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FEBRUARY 2017

HOW TO BUILD SECURE AND MANAGEABLE IOT SYSTEMS

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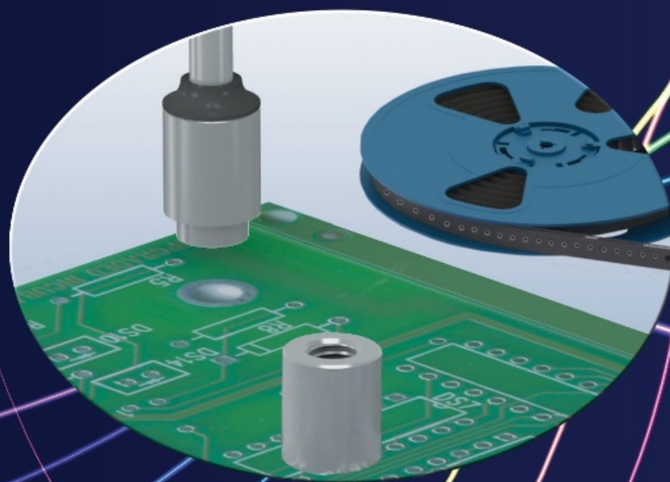

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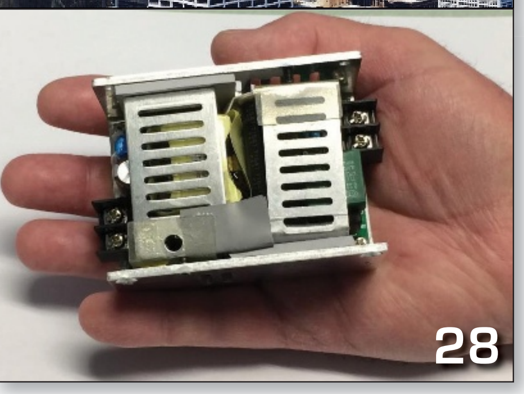

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EDITORIAL STAFF
516-667-2300 FAX: 516-667-2301

Managing Editor **Greg Lupion**
516-667-2379 • glupion@aspencore.com

Senior Technical Editor **Paul O'Shea**
941-359-8684 • poshea@aspencore.com

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1225 Franklin Avenue, Suite 400
Garden City, New York 11530
TEL: (516) 667-2300 • FAX: (516) 667-2301

Victor Alejandro Gao
General Manager

Steve Cholas
Group Publisher Electronics Group

Alliance for Audited Media

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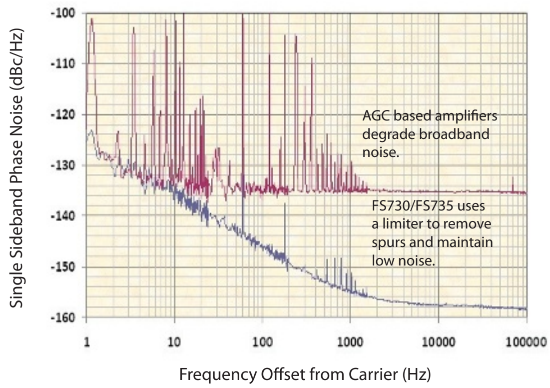

Additive phase noise in 10 MHz Distribution Amplifiers: Limiter vs. AGC Designs

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The risk of RISC-V

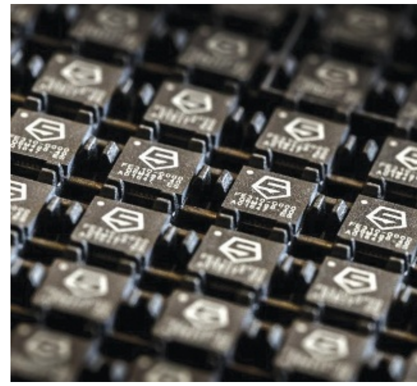
This month, SiFive will launch an Arduino version of its open-source RISC-V processor on Crowd Supply. In doing so, it spotlights the question of just how practical it is to launch a new processor architecture when so many efforts to do so have failed, especially when there are two perfectly good architectures available and there are so many other ways to innovate — on top of the hardware.

The argument for RISC-V goes something like this: It's an inherently better architecture than the x86 (complex instruction set computer, or CISC) or ARM (reduced instruction set computer, or RISC); free is good; and being open and extensible at the instruction-set level allows for unprecedented levels of innovation and flexibility from "the community."

Given the cost of custom silicon, the need for ultra-low power, the dependence upon the x86, and the uncertainty surrounding ARM with its buyout by Softbank, RISC-V's star is rising rapidly. It was hailed as "the Linux of microprocessor architectures" by none other than Linley Gwennap's Microprocessor Report, which signed off on it as the best technology of 2016.

Of course, over the years, we have seen many great technologies come and go: the famous transputer, then Transmeta, and during the 1990s and early 2000s, there were a host of wonderful signal-processing architectures to tackle wireless and wired communications. But they're gone. Why?

Putting marketing and timing aside for now, it's just plain hard to launch a new architecture: Infrastructure support, software support, manufacturing, and related IP support are just a few of the issues. Then there's fear of the unknown: There needs to be a really clear return on



With the RISC-V ISA, SiFive is working to make custom ICs viable.

risk (RoR) for a designer to even think about putting their company's fortune on the line by selecting a new architecture, especially when there are at least three perfectly good architectures available: x86, ARM, and MIPS (also RISC).

The x86 and ARM architectures are also well supported and have solid roadmaps. While there are fees associated with using them, those fees are a small portion of any given design, and with them come assurances of continuity and ecosystem support. This support is critical for even ultra-low-cost MCUs in which a "free" RISC-V architecture might start to look attractive, especially if it can follow through on processing efficiency.

Still, the 50 paying members of the RISC-V Foundation aren't newbies to the processing game, including Google, Hewlett Packard Enterprise, IBM, Nvidia, AMD, and Qualcomm. They are encouraging the groundswell of support for the RISC-V, particularly from academia. In fact, the group's latest workshop was held on the Google campus in December to packed rooms.

For many, this groundswell of support is almost like the early days of Linux, and that's where RISC-V starts to get interesting: it's almost got a cult feel to it. At the head of the cult is David Patterson, who coined the term RISC and set the RISC-V movement on fire with a 2014 paper on the topic, "Instruction Sets Should Be Free: The Case For RISC-V" (EECS, August 6, 2014). In the paper, Patterson laid out the case, including the patent minefield that current architectures represent, performance compromises, and the comment that even long-standing companies that may support current ISA architectures do go away in time, giving DEC as an example.

Of particular interest, given what's happening in today's highly charged security environment, is the note that a shared open core design would mean, "…transparency that would make it hard, for example, for government agencies to add secret trap doors." That in itself might be enough to fan the flames of the RISC-V movement.

Still, there's another factor: The interest of Google can always be dismissed as yet another fire into which Google would like to stick a poker — just to see what happens. But there's more to it than that. While open-source hardware is a whole lot more complex than open-source software (*à la* Linux) — and we know how hard that was to get off the ground – there is the same level of engineering community interest in making it happen.

While open-source hardware is a whole lot more complex than open-source software, there is the same level of engineering community interest in making it happen. Why? Because it's a challenge and a chance to up-end the status quo.

Why? Because it's a challenge and a chance to up-end the status quo. Engineers are happy to devote time, free of charge, just for the chance to be a part of that. With someone like (now-retired) David Patterson at the helm, that has staying power — much more than a venture-capital-funded startup with its own closed, proprietary architecture. It's going to be an interesting couple of years ahead.

Patrick Mannion

Reference:

https://people.eecs.berkeley.edu/~krste/papers/EECS-2014-146.pdf

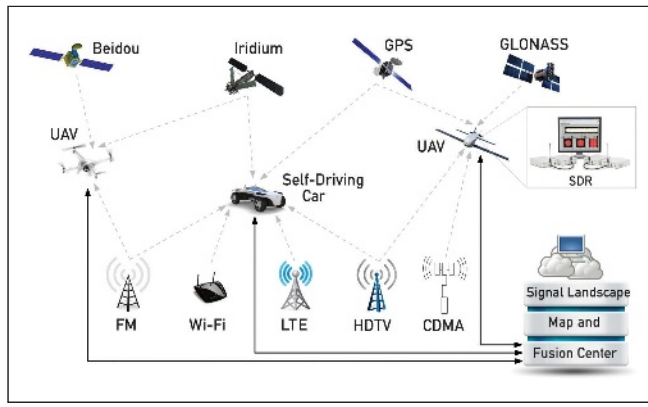
Innovations impacting products, technology, and applications

Next-gen navigation systems will use existing cellular signals to support autonomous vehicles

Researchers developed a highly reliable and accurate navigation system that exploits existing environmental signals and Wi-Fi instead of GPS

Researchers at the University of California, Riverside, have developed a reliable and accurate navigation system that exploits existing environmental signals, such as cellular and Wi-Fi, rather than the Global Positioning System (GPS). The technology can be used as a standalone alternative to GPS or complement current systems to enable highly reliable, consistent navigation. Additionally, this technology can be used to develop navigation systems that meet the stringent requirements of fully autonomous vehicles, such as unmanned drones or driverless vehicles.

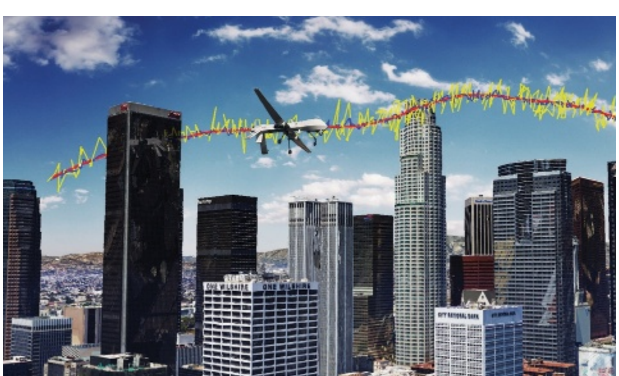
Spearheaded by Zak Kassas, assistant professor of electrical and computer engineering in UCR's Bourns College of Engineering, the team presented its research at the 2016 Institute of Navigation Global Navigation Satellite System Conference in Portland, OR, last September. The two studies, "Signals of Opportunity Aided Inertial Navigation" and "Performance Characterization of Positioning in LTE Systems," both won best paper presentation awards.



The schematic shows how UCR researchers are using existing communications signals to complement satellite-based navigation systems such as GPS for the control of driverless cars and UAVs. Image source: UCR.

Most navigation systems in automobiles and portable electronics use the space-based Global Navigation Satellite System (GNSS), including the U.S. system GPS, Russian system GLONASS, European system Galileo, and Chinese system Beidou. When it comes to precision technologies, such as aerospace and missiles, navigation systems usually combine GPS with a high-quality on-board Inertial Navigation System (INS), which delivers a high level of short-term accuracy but eventually drifts when it loses touch with external signals.

But despite advances in such technology, current GPS/INS systems won't be able to meet the demands of future autonomous vehicles for a number of reasons. On their own, GPS signals are weak and unusable in certain environments, such as deep canyons. They're also susceptible to intentional and unintentional jamming and interference, and civilian GPS signals are unencrypted, unauthenticated, and specified in publicly available documents, making them hackable.



Simulation results for an unmanned drone showing the true trajectory (red) with GPS navigation only (yellow) and GPS aided with cellular signals (blue). Image source: UCR.

Because of the reasons above, current trends in autonomous vehicle navigation systems rely not only on GPS/INS but a suite of other sensor-based technologies, such as cameras, lasers, and sonar.

"By adding more and more sensors, researchers are throwing 'everything but the kitchen sink' to prepare autonomous vehicle navigation systems for the inevitable scenario that GPS signals become unavailable," Kassas said. "We took a different approach, which is to exploit signals that are already out there in the environment."

