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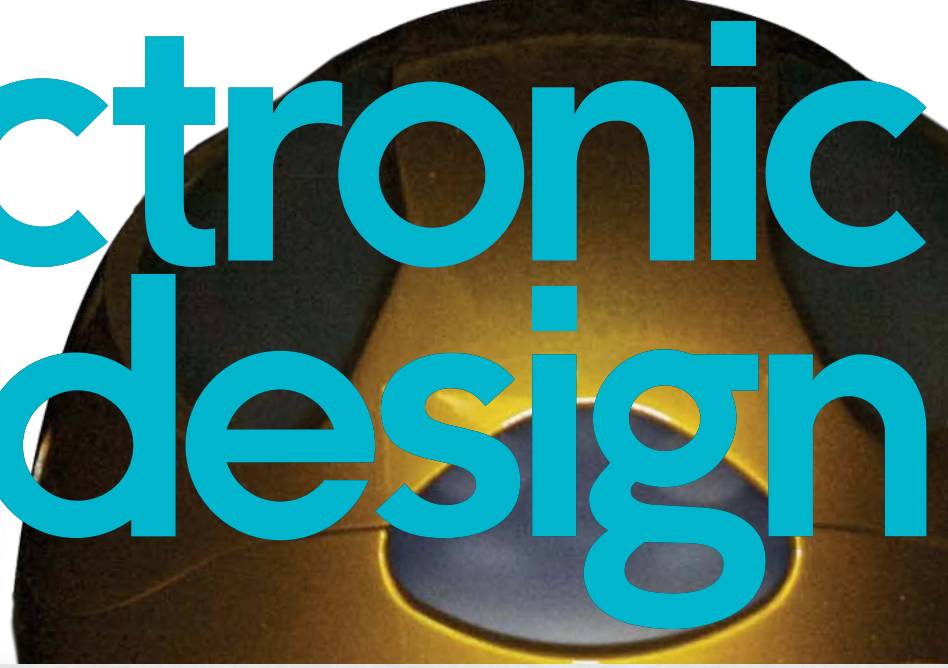

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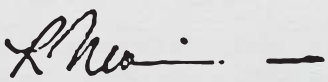

Ron Nersesian, CEO

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SAFER ROBOTS DO NO HARM

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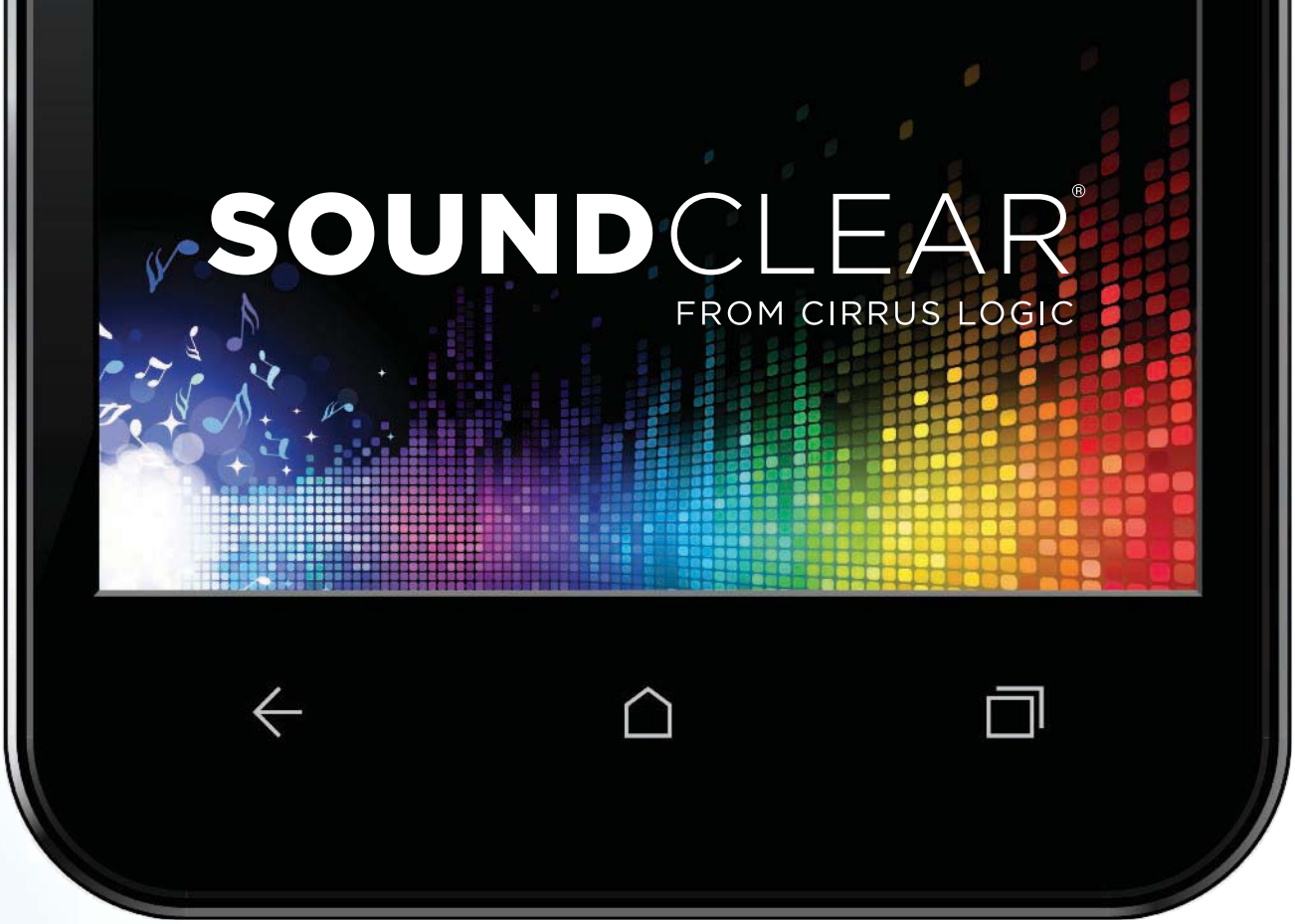

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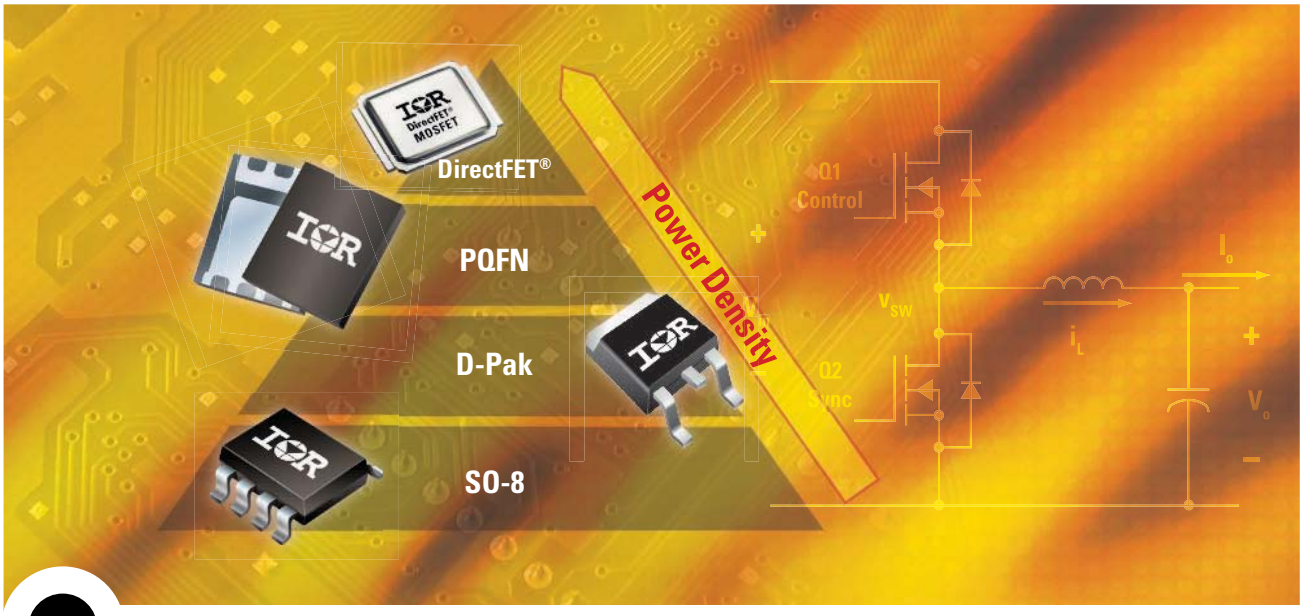

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		Sync		3.0	34
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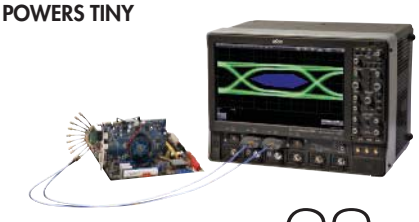

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To provide the most current, accurate, and in-depth technical coverage of the key emerging technologies that engineers need to design tomorrow's products today.

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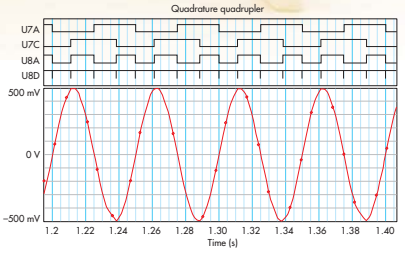

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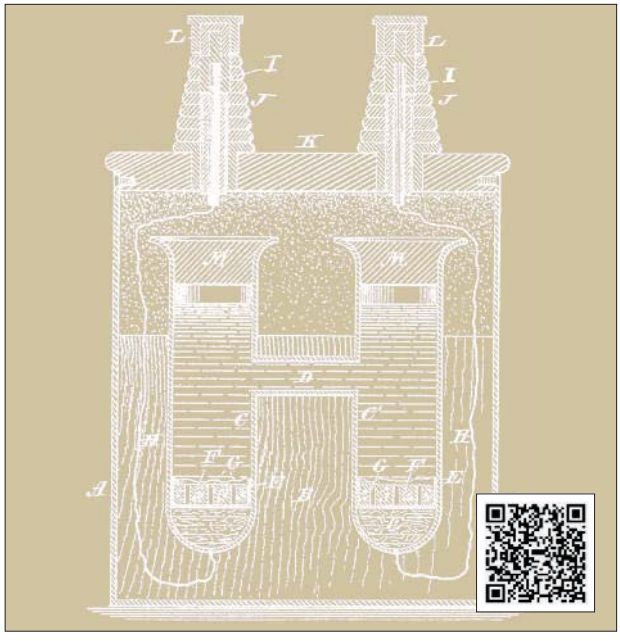

MODERN DESIGN TOOLS MEASURE THE INVISIBLE AND MAKE CIRCUITS SAFER

Proper system design and calibration will ensure accurate voltage measurement, and that is important for safety.

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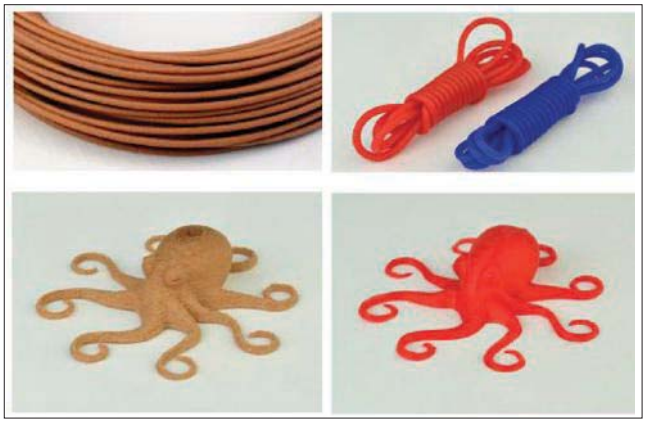
Some types of systems benefit from power-management blocks capable of bi-directional power flow.



3D PRINTING MATERIALS OFFER PROTOTYPING OPTIONS

An assortment of new materials from LulzBot for desktop 3D printers can aid in on-demand creation.

WEARABLE TECHNOLOGIES PRESENT PACKAGING CHALLENGES

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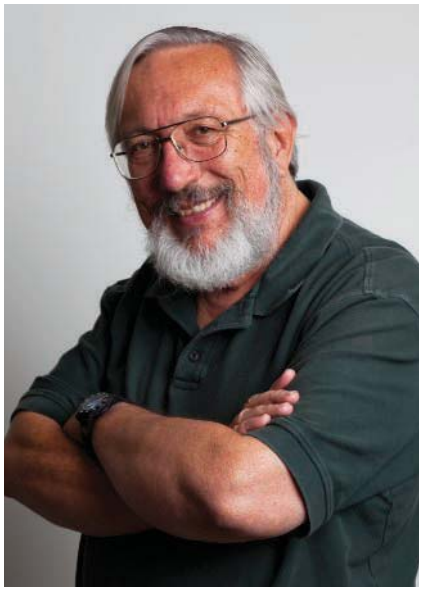


What's All This About Contributed Articles?

Most engineers prefer to write as little as possible. There are occasional exceptions, though. At most companies, there are financial rewards for writing articles for publication. If you're looking to advance your career, it doesn't hurt to have some publications to list in your curriculum vitae. If that sounds interesting, here's some advice.

First, never contact anybody at a magazine or conference until you've talked to your boss and to whoever handles "media relations" inside and outside your company. There could be intellectual property (IP) issues, product timing issues, and ego issues you need to avoid.

Working with a media-relations professional will simplify your life considerably. This person will handle all the phone calls and e-mails that would otherwise waste your time. Also, you will get advice and help in writing a better article, with fewer revisions and less time wasted overall. For instance, maybe somebody in your company already is writing a similar article. The professional will know about it and help you repurpose your idea.

Also, you must be mindful of what a publication wants out of a contributed article. Primarily, it wants to build and maintain a reputation for providing accurate, authoritative, and up-to-date information about solutions to interesting engineering problems. These days, that reputation is based largely on Web metrics, which involve page views, search referrals, unique visitors, and other subtle indices of the content's popularity. Publications will look at your contributed article based on how well it can serve these needs.

With the Web, the article's potential audience and lifetime are infinite. But you still need to attract that audience. So in writing your article, first think about describing a problem, in terms of where it arises, why it's hard to avoid, and what the characteristics of a good solution would be. Then you can generally discus possible solutions and the tradeoffs between them. Finally, finish off with your solution and where it fits.

Then it's time to work again with the media professional, who will make sure your hard-won insight is expressed clearly, effectively, and eloquently. (There's much more to editing than running spellcheck!) You wouldn't go to a job interview without looking your best, and you shouldn't submit your article to a publication unless it similarly shines. Clean copy makes editors happy—and more inclined to accept your work.

Electronic Design has a long and proud history of publishing contributed material, from the earliest days of our popular Ideas for Design department 60 years ago to the newest members of our roster of Contributing Technical Experts. Of course, we're eager to see what submissions we'll receive next. Keep this advice in mind, and perhaps we'll see your byline in these pages sometime soon too. ed

MIKE FAHRION | Contributing Technical Expert
mfahrion@bb-elec.com

The IoT Prepares To Tackle Global Problems

News stories about the Internet of Things (IoT) tend to focus on fun, new consumer gadgets like an Internet-enabled doorbell that sends audio and video to your smartphone. But the real story of the Internet of Things will be industrial machine-to-machine communications (M2M) connectivity.

Our network topologies and capabilities will expand with new technologies and billions of new devices. We'll keep existing equipment connected and communicating as well, as much of our legacy infrastructure is too complex and too valuable to be cast aside. Short-term goals will include eliminating unplanned device downtime and optimizing asset performance. But IoT technology will also help us address the macro trends that pose genuine threats to future prosperity.

CLIMATE CHANGE

Media hyperbole aside, it has become increasingly obvious that we have entered an era of global climate change caused by carbon dioxide. If we want to cut carbon emissions we'll have to use energy far more efficiently than we do now. Shutting down the world's economy isn't an option.

IoT technologies will prove indispensable. They'll greatly increase efficiency in virtually everything we do, and they'll help us attack the carbon problem in other ways as well.

Located on the California-Nevada border, the new Ivanpah Solar Electric Generating System can produce nearly 400 MW without generating any carbon dioxide. It relies upon hundreds of thousands of reflecting mirrors that must be continually positioned to aim their light at a single focal point *(see the figure)*. The Earth rotates, so the mirrors must keep moving as well. Until recently, there would have been no practical way to keep so many mirrors aligned. But with the IoT, managing enormous numbers of remote devices will be commonplace. We're already doing it.

NATURAL RESOURCES

Population growth, along with rising living standards and consumption, is increasing the pressure on all of our natural resources. Improved extraction techniques can only increase short-term supplies. They can't increase the total quantity of a finite resource. We'll need to find ways to make more efficient use of everything from natural gas to irrigation water.

IoT Technologies can coordinate the rotation of the hundreds of thousands of mirrors to maximize energy production at the Ivanpah Solar Electric Generating System on the California-Nevada border. *(courtesy of Business Wire)*

The Ogallala Aquifer under the North American Great Plains provides a useful example. It supplies drinking water for nearly 2 million people in eight Great Plains states, as well as 30% of the irrigation water used in the entire United States. It's being drained at a prodigious rate, though, and at current usage levels it may only last for another 25 years. It would take nature 100,000 years to replace it.

No single solution will solve the problem, but there's already one IoT technology that can make a big difference. It's estimated that as much as 50% of irrigation water is wasted due to evaporation or runoff. So in Europe, a prototype of the new "WaterBee" smart irrigation system is being tested.

Older irrigation systems typically used timers, but the WaterBee is far more sophisticated. It monitors soil conditions in real time with a network of wireless sensors, and it uses the data to determine where and when water actually needs to be released. The WaterBee test sites have already reduced water usage by an average of 40%.

POPULATION

After growing slowly and steadily throughout human history, the world's population passed 1 billion somewhere around 1820. Population growth then began to explode. By 1920 there were 2 billion people. Half a century later it had doubled to

4 billion. The world's population is currently over 7 billion. Every time the population doubles we theoretically need twice as much of everything, from food to transportation systems—that's if we want things to stay the same, much less improve.

