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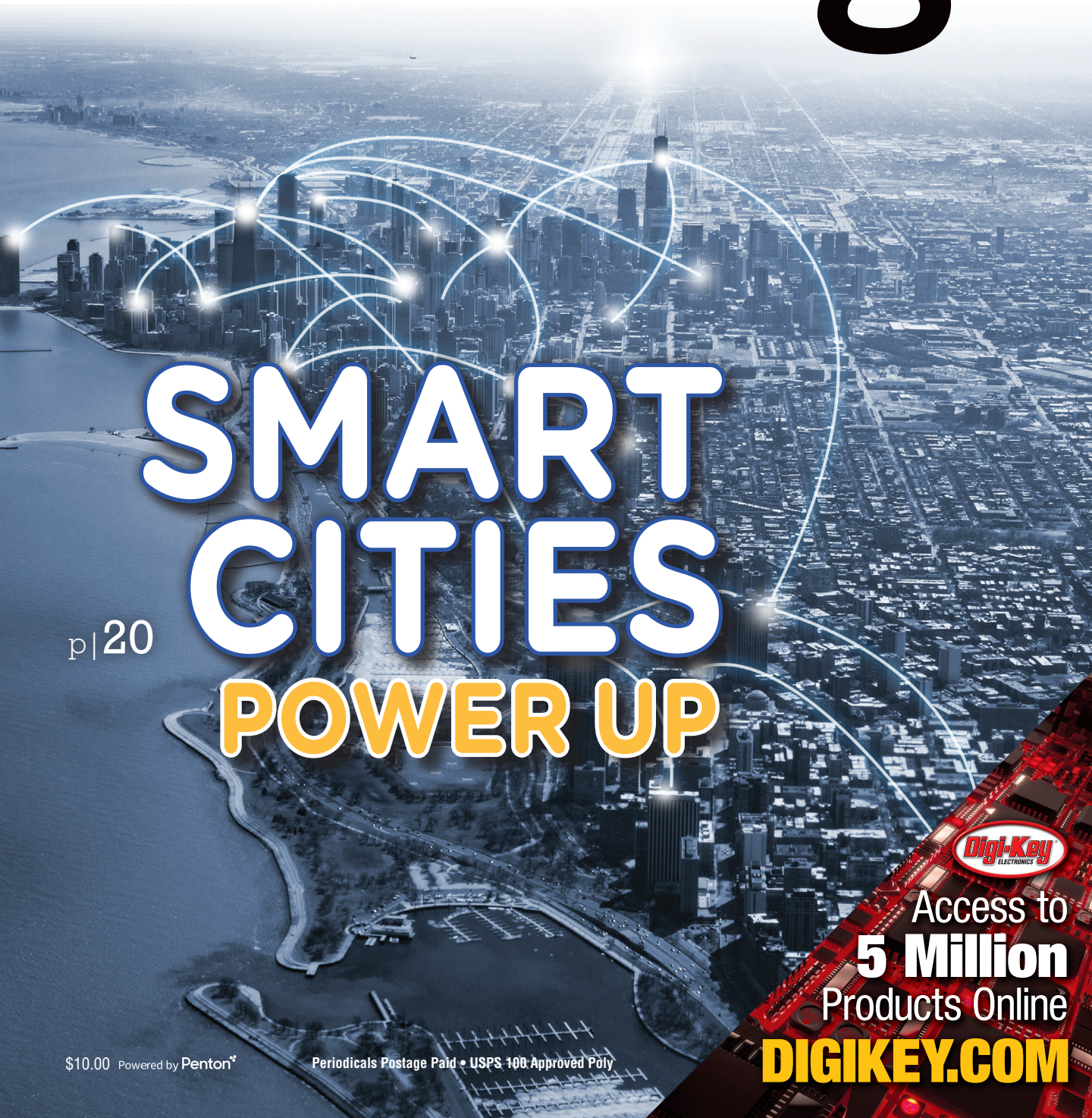

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*AspenCore's 11th Design Engineer and Supplier Interface Study gathered information from engineers regarding their need for product information and other services, as well as how and when they interface with suppliers and how they see the quality and value of that interface. 1,750 U.S. engineers participated in this year's web-based survey. The results represent those surveys completed by April 2016.

When asked "Best in Class: Broadest Overall Product Selection?" The chart below shows the results among the industry's electronic component distributors.

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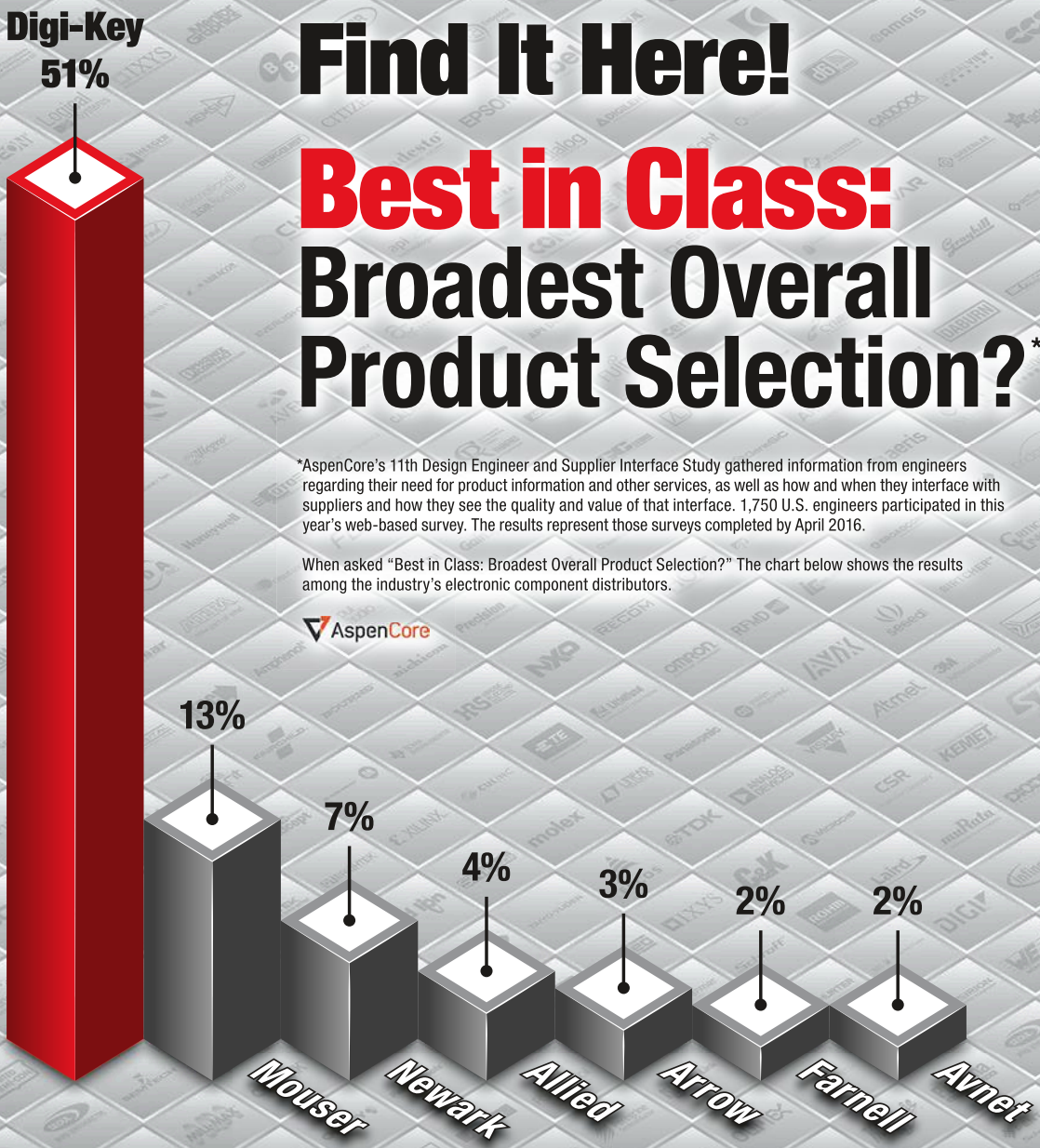

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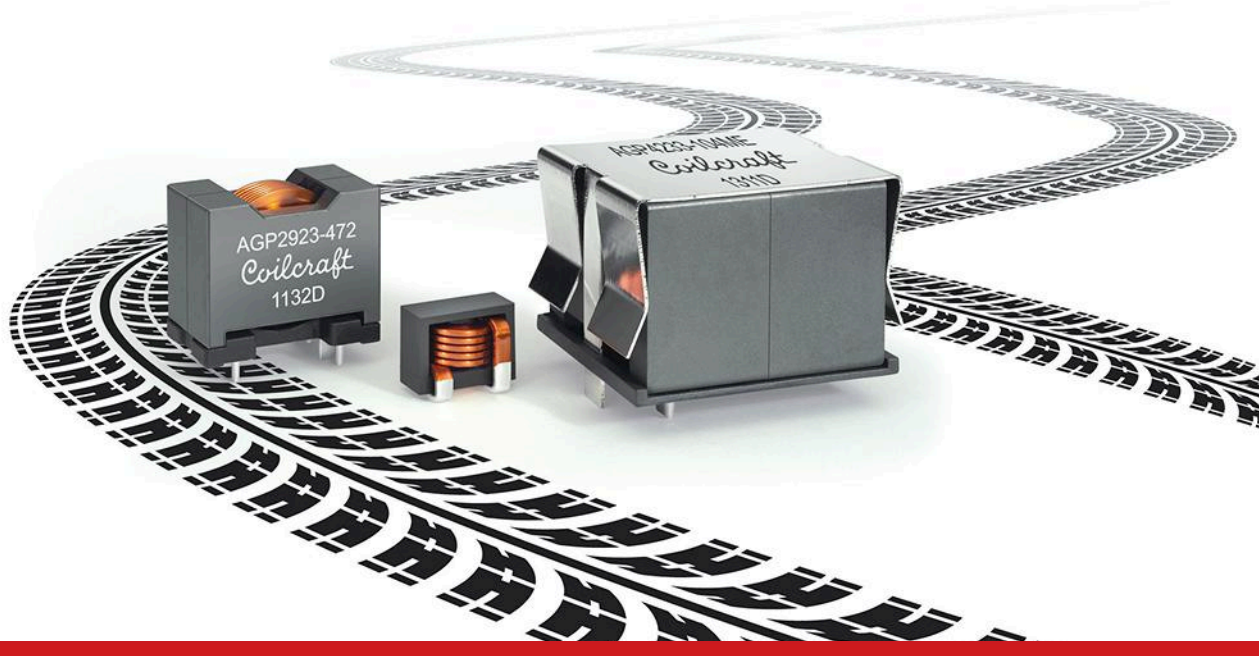

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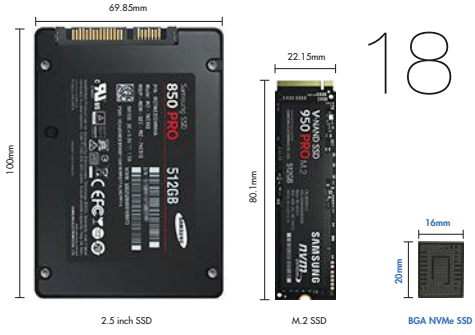
FEATURES



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

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WHAT IS ALL THIS 555 TIMER STUFF, ANYWAY?

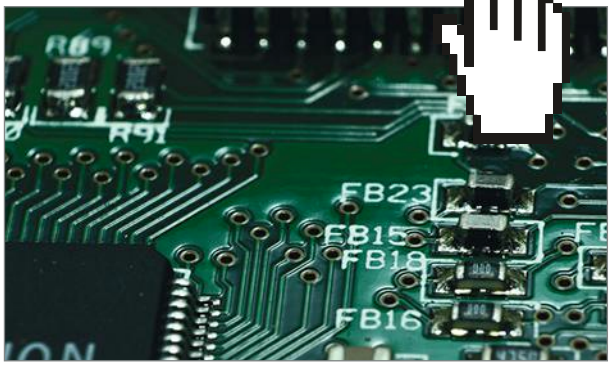
http://electronicdesign.com/analog/what-s-all-555-timer-stuff-anyway

When it comes to the venerable 555 timer, Contributing Tech Editor Paul Rako agrees with the legendary, late Bob Pease—avoid using it if your application demands any kind of precision.

WHAT YOU NEED TO KNOW ABOUT BLUETOOTH 5

http://electronicdesign.com/blog/5-things-you-must-know-about-new-bluetooth-5

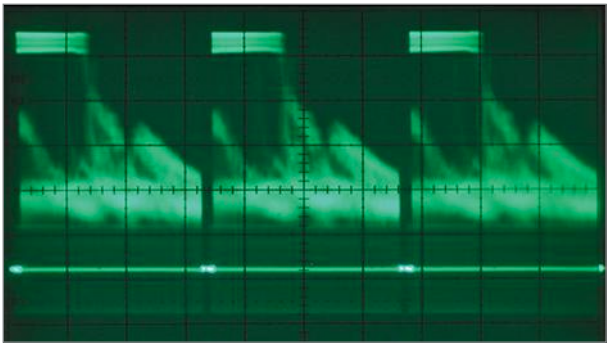
Longer range, faster speed, and larger broadcast message capacity come with Bluetooth 5, which makes it an even stronger wireless competitor in the IoT space. Find out what else you should know in Lou Frenzel's latest blog.



11 MYTHS ABOUT PCB LAYOUT

http://electronicdesign.com/boards/11-myths-about-pcb-layout

PCB layout is not as straightforward as one might think—there is an art form to being effective. Sunstone Circuits' Matthew Stevenson helps clear the air by dispelling some common myths about printed circuit board design.



THE DIFFERENCE BETWEEN A DSO AND A DPO

http://electronicdesign.com/test-measurement/what-s-difference-between-dso-and-dpo

A digital phosphor oscilloscope is also a digital storage oscilloscope, and the same can be true in reverse. So what exactly separates the two?

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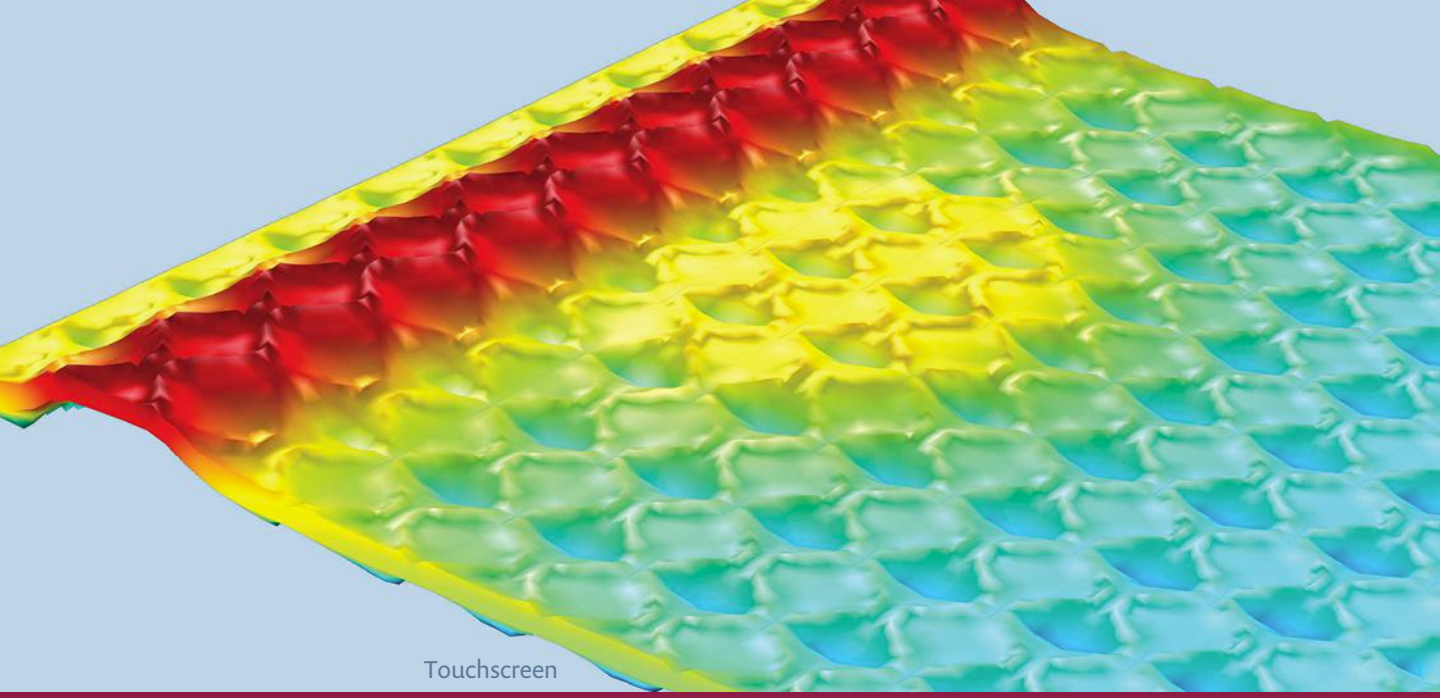