Instead of adding more internal sensors, Kassas and his team in UCR's Autonomous Systems Perception, Intelligence, and Navigation (ASPIN) Laboratory are developing autonomous vehicles that could tap into the hundreds of signals around us at any point in time, like cellular, radio, television, Wi-Fi, and other satellite signals.

Nicole DiGiose

How to implement fingerprint authentication in automobiles

BY RAJA BOSE
Scientist and Research Technologist
Synaptics
www.synaptics.com

Automotive engineers continue to look to the smartphone to provide a model for the development of an increasingly sophisticated user experience, with the large center information display (CID) capacitive touchscreen being a good example. Now designers are adding another smartphone feature, the fingerprint sensor, to enhance and modernize the driver's interface to functions in and beyond the automobile.

This, and other forms of biometric authentication, show great promise if implemented with sensitivity to user privacy and the extremes of the automotive operating environment. However, developers must factor in that the use cases of biometric authentication in the car look set to differ, perhaps surprisingly, from those of the smartphone.

Personalizing the user experience

The obvious assumption about fingerprint sensing in the car is that it should be used as a convenient and secure replacement for the key — both for providing access to the cabin and for starting the engine. However, fingerprint sensing is an unsatisfactory form of security in vehicles for two reasons.

The first is convenience tied to usage model. A car may be driven by someone other than its registered owner in emergencies or when using a valet service. A fingerprint sensor, then, can never entirely replace a key.

The second is security. Fingerprint sensors have a "false acceptance rate" specification as they occasionally accept a stranger's fingerprint as that of the registered user. This is *not* acceptable to automobile manufacturers, so conventional wireless keys are not about to be superseded by fingerprint sensors on the door handle or start button.

However, fingerprint sensing does enable two far-reaching improvements to the user experience: personalization and payment authentication. The fingerprint sensor can quickly identify who is driving and configure user preferences accordingly, including seat, climate, and entertainment settings.

While personalization enhances the user experience, it also helps drivers take advantage of a car's sophisticated features and functions, many of which, in today's cars, are hidden behind multi-layered menu structures and complex sets of commands. Research has shown that for every step added to a user interface, 10% of the users drop out. Personalization via a fingerprint sensor reduces the number of steps to one or even none.

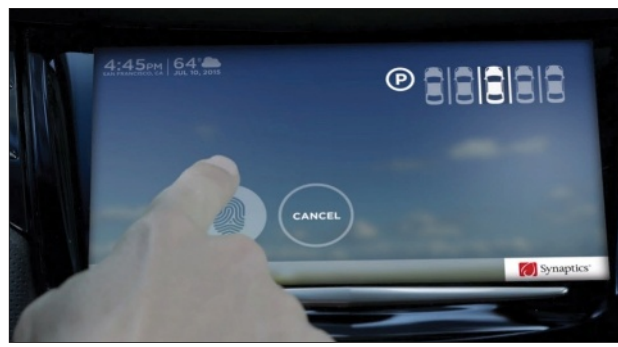


Fig. 1: Fingerprint sensing provides a quick and convenient way for the driver to authenticate a payment.

In-car fingerprint sensors can also simplify payments inside the car; for instance, when paying road tolls and parking fees or to charge a payment card at a drive-through store. At a parking garage, for example, a number-plate recognition system would automatically identify the car, and a payment backend would link the car to a pre-registered payment card (*Fig. 1*).

The payment terminal would then send a payment authorization request wirelessly to the car. The driver would then authenticate use of the payment card with a fingerprint.

Standards such as the UAF specification published by the FIDO Alliance (*fidoalliance.org*) define processes for acknowledging biometric indicators such as fingerprints as an alternative to passwords or PINs. Authentication by fingerprint is a far quicker and easier operation than leaning through the driver's door window to insert a card into a reader and then enter a PIN on a keypad.

Biometric indicator options

Along with fingerprint sensors, other forms of biometric sensing under consideration by automotive designers include facial recognition, iris recognition, and heart-rate variability (i.e., taken from a wireless health-monitoring wristband). There is also some interest in the potential to combine biometric indicators — such as heart rate, blood pressure, and perspiration — to determine the driver's state of health and state of mind. This might allow the car to issue an alert to the driver, for instance, to park the car and rest if the indicators suggest that the driver is drowsy or otherwise at risk. With the advent of advanced driver assistance systems (ADAS), the car may even take control from the driver and park itself in a safe place.

In the meantime, the preferred biometric indicator is the fingerprint as its operation is well understood by users and because the technology has already been proven in smartphones.

Choosing the optimal fingerprint sensor

When choosing a fingerprint sensor, the factors to consider include overall solution size and power consumption, reliability, accuracy, and range, such as in 3D applications. With this in mind, there are three mainstream fingerprint-sensing technologies available for automotive applications:

- Capacitive sensing: This is used in the world's best-selling smartphones due to small size — a sensing pad just a few tens of microns thick and a small controller IC — and low power consumption. Note, however, that there are a small number of instances when capacitive fingerprint sensing might fail due to "dry finger" problems or when the user has severe scarring or calluses.
- Optical fingerprint sensing: Optical sensors are highly reliable and accurate, and so they are widely used at border crossings. However, the sensors require a backlight to illuminate the finger and are still comparatively bulky compared to capacitive solutions.
- Ultrasonic sensing: This offers reliable detection of fingerprints in 3D but has not found its way into mainstream mobile devices and is a relatively expensive and unproven option.

Another consideration is design flexibility: It's important to ensure that the sensor can be included without adding surface space or cluttering the cabin. From this perspective, the same benefits of capacitive fingerprint sensing that appealed to smartphone designers appeal equally to automotive designers. A capacitive sensor's ultra-thin sensing pad gives designers more freedom with regard to styling, shape, and configuration of the sensor unit to suit the form and functions of the cabin (*Fig. 2*).

Along with saving space, this particular design allows the fingerprint sensor to be used with both the driver's hands on the steering wheel. In the demonstration, the fingerprint sensor was combined with a force sensor so that an authentication event may be triggered only when the pad is deliberately pressed. This avoids accidental authentication while hands are resting on the wheel.

Requirements for a successful implementation

There are three elements to a successful fingerprint-sensing implementation: the mechanical design of the sensing pad, the sensitivity of the controller IC, and the algorithms running on the IC for accepting or rejecting fingerprints.

The sensing controller IC and the software require specific domain expertise, so automotive system and subsystem designers should consider sourcing the technology from third-party suppliers instead of designing from scratch. Look for a supplier that has a proven track record,

Fig. 2: In a working steering-wheel demonstration (circled in red), the capacitive fingerprint sensor (inset) also doubles as a directional pad (D-Pad) for navigating the in-car user interface.

particularly in smartphones, in which high volumes and reliability are critical.

The mechanical design — the area and thickness of the sensing pad, the material it is made of, and its positioning in the vehicle — will be decided by the car manufacturer. However, OEMs can leverage a third-party fingerprint-sensor supplier's experimentation with many different configurations of the sensing pad for smartphone customers.

That said, the differences between consumer and automotive operating requirements are significant. For example, while a smartphone is typically upgraded every 24 months or so, cars can remain in operation for 10 to 12 years before replacement. This means that the fingerprint sensor, the material covering the sensor, and the MCU all have to operate reliably and look cosmetically appealing for a much longer period of time.

This is particularly challenging in an automotive environment that requires components to support extreme operating temperatures (–40°C to 85°C); be resistant to humidity, dust, sunlight, liquids and other environmental factors; and offer more robust resistance to ESD and RF interference.

To ensure reliability, designers should make sure that components adhere to automotive engineering standards like the ISO 11452 standard for automotive electromagnetic compatibility (EMC) and the Automotive Electronics Council (AEC-Q100) specification for use in harsh automotive environments.

Because they are used to protect access to sensitive information, fingerprint sensors will be attractive targets for hackers using a counterfeit fingerprint to gain access. This will require fingerprint systems to receive regular security software updates once the car leaves the factory, and future generations of a particular car model may also need to upgrade their fingerprint-sensor solution's processing and storage capabilities to keep pace with more complex anti-spoofing software.

As such, automotive designers and OEMs should look for fingerprint-sensor solutions from vendors with a roadmap for MCU support that allows for pin and software compatibility between MCU generations. It is also recommended that OEMs source their components from vendors with a solid track record for long-term product support.

Conclusion

As a proven technology, then, the capacitive method is set to be the first technology for fingerprint sensing to be adopted in the car. However, for a successful implementation, designers must be aware of the usage models and privacy concerns as well as the criteria under which to select a fingerprint-sensing option.

Time will tell whether it turns out to be preferred by the automotive industry in the longer-term, and there is no doubt that optical, ultrasonic, and other technologies will be evaluated and other forms of biometric sensing may be introduced.

In the meantime, capacitive fingerprint sensing is both liked and understood by users of smartphones, and it provides a ready-made way for automotive designers to make the user experience more convenient, more personal, and more secure. ☐

Advanced packaging: five trends to watch in 2017

Here is a bird's-eye view on how advanced packaging technologies are catching up with demands for integrating more die content in a single package in order to enhance chip bandwidth and lower power consumption

BY MAJEED AHMAD
Contributing Editor

Where does advanced packaging stand in 2017? Is it nearing an inflection point? The semiconductor industry is steadily running out of transistor scaling options, so the spotlight is inevitably turning to heterogeneous integration at the package level.

The innovation in packaging technology is also intertwined with the increase in functional density of large SoC solutions. So the focus on heterogeneous integration and wafer-level packages (WLP) has led the chip industry to a new set of solutions collectively known as advanced packaging.

It offers greater connectivity and lower power consumption compared to traditional packaging solutions. So they are faster despite the fact that they integrate more die content per package. Not surprisingly, therefore, advanced packaging has become a part of the chip industry's scaling and functionality roadmaps.

1. Watch out for TSMC's InFO

Fan-out, which offers much simpler implementation of heterogeneous integration than 2.5D and 3D packaging, offers smaller form-factors, thinner packages, and higher density I/Os. Moreover, it eliminates the need for process flows such as wafer bumping, fluxing, cleaning, underfill dispensing, and curing.

Fan-out technology made waves in 2016 when it integrated Apple's 16-nm A10 application processor with mobile DRAM in one package inside the iPhone 7. Apple used TSMC's Integrated Fan-Out (InFO) packaging technology, which the foundry had been developing since 2014.

Some media reports suggest that other mobile chipset suppliers — Qualcomm, MediaTek, and HiSilicon — are also considering TSMC's InFO technology for their 10-nm and 7-nm application processors.

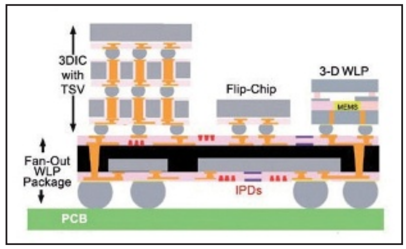


Fig. 1: Fan-out technology is extending to new application categories requiring greater pin counts.

However, when it comes to high-volume adoption of fan-out, the cost is still the elephant in the room.

TSMC's InFO initiative is most likely aimed at creating the economy of scale for fan-out packaging technology. It could bring down the cost and manage processing-centric challenges. For instance, handling signal routes going down to 1 to 2 microns.

2. How to make 2.5D/3D cheaper?

The technology media usually lumps 2.5D and 3D packaging solutions into a single industry jargon, mostly because they stack up multiple dies using interposers like through-silicon via (TSV).

However, 2.5D is an incremental step from traditional 2D IC packaging technology. It's easier to implement in terms of thermal and electrical properties and offers better capacity advantages due to shorter signal routing. In 3D IC packages, two or more dies are mounted on each other in full-fledged vertical mode.

The packaging solutions leverage high-bandwidth memory, high-speed interconnect, and space efficiency to move everything much closer. They stack die using silicon, glass, or organic interposers like TSV to manage communication between the die and the wafer.