But you can achieve the same effect if you make existing systems twice as efficient. By extending intelligence to the edge of our networks, collecting and analyzing unprecedented quantities of real-time data, and making intelligent decisions, IoT technologies will vastly increase efficiency. And when you increase efficiency in a system, you've increased its capacity.

AGING

Studies indicate that population growth has begun to slow down. But at the same time, people are living longer with profound social and economic impacts. Over time, a steadily increasing percentage of the world's population will be made up of the elderly.

IoT technology will help us keep up. For example, NEHI (formerly the New England Healthcare Institute) has estimated that poor medication adherence alone accounts for up to 13% of total health care expenditures, or $290 billion annually in unnecessary costs. Patients fail to take their pills according to the correct schedule, and sometimes they forget to take them at all. A "smart" prescription bottle could compare prescriptions to actual usage and alert the appropriate person if a scheduled medication has been forgotten.

Future intelligent remote devices will let users monitor and test many aspects of their own health without leaving home, and they'll be able to upload the data to be analyzed in the cloud. IoT technology may not be able to talk you into changing your diet or getting more exercise, but it will make health care incredibly more efficient. We'll need that efficiency as the elderly population and their associated health care costs continue to grow.

WHAT'S NEXT

As we face the problems of the future, the deployment of IoT technologies will become increasingly important. Intelligent doorbells will only help us fend off small problems like pesky siding salesmen. Industrial IoT technologies will help us face the problems that really matter.

MIKE FAHRION, director of product management at B&B Electronics, has more than 20 years of design and application experience overseeing M2M connectivity solutions.

News & Analysis

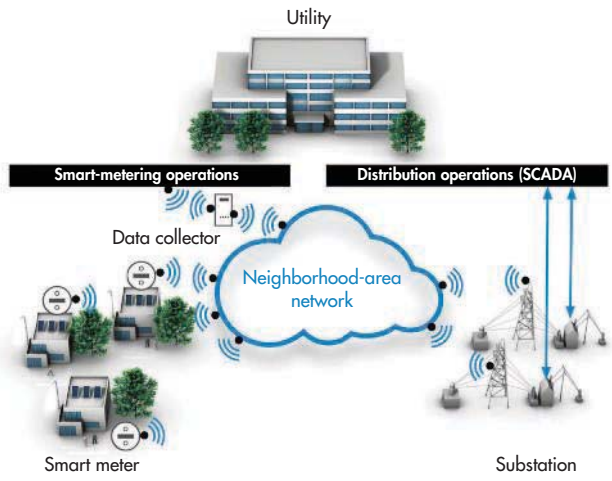
LOU FRENZEL | COMMUNICATIONS EDITOR

The ZigBee Alliance and a group of leading smart-metering and Smart Grid member companies are developing a communication profile aimed at achieving true plug-and-play interoperability between the members' wireless Smart Grid neighborhood-area network (NAN) products and solutions. The NAN is defined as a utility's last-mile, outdoor access network that connects smart meters and distribution automation devices to wide-area network (WAN) gateways.

The ZigBee wireless technology is widely used in home-area networks (HANs) to connect smart meters to home monitoring and control consoles. Up to now there has been no one standard for connecting the smart meter back to the utility. Multiple wireless and wired technologies have been used. Now this new effort may result in a ZigBee standard that can be widely adopted *(see the figure)*.

There is a global requirement from regulators and utilities for a standards-based interoperable NAN. Open global standards give utilities a wider choice of product features, increased price competition, reduced supply risk, and flexibility in selecting vendors, all while ensuring that products

The proposed NAN standard will use the IEEE 802.15.4g wireless standard to collect smart-meter reading from homes and businesses and grid infrastructure and relay the data back to the utility.



will interoperate seamlessly. Existing IEEE and IETF standards on their own do not ensure interoperability due to the many options available within the standards. The NAN specification will fill the gap by selecting the most appropriate options between standards and defining a communications profile with certifiable interoperability. This will be a significant improvement for utilities compared to non-interoperable, proprietary single-vendor solutions.

To ensure interoperability, a full wireless communications protocol is being defined for Layers 1 through 4 of the ISO OSI communication stack, which provides a harmonized transport network supporting different IP-based (Internet protocol) applications. Layers 1 and 2 will be based on the IEEE 802.15.4g amendment to the IEEE 802.15.4 (2011) standard that was introduced to enable the development of interoperable NANs. Layers 3 and 4 will be based on IEFT standards including the IPv6 network layer and associated networking schemes, appropriate routing and transport protocols, and relevant security mechanisms.

This wireless communications profile will enable interoperability between different vendors that have all implemented their smart meters, Smart Grid devices, and communication infrastructure node products according to the certifiable NAN communications profile. Today's existing Smart Grid applications such as smart metering and distribution automation will run on top of this interoperable wireless IPv6 communications profile.

This NAN standardization work will establish a test and certification program supported by independent test houses to certify the interoperability of different manufacturers' Smart Grid products and solutions. The ZigBee Alliance will maintain a register of certified smart-meter and Smart Grid products to provide confidence for utility customers when selecting a Smart Grid vendor.

To date, the definition and documentation of the market requirements and the detailed technical requirements for the NAN have been completed. "Proof of concept" events to test the interoperability of the physical layer and media access controller (PHY/MAC) functions that will be included in the NAN standard have been held during the past year involving companies from around the world. All participants' NAN products were able to communicate with each other through the PHY and MAC layers. In addition, several companies demonstrated interoperability for basic IP functions. ■

Researchers at the Pacific Northwest National Laboratory have developed a smaller and more powerful micro-battery that will improve studies that track the migration of salmon and other fish. *(courtesy of the Pacific Northwest National Laboratory)*

BATTERY BETTER Powers Tiny Fish Trackers

RESEARCHERS USE TINY transmitters to track the migration of salmon and other fish. These transmitters must be powered by batteries, though, affecting the age and range of the fish that can be monitored and limiting the scope of the studies. The Pacific Northwest National Laboratory has developed a smaller and more powerful battery that should improve this tracking.

At 6 mm long and 3 m wide, the micro-battery is a little larger than a long grain of rice (see the figure). Smaller batteries mean smaller transmitters, which then can be implanted in younger fish to give scientists a better view of their life cycle. With more power, these transmitters can broadcast signals over longer distances so researchers can track fish further from shore or from dams, or deeper in the water.

The battery uses the "jellyroll" technique commonly used in household cylindrical batteries. Battery materials are placed on top of each other in a process known as lamination and then rolled up together. The layers include a separating material sandwiched by a cathode made of carbon fluoride and an anode made of lithium.

This technique increases the area of the electrodes without increasing their thickness or the battery's overall size. It also keeps the impedance from getting too high, which can be a problem in small batteries as electrons don't have the space to flow easily or quickly along their required routes. The jellyrolling creates a larger space for the electrons to interact.

The battery weighs 70 mg and boasts 240 watt hours per kilogram, compared to the 135 mg and 100 watt hours per kilogram of commercially available silver-oxide button micro-batteries. It can power a 744-µs signal sent every three seconds for about three weeks, or five seconds for a month. Also, it works better in the cold waters where salmon often live, thanks to its lithium and carbon-fluoride chemistry. ■

RICHARD GAWEL

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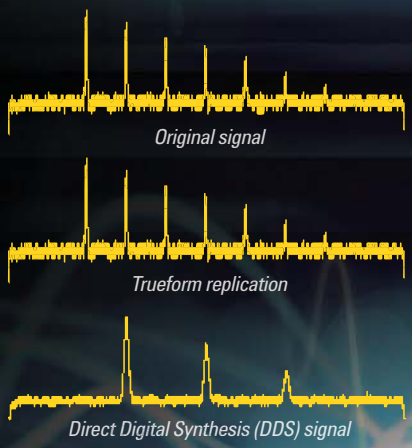

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These ROBOTS

The word *robot* conjures up a range of visions, from the helpful R2-D2 of *Star Wars* to Arnold Schwarzenegger's terrifying Terminator. These robots got up close and personal with people. While robots aren't fully integrated into our society yet, they have had a long run on the assembly line.

Autonomous drones have plied the airways safely. But robots that work with human beings and other delicate items require significantly more safety considerations. Designers can make them very small and simple, like iRobot's Roomba line. Vacuum cleaners tend to be safe, and you'll probably only get hurt if you trip over one.

Other companies are producing robots that mow lawns, which is a bit more dangerous. These autonomous mowers have safety shutoffs for their blades, but their larger size still could present some problems. Many other larger and more complicated robots are emerging in different applications, so designers need to account for safety as well as performance.

As robots move off the factory floor and into our streets and hallways, designers are using hardware and software safety features alike to minimize potential accidents and injuries.

ARE NO DANGER, WILL ROBINSON!

TELEOPERATED ROBOTS

The definition of a robot is like the definition of the Internet of Things—it's fluid. Teleoperated devices normally are considered robots, and many are semi-autonomous. The main difference between these teleoperated and autonomous robots is that a user oversees the operation of the teleoperated robot.

I've used Suitable Technologies' Beam *(Fig. 1)* to attend a number of conferences remotely. Telepresence robots are a manifestation of the numerous flying, rolling, and floating unmanned vehicles that currently exist.

Remote users directly control some teleoperated robots—for example, by driving them to a specific point. Other robots operate in a semiautonomous mode by using waypoints. Remote feedback often cannot operate quickly enough, so semiautonomous operation may be required for seamless operation. For example, most copters provide automatic stability control so the operator specifies direction or position, and the device responds accordingly. The typical default state is to hover in place.

Some devices can operate in autonomous mode. When many copters enter failsafe mode, some gently land, while others return to a predefined spot. Electric vehicles may enter this mode when their batteries begin to run low.

RESEARCH ROBOTS

Today's state-of-the-art robots have required a lot of research, but much more needs to be done. That's why robotics is such a hot subject for science competitions and universities. It encompasses a wide range of disciplines, from mechanical and electrical engineering to embedded programming and artificial intelligence.

Companies like ABB are looking to tackle many of the challenges robots are encountering in working with people. The ABB Dual Arm Concept Robot (DACR) research platform highlights some of these challenges and solutions. It consists of a portable torso and two arms *(Fig. 2)*. It also uses single-phase power, and all of its surfaces are designed for easy cleaning.

ABB's designers focused on allowing the arms to work in confined spaces by employing seven-axis kinematics for each arm. With this kinematic redundancy, the robot can move its elbows independently from the tool center point (TCP), while typical robotic arms could not. The controller then can employ more sophisticated avoidance algorithms in moving the arm.

The DACR has no exposed cabling, which sometimes is found on industrial robots, minimizing problems where cables could become entangled with nearby people or objects. The system is designed for light payloads, minimizing arm inertia when moving to soften any collisions with people or objects.

The system employs a software-based collision detection system. It also is designed so no human body part can be clamped between the axes of the system. Still, there are pinch points. But if a clamping force is detected, the software turns off the motors.

NASA's Robonaut 2 has more of a challenge in the International Space Station (ISS) compared to its earthbound counterparts. It has legs that climb, enabling it to move in zero gravity and work with astronauts with both hands while keeping at least one leg anchored to the ISS *(Fig. 3)*.

The system is designed for supervised control, although the arms and hands can be teleoperated. It is double-fault tolerant because of its critical environment. Everything has a double ground path, so nothing gets shocked. Some of these safety issues could be less important on the ground, but in space it is best to anticipate every problem to prevent failures that can turn into catastrophes.

Robonaut 2's hands have five fingers, and its legs are 3 m long with seven joints. Its legs also have special end effectors that are designed to clamp onto the rails that are spaced inside and outside the ISS. Robonaut 2 uses these effectors to move from one rail to another without ever floating freely like the astronauts inside the station.

The brushless direct current (BLDC) motor control for each joint is an FPGA with PowerPC or ARM hard-core processors. The motor controls have sensors attached in addition to motor feedback. The joints have a torsional spring so their stiffness can be controlled using the motors and the spring's response.

Another challenge was changing the usual velocity control found on ground-based robots to a momentum-based approach because the robot is designed to move around the ISS. The surfaces on the station are designed with a 125-pound kick limit so astronauts can push off any surface to move about. Robonaut 2 tries to limit its pressure to 100 pounds. That can be tough for a 600-pound robot, including the battery pack. The legs were designed later, so NASA initially used this approach. The upper body is being reprogrammed to match these requirements.

ROBOTS NOW

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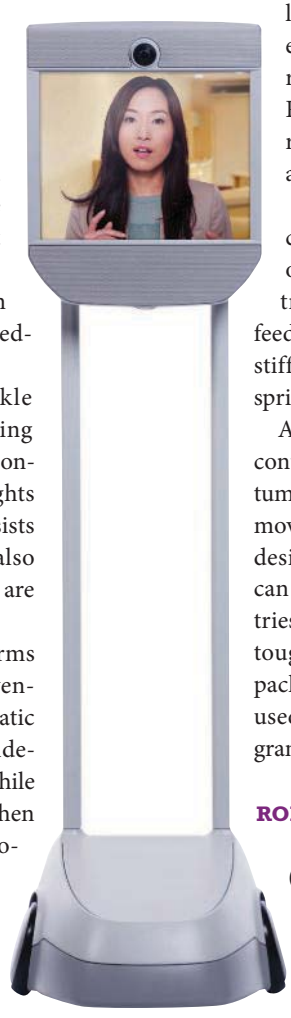

1. Suitable Technologies' Beam is a telepresence robot that requires a remote user to control its movement.

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2. The ABB Dual Arm Concept Robot (DACR) research platform is designed to operate in close proximity with people. It is free from sharp edges and has padding to soften any bumps or contact with people or other objects.

standard developed by the Robotic Industries Association. It matches the International ISO 10218:2011 standard. These standards provide a range of safety specifications for robots, including risk assessment and proper implementation of safeguarding robot systems. Developers working in this space can design their robots to address these standards. But what about those who do not want to start from scratch or have jobs for robots right now? There are alternatives.

Rethink Robotics' Baxter has found a home on many production lines. Like the DACR, it's a field-ready two-armed torso. Its built-in software can be trained by example, allowing fast repurposing on an assembly line as demands change. It has been used in many production environments, like one plastic injection molding facility where it packed more than 800,000 medicine cups in its first six weeks of operation. Contract packages have found its ability to be reprogrammed invaluable. It is so simple that reprogramming could be done on a daily basis if necessary.

Baxter's two arms may look large and heavy, but they are light. The motors inside drive a spring that provides flexibility if the arms come in contact with an obstacle like a person. Onboard sensors with cameras help detect obstacles, including people. Cameras are located on the hands as well as the upper body. The display provides operator feedback.

Baxter already knows it has two arms and to keep them away from each other, since it doesn't have to scratch any itches. They can perform independent tasks without colliding. If these tasks ever conflict, one arm will wait to make its next move while the other completes its operation.

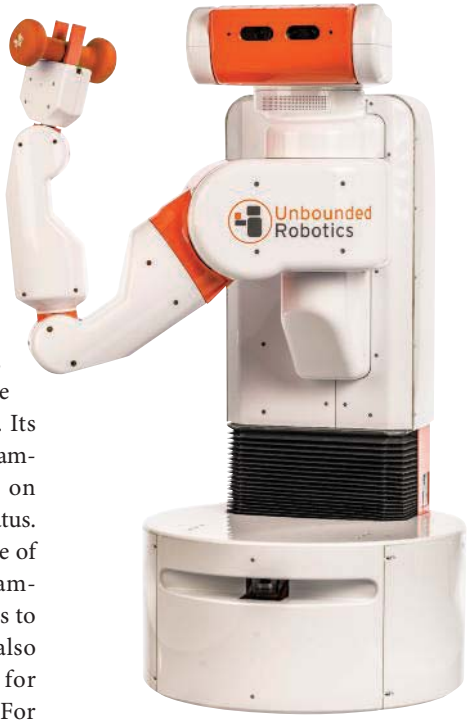
3. Developed by NASA and General Motors, the Robonaut 2 can maneuver around the International Space Station thanks to special end effectors on its legs that can clamp onto rails posted inside and outside the ISS. (courtesy of NASA)

The latest software update to Baxter included a number of new features. Baxter's training initially would allow an object to be moved from a plane to another plane parallel to the first, such as picking up a block and putting it on top of another block nearby. Now it can take an object that might be on an angle and move it to another position on a different angle. Of course, moving from point A to B is just the simplest task Baxter can perform. Its cameras and sensors allow more dynamic recognition and actions based on characteristics and environmental status.

Baxter now can hook into a range of additional equipment, from programmable logic controller (PLC) devices to barcode scanners and cameras. It also can hold an object in a location for a predetermined amount of time. For example, it might pick up an object, pass it by a barcode scanner, then place it in a particular area based on the result of the scan, and finally initiate an action via a PLC device. Alternatively, it may hold an object in front of a paint sprayer.

People working with Baxter have been amenable to its operation. It helps to have an assistant that handles repetitive tasks and is safe to work around. Baxter also can be used out of the box, though a research version is available for those who want to program it directly. Baxter utilizes the Robot Operating System (ROS), but the research version makes all the source code that is delivered with the system available. Researchers are utilizing the platform to experiment with their own software for new applications.

The Unbounded Robotics UBR-1 is a one-armed robot that also runs ROS *(Fig. 4)*. Unlike Baxter, UBR-1 is mobile so it adds a suite of sensors to detect obstacles around itself, including a 2D laser scanner in its base. UBR-1 is more of a development platform, but it could be a delivery vehicle with additional software. It already can be used with ROS-related software packages like Navigation and MoveIt to control its arm.



4. The Unbounded Robotics UBR-1 runs ROS, the Robot Operating System.

The back-drivable arm has seven degrees of freedom. Its weight limit is 3.3 pounds, so even when it's fully loaded it shouldn't hurt anyone it bumps into. The various sensors also can help to detect and avoid collisions. The torso can lift, allowing UBR-1 to reach higher. Its modular, parallel jaw gripper has interchangeable fingertips.