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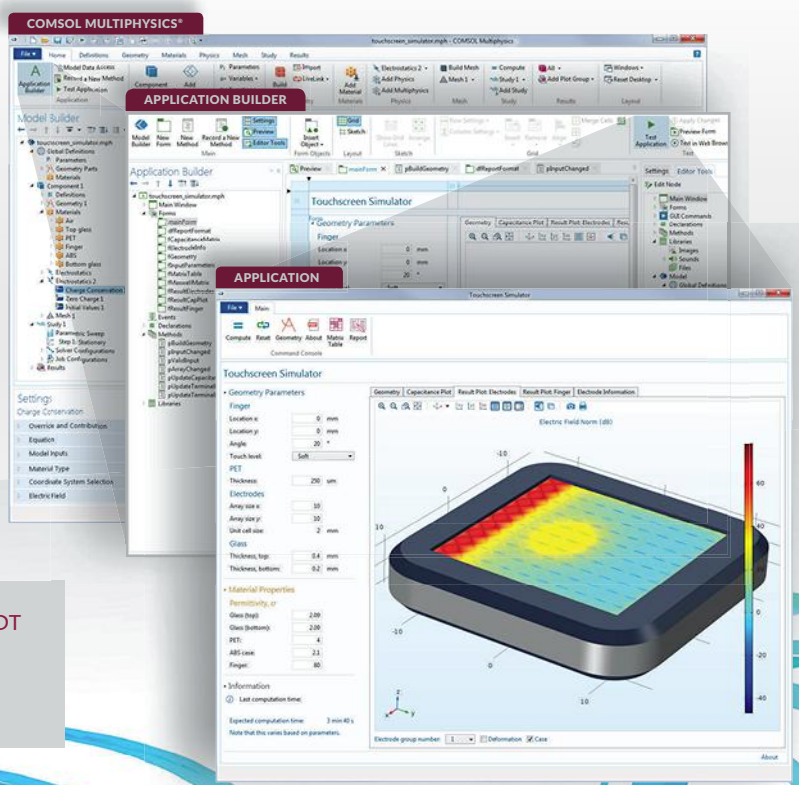

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Reliability and the SELF-DRIVING CAR

Renesas and Blackberry's QNX software were at the heart of the self-driving car demo at the 2017 Consumer Electronics Show.

The race to launch a commercially available self-driving car was front and center at this year's Consumer Electronics Show *(see "Car Technology Drives CES 2017" on electronicdesign.com)*. I took more than one ride in a self-driving vehicle and came out unscathed and usually awed by the current state of affairs. We are still a long way from a true self-driving car, but the gains that have been made in the last couple of years have been extremely impressive.

One area that is often left to the future is safety and reliability. Just getting things to work is a challenge. Most developers working in this area are addressing these issues, but they often do not talk about them much. The demo I had from Renesas did.

Renesas has worked with a number of partners—including Blackberry with its automotive software, the QNX RTOS. The latest demo is built around multiple Renesas' R-Car starter kits that can meet the ASIL-B standard while each pair was managed by a Renesas RH850 that can meet ASIL-D. This should allow the combined system to meet ASIL-D requirements.

The particular demo utilized a triple, software-redundant configuration where three of four R-Car chips were used. The system would detect when one of the three was out of synch allowing it to be isolated with the other two continuing to operate.

Another part of the demo highlighted monitoring of network communications. It could identify some types of attacks and then isolate the portion of the network under attack.

A couple of examples were demonstrated while I was in the car. One part of the demo had the car pull over in a designated spot when the system detected a simulated error that reduced the system to a minimal safe configuration. A commercial solution would need to do much more but it will need to have the same type of checking and redundancy that was demonstrated by Renesas and Blackberry QNX.

The wave of self-driving technology is unstoppable at this point *(see "Self-Driving Cars Are Coming Whether You Like It or Not" on electronicdesign.com)*. We are not even close to the first self-driving car that will operate at large under most driving conditions and it is going to take a lot more technology, redundancy, and good design to make it happen. ed

Renesas employs a triple redundant, software managed system in its self-driving car demo at the 2017 Consumer Electronics Show. It runs Blackberry's QNX ROS.

News

THE CHEMICAL TESTS of the Future Could Move onto Chips

Marcel Zevenbergen imagines chemical sensors that are the size of a fingernail, measure chloride levels in a farm's water supply, and stream data wirelessly for months. These are not the cattail-shaped electrodes and analytical machines that scientists have traditionally used to measure chemicals in fluid.

Zevenbergen is a senior researcher at the Holst Centre, a Dutch microelectronics lab where engineers are trying to shrink such chemical sensors down into silicon chips. These devices largely missed out on the falling cost and dimensions of other sensors for measuring pressure or temperature.

The Holst Centre unveiled a new chemical sensor that dwarfs other devices built with ion-selective membranes, but is small enough to be integrated on a circuit board with computers and wireless transmitters.

Founded in 2005, the Holst Centre is the result of a partnership between the Netherlands Organization for Applied Scientific Research and Imec, a leading microelectronics research center in Belgium. It is trying to bring the same transformative advances to sensors as Imec has done with some of the world's smallest and most sophisticated computer chips.

Today, that goal is shared by many other researchers in fields ranging from industrial control to healthcare. In December, scientists from the University of California, Santa Cruz, published a paper that described a lab-on-a-chip that helped detect the hallmarks of cancer in blood. The tiny system is faster and requires less blood than traditional lab equipment, they said.

At the IEEE International Electron Devices Meeting in San Francisco, Zevenbergen and his colleagues showed a new chemical sensor that dwarfs other devices built with ion-selective membranes, the gold standard for measuring chemicals in fluid. The big news is that it's small enough to be integrated on a circuit board with computers and wireless transmitters.

The advance could make it possible for the tiny parts to have the same lifespan and accuracy as ion-selective sensors, which contain electrodes that react with ions floating in fluids, generating an electric current based on the reaction's intensity. That would make them useful for large networks of wireless sensors on farms, hospitals, or factories.

In an interview, Zevenbergen said that the challenge has been slowing how fast the sensors' electrodes break down, causing their readings to drift. The sensors typically only last three to six months before they must be cleaned, recalibrated, or replaced. Making the reference electrode smaller has meant that it breaks down faster.

The problem is with the reference electrode, which connects to the membranes that interact with chemicals dissolved in the fluid to measure the concentration. A voltage created from the chemical reaction at the membrane is compared to the behavior of the reference electrode. The electrode can also be compromised by temperature, light, or contaminants.

Typically, the reference electrode contains a reservoir filled with around 10 milliliters of electrolyte that slowly leak out of the sensor and cause drift. But the Holst researchers carved a tiny channel in the reference electrode to better hold onto the electrolyte. The other benefit: the sensor only needs 10 microliters.

The "microfluidic channel" acts like a contact between the reference electrode and iridium oxide and silver chloride membranes, which measure for acidity and chloride, respectively. Hardly anything will slosh out of the channel, Zevenbergen said, allowing the sensor readings to remain stable as long as larger devices.

The result is that the devices can be fabricated on silicon substrates much smaller than previously thought. They also have the same or better accuracy, said Zevenbergen. Potentially, the sensors can be produced at lower costs, too.

Holst researchers are far from the only ones trying to etch fluid sensors into silicon. In 2014, researchers at the Vienna University of Technology made a prototype sensor using miniaturized laser technology to cast infrared light into fluid. The sensor measured chemicals by detecting the presence of molecules – like oxygen in a newborn's blood – that absorb the light.

More recently, electrical engineer Anurahda Agarwal and MIT researchers created glass lenses that emit infrared light to measure specific chemicals. Such innovations, she said, could enable applications like minimizing waste in oil processing, quality monitoring in a water purification plant, and inspecting food for freshness.

Holst's sensors are still in the early stages. Zevenberg said that he was working with several companies on the precompetitive research, though declined to name names. But, he said, that the new advance could have wide implications beyond chloride and acidity sensors.

One idea, he said, was to integrate sodium sensors into vests that detect symptoms of dehydration in an athlete's sweat. Another is using the sensors on farmland to measure soil nutrients. ■

SK HYNIX TO BOOST NAND Output with $1.8 Billion Fab

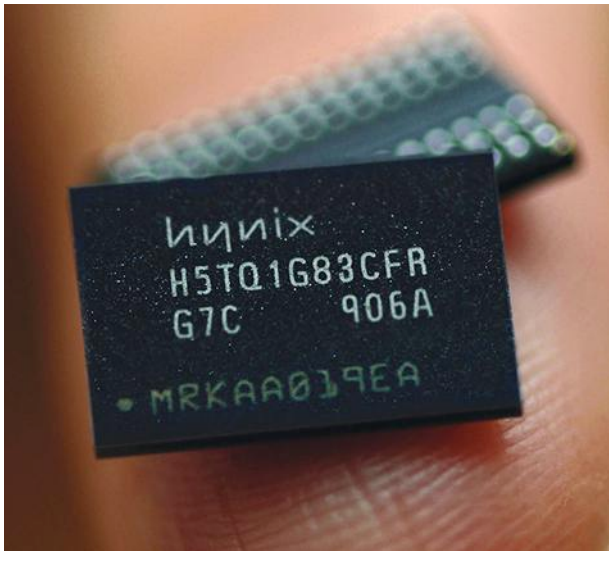
SK HYNIX, the world's second largest memory chip maker, plans to build a factory in South Korea to meet the increasing demand for its NAND flash memory. In January, the chip manufacturer said that it would invest around $1.8 billion in the construction.

The new plant will primarily make NAND chips used inside smartphones and personal computers for everything from storing photographs to playing videos. But like other memory chip makers, SK Hynix is increasingly tailoring its chips for manufacturing equipment and automobiles. Right now, some of its big-name customers are Apple and Sony.

The memory market has been improving with growing demand for faster processing power and greater storage in mobile devices and computers. Most major chip makers in the field are pouring vast sums into devices with multiple layers of semiconductors, also known as 3D NAND, which has more capacity than single-layer chips.

One question facing the industry is whether the three-dimensional chips can be produced as cheaply as planar NAND. Companies like Toshiba and Samsung are devising chips with as many as 64 memory layers, but none have said when their devices might become comparable to NAND in cost per bit.

The new plant, which will be located in Cheongju, South Korea, will begin construction in August 2017 and is scheduled to be completed in 2019, the company said in a statement. SK Hynix also plans to convert parts of its M14 fab in Icheon, South Korea, to produce 3D NAND. The factory, which cost $12.7 billion to build, opened last year.



SK Hynix is also known for making dynamic-random access memory, or DRAM, which is used in mobile devices and computers to help run multiple programs simultaneously.

"The new fab to be constructed in Cheongju will become a part

(Continued on page 11)

RASPBERRY PI OPERATING SYSTEM Language for the Internet of Things

EBEN UPTON, the founder of the Raspberry Pi Foundation, has said that the purpose of making its $35 computer boards was so that everyone, even schools, could afford them. Now, he has a goal of making the Raspberry Pi's operating system similarly accessible.

Upton announced in a January blog post that the operating system, called Pixel and originally developed for the 10 million Raspberry Pis sold over the last five years, had been reworked to run on Macs and other personal computers.

The release gives people access to "the same productivity software and programming tools, in exactly the s ame desktop environment," without using Raspberry Pi hardware, Upton said. The blog post has instructions on how to download the new software.

Pixel was first released in September 2016 and overhauled the main desktop interface, which is known as Raspbian, for developers working on Raspberry Pi devices. It is based on a version of Linux software optimized for the Raspberry Pi, which in February entered its third generation.

Upton said that the new operating system was built in the same spirit as the Raspberry Pi itself, which was first released in 2012 as an educational tool for computer programming. "A school can now run Pixel on its existing installed base of PCs, just as a student can run Pixel on her Raspberry Pi at home," Upton said.

"She can move back and forth between her computing class or after-school club and home," he added. "There is no learning curve."

Upton admitted that the software was experimental. He warned that that minor bugs could appear as a result of the wide range of hardware configurations for personal computers. But he said that Raspberry Pi's developers would continue working out kinks in the new version of Pixel. ■

DEVICE HARVESTS ENERGY from Wind, Rain, or Smartphone Scrolling

THE MECHANICAL ENERGY involved in touching a smartphone screen or being struck by a raindrop could be converted into electricity using a new energy harvesting concept devised by Penn State researchers. It contrasts from other methods of harvesting energy from motion, which normally generate current from constant vibrations.

The scientists say that they have built a device to capture energy from gentler and more infrequent motions, like scrolling through a news article on a smartphone. They described the device in a paper published in the journal Advanced Energy Materials, a transducer made out of an organic polymer that creates electricity when compressed.

The study gives a twist to the field of energy harvesting, which typically depends on piezoelectric materials that harvest electricity from frequent vibrations or mechanical stress. In recent years, engineers have increasingly tried to exploit this piezoelectric effect, resulting in devices like a sound sensor that only uses power when actually hearing noises.

Penn State scientists say they have built a device to capture energy from gentle, infrequent motions, like scrolling through a news article on a smartphone.

Their device is known as an ionic diode, which contains two electrodes filled with ions almost like batteries. When a mechanical force is applied, the ions spread out on the membrane, creating a continuous direct current that imparts microwatts of power to the main battery.

"Because the device is a polymer, it is both flexible and lightweight," said Qing Wang, a materials science and engineering professor at Penn State, in a statement. "When incorporated into a next-generation smartphone, we hope to provide 40 percent of the energy required of the battery."

The charge dissipates once the ions settle down. The complete cycle occurs once every ten seconds, as opposed to devices drawing energy from the piezoelectric effect, which operates most efficiently a hundred times faster, or around 10 vibrations per second.

The device adds to the list of technologies trying to prolong the life of devices like smartphones, wearables, and wireless sensors. In 2016, a Georgia Institute of Technology team reported a tiny generator that could allow fitness bands and smart watches to harvest energy from running and walking. Other innovations involve soaking up power from stray radio waves.

Though the transducer is targeted at smartphones, there are many applications that would benefit from harvested energy. It could be used in biomedical devices pasted onto hospital patients or sensor tags for livestock powered by muscle contractions.

The device could also gather energy from wind or ocean waves as "a source of abundant, environmentally benign and sustainable power," the researchers wrote in their paper. ■

(Continued from page 9)

of our key production facilities to gear up for the upcoming fourth industrial revolution," Sung Wook Park, chief executive of SK Hynix, said in a statement, referring to the process of digitizing and connecting factory equipment to make them more efficient.

SK Hynix is also known for making dynamic-random access memory, or DRAM, which is used in mobile devices and computers to help run multiple programs simultaneously. The chips contrast from NAND in that their information can be accessed faster. But unlike NAND, the data vanishes when power is lost.

In recent years, SK Hynix has not always had the luxury of investing into its manufacturing output. Only three years ago, it was struggling to rebuild it. In 2013, a fire broke out at its plant in Wuxi, China, which today is responsible for around half of the company's DRAM production. The conflagration took the plant out of commission from September to November, causing prices for DRAM to increase sharply.

That factory is also getting an update. The company said last week that it will undertake an almost $800 million expansion of its Wuxi factory, which was built in 2006. The expansion will make room for additional equipment used in the increasingly complex process of making DRAM chips. ■

WHITE HOUSE URGES FASTER CHIP
Innovation to Compete with China

IF ALL GOES according to plan, China's $150 billion fund to build its domestic chip industry will be empty by 2025 and the country will produce 70% of the chips that it buys. But how China spends that money in the meantime is coming under scrutiny.

A White House panel of semiconductor experts released a report in January saying that China's push into microchips threatened to harm American chip makers and risk U.S. national security. In the report, the panel advised Congress to invest heavily in advanced research and work with allies to impose stricter export controls for semiconductors.

The report underlines the growing concern in Washington about the implications of China's push to acquire insight into chip manufacturing. In recent years, the country has been accused of using subsidies to fund acquisitions of foreign firms and to bolster national champions like Tsinghua Unigroup, which bid $23 billion for Micron Technology in 2015.

"We found that Chinese policies are distorting markets in ways that undermine innovation, subtract from U.S. market share, and put U.S. national security at risk," the report concluded. ■

ZIGBEE PROMISES ANOTHER
Universal Language for the Internet of Things

EVERYTHING FROM THERMOSTATS, light bulbs, and smartphones would be able to talk wirelessly with each other using a new software language that the makers of ZigBee, the popular wireless standard for linking household devices, revealed last month.

