully compatible with USB 3.0 SuperSpeed (5Gbits/s), USB 2.0 High Speed (480Mbits/s) and USB 2.0 Full Speed (12Mbits/s) data transfer, the UMFT60xx modules support 2 parallel slave FIFO bus protocols with an achievable data burst rate of around 400MBytes/s. The multi-channel FIFO mode can handle up to 4 logic channels. It is complemented by the 245 synchronous FIFO mode, which is optimised for more straightforward operation.

FTDI Chip
www.ftdichip.com

Video fusion IP core targets FPGA and SoC systems

RFEL has updated its flagship Video Fusion high definition video processing IP core for FPGA and System-on-Chip systems, with sophisticated enhancement and customisable pseudo-colour mapping features to help product designers add a competitive edge to their systems. Fusion as a concept is simple: create a single video of a scene that combines feature information from two cameras, one operating in the visible spectrum and one in the infrared (IR) spectrum. The fused result provides complementary information that can sustain operation in low light, poor weather conditions and in the presence of smoke or other obstructions. To meet the highest Fusion performance, RFEL has taken the multi-resolution approach at the heart of the Video Fusion IP core, and added important enhancements, such as colour noise suppression, important for natural looking results in low-light conditions. Pseudo colour pixel depiction is also new for 2015, and gives designers the ability to highlight key temperature differences in a scene, with fully customisable colours for hot objects in the scene, in preference to the natural contrast grey levels. This can be controlled in realtime, so that users do not have to compromise when their mission changes from situational awareness to surveillance. The IP includes real-time warp capability to pixel-align the slightly different fields of view typical of side-by-side sensors arrangements, which relaxes mechanical design tolerance and maintains accurate results.

RFEL
www.rfel.com

Printable electronic inks cure at only 60°C

DuPont Microcircuit Materials (DuPont) is launching electronic inks that cure quickly at low temperatures, down to 60°C, expanding the possibility of printing electronics onto an entirely new group of plastic films. The technology is expected to enable electronic components such as sensors, heaters and antennas to be printed on more versatile and less expensive substrates. Historically, electronic inks have required curing temperatures between 100°C and 140°C restricting electronic substrates to those that can survive at high temperatures. The new DuPont PE827 and PE828 low-temperature inks expand substrate choices for new fields of applications using substrates such as PVC, polystyrene, high-density polyethylene, and acrylic polymers, among others.

DuPont Microcircuit Materials
http://mcm.dupont.com
4-quadrant positioning motion controllers feature integral output stage

Pittman Motors is introducing its latest offering: the BGE Series of Servo Motor Controllers, a family of compact 4-quadrant positioning motion controllers with integral output stage to control Pittman brushless and brushed DC motors. The motion controllers can be operated in stand-alone operation with digital or analog IO or as a slave in a CANopen network with device profile DSP 402, protocol DS 301. The family of motion controllers is rated from 12VDC to 60VDC input voltage and 4 amp to 20 amp continuous output current. The BGE Series controllers are suitable for use with Pittman brushless or brushed DC motors. Information about the motor’s rotor position can be supplied to the positioning controller by an encoder or integrated Hall sensors contained within a brushless motor. The controls incorporate protection against over-voltage, low voltage and excessive temperature. If 4-quadrant digital speed control is desired, the control can be commanded to run in either direction, stop and hold with torque, and stop without torque (coast) through digital inputs. Other inputs can switch between programmed speeds or allow for a variable analog speed reference. Accel/decal ramps for the motor also can be programmed. The control offers the capability for a motor to function as a stand-alone or programmed servo, which interfaces to the rest of the machine via digital and analog IO. The BGE Series electronic controllers offer many different modes of operation to choose from, such as analog or digital torque control, analog or digital speed control and digitally selectable position control (relative, absolute, and modulo). The controls incorporate protection against over-voltage, low voltage and excessive temperature. If 4-quadrant digital speed control is desired, the control can be commanded to run in either direction, stop and hold with torque, and stop without torque (coast) through digital inputs. Other inputs can switch between programmed speeds or allow for a variable analog speed reference. Accel/decal ramps for the motor also can be programmed. The control offers the capability for a motor to function as a stand-alone or programmed servo, which interfaces to the rest of the machine via digital and analog IO. The BGE Series electronic controllers offer many different modes of operation to choose from, such as analog or digital torque control, analog or digital speed control and digitally selectable position control (relative, absolute, and modulo). The controls incorporate protection against over-voltage, low voltage and excessive temperature. If 4-quadrant digital speed control is desired, the control can be commanded to run in either direction, stop and hold with torque, and stop without torque (coast) through digital inputs. Other inputs can switch between programmed speeds or allow for a variable analog speed reference. Accel/decal ramps for the motor also can be programmed. The control offers the capability for a motor to function as a stand-alone or programmed servo, which interfaces to the rest of the machine via digital and analog IO. The BGE Series electronic controllers offer many different modes of operation to choose from, such as analog or digital torque control, analog or digital speed control and digitally selectable position control (relative, absolute, and modulo). The controls incorporate protection against over-voltage, low voltage and excessive temperature.