However, the proximity of dies in 2.5D and 3D packaging cuts both ways. First, it leads to thermal issues caused by higher levels of integration. Second, warpage, caused by material and temperature differences between die and wafer, can eventually result in chip failures.

Companies like eSilicon are now offering analysis tools for thermal stress and warpage. Expect more tools to manage thermo-mechanical stress issues like materials mismatch during 2017. Still, the biggest challenge remains the high cost of the complex TVS process.

3. Seeking RDL improvements

Redistribution layers (RDLs) relieve I/O pitch on large chipsets that are packed with I/O features and play a critical role in signal distribution among multiple chips. So they have become an integral part of 2.5D/3D packaging solutions for providing communication between chips attached through the interposer.

The improvements in RDL technology will bring new levels of efficiency in routing and signal integrity domains. For example, it will be worth watching how mechanical stress is minimized in RDLs.

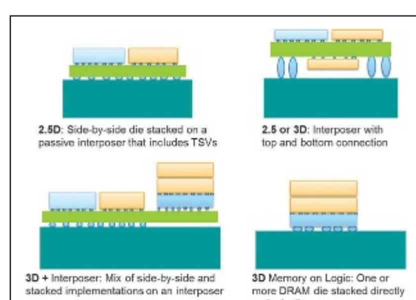


Fig. 2: 2.5D and 3D packaging solutions come in a variety of technical flavors. Image source: Mentor Graphics.

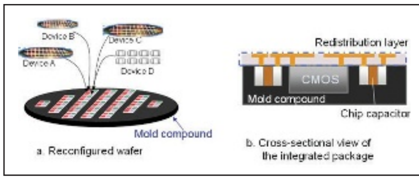


Fig. 3: Fujitsu's RDL packaging combines millimeter-wave signals generated by power amplifiers within an off-chip module.

4. TSV for consumer chips?

TSV is a key enabling technology in 2.5D and 3D packaging solutions. However, cost points are a major obstacle to their use in consumer chip markets like smartphones. So making TSVs cheaper is going to be a major goal in 2017.

Yole forecasts that TSVs will continue to grow in chip packaging markets for high-end graphics, networking, and datacenters. And TSV could also penetrate into new areas, such as ambient light filters, LED drivers, and RF filters.

5. The next HBM interface

The high-bandwidth memory (HBM) technology has already been implemented in 2.5D packages for high-end server and networking chips from vendors like AMD and Nvidia.

The fact that Hynix and Samsung have adapted the HBM2 standard is considered a huge boost for the 2.5D packaging industry. The HBM2 standard addresses capacity and clock rate limitations in the original HBM version. Take Hynix, which used HBM1 stacks for its 29-nm DRAM dies; the Korean chipmaker later moved to implement HBM2 memory for its 21-nm process.

Similarly, Samsung has started producing 4-GB DRAM packages using the HBM2 interface. And now both Hynix and Samsung are working on the follow-up technology to bring down the higher costs associated with HBM1 and HBM2 packaging. The HBM3 technology also promises to improve the density, bandwidth, and power efficiency of IC packages. ☐

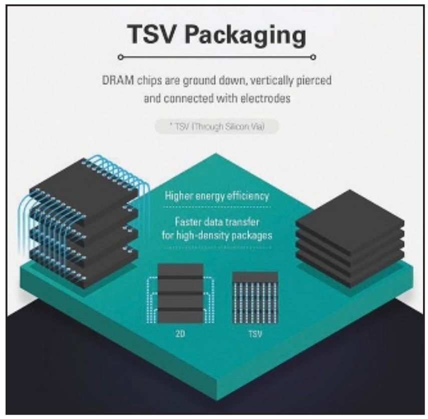


Fig. 4: TSVs pierce hundreds of fine holes through the dies and then vertically connect dies through the holes. That allows for faster data speeds and lower power consumption. Image source: Samsung.

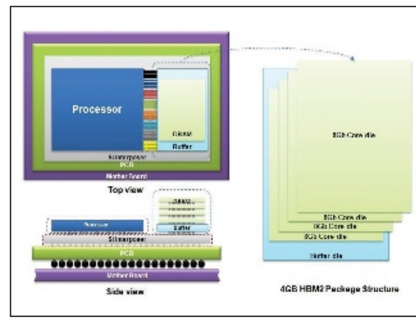


Fig. 5: Samsung's HBM2 package features 256 Gbps of bandwidth, doubling capacity of HBM1 DRAM package.

Wireless charging: evaluating the standards for next-gen products

BY AJ ELJALLAD
Senior Manager, Wireless Segment
ON Semiconductor
www.onsemi.com

Wireless charging is evolving to become a feature that users of smartphones, tablets, notebooks, and wearables are coming to expect as a basic product capability. One remaining challenge is that, while these devices don't all have the same power requirements, users want to limit the number of wireless charging stations they need — ideally, to just one. And among the factors to be considered in developing a single-station solution are the various standards that have emerged. This article looks at these competing standards and the optimum combination of standard and technology.

For years, mobile device users have been surfing the web, talking on the phone, and creating peer-to-peer connections — all without any physical connection. Such wireless convenience has generated new applications and market sectors. Yet most wireless users are only partially "wireless." When it comes to charging, the vast majority continue to connect devices to a wall outlet — with a cable.

The growth of wireless charging

According to research firm IHS, the market is substantial and will show rapid revenue and unit growth until it reaches maturity and saturation toward the middle of next decade.

IHS user research indicates that, in 2015, about 90% of consumers would choose to have wireless-charging functionality in their mobile devices. Approximately one-fifth of these consumers have already adopted the technology, while most have not used it yet but are keen to do so — a huge potential market in which the consumer is convinced of the need and the technology needs to deliver.

Consumer desire is clear: to be able to charge devices as quickly and fully as possible, allowing at least a day's usage between charges.

Wired charging has evolved; chargers have become smaller, more efficient, and smarter. Mobile consumers can carry a portable battery to allow "on-the-go" charging during periods of heavy use, although charging the battery pack and, subsequently, the device remains predominantly wired. Batteries are improving, yet weight remains significant — often more than the device itself.

Wireless charging represents the logical next step of the charging evolution. While still in the "early adopter" phase, over the past two years, 221 million devices capable of being charged wirelessly have shipped. In parallel, 83 million charging stations (mostly standalone charging pads) have shipped.

Many of today's chargers are in public spaces such as cafés and airports; indeed, most consumers who tried wireless charging experienced the technology somewhere other than at their home or office.

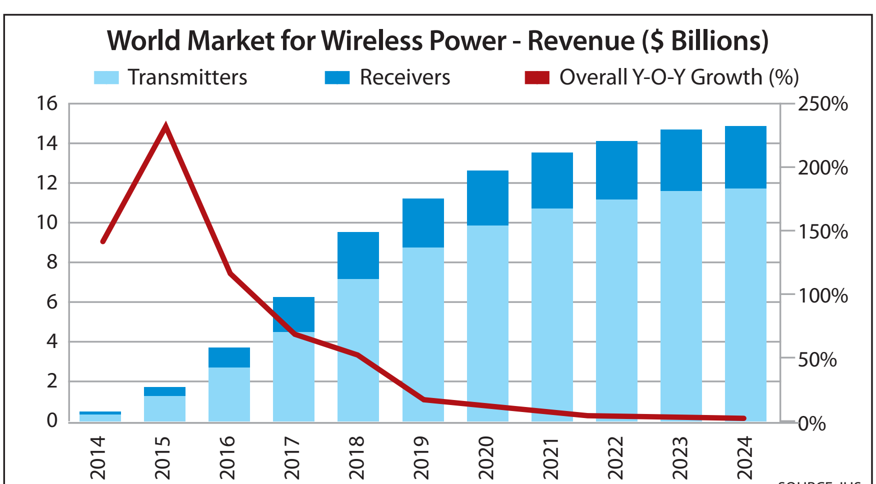


Fig. 1: World market for wireless power indicates significant growth for the rest of this decade.

Standards and alliances

As with many emerging technologies, especially those with huge revenue potential, multiple (often incompatible) standards are being developed. While these serve to drive the technology, the lack of a truly universal solution might also stifle adoption.

The Wireless Power Consortium (WPC) was founded in 2008 and is comprised of about 230 members from 20 countries, including consumer electronics, semiconductors, and wireless operators. WPC members support the Qi (pronounced "chee") standard.

The WPC verifies product compliance through a network of WPC-authorized labs. There are more than 1,200 Qi-certified products on the market, including more than 300 transmitter/charging devices and more than 90 Qi-enabled smartphones. The installed base is estimated at more than 150 million devices and ABI Research forecasts that this will exceed 700 million devices by 2020.

Through partnerships, Qi is being installed in cars, restaurants, hotels, airports, and corporate offices — there

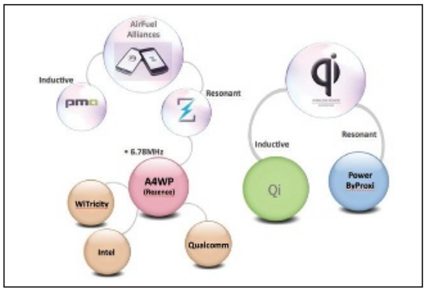


Fig. 2: After the 2015 merger of PMA and A4WP, the AirFuel Alliance is the leading driver of wireless power technology.

are in excess of 4,000 public Qi charging locations already deployed.

From a technical perspective, Qi is an inductive standard that supports tightly coupled charging. Under the WPC banner, PowerbyProxi is a resonant solution that offers full spatial freedom and delivers up to 5 W in a one-to-one or one-to-many charging scenario. The technology fits inside smartphones due to a proprietary wireless receiver, while a built-in Foreign Object Detector ensures that metallic objects do not interfere or overheat.

The Power Matters Alliance (PMA) and the Alliance for Wireless Power (A4WP) were formed as separate organizations in 2012 from various telecom, consumer device, automotive, furniture, and other companies. PMA was primarily focused on tightly coupled inductive solutions, whereas A4WP was working on loosely coupled resonant technology.

In June 2015, the two organizations were formally merged and, later that year, rebranded as the AirFuel Alliance (see *Fig. 2*). The merger reduced the number of organizations (and competing standards) from three to two and was praised for bringing the goal of a single, interoperable standard one step closer. ON Semiconductor numbers itself among approximately 160 post-merger members.

The AirFuel Alliance has a broad technology platform encompassing inductive, resonant, and uncoupled technologies.

Inductive technology is relatively mature and is deployed in millions of devices worldwide. This close-coupled technology offers efficiencies up to 80% with scalable charging to suit devices with different power requirements.

AirFuel's resonant technology allows for a "drop-and-go" charging experience through any surface and was branded "Rezence" in 2013. Rezence offers scalable charging and is not affected by the presence of metallic objects such as keys or coins.

Looking to the future, the AirFuel Alliance is also working on uncoupled technologies that will transmit power up to several meters. There are multiple technologies/transmission media being considered, including RF, ultrasonic, and laser. The initial specification supports power up to 5 W over distances of 15 feet (5 meters); this is expected to increase to 15 W in the second release in 2017.

Alongside the technology aspects, the AirFuel Alliance is developing infrastructure standards for wireless charging. These include definitions of interfaces, command and reporting structures, and network protocols — all of which will add sophistication and user benefit.

While there is still some way to go, the ultimate goal is to deliver a single, fully interoperable system that is capable of charging multiple devices with different power needs at the same time without interference. Once this is achieved, then we will have arrived at the true "drop-and-go" charging experience that will drive universal adoption by consumers.

The role of semiconductor technologies

There are two fundamental aspects to wireless charging: power and magnetics. In many ways, the technology shares much of its heritage with modern switch-mode power supplies (SMPS). These typically consist of a primary and secondary conversion stage coupled by a transformer and often use resonance as a means of increasing efficiency. As such, much of the R&D being carried out by leading semiconductor firms into improving the efficiency of SMPS is applicable to building better wireless solutions.

