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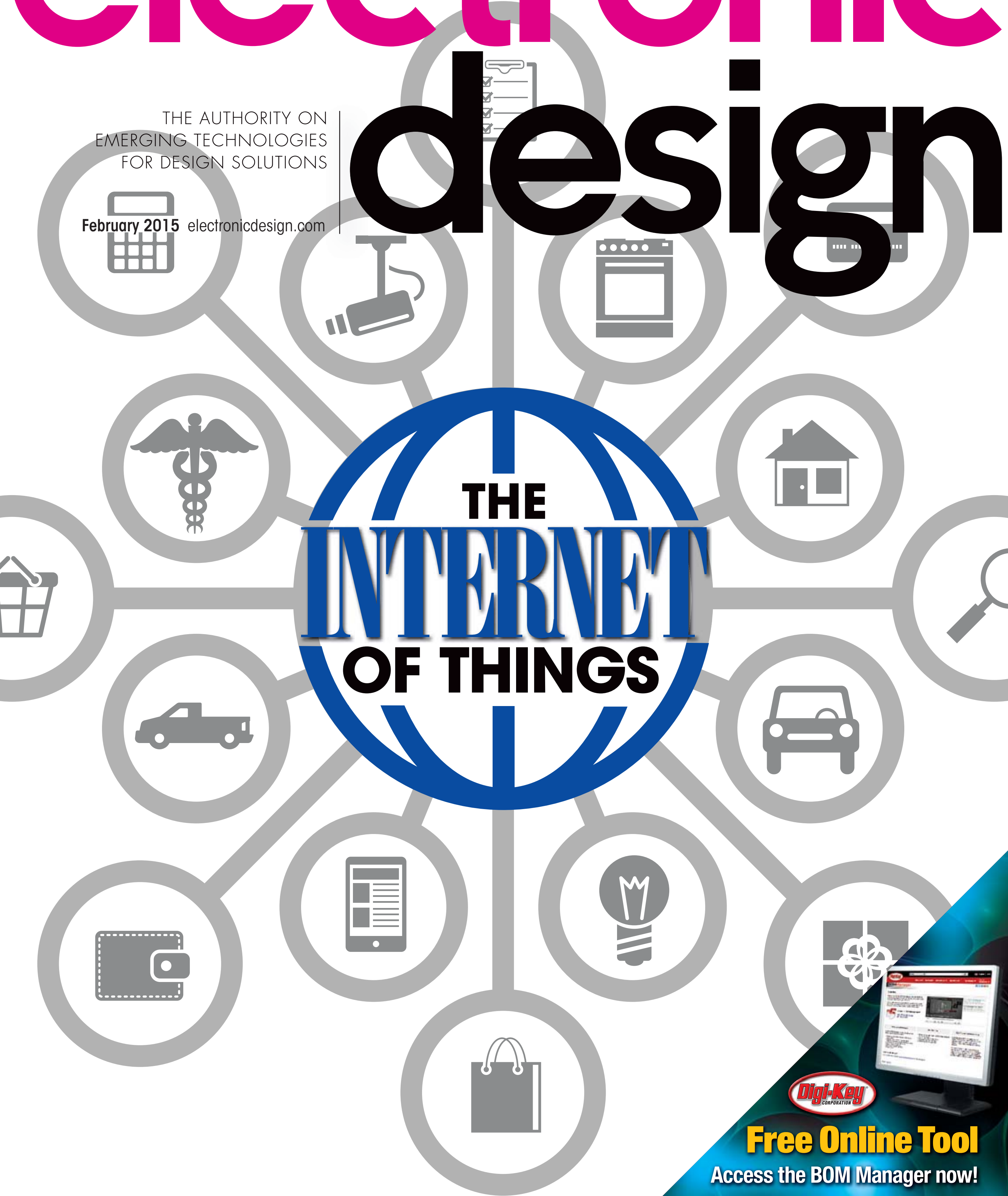

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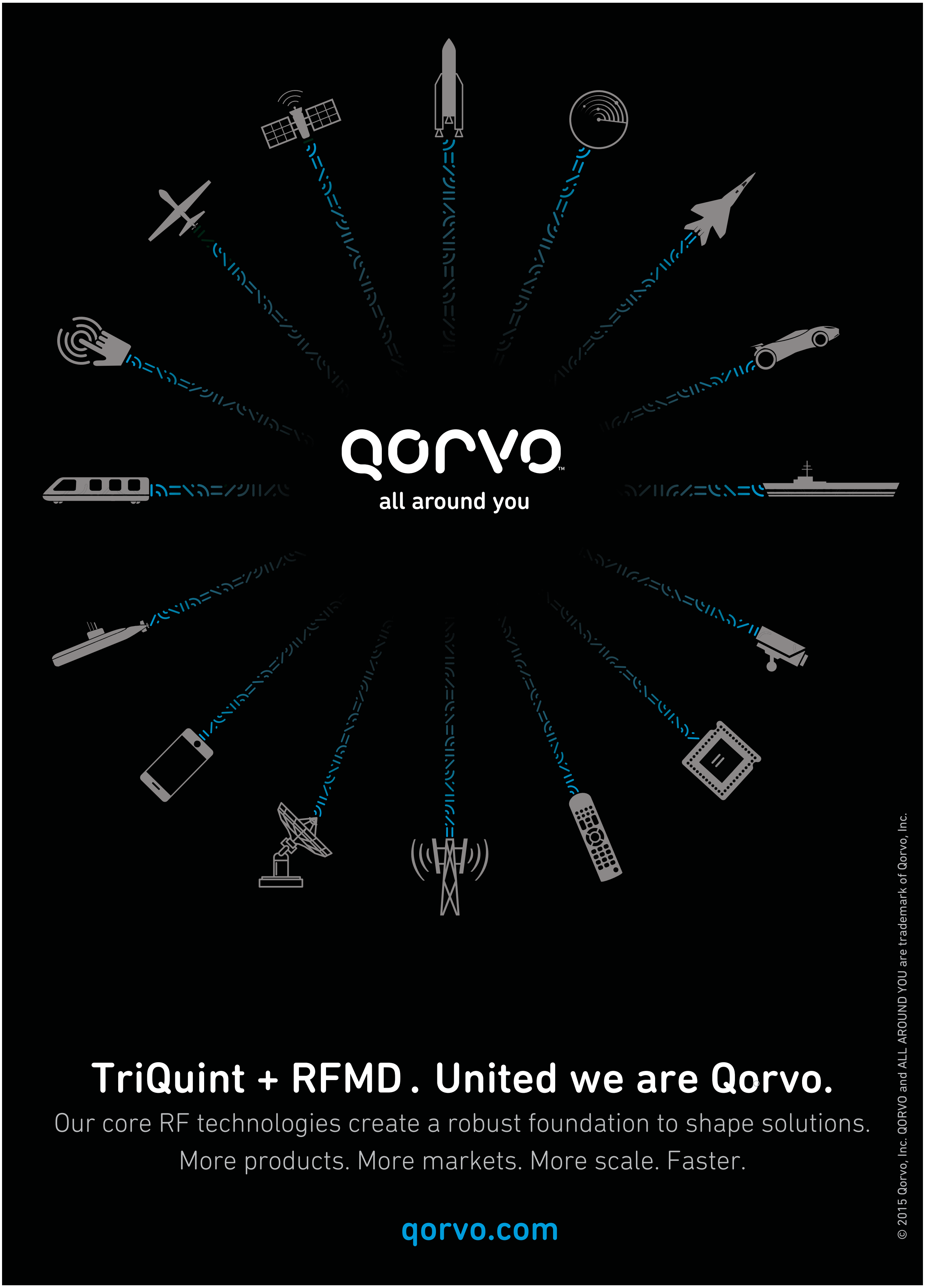
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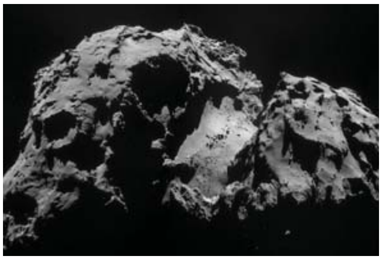

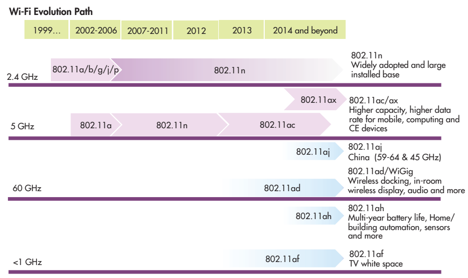

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EDITORIAL MISSION:
To provide the most current, accurate, and in-depth technical coverage of the key emerging technologies that engineers need to design tomorrow's products today.

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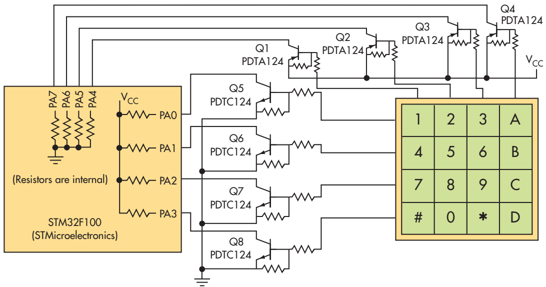

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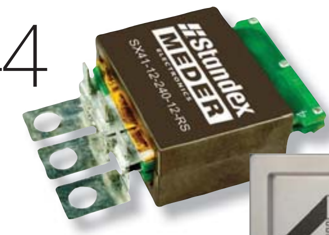

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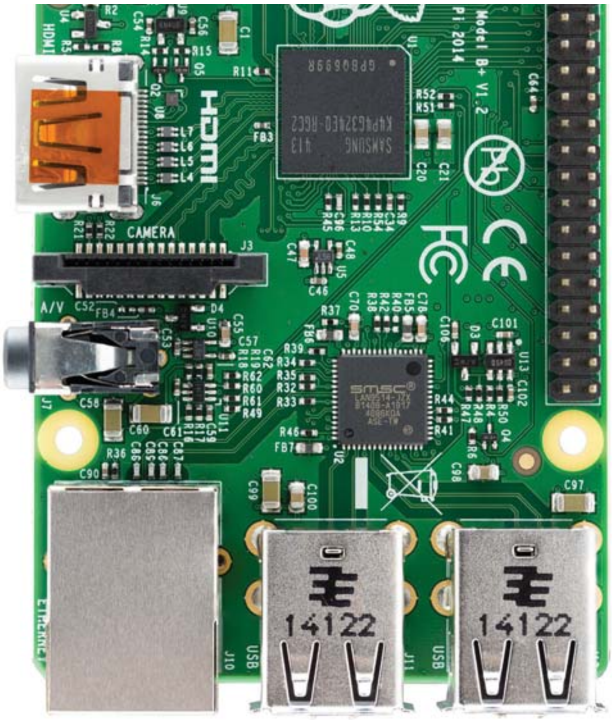

LOOKING AT THE LATEST EMBEDDED DEV BOARDS

electronicdesign.com/boards/what-s-difference-between-latest-embedded-dev-boards

With many boards to choose from, electronicdesign.com looks at the different capabilities for the leading options and the best ways for embedded developers to access user support.

blogs

LOUIS FRENZEL
COMMUNICATIONS

- What's Happening with Heathkit and Radio Shack?

BILL WONG
EMBEDDED/SYSTEMS/SOFTWARE

- Create Great-Looking Text on IoT Devices

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VIDEO: 3D FOOD PRINTER

electronicdesign.com/3d-food-printer

The Star Trek food replicator may be one step closer to reality with this 3D food printer from Taiwan's XYZprinting. Instead of inedible plastic filament, it dispenses consumables such as cookie dough or icing in layers to create 3D (edible) objects.

WHAT'S NEXT BEYOND 10 GIGABIT ETHERNET?

electronicdesign.com/communications/data-center-networking-what-s-next-beyond-10-gigabit-ethernet

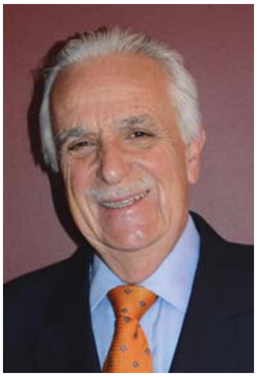
As internal data-center traffic begins to tax the capacity of 10-Gb/s Ethernet links, an emerging set of Ethernet speed specifications based on 25-Gb/s signaling is coming to fruition.

25G 50G Ethernet Consortium

Q&A: DR. LUCIO LANZA

electronicdesign.com/eda/qa-interview-kaufman-award-winner-dr-lucio-lanza

Technology Editor Bill Wong talks with Dr. Lanza about EDA and the electronics industry, investing in interesting technology, receiving the Kaufman Award, and working closely with Phil Kaufman at Intel.



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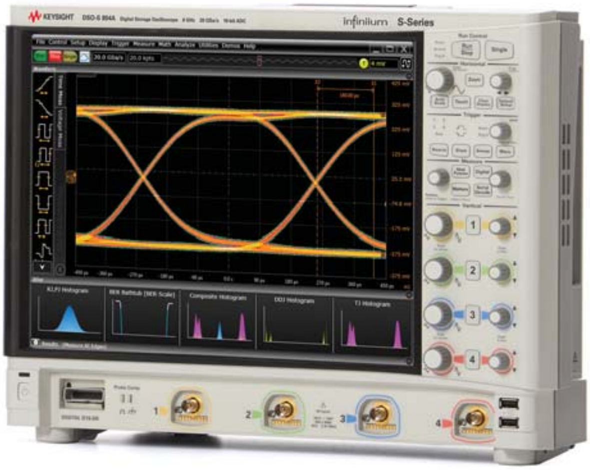

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BILL WONG | Embedded/Systems/Software Editor
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IoT is here whether you like it or not

Never mind that everyone has their own idea of what the Internet of Things (IoT) is. It is here to stay whether we like it or not. The challenge will be living with the plethora of devices as well as issues such as battery life, reliability, connectivity, and security. The vast majority of embedded devices are still standalone, but the number of connected devices continues to grow astronomically.

Best of all, many of the services and sometimes the devices themselves will be free! Sort of.

The cost will often be in non-monetary forms like forced advertising, giving away information sometimes on a continuing basis, or restricting other purchases to compatible devices. Often hidden from view is digital rights management (DRM), communication with various Internet sites, and logging of information that may not be available to the user.

I don't want to be too down on IoT. The benefits are significant. The advantages in the medical space alone will be major. New remote patient monitoring systems will give physicians access to diagnostic information never available before with significant cost savings. New sensors and sensor fusion can provide not just simple pieces of information such as pulse rate, but a range of data from skin temperature to ambient temperature and movement information. Did you really walk a mile today?

1. Sengled's Pulse Solo is a 3-W JBL Bluetooth speaker that screws into a light-bulb socket. It is an LED light bulb as well.

The trend leads to all sorts of products you might not have thought of or ever thought you'd need until you see them. Take Sengled's Pulse Solo (see the figure). It packs a Bluetooth stereo speaker system into a light-bulb package. Just screw it into a socket and stream music from your Bluetooth-enabled smartphone. It is also an LED light bulb just in case you needed a smartphone-controllable light, too.