Pittman Motors
www.pittman-motors.com

Circular customisable OLED modules 2.87cm in diameter

Custom and semi-custom display specialist andersDX has extended its range of circular display modules with the addition of a round OLED display module. The new 1.13” (2.87cm) Passive Matrix OLED TFT Display is again targeted at wearable electronics, especially in the healthcare and fitness sectors and is manufactured by Truly Semiconductor. The module is fully customisable and also offers an attractive option in a number of industrial applications. andersDX announced a 1.48” round touchscreen module in July. The andersDX OEL9M0082-W-E PMOLED module has an active area of 28.8x28.8mm and a resolution of 128 x 128 dots. The recently announced round touchscreen module is also fully customisable with affordable NRE and tooling cost structures.

andersDX www.andersdx.com

MEMS crash sensors complete airbag kit from ST

STMicroelectronics has introduced two central airbag crash sensors alongside its peripheral crash sensors, airbag system ICs, and safety microcontrollers, creating a complete airbag-electronics kit that supports stringent automotive-application and functional-safety requirements. The AIS1120SX and AIS2120SX single- and dual-axis 120g in-plane MEMS accelerometers are designed to be mounted in the vehicle’s Airbag Control Unit (ACU) responsible for evaluating the sensor data and triggering the appropriate restraint system. Each sensor includes two independent sensing channels for redundancy and incorporates both slow and fast offset cancellation as well as precise temperature compensation for optimum stability. Built-in power-on self-test ensures reliability and run-time diagnostics help developers achieve the required level of functional safety. Both sensors have standard 400 Hz signal bandwidth, which the engineer can extend to 1600 Hz. ST has used its MEMS technology to integrate the precision mechanical sensing element in the same package with a 3.3V-compatible interface IC featuring a 14-bit digital SPI output. The AIS1120SX and AIS2120SX sensors are specified over the extended temperature range from -40°C to +105°C. They will enter full production in Q1 2016 in a plastic fully-moulded SOIC8 package. ST offers the devices as a package that includes a safety microcontroller, which coordinates airbag activation. Three airbag system ICs, the L9678, L9679, and L9680 meet the demands of applications ranging from entry or mid-level to high-end vehicles with multiple airbag firing loops. These devices, which integrate system power management, sensor interfaces, switch interfaces, and arming safety logic, are responsible for decoding the sensor data and forwarding results to the microcontroller.