Additional peripherals can be connected via USB 3.0, and extra mounting holes are spaced around the robot to allow external customization. UBR-1 can run continuously for three to five hours and idle for up to 10. It also can be used as a more sophisticated telepresence robot. Its pivoting head has a 3D color sensor as well as microphones. Stereo speakers are mounted in the neck.

ROLLING ROBOTS

Robots with arms and mobility increase system complexity while providing additional functionality. Still, there are many applications where autonomy and mobility are sufficient, such as driverless cars. Many companies

5. Aethon's Tug pulls a trailer that can deliver drugs from the pharmacy or lunch from the cafeteria throughout a hospital.

are working on these autonomous vehicles, though it's a harder problem than getting from here to there. Today's roads are much more complex than factory floors, and their conditions are much more variable.

Safe solutions are challenging, but what if the constraints were different? That's the approach Induct Technologies took in its Navia driverless shuttle. This automated electric system is designed for flexible transportation of up to eight people around campus settings such as parks, and airports.

The Navia is ringed with laser sensors that have a twofold purpose. One is to detect objects so they can be avoided. Running over potential passengers would be a bad idea. The other is to detect the vehicle's position based on nearby buildings by using image recognition instead of GPS or special beacons. The maximum speed of the vehicle is 12.5 miles/hour.

The Navia has to do more than just get from point A to point B. It also needs to allow people to get on and off, often at predefined points. Cones or lines might mark a stop for passengers rather than the shuttle. The Navia also needs to open and close its gates so people stay within it while it is moving.

Induct Technologies has a system that manages multiple routes and vehicles for a more on-demand type of operation. An empty unit could move to pick up passengers when they arrive at a location, possibly prompted by a smartphone text. Vehicles could cycle through a path with more added as demand increases. The system can even handle charging, replacing a vehicle with a fully charged unit.

Being electric, the Navia can operate indoors or outdoors, although its current open nature will limit operation for passenger comfort. It requires no special infrastructure other than plugging in a charging station or two. Induct Technologies was running the Navia at the 2014 International CES.

Aethon's Tug is designed to operate indoors in locations like hospitals where the company has been very successful *(Fig. 5)*. It delivers objects including drugs, food, and laundry instead of people. Like Navia, it can operate 24/7.

The hospital environment is amenable to the Tug and its cargo because of the automation already built into many hospitals, such as doors and elevators that open electronically. It can pull a carrier to an elevator and then through a series of doors without user intervention. The Tug normally stops at a designated location where a person would then add or remove items.

The Tug is like the Navia with a sensor cluster including LIDAR, which helps it avoid people and objects. Usually it can navigate around objects, assuming a path is not completely blocked. It isn't designed to remove obstacles, but it can notify a person that it needs help. And like Baxter, the Tug can handle repetitive tasks so people can address more critical chores that robots can't handle. ED

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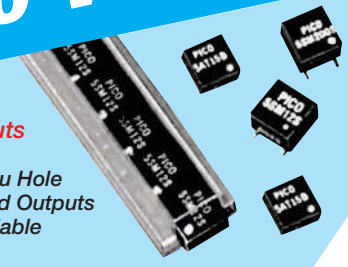

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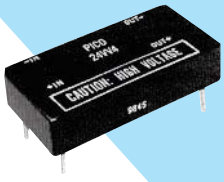

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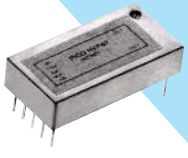

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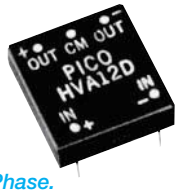

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LOU FRENZEL | Communications Editor
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Beyond computers and smartphones, IoT and M2M technologies promise devices that talk to their users and to each other.

The CONNECTED

The Internet of Things (IoT) and machine-to-machine (M2M) communications are hot technologies, dominating recent articles, conferences, and webinars. They won't fully emerge this year, but great progress is being made in developing and deploying them *(see "Who's Doing What In IoT And M2M" at electronicdesign.com)*.

M2M has been around for a while, but the IoT movement is still developing. Both technologies are looking for a few good applications, with several now on the market. The future will be more interesting when everything is connected.

IOT VERSUS M2M

M2M is the automated remote monitoring and control of objects, such as pipelines, vending machines, and fleet vehicles. It connects machines to one another and facilitates communications between them. This connectivity has largely been cellular, although other technologies like Wi-Fi are used.

M2M-enabled devices can exchange information, make decisions, and implement operations without human assistance. In development for more than two decades, M2M began with various applications in telemetry, industrial automation, and systems like SCADA (supervisory control and data acquisition).

M2M forms the basis for IoT. Also known as the Internet of Everything, IoT is a broader vision for connecting machines to machines or people to machines. While M2M focuses predominantly on industrial, business, and commercial applications, IoT is more for consumer applications.

The goal is to put almost anything on the Internet so it can communicate with remote computers, other devices, or even people. According to Juniper Research, "the management of devices is key to M2M and distinguishes it from the Internet of Things where any object may be furnished with connectivity on an ad hoc basis."

The term "smart" is used to describe M2M and IoT devices and applications. The availability of Internet Protocol version 6 (IPv6) makes it possible to connect billions of devices thanks to its 128-bit addresses. So why not?

There do not seem to be any formal definitions of IoT or M2M, and many people believe they are the same thing. One view is that M2M does not necessarily use the Internet, while IoT assumes an Internet path for communications. Both M2M and IoT are similar in their objectives but with slightly different applications and implementations.

Rejeev Kumar of Freescale calls IoT the technology of connecting any device with an embedded controller. Since virtually every electronic device has some kind of microcontroller, they all are candidates for an IoT application. Billions of devices are potential nodes on the Internet. Some sources expect 50 billion devices to be connected by 2020. Other estimates range from 20 billion to 100 billion connected devices by the 2018-to-2020 time frame.

WORLD AWAITS

The Nest thermostat uses a Wi-Fi connection to the Internet, enabling users to control the temperature at home via a smartphone.

The overriding goal of M2M and IoT is to add value. They aim to improve efficiency, cut costs, provide greater convenience, and improve customer service. When that can be demonstrated, they will be quickly adopted.

Just because we can do something technologically, though, it doesn't necessarily mean that we should. Do we really need microwave ovens or toys connected to the Internet? The possibilities are endless, but common sense will prevail and practical applications will identify themselves.

HOW IT WORKS

In IoT applications, the device to be monitored or controlled has an embedded wireless transceiver that talks to a gateway or router that has an Internet connection *(Fig. 1)*. For example, a home thermostat would communicate by Wi-Fi with the home Wi-Fi router that connects to the Internet via a cable TV link. That link connects with a remote cloud-based server that supplies the application's intelligence, collects the data, analyzes it, stores it, makes decisions, and initiates actions. This server connects by way of the Internet to the applications interface, where another machine like a PC analyzes and displays status and actions. Smartphones are popular interfaces, quickly becoming our all-purpose remote control.

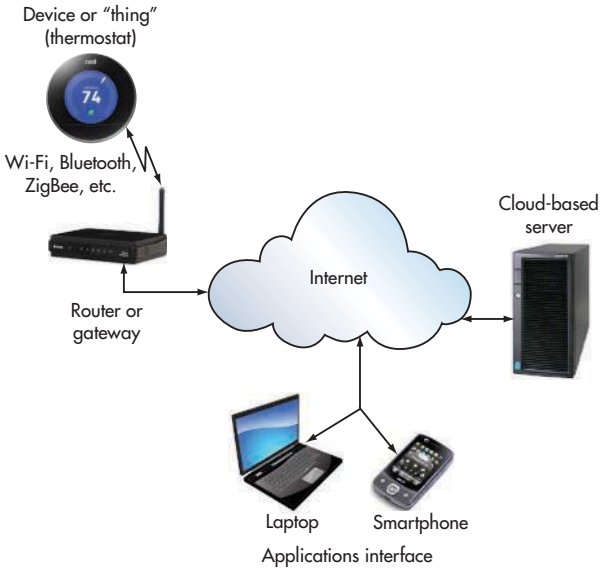
An alternative scenario more fitting for an M2M application is a cellular telephone module embedded into the product to be monitored or controlled. The module talks directly to a nearby cell site through the standard cellular network. The cellular carrier routes the connection to the remote cloud-based server and the applications interface. In some cases, the application server may be a part of the cellular supplier's service.

Most IoT and M2M applications are simple and not demanding, with modest data rates that do not require high-speed connections. Wi-Fi and 3G/4G cellular are usually overkill but are used anyway. A typical application may require only an 8-bit embedded controller. Communications connections like TCP/IP or UDP/IP and Ethernet, though, typically require a 32-bit processor including Linux or some smaller real-time operating system (RTOS).

THE WIRELESS TECHNOLOGIES

The heart of most IoT and M2M products is one or more wireless connections. The technology that's chosen depends on the application and services available. Most short-range wireless technologies are used in some form, with cellular and Wi-Fi dominating.

M2M applications mostly use an embedded cellular radio. Multiple suppliers of cellular modules offer 2G, 3G, and 4G technologies. All the major cellular operators in the U.S.,



1. Any Internet of Things application includes the "thing," a wireless gateway to the Internet, the application server, and the application interface.

including AT&T, Sprint, T-Mobile, and Verizon, offer M2M connectivity service.

GSM with GPRS 2G has been the most popular since it only involves low-speed data. But with most carriers phasing out 2G service or repurposing its spectrum in the coming years to better accommodate 3G and LTE services, the 2G option may be going away. Some carriers plan to phase out 2G by 2017, although others have no announced agenda for that.

For new applications, 3G like WCDMA or CDMA2000 is a better choice. Most M2M applications are fixed and typically will remain the same for years, so it is best to have a solid guarantee of service for the future. For video and other high-speed applications, fast 3G and LTE modules and services are available to handle speeds to many megabits per second as needed.

About 40% of M2M is cellular. ABI Research predicts that by 2018, nearly 60% of M2M will be cellular and most of the M2M revenue will come from carrier services. With the maturity and saturation of the cell-phone business in the U.S. and Western Europe, the carriers are looking for paths to increased growth. M2M seems to be that route.

Wi-Fi is also a major technology for both IoT and M2M. Multiple vendor modules offer 802.11a/b/g/n connectivity, mostly in the 2.4-GHz band. Multiple vendors also supply routers and gateways that feature Wi-Fi. A common configuration is a Wi-Fi router with an Ethernet connection to a cable or DSL modem. Another variant is a gateway that takes Wi-Fi on one side and a cellular connection on the other.

Wi-Fi dominates where power is readily available, such as home appliances. Most major appliance manufacturers have already embedded Wi-Fi into refrigerators, washing machines, and dryers to report usage and various physical characteristics such as wear and time of use. Some home thermostats use Wi-Fi as well.

Furthermore, many homes already have a Wi-Fi router and Internet connection, making connectivity fast and easy. Wi-Fi is also the choice if longer range is needed. Most Wi-Fi connections can be achieved at a range up to 100 meters depending on the environmental conditions, especially obstacles like walls or foliage.

When low power consumption is mandatory and shorter ranges and multiple devices are involved, other wireless technologies are better options. Bluetooth Low Energy (BLE) is emerging as a key player, especially in health/fitness and medical monitoring applications. BLE is also a popular choice for wearable technologies.

Its very low power con-

2. The Belkin WeMo Internet-controlled crockpot for slow cooking uses a Wi-Fi link to provide Internet access.

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When multiple sensors must be monitored, wireless technologies like ZigBee are a good choice as they offer the mesh network topology that allows hundreds or even thousands of nodes to be monitored or controlled. Building automation is one area. So are home-area networks (HANs) where the utility's smart electric meter can provide energy consumption data wirelessly. In industrial settings, other wireless mesh networks may make more sense, like Linear Technologies Dust Networks' WirelessHART and ISA 100a. Z-Wave is also an option in some consumer applications.

And let's not forget RFID. Some "things" may only require a cheap and simple connection that an RFID tag can provide. Near-field communications (NFC) is another choice. Both are very short-range technologies (less than a few feet), but some applications are perfectly useful in this range. In all cases, these short-range wireless devices typically require an intermediate gateway to collect the data and then connect to the Internet or a cellular carrier by another wired or wireless technology.

Cabling also can be used in some IoT or M2M applications if it is available. Dial-up telephone lines have been used with modems for M2M. Power-line communications (PLC) is another alternative where applicable. PLC is more viable than ever wherever ac power lines are a clear choice for the communications medium. Multiple PLC technologies are available, such as HomePlug, IEEE P1901, PRIME, and G3.

M2M APPLICATIONS

M2M uses fall into several major vertical categories: transportation, energy, industrial, sales and payment, security, and healthcare.

Transportation includes automotive fleet management. Trucking companies can use M2M to monitor the location and status of their tractors and trailers. Any large asset can be tracked via an embedded GPS receiver. Trains and boats also use M2M to a lesser extent, but that may increase in the future. Most of these applications use cellular connections. Other automotive uses are emerging as well *(see "The Connected Car" at electronicdesign.com)*.

Energy applications are based on the Smart Grid. M2M is increasingly used to monitor electric generating facilities, substations, and related equipment. It is extensively used in wind and solar generation plants. M2M has also come to some neighborhoods to send utility meter data back to the utility. Smart meters in homes transmit electric or gas usage to a nearby concentrator hub using ZigBee or some other wireless technology. The concentrator then connects back to the utility via the cellular network or some other wireless method.

Industrial M2M is simply a variation of industrial automation communications. There are many forms of industrial networks, and the number of wireless networks is growing.

3. The Vignet hub collects patient monitoring data with Bluetooth or Wi-Fi and then transmits it over the cellular network using Gemalto's Cinterion embedded cellular transceiver.

Telemetry is the biggest category with the monitoring of oil and gas pipelines, tank farms, oil rigs, and other remote facilities by cellular or other connections.

Sales and payment uses are everywhere. Point-of-sale terminals are all networked, many wirelessly. Vending machines and kiosks are often monitored by cellular. M2M also is used for security applications, particularly video that's recorded and sometimes monitored by a person. Cellular is the usual choice, although other wireless links are often involved. Healthcare applications mostly involve remote patient monitoring.

THE INTERNET OF THINGS

IoT is like M2M, with a broader scope of applications. It is more commercial, but there is also an industrial IoT for more hardened and secure applications. For the most part, IoT assumes that each "thing," which can be almost anything, has an IP address. It has been a good concept for years, but now it's in the very early stages of development. Like all new technologies, it has started with proprietary products and systems but seems destined to develop where standards are available to move the concept forward to implementation.

Most applications target the home, such as the slow-cooking crockpot from Belkin's WeMo family of IoT products *(Fig. 2)*. You can turn it on and off and even control its temperature through an app on your iPhone. Other WeMo products include Smart LED lighting control and the WeMo Maker, a generic device that lets do-it-yourselfers build solutions by adding Internet connectivity to any device controlled with a dc switch such as robots, motors, and sprinklers via an iPhone app.

The Nest Learning Thermostat can replace most existing thermostats for improved monitoring and control of heating and air conditioning for energy savings *(see the opening figure)*. It is linked by Wi-Fi to the home router. A smartphone

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app lets you view and change the setting. Google recently acquired Nest, which also offers IoT smoke and carbon-monoxide sensors for the home.

Note the theme here. A smartphone or a tablet is used as the monitor and control device. They are ideal platforms for Internet connections. That means more machine-to-human rather than machine-to-machine conversations, unlike pure M2M. And the number of possible home applications is huge. Besides appliances, IoT will include garage doors, door locks, security systems with remote video, lighting, and more.

However, home automation is still a niche. Not many households are willing to add all that technology with its high cost and management overhead. Too much tech support is required to get everything installed and working, and trouble-shooting takes up lots of time. Few people want the hassle of programming and coordinating all the connected products.

The things in the Internet of Things only are connected so people can monitor and control them. They do not talk to one another. It doesn't make sense for your crockpot to talk to your door lock, but such communications eventually can be implemented. Security systems can be connected to lighting systems, for instance. That's the IoT of the future.

Health and fitness is another burgeoning IoT area. Patient monitoring has become popular with sensors like electrocardiogram patches, sleep sensors, blood glucose and blood pressure monitors, and thermometers for specific body functions. Patients can be quickly and easily instrumented with sensors and wireless connections that gather data for transmission later or even in real time.

Vignet's hub collects data from wireless sensors using Bluetooth, Wi-Fi, or some other wireless link and stores and consolidates it *(Fig. 3)*. Gemalto's embedded Cinterion 3G/4G cellular module sends the collected data to the health care provider. Unlike other solutions, this hub meets Health Insurance Portability and Accountability Act (HIPAA) privacy requirements, an important feature when dealing with personal medical data.

4. Samsung's Gear smartwatch connects to the Galaxy smartphone using Bluetooth.

Wearable technologies are another IoT category, including Google Glass, smart watches such as Samsung's Gear, and sensor-embedded clothing like vests and coats *(Fig. 4)*. These devices usually connect via Bluetooth to a smartphone or other platform for further processing and connectivity. Fitness devices transmit exercise data like heart rate or pedometer steps from Bluetooth sensors to a smartphone for collection, storage, and analysis. The general acceptance of wearables has yet to be determined, but they definitely will be part of the IoT mix.

CRITICAL ISSUES

Security, certification, and standards all are slowing full M2M and IoT adoption. For example, the Federal Communications Commission (FCC) must certify all wireless products. If you embed wireless chips into your product, you will need to comply with the Code of Federal Regulations (CFR) 47 Part 15. These regulations mostly involve tests to ensure proper power output and frequency as well as minimal electromagnetic interference (EMI) with other products and services. The finished unit must be tested and certified before you can use or sell it.

This is a huge issue if you aren't an experienced wireless engineer. Most designers have a certified compliance test lab perform the testing, which can cost around $10,000. You can do some initial compliance testing yourself if you have a spectrum analyzer. Some newer oscilloscopes like Tektronix's MDO4104B have a built-in spectrum analyzer that will let you check your own compliance *(Fig. 5)*. Incidentally, if you embed pre-certified Wi-Fi or other wireless modules in your design, you won't have to endure the compliance testing.