On the plus side is the functionality provided by these products. On the minus is the added complexity and increase in the attack surface for hackers. Embedded designers have a challenge before them to deliver flexibility while keeping the electronic environment secure. It is not going to be easy. ed

News
& Analysis

SIDE-CHANNEL EMISSIONS: A Nefarious New Portal to Hack Attacks

With the recent Sony and iCloud breaches, the protection of electronics and data now garners mainstream news headlines. Meanwhile, researchers at Georgia Tech have begun combatting an entirely new kind of hack. By analyzing the low-power electronic signals from laptops and smartphones, hackers can see what you're doing—even without hooking up to a potentially unsecure network. Known as side-channel signals, researchers are now investigating where these "information leaks" originate to help hardware and software designers "plug" the gaps.

According to the research team, the side-channel emissions are measurable from several feet away using a variety of methods. Electromagnetic emissions can be received using hidden antennas or acoustic emissions, while sounds produced by electronic components can be picked up by hidden microphones. Also, fake battery chargers plugged into adjacent outlets will measure data on power fluctuations, which translate into the operations performed by computers. Simple AM/FM radios can even pick up some signals.

Researchers at Georgia Tech are currently studying side-channel emissions from laptops and smartphones, which hackers can use to passively gain information without notice.
(Image courtesy of Thinkstock)

As part of a demonstration, Alenka Zajic, an assistant professor at Georgia Tech's School of Electrical and Computer Engineering, modified keyboard software to make the characters easier to identify, showing just how easily it can be done. Nothing was added to the code to raise any serious suspicion—it just looked like a less efficient version of normal keyboard driver software. In many applications, including spell-check, grammar-checking, and display-updating, the existing software contains enough loopholes to carry out an attack.

The team believes it's only a matter of time before hacking via side-channel emissions becomes more commonplace. By determining where the leaks originate, the team can help manufacturers mitigate potential attacks by redesigning components from an architectural level. Each computer operation has a different leak potential—for instance, processors that draw different amounts of power creating measurable fluctuations, or the "loud" power draw of saving data to memory.

Noticing these fluctuations, the team developed a metric known as "signal available to attacker" (SAVAT) to measure the strength of the signal emitted. They then measured the SAVAT for 11 different instructions on three different laptops. They found that the largest signals were produced when the processors accessed off-chip memory. The team is now studying smartphones, where compact design and large differential between idle and in-use power modes mean extreme vulnerability.

While the technology seems rudimentary, with much focus being placed on securing the Internet/wireless communication side of things, hackers can nonetheless use these techniques to do some serious damage. Passwords can be stolen while they are being typed just by intercepting the side-channel signals produced by a keyboard's software, reading them from a disconnected laptop in an adjoining room. The passive nature of the hack makes it impossible for the victim to notice anything going on. ■

COPPER BONDING Technology Reduces Pitch for 3D Chipsets

DEMANDS FOR INCREASED functionality in ever-smaller IC packages necessitate advances in bonding techniques to build memory stacks and other integrated circuits. Along these lines, the recently formed CoW Consortium will focus on enhancing a chip-on-wafer (CoW) bonding technique via copper-copper (Cu-Cu) diffusion bonding technology in an effort to develop commercially viable 3D chipsets. The consortium, founded by A*STAR's Institute of Microelectronics (IME), includes members such as ON Semiconductor, KLA-Tencor, Panasonic Factory Solutions Asia Pacific (Panasonic), Singapore Epson Industrial Pte Ltd. (Plating Division), Tera Probe Inc., and Tokyo Electron Ltd.

The copper-copper (Cu-Cu) bonding technology will influence manufacturers who make ICs, like the ones seen above, pictured on a silicon wafer. ***(Image courtesy of the ESA)***

The new Cu-Cu diffusion bonding involves the diffusion of copper atoms to form a metallic bond, eliminating the solder-assisted process. Members of the consortium successfully demonstrated the technology at 200°C and at a reduced pitch (an average of 40 µm to 10 µm, with researchers aiming to get it down to 6 µm). Thus, chip-device manufacturers now have the potential to further integrate their 3D chipsets with CMOS image sensors, signal processors, logic and memory, and memory stacks.

Conventional CoW bonding techniques have relied on a solder-assisted thermo-compression bonding process that can last more than 15 seconds at 300°C. This method, which attaches the chip to a piece of semiconductor wafer, slows the overall production process and results in higher manufacturing costs. Other limitations also exist, including the inability to scale down the pitch, and the distance between wirings. ■

ESA PURSUES 3D-Rendering Software Solution to Study Comets

This composite image of comet 67P, also known as Churyumov-Gerasimenko, was taken by Rosetta in August 2014. ***(Image courtesy of the European Space Agency)***

THE EUROPEAN SPACE Agency's (ESA) Rosetta mission, established to seek the origin of comets, is currently studying comet 67P to create a portrait of its nucleus, makeup, and orbit around the sun. The ESA recently announced it will work with the Qt Company to develop a 3D-rendering software module as part of its Mapping and Planning of Payload Science (MAPPS) tool. To date, developing such software has proven difficult in terms of meeting the mission's goals due to the irregularity of comets, which makes them unsuitable for modeling as flattened spheres (the typical approach taken with planetary missions).

A two-step approach will be taken to render the elements required in creating a 3D model of the comet. First, the elements will be rendered on a texture map representing the surface of the comet, including its irregular shape. That texture will then be sent to the MAPPS tool, which will apply it to the surface of the 3D model to allow for planning and data analytics. The ESA chose Qt Company as a partner because of its development framework—it enables rapid development and supports GPU hardware acceleration, a necessity for complex 3D rendering software.

Qt, a cross-platform application and UI framework, can be used for embedded device creation and application development. UI can be developed with Qt Quick (written with the Qt-specific language, QML, which has a C++ backend), C++, HTML5, or a hybrid of all three. Qt runs on Windows, Linux, and Mac, and offers a drag-and-drop interface to promote easy prototyping and use. The original MAPPS tool was developed as part of the Mars Express, and later on Venus Express, which were experiments to provide detailed terrain data. ■

BILL WONG
Technology Editor

THE INTERNET OF THINGS IS HERE

Everyone has their own idea of what the Internet of Things (IoT) is, but one thing we can all agree on is this: It is here to stay whether we like it or not. The challenge will be living with the plethora of devices that will be connected in some fashion.

The smartphone provides the ultimate mobile hook into the cloud/Internet. It is considered an IoT device because it not only provides a way to view information from the cloud, but is also a major source of information about the phone's owner. The phone has a collection of sensors that can provide details about location, movement, and use and quite, and quite a bit of that is going to the cloud where "big data" analysis is putting it to use.

This information is often used to provide targeted advertisements and this only gets more effective, or invasive depending on your perspective, as the surrounding electronic landscape gets populated with even more IoT devices. These devices may not be connected to each other directly, but often the data they generate is correlated via big data analysis.

THE IoT CAR

Automotive solutions highlight integrated IoT growth with the amount of sensor information growing by leaps and bounds. Even tire-pressure sensors are part of the mix (see "Tire-Pressure Monitoring Pumps Up Performance" on electronicdesign.com). These wireless sensors, which are found on all new vehicles, can pinpoint a leak or let a driver know if the tire pressure is too low.

An Advanced Driver Assistance Systems (ADAS) utilizes an array of sensors generating immense amounts of information that can be processed and sent to the cloud (*Fig. 1*). The sensors include ultrasound and surround-view cameras for locating nearby obstacles for parking-assist operations. Short-, medium-, and long-range radar can be used for features like adaptive cruise control and emergency braking. Cameras can be used for traffic sign recognition. GPS provides location information, while hooks into the speedometer can provide information for tracking traffic patterns.

Of course, this information can also be used for other purposes, such as locating the nearest gas station or a store with a sale on a driver's favorite purchases. There are even dongles from insurance companies that plug in to capture braking and acceleration data among other information.

Telematics, ADAS, and engine control are only part of the story when it comes to the connected vehicle. That ever-present display is providing more information to the driver, and the system is often hooked into more IoT devices like smartphones. They already provide navigation, multimedia capabilities, and smartphone connectivity as well as controlling and monitoring the entire car. That alone makes the automotive platform a significant IoT environment but that is just the beginning.

Trucks such as Ford's F-150 (*Fig. 2*) can link with a host of IoT devices, such as tools that can allow a user or company to track when devices are loaded in the vehicle. Such a system can track when vehicles are used at a job site employing the same wireless location approach used for key fobs that unlock

TO STAY

IoT means different things to many people, but it is all about connectivity

a car door when the user with the fob is outside the door and pulling on the handle.

Automotive platforms are just one example of how IoT systems can work. The home is another environment where the technology is proliferating. Even light bulbs like Sengled's Pulse Solo (see "IoT Is Here Whether You Like It or Not" on electronicdesign.com). The Pulse Solo is an LED lightbulb with a built-in, wireless amplifier and speaker system. A smartphone can stream audio to the Pulse Solo using Bluetooth.

The view of IoT thus far glosses over the communication and security challenges. Many devices will connect directly to the Internet, but others will communicate locally or through gateways. The use of standard protocols like TCP/IP allows traffic to move across standard routing systems, while it is the higher-level protocols that allow the interchange of data. This level is where there are fewer standards.

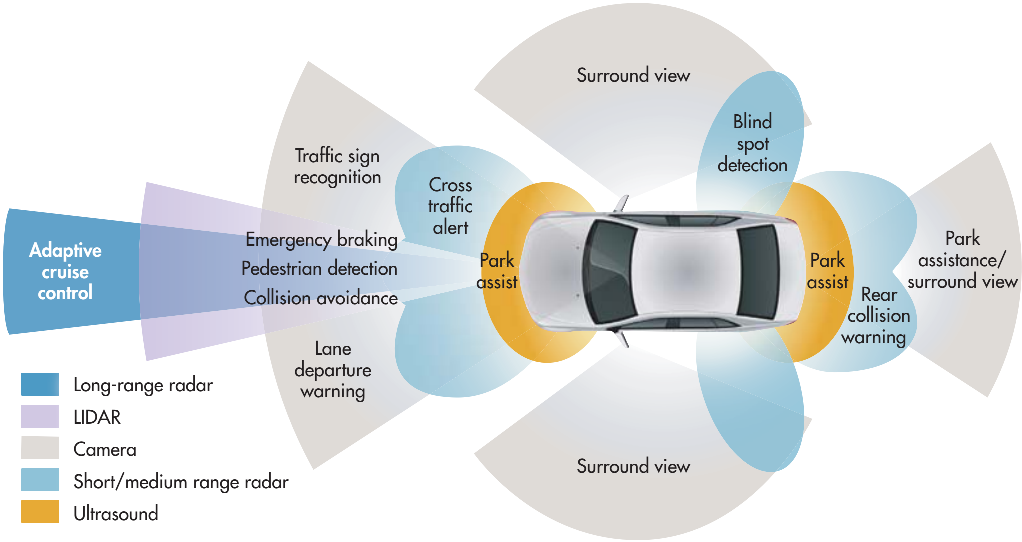
IoT COMMUNICATION FRAMEWORKS

The lack of high-level standards has not prevented a vast array of IoT frameworks from emerging. Wind River's Edge Management System (EMS), for example, is designed to address the array of services needed to deploy and manage sophisticated IoT

2. Ford's F-150 can be equipped with wireless systems that check when devices are loaded into the vehicle automating inventory tracking.

environments (*Fig. 3*). It targets IoT devices such as those used in medical applications. An agent runs on the device. This supports the various services from control and monitoring to provisioning and remote updates. To simplify programming, the system supports a rule system and data model that maps a consistent interface onto the agent. Developers dealing with data from and control of IoT devices can utilize this vendor-specific API to handle the remote agents. Details of communication, connectivity, and security can be ignored when dealing with the content. Of course, the system deals with these details and others can address this management using other tools within the framework.

Wind River's EMS is only one of many solutions available to developers. In gen-



1. An Advanced Driver Assistance Systems (ADAS) utilizes an array of sensors generating immense amounts of information that can be processed and sent to the cloud. (Courtesy of Texas Instruments)

Automotive solutions highlight integrated IoT growth with the amount of sensor information growing by leaps and bounds. Even tire-pressure sensors are part of the mix.

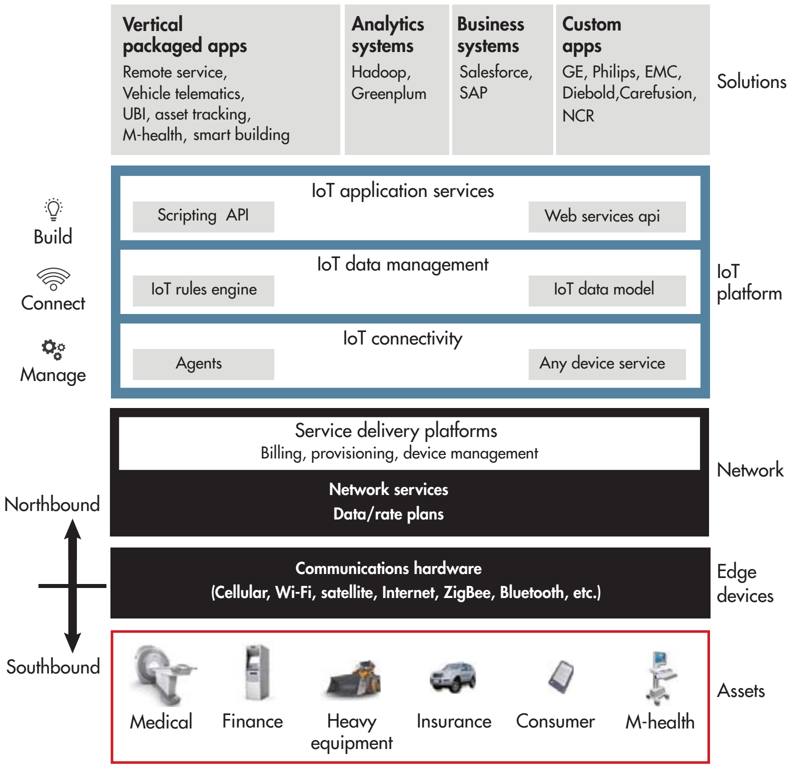
eral, the frameworks have a similar architecture with an agent that runs on the device. The frameworks and their protocols are built on top of communication standards such as TCP/IP, allowing the frameworks to take advantage of standard communication interfaces like WiFi and Bluetooth.

EMS is integrated with Wind River's application development support. It can handle end-to-end security strategies that are customizable and is designed for large-scale IoT deployments.