STMicroelectronics www.st.com

16-bit flash MCU drives 352 segment display

Seiko Epson has released samples of its S1C17W18, a 16-bit flash microcontroller at 1.2V and capable of driving 352 segment displays by achieving 40% less current consumption in operating mode than the company’s previous offering. Delivered in a SQFN9-64 pin package, the device can operate on a small, low-capacity button battery and can be connected to a variety of sensors making it suitable for mobile applications. Target applications include high-performance watches, remote controls, healthcare devices, security tokens or any other small portable electronic devices. The S1C17W18 draws just 150µA/MHz in RUN mode, with a 0.15µA current consumption in SLEEP mode. This low current consumption was achieved through the development of a new flash memory that can be rewritten on a single 3V power supply, with 1,000 guaranteed rewrite cycles. Built-in oscillator circuits can output seven different frequencies, as precise temperature compensation for optimum stability. Built-in power-on self-test ensures reliability and run-time diagnostics help developers achieve the required level of functional safety. Both sensors have standard 400 Hz signal bandwidth, which the engineer can extend to 1600 Hz. ST has used its MEMS technology to integrate the precision mechanical sensing element in the same package with a 3.3V-compatible interface IC featuring a 14-bit digital SPI output. The AIS1120SX and AIS2120SX sensors are specified over the extended temperature range from -40°C to +105°C. They will enter full production in Q1 2016 in a plastic fully-moulded SOIC8 package. ST offers the devices as a package that includes a safety microcontroller, which coordinates airbag activation. Three airbag system ICs, the L9678, the L9679, and the L9680 meet the demands of applications ranging from entry or mid-level to high-end vehicles with multiple airbag firing loops. These devices, which integrate system power management, sensor interfaces, switch interfaces, and arming safety logic, are responsible for decoding the sensor data and forwarding results to the microcontroller.

Seiko Epson Corporation www.epson-electronics.de
Compensated, amplified pressure sensor takes 1 psi to 150 psi
Acal BFi is now stocking Honeywell’s new ABP series of basic amplified board mount pressure sensors to the European market. Boasting high performance and reliability in a compact package, Honeywell’s ABP series provides the industry’s smallest, compensated, amplified pressure sensor in its class at 8x7x3mm. In addition, its small size helps to significantly save board space and reduce manufacturing costs and its low current consumption (2uA) with sleep mode enabled allows for use in battery powered applications. Suitable for use across a wide pressure range, from 1 psi to 150 psi, the ABP series is ideal for medical and industrial applications, including blood pressure monitoring, ventilators and air brakes due to its enhanced sensitivity.
Acal BFi
www.acalbfi.com

USB-to-SDIO host IC expands microSD-compatibility
Designed by Elan Digital Systems, the VUB300 is a unique IC that converts a USB interface into an SDIO Host Interface, suited to SD or microSD cards. The VUB300 is a single-chip USB-to-SDIO hardware bridge that allows SDIO- and SD-compliant devices to be connected to any host PC via its USB port. The VUB300 is the ideal solution when a target system has no spare SDIO ports but does have available USB ports. The capability and intelligence to handle both the USB and SDIO protocols is all in hardware, allowing the IC to seamlessly translate data between the two formats.
Saelig
www.saelig.com

Crowdfunded CodeBug nano-board now at element14
CodeBug is a GBP12.50 crowdfunded nano-board designed to teach beginners the fundamentals of programming and electronics in a friendly non-intimidating way. First announced on Kickstarter in March 2015, following 3 years of development, CodeBug made the leap into mainstream development and is now being launched on a global scale with the help of electronics distributor element14. CodeBug defines a new class of microprocessor board that anyone can get results with in minutes using just a web browser. The device is programmed in a standard web browser through the companion website www.codebug.org.uk with the drag and drop ‘Blockly’ blocks, eliminating the need for any complicated setup or drivers/software to be installed.
Farnell element14
www.element14.com/codebug

FreeStor Software now available throughout EMEA
FalconStor Software, a 15-year innovator of software-defined storage solutions, is now making its FreeStor platform available in the EMEA region through London-based Beta Distribution, one of the UK’s largest independently owned IT product distributors. By distributing only a small handful of vendors and products in each category – FalconStor now one of them – Beta is able to offer best-of-breed IT products at competitive pricing. As the first to resell FreeStor in the UK, Beta will take a lead role in the country and more broadly throughout EMEA, particularly in the – Belgium, the Netherlands and Luxembourg where the demand is strong. With FreeStor, resellers have a trouble-free way to transition their customers’ legacy storage environments to modern paradigms like flash and cloud.
Beta Distribution PLC
www.betadistribution.com