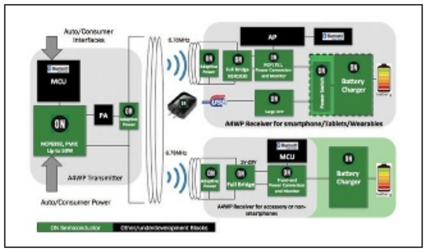


Fig. 3: Block diagram of a typical resonant wireless charging solution.

As *Fig. 3* shows, a wireless charging system consists of a transmitter and receiver, which are very close in function to the primary and secondary of the SMPS. The difference is that with wireless power, the "transformer" is split into two coils — one in the charger and one in the device. Even though the device is placed on the charging pad (and therefore "touching"), it is correct to use the term "wireless charging" because the charging surface and device case are non-conductive and the charging coils are separated by an insulating gap of several millimeters or more.

Semiconductor vendors are now developing complete wireless charging solutions, including power management, bridge rectifiers, power conversion stages, power switches (MOSFETs), and battery chargers. R&D research continues to focus on reducing size and cost while driving efficiency ever higher. In addition, many companies also now offer advanced development tools and reference designs that make it easier for design engineers to bring wireless charging systems to market quickly.

Clearly, there is some time needed before a truly universal "drop-and-go" standard is adopted globally, but with resonant technologies maturing and enabling loosely coupled charging, hundreds of major manufacturers backing standards, millions of devices shipping, and 90% of consumers wanting a solution, the future for wireless charging as the primary charging method of the future is assured. ☐

How to build secure and manageable IoT systems

BY NICK DUTTON,
VP Embedded, and JULIE MULLINS,
Director of Marketing
Zentri
www.zentri.com

Fig. 1: Securing an IoT product or system starts at the manufacturing plant and continues through the product's life cycle, so designers need to build it in from the start and be able to support it long-term.

It's no longer a question of whether or not developers *should* build connected products, but *how* they will build connected products. Two critical elements of connected systems and products are device management and security. Both require careful consideration early in the design cycle for an effective design, all the way from development through manufacturing and product lifecycle management.

To get it right, designers and developers need to understand the underlying hardware as well as the operating system (OS), firmware, communications stacks, cloud services, application software, and security. Only then can they optimize for power, cost, connectivity, performance, and scalability.

The criticality of device management and security

The IoT journey involves four key, easily identifiable sections that include:

1. The physical hardware, with its design incorporating plastics, electronics, and embedded firmware.
2. The user experience with the mobile application.
3. The cloud service allowing the company to manage the connected product post-deployment.
4. The ability to connect to and change cloud vendors to make use of commercially available cloud services for storage, analytics, and so forth.

Most designers or developers have specialty skillsets within hardware selection, embedded development, or design but might not be intimately familiar with device management and security in each of the four key IoT sections. IoT developers must understand the full product lifecycle from hardware to RF to internet to cloud and all security in between. It's hard for a developer to be an expert at all of these, though it's important to understand their role, along with the role of relatively new concepts, such as device management.

Device management is a term that has risen to the fore with the IoT. A device management service provisions, authenticates, and authorizes each individual device such that there is now remote insight to a product's status, location, firmware version, and more. This connection to the device is used for collecting and analyzing data, driving business logic rules, predicting and performing remote maintenance, enabling machine learning, and more.

The more comprehensive device management use cases enable the management of entire product fleets because of device management's per-device granularity. Regardless of the number of products deployed, the firmware, features, and more can be adjusted based on user segments from business logic rules like opt-ins and usage statistics, location, product purchased, or nearly any other data point. For example, all weather monitors and drip systems in Europe can be updated to comply with the strict, European data governance laws versus those in the United States with the click of a button. If laws change, the firmware can be instantly updated to maintain compliancy. There is no need for multiple product SKUs (with different hardware) or strict, blanketed compliance software. The same is true for user opt-ins or social network-based upgrades that reward customers for partaking in a product community. The opportunities provided by this flexibility are limitless.

Today's most successful IoT companies are those who have figured out device management, such as Apple and Tesla. In 2016, Tesla announced that their autonomous driving feature would be available as an over-the-air upgrade for $8,000. This is made possible by a device management service accessing each individual device to check software statuses, update firmware, and likely pair with a mobile app with a payment system.

Despite the seeming simplicity of device management, it's much more than a fancy term for firmware updates. Beyond the operating system, it's probably the most important piece in the connected product lifecycle.

Device management tracks and manages each particular device in the same way that a mobile device management (MDM) system knows your phone's software version, ensures the correct apps are downloaded to the correct devices, and sends payments securely to the appropriate app store. Device management for IoT also enables the product manufacturer to, for example:

- Perform remote diagnostics
- Secure data
- Improve efficiencies
- Minimize costs
- Innovate
- Increase product agility
- Be closer to the customer (know which buttons are being used, communicate via an app, save favorites on the device, etc.)
- Get real-time analytic data on a product
- Obtain recurring revenue via updates and upgrades
- Transform a stagnant business model

When firmware is developed, the device management system can act as an internal, developer "app store" for features or applications to be viewed, stored, and shared to accelerate future product development. For example, with products that share mutual functionality, such as common temperature sensors, the majority of the code for a security camera with temperature sensors can be reused for a smoke detector with the same temperature sensors. This reduces the overall workload for new product development and can even be integrated with other systems such as workflow or project management platforms with the proper APIs.

Device management orchestrates cloud APIs where data is collected, parsed, dispersed, or shared for further benefits. This is the point when stored data can become actionable data to help dictate future business and development decisions. Because of device management's importance and the amount of data it manages between the device, mobile app, and cloud services, it's critical to have proper connected product security.

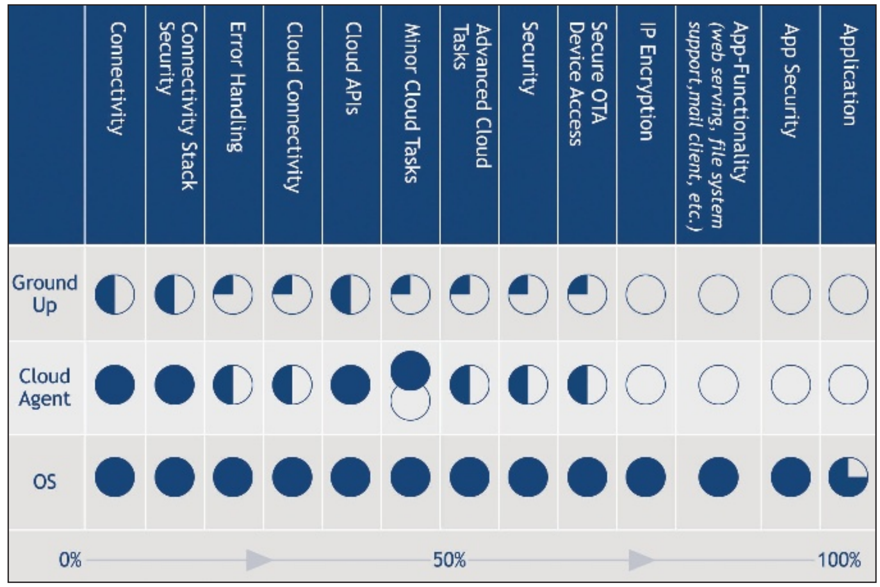


Fig. 2: Building an IoT product from scratch could take two to four years versus less than a year using currently available platforms, including a purpose-built OS.

IoT is often touted for its benefits but known for its security breaches because of security cutbacks during product development. Once budgets or timelines are compromised, security tends to get lower priority.

Some don't realize that they need security or are too anxious to launch their product. Some believe that the risk of a hack is more acceptable than implementing proper security or have fear that it will add extra, complex steps for the user experience. Others only think about securing the mobile device or cloud and forget about securing the device. But the product is only as secure as the weakest link, and reactively redesigning the product to patch security holes can be complex and costly. To avoid risk of massively tarnishing the brand, keep security a priority from start to finish and don't forget to secure the device, such as with unique firmware. Sometimes developers need to take a strong position on this for the sake of their teams and the company.

To properly secure the product, include security during all three product phases: during production at the factory, in the product or cloud as the data is at rest, and while the data is in motion between the product, cloud, and mobile app (*Fig. 1*). Because it's difficult to maintain security, look for an IoT platform that covers the entire product lifecycle as opposed to one aspect of the product.

While the product is in the factory, a secure product is one that will secure your IP, encrypt firmware images, and securely inject product credentials and keys so the units ordered equal the units manufactured. Consider a scenario in which 20,000 units are manufactured despite only ordering 10,000. The additional 10,000 create a grey market using your stolen IP. This security is delivered by a secure operating system.

Once the product is generating data, its data must be secured at the storage site in the product and the cloud. To secure this at-rest data, the product needs encrypted product data, a per-product encrypted software binary, and secure device access to prevent hacks. A secure operating system and secure device management make this possible.

When the product or system is in use, it's vital to secure the data in motion as it travels between device, cloud, and mobile app. All firmware updates should be encrypted and the product should enable secure data exchanges. Look for IoT platforms that include bank-level security with authentication and authorization from the data origination to where the data is being transferred. This security is driven by secure device management but must be coupled with a secure operating system.

Device management and security: make versus buy

There are three ways to approach connected product development:

1. A native ground-up approach: build it all
2. IoT platform using an agent: build the application on a platform supplied by a cloud vendor
3. IoT platform with a full operating system: build the application on a platform built from the ground up

As expected, there are trade-offs associated with each (*Fig. 2*). Building an

IoT is often touted for its benefits but known for its security breaches because of security cutbacks during product development. Once budgets or timelines are compromised, security tends to get lower priority.

IoT product with nothing but low-level libraries and tools will take an average of two to four years to complete. Every piece of the stack — including connectivity, networking services, file systems, wireless services, RTOS, cloud services, cloud service connectors, security, and more — must be pieced together and then consistently updated throughout the product's lifetime.

IoT platforms already include this core foundation so that you can focus on your application and get to market in less than a year, on average. It doesn't make sense to recreate an operating system simply to develop a word-processing application. Instead, the application should be developed on a complete OS that already includes the necessary framework, like Mac OSX. In the same way, it often doesn't make sense to develop an IoT product without using the foundation of an IoT platform.

IoT platforms: agent versus OS-based

There are two types of IoT platforms to consider: one with an agent offered by a cloud vendor and one with its own operating system. The agent option is often selected when a company requires specific functionality that the agent's cloud service offers, such as analytics. However, if you need an open platform with APIs that allow for easy extensibility and multiple cloud services, such as Amazon AWS for storage and IBM Watson for analysis, then the IoT platform with a built-in OS will be the most effective option because an agent typically locks you into its cloud service. The OS option is also more secure with security built into the OS to further secure the application. An agent can introduce a security hole at the junction where the agent begins. A breach below the agent could threaten the entire product.

Conclusion

Connected products are more involved and require new skillsets in the areas of device management and security to ensure a product's success. While IoT features and functionalities can be added post-deployment, it's important to build device management and security into the product from the start to avoid the complexity and cost of adding them in the future.

In the process of doing so, developers need to choose between building from scratch, using an agent, or opting for a full OS-based solution. The considerations when making the decision include time, resources, skillsets, cost, application functionality, the level of security required, and the team's level of commitment to full product lifecycle management. ☐

Implement liquid-level sensing with capacitive sensors

Capacitive sensing is a superior approach for implementing liquid-level sensing compared to traditional mechanical- and MCU-based techniques

BY SUBBARAO LANKA,
Senior Staff Applications Engineer, and
SHRUTI HANUMANTHAIAH,
Staff Applications Engineer
Cypress Semiconductor
www.cypress.com

Liquid-level sensing is used in consumer electronics appliances like washing machines to detect the detergent level. The sensor technology has progressed to such an extent that refrigerators can now detect milk levels and notify users to buy more by messaging their cell phone.