The new language, which is called dotdot, is the latest attempt at desegregating Internet of Things devices, which still have trouble talking to devices built by different manufacturers or with different radio technology. The software, or application layer, aims to be a universal language that all devices can understand, whether they use Wi-Fi, Bluetooth, ZigBee, or other networks.

That contrasts with the current process of sending information through an internet gateway to the cloud, where it can be translated for different gadgets, like a Nest Labs security camera and a door lock developed with ZigBee. With a universal language like dotdot, the two devices could talk to each other directly.

The language is not completely new. It is just the latest brand for an application layer formerly known as the ZigBee Cluster Library, which has been used to connect the roughly 100 million devices shipped with ZigBee.

But the ZigBee Alliance behind the standard wants to make dotdot more generally usable. The application layer will include new specifications and a certification program. According to a statement, the first products are expected to be certified in late 2017.

"Recognizing the value of the evolving application layer that has been the core language of ZigBee devices for over a decade, market leaders within the alliance have come together to transform it into a universal language for the IoT," said Tobin Richardson, the chief executive of the ZigBee Alliance, in a statement.

But for now, it will not work with much else unless other application layers are abandoned. There are many competing plans among chip suppliers and device makers to draft a similar universal language. In October, the Allseen Alliance and the Open Connectivity Foundation—two of the largest standards groups with members like Intel, Samsung, and Qualcomm—said that they would create an industry standard under the name IoTivity.

It is also not clear what other wireless technologies it might work with. A spokeswoman for the ZigBee Alliance didn't respond to a request for additional information.

To start, the ZigBee Alliance is working toward an early implementation of dotdot on Thread, which uses the same underlying technology as ZigBee. The effort quietly started over a year ago when the ZigBee Alliance agreed to share its software language library with the Thread Group, which was founded in 2014 with many of the same members.

The first results of that partnership were displayed at CES in Las Vegas last month. The companies that displayed dotdot products included Osram Opto Semiconductors, NXP Semiconductors, Schneider Electric, and Silicon Labs. ■

MARIA GUERRA | Technical Editor

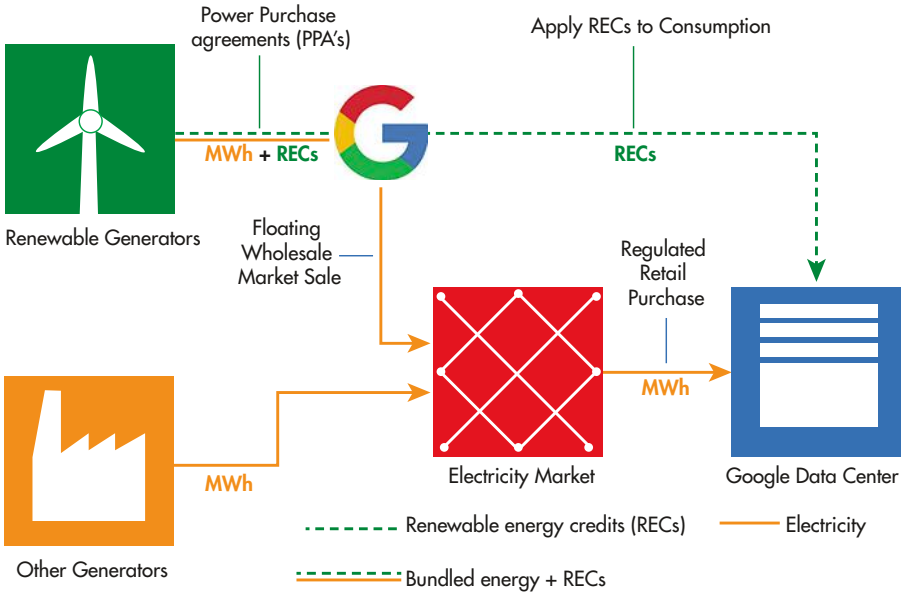
Is Google's Renewable Energy Plan WHAT IT SEEMS?

Google announced that it will purchase enough renewable energy to match 100% of its operations in 2017 in hopes that regulated utilities will eventually offer better retail options to purchase renewable energy.

When I first heard about Google's latest announcement, I thought the company was going to rely completely on renewable energy to directly energize its data centers. I was surprised by such an achievement, as data centers operate 24/7 and wind and the sun are not constantly available resources. But it turned out that is not the case—yet. Google's renewable energy plan is just an excuse for all the greenhouse gas (GHG) emissions that it will keep generating as it mostly energizes its data centers with fossil fuels. In addition to delving into the significance of this announcement ourselves, we asked some experts to weigh in on this trend and the reasons that data-center owners are making these moves.

To provide some background, owners of big data centers like Google had started to rely progressively on renewable sources because data centers require such significant amounts of energy. In 2015, Google consumed 5.7 terawatt-hours (TWh) of electricity, which is nearly as much electricity as the city of San Francisco used in the same year. Google's long-term goal is to run on clean, zero-carbon energy full-time, every day of the year. To achieve the 100% renewable energy purchasing goal, Google is currently participating in a number of large-scale deals with renewable producers and partnerships with utility providers such as:

- A "direct" renewable purchase in competitive retail markets in areas with deregulated wholesale and retail power markets
- A fixed-floating swap approach, whereby Google buys fixed-price renewables directly from a wind or solar farm and then resells it into the wholesale market at a floating market rate, retiring the associate renewable energy certificates (RECs). It then sells the power back into the same grid from which we later draw power at the consumer level *(Fig. 1)*.



1. An illustration of how Google purchases and uses renewable energy. *(Image courtesy of google.com)*

2. By purchasing energy from not-yet-constructed generation facilities, Google will promote the advancement of new technologies. Above, a Google data center in Douglas, Ga. *(Source: google.com)*

"From a physical perspective, this is just as good as consuming the renewable energy directly. That's because electricity on a grid is fungible; electrons generated in one spot can't be directed to any specific user on the grid, any more than a cup of water poured into a river could be directed to a particular stream. So it doesn't make much of a difference where the renewable energy that we buy is located, as long as it's on the same grid as our data center," says Gary Demasi, director of Data Center Energy and Location Strategy for Google.

But not many people agree with Google's approach on renewable energy and its description of electricity on a grid as "fungible." In a blog, Ed Kraples, founder and CEO of Anbaric, states, "Essentially, Google is contracting for green energy from places that can never reach its data centers. If it were as simple as Google claims, it would be easy to build a renewable power sector. New York City could execute a massive number of contracts with wind farms in upstate New York because they are on the same grid. "

Basically, Google is promising to buy—on an annual basis—the same amount of megawatt-hours (MWh) of renewable energy as the amount of megawatt-hours of electricity that it consumes for its worldwide operations. This approach will benefit the renewable energy market even though it is still generating the same amount of greenhouse gas (GHG) emissions with or without its 100% renewable energy purchasing plan. By purchasing energy from not-yet-constructed generation facilities, Google will promote the advancement of new technologies. In the long term, it also should generate new green power on the grid while spurring economic growth and new employment opportunities (*Fig. 2*).

Many are speculating about why the owners of the largest data centers are including renewable energy: Is it because it gives them very good publicity? Or is it because renewable energy is getting cheaper and easily scalable? While renewable energy is becoming cheaper to produce, does it mean we are getting closer to replacing fossil fuels with renewable energy? Dr Eduard Oró, an energy consultant from Catalonia Institute for Energy Research in Spain, was a speaker at one of the sustainability sessions (Cities Moving Forward on Clean Energy) held at Smart City Expo World Congress. *(For more on this event, turn to page 20.)* He gave us his take on the future of renewable energy and data centers:

"The data center industry is really traditional and business-focused, so they are really concentrated on their business, which is providing IT services. It is really difficult (I would say impossible) to find any data center operator/maintenance whose first priority is energy efficiency. They try to cover their backs, and therefore they prefer to install another chiller rather than an energy management system which controls and optimizes the overall system. You have

There are many reasons for big-scale data centers to include renewable energy and it seems that the day that renewable energy will replace fossil fuel is getting closer as investments in renewable energy soar, new technology innovations emerge, and renewable energy subsidies increase.

to think that Uptime Institute, the worldwide-reference for data center advisory organization, came from CAT—so big machines and diesel-generators. If you want to be a top data center (getting TIER IV certified), you should install redundancy systems that are connected all day long, so it is impossible to be energy-efficient."

Oró continues, "From my humble opinion, just big players are worried about implementing renewables into their portfolio. But it's more a corporate social responsibility rather than install on-site renewables on the data center. They prefer to invest in wind turbines far away or to get a green-agreement with some electricity company rather than build up a Net Zero Energy Data Center from scratch.

"But I don't want to be negative," Oró adds. "There are many initiatives in the private industry and also in governments (in particular the European Commission) to bring more renewables into the data center industry. It would be difficult but we are working on that. For instance, at IREC, we have coordinated RenewIT, which is an EU-funded project aiming to spread the knowledge and break the technical and industry barriers about implementing renewables into the data center portfolio."

There are many reasons for big-scale data centers to include renewable energy and it seems that the day that renewable energy will replace fossil fuel is getting closer as investments in renewable energy soar, new technology innovations emerge, and renewable energy subsidies increase. If regulated utilities offer better retail options to purchase renewable energy, many small and medium data centers will benefit. And with more demand, renewable energy will become sustainable and affordable. ed

Q&A

BILL WONG | Technical Editor

What's New in the Wireless Audio Market?

Electronic Design talks with Jawad Haider, senior product marketing manager at Marvell Semiconductor, about the latest wireless audio trends, opportunities, and developments.

Jawad Haider is a senior marketing manager at Marvell Semiconductor. He supports the Wireless Connectivity business unit with technical marketing, competitive analysis, product definition, and customer account management activities. Most recently, he has been driving Marvell's solutions in to the rapidly growing wireless audio and streaming devices segment. He previously held marketing and engineering roles at Broadcom and ZTE. We recently spoke with him about the latest wireless audio trends, opportunities, and developments.

What trends are you seeing in the wireless audio market?

Haider: Wirelessly connected speakers using Bluetooth technology have been around for a few years now. But Bluetooth has its limitations in terms of bandwidth and range. Sonos came in as a trendsetter a few years ago by introducing a Wi-Fi based wireless speaker system using its SonosNet mesh-networking technology. Since then, we have seen Apple AirPlay, Digital Living Network Alliance (DLNA), DTS's Play-Fi and, most recently, Google Cast protocols emerge with different ways to send audio over Wi-Fi. As there is no one golden standard, a lot of fragmentation exists in the audio ecosystem, which has given consumers many different choices.

The key players driving volume over the next few years will be Amazon, Google, Sonos, Bose, Harman, and Sony, among a few others. Amazon disrupted the market with the introduction of its highly successful Amazon Echo voice-enabled speaker and virtual assistant. Google also recently announced its Google Home device, which acts as a virtual assistant and smart-home control center. The future of the wireless audio market will pivot around these voice-enabled interactive products, which will ultimately free us all from looking at our phone screens all the time!

Another emerging technological trend in this space is "hearables," which include wireless headsets, headphones, and earbuds using Bluetooth, Bluetooth Low Energy (BLE), and possibly Wi-Fi in the future. With the recent introduction of wireless AirPods by Apple, we will see a huge market building up with Bluetooth- and Wi-Fi-enabled hearables. The key requirements for this market segment will be long battery life and super-low current consumption.

What are the key technology challenges in delivering wireless audio?

Haider: With the introduction and consumer uptake of multi-channel and multi-room audio, a key challenge is delivering a synchronized audio stream to all of the devices on the network. Precise time-stamping algorithms need to be used on packets entering or leaving the system to ensure that the audio output on speakers is synchronized. Another key factor is the latency between different nodes on the network. As audio OEMs introduce multi-channel systems like 5.1, 7.1, and so on, you need minimum latency introduced between these channels—over the air as well as through the system.

For voice-enabled products, a key challenge is developing the microphone-array design so that the device can accurately listen to users in near-field as well as far-field scenarios. Amazon Echo has done a great job in designing a first-of-its-kind voice-enabled product with excellent voice-listening capability.

For hearables, the key challenge will be to build extremely low-power Wi-Fi and BLE solutions that can sustain music

streaming without requiring frequent recharging. One of the techniques that can be deployed will be opportunistically switching between Wi-Fi and BLE, based on range and data-throughput requirements.

What are the advantages of various wireless audio standards?

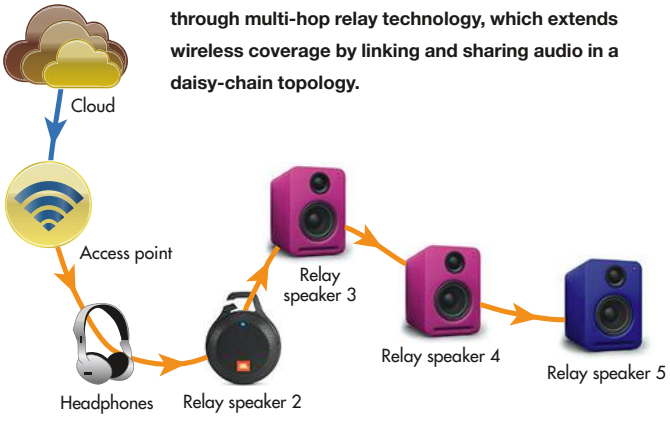
Haider: Some of the common wireless audio standards are Bluetooth A2DP, Apple's AirPlay, Google Cast, Spotify Connect, SonosNet, DTS Play-Fi, DLNA, and Miracast. All of these standards have their own differentiating features and ecosystem plays. Industry leaders have business and technological reasons to push their own ecosystems, which ends up creating fragmentation. However, these various standards continue to remain popular because there's no one size that fits all.

Bluetooth's biggest advantage is its ubiquity, as the technology is built into a wide range of devices in the market. Bluetooth is popular for being an easy-to-use, low-power, and low-cost solution. AirPlay, which just works with Apple hardware and software, Google Cast, and Spotify Connect all work over Wi-Fi, enabling a longer distance range for streaming. Play-Fi is another notable protocol for enabling high-resolution audio streaming and the ability to stream audio to multiple speakers at once.

How is the industry advancing to deliver next-generation wireless audio?

Haider: One of the key trends for next-generation wireless audio is multi-channel and multi-room audio for speakers and sound bars. Consumers want to be able to sync audio seamlessly across different devices and rooms, without range limitations.

One innovative way to enable multi-room audio is through multi-hop relay technology, which extends wireless coverage by linking and sharing audio in a daisy-chain topology. Since accurate time-stamping is also critical for seamless multi-channel and multi-room audio synchronization, the industry is adopting the IEEE 802.11mc standard to deliver synchronization accuracy in microseconds.



One innovative way to enable multi-room audio is through multi-hop relay technology, which extends wireless coverage by linking and sharing audio in a daisy-chain topology.

Consumers want to be able to sync audio seamlessly across different devices and rooms, without range limitations.

What are some new applications for wireless audio technology?

Haider: The wireless audio market is growing at a significant pace, expected to reach $54.07 billion by 2022 at a CAGR of 23.2% between 2016 and 2022, according to MarketsandMarkets. The introduction of voice-assisted products, such as Amazon Echo and Google Home, will prove to be one of the most disruptive innovations in the wireless audio segment. All tier-one audio OEMs will introduce an audio-streaming device with voice capability in the near future, with a lot of integration—think of all of your favorite applications like maps, Gmail, Hangouts, Uber, Amazon.com, WhatsApp, YouTube—all readily available through voice interaction while sitting at your couch.

We're also starting to see more ultra-low-power wireless and Bluetooth/BLE solutions on the market, enabling connected devices to last even longer on the go with an extended battery life and better throughput and range for high-resolution wireless audio. According to market research firm WiFore, the volume forecast for this segment will surpass 120Mu in 2020, dominated by wireless headsets and earbuds.

Can you tell me about Marvell's wireless audio solutions?

Haider: Marvell's wireless solutions provide high-performance and low-power connectivity for many of the most popular audio products on the market today. Marvell's newest Avastar wireless connectivity combos incorporate Dynamic Multi-Hop Relay (DMHR) Technology to connect up to 15 devices in a daisy-chain fashion. Combining a core Wi-Fi technology developed by Marvell and application stack, and system-level intelligence and synchronization algorithms developed by our partners, the Avastar solutions extend the range of traditional Wi-Fi networks 15 times from 40 m to almost 600 m in a typical home—a true game changer for many home and enterprise audio applications.