Right angle tricolour SMT LEDs light up to 155 degrees
Kingbright’s KPFA-3011 series of tricolour (RGB) chip-type LEDs are now available in the UK from specialist passives distributor Components Bureau. Featuring a wide viewing angle (up to 155 degrees), the compact size, narrow footprint and low profile (only 1.0mm high) makes this right-angle LED well suited for backlighting and indicator panel applications. Each of the three colours on the KPFA-3011 series LED can be controlled independently via the 6-pin inputs. To facilitate pick and place, the LEDs are tape & reel packaged with a moisture sensitivity level (MSL) of 3 and in quantities of 2000 pieces.
Components Bureau
www.componentsbureau.com

RS adds electrical design tool to free CAD portfolio
DesignSpark Electrical is the latest free software package to be made available by distributor RS Components. The tool brings time-saving and error-reduction benefits to electrical system design, RS says. In electrical design, there are many engineers who have not had the productivity gains taken for granted in, for example, the PCB design sector – RS asserts. The tool offers a wiring-based approach – wiring line diagrams – to system planning that is familiar to electronic and PCB engineers. From a connectivity base, engineers can call real components from a library, complete connectivity with automatic wire numbering (maintained through changes), and proceed to populate cabinets, with assistance in making the optimum choice in terms of cabinet size and similar parameters.
RS Components
www.rs-online.com
Volkswagen’s failure
By Christoph Hammerschmidt

It went through the press like a thunderstorm: Volkswagen installed a software in its diesel engine controllers that detected when the car was under test. In such situations it reduced the harmful exhaust to the legal limit; otherwise it blew untenable many exhaust fumes into the air. The trick clearly was applied to circumvent the environmental legislation in the USA and other countries. Volkswagen CEO Martin Winterkorn was forced to step back – but which effects will this revelation have?

It’s a shame for the German automotive industry that an honourable company like Volkswagen resorts to such means to better its position in the competition. There could be no other solution for Mr. Winterkorn than to step back. There is reason to fear that this dirty little trick has the potential to substantially damage the standing of the Volkswagen group, the diesel technology and the German automotive industry as a whole.

The damage obviously includes Audi as Volkswagen’s noblest sister, simply for the reason that Audi uses the same engines. The same holds true to the other members of the Volkswagen group, SEAT and Skoda. As far as I know, Audi already admitted that they used the same software. Porsche is in a different position. First because they only joined the VW group in 2009 while the technology in question was developed before 2005. Porsche never used these engines, and the diesel technology has only a subordinated significance for Porsche with its roots deeply in the sports car business.

The move also damages the credibility of the diesel technology across all manufacturers. While well established in Europe as a very economic and lasting type of engine, in the US the diesel technology always fought an uphill battle. I believe the reason for the distant attitude of the American customers towards the diesel technology was not due to the exhaust behaviour of these cars, but the current scandal is grist to the mill of the adversaries. Their impression must be that apparently the technology is difficult to handle in terms of eco-friendliness, and that it takes many engineering efforts to get the exhaust into the legal limits. While I still believe diesel is environmentally friendly, the simple fact that Volkswagen believed they needed such a shabby trick hints that it really takes more efforts to tame a diesel than a gasoline engine.

And there is another open question: How can it be that a rock-solid engineering company like Volkswagen is unable to achieve the correct exhaust gas limits if their competitors can? Are Daimler, BMW or Opel engineers better persons? I don’t believe so. In particular not because the German auto industry has, despite all competition, somewhat of a family, every member knows pretty well what the other one does. So if the competitors get their diesel values right, is this because their engineers and engines are so much better than Volkswagen’s?

Or - horrible idea - did they perhaps use similar means? Daimler’s Zetsche already said they did not, and Zetsche seems to me like an honest man. But Winterkorn seemed trustable too, until very recently. But potential car buyers across the world will ask themselves the same question. And this is the real damage: The customer’s confidence is annihilated. This is a much bigger damage than any penalty Volkswagen may have to pay.

After this catastrophic scenario, Volkswagen and the German automotive industry have to look ahead. The only way to handle such a situation is: Clear up, take the measures necessary to prevent such a dumb, idiotic conduct for all times, clean up the wreckage and continue to build fine cars. Without any tricks.
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**PRODUCTRONICA 2015: WHERE INNOVATIONS ARE AT HOME.**

Find out more: productronica.com/exhibition-profile

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**PCB & EMS CLUSTER.**
PCB and circuit-carrier manufacturing, electronic manufacturing services (EMS).