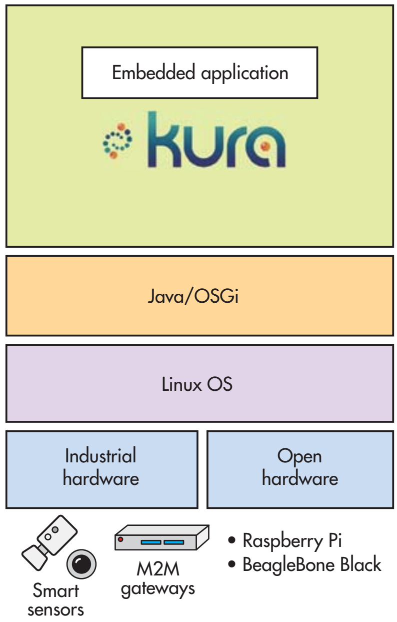
Gateways that can provide additional services are typically defined within the framework. They can usually run applications that provide translation, correlation, and local management and are often firewalls between a network of IoT devices and the cloud.

It is possible to create an IoT device without utilizing a framework, but it takes a significant amount of work to match the range of services provided by a framework. Keep in mind that these frameworks do not just involve moving data from the IoT device to the cloud. Distribution of data, security, and a host of other details need to be managed as well. For example, some frameworks provide a publish/subscribe infrastructure that allows data to be shared with any number of devices within the environment. These may be peers, gateways, or servers running applications that also run on the framework. Data generated by IoT devices may wind up in SQL databases in the cloud or big data databases. In general, the agents on the IoT devices do not have to deal with details of where the data it generates is going.

There are open-source solutions in this space and some vendors are basing their frameworks on them. Note that this is not the same thing as having an IoT framework that is built on open-source or standard APIs. Those are typically inter-



3. Wind River's Edge Management System is designed to address the array of services needed to deploy and manage sophisticated IoT environments.



4. Kura is an open-source IoT framework built on Java and OSGi.

faces and protocols that provide the communication between nodes within an IoT framework and almost all IoT frameworks use these. The open-source IoT frameworks open the APIs used within the framework.

Kura is an open-source IoT framework hosted by the Eclipse Foundation (see "Developers Discuss IoT Security and Platforms Trends" on electronicdesign.com). Kura is built on a Java/OSGi framework (*Fig. 4*). It uses MQTT to exchange data. MQTT can run over protocols like TCP/IP. Kura agents and gateways can run on low-end platforms like Raspberry Pi or the Beaglebone Black.

There are complementary projects to Kura like Mihini, a high-level, Lua API for machine-to-machine (M2M) applications. (The term "M2M" is gradually being overtaken by IoT.) Mihini is designed for microcontrollers with a few megabytes of storage, so it does not necessarily target the very low end of the IoT spectrum.

FUSING SENSORS

Sensor fusion is often associated with IoT devices that provide additional context-related data by combining information from other local sensors. This fused data essentially implements a virtual sensor. Platforms such as smartphones often have sufficient resources to utilize sensor data directly using native applications. Other platforms may just move this information up the food chain. The virtual sensor information is often much more compact in terms of data compared to the sensor data that is used to generate it. For example, a virtual sensor that indicates where the device is and how it is moving can prove useful. Some sensor fusion technology can currently indicate whether the device is moving on a train or in a car.

Sensor fusion hubs are a popular means of integrating sensor hardware. The microcontrollers in the hub handle the integration of data, providing it and virtual sensor information to the local host. In many cases, these can be viewed as IoT devices.

The idea of analyzing data from multiple sources is not restricted to sensor fusion hubs. The approach is applicable to combining data from IoT devices as well. Analysis of big data is simply the other end of the spectrum.

Hardware and software make IoT possible, but many of the costs of using these devices will remain hidden from users. Not all connectivity is free. Most data will not be under the direct control of users. Security of these systems is another area of concern because they greatly increase the attack surface of a user's electronic environment. There are also some concerns about the legitimate, or at least legal, use of this information.

There are many opportunities and advantages of IoT as well. In any case, the Internet of Things is here to stay, whether we like it or not.

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Connectivity Options Abound for the Internet Of Things

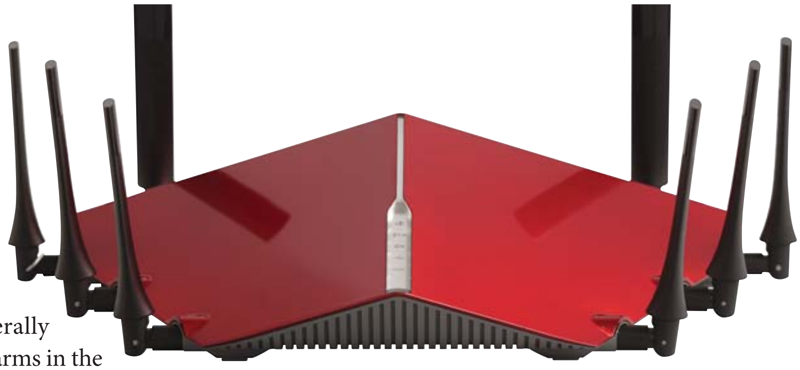
Wi-Fi, Bluetooth, 802.15.4, Z-Wave, and DECT technologies, among others, can meet specific needs for developers across the IoT spectrum.

The Internet of Things (IoT) implies connectivity, and developers have lots of wired and wireless options at their disposal to make it happen. Ethernet tends to dominate the wired realm. IoT frameworks map higher-level protocols on this type of connectivity, but the devices don't work until they have a method of communication with the network.

At this point, Ethernet implementations range from 10 Mb/s up to 100 Gb/s. The high end generally targets the backbone of the Internet to link server farms in the cloud, while the low to mid-range runs on the rest of the devices. Today, the median implementation is 1-Gb/s Ethernet.

Legacy devices reside in the low end, namely 10- and 100-Mb/s Ethernet. Low-end microcontrollers, especially ones with built-in Ethernet controllers, are also found here. The typical low- to mid-range Ethernet switch handles 10/100/1000-Mb/s Ethernet. These gigabit switches work with just about any device by handshaking to find a compatible speed and protocol. Protocols can be complex, including details like quality-of-service (QoS), flow control, and virtual private network (VPN) support. These are often transparent to IoT developers working at the TCP/IP protocol level or higher.

Though 10-Gb/s Ethernet is gaining ground, especially for mid-range server interconnect, a new class of Ethernet speeds looms on the horizon. Essentially, 1-Gb/s Ethernet is bumping up to 2.5 Gb/s with a corresponding hop up for higher-speed Ethernet like 10 Gb/s moving to 25 Gb/s. This change essentially provides faster throughput using the same cabling.


1. D-Link's AC5300 handles Wi-Fi speeds up to 5.3 Gb/s using eight MIMO antennas and a 1.4-GHz dual-core processor.

With Ethernet essentially serving as the backbone for wireless communication, various wireless access points have an Ethernet port that's typically faster than the wireless side. As a result, the wireless link can operate at full speed. Multiple access points usually exist in a commercial/industrial settings–a single Ethernet backbone connects them together as well as provides a link to the Internet when appropriate.


2. The SCiO, developed by Consumer Physics, employs a near-infrared (NIR) spectroscopy sensor to examine materials such as food, and then sends the data to a smartphone app using Bluetooth.

WI-FI DELIVERS BANDWIDTH

Wi-Fi, with its array of 802.11 variants, provides the highest throughput of wireless technologies. It started with 802.11a and b, and progressed to 802.11ac. The 802.11b standard had a raw data rate of 11 Mb/s and only utilized the 2.5-GHz band, while 802.11ac uses the 2.5- and 5-GHz bands with a combined bandwidth of 5.3 Gb/s. Indoor range is 100 to 200 feet. The next evolution—802.11ax—is poised to succeed 802.11ac.

One example of the latest in Wi-Fi routers comes from D-Link *(Fig. 1)*. The AC5300 handles speeds up to 5.3 Gb/s.

3. The ULE Alliance's DECT technology is the same as that integrated into VTech's DECT 6 cordless phones.

The system, driven by a 1.4-GHz dual-core processor, features eight antennas for MIMO (multiple-input, multiple-output) support.

The challenge with 802.11 concerns spectrum utilization. Anyone using Wi-Fi at a tradeshow has run into the problem of spectrum over-utilization. For example, a show's 2.5-GHz band has 11 channels (depending on the country), but the channels overlap and that can actually reduce data bandwidth for all parties. Non-overlapping layouts of multiple access points normally use channels 1, 6, and 11. Though access points on the same channel can coexist through negotiation, data bandwidth is limited.

Wireless protocols incorporate security standards. The 802.11 Wired Equivalent Privacy (WEP) has been broken and should not be used, since it's generally limited to older 802.11b platforms. The Wi-Fi Protected Access (WPA) and 802.11i, also known as WPA2, are the security protocols of choice these days. Open wireless access points can operate with no security protocols.

A key challenge for IoT developers surrounds power requirements. Not so much for wireless devices with wired power or sufficient battery resources, but rather for mobile devices like smartphones and tablets. Still, Wi-Fi is often the choice for these devices because of the bandwidth, especially when it comes to streaming video applications (e.g., watching movies or video cameras). Battery usage for these applications is typically measured in hours of continuous use; often, other aspects of the system, such as displays and processors, use more power than the Wi-Fi support.

Wi-Fi for more power-limited budgets is possible, depending on the requirements. For example, applications that only need to send a burst of data don't necessarily have to communicate continuously. They can turn on the Wi-Fi support at a predetermined time and later shut it down. Power and range also are adjustable.

BLUETOOTH

Bluetooth is a short-range technology that uses the 2.4- to 2.485-GHz ISM (industrial, scientific, and medical) band. Designed for mobile personal area networks (PANs), Bluetooth is found on devices like smartphones and headphones. The Bluetooth Special Interest Group manages the technology, with the latest standard being Bluetooth 4.2.

Bluetooth has "classic" and Low Energy (LE) versions; the 4.x standard allows one or both to be implemented. Bluetooth LE is also known as Bluetooth Smart. They aren't backward-compatible, so they may not work with older devices.

The LE version is important because it is designed to allow for devices that run and communicate for months or years using low-power sources like button cell batteries or energy-harvesting devices. It's compatible with most smartphones and tablets that have been based on Bluetooth 4.x for some time.

Classic and Smart Bluetooth maximum range is about 100 m (330 feet), while data rate is up to 3 Mbs/s and 1 Mb/s, respectively. However, actual application throughput, like most wireless technologies, is less—2.1 Mb/s for classic and 0.27 Mb/s for Smart.

Classic is limited to seven device connections, but it's not defined for Smart. This is different than the number of paired devices a device can have, since many may not be active at one time. Smart devices having no device limitation becomes an important factor, because more applications now can utilize a large number of simultaneous connections.

A relatively new facet to the technology that's gaining interest is the use of Bluetooth beacons. This standard is designed to allow battery-operated beacons to operate for long periods of time, transmitting information to passing Bluetooth devices. They can provide personalized information, such as a coupon for a product on display in a store. The beacons target devices like smartphones; the smartphone can be set up to ignore or highlight information from the beacons based on user preferences and beacon information. The beacons are essentially IoT devices, too.

This technology can be utilized in multiple scenarios. For example, an exercise machine may have a beacon that indicates availability (in use or not in use) as well as results. An exercise app that has a schedule could indicate what machines were available and then lock the machine to issue results only to the smartphone. The machine might even unlock automatically once the mobile device moves out of range, since Bluetooth can provide location information based on beacons.

A number of defined Bluetooth variants haven't necessarily reached significant adoption. For example, Bluetooth 3.0+HS combines support for conventional Bluetooth with 802.11 Wi-Fi to sport 24-Mb/s throughput. The Wi-Fi component handles faster throughput, while Bluetooth provides handshaking. This is only supported by devices with the +HS designation.

Bluetooth has become the wireless technology of choice for personal mobile devices, especially since they can be managed from a Bluetooth-enabled smartphone. This includes novel devices like Consumer Physics' SCiO *(Fig. 2)*. The device uses the company's near-infrared (NIR) spectroscopy sensor to analyze materials such as food and water. It takes about a second or two for an IR emitter to illuminate a sample and for the sensor to detect results. The microcontroller analyzes the results and sends these via Bluetooth to a smartphone app. The unit, which operates for about a week under normal use, incorporates a micro USB connection to recharge the battery.

LOW-ENERGY WIRELESS

Other low-energy wireless technologies include 802.15.4 and Z-Wave. Another is DECT (Digital Enhanced Cordless Telecommunications), which can be applied to IoT applications.

The 802.15.4 standard defines a 250-kb/s data rate and 10-m range, and supports point-to-point and mesh configurations. It utilizes three bands: 868 MHz, 915 MHz and 2.45 GHz. Regarded as a raw protocol, the standard is used as the basis for higher-level protocols like 6LoWPAN (IPv6 over Low power Wireless Personal Area Networks) and ZigBee. Also, a number of vendor-specific protocols are built on 802.15.4, such as Microchip's MiWi, which are often lighter weight and have fewer licensing restrictions.

Most networks support IPv4 and IPv6, but IPv4 is currently the entrenched version on the Internet. It has a number of problems that are solved by IPv6 (e.g., address limitations). Essentially most of the IPv4 address space has been assigned. IPv6 greatly expands the address space, which will be needed with the plethora of IoT devices requiring unique IDs.

4. QuickLogic's TAG-N module uses the Nordic Semiconductor's nRF51822 Bluetooth Smart and the ArticLink 3 S2 smart sensor hub.

Z-Wave, supported by the Z-Wave Alliance, exploits the 900-MHz ISM band using GFSK Manchester channel encoding. Performance characteristics are similar to 802.15.4, including 100-kb/s throughput and a 100-ft. (30.5 m) range. It also handles point-to-point and mesh networks, and targets similar application areas such as home automatic and lighting controls. A network can have up to 232 nodes, and controller and slave devices help simplify control and configuration.

IoT PHONES HOME

The ULE (ultra low energy) Alliance uses DECT technology, which is common in newer cordless phones like those from VTech Communications *(Fig. 3)*. High voice quality was important for the design of DECT, thus translating into high-reliability connections needed for IoT data.

The DECT ULE range of frequencies hovers around 1.9 GHz, providing 120 duplex channels. Its TDMA multiplexing scheme maintains 24 time slots with a 10-ms frame length, which equates to 1.152 Mb/s. For speech, this means 32-kb/s ADPCM or 64-kb/s G.722 encoding. Packet size scales from 32 to 256 bytes. It can even handle images and video data.

DECT ULE's typical range of 300 m tends to provide more coverage than some competing technologies. It can support higher-level protocols like 6LoWPAN. In addition, DECT ULE uses the stronger 128-bit AES encryption scheme rather than the 64-bit encryption integrated into standard DECT devices. Packet authentication and encryption are standard.

The systems are designed for low-power usage—RF power averages 10 mW with a 250-mW maximum power specification. Latency falls below 100 ms. The architecture supports over 400 nodes, with 256 nodes being directly addressable. A typical sensor application with a 20-second sleep cycle that consumes 20 µA can run for 10 years on a AAA battery.

CELLULAR CHALLENGES

Most cellular IoT devices target Long Term Evolution (LTE) 4G and 5G standards. Cellular has the advantage of coverage, which is essentially global, although wide swaths still lack cellular coverage. Likewise, coverage can be spotty in areas with many cell towers due to, say, service providers and roaming conditions or natural and man-made obstructions. Nevertheless, it's the only alternative, except for some limited satellite technologies, for IoT designers that need coverage outside of fixed areas available to Wi-Fi, as well as for local coverage similar to Bluetooth and other short-range wireless.