We've also enabled new features such as connecting up to 31 clients to your speaker or sound bar, which acts as a soft access point. In addition, our new chipsets have support for the new IEEE 802.11mc standard to support applications in highly synchronized audio solutions. ED

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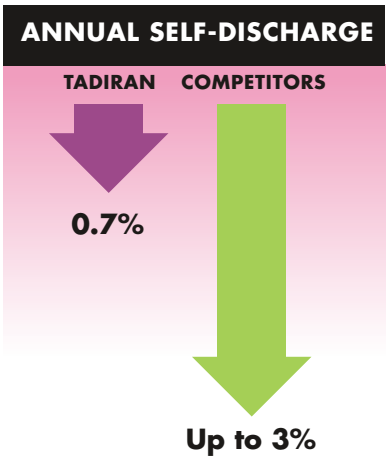

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WILLIAM WONG | Embedded/Systems/Software Editor

Embedded Flash Storage Gets Smaller and Faster

Some new form-factor options for non-volatile storage offer distinct advantages to developers.

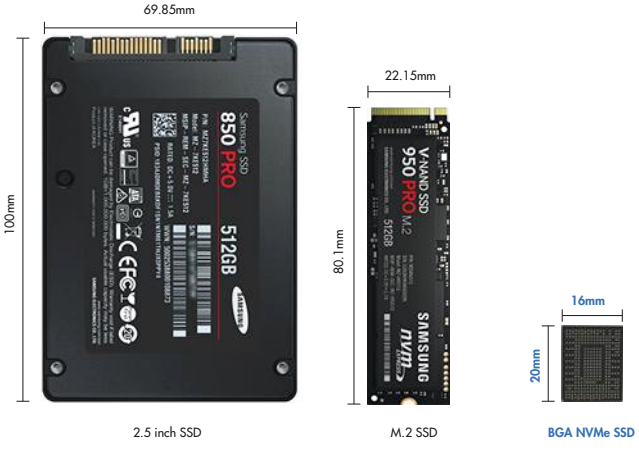
Embedded developers have never had so many options when it comes to non-volatile, industrial-grade storage. Even the number of form factors is mind-boggling, ranging from conventional disk-drive formats—e.g., the now-ubiquitous 2.5-in. drives—to chips as well as modules like M.2.

Flash memory is the dominant storage mechanism, but alternatives like MRAM, FRAM, RRAM, and so on are growing in availability, performance, and capacity. Very ambitious developers might work directly with storage chips, but most developers will prefer to deal with storage that provides standard interfaces from SPI to PCI Express (PCIe), as well as variants like PCIe-based NVMe *(see "NVMe Bids to Win the Storage Wars" on electronicdesign.com)*.

Even conventional interfaces and form factors like SATA-based, 2.5-in. solid-state drives are morphing into new configurations that work nicely with motherboards such as Virtium's StorFly SATA modules *(Fig. 1)*. This works nicely in the vertical orientation for a development board, though a production board would use a horizontal orientation that allows the module to be bolted down.

SATA, USB, and PCI Express tend to be the common interfaces for storage modules. I2C and SPI—including its variants, such as quad SPI (QSPI)—tend to address chip-based storage, although this is also changing in concert with rising capacity and performance demands. For example, Cypress Semiconductor's serial HyperBus family *(see "HyperBus Fills Memory Niche" on electronicdesign.com)* runs at 333 MB/s using 12 pins.

1. Virtium's StorFly compact SATA SSD with NVidia's Jetson TX1.



2. Samsung's NVMe chip (right) provides the same high-speed storage interface available on high-performance 2.5-in. solid-state disks (left) and M.2 modules (center).

Even storage chips are no longer limited to conventional parallel and serial interfaces. Samsung has NVMe-based chips that support NVMe *(Fig. 2)*. The 512-GB PM971-NVMe utilizes Samsung's 48-layer V-NAND (*see "Flash in the 3D Pan" on electronicdesign.com*), 4 Gb of LPDDR4 mobile memory, and Samsung's controller. These are packed into a 20- by 16- by 1.5-mm BGA that weighs only one gram.

Developers need to take a number of factors into account—not just physical size or memory capacity. Performance is typically on the checklist, but application and data lifetimes matter. The latter can be more or less important depending on the technology employed. It is critical for flash storage, but less of an issue with technologies like MRAM. ED

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MARIA GUERRA | Technical Editor

What Exactly Is a SMART CITY?

According to the United Nations, two-thirds of the world's population will live in urban areas by 2050, leading many—from engineers to political leaders—to concentrate on developing smart-city initiatives.

The goal of smart cities is to improve the quality of life for its citizens through technological means, ultimately creating more sustainable cities. It is a team effort that requires many sectors of a society to safely and strategically integrate technology, information, and data solutions.

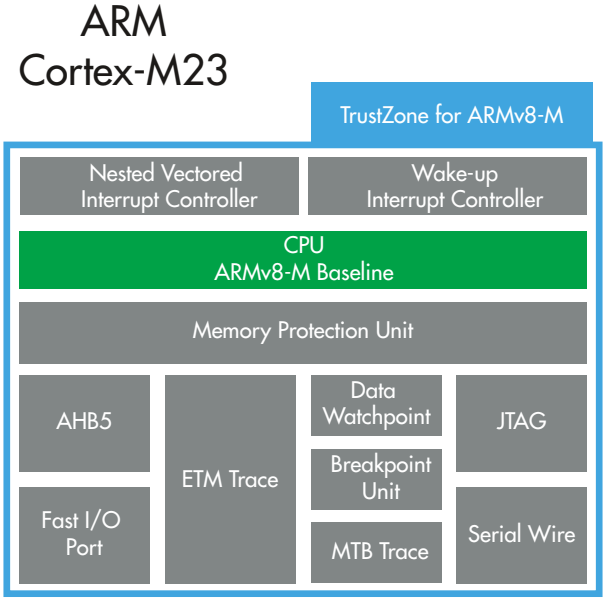
The vision of a smart city might differ for citizens living in different geographical locations, because every city has its own challenges and needs. Some of these diverse challenges include density of the population, infrastructure, topography, transportation systems, waste-management programs, or even the disposition of the local government and private business of investing money to create smart-city initiatives.

Smart cities are based on intelligent sensors. Data from those sensors is pulled and processed to create innovative programs or solutions associated with everyday aspects of city life, such as energy, utilities, urban mobility, public safety, air quality, waste management, education, healthcare, etc. Smart sensors can be found in utility poles, water lines, buses, traffic lights, etc.

Use of smart sensors is on the rise, with estimates that there will be 50 billion smart sensors connected by 2020. Those sensors are giving smart cities and the Internet of Things (IoT) a wide range of new applications that will help improve infrastructures and services.

Most of the power consumed by smart sensors comes from the wireless links used to transmit data, which means energy efficiency and security become paramount concerns. Thus, smart-city solution providers, system integrators, software designers, and chip designers are working together to develop more secure sensors that are power-efficient and easy to control and monitor, as the demand grows for low-power chips and more secure sensors.

Chipmakers like Microchip, Analog Devices (ADI), and NXP are actively working to develop better chip designs that meet low-power requirements for battery-power applications. For example, many battery-operated smart sensors are driven by microcontroller units (MCUs) made by manufacturers that licensed their MCUs from ARM. The latest ARM Cortex-M processor, the Cortex-M23 *(Fig. 1)*, specifically targets IoT devices and power efficiency to handle power in active and sleep phases of MCUs with the same energy efficiency of the Cortex-M0+.



1. The Cortex-M33 has a two-stage pipeline and a wakeup interrupt controller. *(Courtesy of ARM)*

COPENHAGEN LEADING THE WAY

Smart cities are emerging around the world, with the Danish capital of Copenhagen considered at the forefront because of its excellent urban-planning projects. Copenhagen has the ambition of becoming the first carbon-neutral capital by 2025. In fact, it has successfully started to apply sustainable city solutions to face climate changes. For example:

Smart cities are based on intelligent sensors. Data from those sensors is pulled and processed to create innovative programs or solutions associated with everyday aspects of city life, such as energy, utilities, urban mobility, public safety, air quality, waste management, education, healthcare, etc. Smart sensors can be found in utility poles, water lines, buses, traffic lights, etc.

- Increased mobility through integrated transport and cycling solutions has significantly reduced congestion and improved the health of its citizens. Approximately 45% of Copenhagen's citizens bike to work or school every day, which overall is a much healthier alternative than driving or taking mass transit.
- A new district cooling system, where cold water is taken from the harbor water, saves 70% of the energy compared to traditional air conditioning. Seawater and an environmentally friendly natural refrigerant—ammonia—are used for the cooling system. A central plant produces chilled water and then distributes it through a pipeline network to customers. When the seawater is cold enough (from November to April), just the seawater works alone in a free cooling unit with plate heat exchangers. During the other months, the seawater acts a cooling agent in the condensers of compressor chillers that use ammonia as a natural refrigerant. When demand is at its highest (summer time), the plant also uses an absorption chiller that runs on waste steam from a local waste incineration plant, a process called "absorption cooling."
- Nordic firms SLA Architects and engineering office Ramboll were the winners of the "Nordic Built Cities Challenge." They will redesign Copenhagen's Hans Tavsens Park and its surrounding areas alongside a team of architects, social bodies, and climate change experts. The £16 million project, called "The Soul of Nørrebro" *(Fig. 2)*, aims to regenerate the city's Inner Nørrebro area, particularly addressing the issue of cloudbursts (sudden, heavy bouts of precipitation that can result in flooding and other issues).

Meanwhile, in the United States, the U.S. Department of Transportation (U.S. DOT) launched a Smart City Challenge earlier this year, with the "prize" being a $40 million grant. The DOT received 78 applications, with the city of Columbus, Ohio, coming out on top.

Columbus proposed the deployment of three electric self-driving shuttles to link a new rapid transit center to a retail district, connecting more residents to jobs. The city also will use data analytics to improve healthcare access in a neighborhood that currently has an infant-mortality rate four times higher than the national average—it will allow the city to provide improved transportation options to those most in need of prenatal care.

2. When completed, Copenhagen's Hans Tavsens Park will serve as a rainwater catchment for the inner "Nørrebro" neighborhood capable of capturing and delaying of 18,000 cubic meters of rainwater at any given time. *(Courtesy of Dezeen)*

WHAT COMPRISES A SMART CITY?

As many cities around the world seek to become smart cities, how can we define and even rank a smart city? What are the indicators? Several smart city indexes (e.g., A.T. Kearney Global Cities, the Global Power City Index (GPCI), etc.) help make those determinations.

Let's take a look at the smart cities index prepared by the IESE Center for Globalization and Strategy, called "The Cities in Motion Index" (CIMI). CIMI takes into account 10 categories: economy, technology, human capital, social cohesion, international outreach, environment, mobility and transportation, urban planning, public management, and governance. The *table* (on page 22) shows the top 15 cities and their ranking according to the 2016 CIMI.

In the table, seven American cities are listed in the top 15: New York City, San Francisco, Boston, Chicago, Washington D.C., and Los Angeles. New York City is ranked first on the overall ranking due to taking first place in the economy category, third place in technology, and fourth place in the human capital, public management, governance, international outreach, and transport categories.

2016 CIMI TOP 15 SMART CITIES											
City	Economy	Human capital	Social cohesion	Environment	Public management	Governance	Urban planning	International outreach	Technology	Mobility and transportation	Cities in Motion (overall ranking)
New York City, U.S.A.	1	4	161	93	4	4	68	4	3	4	1
London, U.K.	3	1	129	20	33	16	66	2	8	3	2
Paris, France	11	6	91	64	44	31	30	1	24	6	3
San Francisco, U.S.A.	2	9	75	92	12	15	48	45	16	27	4
Boston, U.S.A.	8	2	30	88	7	4	65	80	21	15	5
Amsterdam, Netherlands	27	34	40	42	53	23	3	7	4	20	6
Chicago, U.S.A.	7	7	103	89	10	4	29	27	9	17	7
Seoul, Korea	20	13	11	53	38	21	73	22	2	1	8
Geneva, Switzerland	14	102	12	9	2	49	9	46	12	65	9
Sydney, Australia	18	21	70	32	16	25	28	32	7	22	10
Copenhagen, Denmark	34	61	3	15	163	11	1	34	26	30	11
Tokyo, Japan	5	8	69	27	56	71	133	17	1	34	12
Washington, D.C., U.S.A.	9	3	96	98	1	4	114	37	15	154	13
Zurich, Switzerland	19	80	8	1	25	18	101	49	34	7	14
Los Angeles, U.S.A.	4	5	112	124	14	9	127	30	17	24	15

CIMI = Cities in Motion Index. Courtesy of IESE Center for Globalization and Strategy.

NYC'S SMART APPROACH

The fact that New York City ranks first on the overall ranking doesn't mean that there's no room for improvement, though. For instance, it ranks quite low in the categories of social cohesion (161) and in environment (93). The city is trying to improve those areas through different initiatives, which include:

- *Smart Indoor Lighting:* The city of New York created the Accelerated Conservation and Efficiency (ACE) program to help decrease New York City's energy bill and reduce greenhouse gas emissions in city agencies. The numerous facilities of the New York City Fire Department (FDNY), for example, operate 24/7 and could be one focus area for significant energy savings. The ACE program installed smart-lighting solutions (including LED upgrades and advanced lighting controls), reducing energy use by an estimated 3 million kilowatt-hours and eliminating gas emissions by approximately 520 metric tons of carbon-dioxide equivalent annually.
- *Wireless Water Meters:* New York City's Department of Environmental Protection (DEP) has installed an advanced Automatic Meter Reading (AMR) system comprising more than 800,000 water sensors distributed throughout the five boroughs *(Fig. 3)*. The DEP system uses a combination of Aclara's STAR Network meter transmission units (MTUs) and data collector units (DCUs) to read meters and transmit data back to the utility. The MTUs read the meter and forward the data on an FCC-licensed wireless channel at customer-specified intervals.

3. Data collector units forward information directly to New York City's Department of Environmental Protection through Ethernet connections to the city's NYCWiN wireless system. *(Courtesy of SILive.com)*

- *Responsive Traffic Management:* The NYC Department of Transportation (DOT) established "Midtown in Motion," a smart-city approach to traffic management. Midtown in Motion uses microwave sensors, traffic video cameras, and E-ZPass readers to measure traffic speeds and spot congestion to remotely adjust traffic-signal patterns in the Midtown area of Manhattan, which covers an area of 270 blocks approximately. The data from the sensors and cameras is transmitted wirelessly in real time to the Traffic Management Center (TMC) in Long Island City, where engineers make constant adjustments to traffic signals. Current traffic data is captured by TransCore's RFID readers and other sensors, and then transmitted via NYCWiN

(Continued on page 35)

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11 MYTHS About XYZ Color Sensing

With the emergence of nano-photonic interference filter technology, is affordable XYZ sensing the best answer?

With the recent application of nano-photonic interference filter technology, XYZ color sensing is moving out of the realm of laboratory instrument into more mainstream applications, including in-situ spectral sensing and lighting. In this article, we tackle 11 of the most common misconceptions about XYZ and its applications.

1. XYZ is just color like RGB, so who needs it?

Life (or at least light) is more than just red, green, and blue (RGB). In fact, when it comes to human vision, natural light sources deliver a broad spectral power distribution of visible light. Humans are fairly well adapted to the sun as our primary visible light source, and we're also rather discriminating about color. However, the eye can be fooled when it comes to emitted light—so much so that a simple mix of blue and yellow was enough for us to see the early LEDs as white. But our eye isn't so easily fooled when it comes to reflected light, especially in relation to color perception.

A particular color is perceived by an object reflecting some combination of wavelengths. In the simplest terms, the color has to be in the light in the first place. If some wavelengths are missing, the color isn't represented accurately. For quick proof of this assertion, pull up a blank white screen on your monitor, and then use it as a light in a somewhat darkened space. Skin tone is a good thing to evaluate with this makeshift RGB light source; what you'll see can be enough to send you to the doctor to figure out why you look so sickly.

XYZ is the model for the standard response curve of the human eye, and is a result of how the long, medium, and short photoreceptor cone cells in the retina respond to spectral power distributions of light. You can see in the figure that while generally representative of the red, green, and blue areas of the visible spectrum, it does not match an actual RGB distribution.

It's not difficult to imagine that if you draw some vertical lines representing a few reflected wavelengths that make up a color, you would get very different channel counts from an XYZ filter set, as compared to an RGB filter set. In fact, no amount of math can create an accurate value when data (wavelengths that weren't sensed) aren't present in the dataset.

2. XYZ sensors are expensive.

This myth was true in 2015, but not today. Interference filter technology, which builds up filters layer by layer in a CMOS-like process, has intersected high-volume integrated-sensor semiconductor manufacturing. The result is XYZ sensing that's accurate and well-priced (generally $2 or less in high volumes). These benefits open up a host of new appli-

cations that did not make commercial sense just a few years ago.