**SEMICONDUCTORS CLUSTER.**
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**CABLES, COILS & HYBRIDS CLUSTER.**
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Find out more: productronica.com/exhibitionfields
HIGHLIGHT DAYS IN 2015.

FIND OUT TODAY WHAT WILL MOVE THE INDUSTRY TOMORROW.
Anyone who wants to find out what moves the industry will find answers about the future here. Thanks to all its panel discussions, lectures and roundtable discussions, productronica is the best place to get up to speed on the latest developments quickly. Which makes it the perfect opportunity for you to get ideas and information on three aspects of electronics production that will give you lasting inspiration.

HIGHLIGHT DAY:
AUTOMOTIVE ELECTRONICS MANUFACTURING.
Experience tomorrow’s mobility today—among other things, these events will examine the role of electronics production in autonomous driving, future-oriented operating and display concepts and connectivity between people and their vehicles.

When: November 11, 2015
Where: Cables, Coils & Hybrids Speakers Corner,
Hall B2, Stand 365
What: Lectures, discussions, roundtable

Find out more: productronica.com/en/highlights
HIGHLIGHT DAY:
ELECTRONIC MANUFACTURING SERVICES (EMS).
Although EMS used to be limited to the mass production of electronic assemblies, suppliers have since expanded their areas of expertise. That includes things like safeguarding their ability to deliver as well as obsolescence management and automation concepts in process and workflow management. If you have an idea for a new product, you will find a suitable system solution here.

When: November 11, 2015
Where: PCB & EMS Speakers Corner, Hall B1, Stand 360
What: Lectures, discussions, roundtable presentation of the BestEMS 2015 Reader Award

HIGHLIGHT DAY:
MANUFACTURING INDUSTRIAL ELECTRONICS.
As a whole, the machine-building industry is a large consumer industry for electronics: Manufacturers must meet special requirements when it comes to reliability and precision and deal with constant competition for export markets around the world. Manufacturing industrial electronics always calls for new solutions to meet the market’s needs such as complexity, just-in-time delivery, zero-defect strategies and price pressure. Frequently mentioned catchwords include intelligent software solutions, networking and Industry 4.0. But where do things really stand today? Information about the latest trends is available here.

When: November 12, 2015
Where: Innovation Forum, Hall B3, Stand 451
What: Lectures, discussions, roundtable
OPENING UP NEW VISTAS.
A trade fair like productronica wants to do more than provide comprehensive information. All the insights and outlooks that you can get at our special shows are just as important. To develop your own ideas, find solutions to problems that appear unsolvable or simply discuss things with the right person.

SPECIAL SHOW:
ELECTRONICS.PRODUCTION.AUGMENTED.
Making production innovations from the five new clusters an experience to remember—that is the motto of the special show at productronica. The world’s leading trade fair for electronics production will examine the hot topic of Industry 4.0 from a new perspective: Visitors should be able to personally experience previously concealed procedures that machines and workpieces negotiate during production and find out how people are integrated into Industry 4.0—using augmented and virtual reality on five selected electronics manufacturing machines.

When: productronica.com/event-database
Where: Hall B3, Stand 133

SPECIAL SHOW: IPC HAND SOLDERING COMPETITION.
Who solders the best? For the second time, productronica and the IPC (USA/Europe) are organizing a hand-soldering competition. Soldering complex circuit boards is a form of high art. After all, maximum dexterity is the only way to get fault-free products. That is why we are looking for stars in this discipline. Would you like to be crowned champion? Then take part in the IPC Hand Soldering Competition!

When: productronica.com/event-database
Where: Hall A2, Stand 405

Find out more: productronica.com/specialshows
SPECIAL SHOW: CLEANROOM EVENT STAGE.
“Cleanroom Experience—Modern Art of Cleanliness.”
Live interactive sessions on the entire process chain cover everything from planning, designing and setting up a cleanroom to operation, equipment including furnishings, providing clothing and consumables, the final metrological inspection and cleaning and training in everyday surroundings.

When: Several times every day
Where: Hall B3, Stand 151

SPECIAL SHOW: HANDS-ON SESSION.
Live demonstrations of products and processes as well as presentations by several exhibitors.