The major issue, though, is recurring cost, since cellular operation requires plans from service providers. Assuming these requirements can be met, the cellular features look very good. Throughput for 4G LTE-Advanced tops out at about 1 Gb/s, while 5G promises 10 Gb/s. Of course, this is the maximum amount; in practice, speeds drop based on distance and utilization within a cell.

Power requirements can be an issue, especially for mobile applications with high-speed and continuous-connectivity needs. No doubt, cost comes into play as well, being that prices are typically by the byte.

Other less common networking possibilities exist on both the wired and wireless side, but are worth mentioning. For example, the HomePlug Alliance's Powerline networking uses power connections to power the interface as well as a transmission medium. A host of interoperable products include devices such as wireless access points and bridges to Ethernet.

A variety of development kits and reference designs are available for all of the technologies addressed in this article. For example, QuickLogic's TAG-N module uses Nordic Semiconductor's nRF51822 Bluetooth Smart and ArticLink 3 S2 ultra-low-power smart sensor hub that fits into a smartwatch form factor *(Fig. 4)*. It can perform functions such as tracking gestures and determining location contexts. The module, which links to the QuickLogic Android app for development, also works with Nordic's nRF51822 development kit. ed

Testing Presents Challenges to **Would-be IoT Developers**

It seems so easy to join the IoT bandwagon, but development and certification testing hurdles stand in the way.

This year is considered by many as when the Internet of Things (IoT) comes of age. Judging by the IoT introductions dominating this year's Consumer Electronics Show, it appears the pieces are coming into place.

One would think it would be easy to come up with a novel idea and bring it to market. But how do you know that your design really works? Perhaps more importantly, how do you know that it meets government regulations? In other words, how do you debug the design during development and test it to verify that it meets both industry standards as well as government requirements?

To find out, *Electronic Design* proposed a situation to two test-and-measurement companies. At Tektronix, I emailed Dorine Gurney, the company's product planner for its Source Analyzer Product Line. At Keysight, I dealt with Jan Whitacre, the company's Mainstream Wireless Technology Lead.

Suppose I envision a wearable product for health and fitness: How can I be sure it's going to work in all kinds of RF environments?

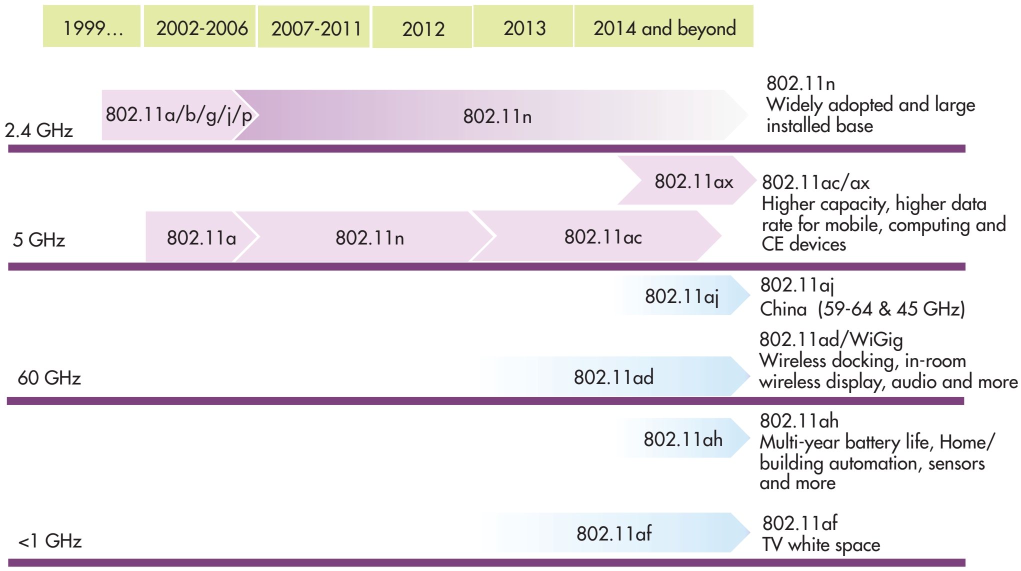
Gurney: This is not easy testing, a lot of companies are struggling with this one, even the RF IC manufacturers. The issues are being able to define multiple possible environments. Typically there will be Wi-Fi in it, but Wi-Fi can come on different channel bandwidths and in different flavors, such as 802.11b used for beacons or for traffic when older Wi-Fi devices (older computer) are expected to be lying around—but also OFDM for the more recent flavors of Wi-Fi (*Tables 1 and 2*). Interference from a microwave oven can also be in the environment, even in a corporate environment.

Another major issue is reflections and fading, because the RF waves will be combining themselves or destroying themselves, so the environment will not be uniform. So the short answer is that you can never be really sure until you test.

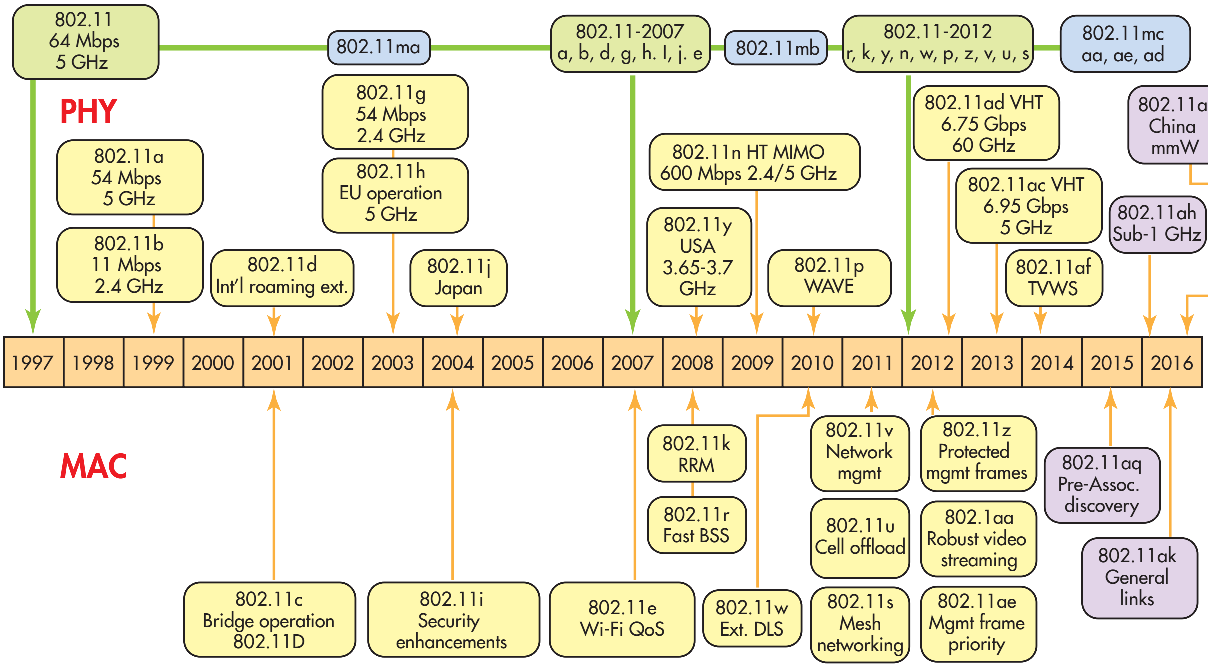
Whitacre: Here is a list of technologies used for medical devices. The first part of the list cites the general technologies used—or you could call them 'off-the-shelf.' The second set comprises dedicated technologies.

General:
- WLAN—802.11 a/b/g/n
- Bluetooth—802.15.1, Low Energy
- Zigbee—802.15.4
- RFID/NFC
- Cellular—HSPA, HPSA+, LTE
- Mobile WiMAX—802.16e

Wi-Fi Evolution Path



IEEE 802.11
Standards, amendments and recommendations



Dedicated medical:
- Inductive coupling implants
- Medical-device radio communication service
- Medical micropower networks
- Medical body area networks (MBANs)
- Wireless medical telemetry (WMTS)

RF areas also need to be tested, such as:
- Coverage range or sensitivity
- Radio spectrum/frequency
- Data rate
- Interoperability
- Power

TABLE 1: WIRELESS TECHNOLOGIES IN MEDICAL DEVICES

Technologies	Major application	Frequency (MHz)	Data rate (kb/s)	Coverage (m)
Inductive-coupling implants	Low-data-rate monitoring / control with implanted devices	Less than 1	30	Less than 1
Medical-device radiocommunication service	High-data-rate communication with implanted/on/near body devices	401-406	250	2-10
Medical micropower networks	Implanted micro stimulators for artificial nervous system	413-419, 426-432, 438-444, 451-457	Various	Less than 1

In all of these, interference—electromagnetic interference/compatibility (EMI/EMC)—is key. EMI presents a risk of patient safety because more and more medical devices on or in patients are frequently used in environments that include broad EMI sources, such as mobile phones, tablets, and both consumer and industrial electronic products.

Beyond 802.11, what are the standards?

Gurney: One of the main requirements for wearables is that they be battery-operated. Even if Bluetooth doesn't consume as much as 802.11n, it still requires more energy than a coin cell or energy-harvesting technology could produce. That leads a designer to Bluetooth Low Energy, because one of the objectives of the standard is that it's able to run off coin cells.

However, if the device requires long-range connectivity, then sub-gigahertz wireless standards are better suited.

What test equipment do I need in order to show I meet these standards?

Gurney: Every standard has different requirements; some don't have any. For Bluetooth design, the Bluetooth SIG provides some detailed explanations at *www.bluetooth.org*.

However, in general, to test compliance at the RF layer would require a spectrum analyzer with some vector-signal-analysis capability, although a few communications standards, such as near-field communications (NFC), might be verified on an oscilloscope.

For the upper layers of the communication stack, protocol analyzers should be used. In some cases, if a reference design is strictly followed and the profiles are not changed, then there is no need to go through the complete qualification process. On the other hand, it may be really hard to verify in a product with a wearable as the form factor, because placement of the antenna will affect the emission of the IoT product compared to the reference design.

Ultimately, the wearable product also must comply with the regulatory requirements of the countries where it will be sold. To prepare for that, we recommend a spectrum analyzer that can test up to the tenth harmonic of the main signal.

Whitacre: Focusing just on test equipment, Keysight's Electromagnetic Professional (EMPro) electromagnetic (EM) simulation software design platform analyzes 3D EM effects on components. Essentially, the software works with the company's test equipment to set up and run analyses using both frequency-domain and time-domain 3D EM simulation technologies, specifically finite element method (FEM) and finite difference time domain (FDTD).

Regarding specific test equipment, spectrum analyzers for transmitter, components, and interference testing, for example Keysight's PXA along with 89600 VSA software with high-performance measurements and 160-MHz bandwidth going all the way to 50 GHz, will cover many testing needs.

Also, the MXA signal analyzers and MXG signal generators provide broad test capability for measuring the transmitter and receivers of the devices with off-the shelf technologies such as WLAN and Zigbee.

TABLE 2: WIRELESS TECHNOLOGIES IN MEDICAL DEVICES—DEDICATED

Technologies	Major application	Frequency (MHz)	Data rate (kb/s)	Coverage (m)
Medical body area networks	PAN for multiple on/near body sensors for patient monitoring; not for implanted sensor	Less than 1	Up to 1000	Less than 1
Wireless medical telemetry	The measurement and recording of physiological parameters and patient information	608-614, 1395-1400, 1427-1429.5	250	Up to 60

And the N9038A MXE EMI receiver for EMI testing provides diagnostic tools for finding the causes of problems. There are also one-box testers such as the EXM for the high-speed manufacturing of these devices.

Oscilloscopes are used to test the high-speed interfaces within the chipsets.

How do I do the testing? Is it the Wild West? Are we now just at some kind of plugfest stage? Or, can we be truly analytical about compatibility?

Gurney: Again, it depends on the standard to be implemented. Bluetooth SIG and Wi-Fi Alliance, for example, are very organized and provide documents that guide you through the process to qualify a part. Actually, Bluetooth suffered bad press for incompatibilities with manufacturers, so they have been trying this process to the extreme.

Ultimately, it depends on the wearable product. (Is it an upgrade from an existing certified product? How much does it differ from a pre-certified reference design that was obtained from the wireless semiconductor supplier?) The new product designer needs to do some internal testing to make sure the new device has a chance to be compliant and then go to one of test houses that have been approved by the Bluetooth SIG or Wi-Fi Alliance.

What about FCC certification?

Gurney: Yes, this needs to be done before being able to sell the final product. In some countries, there are some dispositions in which this certification can be accepted if it has been embedded already and has some modular level certification. Otherwise, certification costs on the order of $1,000 per day. Testing must be performed in an accredited test house, and may take several days.

Could a designer simply use an off-the-shelf RF module?

Gurney: RF module manufacturers are working to get the module smaller and smaller—some of the latest ones are below 100-mm square and designed to be surface-mounted.

It will depend on the wearable, really. A big decision in the design will be the antenna. Tektronix offers a suite of mixed-domain oscilloscopes and signal analyzers that can be equipped with software modules to test various wireless-connectivity approaches used in the Internet of Things.

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Select the Right Varistors for Overvoltage Circuit Protection

Though MOVs are relatively simple devices, choosing the right one requires some knowledge.

Varistors, also called metal-oxide varistors (MOVs), are used to protect sensitive circuits from a variety of overvoltage conditions. Essentially, these voltage-dependent, nonlinear devices have electrical characteristics similar to back-to- back Zener diodes.

Varistors feature high durability, which is essential for withstanding repeated high-peak pulse currents and high-energy surge transients. They also offer a wide voltage range, high energy absorption, and fast response to voltage transients. Peak current ratings range from 20 to 70,000 A, while peak energy ratings range from 0.01 to 10, 000 J.

1. Metal-oxide varistors (MOVs) are available in a variety of form factors and sizes for a broad range of applications. The radial leaded disc type is the most common version.

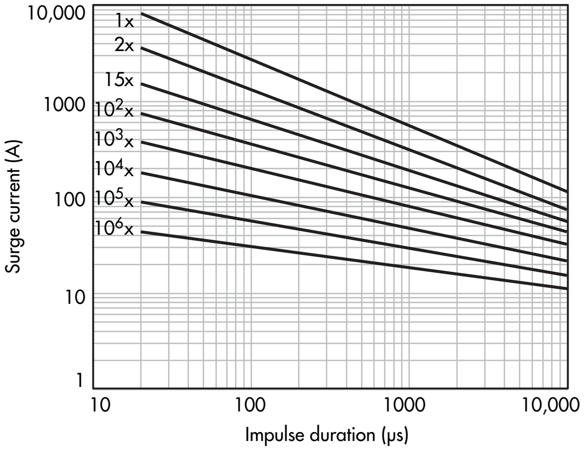
VOLTAGE TRANSIENTS

In this context, "voltage transients" are defined as short-duration surges of electrical energy. In the electrical or electronic circuits that varistors intend to protect, this energy may be released either in a predictable manner via controlled switching actions, or randomly induced into a circuit from external sources. Common sources include:

• *Lightning:* In fact, transients induced by lightning are not the result of a direct strike. A lightning strike creates a magnetic field that can induce large magnitude transients in nearby electrical cables. A cloud-to-cloud strike can affect both overhead and buried cables. The outcome also is unpredictable—a strike that occurs a mile away can generate 70 V in electrical cables, and another can generate 10 kV from 160 yards away.