The lack of standards is impeding progress as well. The wireless standards are fixed, but the protocols for transferring data aren't. Most products and systems use proprietary protocols. However, there are several efforts to develop some proto-

5. Tektronix's MDO4104B oscilloscope has an internal spectrum analyzer that can help you perform pre-certification tests for your wireless products.

cols that most devices can use. This will speed development and perhaps even make it possible for seamless interoperability among products. Standards have yet to be finalized, though. So if you're planning an IoT product or business, take a close look at the alternatives and support the one that's best for you.

The International Telecommunications Union (ITU) is working on M2M standards, but it will be a while before we see final ratification. In the meantime, the Telecommunications Industry Association (TIA) TR-50 Smart Device Communication Standard now standardizes the link that smart devices use to communicate with services and applications. It provides an agnostic framework to allow all devices, routers, gateways, and other equipment to work together. The work is still in progress, but final results are expected this year.

Another major effort is the AllJoyn protocol developed by Qualcomm. Based on Linux, it is like an application programming interface (API) that lets devices talk to one another and provides a programming framework for development. Qualcomm recently transferred AllJoyn to the Linux Foundation, which created the AllSeen Alliance to support and further develop the standard.

Another protocol to consider for IoT is 6LoWPAN. This encapsulation and header compression standard developed by the Internet Engineering Task Force (IETF) allows IPv6 packets to be used with the IEEE 802.15.4 wireless standard. It supports mesh networking and is the basis for ZigBee and other short-range wireless standards.

Finally, how will widespread IoT/M2M affect existing networks? Will the "big data" created in the cloud overwhelm the Internet or clog the cellular systems? Will the EMI from billions of wireless nodes overwhelm the spectrum? While most applications only generate small bits of data usually at low speeds at low power, will the volume of billions of connections bring our networks to their knees? We shall see. ed

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Scopes Move Into A More Intelligent Future

The basic bench oscilloscope's days are numbered as new devices integrate adaptable and easy-to-use functionality that used to require multiple tools.

Historically, one of the things that has characterized oscilloscopes was that learning to use one properly was a little like learning to fly a small plane. It wasn't all that hard, but it took some engineering knowhow, a bit of practical experience, and a good teacher before you were adept.

That's been changing over the last few years. Downloadable firmware has made scopes a lot more versatile in terms of how well they can concentrate on the measurements needed for specific tasks. These days, it's all in the software.

EASE OF USE TAKES CENTER STAGE

Test and measurement vendors often will assert that their particular instrument sets the standard for intuitive operation and ease of use. Most of today's innovation around tools for validating or debugging electronics designs isn't about speeds and feeds, but more "touchy feely" factors like usability, productivity, and intuitive operation. While it's easy to dismiss improved usability as a significant development, the day-to-day requirements placed on design engineers suggest that it has emerged as a critical feature.

First off, there's the question of emphasis. Design engineers first and foremost are designers, not necessarily test and measurement experts. The time they spend building test fixtures, writing MATLAB scripts, or struggling with complex, convoluted user interfaces all equate to lost time doing what they are really good at—designing.

1. The Rohde & Schwarz RTE oscilloscopes are available with two or four channels and bandwidths from 200 MHz to 1 GHz. They sample at 5 Gsamples/s and store 10 Msamples per channel (expandable to 50 Msamples per channel).

Along the same lines, economic pressures and budget cuts mean today's engineer must be a jack of all trades. The engineer in the past who could focus on digital design now must get involved with validating power supplies or sorting out wireless local-area network (WLAN) interference problems.

To make those different tasks easier, automated measurements and test suites are becoming increasingly important. From power analysis measurements like switching loss and safe operating area to common measurements on an RF radio like occupied bandwidth and channel power, these automated measurements make highly complex measurements simple and repeatable even for engineers whose primary jobs revolve around design.

Using the various tools, designers can take on many common tasks such as validating the operation of an embedded power supply or checking the functionality of an integrated wireless radio module without complex programming. Given the importance of usability, automation, and versatility for many designers, advanced test suites now are becoming available on more affordable instrumentation.

THE IMPORTANCE OF RAPID ANALYSIS

Following the incorporation of greater computing power in digital oscilloscopes, vendors have pulled increased measurement functionality into these instruments. Through software systems for compliance testing, full "push button" pass/fail analysis of popular buses such as USB and Ethernet is now possible.

Additionally, these software packages can even decode and provide compliance or signal quality tests for RF signaling. Near-field communications (NFC) is a standard that can be difficult to ensure interoperability on. Utilizing an automated software package can provide confidence and consistency to the evaluation of these signals.

Now that the automation of common digital standards has been incorporated into modern oscilloscopes, the next frontier of complex new problems arises. The introduction of these very same RF signals and the high-speed signals in many digital standards brings about yet another challenge for designers in the modern era.

The high switching rates of these signals and the power levels of some RF signals can cause significant electromagnetic interference (EMI) issues. The problems created can range from in-system issues such as coupling into nearby and lower power traces to EMI compliance standards issues.

One example might be a buck converter (step down) power supply operating at 600 kHz that is taking a 12-V input and creating a 1.8-V supply to another part of the system. Nearby signal traces might see coupling from the harmonics of this supply during certain load conditions. If a test engineer only sees the disturbance and cannot trace back to the source, how will the designer modify the design for proper functionality?

Another example is FCC Class-B radiated emissions between 30 MHz and 1 GHz at 3 meters. These emissions cannot exceed 40 dbμV/m (or 54 dbμV/m, depending on the frequency band). Often, engineers don't think about the EMI issues during the debug phase. So, what is to be done when the test report comes back with a failing result?

Enter the next advance in oscilloscope technologies. Utilizing hardware-based fast Fourier transform (FFT) technology and highly sensitive front ends with high dynamic range, some modern oscilloscopes also can function as a spectrum analyzer with perfect correlation to the time domain. This technology allows for both of these issues to be understood, debugged, and resolved.

The major contribution allowing this has been the movement of FFT analysis into hardware in the oscilloscope architecture. This creates a high update rate or "feel" when using an FFT to give the impression of a live spectrum update. Using an oscilloscope like this provides multiple benefits over a traditional approach using a separate oscilloscope and spectrum analyzer.

Due to the broadband nature of the oscilloscope, multiple gigahertz of spectrum can be viewed at once. Transient and intermittent signals at varying frequencies then can be seen and analyzed at the same time. You might not always know where specifically to look within the spectrum. With a high-update-rate FFT, you can look everywhere.

Interference between harmonic signals or non-harmonic anomalies can be quickly identified and traced back into the time domain. This could allow for fast troubleshooting of a power supply that is creating distortions in nearby signals.

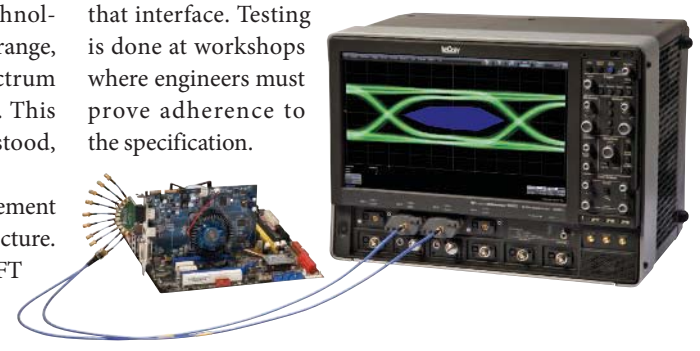
Stopping on an event utilizing frequency masks can allow for time-relevant debug of intermittent events and even the ability to go back in time to evaluate root cause events. This might be utilized when a rare but significant event turns on and causes an EMI violation in the chamber.

Modern oscilloscopes such as the recent RTE series and the popular RTO series from Rohde & Schwarz are bringing measurements like these to oscilloscopes, starting at 200 MHz *(Fig. 1)*. Important considerations are the type of FFT being used, along with the bandwidth needed for the analog measurements and the frequency domain measurements needed.

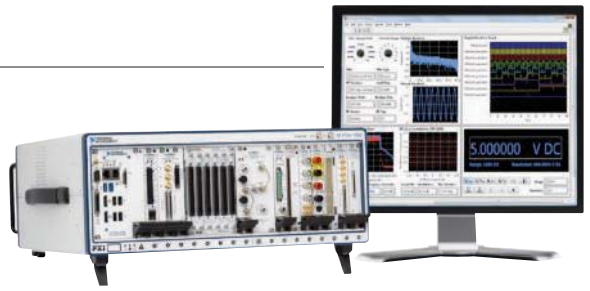
WHEN MULTIPLE SERIAL-DATA PROTOCOLS ATTACK

The days when designers worked with one or two serial-data protocols for any given project are largely over. Now, system designs often integrate a host of serial protocols: SATA for the disk drive(s), USB for external connectivity, DDR for memory interfaces, and a display bus such as DisplayPort *(Fig. 2)*.

Automated compliance testing has been one of the most important trends in test and measurement in recent years. Standards organizations for certain serial protocols such as USB, PCI Express, and SATA have very strict "logo programs" in which they specify a set battery of tests that an interface must pass before they will permit their logo to grace the end product. Without that logo, you will not be shipping your product with that interface. Testing is done at workshops where engineers must prove adherence to the specification.



2. The QPHY-DisplayPort software for Teledyne LeCroy's WaveMaster/SDA/DDA 8 Zi series of oscilloscopes provides an automated test environment for running all of the normative real-time oscilloscope tests for sources in accordance with Version 1.1 of the Video Electronics Standards Association (VESA) DisplayPort PHY Compliance Test Standard.



3. National Instruments chassis like this one for PCI Express combine high-performance backplanes and a rugged, mechanical package. The combination of hardware and NI's LabVIEW form a software-defined test system that scales with increasing device complexity.

With some other protocols, a test specification exists but leaves compliance up to system integrators. In such cases, compliance testing is still a necessity, especially for manufacturers of subsystems that integrate some serial protocols (DDR and Serial Attached SCSI, or SAS, for example) so system integrators have a performance baseline for comparison.

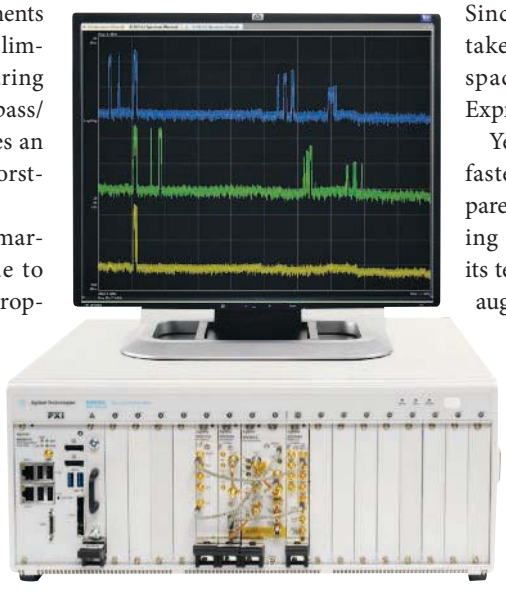
Given the compelling need to validate serial interfaces, automated compliance testing continues to grow in popularity. Once a compliance test package such as Teledyne LeCroy's QualiPHY is installed on a Teledyne LeCroy oscilloscope, compliance testing becomes a pushbutton operation.

Distinct advantages emerge from the adoption of automated compliance testing. First, there is a dramatic reduction in the time and effort required for a given battery of tests. For each test, the software presents the user with a connection diagram to ensure the setup is correct. Second, it would be quite a challenge for an engineer to become an expert in the validation of multiple serial-data standards. Automation eliminates that requirement, as the software encapsulates all of the relevant tests for a given standard as well as the specified measurement limits for each test.

Automation ensures uniformity in testing no matter where in the world it takes place. This promotes collaboration between test and validation engineers for multinational or global enterprises.

Then there is the matter of documentation, which is another tedious aspect of compliance validation. The automation software fully documents measured values as well as the spec's limits for each test in the suite, comparing measurements with the limits for a pass/fail result. The software also attaches an accompanying screen capture for worst-case measurements.

With ever-rising bit rates, error margins for serial interfaces continue to shrink. Compliance testing and interoperability between systems require designers to validate devices for timing, jitter, and other critical parameters. The revolution in test automation for compliance testing goes a long way toward ensuring first-pass design and debug success.



4. Agilent Technologies' M9393A PXI Express performance VSA offers Agilent's microwave measurement technology in a PXI form factor for manufacturing and design validation of transmitters and components for radar, military, satellite, and commercial wireless communications.

EVOLVING WITH NEW TECHNOLOGY

The way we interact with devices is constantly changing because we live in a software-oriented world. Embedded software now defines smartphones, set-top boxes, and even automobiles. Now, the challenge is keeping up with the pace of innovation and its resulting complexities.

Devices under test (DUTs) are moving away from single-purpose, hardware-centric entities with limited capability to multipurpose, software-centric entities with endless capability. The software-defined philosophy embraces an architecture that combines PXI, a modular standard, and National Instruments LabVIEW system design software.

Through this approach, you can use technologies such as multicore microprocessors, user-programmable FPGAs, PCI Express hardware, and system design software to meet the flexibility and scalability demand for future test and measurement applications.

PXI, or PCI eXtensions for Instrumentation, is an open specification governed by the PXI Systems Alliance (PXISA) that defines a rugged, high-performance platform that's optimized for test, measurement, and control. Since PXI is based on PC technology, it takes advantage of the evolution in this space, as with the introduction of PCI Express in 2005.

Yet by 2007, Qualcomm saw 10 times faster performance improvements compared to its traditional approach by adopting PXI hardware and NI LabVIEW. As its test needs evolved in 2012, Qualcomm augmented its automated test system with a user-programmable FPGA solution (NI PXIe-5644R) from National Instruments that saw a twenty-fold improvement of test times over its previous PXI solution and up to 200 times compared to its traditional instrument solution *(Fig. 3)*.

The software-defined instrumentation approach uses open software and modular hardware with key elements (multicore CPUs, user-programmable FPGAs, PCI Express, data converters, and LabVIEW system design software)

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5. The basic bench scope still lives, but with a difference. In February, Tektronix introduced a $3500 platform in which every device sold comprises a scope, a spectrum analyzer, an arbitrary function generator, a logic analyzer, a protocol analyzer, and a digital voltmeter/counter. Dongles that cost $500 let customers choose the functions they need and move those functions among multiple scopes.

to address the most demanding challenges. As instrumentation evolves to meet newer standards, more complex protocols, and higher bandwidths, these tools provide a foundational platform of a test approach that can stand the test of time.

PRE-DEFINED MEASUREMENTS

Wireless devices require fast, accurate testing, from basic power and distortion measurements to advanced modulation analysis. The complexity of modern wireless systems and signals complicates RF measurements in terms of both measurement setup and interpretation.

One of the largest challenges faced is the need to reduce the amount of time it takes to set up a test system while incorporating test algorithms that are in line with the latest standards, can meet the most stringent test requirements, and don't require users to rewrite code or relearn testing procedures.

From design and simulation software to R&D prototype performance testing to high-volume manufacturing, Agilent provides pre-defined measurement solutions, including applications with one-button test capabilities.

For example, the 89600 vector signal analyzer (VSA) software and X-Series measurement applications from Agilent Technologies provide pre-defined measurement algorithms, standard setups, a range of graphic and tabular measurement displays, and confidence in measurement results across benchtop and modular signal analyzers throughout the product development lifecycle.

The 89000 VSA software user interface lets users perform multi-channel signal analysis and demodulate more than 75 signal formats.

The standards-based X-Series measurement applications focus on common and essential measurements. They are well suited to design verification and manufacturing applications where the essential RF tests are well defined and where speed and simplicity are paramount.

To perform reliably over time, these algorithms must be validated on example signals, including any changes in signal definition or modes as standards evolve. The algorithms also must be regression-tested to ensure that related software developments have no inadvertent effects.

Agilent tests the core algorithms to ensure that different hardware platforms provide comparable results that allow engineers to troubleshoot and optimize designs even when the hardware acquiring the signal may be different. Agilent's M9393A PXI express performance vector signal analyzer facilitates design characterization through the use of the pre-defined tests *(Fig. 4)*.

The Agilent software works with test equipment such as the M9393A PXI VSA. The pre-defined measurement capability provided by the combination of hardware and software reduces the need for re-training and re-programming and simplifies measurement setup, minimizing user errors in both measurement setup and interpretation, enabling users to adapt more quickly and easily as standards evolve and as new ones are introduced.

AN ALTERNATIVE PARADIGM

Tektronix changed the rules of the game. The company developed its most recently announced scope for the general-purpose area by adding it to its mixed-domain line (while shaving the price). The MDO3000 series portable/bench scopes also embody a spectrum analyzer, an arbitrary function generator, a logic analyzer, a protocol analyzer, and a digital voltmeter/counter *(Fig. 5)*.[1]

Don't need all that? These tools remain latent until you unlock them with tiny dongles. There's a single base price and separate prices for each dongle. Tek calls them "chiclets," because, if you remember the candy-coated chewing gum, that's about how big they are.

The new thing is that each chiclet will only activate one instrument at a time, but they're portable. A company or a college can have a number of mainframes and a smaller number of, say, spectrum analyzer chiclets. And, yes, there are security protocols that make the chiclets replaceable if lost, but useless in the wrong hands. ed

REFERENCE

1. "Mixed Domain Oscilloscopes: MDO3000 Series Datasheet," www.tek.com/sites/tek.com/files/media/media/resources/MDO3000-Oscilloscope-Datasheet-1.pdf.