When: productronica.com/event-database
Where: All halls

CEO ROUNDTABLE.
Be there when the industry’s most brilliant minds evaluate the latest trends and developments and present their visionary ideas. This event will give you valuable insights into future requirements and allow you to experience entrepreneurs that you would otherwise only know from the press.

When: November 10, 2015, 11:00–12:30
Where: Innovation Forum, Hall B3, Stand 451
What: Cyber Security—Challenges for the Manufacturing Industry
PRODUCTRONICA INNOVATION AWARD 2015.

To mark its 40-year anniversary, productronica and “productronic” magazine are presenting the productronica innovation award in all five cluster categories. All exhibitors can submit their innovations and present them to a global forum. The winners and their product innovations will be announced directly at the exhibition stands of the respective exhibitors.

When: November 10, 2015, 18:15
(for exhibitors only)
Where: Hall A1, SMT Speakers Corner

PCB & EMS MARKETPLACE.

CENTRAL, CONCENTRATED AND NETWORKED.
The PCB & EMS Marketplace is a very special success story. It is being held for the third time and is certain to be a popular attraction again this year. After all, nowhere else is the fascination of productronica so immediately tangible. So be there when all of the industry’s relevant players come together at this unique discussion and lecture platform.

When: On all four days of the fair
Where: Speakers Corner: Lectures and discussions on future industry topics.
Meeting Corner & Lounge Corner: The forum for exciting discussions.
First-rate lectures and exciting panel discussions await you at productronica. There will be multifaceted sessions on current and future market and technology topics. The Speakers Corners depict all the clusters and are platforms for in-depth discussions. Take advantage of this opportunity to be inspired.

**FORUMS.**

**INNOVATION FORUM.**
CEO Roundtable, presentation of the Global SMT Awards, highlight topic “Manufacturing industrial electronics,” lectures about topics that pertain to the Semiconductors and Future Markets clusters.

**When:** productronica.com/event-database
**Where:** Hall B3, Stand 451

**SMT SPEAKERS CORNER.**
Presentation of the productronica innovation awards, award ceremony for the IPC Hand Soldering Competition, lectures on topics that pertain to the SMT cluster.

**When:** productronica.com/event-database
**Where:** Hall A1, Stand 411

**PCB & EMS SPEAKERS CORNER.**
Highlight topic “Electronics manufacturing services” (EMS), EMS Roundtable, lectures on topics that pertain to the PCB & EMS cluster, presentation of the BestEMS 2015 Reader Award.

**When:** productronica.com/event-database
**Where:** Hall B1, Stand 360

**CABLES, COILS & HYBRIDS SPEAKERS CORNER.**
Highlight topic “Manufacturing automotive electronics,” Automotive Roundtable, lectures on topics that pertain to the Cables, Coils & Hybrids cluster, Student Day.

**When:** productronica.com/event-database
**Where:** Hall B2, Stand 365

Find out more: productronica.com/forums
IT2INDUSTRY.
Trade fair and accompanying open conference, focuses on networking important topics such as production, information technology and IT security as we move toward the industrial Internet of Things.

When: November 10–13, 2015
Where: Hall B3

JOB-AREA.
Our partner semica has two attractions for people who are looking for jobs. Interested parties can search for their dream job at the fair’s job wall, or they can search for interesting job offers online at semica.de/en.

When: On all four days of the fair
Where: Hall B3, Stand 124

STUDENT DAY.
Our careers partner semica also has an encounters platform for students. This is a unique opportunity to meet potential employers and sound out future prospects together.

When: November 13, 2015
Where: Cables, Coils & Hybrids Speakers Corner, Hall B2, Stand 365

Find out more:
it2industry.de/en & productronica.com/events
AWARDS.
- productronica innovation award
- BestEMS 2015
- Global SMT Award

When:  All award ceremonies at productronica.com/event-database
Where:  SMT Speakers Corner, Hall A1, PCB & EMS Marketplace, Hall B1 and Innovation Forum, Hall B3

MATCHMAKING.
To help you perfectly plan your visit to the fair, every week you will receive a list of all exhibitors that match your profile. You can also use the productronica matchmaking planner to make appointments directly.