There are two forms of liquid-level sensing: point-level sensing and continuous-level sensing. With point-level sensing, sensors are placed at discrete levels on the tank that holds the liquid to be measured. These sensors can be used to detect a full tank, an empty tank, and discrete liquid levels for lower resolutions, such as ¼ full, ½ full and ¾ full.

Take the case of an espresso machine with two reservoirs. The main reservoir is for the water used to produce coffee, while the other reservoir is a drip tray used to catch wasted water. A cappuccino machine will have a third reservoir for milk. Here, system operation needs to be interrupted when water levels in the main reservoir are below a predefined level to prevent the machine from burning itself.

System operation also needs to be stopped when the level in the drip tray has reached the maximum level allowed for its safe removal by the user. The machine needs to know whether the water supply is empty and the drip tray is full, and that's where point-level sensing comes into play.

Next, continuous-level sensing allows the liquid level to be measured to a greater level of resolution. It's particularly useful in systems like automobiles. For instance, many vehicles have started to measure diesel exhaust fluids that are mostly used in trucks and other diesel vehicles to help reduce emissions.

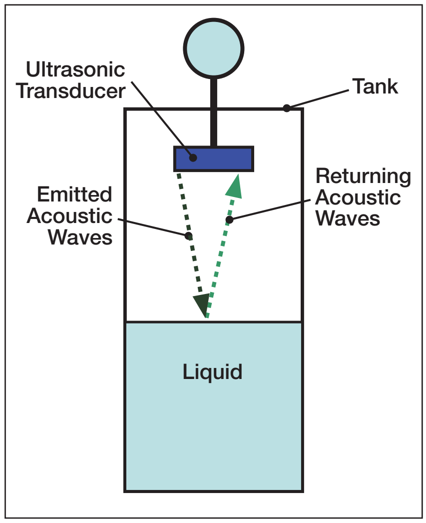


Fig. 1: Ultrasonic liquid-level sensor.

The fluid is sprayed into the exhaust of diesel vehicles — after the diesel has been combusted — to help convert oxides of nitrogen into harmless gas and water vapor. Diesel Exhaust Fluids (DEFs), which are likely to become a standard requirement in all diesel vehicles in the future, are stored in a separate tank from the fuel tank, away from the engine.

Traditional sensing techniques

Liquid-level sensing techniques can be broadly classified into mechanical- and microcontroller-based approaches. In mechanical-based sensing environments, a magnet is mounted on a float that moves at the level of liquid as it changes in the tank.

The float actuates a reed switch to control the system — it allows the flow of liquid or stops the flow of liquid. The mechanical floats offer high repeatability. However, because they have moving parts, they wear out over time.

The microcontroller-based sensors have largely been replacing the sensors using techniques like mechanical floating due to their lower accuracy, reliability, and operating life. First, there is conductivity sensing, in which two conductive electrodes are employed to measure conductivity. It's a reliable method as compared to the mechanical-centric sensing method, but it cannot be used for beverages and flammable liquids.

The second MCU-based technique allows the level of liquid in a container to be measured using a pressure sensor. The sensor is placed at the top of the tank and is connected to a tube that is inside the tank. The amount of fluid in the tank exerts a proportional amount of pressure on the sensor via the compressed air in the tube.

The sensor produces a pressure-equivalent voltage, which can be converted

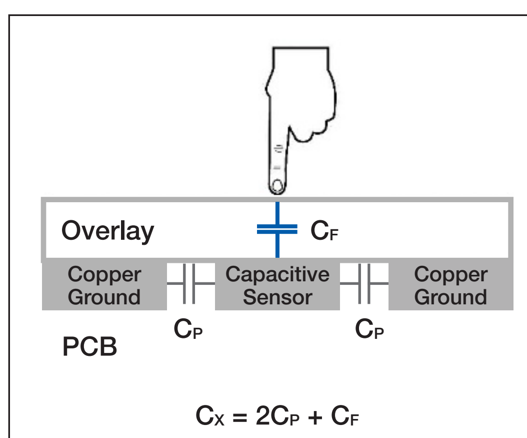


Fig. 2: Self-capacitive sensor with finger touch.
C_X = Total self-capacitance of capacitive sensor
C_P = Parasitic capacitance
C_F = Capacitance added by a finger touch

to a digital signal for processing and evaluation. This method is suitable for low viscous liquids. However, it strongly depends on the atmospheric pressure and can be used only in non-pressurized tank applications.

The third popular approach is ultrasonic sensing, in which ultrasonic transmitters and receivers are mounted on top of the tank pointed toward the liquid. The MCU transmits ultrasonic pulses to the liquid's surface and observes the echo signal. The delay between the actual signal and the echoed signal indicates the presence or absence of liquid in a given reservoir.

But ultrasonic sensing doesn't work in all environments. For example, it cannot be used in high-turbulence applications or applications that may have steam, foam, or high variances in the concentration of the process material. Turbulence and foam prevent the sound wave from being properly reflected back to the sensor while steam and vapors absorb the acoustic signal.

Enter capacitive sensing

With a capacitive sensing-based solution, no moving parts or sensors need to be in direct contact with the liquid to be measured. Instead, the liquid level is measured with a non-contact capacitive sensor deployed externally to the reservoir.

It makes capacitive sensing a more reliable solution than sensors that must be deployed within the reservoir. Capacitive sensing can be largely categorized into two methods: self-capacitive sensing and mutual-capacitive sensing.

A self-capacitive sensor is used to measure the change in capacitance of an electrode connected to a pin with respect to ground. The presence of a finger or liquid adds capacitance, as shown in *Fig. 2*, and this difference can be measured to detect a sensing event.

Capacitive-sensing circuitry converts the measured capacitance to a digital count called raw count (*Fig. 3*). The raw count value of a sensor may vary gradually due to environmental changes such as temperature and humidity.

Therefore, the algorithms used to evaluate sensing events need a reference — also known as a baseline — to keep track of and compensate for gradual changes in raw count. Through the use of a baseline, algorithms are less sensitive to sudden changes in the raw count caused by a sensing event.

A finger touch or presence of a liquid increases the self-capacitance of the system, which, in turn, increases the raw count. An increase in the raw count above a user-defined threshold registers a touch or presence of liquid. The difference between the raw count when touched and the baseline is called the signal.

A mutual-capacitive sensor is used to measure the capacitance between two electrodes, Tx (Transmitter) and Rx (Receiver), connected to two pins as shown in *Fig. 4*.

Capacitive-sensing circuitry converts the measured capacitance to a raw count. A finger touch or the presence of liquid decreases the mutual capacitance of the system, which, in turn, decreases the raw count.

The raw count is normalized — after being subtracted from a given maximum value — in the post-processing phase to ensure that it increases during a sensing event. An increase in the raw count above a user-defined threshold registers a sensing event. ☐

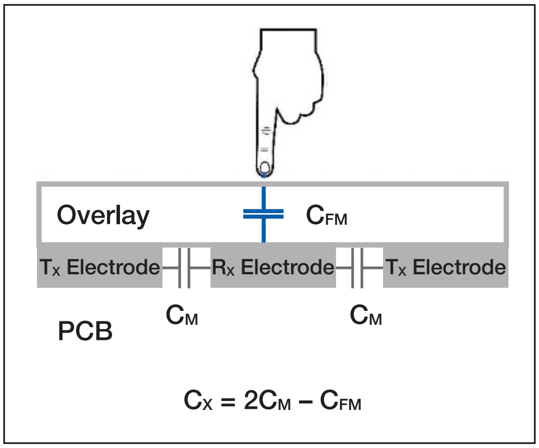


Fig. 4: Mutual-capacitive sensor with finger touch.
C_X = *Total mutual capacitance between the Tx and Rx electrodes*
C_M = *Mutual capacitance*
C_{FM} = *Mutual-capacitance reduction due to finger touch*

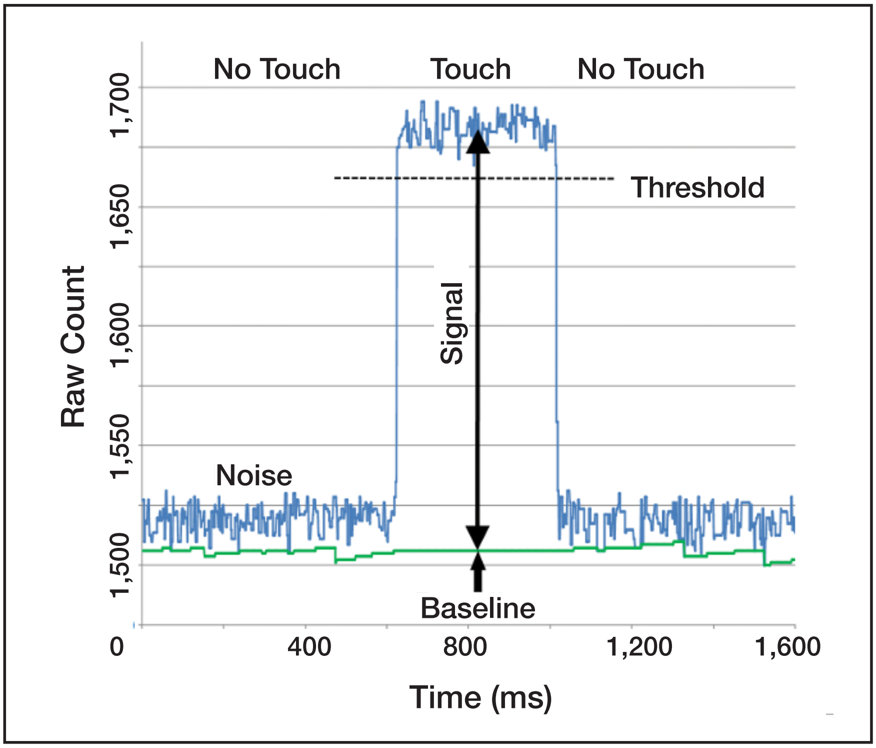


Fig. 3: Raw count variation on finger.

Insight into current product developments

Battery product trends for IoT, automotive, and smart grids

BY PAUL O'SHEA
Senior Technical Editor

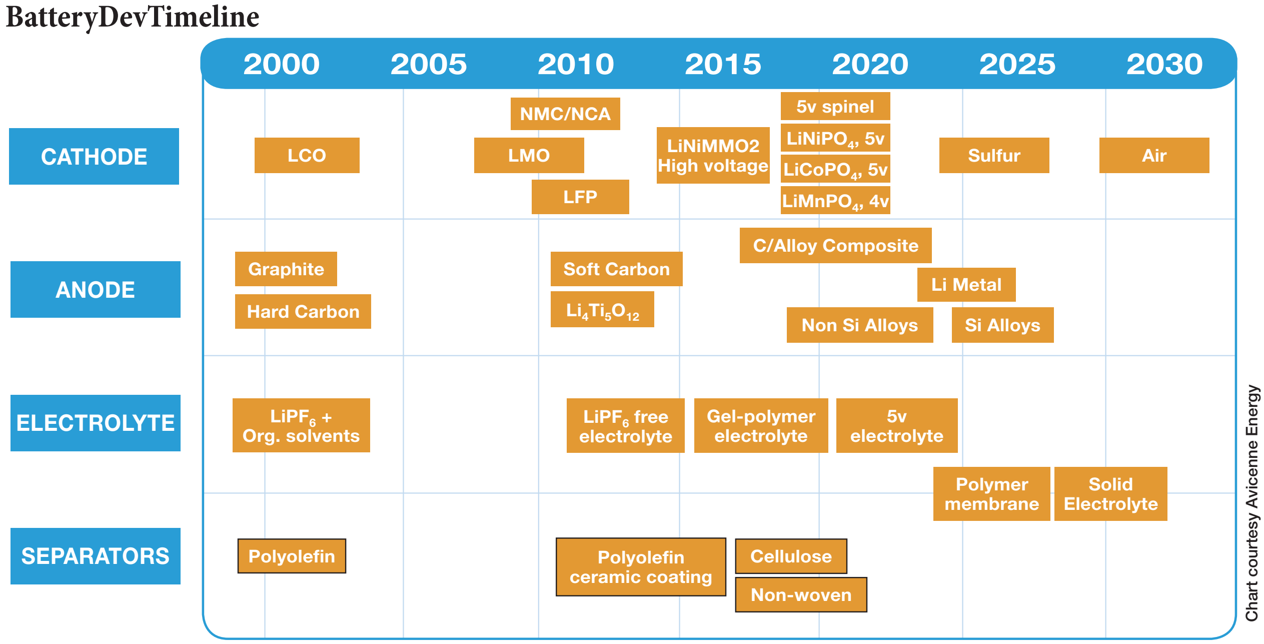
Batteries are constantly in the news — mostly about exciting breakthroughs and some reports on problems. Regardless, it's a thrilling time for batteries and energy storage.