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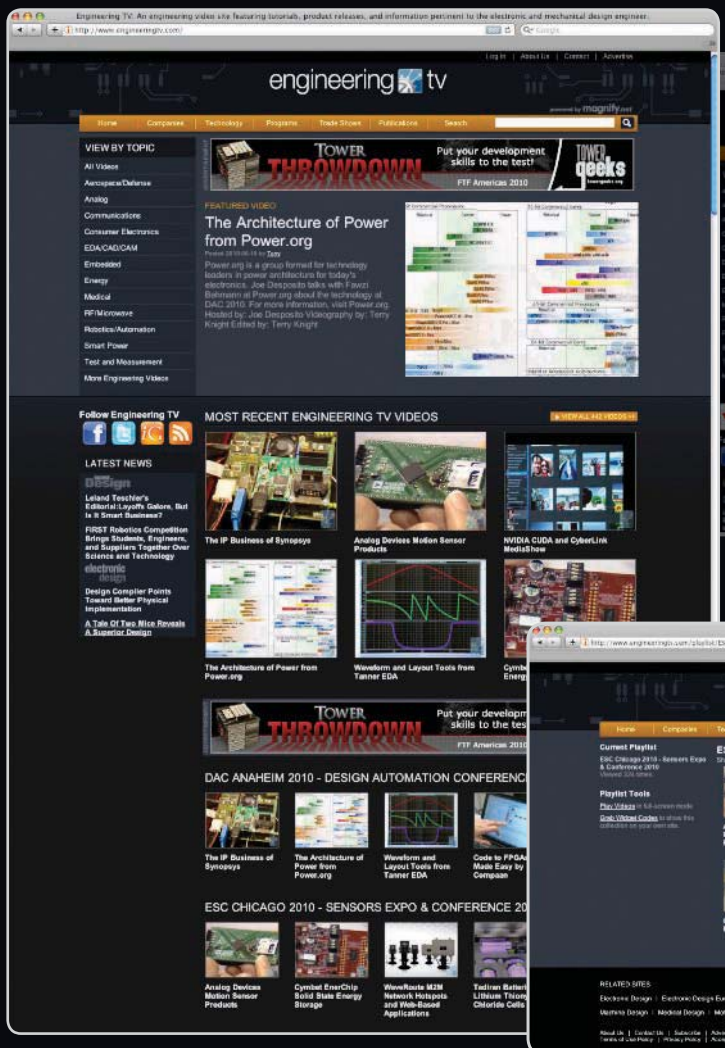

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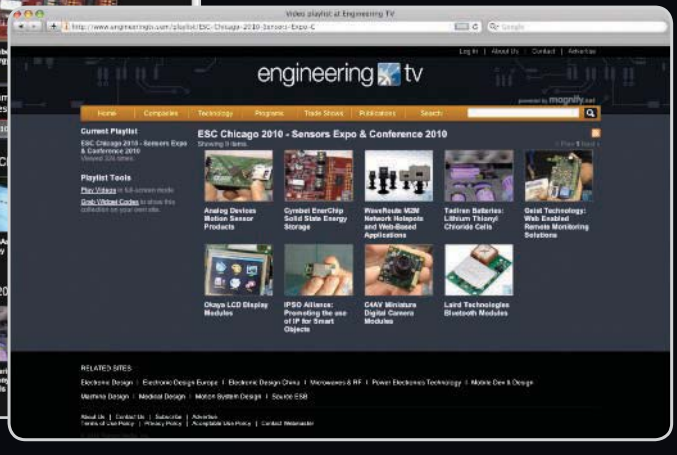

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IP&E Specialist Focused On Growth

Top 50 distributor Sager Electronics is focused on adding lines, building its power supply business, and sharpening its focus on medical, industrial, and instrumentation customers.

FLAT MAY STILL BE the new "up" in the electronics business, but Massachusetts-based Sager Electronics is trying to buck the trend by becoming more of a business creator in the traditional original equipment manufacturing (OEM) markets that it serves. The company is sharpening its focus on medical, industrial, and instrumentation customers and adding new product lines, especially in its power supply business. Sager Electronics

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Electronics Suppliers Launch New Web Tools

Technology resources, product finders, and revamped websites are among the newest online services from top component suppliers.

ELECTRONICS DISTRIBUTORS AND manufacturers continue to revamp the online resources they provide to meet engineers' growing demands for Web-based product information and technical resources, as well as for online shopping. A microsite from Mouser Electronics, Coilcraft's Power Inductor Finder, and a top-to-bottom overhaul of Onlinecomponents.com are among the newest offerings in the electronics supply chain.

MOUSER'S OSHW SITE

Mouser Electronics has launched a microsite, available at mouser.com, dedicated to open-source hardware (OSHW) technology. It offers the latest information on OSHW boards and accessories, including BeagleBone, Arduino, Netduino, STMicroelectronics' Nucleo, Texas Instruments' LanchPad, and Intel's Galileo.

The site is the newest in the distributor's line of application and technology microsites, covering everything from automotive applications to wireless mesh networking. Mouser now offers 25 specialized online application and technology resources. The OSHW technology site features schematic diagrams, technical details, and compatible expansion boards for the most common OSHW boards. Videos, white papers, technical articles, and other resources are available as well.

The project-oriented site enables developers to easily sort and select parametric data for the desired board requirements of their particular project, according to the company. Parameters include processor type and speed; number of analog and digital inputs; wireless options including Wi-Fi and Bluetooth; USB ports

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IP&E Specialist

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president Frank Flynn says that these strategies are central to the distributor's growth and expansion goals.

"We're expecting growth in this valuable segment within the IP&E (interconnect, passive, and electromechanical) space," Flynn said of the power supply business during a recent interview with *Global Purchasing*.

"As we see an opportunity to support design engineers at our customers at a critical point in their design of new products, developing our power program ties into our overall strategy of demand creation especially within our medical, industrial, and instrumentation OEM customers," he added.

Flynn sat down with *Global Purchasing* as part of our ongoing Top 50 executive interview series to talk about how business is unfolding early in 2014.

GLOBAL PURCHASING: It's still early in the year, but how is 2014 shaping up for the electronics industry in your opinion?

FRANK FLYNN: Like many segments of the economy, the electronics industry has been flat for a number of years. With markets like housing and automotive rebounding, economic cycles would indicate it is time to expect growth in the electronics industry.

At Sager Electronics, we are experiencing a strong daily activity level. Our bookings have been solid and consistent and we have had a positive book to bill. While the economic backdrop may be telling us that the market is flat, our goal is to move beyond the market, and our booking levels support that goal.

We are furthering our drive to be more of a business creator. We're adding new industry-leading lines to drive further growth. We've enhanced our focus on OEM customers specifically within the medical, industrial, and instrumentation space.

GLOBAL PURCHASING: Are there any particular bright spots in terms of end markets that your company is homing in on?

FLYNN: More and more suppliers are looking for support within the traditional markets of medical, industrial, and instrumentation as North American manufacturing has transitioned away from telecom, networking, and large contract manufacturers. This is welcome news for Sager as we are already well established in these spaces and are positioned to build on this historical strength.

Because we aren't chasing new markets, we are able to focus on our customers and their needs within these end markets. For example, the medical market is evolving rapidly as the need to support home-health-care options increases. We're seeing a rise in portable medical devices and other innovations to meet these changing health care needs.

"Like many segments of the economy, the electronics industry has been flat for a number of years. With markets like housing and automotive rebounding, economic cycles would indicate it is time to expect growth in the electronics industry," said Frank Flynn, president of Sager Electronics.

GLOBAL PURCHASING: There is much talk about wearable technology, medical electronics, and lighting—particularly LED technology—as key growth areas. Are those important areas for your company?

FLYNN: Wearable technology is not a focus area for Sager. We do not see ourselves playing a role in high-volume consumer devices.

However, as we previously referenced, medical electronics is a sweet spot for our company. As the population ages and home-health-care needs increase, there will be a corresponding increase in the need for portable devices and local health-care centers. Medical equipment such as CPAP (continuous positive airway pressure), dialysis, and home diagnostic devices are increasing in volume as care moves away from the traditional hospital setting.

Lighting is a large and fragmented market with many emerging customers. While the overall market may not be a focus for Sager, we are designing in and selling LED drivers as part of our power supply strategy. LED drivers represent one of the faster-growing areas inside of our power supply business.

GLOBAL PURCHASING: What do you see as some of the greatest supply chain challenges facing your customers today, and how is Sager helping to address those issues?

FLYNN: The traditional challenges of the supply chain really haven't changed over the years. It is still about reliability and the speed of response. It is the nature of our business. But in today's business environment, the flow of information is even more critical. Product changes and obsolescence, compliance, and environmental issues around conflict minerals, REACH (Registration, Evaluation, Authorization, and Restriction of Chemicals), and RoHS (Restrictions on Hazardous Substances) challenge today's customers. Information is critical to addressing these issues.

From our new product introduction and product change notification system, News2Know, to our BOM tool, and our forecast management system, Sager has implemented a number of communication tools to keep customers well informed. We've put automation into our forecasting tools that pushes information directly into our planning system for our purchasing team to act on. With inventory in place to support forecasted needs, we can help customers avoid problems. ■

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Digital Power Market On The Rise

The global market for digital power is set for rapid growth in 2014.

THE WORLDWIDE MARKET FOR digital power is on the rise, according to a new report from industry researcher IHS predicting "explosive growth" in the segment this year. Revenues for digital power supplies and digital power ICs are projected to increase nearly 65% in 2014, the researcher said in a new report, "The World Market for Digital Power—2014."

Global revenue for digital power supplies will approach $3.3 billion in 2014 before climbing to $11.8 billion in 2018, according to IHS. Global revenue for digital power ICs will top $605 million in 2014 and then reach $3.1 billion by 2018. IHS points to the expansion of digital power into new applications as a key growth driver.

"The market for digital power solutions is already well-established in the server and telecommunication markets," said Jonathon Eykyn, power supply and storage component analyst for IHS. "However, IHS is now starting to see growing adoption across a much broader range of products and applications, which is driving rapid growth."

Digital power provides customers with advantages over traditional analog power, particularly in reducing the overall bill-of-material cost, according to Eykyn. It consolidates discrete components, reduces the carbon footprint, increases power density, provides the ability to monitor and optimize power levels and system requirements while in operation, and speeds time-to-market for products.

The report also points to the fragmented nature of the power supply market and resulting high level of competition. The largest players in the power supply market are Delta Electronics, at roughly 10% of the market; Eltek, at roughly 9%; and Emerson, also around 9%, the researcher says. Texas Instruments leads the digital power IC market, with an estimated 9.8% of the market, followed by Infineon at 9.6% and Powervation at 8.9%.

"Both the digital power supply and digital power IC markets remain fairly fragmented, with no suppliers having a dominant position," Eykyn said. "This means that competition and innovation remain high as companies seek to win major customers." ■

Electronics Suppliers

Continued from Page 45

including host, client, and/or OTG; and video connectivity.

Detailed documentation and links to supporting software for each board are available for fast, direct download. BeagleBone Capes, Arduino Shields, and other compatible add-on hardware for each board can be compared and selected for a given project.

COILCRAFT'S POWER INDUCTOR FINDER

Available at www.coilcraft.com/PowerTool, Coilcraft's Power Inductor Finder Web tool lets users quickly find and compare inductors based on current, ripple, frequency, and ambient temperature *(see the figure)*. It combines elements of other popular Coilcraft Web tools and instantly calculates core and winding losses, computes temperature rise, and plots L versus I curves for up to six parts on the same graph, according to the company.

With the tool, users also can search for a range of inductances and then optimize those search results for size, dc resistance, price, and other parameters. In addition to seeing performance at actual ambient temperature, users can evaluate the effects of self-heating as current is applied.

Coilcraft's new tool is designed to provide a better user experience with the ability to move and delete columns, view only selected products, see actual-size photos, and export results to Excel or PDF files. Users also can request free evaluation samples.

Coilcraft's Power Inductor Finder Web tool lets users quickly find and compare inductors based on current, ripple, frequency, and ambient temperature.

ONLINECOMPONENTS.COM GETS REDESIGNED

Onlinecomponents.com has launched a redesigned website with decision-making resources and quick-sort features while consolidating the user's experience. This authorized Web-based distributor now offers flat-rate shipping on both domestic and international orders, accepts additional payment methods including PayPal, and lets users complete orders faster and easier with an enhanced checkout process. Aside from mechanical changes, the site is also more visually appealing, the company said.

"With a clean Web interface coupled with our growing customer service team, we are committed to providing our customers with an informative and purchase-oriented website," says Jane Judd, general manager at Onlinecomponents.com. The company features more than 1 million products for sale—350,000 in stock and ready to ship from 300 different brands. The website is already preparing to enhance the "my account" section and include a "best in class" bill of materials (BOM) tool too. ■

Reduce IGBT Gate Drive Design Costs and Space

Introduction

The ACPL-337J is an advanced highly integrated gate drive optocoupler, designed to ISOLATE, DRIVE, PROTECT and FEEDBACK the IGBT's operational status.

It has a rail-to-rail output that can deliver 4A of maximum current capable of driving high power IGBT directly. The integrated DESAT detection protects the IGBT during short circuit condition and the isolated feedback reports this fault to the controller.

In addition to these basic functions, the ACPL-337J integrates more new features to further reduce external discrete components used by designers to improve the system overall power efficiency and reliability. The end result is an easy-to-use, compact and affordable IGBT gate drive optocoupler solution.

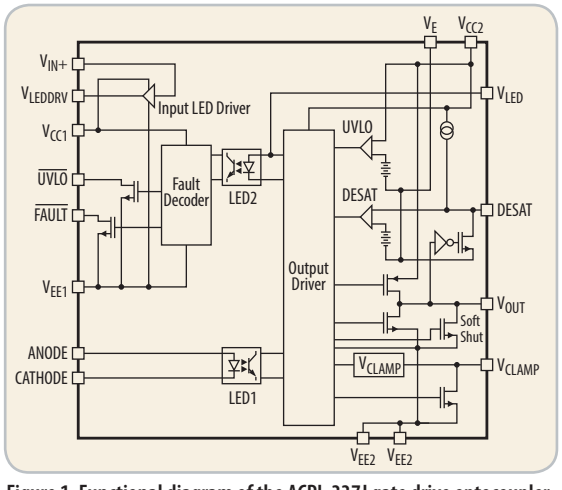

Figure 1. Functional diagram of the ACPL-337J gate drive optocoupler

In the Beginning

Optocouplers are used to provide high voltage reinforced galvanic insulation and noise isolation in inverter or motor drives applications. Basic gate drive optocouplers which can deliver high output current are usually used to charge and discharge the gate capacitance of the IGBT in order to switch the IGBT on or off quickly. A current buffer is sometime used when driving higher power IGBT.

IGBT desaturation sensing circuit, which is made up of discrete components like voltage comparator, constant current source and transistor switches are used to protect the expensive IGBT during short circuit fault. This fault will give feedback to the low voltage controller side through another galvanic isolated path, usually a digital optocoupler.

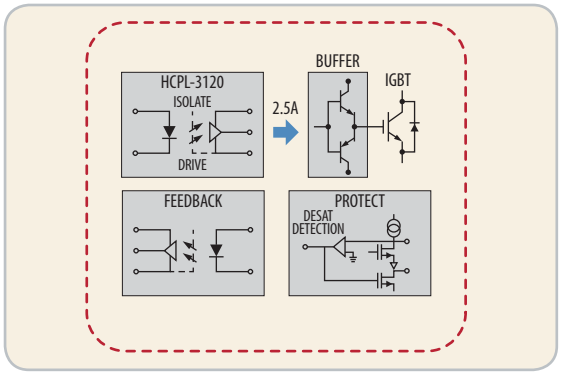

Figure 2. Basic gate driver optocoupler and discrete components to isolate, drive, protect and feedback IGBT's operation status

The First Integration

Avago Technologies first integrated the complete gate drive solution to isolate, drive, protect and give feedback into the HCPL-316J. The HCPL-316J is the first 2.5A gate drive optocoupler with integrated DESAT (desaturation) detection and isolated FAULT feedback.

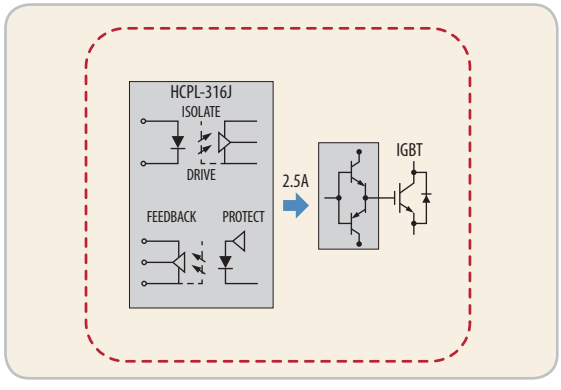

Figure 3. HCPL-316J, 2.5A gate drive optocoupler with integrated DESAT detection and isolated FAULT feedback

To further maximize design flexibility, the HCPL-316J also comes with undervoltage lockout (UVLO) to prevent insufficient gate voltage from driving the IGBT and "soft" IGBT turn-off to prevent high voltage turn off transient stress across the IGBT.

Over the years, designers have been adding more peripheral circuits to meet the increasing demand of higher power, better efficiency and reliability in inverter and motor drives. The circuits include:

To Improve Efficiency

- Current buffer to switch the IGBT faster for lower switching loss
- Higher positive supply to compensate for current buffer voltage drop to achieve optimum gate voltage

To Improve Reliability

- Negative supply to ensure IGBT switch off safely
- Extra blanking current source to prevent false DESAT fault detection
- UVLO feedback to report insufficient supply causing low IGBT gate voltage
- Direct LED drive with split resistors network to improve the common mode rejection ratio (CMRR)

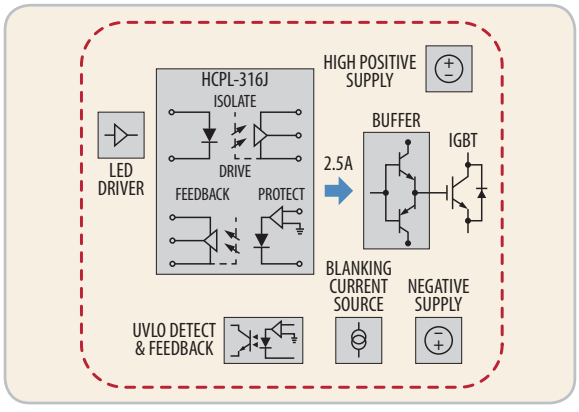

Figure 4. Peripheral circuits to improve the efficiency and reliability of the IGBT gate drive

More Integration

The new ACPL-337J is Avago's response to customer feedback for a compact gate drive optocoupler solution to further integrate peripheral circuits.