• *Inductive-load switching:* Generators, motors, relays, and transformers represent typical sources of inductive transients. Switching inductive loads on or off can generate high-energy transients that intensify in magnitude with increasingly heavy loads. When the inductive load is switched off, the collapsing magnetic field converts into electrical energy, which takes the form of a double exponential transient. Depending on the source, these transients can be as large as hundreds of volts and hundreds of amperes, with durations of 400 ms. Due to varying load sizes, there will be variance in wave shape, duration, peak current, and peak voltage of the transients. Once these variables are approximated, circuit designers will be able to select a suitable suppressor type.

• *Electrostatic discharge (ESD):* This energy is the result of an imbalance of positive and negative charges between objects. It's characterized by very fast rise times and very high peak voltages and currents.



2. The MOV's datasheet will provide a pulse-rating curve; this example is for a 20-mm MOV.

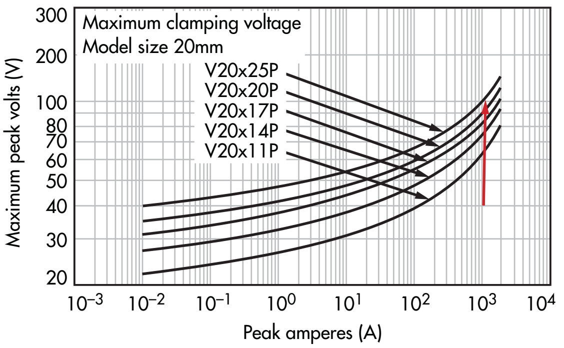
VARISTOR BASICS

Varistors primarily consist of arrays of zinc-oxide (ZnO) balls, in which the ZnO was altered with small amounts of other metal oxides such as bismuth, cobalt, or manganese. In the MOV manufacturing process, these balls are sintered (fused) into a ceramic semiconductor. This produces a crystalline microstructure that allows these devices to dissipate very high levels of transient energy across their entire bulk. After sintering, the surface is metallized, and leads are attached via soldering.

Thanks to the MOVs' high energy dissipation, they can be used to suppress lightning and other high-energy transients found in ac power-line applications. They're equipped to withstand large amounts of energy and divert this potentially destructive energy away from sensitive electronics located downstream. MOVs, which are also used in dc circuits, come in a variety of form factors *(Fig. 1)*.

MULTILAYER VARISTORS

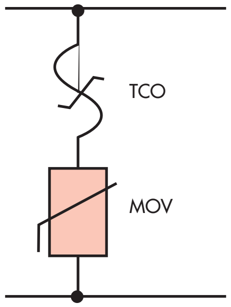
Multilayer varistors (MLVs) address a specific part of the transient-voltage spectrum: the circuit-board environment. Although lower in energy, transients from ESD, inductive load



3. An MOV datasheet will also feature a voltage-versus-current curve, such as this maximum clamping-voltage curve for the 20-mm device in Fig. 2.

switching, and even lightning-surge remnants might otherwise reach sensitive integrated circuits on the board. MLVs are also made of ZnO materials, but they're fabricated with interwoven layers of metal electrodes and produced in leadless ceramic packages. They're designed to transition from a high-impedance state to a conduction state when subjected to voltages that exceed their nominal voltage rating.

MLVs come in various chip form sizes, and are capable of dissipating significant surge energy for their size. Thus, they suit both data-line and power-supply transient-suppression applications.



4. A thermal disconnect can open a circuit, preventing a catastrophic failure of a degraded MOV.

APPLICATION GUIDELINES

When choosing an appropriate MOV for a specific overvoltage-protection application, the circuit designer must first determine the operating parameters of the circuit being protected, including:

- Circuit conditions such as the peak voltage and current during the surge event
- The MOV continuous operating voltage (should be at 20% above maximum system voltage under normal conditions)
- The number of surges the MOV must survive
- Acceptable let-through voltage for the protected circuit
- Any safety standards with which the circuit must comply

For the sake of simplicity in this example, assume the objective is to select a low-voltage dc disc MOV for the following circuit conditions and requirements:

- A 24-V dc circuit
- Current waveform for surge is 8 × 20 µs; voltage waveform is 1.2 × 50 µs (these are typical industry-standard waveforms)
- Peak current during the surge = 1000 A
- The MOV must be able to survive 40 surges
- Other circuit components (control IC, etc.) must be rated to withstand 300 V maximum

Step 1: To find the voltage rating of the MOV, allow for 20% headroom to account for voltage swell and power-supply tolerances: 24 V dc × 1.2 = 28.8 V dc. Given that no varistors have a voltage rating of exactly 28.8 V, check the datasheets for specifications for 31-V dc MOVs.

Step 2: To determine which MOV disc size to use, first identify the MOV series that minimally meet the 1000-A surge requirement. Inspecting the table suggests a 20-mm MOV with

DESIGN NOTES

Monolithic Linear Battery Charger Operates from Inputs Up to 60V

Design Note 535

Joshua Yee

Introduction

For charging relatively low capacity batteries, or maintenance charging backup and keep-alive batteries, linear topology battery chargers are valued for their compact footprints, simplicity and affordability. Even so, there is a dearth of linear chargers that accept a 10V or higher input voltage, leaving many industrial and automotive systems underserved.

Some switch mode solutions can accept high input voltages and switching topologies offer current and efficiency advantages, but they also incur significant costs in complexity and solution footprint. In the end, a switch mode solution is usually overkill for the low currents necessary in keep-alive systems or backup battery chargers. Furthermore, few are suitable for automotive and industrial applications up to 60V.

LTC®4079 is a wide input range standalone charger that can be powered by any DC source from 2.7V up to 60V, enabling CC/CV charging directly from 12V and 24V DC system rails, or even 48V industrial supplies. Its marriage of simplicity and robustness allow it to easily satisfy the charging needs of keep-alive systems or backup battery solutions in these environments. Figure 1 is an example of a simple Li-Ion battery charger.

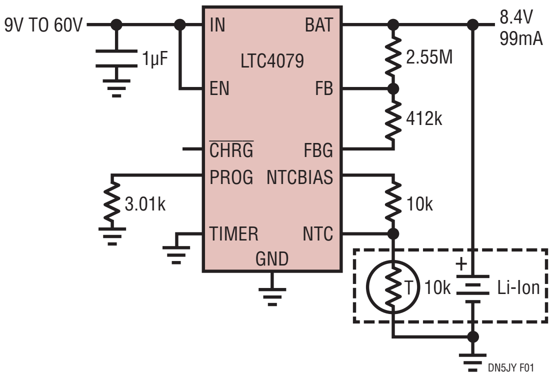


Figure 1. Wide Range Linear Standalone Charger for 2-Cell Li-Ion Backup Battery

Fortitude and Flexibility, Neatly Packaged

The LTC4079's charge voltage is resistor programmable, matching the flexibility of its wide input voltage range for practical purposes. The circuit is stable across the entire input voltage range with minimal input and output capacitance.

Using a single resistor on the PROG pin, charge current is programmable up to 250mA and can be monitored in proportion to the PROG voltage. Charge termination functionality is familiar: timer-based, programmed via TIMER pin capacitance, or, C/10 current detection by connecting the TIMER pin to ground. $\overline{\text{CHRG}}$ status signals termination by either method. The timer capacitor is also used for bad-battery detection.

Temperature-qualified charging can be implemented via the NTC and NTCBIAS sensing network to round out the full charger circuit. The LTC4079's thermally enhanced 3mm × 3mm DFN package includes an internal pass element, producing a compact and comprehensive solution. The complete circuit featured in Figure 2 shows its compact footprint.

Innovative Regulation for Utility and Facility

The LTC4079 includes a number of enhancements over conventional chargers with several distinctive charge current regulation methods. First, for wide range, but current-limited or high impedance sources, the input voltage can be regulated to at least 160mV above the battery voltage ($V_{IN(MIN)} \geq V_{BAT} + 160mV$). Charge current is reduced to prevent the input voltage from collapsing below this value, maximizing charge current. No external components are required to exploit this internal regulation scheme. Figure 3 shows an example of temperature-compensated float charging a 12V sealed lead acid battery stack from a solar panel, though any combination of input and battery voltages are possible.

The LTC4079's differential voltage regulation is particularly useful when very low power sources such as energy harvesters or small solar panels cannot continuously provide the minimum 10mA charge current. Instead of the somewhat arbitrary halt to charging in the face of an undervoltage lockout (UVLO), this feature allows charging to continue whenever possible—a more efficient use of available input power.

For a more specific input voltage regulation setpoint, the enable input pin, EN, can servo to a resistor divider. As the input voltage reaches this setpoint, the charge current is reduced to prevent loading the source any further. In this manner, the enable input can be used to set a minimum operating voltage for a given source.

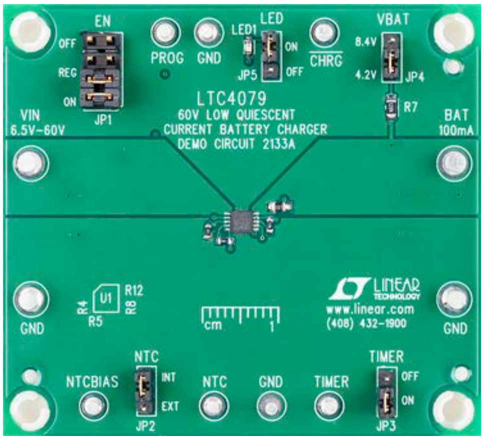


Figure 2. Complete Demo Board Circuit Footprint Shown Actual Size

The final current regulation method—thermal regulation—is important for a monolithic device in general, but should be mandatory for a linear regulator. This is especially useful in harsher ambient environments and for high V_{IN}/V_{BAT} ratios, where the charge voltage is much lower than the nominal input voltage. Charge current is reduced until the IC junction temperature is reduced below 118°C. See Figure 3 for an example circuit with input voltage regulation that prevents weak input sources from being overloaded.

Low Quiescent Current Draw

When charging, the LTC4079 consumes only 4µA, maximizing energy transfer from the source to the battery. This is particularly important when transferring energy from a higher capacity battery to a smaller backup battery. In battery backup systems, the voltage feedback divider is taken out of the circuit to further unload the battery, reducing shutdown current to 10nA (typical) and ensuring that capacity is not unexpectedly degraded in long-term standby or storage of the entire battery system. This makes the LTC4079 especially suited for low or zero-maintenance set-and-forget designs with embedded charging capability.

Summary

The LTC4079's compact and comprehensive design is ideal for maintenance and keep-alive battery charging solutions, but it is not limited to these applications. Its rich feature set makes it easily adaptable to any number of charging roles in industrial, automotive, solar, medical, military/aerospace and consumer electronics.

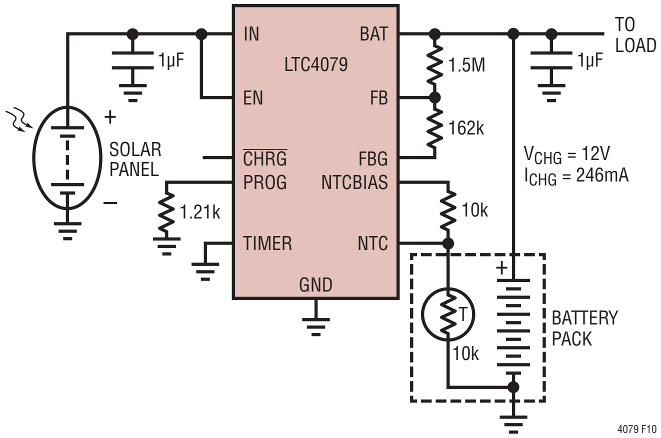


Figure 3. Prevent Weak Sources from Being Overloaded with Input Voltage Regulation

Data Sheet Download

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a 31-V dc maximum continuous voltage rating (part number V20E25P) as a possible solution to meet the requirements.

Step 3: Use the pulse-rating curves *(Fig. 2)* in the same datasheet to determine pulse capabilities relative to the 40 pulses at the 1000-A requirement.

Step 4: Use the V-I curve *(Fig. 3)* in the MOV's datasheet to verify that leak voltage will be less than the 300-V ceiling.

Typically, drivers are rated to handle surges in the range of 1 to 4 kV. The varistor, ranging from 7 to 14 mm in diameter, is usually located downstream of the fuse on the ac mains. However, to provide higher-level surge immunity for lighting installed outdoors in exposed surge environments, outdoor-lighting OEMs may want to add surge-protection devices (SPDs) on the ac input lines of their luminaires ahead of the LED driver.

PROTECTING MOVs AGAINST THERMAL RUNAWAY

The varistor's absorption of the transient energy during a surge event produces localized heating within the component, which eventually leads to its degradation. If left unprotected, the degradation of a varistor can increase heating and thermal runaway. As such, a growing number of varistor-based surge-protection devices offer a built-in thermal disconnect function. It provides added protection from catastrophic failures and fire hazards, even under extreme circumstances of varistor end-of-life or sustained overvoltage.

MOVs are rated for specific ac-line operating voltages. Exceeding these limits by applying a sustained abnormal overvoltage condition could result in overheating and damage to the MOV.

MOVs tend to degrade gradually after a large surge or multiple small surges. This degradation leads to increasing MOV leakage current; in turn, this raises the MOV's temperature, even under normal conditions such as a 120-V ac or 240-V ac operating voltage. A thermal disconnect adjacent to the MOV *(Fig. 4)* can be used to sense the increase in MOV temperature while it continues to degrade to its end-of-life condition. At this point, the thermal disconnect will open the circuit, removing the degraded MOV from the circuit and thus preventing potential catastrophic failure.

LED DRIVERS AND LIGHTNING

Generally, most LED power supplies are a constant-current type, and are often referred to as LED drivers. These can be purchased as off-the-shelf assemblies containing MOVs to meet lower-level surge requirements.

MOV DESIGN EXAMPLE: INDUSTRIAL MOTORS

One aspect of ac motor protection is the surge-withstand capability of the motor itself. Paragraph 20.36.4 of the NEMA motor generator standard MG-1 defines a unit value of surge as:

$$u \times V_{L\text{-}L} \text{ (or } 0.816 \times V_{L\text{-}L}\text{)}$$

where VL-L is the line-to-line voltage of the ac power system.