The chemical make-up of batteries and the anode/cathode improvements are where progress occurs for batteries. Some recent examples include the cutting-edge development of solid-state batteries, such as those defined by researchers at the University of Maryland. They have developed intrinsically safe, all-solid-state Li-ion batteries (SSLiBs) by incorporating high-conductivity garnet-type solid Li-ion electrolytes into tailored tri-layer microstructures, by low-cost fabrication techniques, to form electrode-supported dense thin-film (~10 µm) solid-state electrolytes. The porous garnet scaffold support increases interfacial area, overcoming the high impedance typical of planar geometry SSLiBs resulting in an area-specific resistance of only ~2 Ωcm^2. The unique structure further allows for Li-metal, high depth of discharge ability without cycling fatigue. Researchers presented their findings at the 7th annual Battery Safety Conference this past November in Bethesda, MD.

"The first revolutionary technology is the emergence of solid-state batteries," agreed John Warner, Chief Marketing officer at EnerDel. "The solid-state battery uses a solid electrolyte that is deposited over the cathode and then the anode is coated on top of that." The two big benefits here are energy density and safety. The solid-state battery has the potential to drive very high energy density into very small battery space. And the use of solid electrolytes means that there is no flammable material in the battery, so a thermal failure is, at the very least, extremely unlikely, if not impossible, to occur. However, Warner continued, at the current state of the technology, solid-state cells are limited to the mAh scale and are mainly applicable for very small applications. We will see this technology begin to take hold in places like medical devices and consumer electronics over the next five years. As the technology matures and larger cells become possible, we can envision a time when they begin to power vehicles and larger applications, but that is still more than a few years away.

Another developing technology trend that shows great promise is the lithium-sulfur batteries. Lithium-sulfur batteries have the potential to offer very low costs due to the sulfur in place of the high-cost nickel, cobalt, aluminum, and other rare earth metals used in current lithium-ion cells. In addition to the low

BatteryDevTimeline



Academic and aftermarket research drives the invention and innovation of battery technologies from lab to market. Typically, it takes many years between initial research and manufacturing implementation.

cost, they may offer energy densities in the range of 500 Wh/kg. Current lithium-ion cells range from about 160 Wh/kg up to about 220 Wh/kg, with the maximum limit for current technologies expected to be about 300 Wh/kg. So it may very well be that lithium-sulfur cells will replace current lithium-ion batteries. However, as of today, there are only a handful of companies actively developing lithium-sulfur cells, and none are commercially available. As long as there are no major hurdles that occur, I would expect to see these cells beginning to emerge in product form in about five years and becoming the new standard in between five to 10 years.

Industrial IoT batteries

Advancing technology and the rapid emergence of the Industrial Internet of Things (IIoT), according to

Sol Jacobs, VP and General Manager for Tadiran Batteries, have increased demand for industrial-grade wireless sensors that can monitor virtually all external environments. He said that applications involving remote inaccessible locations and extreme environments mainly demand the use of long-life bobbin-type lithium thionyl chloride ($LiSOCl_2$) batteries that can power remote wireless sensors for up to 40 years. The ability of bobbin-type $LiSOCl_2$ batteries to deliver long-term reliable performance in extreme environments serves to reduce the total cost of ownership.

According to Mr. Jacobs, the burgeoning IIoT has also created demand for energy harvesting devices used in combination with rechargeable Li-ion batteries to store the harvested energy. Industrial-grade applications often cannot use consumer grade Li-ion batteries that have a limited lifespan of five years and 500 full recharge cycles, along with a limited temperature range and the inability to deliver the high pulses required to power two-way wireless communications. To serve this need, an industrial grade Li-ion battery has been developed that can operate for up to 20 years and 5,000 full recharge cycles and also features an extended temperature range of –40°C to 85°C and can deliver high pulses to support advanced two-way communications.

The battery manufacturers are responding with battery technologies that respond to customer needs for more energy density, lifetime, and safety characteristics for medical, automotive, consumer, and industrial applications. Please find some of the latest products and research available:

Panasonic: pin-type Li-ion battery and flexible Li-ion battery

A rechargeable pin-type lithium-ion (Li-ion) battery (CG-320A, CG-425, and CG-435), as well as its flexible Li-ion battery (CG-062939, CG-063555, and CG-064065), were recently introduced. The pin-type Li-ion battery CG-320A has a nominal capacity of 15.0 mAh with a diameter of 3.65 mm and a weight of 0.6 g. It is suitable for powering small applications such as wearable devices. In addition to being small, the cylindrical-shaped, rechargeable Li-ion battery features high reliability and high output. Applications include wearable devices, active stylus pens, measuring devices, near-field communications, and specialty eyewear.

Tadiran: long-life rechargeable Li-ion batteries

The expanded TLI series offers a family of long-life rechargeable Li-ion cells designed for use in harsh environments. The batteries are available in AA and AAA diameters and custom battery packs. The cells can be recharged using dc power or can be used in conjunction with photovol taic solar systems or other energy-harvesting devices for long-term power.

Saft: innovative smart grid installation

Saft is supplying its Intensium Flex battery system to supply backup energy for essential command and control equipment for French transmission grid operator RTE to provide vital backup power for its innovative Blocaux smart substations project. The modular Intensium Flex battery system can be built up to closely match the system requirements. The system will deliver 11 kW at 110 V for up to four hours of autonomous operation.

Navigant Research

A report from Navigant Research explores the concept of reusing plug-in electric vehicle (PEV) Li-ion batteries for stationary energy storage system (ESS) applications, focusing on the key issues, market drivers, and challenges related to reusing second-life PEV batteries. Li-ion battery packs in EVs have shown less degradation and better performance than expected thanks to robust pack design and careful thermal and charging management. The study examines the issues, including market drivers and challenges, related to second-life batteries and suggests moves for stakeholders to help make the concept become a reality.

EnerDel

The PP320-738-LP Vigor+ battery pack offers a robust transportation-grade package with built-in system control redundancies to ensure enhanced pack protection and user safety. The packs are designed for transportation power applications such as buses. Each battery pack has 24 cells/module with a maximum of 737 V and a minimum of 450 V. It has a rated capacity of 32 Ah and rated energy of 20 kWh. The maximum pulse discharge is 350 A for 5 s and a maximum continuous charge of 160 A. The pack is designed to accommodate ambient or chilled air.

Tesla

The second-generation home-energy battery-storage unit and a new aesthetic solar roof design were recently introduced. The Powerwall 2 has twice the energy density and capacity of its predecessor and can power a two-bedroom home for a full night. Compact, stackable, and with a built-in dc-to-ac inverter, the new unit costs $5,500 (plus $1,000 for installation and supporting hardware). The included inverter is a new design by Tesla. Its capacity is now 14 kWh, with 7 kW peak output, 5 kW continuous, and a weight of 264.4 pounds. ❑

Electromechanical Components

MEMS switches boost accuracy, channel density in ATE systems

Analog Devices Inc. (ADI) has introduced two RF MEMS switches that allow OEMs to significantly improve the accuracy and versatility of automatic test equipment (ATE) and other instrumentation tools.

ADI's ADGM1304 and ADGM1004 RF MEMS switches replace electromechanical relays with a co-packaged solution that offers superior dc precision and RF performance. ADI claims that these MEMS switches are 95% smaller, 30 times faster, 10 times more reliable, and use 10 times less power than conventional relays.

It's a two-die RF MEMS device. The first one is an electrostatically actuated switch in a hermetically sealed silicon cap. The second die is a low-voltage and low-current driver IC. The switching element features a highly reliable metal-to-metal contact, which is actuated via an electrostatic force generated by the companion driver IC.

The packages for ADGM1304 and ADGM1004 MEMS switches boast small height, and that allows designers to surface-mount them on both sides of ATE test boards. That, in turn, boosts channel densities at reduced cost and without an increase in the instrumentation equipment footprint.

Next, an integrated charge pump removes the need for external drivers. And that further reduces ATE system size and simplifies the fan-out structure. ADI says that these MEMS breakthroughs extend cold-switching lifetime by a factor of 10 compared to conventional relays.

Moreover, ADGM1304 and ADGM1004 RF MEMS switches increase ATE system operating life and reduce costly downtime caused by electromechanical relay failures. ADI is planning to offer these MEMS switches to other industries such as aerospace, defense, healthcare, and communications infrastructure.

Analog Devices: www.analog.com

High-power latching relay facilitates battery disconnect in 12-V vehicles

Fujitsu Components America has unveiled a high-power latching relay for enabling high-current safety and power efficiency solutions in 12-V battery vehicles. The FTR-V1 relay comes in a low-profile sealed package that occupies a compact footprint of 85 x 52 mm and weighs 120 grams.

The compact and lightweight PCB relay is primarily targeted at automotive applications like battery coupling, emergency battery disconnect, regenerative braking systems, and switching control between two batteries.

FTR-V1 is a 210-A relay that offers continuous current carrying capabilities of 160 A at 25°C and 110 A at 120°C. Fujitsu's new latching relay — when used in an ambient operating temperature range of –40°C to 120°C — delivers a contact life of 100,000 operations.

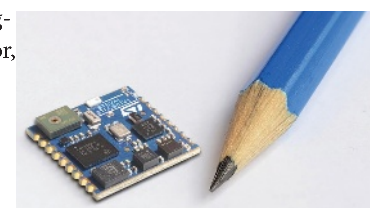
Moreover, the FTR-V1 relay features a double-winding latching coil and contact resistance of 600 μΩ. The press-fit terminals on the control side of the relay eliminate the need for harnesses and allow direct connection to the PCB. There are also terminal screws available for the load.

The price of these latching relays starts at $62.65 for single- to five-piece quantities.

Fujitsu Components America: us.fujitsu.com/components

Multi-sensor board speeds up wearable, IoT designs

STMicroelectronics has released a turnkey sensor board that provides a sensing and connectivity hub for wearables, gaming accessories, smart home, and IoT devices. For the sensing part, the 13.5 x 13.5-mm SensorTile module contains a MEMS accelerometer, gyroscope, magnetometer, pressure sensor, and MEMS microphone.



Then there is a low-power STM32L4 microcontroller and a Bluetooth low-energy (BLE) transceiver that also includes a miniature single-chip balun. A broad set of system interfaces is available to turn the module into a sensor fusion hub as well as a reference platform for firmware development.

The compact SensorTile board also comes with a microSD card socket and a lithium-polymer battery (LiPo) charger. Moreover, it's accompanied by a developer kit that includes a cradle/expansion board with an analog audio output, a micro-USB connector, and a programming cable.

Furthermore, the SensorTile kit features an Arduino-like interface, which can be plugged into any STM32 Nucleo board to expand design options for system and software development.

Developers can simply plug the multi-sensor module into a host board and power it immediately. It will start streaming inertial, audio, and environmental data to STMicro's BlueMS smartphone app, which can be downloaded free of charge from popular app stores.