When:  As of August
Where:  productronica.com/matchmaking-2015
ALL OF PRODUCTRONICA AT A GLANCE.

Find out more: productronica.com/exhibitionfields
The West Entrance will be open for productronica 2015. The East Entrance will be used for InPrint 2015, which takes place at the same time as productronica.

**A1 SMT cluster**
Test and measurement, quality assurance
- SMT Speakers Corner

**A2 SMT cluster**
Test and measurement, quality assurance • Component mount technology • Production logistics and material-flow technology

**A3 SMT cluster**
Component mount technology

**A4 SMT cluster**
Soldering and joining technology for PCBs • Product finishing

**B1 PCB & EMS cluster**
PCB and other circuit carrier manufacturing • Electronic manufacturing services (EMS)
- PCB & EMS Speakers Corner

**B2 Cables, Coils & Hybrids cluster**
Technologies for cables processing and connectors • Coilware production • Hybrid component manufacturing
- Cables, Coils & Hybrids Speakers Corner

**B3 Future Markets cluster**
IT2Industry IT²
November 10–13, 2015
IT to Production, Industry 4.0, Technologies for batteries and electrical energy storage • Organic and printed electronics • 3D printing, additive manufacturing

**B3 Semiconductors cluster**
Semiconductor manufacturing • Display manufacturing, LEDs and discrete devices • Photovoltaics manufacturing • Micro-/nano-production • Cleanroom technology • Materials processing • Innovation Forum

In the halls of productronica
Overall Production Support:
Production subsystems, operating supplies and equipment, environmental technology, services

**A6 Parallel event**
InPrint 2015 INPRINT
November 10–12, 2015

Find out more:
productronica.com/exhibitionfields
PRODUCTRONICA’S OPENING HOURS.

Tuesday–Thursday: 9:00 to 18:00
Friday: 9:00 to 16:00

THE PRINT@HOME TICKET: QUICK, CONVENIENT, AFFORDABLE.
The new Print@home Ticket saves you time otherwise spent waiting at the box office and allows you to plan your visit to the fair more effectively. Simply go online, register in advance and print out your admission ticket. Please keep in mind that your ticket does not entitle you to use public transportation free of charge.

THE PRODUCTRONICA APP.
Completely revised and with improved performance, the new productronica app allows you to call up exhibitor lists, events, dates, interactive hall diagrams and much more directly from your Android smartphone or iPhone.

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<th>PRICE LIST.</th>
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<td>1-day ticket*</td>
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<td>2-day ticket*</td>
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<td>Permanent pass*</td>
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<tr>
<td>Discount tickets* (groups of 10 people, students, retirees)</td>
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* Includes the exhibition catalog
Detailed information about prices, discounts or special conditions is available at productronica.com/en/tickets

FREE FOR REGULAR VISITORS!
If you attended productronica in 2011 or 2013 or have registered for our newsletter, you will automatically receive a voucher for a 1-day ticket by e-mail.

GETTING THERE & ACCOMMODATIONS.

GETTING THERE BY PLANE.
If you want to fly to Munich, be sure to contact Lufthansa, productronica's official airline, and ask about our special fares. And use our shuttle service, the convenient way to get from the airport to productronica.

GETTING THERE BY TRAIN.
Thanks to a special offer from Messe München GmbH and German Rail, fares to Munich start at just EUR 99. Then take the U2 subway directly to the “Messestadt West” station.

GETTING THERE BY CAR.
The Messe München trade-fair center is located directly on the A 94 motorway; take the “Feldkirchen-West” or “München-Riem” exit. Simply follow the signs or enter the following address into your navigation system: Am Messesee, 81829 München. A traffic-guidance system at the trade-fair center will direct you to the nearest available parking.

OVERNIGHT ACCOMMODATIONS.
Please be sure to book your hotel room early. After all, productronica is real visitor magnet.

Find out more: productronica.com/travel & productronica.com/accommodation
productronica enjoys the support of international trade associations, organizations, interest groups and the media. As a result, it has valuable ties to the industry that guarantee that the fair’s structure is in touch with the industry’s latest developments.