3. XYZ sensors are only for high-end applications and won't make sense for applications such as lighting.

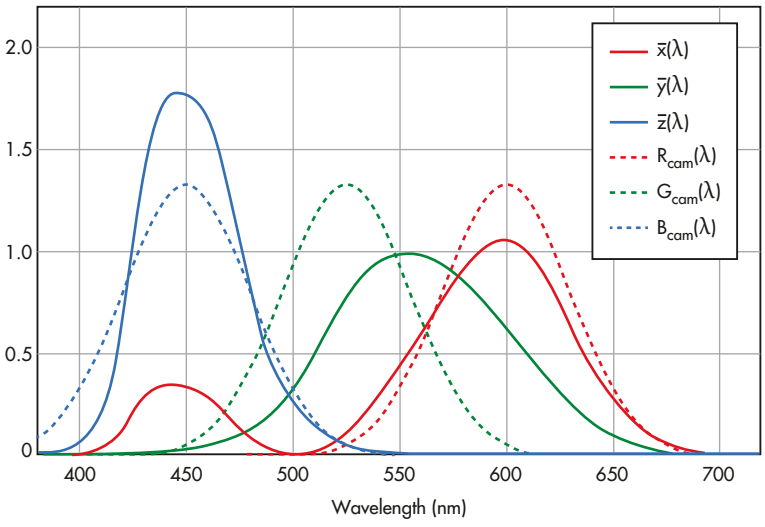
If it's agreed that XYZ is better for general color sensing, then the issue becomes one of value. When cost isn't much of an issue, the argument against XYZ for cost-sensitive applications such as standard commercial-grade lighting, and perhaps even replacement lamps and tubes, goes away. Granted, there is a cost, and throwing in an XYZ sensor just because it sounds cool doesn't make sense.

If, for instance, light-to-light consistency over the full lifetime of a white/color tunable LED light is important, XYZ does makes sense. That's because human color perception is typically discriminating enough to clearly spot a color difference between two adjacent color points that are just 0.2% apart. That means humans are very good at spotting the difference from light to light, so consistency requires sensing. For those who wish to lower their overall component costs, have access to a more cost-effective driver, or liberate a white- or color-tunable design from being captive to a single type of LED and supplier for ever and ever, then XYZ sensing can provide more than a little value.

The point of sensing in the first place is to find out what's going on, and the reason to find out what's going on in terms of color with a light is so it can be adjusted. What's intriguing about the concept of closed-loop sensing is it will often enable a system designer to use lower-precision components, and gain a higher precision and/or more feature-filled result.

For example, the designer of a car's power window could include highly precise window molding and manufacturing alignment, plus millimeter-accurate drive motors, or the designer could add a force-feedback sensor so that when the window hits the limits (either up or down), it stops the motor. In the latter case, lower-priced motors and looser tolerances on the glass could do an equally good job, and the designer has the benefit of an auto-stop if a finger or other object gets in the way. The result is a better product at lower cost.

That's not to say that there isn't a place for higher-end XYZ sensors. Companies get what they pay for in terms of sensitivity, dynamic range, or out-of-band rejection. Those can be important factors in some types of spectral sensing or in very low-light color sensing (admittedly it's difficult to tell why one might care about color in low light, but no one knows what the next great app will be).



XYZ sensing enables color perception analogous to the human eye.

4. XYZ is complicated.

XYZ is complicated… at least when it comes to building a sensor to interpret it. Fortunately, the semiconductor R&D team only has to figure out that part once. Taking an XYZ value and mapping it to a color point or CCT is well-known "plug in the equation" math. That makes it simple for the rest of us to use XYZ sensing in our applications. And, conveniently, XYZ data is readily convertible to all kinds of other color maps, including RGB, sRGB, CIE-L*ab, L*ch, or L*uv.

5. XYZ sensors are large and power-hungry.

Those who define "large" as anything bigger than a square millimeter will find XYZ sensors to be large. But this myth is busted for those who are okay with a device that's on the order of 2 × 2 mm. For power use, 150 µA in a high active state and 5 µA in sleep state makes XYZ just another low-power light sensor.

6. XYZ is of no use in a mobile device.

Often, designers need to see the technology is there to visualize its best application. Therefore, it's likely that if a desirable app can make good use of true color-point detection in a mobile device, then, all else being equal, XYZ sensing will be of use. In this case, though, all else is not equal: XYZ gives a better result, and doesn't necessarily have to cost more. Once a good app or two appear, XYZ will be in heavy demand to serve applications we had not originally imagined, but that will be highly useful.

7. XYZ calibration changes over time.

The XYZ sensor consists of several pieces—the filter, the diodes, and in an integrated device, analog-to-digital

converters and some logic to provide a standard interface, such as I2C. Like most CMOS technology, the diodes and logic are all very stable over their lifetimes. Diode responses can vary greatly over temperature. However, that's very straightforward to compensate for the addition of a dark channel, which delivers up a baseline count versus temperature that serves as a reference relative to the rest of the diode set. Subtracting the dark count from the active count on any particular channel provides the temperature-compensated value.

Because the filter response curves aren't standard Gaussian designs (for instance, the extra bump in the blue region for the mostly red X curve), organic blocking filters, which do change over time, aren't really an option for building an XYZ-shaped filter curve. The new generation of XYZ filters are typically based on interference filter technology, which involves complex layers of materials such as silicon dioxide effectively built up as glass in a CMOS-type process. Those filters are as stable as high quality glass.

In our labs at ams, we've seen the filter shift over temperature of approximately 1 picometer per degree Celsius. For a typical –40 to 85°C device, that's less than one tenth of a nanometer across the visible range of 390 to 700 nm. That stability over lifetime and temperature range means that for all intents and purposes, a calibration done on any interference-filter-based XYZ sensor is good for life.

Incidentally, RGB filters are now being built with interference-filter technology as well. That comes in handy for RGB applications where sensing how much R, G, and B are present is important. However, it's not the best option for true color identification.

8. I can convert RGB to XYZ, so I don't need XYZ.

Given that the human sensitivity to differences in color is on the order of 2/10ths of 1% or less, RGB can provide a decent answer, but not a perfect one. It's important to note that if an RGB sensor was calibrated in a specific light, it can give very accurate color-point results for that specific light.

The advantage of XYZ is that it gives true color-point identification for light in general. By adding some intelligence, it gains the advantage of being calibrated as part of the chip manufacturing and test. That can eliminate the need for light-by-light calibration as part of the luminaire manufacturer's build/test process, which can result in substantial time and cost savings. And with interference filters, that's a lifetime calibration.

9. No applications require XYZ.

There certainly haven't been many deployed applications using XYZ beyond light meters and other tools to evaluate lights and lighting, perhaps in some photography and broadcast settings, too. So, it's true that not many applications benefit from XYZ sensing. However, that's not to say many applications could benefit from XYZ sensing.

Tunable lighting is an obvious area that may very well benefit from true color metrics, as can some display technologies. With affordable XYZ sensing, we can also expect to see the emergence of myriad new spectral sensing applications.

One new application that has recently surfaced is portable true color evaluation for paint matching. Typically, consumers would have to take a swatch of material or a chunk of painted wall to the paint store, so that it can be analyzed for a matching color. Now they can use a compact, affordable instrument that will evaluate a color in-situ and then, with the help of a smartphone app, identify the exact paint code needed for a perfect match from a variety of paint manufacturers.

We can also expect to see a rapidly growing set of applications as XYZ sensors begin to appear in mobile devices, or as add-on accessories. "Enable it, and the apps will come" is becoming a standard mantra for many of our mobile devices.

10. There are no XYZ sensors on the market.

The expertise, technology, and equipment to build XYZ sensors is complex, so only a handful are on the market. However, they're in production and available in several performance ranges from at least one large sensor manufacturer.

11. XYZ sensing always gives a better color answer.

Unfortunately, XYZ sensing doesn't always provide a better color answer. It does give a better answer for the reflected true color of an object. However, when it comes to light sources, XYZ, similar to the human eye, can be fooled.

Fluorescent lamps are a case in point. If one makes a quick comparison of the spectral power distribution from a typical compact fluorescent light (CFL) to that of a warm LED, it's clear that the CFL has several distinct spikes. It's not by coincidence that those spikes match with the original color-rendering index test swatches.

While the easy path to efficiency is to produce only the wavelengths of light needed to obtain a good grade on the test, that's not the best path to good color rendering of objects. If one evaluates the color of a CFL with an XYZ sensor calibrated for a more broadband light source, it can't distinguish exactly where under the curve the energy is coming from, which can limit the accuracy. In that case, a sensor with more individual, narrower-band color channels could provide a better answer in identifying the color of the emitter. Those sensors also are currently available. ed

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JOHN SIMPSON | Contributing Editor

Dodd-Frank in the Crosshairs as Conflict-Mineral Controversies Loom

The electronics industry's efforts to rid its supply chain of metals sourced from conflict-ridden areas could keep Dodd-Frank on the front burner.

Prospects for the repeal of some or all of the 2010 Dodd-Frank Act received a boost with the November election of Donald Trump as President and the return of Republican majorities to both houses of Congress.

Just how much relief that would afford electronics manufacturers—assuming such repeal were to include the lifting of disclosure requirements regarding sourcing of conflict minerals—is open to question, however. Impending European Union (EU) conflict minerals regulations, continuing pressure from the public and non-governmental organizations (NGOs), and the electronics industry's own voluntary efforts to rid its supply chain of metals sourced from conflict-ridden areas could well keep the issue on the front burner.

For his part, the new president wasted little time following the election to underscore his desire to repeal the sweeping financial industry reform bill enacted in response to the 2008-09 recession. "The Financial Services Policy Implementation team will be working to dismantle the Dodd-Frank Act and replace it with new policies to encourage economic growth and job creation," his transition website stated.

Trump will have a key ally in House Banking Committee Chairman Jeb Hensarling (R-Texas), sponsor of the Financial Choice Act, which would, among other things, wholly repeal the conflict minerals provisions of Dodd-Frank. Since the election, Hensarling has reaffirmed that the bill—passed by

> "What I hear from our member companies is that it's been difficult to comply with Dodd-Frank with respect to conflict minerals because the supply chain is very convoluted. There are really very few accurate ways to determine where the ore comes from."
>
> —Robin Gray, Electronic Components Industry Association

the committee in September 2016 but never a likelihood to become law in an election year—is likely to form the basis for new repeal legislation he expects to introduce in 2017.

"It would not be appropriate for us to speculate on what the new administration may or may not do regarding specific legislation," says Leah Butler, program director at the Conflict-Free Sourcing Initiative (CFSI), a broad-based association of manufacturers from the electronics and other industries that provides resources to help companies source conflict-free minerals. Noting that the organization predates the Dodd-Frank Act (DFA), she added that CFSI "will continue its mission to facilitate responsible sourcing regardless of what happens to DFA."

Among the compliance tools CFSI provides electronics companies and other manufacturers is a program to help them assess the conflict status of the smelters and refiners that produce the tantalum, tin, tungsten, and gold that are incorporated into their products. To be included on CFSI's list of conflict-free smelters, a facility must undergo an independent, third-party audit process. Butler says the process is now being updated to include a broader definition of conflict-affected and high-risk areas that will include, "but will not be limited to," the 10 countries named in the Dodd-Frank Act. Those new requirements will take effect in mid-2017, she says.

Identifying those smelters that are conflict-free could help streamline the process for compliance with the spirit, if not the letter, of Dodd-Frank.

"What I hear from our member companies is that it's been difficult to comply with Dodd-Frank with respect to conflict minerals because the supply chain is very convoluted," says Robin Gray, chief operating officer and general counsel at the Electronic Components Industry Association (ECIA). "There are really very few accurate ways to determine where the ore comes from. And there are lots of ways to circumvent that provision without going to costly, extreme measures to ensure some sort of compliance."

NEW EU REGULATIONS

Moreover, CFSI's broadening of its definition of conflict-affected areas beyond the Democratic Congo and the nine countries that adjoin it could also help sync its voluntary compliance program with conflict minerals regulations forthcoming from the EU.

On November 22, the European Council and European Parliament reached an "informal deal" on binding regulations aimed at stopping the financing of armed groups through trade in conflict minerals. The agreement—which has yet to be ratified—pertains to EU imports of the same four minerals identified in Dodd-Frank but extends the coverage to all countries in the world. Formalization of the accord—in the form of a final vote by the European Parliament—is expected in 2017, with provisions to take effect in 2021.

"That's one of the reasons we can't really put the cat back in the bag—other countries have started along this road as well," says Mike Kirschner, president of Design Chain Associates, which consults with manufacturers on improving their products' environmental performance. "The European Union is on its way to implementing a conflict materials regulation. China has a voluntary approach, but people expect that to become mandatory at some point as well."

Kirschner adds that there are vocal factions—among social-justice NGOs, retailers, consumers, and investors—that have a strong interest in seeing manufacturers deal with the conflict mineral issue rigorously. Those parties are not likely to take the pressure off electronics manufacturers in the event of the repeal of the Dodd-Frank law, he says.

"A lot of organizations, companies, and executives truly *want* to be part of the solution to stem the violence [in the conflict-ridden areas]," says Pamela Gordon, senior consultant at Antea Group, an international engineering and environmental consulting firm. "But many people in the electronics industry honestly weren't aware of it until the conflict minerals rule."

In addition to exercising control over decisions on where and from whom they source minerals, companies also have a degree of choice over which materials their products are manufactured from to begin with, Gordon notes. Some companies are now looking at specifying recycled minerals, which would avoid the issue of potentially benefiting armed groups that are financed by conflict smelters, she says.

With EU conflict minerals regulations on the horizon, ECIA's Gray says that companies' compliance activities could become more arduous than ever—particularly if Dodd-Frank's conflict minerals provisions stay intact.

"It's a global economy and electronic components move all around the world and go into a variety of different industries and products," he notes. "If you have any sort of scale at all, your products are likely to be subject to European regulation and U.S. regulation—and anyone else, too. If you have to comply with multiple government regulations, it can be a real challenge."

KARTHIK RANJAN | Director of Healthcare and Emerging Technologies at ARM
www.arm.com

The Future of DIGITAL HEALTH

Smartphones and health apps continue to grow as key vehicles for managing personal health care.

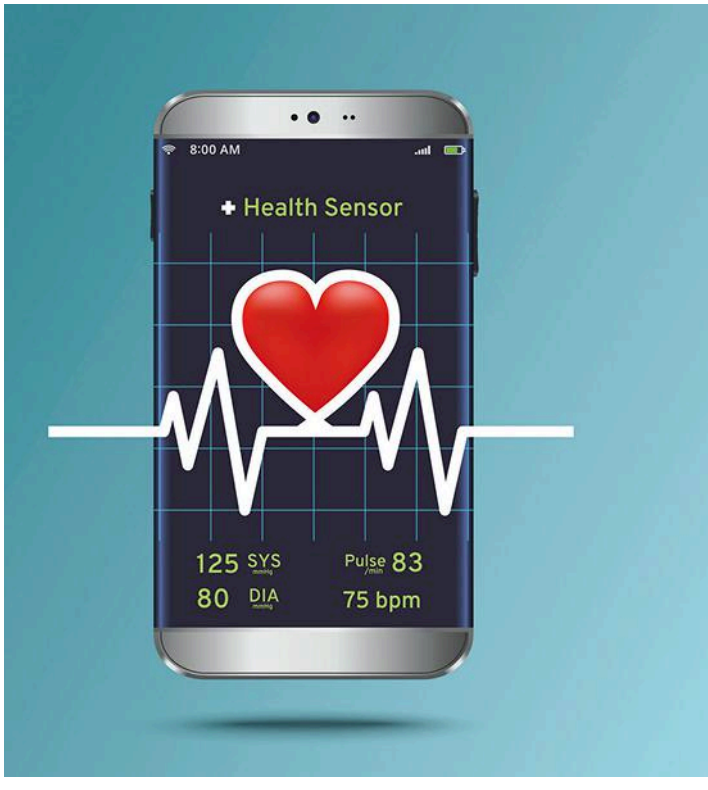
Over the next 15 years, global health care will transform due to perfect storm of clinical imperative, financial burden, and increasingly informed and empowered patients. A growing population, steadily decreasing health care budgets, and the rise of chronic diseases are putting pressure on doctors, health care providers, and governments to look to technology to provide the solution to these challenges.

As a result, global health care and wellness is ideally placed to drive the adoption and maturity of the Internet of Things (IoT). The smart technologies commonly found on a person such as the smartphone, smartwatch, and new emerging technologies like smart plasters, will be at the heart of this revolution, providing insights that will deliver benefits to the physical, emotional, and mental self.

SMARTPHONES AS VEHICLES FOR HEALTH MANAGEMENT

The smartphone is seen by many as their primary compute device—nearly two-thirds of American adults (64%) now own a smartphone, according to survey done in 2015 by Pew Research. Today's smartphone has fingerprint sensors, a camera, and the ability to connect via Bluetooth to activity monitors and medical devices like blood pressure monitors and ECG machines. Sensors are delivering ever more valuable and accurate data, and in the future we will see an increasing number of these distributed over the body cooperatively collecting and processing continuous data.