STMicroelectronics: www.st.com

Actuator with flexure design prevents shaft rotation inaccuracies

BEI Kimco has released a voice coil actuator (VCA) for extreme precision applications in aerospace, clean rooms, laboratory instrumentation, and medical environments. It comes with a

Electromechanical Components

moving magnet and a flexure design, which ensures high alignment accuracy and prevents unwanted shaft rotation..

The new actuator incorporates a shaft with flexures at both ends of travel, which supports the moving magnet field assembly. That, in turn, enables the Housed Linear Actuator Model LAH13-11-000A to prevent shaft rotation inaccuracies.

The flexure design also eliminates friction and side-loads at non-vertical angles as well as unwanted accumulation caused by shedding from bearing and bushing. Moreover, it safeguards actuator's inherent ability to return the magnet to mid-stroke when re-energized.

BEI's plug-and-play actuator offers a peak force of 11.9 N and a continuous stall force of 0.7 N in a small, lightweight package that measures 36 x 30 mm and weighs 0.22 lbs.

BEI Kimco: www.beikimco.com

Power relay offers higher capacity for control applications

Fujitsu Components America has added a high-capacity version to its FTR-K1 power relay series. The FTR-K1-HC relay is targeted at home appliance applications like oven controls, electric heating and air conditioners, and smart home automation.

The high-capacity relay available in a standard industry footprint is also suitable for industrial control applications such as furnaces and power supplies. FTR-K1-HC is RoHS-compliant and conforms to UL 508 safety and UL 94-VO flammability standards.

Fujitsu's new power relay — available in a footprint measuring 29 x 15.7 x 12 mm — features Class F coil insulation and a typical electrical life of 100,000 operations. The power consumption of this high-capacity relay amounts to 400 mW for the 5-, 6-, 12-, and 18-Vdc coils.

Next, the FTR-K1-HC relay boasts a resistive rating of 20 A at 277 Vac (85°C) on the normally open contacts. It's worth noting that Fujitsu's FTR-K1 relay series features dielectric withstanding voltage of 1,000 Vac (50/60 Hz) one minute between open contacts and 5,000 Vac (50/60Hz) one minute between coil and contacts.

The FTR-K1-HC relay is available at $4.28 in quantities of up to 99 pieces.

Fujitsu Components America: us.fujitsu.com/components

Power Sources

Miniature, 1.0-A PoL regulator provides 95% efficiency

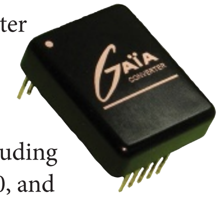
The MSR7805WUP series of miniature switching voltage regulators provide up to 1.0-A output current. They are pin-compatible with linear regulators such as the LM78xx but offer 95% efficiency and don't need a heat sink. Four standard models operate from inputs that range from 6.0 to 36 Vdc, providing tightly regulated outputs of 3.3, 5, –5, 12, –12, 15, or –15 Vdc.

Fabricated as a miniature, unpotted (open-board) unit, the regulator measures 0.689 x 0.453 x 0.295 in. Each model is specified for operation from –40°C to 85°C with no heat sinking required. Cooling is by air convection. All models are approved to EN 60950 and have continuous short circuit protection. The MTBF of the regulator is greater than 2.0 Mh (per MIL HDBK 217F).

MicroPower Direct:
www.micropowerdirect.com

6-W, 12–160-V input dc/dc converters target transportation needs

Gaia Converter released the MGDDI-06 series dc/dc converters that target railway, transportation, airborne, and military applications. The converter series provides an input voltage range from 12 to 160 V that suits typical battery/bus voltages including 24, 28, 36, 48, 72, 96, 110, and 125 V. The device features proprietary



Power Sources

switching techniques with efficiency as high as 90%. With two isolated outputs (for parallel, serial, or symmetrical operation) of 5, 12, 15, and 24 V, the converters can, for example, cover a wide variety of needs, such as single 5- to 48-V output, ±15-V or 2 x 24-V outputs of 3 W each.

The converter has a 0.33-in. profile with a 1 x 0.75-in. footprint, and features an operating temperature range from –40°C to 100°C and is potted for rugged environmental conditions. The units are protected with zero to full-load regulation, trim, and on/off capability, adjustable UVLO, soft start, embedded EMI filter, and overcurrent and over-temperature protection. The converters do not use opto-couplers in the feedback loop. Complying with Mil-Std-704, 1275, DO-160, EN50155/55022, or an equivalent standard becomes straightforward because of the wide input voltage range and the use of fixed switching frequency with an embedded LC filter.

Gaia Converter: www.gaia-converter.com

16th brick offers usable power to 100 W

The CPT 16th brick dc/dc converter series open-frame modules can now be ordered with a base plate heat spreader to provide up to 100 W of usable output power at output voltages of 2.5, 3.3, 5.0, 12, and now 24 Vdc. The converters suit distributed power architecture applications or as a fully regulated intermediate bus converter.

The modules are compliant with DOSA 16th brick footprint and interface standards. They have an input voltage range of 2:1 input up to 100 W and 4:1 input up to 50 W and provide 2,250-Vdc input to output isolation.

The CPT series meets UL/EN 60950 safety standard requirements and is UL94 V-0 flammability-rated. All modules are ROHS II- and REACH-compliant. The modules also meet all of the typical industry requirements, including no-load operation, 2x nominal input voltage transient, and pre-biased load startup.

Other features include fixed-frequency operation; auto-restart OVP, OCP, and OTP protections; UVLO; remote sense; and output voltage trim using industry-standard equations. Remote on/off is standard with positive or negative logic options available.

The modules feature a standard 16th brick pinout with dimensions of 1.3 x 0.9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Power Sources

(33.02 x 22.86 mm). They have a maximum height of 0.374 in. (9.5 mm) to accommodate tight card spacing with minimal airflow blockage of downstream components. Base plate modules offer a standard 0.500-in. height (12.7 mm) for interfacing with heat-spreader/chassis surfaces. A heat sink can be attached to the module using optional M3 threaded holes in base plate.

Semiconductor Circuits: www.dcdc.com

Encapsulated 80-W ac/dc modules feature ultra-compact footprint

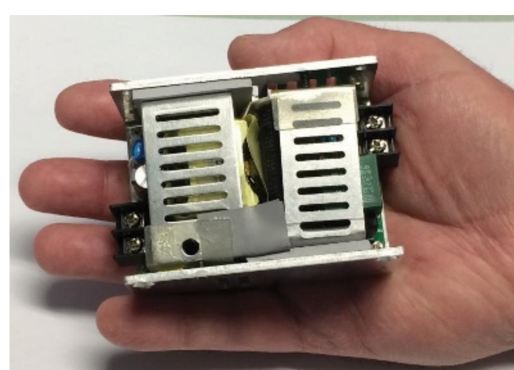
XP Power announces the ECE80 series of 80-W single-output ac/dc encapsulated power supply modules with high efficiency and a low no-load input power. The modules target customers requiring an encapsulated ac/dc power solution in an ultra-compact format for either PCB, chassis, or DIN-rail mounting.

The modules suit Class II applications and offer Class B EMI protection without any additional filtering. Applications include those in automation and process control, broadcast, instrumentation, mobile communications, and home automation. The supplies provide peak load capability of up to 130% of nominal rated power output for 30 s, and can power short-term higher power loads, so designers may not need to specify a higher-rated and possible physically larger power supply. The power supplies have a power density of >11.2 W/in.^{3} and offer five standard output voltages from 12 to 48 Vdc. The PCB mount module measures 3.60 x 1.80 x 1.10 in. and the chassis mount module measures 4.45 x 1.87 x 1.12 in. They feature a no-load power consumption of <0.3 W and efficiency up to 89%.

The operating temperature range extends from –40°C to 70°C (with no derating until 50°C). The modules are able to operate in most environments with no need for additional heat sinking or airflow. They meet Class B-conducted and -radiated EMC limits without any additional components and are UL/CSA/EN/IEC 60950-1 safety-agency-approved.

XP Power: www.xppower.com

600-W dc/dc converters offered in full brick case



The PMD600WFB series full brick case dc/dc converters measure 116.8 x 61.0 x 12.7 mm and provide an output power of 600 W. The series has an input range of 18 to 36 Vdc and 36 to 75 Vdc and output voltages of 12, 28, or 32 Vdc with output currents of 50, 21.5, and 19 A, respectively. .

The converters operate from –40°C to 100°C, have an isolation voltage of 1.5 kVdc, and a transient response time of <500 µs. They are built in a plastic case with an aluminum base plate and feature an efficiency up to 92%. The converters feature undervoltage lockout and overvoltage protection as well as external output voltage trimming.

MTM-Power: www.mtm-power.com

Packaging & Interconnections

Cable assemblies exceed category standards to withstand harsh environments

L-com Global Connectivity has unveiled a new series of premium cable assemblies that are designed to withstand harsh conditions and are being targeted at applications such as industrial Ethernet, industrial controls, factory automation, test equipment, I/O connectivity, and sensor and actuator connectivity.

These cable assemblies are designed to exceed category standards and ensure optimal network throughput even in harsh industrial or extreme weather conditions. Moreover, besides extra strength, the flame-retardant thermoplastic elastomer (FR-TPE) cable jackets are also resistant to oil, sunlight (UV), and weld spatter.

L-com's premium M12 cable assemblies have been built with FR-TPE cable and IP68-rated M12 connectors that are high-flex, outdoor CMX-rated, and double-shielded. A double-shielded braid and foil design provides maximum protection from electromagnetic interference (EMI) and radio-frequency interference (RFI).

The cables are rated for 600 V and are flex-tested to 1 million cycles at 10x cable OD and 10 million cycles at 20x cable OD. These cable assemblies are also available off-the-shelf with connector options that include D-coded, four-position male M12, four-position female M12, and standard RJ45 combinations.

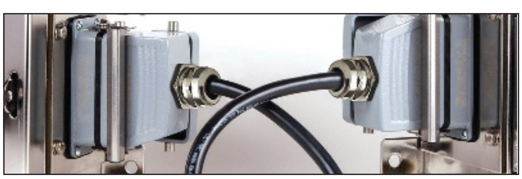
The premium M12 cables are available in 0.5-, 1-, 2-, 3-, 5-, and 10-meter lengths. Furthermore, custom lengths and labeling are made available either with L-com's Custom Cable Configurator tool or by directly contacting L-com.

L-com: www.l-com.com

Online tool simplifies cable harness design and assembly

The HDC Cable Configurator — a design-to-order online tool — simplifies the design and manufacture of custom cable harness and mating assemblies for Weidmuller's Rockstar heavy-duty connectors.

The configurator assigns a single part number to a cable harness or a mating assembly. As a result, no more than three part numbers are required for a complete pluggable connection for use between panels, machinery, and equipment.



That allows the HDC Cable Configurator interface to designate project names and save designs for future access. The online tool also guides the user through available options for each side of the harness and mating assemblies. Moreover, users can select additional options if they require a customized solution for a cable harness application.

Once a project is created and saved, the data resides inside the HDC Cable Configurator so that the user can select the design and print a PDF quote at any time. Quotes include project details, list pricing, a simple rendering, custom part numbers, and more.

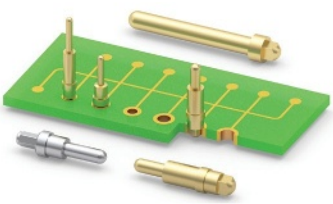
Weidmuller has teamed with a UL-approved cable assembly shop to ensure that cables meet the UL and CSA requirements and that cables offer continuity and short testing on every harness.

Weidmuller: www.weidmuller.com

Press-fit PCB pins boast multi-faceted geometries

Mill-Max has introduced six new press-fit PCB pins that feature multi-faceted polygon geometries and are especially suitable for solderless PCB termination as well as direct soldering to the board. The smallest pin diameter in the group is 0.040 inches while the largest is 0.080 inches.