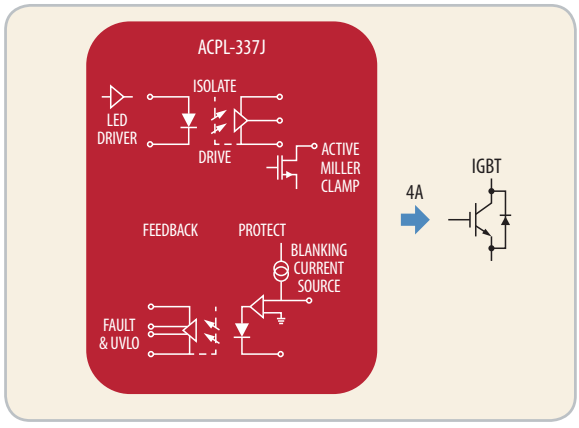

Figure 5. ACPL-337J, a compact gate drive optocoupler solution to simplify the design and board layout

The 4A high output current can be used to eliminate the current buffer and drive the IGBT directly. The rail-to-rail output can reduce the supply voltage and drive the gate of the IGBT without voltage drop. The integrated active Miller clamp can replace the negative supply by shunting parasitic Miller current away and prevent the IGBT from switching on accidentally. The internal DESAT blanking current source is increased by 4 times to charge a bigger blanking capacitor. A bigger blanking capacitor will be able to filter out transient noise more efficiently and prevent false fault triggering. The single isolated feedback path is able carry both DESAT and UVLO fault signal to the low voltage controller side. The controller can use the UVLO feedback as "Ready" signal to begin high voltage IGBT operation or to shut down the operation if the secondary side power supplies go into fault. Lastly, the integrated LED driver allows easy interfacing between the controller and the gate driver. The flexible configuration of the LED driver will allow direct access to the LED to balance its input impedance and improve the CMRR.

Summary

The ACPL-337J highly integrated features reduce external components greatly, providing a complete cost-effective gate drive solution for motor control and power inverter applications.

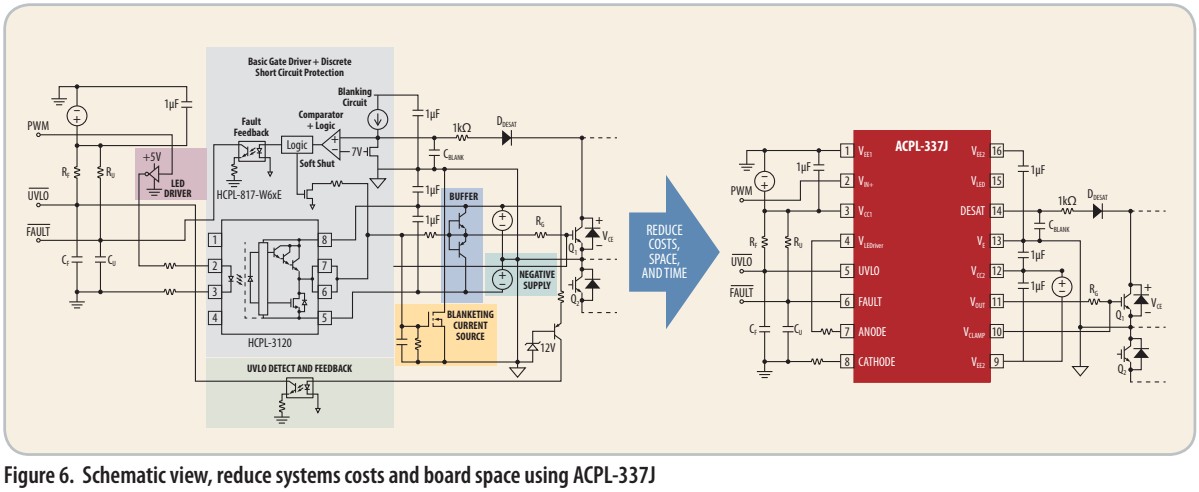

Figure 6. Schematic view, reduce systems costs and board space using ACPL-337J

Contact us for your design needs at: **www.avagotech.com/acpl-337J**

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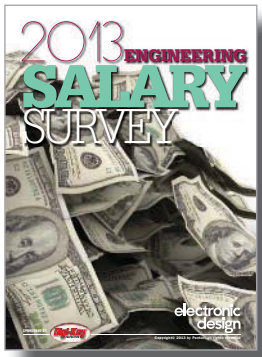

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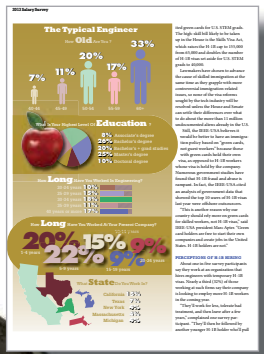

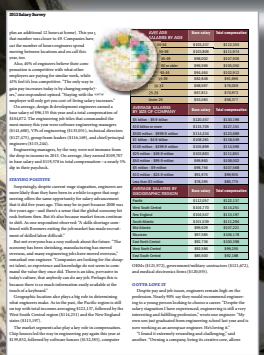

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Q&A

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DARPA's Gill Pratt Explains
Compliant Actuators For Robotic Design

Now on loan to the Defense Advanced Research Projects Agency (DARPA), Dr. Gill Pratt is a professor of electrical and computer engineering at Olin College in Needham, Mass. When he was at the Massachusetts Institute of Technology Leg Lab in the 1990s, he developed compliant actuators known as series elastic actuators (SEAs) with his graduate student Matt Williamson. Since then, these mechanical devices have spurred a veritable revolution in robotic design and electronics.

Q: What are SEAs?
A: An SEA is a traditional motor-powered actuator that's fitted to a load with a spring in between *(see the figure)*. They change the robotic-motion problem from one of positioning to one of force control. Gearmotors, by far the most common actuator in robotics, are good position sources. But they're inaccurate force sources because their gears exhibit variable friction, including stiction.

SEAs make for relatively cheap robotics by putting a spring after the geartrain and adding simple feedback controlling the spring's amount of deflection. So for the low added cost of incorporating a spring, SEAs get high-fidelity force actuation, even if they're built with inexpensive motors and gears.

Engineers can also design mobile robots with SEAs to interact with uncontrolled and unpredictable environments, or store some energy in the spring when it contacts the environment, and then release the energy afterwards.

Q: Particularly in robotics, SEAs enable new designs because they impart compliance. But what specific problem were you trying to solve when you developed SEAs?
A: We were trying to develop walking robots. One of the questions was how we could build them to move through rough terrain without needing lots of software control. We wanted to simplify the problem by changing the mechanical design of the machine itself.

This SEA variation uses one motor (off to the right) to articulate the joint and another (background) to tension the spring. A robot with this type of SEA in its joints can respond to loads with a wide range of force. Called a MACCEPA, the actuator was developed by the Robotics & Multibody Mechanics Research Group, Vrije Universiteit, Brussels. As with other SEAs, a simple mechanical spring (foreground) imparts compliance.

Major manufacturers focus on building sophisticated industrial robots for tasks such as machining, painting, and welding. These must be precise and stiff and hold position reliably. In contrast, tasks of scribing or grinding are better under force control, not position control. But the difficulty at the time was doing it inexpensively.

Q: Why didn't existing robotic actuation work?
A: They just don't adapt well when engineers try to apply them to jobs requiring them to move over rough terrain. That's because many industrial robots are designed for either tightly controlled contact or no contact at all with the environment.

For example, on painting robots, the end tool doesn't touch work surfaces. The same can be said of welding robots, though the end tool technically makes fluid contact with work surfaces.

In fact, we weren't the only research engineers working on compliant force control. Such designs actually have a long history and have proved advantageous for a lot of tasks.

Q: Did you find any inspiration in the designs of nature?
A: Yes, we found inspiration in the design of animal legs, with muscles, tendons, and bones arranged to output soft motion and traverse a world with

hard surfaces that dictate positions of contact with soft locomoting forms. To comply with the solid and unyielding environment, we must be soft. So, I figured we needed actuators that would automatically adjust to the location of objects in the world.

Think about it. Compliant actuators in nature are built to specific tasks. Human muscles connect to joints through relatively stiff tendons. In contrast, the Achilles tendons in kangaroo legs are far more compliant to store energy for efficient hops. Robotic designs have the same range of compliance. Some in traditional precision robots drive applications needing high-bandwidth position control. Others with lots of elasticity are quite soft to drive robots needing force control.

Q: Were there any other sources of inspiration?

A: I also found inspiration in mechanical analogs to switched-mode power supplies. I trained in electrical engineering and worked on designing switched-mode power supplies and inverters to drive motors for electric cars.

At the time, the old technology was voltage mode, in which a power supply puts out a certain voltage. But newer power supplies and motor drives used current mode, with an inner control loop generating a certain amount of current. Transmogrifying voltage and current into the mechanical world gives velocity and force.

Therefore, I thought we should do in the mechanical world what had been done in electronic design of power supplies. So we built an inexpensive SEA precursor with a spring in series, essentially closing an inner feedback loop on the amount of spring deflection.

To be clear, vector control of electric motors is the latest innovation in the motor-drive field. The technology that inspired me was for control of current in motor windings, which predates vector control. Perhaps in time we'll see more equivalent advances in mechanical design.

Q: How safe are SEA-driven robots around people?

A: Besides their lower cost and efficiency, another advantage of SEAs is that they're inherently safe to operate around people. Remember that a geartrain attached to a motor multiplies the effective inertia by the square of the gear ratio. Therefore, even small, high-speed motors with a safe inertia may need gearing to slow the output and raise torque. That raises the effective output inertia on the robot link to a level that's enough to injure a person, as the arm would hit the person like a very large mass.

In contrast, including a spring in the actuator is the same as putting a big

cushion between the mass and person. Then the feedback loop acts to try to control the force of the interaction in the event of contact.

In fact, trying to reduce reflected inertia was part of what drove the SEA design. It doesn't matter how much money a designer spends on a robot. The reflected inertia will always be there unless you put compliance between the geartrain output and load. In this regard, the cost advantage of SEAs is a happy byproduct of the design, because even with an infinite budget, nobody can build a stiff position-control robot that bounces off obstructions.

Q: How do SEAs boost efficiency?

A: Today, the question is how to further increase efficiencies, because many consumer-priced robots are low-power devices and need the highest actuator efficiency possible. We take SEA efficiency for granted because energy doesn't have to go through the geartrain and motor to the power supply and then work its way all the way back to the joint for the energy to be stored and then let back out. Rather, it gets stored in the spring and released directly from the spring, so there are fewer losses than working through a geartrain.

Q: Can designers customize an SEA to specific applications?

A: Yes, geometries abound. Williamson made a cross-shaped torsional spring for MIT's COG robot, and other designers have developed straight springs. Some are proprietary, so I can't comment on them. Even so, a few SEA designs let engineers tune the mechanical compliance with the spring itself rather than the control system used in feedback around the spring.

A large European research program called the Variable Impedance Actuator (Viactor) is investigating that approach. I'm not sure which applications will benefit from tuned compliance, as it adds cost and complexity. But such designs let engineers tune the mechanical characteristics over time, perhaps useful when a simpler option—to pick a fixed spring rate and let controls do the rest—isn't possible.

There are also myriad ways to design SEA springs. Should it be linear or nonlinear? SEAs with linear springs are more common, but SEAs with nonlinear springs get stiffer the more they're stretched. These nonlinear springs benefit designs because their fidelity is a constant fraction of how much force the actuator generates. ed

BOB SCANNELL | Analog Devices
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Wireless Vibration Sensors Enable Continuous And Reliable Monitoring

Before you install a wireless sensor network, though, take note of 10 factors that will affect your data collection process.

Using factory automation to improve overall efficiency is a primary focus in today's manufacturing. Organizations are shifting in this direction not only because it increases their bottom line, but also because it helps reduce or eliminate the severe costs of equipment downtime. Rather than relying on advanced methods to apply statistical data to predict maintenance needs, or simply having better-trained technicians, process control and predictive maintenance program developers can use wireless vibration sensors to enable accurate real-time analysis and controls.

1. Factory process control and maintenance automation represents a high-value target for wireless sensing networks.

Precision industrial processes increasingly are relying on efficient and consistent operation of motors and associated machinery *(Fig. 1)*. Imbalance, defects, loose fittings, and other anomalies in the machinery typically translate into vibration and loss of precision, as well as safety concerns and inefficient performance. When these are left unaddressed, productivity losses become inevitable if equipment needs to be taken off the assembly line for repair. Even slight shifts in equipment performance, usually difficult to predict in a timely manner, quickly translate into measurable lost productivity.

Process monitoring and condition-based predictive maintenance help, and there are proven approaches for avoiding productivity loss. However, the value of these approaches is matched by their complexity. Existing methods have limitations, particularly when it comes to analyzing the vibration data—no matter how it's collected—and isolating error sources.

Typical data collection approaches include handheld data collection tools and simple piezo-based sensors mounted to the machinery. These methods have a number of limitations, particularly when compared with the ideal solution of a complete detection and analysis system that can be embedded in the machinery and act autonomously. Before implementing a fully, embedded, and autonomous sensing system, it is important to understand and consider 10 factors that affect the data collection process, ranging from highly repeatable measurements to proper documentation and traceability.

ACCURATE AND REPEATABLE MEASUREMENT

Existing handheld vibration probes offer some implementation advantages *(Fig. 2)*. They do not require any modification to the end equipment. They're also relatively highly integrated, given their large (brick) size, enabling sufficient processing and storage. One major drawback is the lack of repeatable measurements, though.

Slight differences in the probe location or angle will produce inconsistent vibration profiles, making time comparisons inaccurate. Therefore, the maintenance technician is left wondering whether any observed vibration shift is due to an

2. Existing manual probe methods for equipment vibration shift monitoring lack repeatability and reliability.

actual change within the machinery or just a change in the measurement technique. Ideally, the sensor would be both compact and integrated sufficiently to allow direct and permanent embedding within the equipment, eliminating any concerns of measurement location shift and allowing complete flexibility in the scheduling of measurements.

FREQUENCY AND SCHEDULING OF MEASUREMENTS

Process monitoring can be particularly valuable in a production facility for high-value equipment, as in the manufacture of sensitive electronic components. In this instance, subtle shifts in the assembly line may lead to reductions in factory output, as well as critical end-equipment specification shifts. An obvious limitation of the handheld probe approach is the lack of real-time notification for inaccurate vibration shifts.

The same is true for most piezo-based sensors, which typically have a very low level of integration (transducer only in some cases), with the data transferred elsewhere for later analysis. These devices require external intervention, presenting a chance of missed events and shifts. In contrast, an autonomous sensor processing system that includes sensor, analysis, storage, and alarm capability all in a small form factor delivers the fastest notification of vibration shifts and best can show time-based trends.

UNDERSTANDING THE DATA

Real-time notification from an embedded sensor is only possible if frequency domain analysis is employed. Any given equipment typically has multiple sources of vibration (bearing defects, imbalance, gear mesh), including those sources that are by design, such as a drill or machine press that produces vibration during standard operation. A time-based analysis of the equipment produces a complex waveform, combining these multiple sources and providing little discernible information prior to fast Fourier transform (FFT) analysis.

Most piezo-based sensor solutions rely on external computation and analysis of the FFT. This not only eliminates the possibility of real-time notification, it also places a substantial additional design burden on the equipment developer. With embedded FFT analysis on the sensor, vibration shifts can be isolated to specific sources immediately. Adding a fully integrated sensor also can reduce development time for equipment designers by six to 12 months, depending on the completeness and simplicity of the fully integrated and autonomous sensor.

DATA ACCESS AND TRANSMISSION

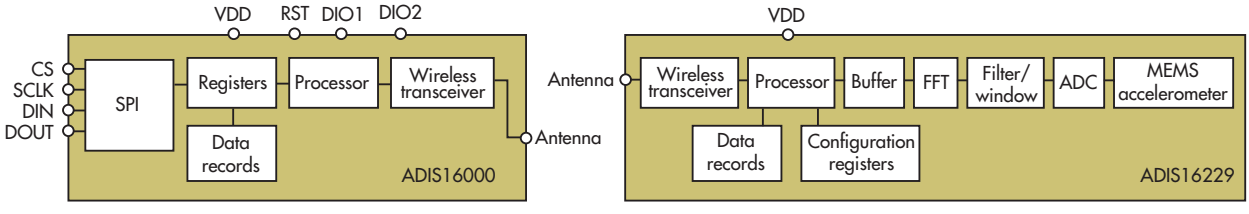
While embedded sensing is an ideal way to achieve accurate and real-time trend data, it complicates the task of transferring data to a remote process controller or operator. Embedded FFT analysis assumes that the analog sensor data has been conditioned and converted to digital to support simplified data transmission. In fact, most vibration sensor solutions in use today are analog output only, leading to signal degradation during transmission and complex offline data analysis.

Given that most industrial equipment requiring vibration monitoring tends to exist in noisy, moving, inaccessible, and even dangerous environments, there is a strong desire to reduce the complexity of interface cabling and to perform as much of the data analysis at the source as possible to capture the most accurate representation of the equipment vibration. A wirelessly enabled sensor node facilitates immediate access and greatly simplifies the deployment of the sensor network at a significantly reduced cost.

DATA DIRECTIONALITY

Many existing sensor solutions are single-axis piezo transducers. These piezo sensors provide no directionality information, so they present a limited understanding of the equipment vibration profile. The lack of directionality translates into the need for very low-noise sensors to enable the nec-

3. The ADIS16229 MEMS-based sensor node offers a 902.5/927.5-MHz RF link to the ADIS16000 gateway controller.



essary discernment. The availability of multi-axis MEMS-based (microelectromechanical systems) sensors allows a significant increase in the ability to isolate the vibration source, while also potentially improving cost.

LOCATION AND DISTRIBUTION

Equipment vibration profiles are complex, time-shifting, and susceptible to variances based on the equipment materials and location. The question of where to place sensors is critical, but also highly dependent on the type of equipment, the environment, and even the life cycle of the equipment. With the high cost of sensor elements limiting the number of probe points to one or a few, this question is more critical.