Moving forward, multiple sensors will be delivered within fabric garments, adhesive patches, and jewelry-type form factors, depending on personal choice and monitoring requirements. Together, this will transform the smartphone into an effective, personal vehicle for health management.



Evidence of this can already be seen, with leading insurance providers in the U.S. subsidizing the cost of the Apple watch for their patients.

IMPACT ON HEALTHCARE, PERSONAL HEALTH, AND THE MARKET

Based primarily on face-to-face interactions between physician and patient (visit to the doctor, flu shot at work,

or annual exam), existing protocols of treating patients are outdated and place undue pressure on current government and non-government structures. Remote health monitoring opens up a brand-new protocol of how a physician treats a patient, with continuous information being collected from the patient—for example, someone coping with a chronic disease such as diabetes or congestive heart failure.

With this approach, physicians and loved ones are in a position to learn and provide better quality of care via deeper, more meaningful engagement with the patient. More actionable information is being continuously captured, ultimately reducing cost to the system. It will also result in curbing the growth of chronic diseases: Genomic research will rapidly lead to clinical reality, and this information must be enhanced with lifestyle monitoring to accurately predict the onset of chronic disease with enough warning to allow effective treatment.

The connected health market is expected to see something close to $117 billion revenue by 2020. As the smartphone and smartwatch evolve into the key vehicles for personal health, this will spurn massive innovations in wellness and medical sensors in, on, and off the body, and on the smartphone itself. New and emerging OEMs will be able to monetize the data collected versus just the hardware, enabling a vibrant ecosystem to develop. This stands in stark contrast to today's model, which is limited to current major OEMs.

HOW MUST TECHNOLOGY EVOLVE TO MAKE THIS A REALITY?

Three of the key areas we need to consider for the success of health-care IoT can be broadly split into the categories of low-power medical and wearable devices; communication between sensors, smartphones (gateways) and the cloud; and security:

- For wearable and medical devices, battery life is imperative. ARM and many of our partners are looking into near-threshold voltage for embedded-class devices. The race is on to get to the lowest power with sufficient compute to obtain the maximum number of critical biometrics.

Key biometrics to be obtained include body fat; photoplethysmogram (PPG) for heart rate and respiration; electrocardiogram (ECG) to measure heart rate, rhythm, and general health of the heart; skin temperature; blood oxygen (SpO2); blood glucose; and blood pressure. Together, these form the crux of the core biometrics required to manage chronic diseases including, but not limited to, hypertension, diabetes, congestive heart failure, and COPD, as well as many of the patients who have comorbidities.

With a long history of ultra-low power and high performance, the ARM Cortex-M family of processors can run many of the algorithms involved in collecting these biometrics. Non-toxic batteries are also important to extend the usage of wearable devices over a long period of time.

- The smartphone is an ideal gateway platform for aggregating data from various medical sensors and for engaging with patients. It's critical to have sufficient security and privacy in place to ensure that data is not stolen, and there's sufficient ability to authenticate and validate the data from user and device.

As sensors on the body need to be able to last for multiple days without recharging, it's imperative that the power budget used for communications is kept to the bare minimum while maintaining compatibility across billions of smartphones already deployed into the market. Already designed into billions of smartphones, Bluetooth Low Energy (BLE) is the most ubiquitous, low-cost radio solution for transmitting data from wearable sensors to be able to talk to the smartphone. ARM Cordio BLE solutions provide a platform for silicon vendors looking to design low-power silicon solutions for medical wearable applications to talk to the smartphone.

- Finally, in the cloud, beyond securing the data, we also need to act upon the data. Predictive analytics and machine learning can play a key role in reshaping the healthcare industry, starting with enabling device manufacturers, caregivers, and pharmaceutical players to improve the quality and the delivery of care we provide to the patient.

The ultra-low cost of BLE combined with low-power embedded processors such as the ARM Cortex-M family can enable developers to easily and cost-effectively integrate connectivity into billions of previously unconnected medical sensors and diagnostics tools. For example we will see connectivity being added to diagnostic devices ranging from HIV, glucose, pregnancy, and chem7, just to name a few.

It's self-evident and imperative that data from such devices is kept secure, private, and only shared with trusted third parties with whom the patient consents to share this data. Solutions such as ARM CryptoCell and ARM TrustZone on both the sensors and the gateway are designed to ensure that data is kept absolutely secure and private from the time of acquiring that data (at the sensor) to the data validation, identity tagging, and consent acquisition of that data at the smartphone. As a result, that data can then be shared with trusted entities in the cloud whom the patient provides digital consent (for example, by swiping their fingerprint). ED

KARTHIK RANJAN is the director of healthcare and emerging technology at ARM. Based in Seattle, Karthik is responsible for strategy in the healthcare vertical, helping the healthcare industry to utilize ARM's low-power, high-efficiency technology in developing new services and increasing operational efficiencies.

MICHAEL WHITE | Mentor Graphics

Are You (Really) Ready for Your Next Node?

Unrelenting transistor scaling has more than a few companies jumping a technology node, but they need to be aware of the challenges that brings—some of which are not so obvious.

The transistor scaling that has been the engine of our industry for 30-plus years continues to relentlessly march forward. We are now about to begin production on the industry's third multi-patterning node—7 nm.

One of the most interesting trends I'm observing is the number of companies choosing to jump a technology node. Of those opting to go that route, skipping to 7 nm seems particularly popular. Skipping any node brings some real challenges, including some that aren't always recognized or planned on.

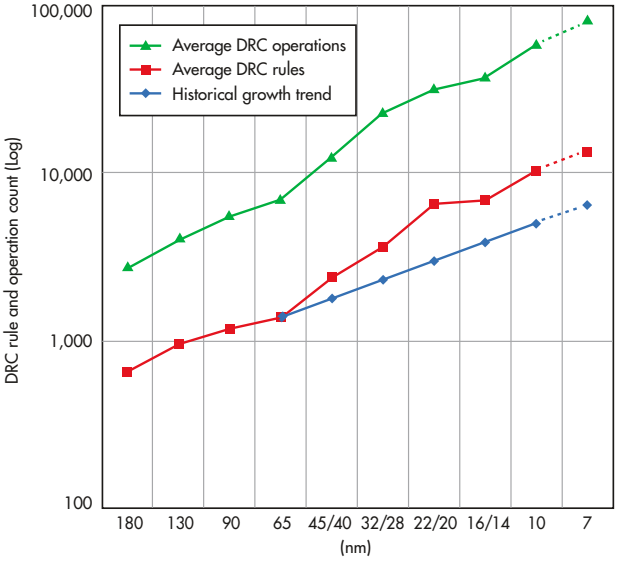
THE COMPUTATIONAL EXPLOSION

Physical verification (i.e., design rule checking, or DRC) just keeps getting harder and harder, whether you're jumping from 65 nm to 28 nm, or the scariest leap—from 28 nm to 16/14 or 7 nm. Stuck with 193-nm lithography for at least 18 more months (best case), foundries have had no choice but to add more design rule checks to ensure manufacturability at these nodes.

The *figure* shows us that since 40 nm, the industry has, on average, been increasing check count by 20-30% every node. Similarly, the complexity of each check also is increasing node over node in concert with the growing complexity of the process. For 20 nm and below, multi-patterning techniques have been essential in enabling the industry to continue to progress along Moore's law for transistor scaling. However, their use also means significant additional computation.

From a foundry deck perspective alone, one must account and plan for a huge computation increase. This is especially the case for those considering jumping more than one node (e.g., 65 nm to 28 nm = 3.2X; 28n m to 16/14 nm = 1.6X; 28 nm to 7 nm = 3.6X).

For very sound manufacturing reasons (to minimize design variability) at the 32/28-nm node, the foundries transitioned from minimizing the number of inserted fill shapes to maximizing the use of fill shapes. At 10 nm and below, these fill shapes are now also being placed at the single mask spacing constraint. Both of these trends have put significant additional computation demand on both the generation and physical verification of DRC-clean fill.



Design rules and operations climb as the technology node scales down.

The entire purpose of pursuing Moore's law for transistor scaling is to deliver more transistors per unit area over time. As an industry, we have been delivering approximately 2X more transistors per technology node, enabling all of the IC-based products our society relies upon. Of course, 2X more transistors per technology also means additional computation effort at each technology node.

LINEAR TECHNOLOGY

DESIGN NOTES

560V Input, No-Opto Isolated Flyback Converter

Design Note 559

George Qian

Introduction

In traditional isolated high voltage flyback converters, tight regulation is achieved using opto-couplers to transfer regulation information from the secondary-side reference circuitry to the primary side. The problem is that opto-couplers add significant complexity to isolated designs: there is propagation delay, aging, and gain variation, all of which complicate power supply loop compensation and can reduce reliability. Moreover, during start-up, either a bleeder resistor or high voltage start-up circuit is required to initially power up the IC. Unless an additional high voltage MOSFET is added to the start-up components, the bleeder resistor is a source of unwelcome power loss.

The LT®8315 is a high voltage flyback converter with an integrated 630V/300mA switch. The LT8315 eliminates the need for an opto-coupler, complicated secondary-side reference circuitry, additional start-up components, and an external high voltage MOSFET.

Performance and Simplicity

The LT8315 integrates a 630V MOSFET and control circuitry inside a thermally enhanced 20-pin TSSOP package with four pins removed for high voltage spacing. By sampling the isolated output voltage from the third winding, no opto-coupler is required for regulation. The output voltage is programmed with two external resistors and a third optional temperature compensation resistor. Boundary mode operation helps to achieve excellent load regulation. Because the output voltage is sensed when the secondary current is almost zero, no external load compensating resistors and capacitors are needed. As a result, the LT8315 solution has a low component count, greatly simplifying the design of an isolated flyback converter.

Figure 1 shows the complete schematic of a flyback converter with a wide input range from 20V to 450V. It has a 12V output and maintains tight regulation with a load current from 5mA to over 440mA. The output current capability increases with input voltage, the output current could reach 440mA when the input voltage exceeds 250V. This flyback converter has 85% peak efficiency. Even with no opto-coupler, load and line regulation remain tight, as shown in Figure 2.

Internal Depletion MOSFET for Start-Up

The LT8315 features an internal depletion mode MOSFET, which has a negative threshold voltage and is normally on. At start-up, this MOSFET charges the $INTV_{CC}$ capacitor to 12V so that the LT8315 has

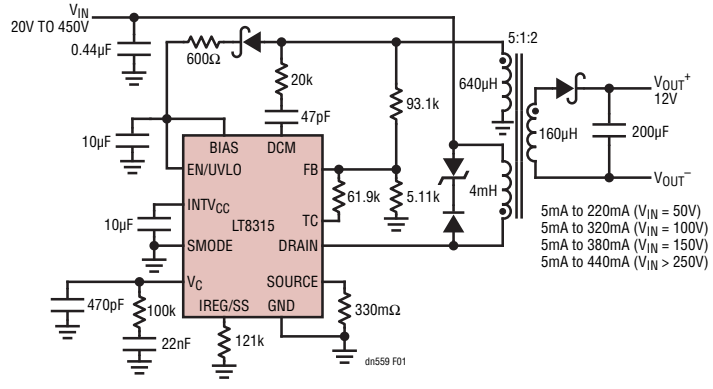


Figure 1. A Complete 12V Isolated Flyback Converter for a Wide Input from 20V to 450V

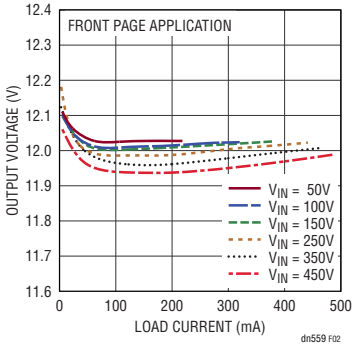


Figure 2. Load and Line Regulation of the Flyback Converter in Figure 1

power to begin switching. As a result, there is no need for an external bleeder resistor or other start-up components. Once $INTV_{CC}$ is charged, the depletion mode MOSFET turns off to reduce power loss.

Low Quiescent Current

The LT8315 typically requires a small preload at the output, which reflects back to the input as quiescent current. As the load gets very light, the LT8315 reduces the switching frequency while keeping the minimum current limit in order to reduce current while properly sampling the output voltage. The typical minimum switching frequency is about 3.5kHz. When the standby mode is enabled, the minimum frequency is further reduced to 220Hz, which is a 16× reduction for ultralow quiescent current.

In standby mode, the LT8315's preload is usually less than 0.1% of full output power, the quiescent current is lower than 100µA—important for applications requiring high efficiency in always-on systems.

Nonisolated Buck Converter

The LT8315's high voltage input capability is easily applied in nonisolated solutions. Nonisolated converters do not require the transformer of an isolated converter, instead adopting a relatively inexpensive off-the-shelf inductor as the magnetizing component.

For a nonisolated buck application, the LT8315's ground pin is connected to the switch node of the buck topology, which is a varying voltage. The unique sensing scheme of LT8315 sees the output voltage only when the switch node is connected to ground, which leads to a simple buck schematic, as shown in Figure 3. The diode, D2 and two resistors at the FB pin form the feedback path.

Figure 3 shows the schematic of a nonisolated buck converter, which converts an extremely wide-ranging input of 20V to 560V, to a regulated 12V output. This circuit can achieve efficiency as high as 85%.

Conclusion

The LT8315 operates at a wide input voltage range of 18V to 560V, delivering up to 15W of isolated output power. It requires no opto-coupler, and includes rich features such as low ripple Burst Mode® operation, soft-start, programmable current limit, undervoltage lockout, temperature compensation, and low quiescent current.

The high level of integration simplifies the design of low component count, high efficiency solutions in a wide variety of applications: from battery powered systems to automotive, industrial, medical, telecommunications power supplies and isolated auxiliary/housekeeping power supplies.

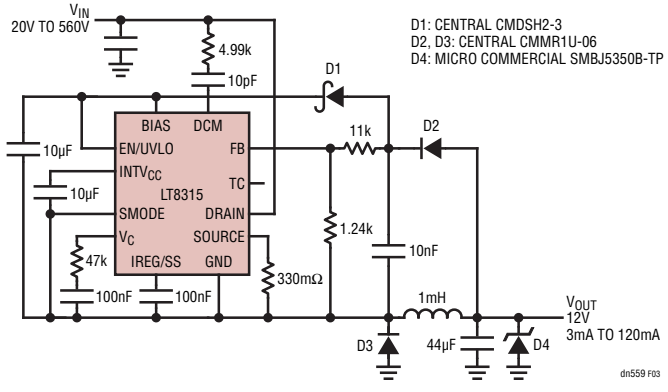


Figure 3. Schematic of a Nonisolated Buck Converter: 20V to 560V Input to 12V at 120mA

Data Sheet Download

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IP COMPLEXITY

The growth in computational effort isn't limited to block and full chip implementation and verification. Where historically it was common for custom and intellectual-property (IP) designers to run DRC and other verification tools on single CPUs, now it's common to run on four CPUs or more.

Growth in the effort per design team isn't just limited to computation: With ever-increasing complex designs, the number of designers needed per design project expands when moving to advanced nodes for both analog/custom and digital implementation. In analog/custom designs, I've seen this staffing need being driven by the rapidly growing number of analog and mixed-signal blocks in a design, an increasing number of complex circuits in nm-node analog, more power-saving modes, etc. Over the last five years or so, it hasn't been uncommon to hear of 50% node-over-node IP designer staffing increases.

There are so many new and evolving techniques at leading-edge nodes (e.g., multi-patterning, advanced fill, design for manufacturing, etc.) that I think I'll save them for a more detailed discussion in another article. Suffice to say that the changes are not only numerous, but challenging to implement.

STAFFING AND RESOURCES

Lack of proper and timely preparation to manage the increase in computation requirements is an issue we're seeing with more companies than would be expected. For quite a few of these firms, we have heard things along the lines of "back in the day, we didn't need to add more resources when jumping to a new node and we still had reasonable DRC, etc. run times—so we didn't budget for more resources," or "My annual budget increase is 10%, so that is all we have." For advanced nodes, and certainly for a node jump, under-investing in computing resources simply results in slower design turns and a longer schedule to market.

Staffing at a rate that can keep up with the increased design effort is another challenge, to be sure. In quite a number of cases, the need for additional headcount is understood. Often, though, a smaller-than-needed staff increase is added, or the staffing ramp is started later than needed to bring in a full team and on-board them to the point where they are firing on all cylinders.

Technical training has been an occasional problem, but most of the companies who reach out to their EDA supplier will get the help they need. The two issues above are the dominant problems we see with many across the industry.

WHAT TO DO?

First, think long and hard about skipping nodes. Yes, certain market situations may dictate that a company must skip a node to try and catch up with its competitors. But if there's any reasonable ability to continue the normal progression, do so. There is so much progressive learning node over node now, and the need for this learning doesn't go away with a node jump. You'll just end up compressing that learning into the critical path of your next design, while management still expects you to complete that design with the same or shorter schedule as the last one. This can only end in tears.