Packaging & Interconnections



These press-fit PCB pins are designed with the electrical and mechanical strength required in applications such as power supplies and power converters. Then there are high-current applications that are otherwise limited by temperature requirements and heat-sinking abilities of the environment.

The devices subject to blind mating or rough handling can also benefit from these PCB pins. The pin material is brass. However, tellurium copper is also available for greater electrical conductivity and more efficient heat dissipation.

You can simply press these pins into a plated through-hole. The polygon points are set in the hole, so the flat sides of the hardware can provide relief. And that allows the remainder of the plated through-hole barrel to remain intact.

As a result, internal board layers are not disconnected when the pin is pressed in. The polygon shaped press-fit allows the pin to be secure in the hole while the hole size is properly specified. That provides continuity across all the layers of the PCB.

Mill-Max can manufacture either square- or hexagon-shaped press-fit PCB pins to suit a variety of hole sizes and assembly requirements. Square press-fit pins usually leave a larger gap between the flat side of the feature and the hole and are useful for solder flow and venting of gasses. On the other hand, hexagon pins provide greater retention.

Mill-Max: www.mill-max.com

1U MicroTCA chassis boosts power functionality

Pixus Technologies has introduced a 1U MicroTCA chassis that boasts advanced power management features such as failover, remote management, and power sequencing. The upgraded PXS0108 chassis enables a mix-and-match deployment approach for the MicroTCA Carrier Hub (MCH), power, and payload modules.

The chassis offers options for one or two MCH modules, single or dual power supplies, and multiple-size variants of Advanced Mezzanine Cards (AMCs). It's worth noting that

MicroTCA is a smaller form-factor version of the AdvancedTCA architecture and that AMCs, which are used in many AdvancedTCA applications as a daughter card, are the core modules in MicroTCA systems.

The chassis can be used in a wide range of communication, industrial, and defense applications. The six-slot MicroTCA system platform has backplane options of up to PCIe Gen3 speeds. Furthermore, a 40-GbE backplane option is also available upon customer request.

Pixus offers MicroTCA chassis platforms in 1U rugged, 2U, 5U, and 8U heights. The supplier of embedded computing and enclosure solutions also provides chassis platforms for OpenVPX, AdvancedTCA, and legacy CompactPCI and VME standards.

Pixus Technologies: www.pixustechnologies.com

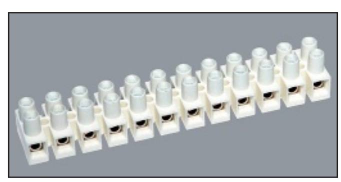
Waterproof enclosure designed for outdoor environments

Polycase has added a compact enclosure for outdoor applications to its NEMA 4X-rated ML Series of waterproof enclosures. The ML-22F enclosure boasts a size of 66.80 x 66.80 x 41.40 mm and is UL-listed to Type 1, 2, 4, 4X, 12, and 13 enclosures.

The ML-22F enclosure — molded from light gray polycarbonate — comes with light gray and clear cover options. Moreover, a form-fitting silicone gasket protects internal components from dirt and water penetration.

The new enclosure also makes available an optional internal aluminum panel as an accessory. Polycase, a manufacturer of plastic enclosures, also claims to have used its expertise in CNC machining and printing while it was creating cutouts and graphics for the ML Series enclosures.

Polycase: www.polycase.com



Terminal strips meet revised glow-wire standard

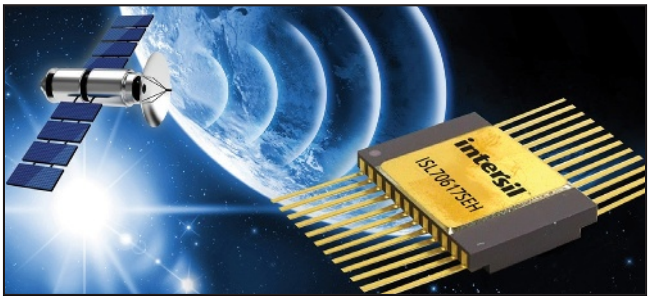
Europa terminal strip connectors are available with an enhanced housing material that complies with revised glow-wire testing standards of the DIN 60335-1 standard for consumer appliances. The new version is constructed using an improved polyamide material that provides the extended flammability protection.

Designed to provide secure electrical connections mounted to a flat surface, the screw-clamp terminal strips are available with 1 to 12 connections in five sizes to accommodate a range of current ratings and wire gauges: Type 4 (up to 20 A/600 V for 22 to 14 AWG), Type 6 (up to 20 A/600 V for 22 to 12 AWG), Type 10 (up to 40 A/600 V for 22 to 10 AWG), Type 16 (up to 65 A/600V for 22 to 8 AWG), and Type 20 (up to 75 A/600 V for 22 to 4 AWG). Additionally, all of the connector types are available with an optional protective guard inside the clamping body to prevent damage to the connected wire — especially useful for stranded wire. Marking accessories are also available for all sizes.

Wieland Electric: www.wielandinc.com

Radiation-tolerant precision amplifier features differential A/D converter driver

The ISL70617SEH radiation-tolerant instrumentation amplifier features a differential A/D converter driver. The high-performance differential input, rail-to-rail output amplifier provides the highest performance for low-level sensor telemetry data critical to communication satellites. It can operate over a supply range of 8 (±4) to 36 V (±18) and features a differential input voltage range up to ±30 V. The amplifier's output stage is powered by separate supplies.



Input offset voltage is a low 30 µV typical; input bias current is 2 nA maximum, 0.2 nA typical; and CMRR is 110 dB minimum, 120 dB typical. The 24-lead ceramic flatpack packaged device has a 6-kV HBM ESD rating. The device is wafer-by-wafer guaranteed to 75 krad (Si) with a low dose rate exposure of 10 mrad/sec, which more closely resembles the space environment than the high dose rate testing used with some other devices.

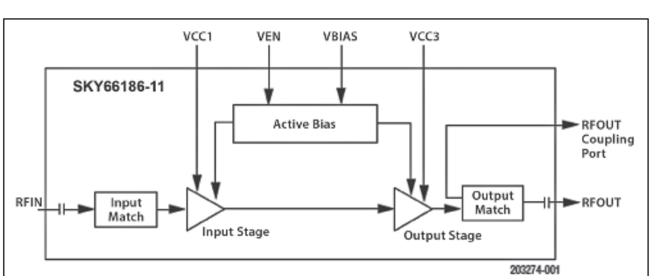
Closed-loop –3-dB bandwidth is 0.3 MHz (AV = 1k) to 5.5 MHz (AV = 0.1) and operating temperature range is –55°C to 125°C. Designers can easily program the IC's gain from 0.1 to 10,000 using two external resistors. The gain accuracy is determined by the matching of RIN and RFB. The gain resistors have Kelvin sensing, which removes gain error due to PC trace resistance.

The ISL70617SEH offers similar features but implements rail-to-rail single-ended output. Both versions are available now. An evaluation board is also available.

Intersil: www.intersil.com

728- to 768-MHz power amplifier IC features high linearity

The Skyworks SKY66186-11 amplifier addresses small-cell communications in the 3G/4G LTE bands 12, 13, 14, and 17. With more mobile devices using LTE cellular to access the internet and 5G cellular on the way, there will be a strong deployment of small-cell systems to meet bandwidth requirements. The IC requires minimal external components and is part of a high-linearity, pin-to-pin-compatible PA family supporting all 3GPP bands.



The SKY66186-11 power amplifier features 37-dB gain with very high linearity and excellent output return loss of less than –20 dB. The GaAs device has an integrated coupler for output power monitoring and needs only a single 3.3-V power supply. The 5 x 5-mm, 28-pin chip has 50-Ω input and output, and its active biasing circuitry compensates amplifier performance over temperature, voltage, and process variations. The amplifier can be turned on or off in 6.5 µs.

Power-added efficiency is specified as 12.5% at +23 dBm out and adjacent channel leakage (ACLR) is –50 dB typical, again at +23 dBm out. Quiescent supply current is 125 mA typical and 160 mA maximum, and typical operational current is 480 mA.

Recommended operating temperature range is 25°C to 85°C. Similar devices include the SKY66184-11 (2,110 to 2,170 MHz) and the SKY66185-11 (851 to 894 MHz). Samples are available now, as is an evaluation board.

Skyworks Solutions: www.skyworksinc.com

Isolated amplifier features low cost, low power, high accuracy

The AMC1301 isolated amplifier has a working breakdown voltage of 1 kVrms. Perhaps more importantly, it's small and very low-power. It also handles 7-kV peak for a minimum insulation barrier lifetime of 64 years, which exceeds VDE0884-10 requirements. The IC has a gain error of just ±0.3% at 25°C with ±50 ppm/°C drift. Offset error and drift is just ±200 µV at 25°C, ±3 µV/°C. Input bias current is 82 µA maximum over the full –40°C to 125°C operating range.

The amplifier's gain is fixed at 8.2 and its ±250-mV input voltage range is optimized for current measurement using shunt resistors or other low-voltage-level signal sources. The chip has no lifetime degradation error like optical solutions.

The IC can yield accurate current control that results in system-level power savings and, in motor control applications, lower torque ripple. Its integrated common-mode overvoltage protection and high-side supply voltage monitoring features simplified system-level design and diagnostics.

The device requires only 81.4 mW for both sides of the isolation barrier (with 3.3-V supplies), which greatly eases PCB and thermal design. VIN to VOUT signal delay (50%–10%) is 0.7 µs typical, and 2.0 µs maximum. It comes in a 5.85 × 7.50-mm SOIC8 package and is priced at only $2.90 ea/1,000. Available now.

Texas Instruments: www.ti.com

New Products

Test & Measurement

GPS logger employs multiple sensors

The Aaronia GPS Logger from Saelig is a tiny, USB-based device that packs six sensors to log position, speed, and height with a signal sensitivity of –165 dBm. Although originally designed for recording the coordinates and orientation of Aaronia antennas, the multi-axis data logger can also be used in a variety of non-RF applications.

Small enough to fit in the palm of your hand, the GPS Logger starts up in about 30 s and captures data at a rate of 35 logs/s. Its 66-channel GPS sensor with built-in antenna offers position accuracy of 1.8 m, velocity measurements of 515 m/s accurate to within 0.1 m, and altitude readings to 18 m. The tilt sensor and digital compass capture the inclination and orientation of an object during the measurement process, while a 3D/triaxial accelerometer measures g-force up to 8 g with 4-mg resolution.

All sensor data can be saved to a supplied 2-Gbyte microSD card or streamed via USB. Equipped with an internal 650-mAh LiPo battery, the logger is able to record up to two days of full-speed data to the card. Lowering the data rate allows logging time to be extended for weeks or even months.

Saelig: www.saelig.com, Aaronia: www.aaronia.com

Insulation testers minimize damage risk

Megger's MIT480/2 series of insulation and continuity testers is not only faster but provides gated access to 500 V to minimize the risk of accidental damage to equipment under test. Intended for the telecommunication and cable-testing markets, the handheld units offer quick single-range continuity testing that is fully automatic from 0.01 Ω to 1 MΩ. They also furnish a user-selectable test current of 20 mA or 200 mA.

The series is comprised of two models — the MIT481/2 and MIT485/2 — both of which employ a three-wire connection for A, B, and E (tip, ring, and ground), eliminating the need to connect and disconnect leads to carry out the full range of tests on a cable pair. The testers have a CAT IV 600-V safety rating and perform insulation testing up to 500 V and 100 GΩ. Their feedback-controlled insulation test voltage is accurate to 2%.

The MIT481/2 offers four fixed test voltages of 50, 100, 250, and 500 V, plus onboard storage of test results, while the MIT485/2 adds a variable test-voltage function and Bluetooth downloading capability. Each instrument comes in a rugged housing with shock-absorbing rubber overmolding.

Megger: www.megger.com