For transient rise times of 0.1 to 0.2 µs, twice the unit value of surge capability is required on stator windings. When rise times reach 1.2 µs or greater, 4.5 times the unit value is stipulated. In the case of external transients such as lightning, this would equate to a surge voltage capability of 918 V_{PEAK} for a 230-V motor (full load current = 12 A) on a 250-V high-line condition. (Lightning surges can exceed these values, so stator windings would also need a suppression element for protection.)

Taking high-line tolerance into account, a 275-V ac-rated MOV may be chosen for this example. Using a 2-hp, single-phase, medium-sized motor, the MOV's required surge-current rating would be determined by the peak current induced at the motor supply. Assuming a service location for the motor and a line impedance of 2 Ω, it was determined that a 3-kA lightning surge was possible.

In this case, one datasheet indicates a maximum clamping voltage of 3 kA at 900 V, which is below the 918-V suggested stator-winding withstand capability. If the motor's operational life were estimated to be 20 years and specified as being able to withstand 80 lightning transients during term of service, the datasheet pulse-rating curves would verify a rating of 100+ surges.

Operating temperatures are another consideration. Assume the ambient operating temperature for this application ranged from 0 to +70°C. This would be within the MOV's -40 to +85°C rating, and there would be no requirement for derating of surge current or energy across this temperature range.

For a more detailed explanation of how to match MOVs to applications, check out the "DC Application Varistor Design Guide" at *www.littelfuse.com/~/media/electronics/design_guides/varistors/littelfuse_varistor_dc_application_varistor_design_guide.pdf.pdf.* ed

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Sensors Drive Mobile IoT

Much of the Internet of Things (IoT) is mobile, and compact MEMS sensors provide much of the status information for these devices.

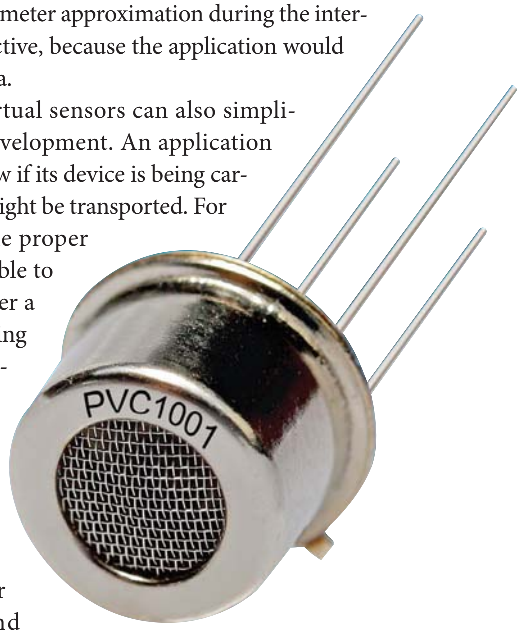
MUCH OF THE INTERNET OF THINGS (IoT) is mobile, and compact sensors play a key role in delivering status information for these connected devices. They range from tiny microelectromechanical-systems (MEMS) accelerometers to high-resolution cameras to time-of-flight (ToF) 3D imaging *(see "Time-Of-Flight 3D Coming To A Device Near You" on electronicdesign.com)*. These devices are common fare on smartphones and tablets.

Sensors often determine information indirectly through measurable changes that are affected by the data desired. For example, Posifa Microsystems' PVC 1000 MEMS vacuum sensor *(see the figure)* is designed to measure pressure *(see "MEMS Vacuum Sensors Offer Ultra Low Power Consumption" on electronicdesign.com)*. It does so by looking at minute changes in resistance to a heated element—a thin-film, platinum resistor on a thermal insulating membrane. The membrane is suspended over a 25-µm-deep micromachined cavity. The bottom surface runs parallel to the membrane to ensure precision measurement of heat transfer. The volume of gas within the cavity is minuscule, allowing the sensor to have a fast response time (under 5 ms) while using little power (under 5 mW). It can measure from 10 millitorr to 30 torr. The sensor suits applications such as leak detection, vacuum packing systems, and portable digital vacuum gauges.

Crucial to today's myriad sensors is sensor-fusion technology. It can integrate information from a set of disparate devices *(see "Q&A: Freescale's Ian Chen Discusses Sensor Fusion" on electronicdesign.com)*. As a result, sensor-fusion platforms are able to provide virtual sensors (*see "Understanding Virtual Sensors: From Sensor Fusion To Context-Aware Applications" on electronicdesign.com)* based on information derived from different but related sensors.

For example, accelerometers and gyroscopes are different devices, but both will provide useful contextual information. In some instances, the power requirements for accelerometers are lower than gyroscopes. For mobile applications that need to minimize power consumption, it would be useful to use only the accelerometer whenever possible. It's possible to extrapolate gyro information from an accelerometer, although the data will not be as accurate as that from a gyroscope sensor. This may be sufficient for many applications. Likewise, the startup time for the gyro may be slower than the accelerometer. Therefore, using the accelerometer approximation during the interim would be effective, because the application would have available data.

Contextual virtual sensors can also simplify application development. An application might like to know if its device is being carried and how it might be transported. For example, with the proper sensors, it's possible to determine whether a device is in a moving car, train, or elevator. Similarly, they could indicate that a device is within a pocket or on a table.



Posifa Microsystems' PVC 1000 MEMS vacuum sensor measures minute changes in resistance to a heated element.

On another front, sensor and microcontroller integration can help simplify system design. The Kionix KX23H combines a 3-axis accelerometer with a Cortex-M0 microcontroller in a 3- by 3- by 0.9-mm package *(see "Sensor Hub Combines 3-Axis Accelerometer And Cortex-M0 MCU" on electronicdesign.com)*. The on-chip software could let a host processor know the movements experienced by a device, such as walking or riding in a train. The hub can also process inputs from external devices like gyroscopes, magnetometers, and pressure sensors.

These types of sensor hubs are ideal for mobile devices that enable the host processor to power down in order to minimize power consumption. However, it only starts when a significant event takes place. ed

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VICTORIA FRAZA KICKHAM | DISTRIBUTION EDITOR victoria.kickham@penton.com FEBRUARY 2015

The IoT Promise

The Internet of Things market spells opportunity for distributors of electronic components, but the real payoff may come from driving demand for new products and answering key questions about safety and security.

VICTORIA FRAZA KICKHAM | DISTRIBUTION EDITOR

GET CONNECTED: THE phrase is everywhere. Go to any industry conference or attend a new product launch, and chances are you will hear all about the benefits of connecting products and systems to the Internet and its potential to change life as we know it. From your kitchen to the factory floor, it seems that enterprising minds can see the potential for simplifying our lives by implementing systems that can anticipate our needs and save us precious time—all by connecting to a World Wide Web that allows us to store, access, and share information.

Continued on Page 38

Image courtesy of Thinkstock

Semiconductor Market Grows; Distributors Reap Benefits

Following its best performance in recent years, global semiconductor market boosts sales for leading distributors.

A CULTURE OF innovation and demand for new products is spurring growth across the electronics supply chain: Last year, the global market for semiconductors saw its best year since 2010. The trend is helping boost sales for some of the industry's top distributors of electronic components, especially those aimed at fulfilling demand for innovative designs for a wide range of applications.

Global semiconductor market revenue was expected to grow more than 9% in 2014, marking the industry's best performance since its 33% growth in 2010, according to a report from IHS Technology released late last year. The researcher estimated that global revenue would reach $353.2 billion, up from $322.8 billion in 2013. The strong performance followed solid growth of 6.4% in 2013, a decline of more than 2% in 2012, and 1% growth in 2011.

"This is the healthiest the semiconductor business has been in many years, not only in light of the overall growth, but also because of the broad-based nature of the market expansion," said Dale Ford, vice president and chief analyst at IHS Technology. "While the upswing in 2013 was almost entirely driven by growth in a few specific memory segments, the rise in 2014 is built on a widespread increase in demand for a variety of different types of chips."

"This year, we experienced an innovation-fueled demand for emerging technologies to support the development of new applications," Chris Beeson, executive vice president of sales and supplier management, Digi-Key Corp.

More than half of the industry's sub-segments was expected to grow by 5% or more in 2014, Ford explained. When added to the ongoing strong performance of key sub-segments such as dynamic random access memory (DRAM) and light-emitting diodes (LEDs), the result is a stronger overall outlook. DRAM was expected to climb 33% for the second straight year, and LEDs were expected to grow by 11%.

"This pervasive growth is delivering general benefits to semiconductor suppliers, with 70 percent of chipmakers expected to enjoy revenue growth this year, up from 53 percent in 2013," according to IHS. The report followed positive news from the electronic components supply chain last fall, when manufacturers and distributors met for the annual Executive Conference of the Electronic Components Industry Association. Economists and electronics industry experts gathered for the event predicted a solid outlook for 2015, pointing to industrial markets, wearable electronics, and the Internet of Things as key growth drivers. Ford, who made a presentation at the event, said industrial markets present the strongest opportunity in 2015.

Electronic components distributor Digi-Key Corp. echoed those sentiments recently when it announced double-digit growth in 2014 and forecast another good year ahead for 2015, driven by innovation and growing demand for electronics across the board. "This year, we experienced an innovation-fueled demand for emerging technologies to support the development of new applications," said Chris Beeson, the firm's executive vice president of sales and supplier management. "A spike in new product introduction (NPI) activity lends itself extremely well to our model, which is ideal for fast-turn production runs and high-mix, low-volume orders."

The distributor cited the growing Internet of Things (IoT) market and the desire to "connect" more systems and solutions wirelessly across a wide range of end markets as keys to the strong performance. The company also cited demand for its engineer-centric, fast, and efficient distribution model. Advances in wireless, embedded, single-board computers, sensors, motion control, and cloud-enabled applications in particular helped spur growth during the year.

"It's an extraordinary time of growth in this industry," said Dave Doherty, Digi-Key's executive vice president of operations. "Particularly here in North America, we're seeing a combination of market trends driving innovative new products that will literally change how we work and play. Along with breakthrough wireless and embedded technologies, the cost of components continues to drop, high-value EDA [electronic design automation] tools are now affordable, and other game-changers like open source software and crowdfunding resources are breaking down the walls for the design engineer."

The IoT Promise

Continued from Page 37

But despite the promise of the Internet of Things market—or as it is variably called, "the Internet of Everything" and even "the Internet of Stuff"—questions linger surrounding its potential as a game-changer for the electronics supply chain. In the near-term, for one thing, IoT has a way to go before it is a household word. It remains largely the domain of engineers, technology companies, electronics manufacturers, and the like. That means the supply chain has work to do to impress upon the general public their need for IoT solutions, some industry watchers say. Then there are the issues of privacy and security. With the sharing of so much information comes the potential for a backlash against how open our lives have become.

"I think the Internet of Things debate needs to be framed in wider terms," says Christian DeFeo, e-supplier manager for electronics distributor element14. He points to the data available simply by talking on your smartphone—it tells where you are, what the temperature is in the room, and other seemingly benign facts, for example. "It used to be that people felt secure about this. But big data allows analysis of this information … As a society, we haven't had a debate about what constitutes security and privacy [in this new era]."

DeFeo and others argue that the promise of the IoT market will depend largely on how well companies work together to make sound decisions about how to best use the technology. Distributors and their channel partners play a key role in this process by helping customers filter through the many new products available, along with their technological capabilities and applications.

DeFeo points to the element14 online community—a forum that consists of upwards of 280,000 engineers worldwide—as one way to do this. In addition to being a forum to discuss ideas, issues, and challenges, the community also offers webinars and design challenges aimed at helping design engineers and others discover the newest and best ways to implement IoT technology. He also notes that partnerships with technology company Cisco and The Eclipse Foundation, a non-profit organization that promotes development of open-source software, will benefit the industry as a whole down the road.

"As a responsible and forward-thinking distributor, we want to give people as much information as possible so they make the best possible decisions," DeFeo says. "We will continue to work with our community of engineers to get them to think about these issues in ways that will help [promote] reasonable decision-making and secure applications development."

BUILDING MOMENTUM

For Robin Gray, chief operating officer and general counsel of the Electronic Components Industry Association, there is still a ways to go before widespread adoption of IoT solutions takes hold and, consequently, before it takes off for the electronics supply chain. ECIA devoted its most recent industry conference to the "Living Connected" theme, examining the influence of IoT, the Cloud, smart devices, and wearable technology.

"We've talked about the Internet of Things over the past years, but I don't think that concept has really crossed into the broad public's awareness," says Robin Gray, chief operating officer and general counsel, ECIA.

"We've talked about the Internet of Things over the past years, but I don't think that concept has really crossed into the broad public's awareness," Gray says, pointing to the need for industry to answer the "why" about this new technology and create demand for new products. "There is this gap between what the industry knows about what's happening and what's going to happen, and what public awareness is."

Wearable technology and a heightened demand for sensors is a more immediate and growing trend, he adds.

"I think wearable technology is a bigger thing—and some think of it as a subset of IoT," Gray explains, pointing to demand for monitors and sensors needed for such products.

Distributors are most concerned about the components designers demand for their newest products, and Gray says if ECIA's conference was any indication, sensors are it today. Indeed, demand for sensors is expected to rise significantly over the next several years. Industry expert Dr. Janus Bryzek told ECIA conference attendees that sensors for wearable devices alone grew by more than 200% from 2007 to 2012. What's more, industry analyst IHS Technology has predicted that sensor sales will rise more sharply than device sales themselves over the next five years. IHS also said in a report late last year that the average wearable device shipped in 2019 will incorporate an average 4.1 sensors, up from an average of 1.4 sensors in 2013.

"If I was in the audience and I was a distributor, I'd make sure I was getting into or expanding my sensor lines," Gray says. "That was definitely the takeaway."

Some would argue that making the leap from sensors and wearables to larger "connected" systems such as factories and transportation systems is not so far off. Element14's DeFeo agrees that the connected marketplace—and the IoT in particular—holds great promise for the electronics supply chain.

"For distributors like ourselves it's an enormous opportunity," he says, pointing to industry estimates that peg the market in the trillions of dollars. "The way that you're going to get there is by embedding electronics into a lot more things than they are in today. That's a lot of silicon. That's a lot of boards. It's a lot of kits and development boards."

SAFETY AND SECURITY

But there is work to do before the IoT opportunity is fully realized, and DeFeo points to safety and security as two key hurdles. The pervasiveness of Internet technology and the accompanying openness the public is susceptible to because of it could just as easily become a turn-off. Consumers, especially, could end up opting for simpler, less invasive devices.

"There are good, solid economic reasons to adopt [this technology], but if enough people feel like they're sharing too much, the momentum will stall and stop," DeFeo says. If the creators of Internet-enabled products and systems aren't careful about making the right decisions, De Feo says the technology could "founder on the rocks of people's objections."