The idea that a design team can get away with the same compute resources as they had for their last design (or some small percent increase) is a pipe dream. This is especially true with a node jump. Industry-leading tools like the Calibre nmDRC and Calibre nmLVS platforms continuously improve the speed of their engines, and partner with the foundries to optimize the foundry-written decks. However, with the exponential node-over-node increase in compute demands, the use of scaling (more resources) is the only remaining means to maintain constant turnaround time.

Collaborate with your EDA partner early to accurately forecast what your compute resources will need to be for that next design. Use this data to justify to management the investment level that's really required to meet cycle-time goals.

Talk with your peer companies, IP providers, etc., to realistically plan for the right staffing level required with the more complex IP needed at that next node. Adequate staffing is especially critical if a node jump is mandated. Consider expanding your use of third-party IP or IP design services as a way to "flex up" in both capacity and next-node technical expertise. This is an option I'm seeing used more and more often, and it's why we're seeing a large number of IP companies working on multi-patterning node IP.

Using the EDA tools involved in developing the foundry's process can be extremely helpful. Because that EDA company helped develop the process with the foundry, it has a great deal of valuable experience in what will be needed to be successful at that node, and how you can avoid some of the largest obstacles.

If your company is like mine, it's now at the beginning of a new strategic planning cycle. Start planning upfront for all your compute and staffing needs that will help ensure a design implementation and verification cycle time that can successfully hit your next market window. Half measures and partial investment will result in late design tapeouts. It's one of those "you get what you pay for" scenarios. By planning early and realistically, you have a better chance of getting the budget approval for the needed investment, compared to trying to shoehorn in the additional resources and staff you will ultimately ask for after the fact. ed

MICHAEL WHITE is director of product marketing for Calibre Physical Verification products at Mentor Graphics in Wilsonville, Ore.

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(Continued from page 22)

to the TMC. Midtown in Motion not only manages the traffic, it also helps the environment by reducing greenhouse gases emitted by vehicles sitting idle in traffic.

- *Smart Waste Management:* The Department of Sanitation collects more than 10,500 tons of residential and institutional garbage and 1,760 tons of recyclables every day. One of the most deployed smart waste and recycling systems in New York is the Bigbelly. The containers, equipped with Qualcomm chips, use the integrated wireless sensors to detect trash level in real-time, alerting sanitation services to empty the bin.
- *The Lowline:* The goal of this unique project is to build an underground park using innovative solar technology to illuminate a historic trolley terminal on the Lower East Side of New York City, below Delancey St. The solar technology would transmit the necessary wavelengths of light to support photosynthesis, enabling plants and trees to grow *(Fig. 4)*. In the end, the Lowline will create more public spaces with green areas that New Yorkers will gladly welcome. The ongoing project will not open until at least 2021.
- *ShotSpotter:* The New York Police Department has started using a detection system that pinpoints the location of gunfire and sends the information to law enforcement. The system, called ShotSpotter, uses acoustics sensors. Detailed incident data is analyzed by a gunfire and acoustics expert, and once validated, an alert is sent to the police in under a minute.
- *LinkNYC:* This free communications network will replace over 7,500 pay phones across the five boroughs with new structures called Links. Each Link will provide fast, free public Wi-Fi, phone calls, device charging, and a tablet for access to city services, maps, and directions.

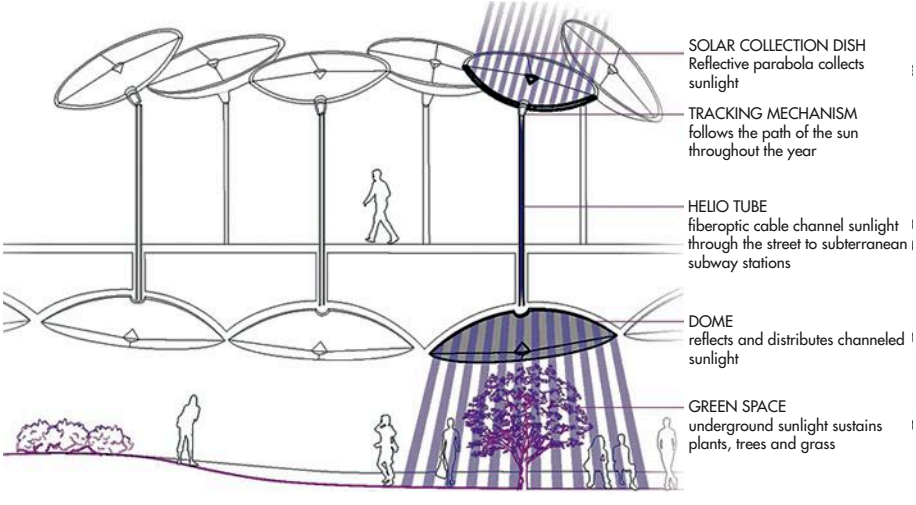
New York City consistently works to integrate advances in sustainability, resiliency, and technology. Just recently, the city was chosen as the Best Smart City of 2016 by the jury of the sixth edition of the Global Smart City Awards. Announced at the Smart City Expo World Congress *(Fig. 5)*, this award was created to recognize the most outstanding initiatives and projects in the urban innovation and transformation industry.

5. The Smart City Expo World Congress (SCEWC), which took place in Barcelona, November 15-17, 2016, was hosted by Fira de Barcelona's Gran Via venue.

Next year, NYC also will welcome an event that's an offshoot of the Smart City Expo World Congress: Smart Cities NYC '17. This event will spotlight new ideas from around the world through panel discussions, events for the public, and exhibitions. It will also highlight the innovations taking place around the five boroughs of New York City.

As evidenced by what's happening in New York example, the concept of smart cities includes a wide range of variables. A city that's successful in being "smart" will improve the quality of life for its citizens through the use of smart infrastructure and smart urban planning. Smart cities should also be able to help communities and empower them to evolve by making city life safer, easier, and greener while using technologies to resolve urban problems.

Even though the future of smart cities is very promising, many issues still must be addressed, such as a better scalable platform for safe and reliable network connectivity. As the participation of the private sector grows, so does the number of new initiatives. Thanks to partnerships with local governments, new cities are now looking to become smart cities, too.



4. In the plans for New York's Lowline underground park, sunlight is transmitted onto a reflective surface on a distributor dish, lighting up the space below ground. *(Courtesy of the Lowline)*

ideas for design

Test Technique Quantifies Jitter of Discrete-Comparator Design

By TIM DAVIS | Engineer

A COLLEAGUE ASKED for the measured jitter number on a single-supply comparator design based on the LM359 IC.[1] He wanted to know how the jitter performance of the discrete comparator compared to an IC comparator, which was used with an ultrasound application.

To set up the test, a special power-supply circuit was designed for the comparator as well as for a crystal-clock module with specified jitter. The power supply, clock, and comparator of the circuit *(Fig. 1)* were placed on a single printed circuit board (PCB) with ground plane. The board used a special scope probe-tip test point with a fitted, spiral ground wire, into which the probe's ground-sleeve can fit. (This technique is often employed to reduce parasitic ringing and give a good return ground.) The rms jitter for this commercially available crystal-based clock module (CTS MXO45HS-3C-1M0000, 5 ps maximum) was better than the comparator could provide.

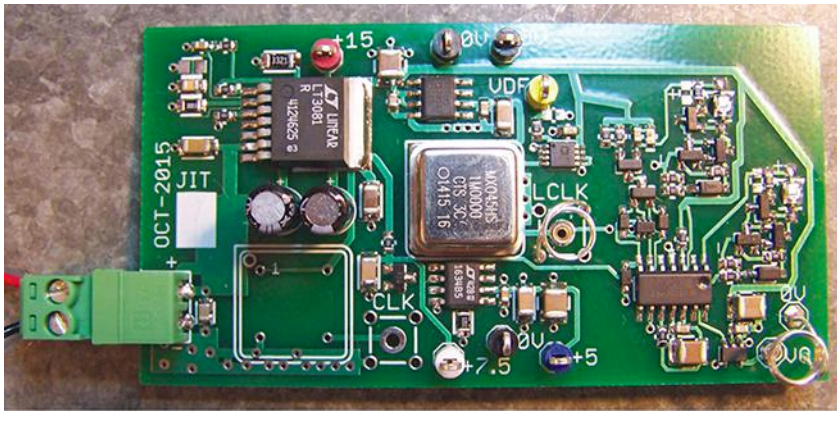
In the circuit *(Fig. 2)*, using R_{SET}, the main regulator (LT3081) can deliver +5 V to power either a basic clock, or +15 V to the level-shifted clock and comparator. The LT3081 was chosen as it is inherently stable with any type of load capacitance. Using this power configuration for flexibility, the non-level-shifted clock's jitter can be measured, or the jitter of the level-shifted clock and comparator can be measured. A 5-V reference (REF195) is biased in series with a 5-V shunt reference (LT1634B-5). The crystal clock's supply is powered with 5 V from the REF195.

The clock's output will swing between 5 and 10 V with respect to ground. The level-shifted clock is applied to the comparator's inverting terminal. The non-inverting comparator terminal is connected to +7.5 V, which is produced by placing another 2.5-V shunt reference (ADR5041B) in series with the 5-V shunt reference.

For test purposes, an instrumentation amplifier (AD8220) with unity gain is placed across the crystal clock's power-supply pins to measure the supply's stability during clock transitions. The integrated scope test points prevent significant overshoot and ringing on the high-speed edges of the signals from the level-shifted clock and comparator *(Fig. 3)*.

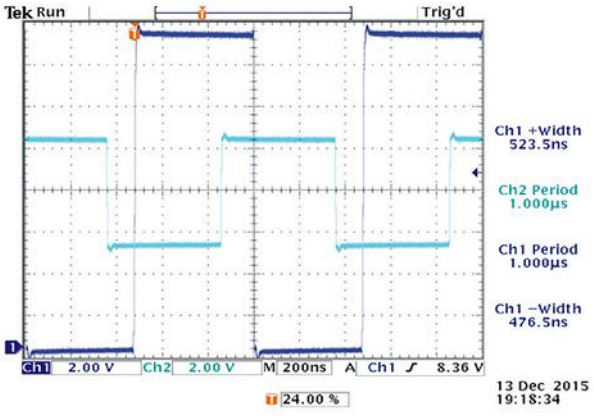
In order to develop a test method to determine the rms jitter, a Tektronix field applications engineer recommended the "TekScope Anywhere Waveform Analysis Application" to analyze voltage-versus-time data from long record-length captures. Data captures from a Tektronix MSO4034 (a 350-MHz, 2.5-Gsample/s scope) were in their .isf format and the collected file sizes were kept to less than 20 MB, to fit email-attachment memory limits and simplify working at different locations. Both the level-shifted clock and the output of the comparator had .isf files generated by the Tektronix scope.

The signals were ac-coupled to ease scaling of the input-signal traces and make better use of the analog-to-digital converter's input range without clipping. The scope settings included a sample rate of 2.50 Gsamples/s, record length of 10 Mpoints, V (clock) of 700 mV/div, V (comparator) of 1.8 V/div, time base of 100 µs/div, and ac coupling on each channel.

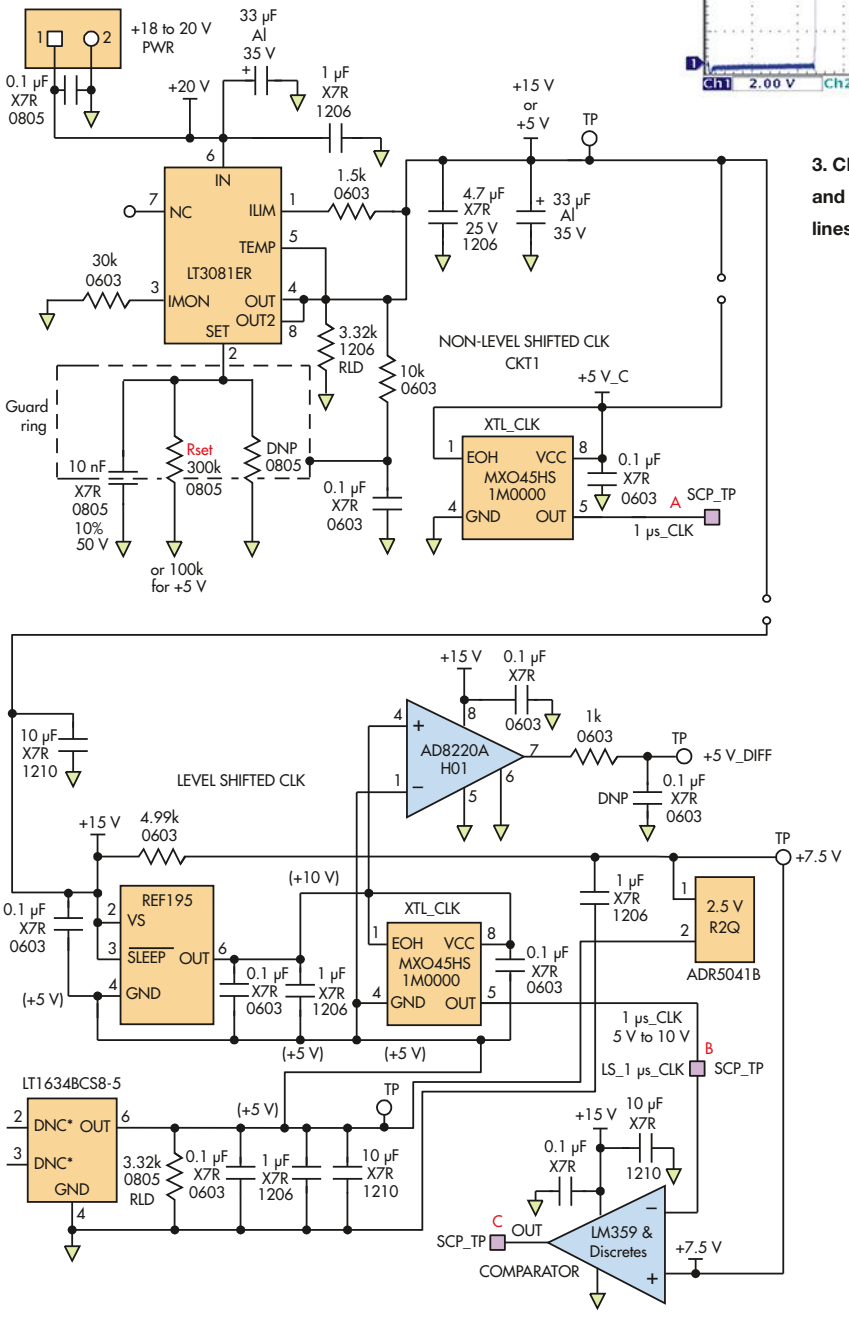


1. In the PCB of the circuit used to test the comparator with a low-jitter clock, the dual comparator is on the far right (one comparator is active, the second is "tied off" as a spare) and the CTS 1-MHz clock module is in the board center.

The measured jitter performance of the comparator—just 23-ps rms jitter at one standard deviation with a 1-MHz input clock—exceeded design expectations.



3. CH1 is the output of LM359 discrete comparator and CH2 is the input level-shifted clock; their baselines are coincident with each other.



2. The LT3081 power supply is configurable for driving one of two possible circuits in the schematic diagram of the test board used to test comparator jitter.

The trigger method involved Trigger-B sequence Trigger Follow by n events, with n = 1000 events. If just an edge trigger were used, the scope triggering would try to compensate for jitter at the trigger point. (The typical jitter specification for an MDO4000 series unit, probably similar to the MSO4000 series, is less than 10 ps rms for edge-type triggers). The chosen trigger method likely reduced the effect of the instrument's trigger jitter.

The Tektronix application was used to generate the data and plots from .isf files collected on the MSO scope, and the data was processed for standard deviation and peak-to-peak jitter. Based on the 3998 clock-period samples captured, a histogram was plotted and merged with the results from the application *(Fig. 4)*. The upper graph is the measured period versus time, and shows that a few spikes occurred in the data at random sampling times; these will produce "outliers" in a histogram (the second graph).

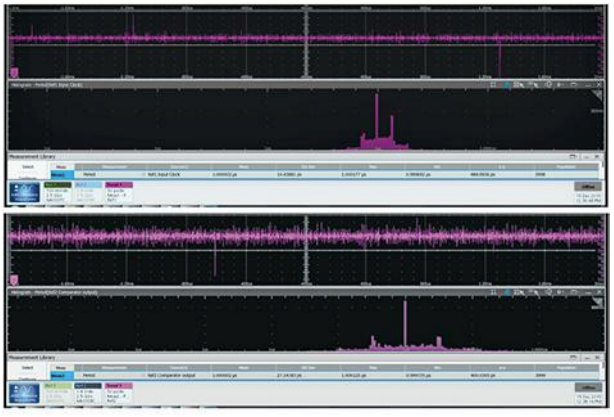
The measured jitter performance of the comparator—just 23-ps rms jitter at one standard deviation with a 1-MHz input clock—exceeded design expectations. It was determined using the following equation with time in picoseconds (the jitter performance of the scope is not included):

$$\text{comparator jitter rms} = \sqrt{27.1^2 - 14.4^2} \quad (1)$$

The conclusion was that it is feasible to build a simple test PCB and collect jitter data from a high-performance circuit, if a good digital scope such as the Tektronix unit is available. The jitter results showed this comparator could work with the colleague's ultrasound application.