This means either significant additional upfront development time to determine optimal placement through experimentation is required, or, in most cases, it compromises the quality and amount of data to be captured. The existence of more fully integrated sensor probes at a fraction of current costs can allow placement of multiple probes per system and less upfront development time and cost.

LIFE-CYCLE SHIFTS

While a handheld monitoring system approach can perhaps be tailored to changes (periodicity, amount of data, etc.) over time, providing that same life-cycle based customization in an embedded sensor requires upfront attention during design and deployment to allow the needed tunability.

The transducer component, regardless of technology, is important. But sensor conditioning and processing wrapped around the transducer is typically more critical. The signal and sensor conditioning and processing is specific to unique equipment and its life cycle. This translates to several vital considerations in sensor design.

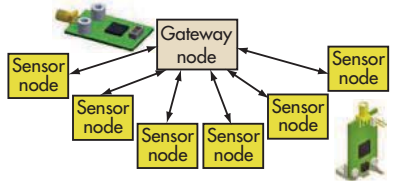
Earlier analog-to-digital conversion allows for configuration and tuning in-system. The ideal sensor would provide a simple programmable interface that would streamline equipment setup through quick baseline data captures, manipulation of filtering, programming of alarms, and experimentation with different sensor locations. With existing simple sensors, some sensor settings must be compromised to accommodate changes in maintenance concerns over the life of the equipment.

For instance, designers need to determine if the sensor should be configured for early life, when equipment faults are less likely, or end-of-life, when faults are not only likely but potentially more detrimental. The preferred approach is an in-system programmable sensor that configures to changes during the life cycle. For example, relatively infrequent monitoring (for lowest power consumption) should be used during the early life cycle, followed by reconfiguration to frequent (user programmed period) monitoring once a shift (warning threshold) has been observed.

PERFORMANCE SHIFTS/TRENDS

Adapting the sensor to changes in equipment life cycle somewhat depends on knowledge of a baseline equipment response. Even simple analog sensors can allow this, assuming the operator takes measurements, performs the offline analysis, stores this data offline, and somehow properly tags to the specific equipment and probe location.

A preferred and less error-prone approach would allow baseline FFT storage at the sensor head, eliminating



4. Six remote sensor nodes can autonomously detect, collect, and process data and wirelessly transmit it to a central controller node.

any potential for misplaced data. The baseline data also helps with establishing alarm levels, which again would ideally be programmed directly at the sensor. Therefore, in any subsequent data analysis and capture where warning or fault conditions are detected, a real-time interrupt can be generated.

DATA TRACEABILITY AND DOCUMENTATION

Within a factory, a proper vibration analysis program may be monitoring tens or even hundreds of locations, whether by handheld probe or embedded sensor. Over the course of a given piece of equipment's lifetime, this may produce the need to capture thousands of records. The integrity of the predictive maintenance program depends on the proper mapping to location and time of the sensor collection point. For the lowest risk, and the most valuable data, the sensor should have a unique serial number and the ability to time stamp the data, in addition to embedded storage.

RELIABILITY

This discussion highlights methods to improve existing sensor-based approaches for vibration monitoring related to process control and predictive maintenance. In that spirit of fault tolerance and monitoring, the sensor itself should be scrutinized. What if the sensor becomes faulty (performance shift) rather than the equipment? Or, when operating with a fully autonomous sensor, how confident can we be that the sensor continues to work at all? With many transducers, such as piezo-based, this presents a serious limitation, as they have no means of providing any sort of in-system self-test.

There is always a lack of confidence in the consistency of data recorded over time. In the end-of-life critical monitoring phase where real-time fault notification is time and cost critical (not to mention a significant safety concern), there is always a concern that the sensor could become non-functional. An essential requirement of a high-confidence process control program is the ability to remotely self-test the transducer. Fortunately, this is possible with some MEMS-based sensors. An embedded digital self-test closes the final gap on a reliable vibration monitoring system.

IN THE FIELD

The ADIS16229 digital MEMS vibration sensor with embedded RF transceiver from Analog Devices is an example of a fully autonomous and wireless frequency domain vibration monitor capable of all of the advantages outlined here. It features embedded frequency domain processing, a 512-point real-value FFT,

LINEAR TECHNOLOGY

DESIGN NOTES

Monolithic No-Opto Isolated Flyback Converter Provides Versatile Solution

Design Note 525

George Qian

Introduction

Traditionally, isolated power supplies use an opto-coupler in the feedback loop to transfer regulation information across the isolation barrier. Unfortunately, an opto-coupler's gain characteristic varies widely over temperature and lifetime, increasing the difficulty of power supply loop compensation.

Linear Technology's line of no-opto flyback converters, such as the LT®3573, LT3574, LT3575, LT3511, LT3512 and LT8300, simplify flyback design by incorporating a primary-side sensing scheme, thereby eliminating the need for an opto-isolator.

The LT8302 monolithic no-opto flyback converter has an integrated 65V/3.6A DMOS power switch with internal loop compensation and soft-start. The LT8302 can operate from an input voltage as low as 2.8V to 42V, and deliver output power up to 18W. It offers low ripple Burst Mode® operation at light loads, providing low standby power loss, and features a low component count.

Performance and Ease of Use

The LT8302 simplifies the design of an isolated flyback converter by sampling the isolated output voltage directly from the primary-side flyback waveform. This solution requires no third winding or opto-coupler for regulation. The output voltage is programmed with two external resistors and an optional third temperature-compensation resistor. By integrating loop compensation and soft-start, the device minimizes the number of required external components, as shown in Figure 1. Boundary mode operation allows the use of a modestly sized transformer, while maintaining excellent load regulation. Low ripple Burst Mode operation yields high efficiency at light load while minimizing the output voltage ripple.

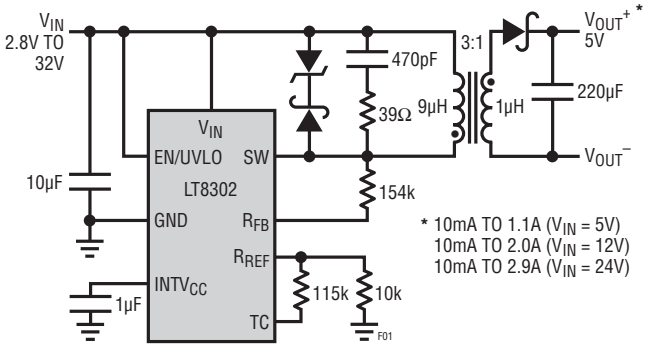


Figure 1. Complete 5V Isolated Flyback Converter for a 2.8V~32V Input

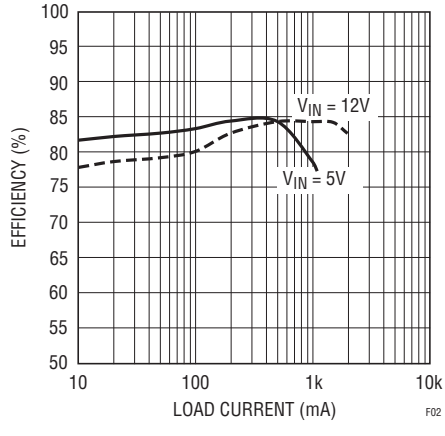


Figure 2. Efficiency of the Flyback Converter in Figure 1

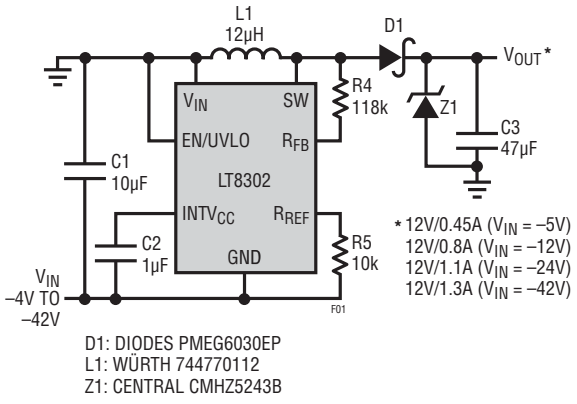


Figure 3. Negative Input to Positive Output Buck-Boost Converter

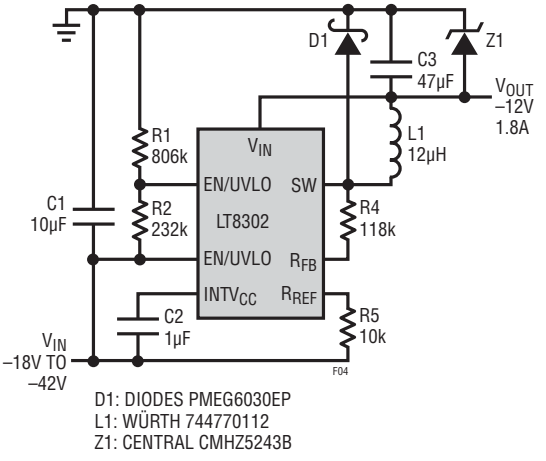


Figure 4. Negative Input to Negative Output Buck Converter

Figure 1 shows a complete LT8302 flyback schematic. This converter has up to 85% efficiency, as shown in Figure 2, and sustains 82% efficiency at a 10mA load with a 5V input, thanks to its low quiescent current.

Low I_Q, Low Preload and High Efficiency

At very light loads, the LT8302 reduces the switching frequency while keeping the minimum current limit. In these conditions, it enters low ripple Burst Mode operation, where the part switches between sleep mode and switching mode. The typical quiescent current is 106µA in sleep mode and 380µA in switching mode, reducing the effective quiescent current.

The typical minimum switching frequency is about 12kHz, with the circuit requiring a very small preload (typical 0.5% of full load). Therefore, the LT8302 power losses in standby mode are very low—a priority for applications requiring high efficiency in always-on systems.

Negative Input Power Supplies

In a typical negative input power supply, the IC's ground pin is connected to the negative input rail, which is a varying voltage. As a result, its output voltage changes with input voltage, assuming no level-shift circuitry. LT8302's unique feedback sensing scheme can easily develop a regulated output voltage directly through switch node voltage waveform, eliminating the level-shift circuitry that would otherwise be required.

Figure 3 shows a simple negative-to-positive buck-boost converter, and Figure 4 shows a simple negative-to-negative buck converter.

Conclusion

The LT8302 operates over an input voltage range of 2.8V to 42V and delivers up to 18W of isolated output power, requiring no opto-coupler or third winding. It integrates a number of features to minimize component count, including low ripple Burst Mode operation, internal soft-start, undervoltage lockout, temperature compensation and internal feedback loop compensation.

The LT8302 is ideal for a broad range of applications, from battery-powered systems to automotive, industrial, medical, telecommunications power supplies, and isolated auxiliary/housekeeping power supplies. The high level of integration yields an easy-to-use, low component count, high efficiency and versatile solution for isolated power delivery.

Data Sheet Download

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and on-board storage, providing the ability to identify and classify individual sources of vibration, monitor their changes over time, and react to programmable threshold levels.

The device also provides configurable spectral alarm bands and windowing options allowing analysis of the full frequency spectrum via the configuration of six bands and two alarms (warning threshold and fault threshold) for earlier and more accurate detection of problems. At its core is a multi-axis, wide-bandwidth MEMS-based sensor with configurable sample rate (up to 20 ksamples/s) and averaging/decimation options enabling more accurate assessment of even subtle vibration profile changes.

The MEMS sensor provides a digital self-test mode to provide continuous confidence in functionality and data integrity. The device is fully embedded and programmable, enabling placement close to the vibration source and early detection of small signals in a repeatable way, avoiding data discrepancies due to differences in location/coupling from measurement-to-measurement, which can be the case when using handheld devices.

A proprietary 902.5/927.5-MHz wireless protocol interface allows the ADIS16229 sensor node to be remotely located. The ADIS16000 gateway node provides a standard serial peripheral interface (SPI) to any system controller device, supporting the ADIS16229 *(Fig. 3)*. Up to six remote sensor nodes can be controlled via the gateway *(Fig. 4)*.

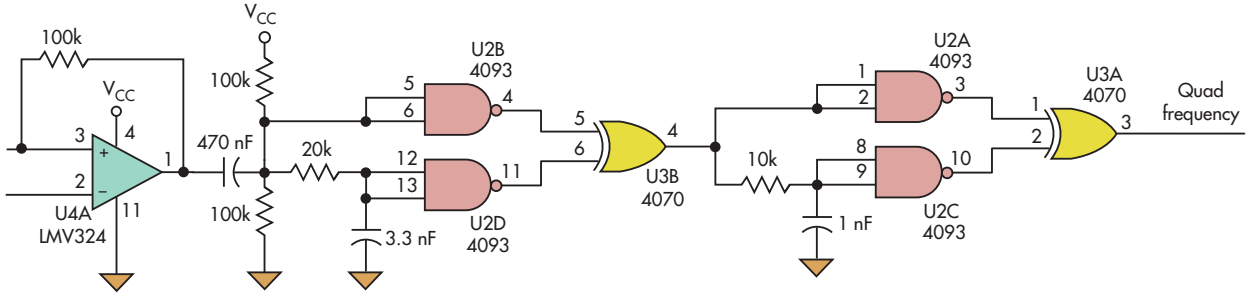
Fully integrated and reliable vibration sensors, capable of autonomous and configurable operation, provide process control and enable predictive maintenance programs to significantly improve the quality and integrity of the data collection process, without the limitations and compromises posed by past vibration analysis approaches.

With the high level of integration and a simplified programmable and wireless interface, these sensors also can enable a more pervasive deployment of vibration sensing. Such fully integrated sensors, which do not depend on retrofitted wiring/infrastructure and more precisely and reliably detect performance shifts, offer the opportunity to drastically reduce upfront and recurring maintenance costs.

BOB SCANNELL is a business development manager for Analog Devices' Inertial MEMs Products. He has been with ADI for 18 years in various functions. He holds a BS in electrical engineering from the University of California, Los Angeles, and an MS in computer engineering from the University of Southern California.

Frequency Quadrupler Enables Low-Frequency Measurements, Spans Up To Four Decades

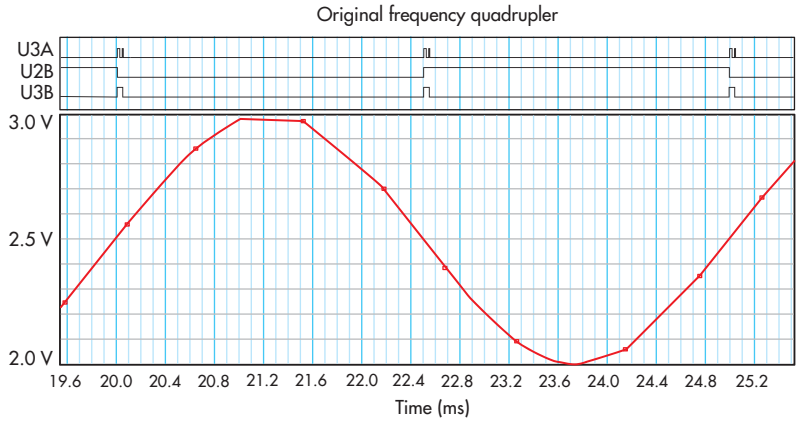
DAVID CONRAD | dconrad@yahoo.com



1. The initial circuit implements ×4 multiplication for inputs up to 40 kHz to enable effective frequency counting despite short frequency-counter gating times.

IN FREQUENCY COUNTERS, THE gating time allotted for counting is often too short to resolve low frequencies. A phase-locked loop could be used to multiply the input frequency. But in some cases, the signal changes too fast or too far for lock to be acquired or maintained.

To solve the problem, the circuit of Figure 1 is used to multiply the input frequency by a factor of four, spanning a range of 1 Hz to over 40 kHz, and it will track a step change anywhere in that range. There is one issue with this simple implementation, though. The constant delay at U2D (as seen at U3B output) tends to cause counting-by-twos in the lower decades *(Fig. 2)*.



2. The circuit's shortcoming is a tendency to initiate counting-by-twos at the lower ranges, due to the fixed delay time of gate U2D.

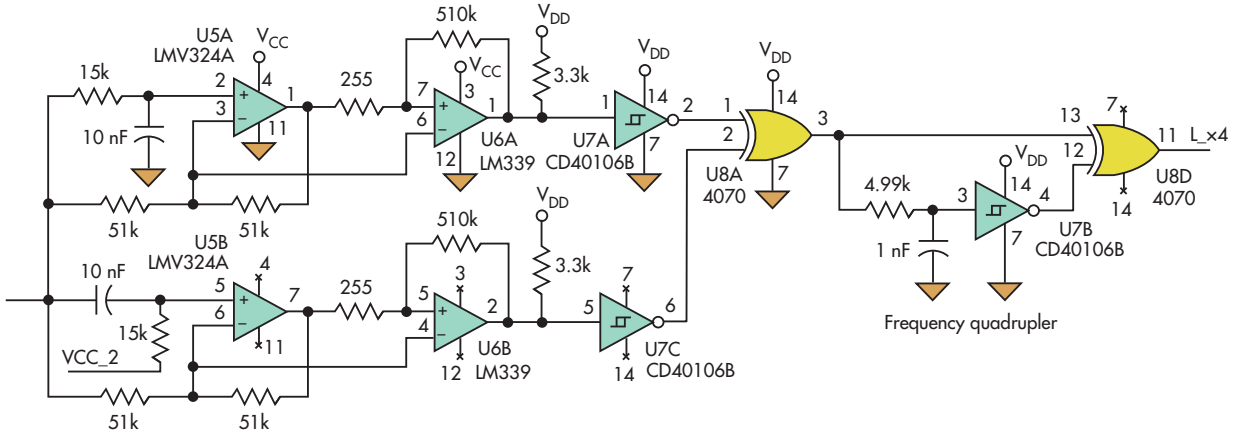
A circuit that eliminates this issue provides a quadrature output over the frequency range *(Fig. 3)*. Phase-lead and phase-lag circuits are used to create a constant 180° phase difference with respect to input frequency, at op-amp outputs (U5A and U5B).

Connecting the comparator inputs U6A and U6B to the op amps U5A and U5B reduces the phase difference to 90°, as measured from one comparator output to the other. Constant phase means variable delay, overcoming the issue with the circuit.