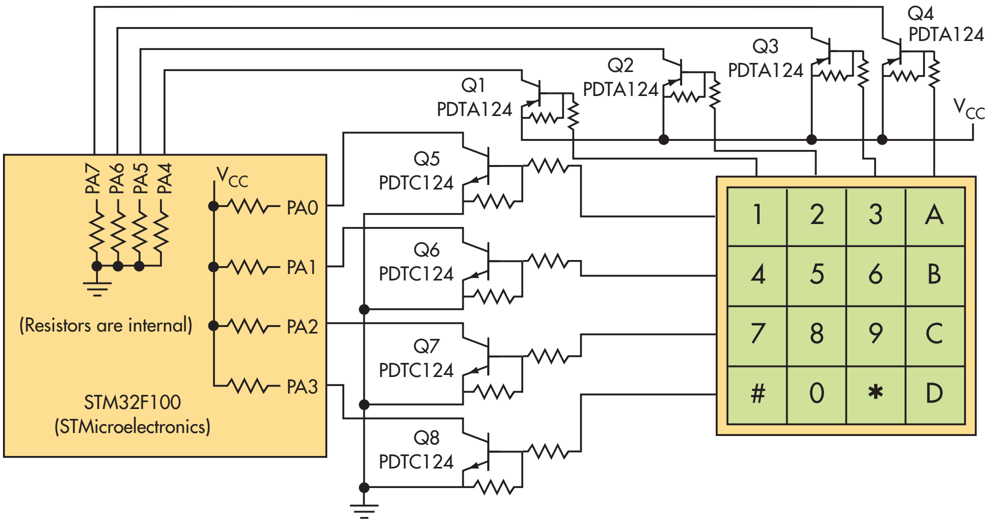
And that's because the IoT, in particular, is less about sensors and other components connecting machines to one another than it is about better, more efficient decision-making, DeFeo says. He uses a small design engineer in Europe as a case in point. The designer created an alarm clock that ties into the Belgian railway system timetable to wake users according to when they need to arrive at their destination—rather than waking them to a specific, pre-set time on the clock.

On a larger scale, such technology can be used to streamline supply chains and make more efficient use of raw materials that go into factories, for example. Despite the considerable talk about smart thermostats, refrigerators, and entertainment systems, there is much more to this technology revolution than home automation, DeFeo argues. He points to an element14 design challenge, in conjunction with Cisco, to develop IoT-enabled pollution sensors, as another example.

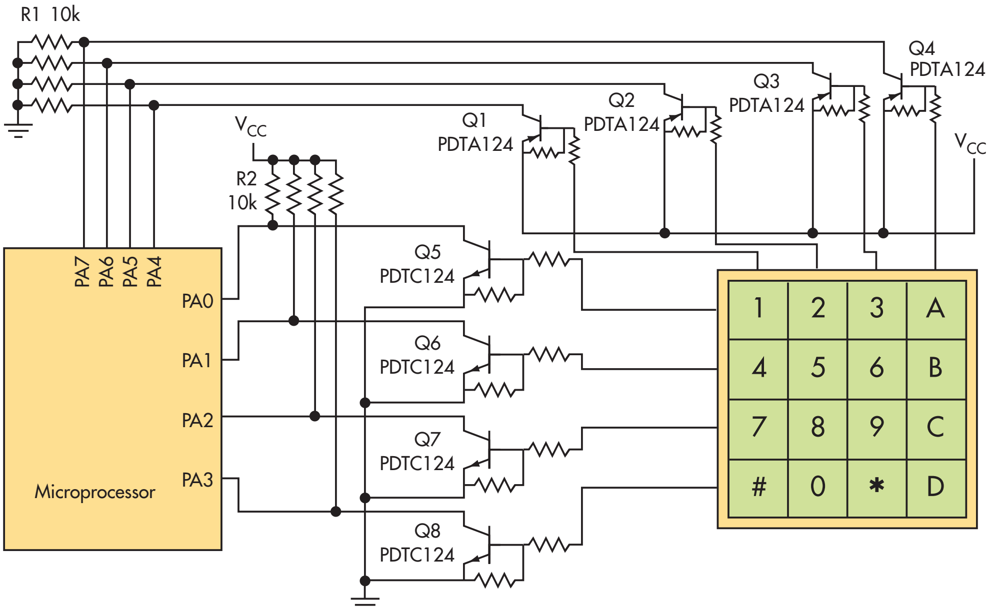
"There is a wider implication for the economy in terms of energy usage, industrial production, and so on," DeFeo says. "Home automation is just the start." ■

Basic Circuit Eliminates Numeric Keypad Polling

RICK MALLY | INDEPENDENT DESIGNS LLC IndependentDesignsLLC.com



1. To simplify decoding of a 4 × 4 keypad matrix, an 8-bit port was configured as inputs using internal pull-up and pull-down resistors.



2. This alternate to *Fig. 1* uses external pull-up and pull-down resistor arrays.

USING EIGHT DIGITAL inputs, this circuit simplifies decoding of the common membrane 4 × 4 keypad matrix and eliminates the traditional requirement of scanning rows or columns. Any X-Y switch matrix, which can be part of some apparatus, can be considered with this device.

The design uses eight pre-biased transistors—four NPN and four PNP. When depressing a given switch, two transistors will turn on via the current through their internal biasing networks, providing a unique signature code that can be recognized and decoded. The generated code, which will be unique for each key, is readable with a simple 8-bit input statement. By enabling a pin-change interrupt on all eight inputs, the keyboard decode program can be entirely interrupt-driven.

The eight lines could also be connected to a shift register, thereby only requiring two to three digital I/O lines for the microprocessor to shift out and read the result.

In the simplest setup, an 8-bit port is configured as inputs, with internal pull-up resistors on bits 0-3 and internal pull-down resistors on bits 4-7 *(Fig. 1)*. This is possible with several microprocessors, including STMicroelectronics' STM32F100. In fact, this circuit was prototyped with the STM32F100, and wound up delivering excellent results.

The design in *Figure 2* employs external pull-up and pull-down resistors. The best solution implements two resistor arrays, such as the widely available four-element surface-mount types—they're compact, inexpensive, and add only two components to the circuit board. For most pull-up and pull-down applications, 10 kΩ will suffice.

Of course, several combinations are possible when simultaneously pressing two keys, also leading to the generation of unique codes. This scenario works as well—any combination in which the two keys don't share a common row or column can be decoded.

RICK MALLY, sole proprietor of Independent Designs, a small-scale custom electronic design and prototyping firm for clients with a limited budget, was home-schooled and self-educated in the electronics field.

Build A Simple Precision Pink-Noise Generator

DENNIS SEGUINE | CYPRESS SEMICONDUCTOR CORP. seg@cypress.com

WHITE NOISE GENERATORS commonly are used for testing purposes such as setting the noise level in bit error rate (BER) measurements, providing broadband signals for vibration analysis, and performing rapid filter-performance evaluation using fast Fourier transforms (FFTs), among other applications.

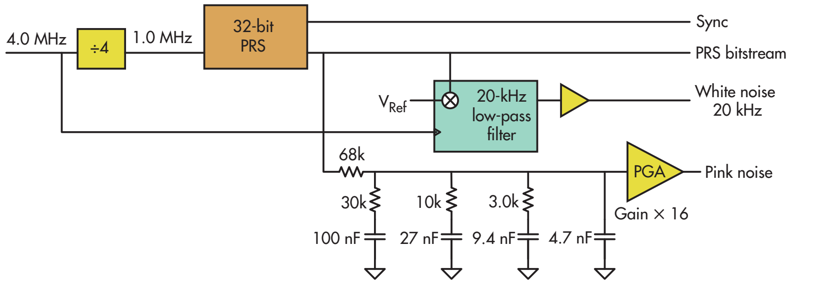
Audio applications that use noise sources such as background noise or room balancing in a public address system are more likely to use "pink" noise. Pink noise is characterized by each octave having the same amount of power, so the range from 100 to 200 Hz has the same power as the range from 1.0 to 2.0 kHz or 10 to 20 kHz.

The pink noise source shown here is based on a pseudorandom sequence (PRS) generator, much like the white-noise source in an earlier article, "Well-Controlled Audio-Band Noise Source Uses Basic Microcontroller Filtering."[1]

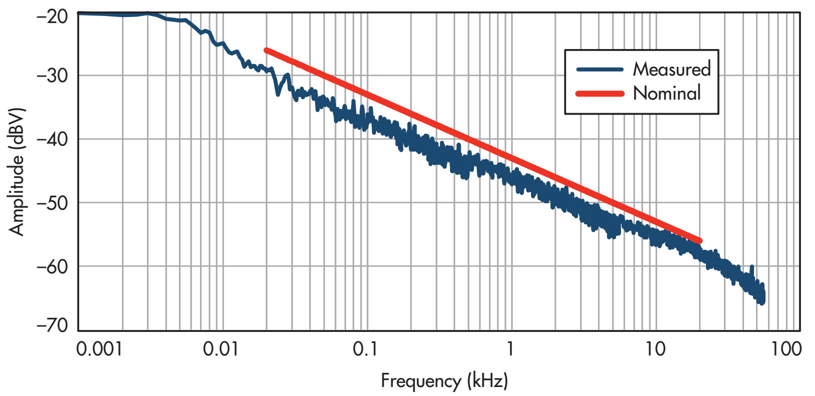
The white-noise output is random (i.e., uniform in frequency and Gaussian in amplitude) if the noise is filtered at a point less than 5% of the PRS clock frequency. A pink-noise generator for the audio band (20 Hz to 20 kHz) meets the randomness requirement and reshapes the frequency content of the analog output.

The frequency characteristic of pink noise falls off at a rate of 3 dB per octave or 10 dB per decade. This is half of the rate of a single-pole low-pass filter. The filter circuit is a little more complex than a simple RC filter. Numerous examples of pink-noise filters can be found using a Google search. The one used here is adapted from the *1976 National Semiconductor Audio Handbook* (long out of print but often reproduced).

The values were adjusted to provide closer-to-nominal performance at the upper end and to increase the load impedance of the filter to the digital output. The complete schematic, implemented using a Cypress CY8C24423 plus a few external parts, provides both white- and pink-noise sources *(Fig. 1)*. The code is limited to setting the polynomial value of the PRS plus a few start commands.



1. The PRS-based circuit provides both white- and pink-noise outputs over the audio band. It is an enhancement of a previously published white-noise-only design.



2. The pink-noise output amplitude versus frequency is within 1 dB of the ideal –3-dB/octave slope over the standard audio band.

The PRS length was increased compared to the earlier white-noise design so the sequence's repeat length is longer than the bandwidth of my spectrum analyzer. Any sequence 24 bits or longer would be suitable for audio applications. The output of the 3-dB/octave filter appears quite small (on an oscilloscope), so a programmable gain amplifier (PGA) was added with 24-dB gain. The PGA output also provides a buffer capable of driving a 32-Ω load.

The output follows the nominal –3-dB/octave slope to within 1.0 dB from 20 Hz to 20 kHz. If attenuation of the signal below 20 Hz is required, a 10-Hz, single-pole, high-pass filter at the input to the PGA is sufficient. If attenuation of the signal above 20 kHz is required, the output of the PGA can be rerouted to the input of the band-pass filter. This is just a matter of selecting a different filter input in the Cypress PSoC Designer development tool.

Reference

"Well-Controlled Audio-Band Noise Source Uses Basic Microcontroller Filtering," Dennis Seguine, http://electronicdesign.com/digital-ics/well-controlled-audio-band-noise-source-uses-basic-microcontroller-filtering

DENNIS SEGUINE is a member of the technical staff at Cypress Semiconductor Corp. He has been an applications engineer for Cypress Semiconductor since 2000, following many years of analog, embedded system, and software design for the underwater, instrumentation, and medical industries.

Op Amps Build Simple Multiphase Signal Generator

PETRE TZVETANOV PETROV | MICRO-ENGINEERING ptzvp1@yahoo.fr

A FIXED-FREQUENCY SIGNAL generator that can produce outputs simultaneously at multiple phases such as 45°, 90°, 135°, and 180° is sometimes needed for testing multi-channel analog-to-digital converters (ADCs), analog filters, sample/hold circuits, and analog multiplexers.

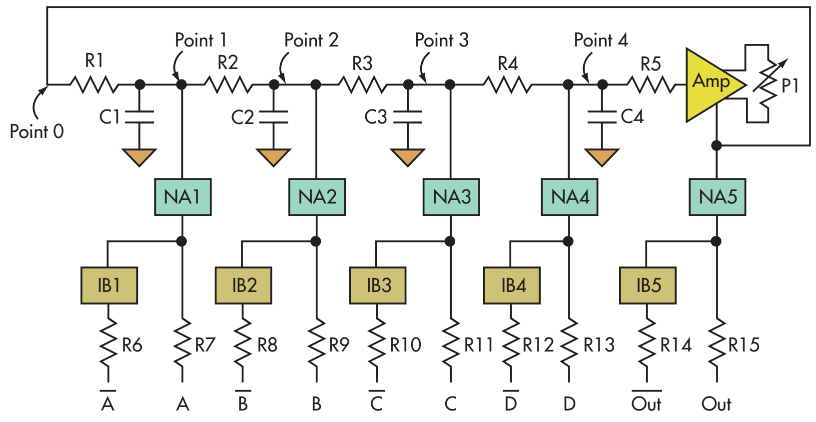
In one fixed multiphase sine-wave generator, the frequency is set by equal-value resistors R1 through R4 and capacitors C1 through C4. (Tolerance of at least ±1% is recommended.) The amplifier maintains the oscillations at stable level. Trimmer potentiometer P1 is used to adjust the oscillations for maximum stable level *(Fig. 1)*.

The phase difference between Point 0 and Point 4 is ideally 180° because the amplifier is configured as an inverting amplifier. The difference between Point 1 and Point 4 is also 180° but divided into four equal parts, so the relative phase difference between each successive signal is 45°.

Outputs 1 through 4 should not be used directly, because any unbuffered load may affect or even halt oscillation. The buffers should also be used to adjust and equalize the signal levels. NA1, NA2, NA3, NA4, and NA5 are non-inverting buffer amplifiers. IB1, IB2, IB3, IB4, and IB5 are the corresponding inverting buffer amplifiers. The gain of each stage is set to –1 to produce the same signal levels at all inverting outputs, so the pair of outputs has the same amplitude but with a phase difference of 180°.

Built around IC1a and IC1b, the circuit of *Fig.p 2* provides eight sinusoidal signals at a fixed frequency, with a phase difference of 45° between each successive output over the entire 360° cycle. It uses three quad op amps (TL084) or six dual devices (TL082) operating from ±15-V supplies ($\pm V_{EE}$), but other op amps and supply rails can be used.