Figure 4 shows the benefits provided by the quadrature circuit. The first XOR gate, U8A, produces the exclusive OR of the two quadrature outputs, U7A and U7C. This multiplies the input frequency by two. The second XOR gate, U8D, produces a pulse for each positive and negative edge of the signal from U8A, again multiplying by two. The result is four equally spaced output pulses at U8D for each cycle at the input.

Quadrature maintains equal output pulse spacing as the frequency changes, so gating the pulse train will always count by ones. Quadrature is maintained within +0/–5° from 1 Hz to 49 kHz, but is lost above 49 kHz with the circuit values shown.

Accurate tracking speed may be limited by the time required to acquire four output pulses at the new frequency from a step change to an accurate count, effectively a



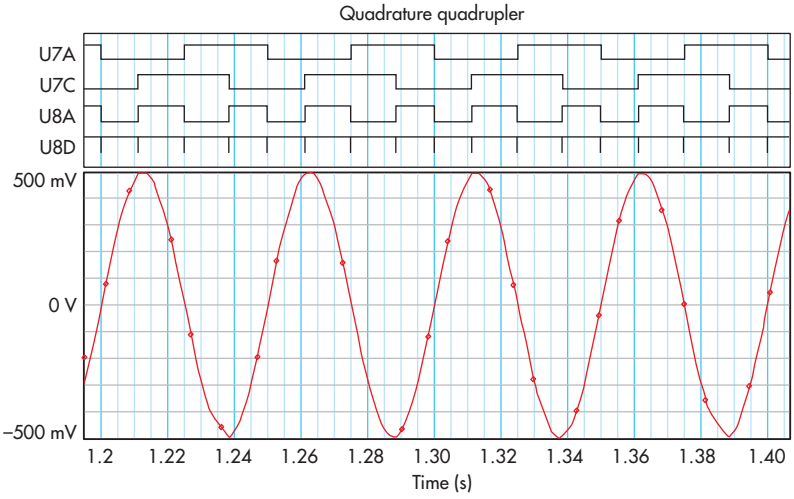
3. The addition of a quadrature function to the circuit changes the fixed delay time to a fixed phase difference, corresponding to variable time delay, overcoming the problem.

delay of 1/f seconds. This implies that accurate tracking is a function of the input frequency. Stepping from a higher to a lower frequency would require at least $1/f_{lower}$ seconds for the output to settle at four times the input frequency.

The output pulse is set wide enough to be reliably captured by the processor or other counter input. If it is too wide, it will limit the upper frequency at which multiplication can be achieved. Too narrow, and the microprocessor or counter will miss counts.

With the components shown, the output is a 5.6-µs pulse. This restricts the maximum theoretical multiplied output frequency to 89.3 kHz (input frequency less than or equal to 22.3 kHz). The quadrature circuit component values limit the maximum input frequency to 49 kHz or 196 kHz at the output of the multiplier. If the output pulse width could be made as short as 2.5 µs, the maximum multiplied output frequency would reach 196 kHz.

Adjusting component values can move the usable range of multiplication higher or lower than that described here to fit the user's requirements. With faster op amps, comparators, and logic components, the design might be able to perform at RF frequencies.



4. With quadrature and frequency multiplication by four at 20-Hz input frequency, the addition of the quadrature circuit clearly improves performance compared to the initial circuit.

DAVE CONRAD is a retired analog/digital hardware engineer who learned electronics by reading (starting at age 6) publications such as the *ARRL Radio Handbook*, *QST*, and *CQ* and later from various library books and *Popular Electronics* magazine. This was followed by a few courses in electronics in high school and junior colleges including TTL logic, along with learning on the job.

DON TUITE | Analog/Power Editor
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Ultracaps Solve Diesel-Cranking Problems

Large-capacitance ultracapacitors offer something of a design challenge. Providing tens or hundreds of Farads for potential power storage, they demand new ways of thinking about potential applications. They're not simply another kind of battery. As a rule, they have 10 times higher power density (W/kg) than batteries, while batteries have about 10 times higher energy density (Wh/kg).

Maxwell Technologies has created two products that solve a problem common to both long-haul and local delivery fleets. Laws and regulations prevent these companies from keeping their diesel engines running when they're stopped for long periods. That's complicated by the amount of power it takes to crank diesel engines, which operate at much higher cylinder compression levels than gasoline engines. Compression, not spark, is what it takes to ignite a diesel-air fuel mix.

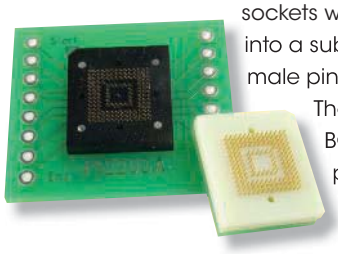
With a conventional battery array, that's a problem. Long-haul drivers use all kinds of appliances for light, entertainment, and climate in the cab and trailer. That can leave scant power for engine cranking. Short-haul companies must shut down the engine at every stop, leading to more frequent cranking, which may not give the batteries time to recharge between stops.

Maxwell's ultracapacitor-based Engine Start Module (ESM) product line includes one version for class 3 through 6 medium-duty trucks and another version for class 7 and 8 heavy-duty diesel trucks. Each combines a charger/ultracap array and replaces one or more of the batteries in the truck's battery box, but is devoted exclusively to cranking the engine during starting.

The original ESM product for long-haul trucks provides 1800 cold-cranking Amperes (CCA) and recharges in 15 minutes. It functions from –40°F to 149°F and weighs 21 lb. The ULTRA 31/900 is essentially half the larger version in a smaller package, delivering 900 CCA. It weighs 16 lb and matches the industry-standard Group 31 battery form factor. It stays fully charged even when the truck's lead-acid battery is as low as 9.5 V.

Socket 153-Pin, BGA-Packaged e-MMCs Without Affecting Performance

IRONWOOD ELECTRONICS' Giga-snaP ball-grid array (BGA) socket adapter pair allows 0.5-mm-pitch, 11.5- by 13-mm, 14x14 array e-MMC modules housed in 153-ball BGAs to be socketed and subsequently operated without compromising performance in memory applications. The socket adapter pair consists of the SFS-BGA153B-52 female BGA sockets with BeCu pins assembled into a substrate that matches the male pin LSS-BGA153B-51 adapter. The RoHS-compliant SFS-BGA153B-52 is soldered to a printed-circuit board (PCB) without warping. Both the BGA socket and adapter are built with high-temperature polyimide and an FR-4 body, which helps ensure matching up with target PCBs and preventing failures due to CTE mismatch. The electrical path of Giga-snaP BGA socket adapters, which is a key performance issue, measures 3 mm from the top connection point on the male adapter to the solder ball on the female socket. The short path provides better transmission of high-frequency signals up to 20 GHz with –1-dB insertion loss. Operating temperature ranges from –55°C to 160°C. Current rating is 3 A per pin.



IRONWOOD ELECTRONICS

www.ironwoodelectronics.com

Crimp-Style Subminiature Connectors Bring Flexibility To LED Apps

THE AUH series of wire-to-board, crimp-style, disconnectable connectors, featuring a mated height of 1.85 mm, offers greater flexibility and reliability for high-density applications, says developer JST Corp. The polarized, side-entry (right angle), surface-mount connectors feature secure friction locking when mated. They incorporate a socket half that's mated with the header vertically. Wires come out of the socket horizontally. Such construction allows the header to be placed anywhere on the printed-circuit board, enabling component placement all around the header without causing mating concerns. The series is available in three (two power/one signal) and five (four poser/one signal) circuits with a 5.0-A (ac-dc) rating, using a 22 AWG wire at 30 V ac-dc. Contacts accommodate AWG 30 to 22 wire sizes and are gold-plated over nickel underplated copper alloy base material. Operating temperature ranges from –25°C to 85°C, including temperature rise in applying electrical current.

JST CORP.

www.jst.com

Wall-Mount Enclosures' Inset Panels Hide Connectors

OKW'S NET-BOX family of wall-mount enclosures features an inset cable connection panel to hide connectors under a removable front lid. The enclosures' flat design facilitates installation of electronic assemblies, displays, and large-volume connectors. A curved top section can be fitted with LEDs, displays, and switches, while a large area on the underside is used to mount interfaces and connectors. Connectors are always accessible. An optional infill cover makes it possible to create an additional compartment for greater installation volume or to protect the connections. They come in three standard sizes with dimensions from 5.51 by 5.51 by 1.83 in. to 8.66 by 8.66 by 1.99 in. Thanks to use of a UL 94 V-O rated ASA+PC material, the enclosures can handle outdoor applications. IP65 (NEMA 4) protection is available when specifying an optional sealing kit. Applications include data-acquisition systems, central control units, measuring and control, data-systems engineering, and medical.

OKW ENCLOSURES INC.
www.okwenclosures.com

MicroTCA Chassis Boasts 40G Capability

VADATECH'S VT866 MicroTCA is designed to handle 40GbE (10Gbas-KR) signals. (A draft specification for 40GbE is in committee in the PCI Manufacturer's Industrial Computer Group or PICMG.) The 5U chassis holds up to 12 full-sized Advanced Mezzanine Card (AMC) modules in the single-width format. Multiple fabrics can be routed on the same backplane. Currently, MicroTCA-based systems use PCI Express, Gigabit Ethernet, and Serial RapidI/O fabrics. The VT866 features a 36-layer backplane with a high-performance dielectric material for clean signals. Also included are dual, rear-mounted 1000-W swappable power supplies. Easy-glide lining allows the power supplies to be smoothly inserted/removed from the chassis. The system integrates a Telco alarm and optional JTAG switch module. In addition, the company offers a 40GbE MicroTCA carrier hub (MCH) and 40GbE line cards.

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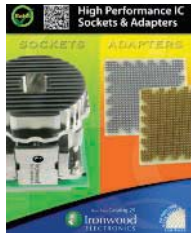

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IR's Robust 100V FastIRFET™ PQFN 5x6 Power MOSFET Delivers Benchmark Performance for Telecom Power Supply Applications

IR has announced the introduction of the IRFH7185TRPbF 100V FastIRFET™ power MOSFET that delivers benchmark performance for DC-DC power supplies used in telecom applications.

The IRFH7185TRPbF utilizes IR's new 100V FastIRFET™ process to offer benchmark Rds(on)*Qg figure of merit to deliver higher efficiency and increased power density as well as enhanced system reliability.

IR's FastIRFET™ devices work with any controller or driver to offer design flexibility while delivering higher current, efficiency and frequency capability in a small footprint. The IRFH7185TRPbF is qualified to industrial grade and moisture sensitivity level 1 (MSL1), and is available in an industry standard 5x6 PQFN package that features an environmentally friendly, lead-free and RoHS compliant bill of materials.

More information is available on the **International Rectifier** website at
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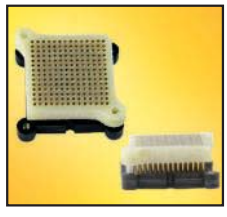
For more information, contact Sian Cummins,
scummin1@irf.com, 310-252-7148.

Micro Giga-snaP™ BGA SMT adapters



Micro Giga-snaP™ line of BGA adapters provide the most reliable interconnect to 0.5mm pitch BGA SMT pads. These patent pending adapters achieve 20 GHz bandwidth with 20mOhms contact resistance and 14g insertion force. 0.5mm pitch Giga-snaP™ BGA socket adapter pair consists of female BGA sockets with etched pins assembled into high temperature substrate. BGA adapter, to which the user attaches a DUT, is plugged into the female BGA socket.

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BILL WONG | Embedded/Systems/Software Editor
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Hard-Core FPGA Provides A Flexible Development Target

Xilinx made a splash when it first came out with the Zynq-7000. Its dual ARM Cortex-A9 cores were at the center of a microcontroller packed onto the same chip as an FPGA. Yet Xilinx is not alone in blending FPGAs with hard-core ARM processors. Microsemi and Altera have offerings as well, and Altera has announced a quad-core version with 64-bit ARM Cortex-A53 cores.

Since then, the Zynq has garnered quite a bit of support. Even LDRA is supporting the Zynq-7000 platform with its LDRA Tool Suite, which addresses everything from unit testing to static analysis.

The Zynq-7000 can be found in platforms like National Instruments' (NI) cRIO-9068 *(Fig. 1)*. NI built the CompactRIO line around a processor and an FPGA. It typically programs using NI's LabVIEW, but the move to an integrated Zynq-7000 chip reduced costs and provided a more flexible development platform that runs on Linux. The Zynq-7000 can easily handle Linux, which is one of the reasons for the chip's flexibility. It can run applications that may or may not need the FPGA support.

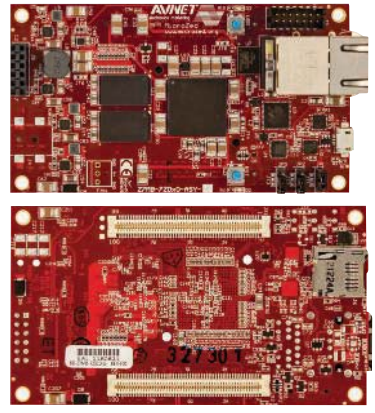
NI is being more open with the latest cRIO platform, enabling developers to utilize Linux directly. Applications written in other languages such as C can be used with the FPGA, opening up some interesting alternatives given the vast number of modules that can be plugged into the cRIO platform.

JUMPING IN

Getting started with the Zynq-7000 has never been easier. Programming the FPGA portion is still as much of a challenge as ever, but Xilinx's Vivado development tool makes it easier.

On the other hand, utilized prepackaged FPGA firmware that can be loaded via the Cortex-A9s means developers can use these systems without needing to develop the FPGA firmware. They can take advantage of the hardware acceleration from applications that run on the hard-core processors.

1. National Instruments' cRIO-9068 is based on Xilinx's Zynq-7000. It runs Linux and LabVIEW applications.



2. Avnet's MicroZed exposes more than 100 I/O ports using two connectors on the bottom.

Another way to get started with the Zynq is to use a system-on-module (SOM) like Avnet's MicroZed *(Fig. 2)* or Digilent's ZYBO *(Fig. 3)*. The MicroZed is a more compact version of the open-source Zedboard available from Digilent. They all support Digilent's Pmod modules, which plug into a 12-pin header. This is handy for prototyping and experimentation because quite a variety of Pmods is available such as capacitive touch interfaces, stereo amplifiers, Wi-Fi modules, and OLED displays.

WHAT'S NEXT?

The MicroZed also has two connectors on the bottom, so it can be plugged into a carrier board. It is practical to use in more rugged applications. Avnet has a set of Zynq Mini-Module Plus boards with even larger versions of the FPGA and GTX ports as well.

3. Digilent's ZYBO (Zynq Board) has 512 Mbytes of RAM and six Pmod connectors.

These platforms also have Ethernet support in common. This makes a big difference for debugging and for providing network access, which is imperative for the Internet of Things (IoT). Linux provides the platform for dealing with the network aspects of an application while the FPGA fabric provides unparalleled performance and flexibility. There is also something to be said about the standardization that Zynq provides. It may get some designers to consider using an FPGA for their next project. Applications like image recognition use the hardware acceleration.

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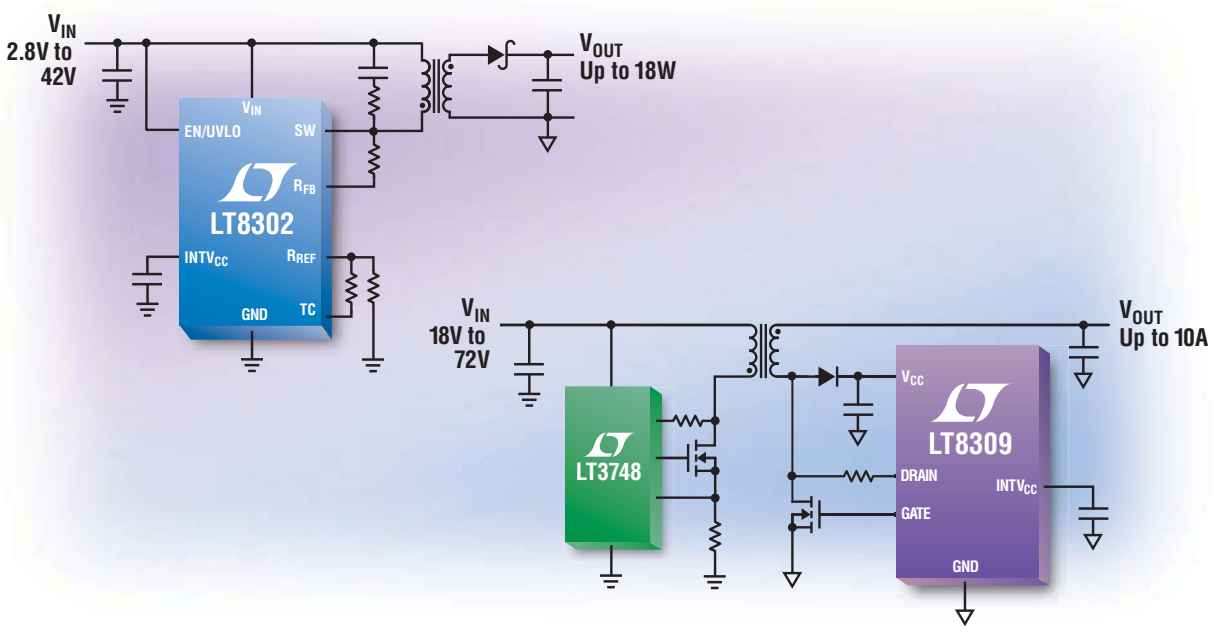

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LT8301	up to 6W	2.8V to 42V	100µA	1.2A/65V	TSOT-23(5)
LT3573	up to 6W	3V to 40V	3.5mA	1.25A/60V	MSOP-16E
LT3575	up to 12W	3V to 40V	4.5mA	2.5A/60V	TSSOP-16E
LT8302	up to 18W	2.8V to 42V	106µA	3.6A/65V	SO-8E
LT3748	up to 100W	5V to 100V	1.3mA	External	MSOP-16(12)

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