IC1a is a buffer-follower that allows high-value resistors and low-value



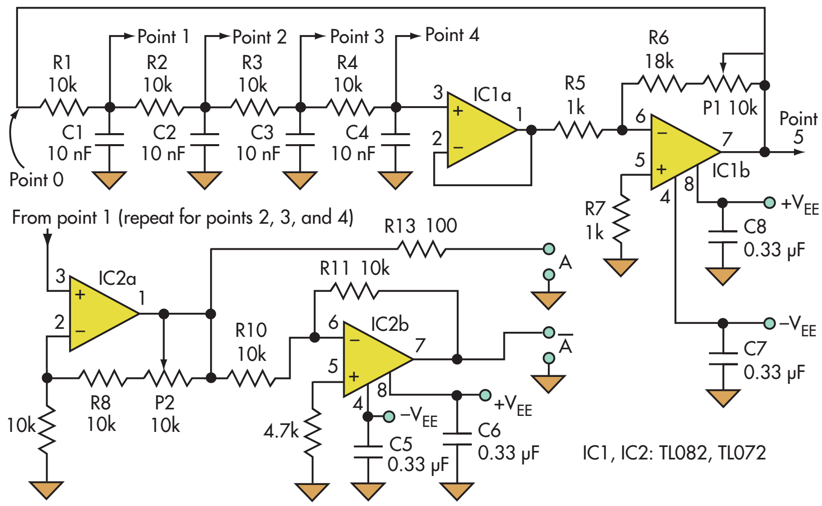
1. The fixed-frequency, fixed-multiphase generator uses repetitive blocks to provide stepped phase differences relative to the original waveform.

capacitors to be used. IC1b is an inverting amplifier with gain adjusted via trimmer potentiometer P1, set for maximum stable amplitude at the generator output. With the values shown, the output frequency is about 2 kHz, but it can be set to any appropriate value with the resistors and capacitors.

The gain of non-inverting buffer IC2a is adjusted with P2 for maximum output amplitude. Each of the other non-inverting buffers has the same circuit, but the values of the gain-controlling resistors are different because the input levels from the RC network are different.

The inverting buffer is built around IC2b. It takes the signal from the output IC2a and provides the output signal with the same amplitude and the opposite phase. The other inverting buffers have the same circuit. Removing one of the RC networks (e.g., R1 and C1 from *Fig. 2)* will change the frequency, which will then have a phase difference of 60° between two consecutive outputs.

PETRE TZVETANOV Petrov is an electronics engineer with Micro-Engineering, Sofia, Bulgaria. He has worked as a researcher and assistant professor at Technical University, Sofia, and has been an expert lecturer at OFPPT, Casablanca, in the Kingdom of Morocco.



2. Formed by IC1a and IC1b, the basic signal generator uses phase-shifted versions for the other outputs, each of which is buffered by a non-inverting and inverting amplifier to provide the additional outputs.

Planar Transformers Ideal for Power Conversion Applications

THE LATEST planar transformers from Standex-Meder Electronics are ideal for 500W-2KW applications. Available in standard or custom designs, the SX41 Series features an enhanced core design that helps promote volumetric efficiency and thermal performance. The large core surface stimulates heat transfer while minimizing AC resistance and proximity Cu loss and the optimized core cross section helps lower core loss. This makes the transformers ideal for power conversion applications in the welding, automotive, telecommunications, renewable energy, and aerospace markets.

STANDEX-MEDER ELECTRONICS

www.standexmeder.com

Geppetto 2.0 Board Introduces Tux-Approved Mappings

GUMSTIX HAS announced the release of Geppetto 2.0, the company's build-to-order tool. Version 2.0 introduces Tux-Approved recommended mappings for buses which helps ensure compatibility between user-created hardware and standard Linux images. 2.0 also offers an expanded module selection, improved dimensioning, video tutorials, and a faster interface. With the release, the Geppetto-designed AeroCore 2 MAV Control Board (compatible with Overo COMs) and the Pepper DVI-D SBC are also available.

AeroCore 2 helps give MAV developers greater selection in finding a solution that fits their needs, adding CAM, Spektrum RC, and GPS interfaces to the ARM Cortex-M4 powered board. The Pepper DVI-D SBC is a complete, compact solution for embedded developers interested in ARM processors and features the Texas Instruments Sitara AM3354 processor. It also offers high-definition video output, 512 Mbytes RAM, Wi-FI, Bluetooth, a microSD card slot, and two USB ports.

GUMSTIX INC.

www.gumstix.com

5th Generation Intel Core Processors Enhance Graphic Capabilities

CONGATEC INC. has revamped its COM Express module and Thin Mini-ITX motherboard to accommodate Intel's 5th generation Core processors. The single-chip processors, built on Intel's 14 nm process technology, feature a low power consumption of 15 W TDP. Designed to enable better graphics and performance, they will help support congatec's IoT solutions by providing crisp, responsive visuals and enhanced security. Both the module and motherboard allow for the connection of up to three independent display interfaces via HDMI 1.4, LVDS, and embedded DisplayPort (eDP).

CONGATEC INC.

www.congatec.com

SRAM-Based Network Search Engine Features Up to 8 Million Flow Entries

THE QUESTFLO 98TX1100 from Marvell is a static random access memory (SRAM)-based network search engine that can flexibly manage, deliver, and secure up to 8 million service and virtualized flows. With deterministic throughput and latency regardless of bandwidth, packet size, and search lengths, the products support next-generation flow-based services for mobile devices and the Internet of Things (IoT). They are typically used with a network packet processor that features standard high-speed Interlaken (ILK-LA) interfaces, Ethernet packet processors, or a customized ASIC or FPGA-based solution to scale the level of service processing.

They also feature 2.4 searches per second; deterministic throughput of 1 clock cycle per search and fixed low latency from 80b to 640b keys; and multi-port configuration for device and resource sharing. Typical applications include carrier and enterprise service/edge routers; security appliances; network probes; data center switches; servers; load-balancers; and software defined network (SDN) and network functions virtualization (NFV) platforms.

MARVELL

www.marvell.com

Tire Pressure Monitoring System Offers Single- or Dual-Axis Accelerometers

THE FXTH87 tire pressure monitoring system (TPMS) family from Freescale Semiconductor is a system-in-package solution that provides low power consumption with a high level of functional integration. It features a dual-axis accelerometer architecture, pressure and temperature sensor, integrated 8-bit microcontroller (MCU), RF transmitter, and a low frequency receiver. Weighing only 0.3 grams and enclosed in a 7 × 7 × 2.2 mm package, the TPMS enables form factors ideal for developers who need to reduce weight and overall costs. RF power consumption of 7 mA Idd extends battery life. In addition, single- and dual-axis accelerometer options improve accuracy and enable more precise tire localization implementation.

FREESCALE SEMICONDUCTOR

www.freescale.com

Rugged RISC-Based Computer Features TFT LCD Touchscreen

THE SEAPAC R9-8.4 from SeaLevel System leverages a reduced instruction set computer (RISC)-based embedded computer with an 8.4-in. thin-film transistor (TFT) LCD to create a wide-temperature, ruggedized, flat panel computer. It is powered by a 400 MHz ARM9 microprocessor and is available with 128 MB RAM and 256 MB flash memory. Local or remote I/O expansion is available through a variety of configurations including optically isolated inputs, Reed and Form C relay outputs, TTL interfaces, A/D, and D/A. The computer features one 10/100 BaseT Ethernet port, two USB 2.0 ports, one USB device port, eight open collector digital outputs, two isolated RS-485 serial ports, one dedicated RS-485 serial port via a RJ45 connector, and one RS-232 serial port. The resistive touchscreen is suitable for a wide range of industrial environments and applications, with an operating temperature range of –30°C to 70°C.

SEALEVEL SYSTEMS

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Dev Platform Uses i.MX 6 Series to Simplify Auto Infotainment

THE SMART Application Blueprint for Rapid Engineering (SABRE) for auto infotainment (AI) by Freescale Semiconductor leverages the company's i.MX 6 series applications processors to simplify Ethernet Audio Video Bridging (AVB) deployment. The development system helps connect an array of onboard multimedia nodes to support real-time data transport throughout a vehicle. SABRE AI is designed to work with Freescale's microcontroller software solutions to further integrate automotive grade Ethernet components. It supports both 100 Mbits/s automotive Ethernet physical interfaces, as well as multi-port switches to allow customers to design for their specific applications.

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BILL WONG | Embedded/Systems/Software Editor
bill.wong@penton.com

Create Great-Looking Text on IoT Devices

How will the text look on your latest embedded device? It is often overlooked or assumed that poor presentation is acceptable with low-cost implementations.

Monotype is well known for its large collection of fonts, but the package's rendering technology has also found its way into many applications and devices. Its latest implementation targets the Internet of Things (IoT). In particular, it addresses devices with microcontrollers; for example, a 50-MHz ARM Cortex-M3 driving application with flexible font-rendering needs, such as automotive clusters or medical devices (*Fig. 1*). Often, these microcontrollers' limited RAM can make advanced font handling a challenge. More powerful systems, like those running Android, have the memory and performance to handle scalable fonts.

1. Monotype's iType Spark and WorldType Shaper Spark target embedded display applications, such as this oxygen monitor that uses multiple fonts.

2. WorldType Shaper Spark handles complex and bidirectional scripts.

In the past, an application typically required a single bit-mapped font for basic display presentation due to the limited display features. Different fonts would be stored if it needed additional styles or font sizes. Changing display hardware often required changing these fonts to accommodate the new hardware capabilities.

Higher-quality displays aren't readily available, and technologies like e-paper allow for high-resolution presentations with minimal power requirements, which is ideal for mobile applications. Consequently, applications are able to utilize techniques such as scalable and downloadable fonts to support better presentations, as well as support different languages.

The challenges for scalable fonts are the support-software overhead and the hinting required for more compact renderings. Some fonts are designed for high resolution or print applications, and their hinting doesn't necessarily translate into efficient and good-looking fonts on a lower-resolution display. What Monotype has done is bring this scalable capability to the low- and mid-range hardware spectrum, including manual and automatic hinting.

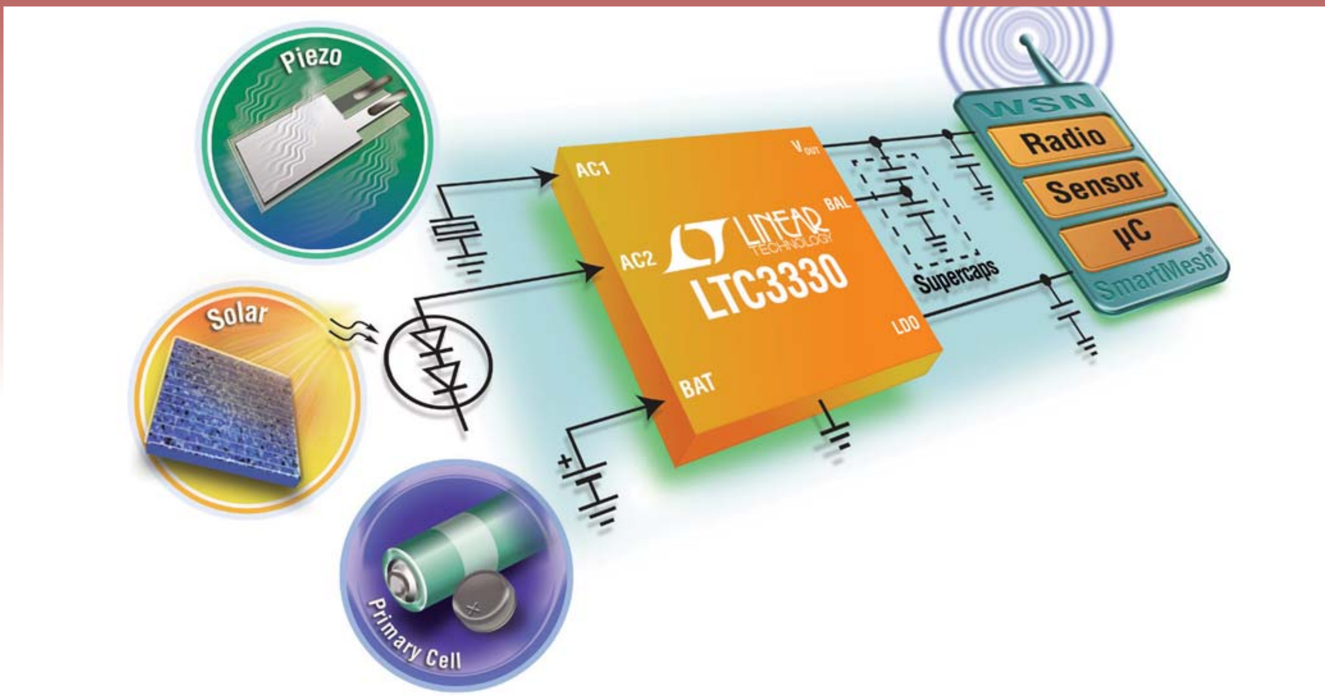
New products include iType Spark and WorldType Shaper Spark. The iType Spark platform, which generates bitmap fonts, supports language types like Latin and Chinese that have unique fonts per character. Though there may be proportional spacing between characters, each glyph is distinct. WorldType Shaper Spark handles more complex scenarios that involve combining multiple character glyphs into a larger combination. This approach is used for languages such as Hebrew, Thai, Devenagri, and Arabic (*Fig. 2*).

The iType Spark platform uses 20 kB of RAM and under 100 kB of flash. WorldType Shaper Spark takes a little more, but is only needed if there are more complex languages. The memory and processing requirements allow either platform to work with microcontrollers and low-end x86 processors.

The output for iType Spark can be monochrome, 8-bit grayscale, or outlines. It supports Monotype lightweight hints and performs its own auto-hinting. There's support for TrueType fonts as well, but the best-quality fonts will be the Monotype Spark fonts. The base system includes a number of them.

Monotype has already delivered the platforms on four development boards with displays—the Keil STM 23 EXL, NXP XPRESSO LPC1769, Microchip PIC32 board, and Renesas SH7264. Support for the iType Spark and WorldType Shaper Spark can easily translate onto other platforms and displays. ed

Extend Battery Life With Harvested Energy



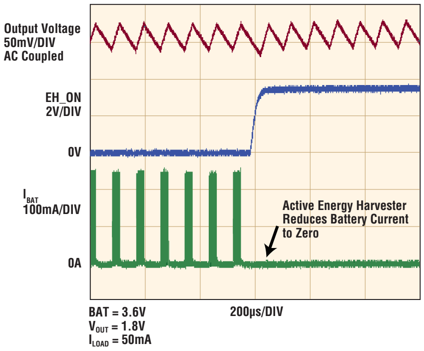
Single Nanopower IC Manages Multiple Input Sources

Our LTC®3330, a nanopower buck-boost converter and battery life extender, is a game changer IC for energy harvesting applications. This device enables a smaller primary battery and/or much longer battery life by prioritizing ambient energy as the primary power source and only switches to battery power when these sources are not present. Primary battery life is further optimized since the LTC3330 consumes zero current when an energy harvesting source is present. Compatible transducers include piezoelectric, solar or magnetic sources. For applications needing peak power periodically, an integrated supercapacitor balancer is included on-chip.

Features

- Dual Input, Single Output DC/DCs with Input Prioritizer:
  - Energy Harvesting Input: 3V to 19V Buck DC/DC
  - Primary Cell Input: 1.8V to 5.5V Buck-Boost DC/DC
- Zero Battery I_Q when Energy Harvesting Source Is Present
- Ultralow Quiescent Current Input: 750nA at No Load
- Low Noise LDO Post Regulator
- Integrated Supercapacitor Balancer

Extending Battery Life with Energy Harvesting



Info & Free Samples

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