REFERENCE
1. "Dual Comparators Match Precision Industrial, Instrumentation Application Needs," *Electronic Design*.

TIM DAVIS graduated with a BSEE from Iowa State University in Ames, Iowa. He has more than 28 years of experience in analog circuit design, power electronics, and IC design, including several patents for electronics in the medical industry. He can be reached at tdavismn@gmail.com.



4. In the merged results of the Tektronix "TekScope Anywhere" application, the top graphic is the input clock along with its histogram (the standard deviation of the input clock is 14.4 ps), while the bottom graphic shows comparator output and its histogram (the standard deviation of the comparator output is 27.1 ps).

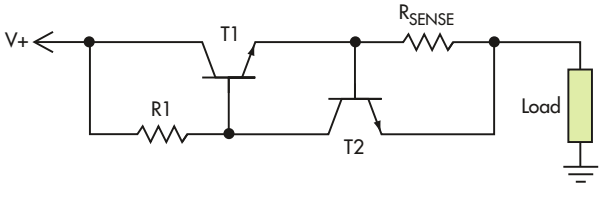
Current Limiter Offers Circuit Protection with Low Voltage Drop

By SAJJAD HAIDAR | University of British Columbia (UBC)

THERE ARE MULTIPLE cases in which a power supply needs an internal current-limiter function, usually built using a current sensor, a control circuit, and a pass transistor. The current sensor itself can be a simple low-value resistor; since the voltage across it is proportional to the current, this voltage can be employed to control the current flow through the pass transistor.

In one example of this configuration *(Fig. 1)*, R_{SENSE} is a low-value resistor used for sensing the current.[1] As long as the voltage across this resistor is less than ~0.6 V, only transistor T1 will conduct. Whenever load current I_L reaches a value such that when R_{SENSE} voltage (equal to $I_L \times R_{SENSE}$) exceeds ~0.6 V, transistor T2 starts conducting. The base current of T1 is drawn by T2 and, as a consequence, the emitter current of T1 drops.

However, this simple circuit has a limitation due to the associated voltage drop; when activated, there will be a voltage drop at T1 ($V_{CE,SAT}$) of ~1 V and across R_{SENSE} of ~0.6 V. The total voltage drop is ~1.6 V. Therefore, if the current limiter is connected with a +5-V supply, the load will get ~3.4 V, which is unacceptable in low-voltage circuits.



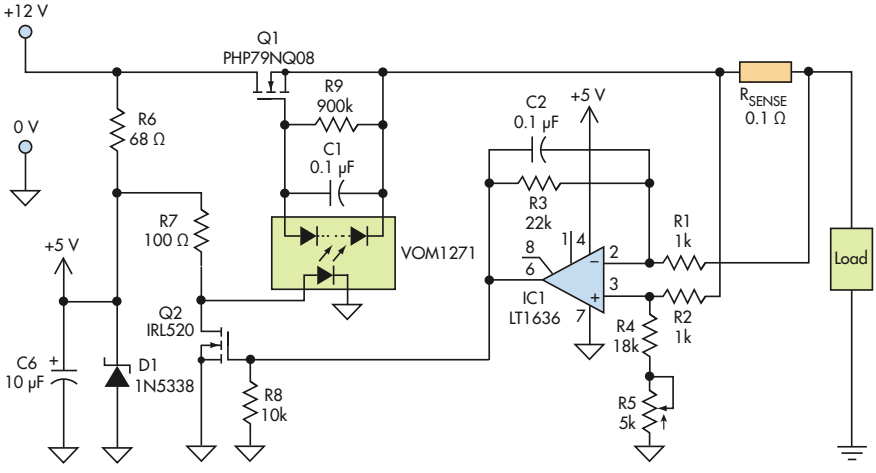
1. A simple, widely used current limiter consists of a current sensor (usually a low-value sense resistor), a control circuit, and a pass transistor.

An alternative is to use the well-known LM317 voltage regulator as a current limiter.[2] This approach also incurs a voltage drop of ~ 2 V. Another current limiter uses a P-channel MOSFET as a pass device, with gate voltage controlled by a transistor that amplifies the R_{SENSE} voltage drop.[3] This circuit experiences a drop as low as ~0.6 V.

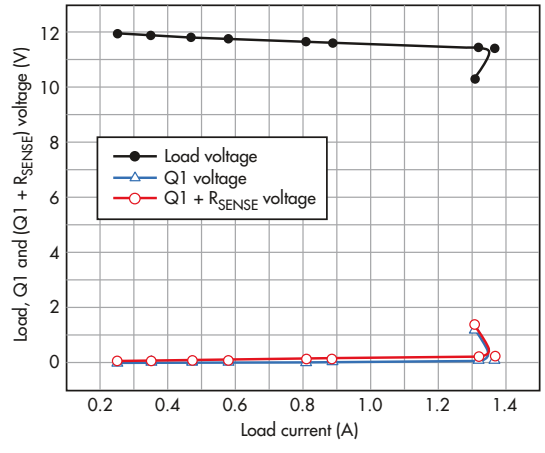
The current limiter of *Fig. 2* has very low voltage drop, so it doesn't hamper low-voltage circuit operation. The circuit operates from minimum supply voltage of 5 V, to higher values set by some components. The voltage across the 0.1-Ω sense resistor is amplified by op-amp IC1 in differential mode; IC1's +5-V supply comes from D1, a Zener-diode acting as a regulator.

For adjustable current limit, the gain of the op amp is controlled by the variable resistor R5. The output of IC1 controls the drain-source resistance (R_{DS}) of low-threshold MOSFET Q2, and the drain current of Q2 controls the LED current of VOM1271, a photovoltaic MOSFET driver.[4]

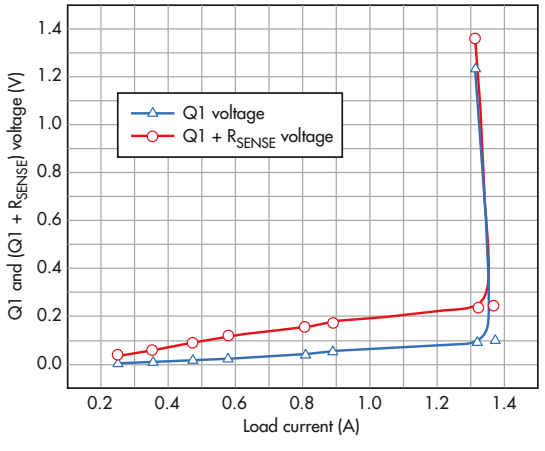
When the load current is low, the R_{SENSE} voltage is low, and the low IC1 output remains below the threshold of Q2. The resultant higher LED current of the MOSFET driver produces an output voltage of ~8 V, which is high enough to drive Q1 well into full conduction. When the load current



2. This more complicated current limiter has the advantage of much-lower voltage drop than the previous design, which is a critical factor in circuits operating from low-value supplies.



3. Variation of load, Q1, and Q1+R_{SENSE} voltages versus a range of load-current values shows relative flatness.



4. The expanded view of Q1 and Q1+R_{SENSE} voltages more clearly shows the current-limiting foldback action that occurs when the load current exceeds the set limit.

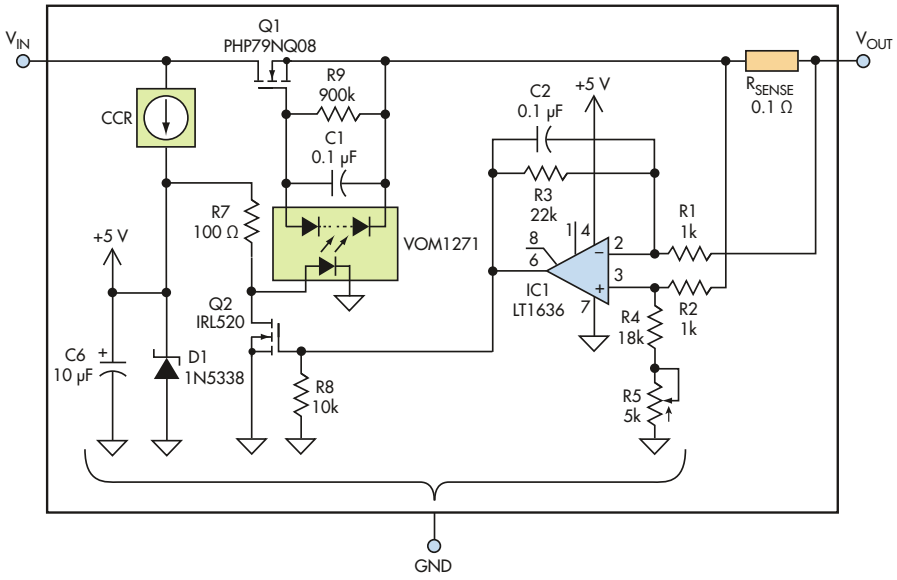
reaches a value that drives Q2 into conduction, gate-source voltage V_{GS} of Q1 goes low, which forces the load current to go low.

The circuit was tested with a +12-V supply and a 100-Ω high-power variable resistor as a load. Potentiometer R5 was adjusted to set the current limit a little above 1 A. The load resistor was slowly reduced from its maximum value, and voltages across Q1, R_{SENSE}, and the load were measured *(Fig. 3)*. For load current from 0.25 to 1.3 A, the voltage drops across Q1 and Q1 + R_{SENSE} were 0.09 V and 0.235 V, respectively.

At the maximum load current of 1.3 A, the voltage drop across R_{SENSE} of 0.145 V is a significant contributor to the overall drop. The drop can be reduced further by choosing lower values of R_{SENSE}. The expanded view of the voltage drops at Q1 and Q1+R_{SENSE} *(Fig. 4)* shows how these two drops vary with load current. When the load current exceeds the set limit, it trig-

gers a current-limiting foldback action.

This current limiter is suitable for low-voltage applications beginning at +5 V. For higher voltages or operation in a wider voltage range, Zener biasing resistor R6 can be replaced with a constant-current regulator (CCR), and Q1 should be chosen for higher voltage or current rating. The entire current-limiter circuit can be packaged and used as a three-terminal device *(Fig. 5)*.



5. Despite its internal complexity, the entire current-limiter circuit can be considered as a three-terminal device.

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SAJJAD HAIDAR is an Electronics Technologist at the Electronics Engineering Services of the University of British Columbia (UBC). He holds an M.Sc. in applied physics and electronics from the University of Dhaka (Bangladesh). Previously, he worked in Japan for seven years in the field of tunable solid-state lasers and optoelectronics. He can be reached at sajjad_haidar@yahoo.com.

COM Express Modules Utilize Gen 7 Intel Cores

CONGATEC IS RELEASING lits conga-TC175 COM Express compact modules in time with the launch of the 7th generation of Intel Core SoC processors (codename Kaby Lake). Features include greater CPU performance, 10-bit video codec, and support of the optional 3D Xpoint-based Intel Optane memory, which lowers latency to 10 µs, yet is capable of handling the same size of data packets. Compatibility with the previous generation, the standardized COM Express form factor, congatec's industrial driver implementations, and personal integration support and individual Embedded Design & Manufacturing services combine to simplify the integration of the new generation. Target applications are found wherever fanless and completely sealed systems must offer high performance at 15 W TDP.

The modules are equipped with 15 W dual-core variants of Gen 7 Intel Core SoC processors (2.8 GHz Intel Core i7 7600U, 2.6 GHz Intel Core i5 7300U, 2.4 GHz Intel Core i3 7100U and 2.2 GHz Intel Celeron 3695U). All modules support up to 32 GB dual channel memory and TDP is configurable from 7.5 W to 15 W. The COM Express compact modules support the Type 6 pinout with PCIe Gen 3.0, USB 3.0 and 2.0, SATA Gen 3, GbE, and low-speed interfaces such as LPC, I²C and UART.

CONGATEC

www.congatec.com/us.html

Modular 5 GS/s PXIe Digitizers Capture DC to GHz

SPECTRUM INSTRUMENTATION has expanded its line of PXIe-based high-speed digitizers with the nine card M4x.22xx series including modules that offer one, two or four fully synchronous channels. Each channel is equipped with its own ADC, real-time signal sampling at rates from 1.25 to 5 GS/s, and scope-like signal conditioning circuitry that allows programming of parameters such as input gain, signal offset and coupling. The digitizers offer bandwidth up to 1.5 GHz for automated testing applications where wideband electronic signals from dc to the GHz range need to be acquired and analyzed.

All of the new digitizers are packaged in a dual-width 3U module incorporating a four lane PCIe Gen 2 interface that allows data transfer speeds in excess of 1.7 GB/s. On-board calibration is standard and a high-quality clocking system drives the 8-bit ADCs on each channel synchronously. Block averaging and block statistics packages are available for high trigger rate applications that require hardware based processing functions. SBench6 Pro software is included as well as software tools for popular programming languages. Third-party support is also provided for LabVIEW, LabWindows, and MATLAB. The M4x.22xx series digitizers are available with immediate delivery.

SPECTRUM INSTRUMENTATION

spectrum-instrumentation-usa.com

SoC Integrates Multiple Communication Protocols

QORVO'S NEW GP695 is a complete SoC for smart home devices, integrating multiple communication protocols, including IEEE 802.15.4, ZigBee 3.0, Thread and BLE for sensors and actuators throughout the home. Designed to optimize energy efficiency and extend battery life, the SoC supports the different connectivity options in order to provide a single development platform and a single SKU, independent of the communication protocol used, allowing BLE-based smart phone connectivity for proximity-based services to combine with Thread or ZigBee 3.0 for smart home services. For example, a mobile phone can connect a GP695-equipped door lock to a ZigBee smart home system using the phone's BLE protocol. The door lock then can be opened or closed from the mobile phone over BLE. The intelligent system can also automatically lock the door over ZigBee when it detects that no one is in the home.

The SoC complements the multi-protocol GP712 for use with smart home gateways. The GP695 uses the ARM Cortex-M4 computing architecture and features the Qorvo Wi-Fi interference mitigation technology with an extended range that covers the entire home.

QORVO

www.qorvo.com

Radiation-Hardened MOSFETs Based on N-channel R9

INFINEON IR HIREL has launched its first radiation- hardened MOSFETs based on the proprietary N-channel R9 technology platform, the IRHNJ9A7130 and IRHNJ9A3130. The devices are fully characterized for TID immunity to radiation of 100 and 300 kRads, respectively. An R DS(on) of 25 mΩ (typical) in combination with increased drain current capability (35 A vs. 22 A) allows the MOSFETs to provide increased power density and reduced power losses in switching applications. The MOSFETs have improved SEE immunity and have been characterized for useful performance with LET up to 90 MeV/(mg/cm²); at least 10% higher than previous generations.

INFINEON

https://www.infineon.com

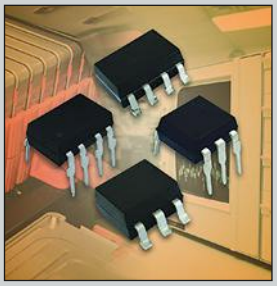
Compact Power Module Controls EV High-Voltage Auxiliaries

THE FAM65V05DF1 is ON Semiconductor's new compact 650 V, 50 A automotive qualified intelligent power module for controlling vehicle A/C compressors and other high-voltage auxiliary motor applications in hybrids and EVs. The module integrates optimized gate drivers along with Field Stop Trench IGBT and freewheeling soft recovery diodes in an automotive-qualified 12 cm2 footprint package which is up to 40% smaller than solutions assembled from multiple discrete components. The device seeks to simplify and shorten the process of designing the power stages of high voltage automotive auxiliary inverters for A/C compressors and oil pumps.

The power module features a 650 V, 50 A 3-phase IGBT IPM with low loss IGBTs and soft recovery diodes optimized for auxiliary inverter in hybrid and EV applications; integrated gate drivers with internal VS connection, under voltage lockout, over-current shutdown, temperature sensing unit and fault reporting; and an electrically isolated DBC substrate with low thermal resistance. The FAM65V05DF1 automotive qualified intelligent power module is offered in an APM 27L Double DIP package and is priced at $38.50 each/1,000.

ON SEMICONDUCTOR

http://www.onsemi.com/PowerSolutions/home.do



Hybrid Solid-State Relays Switch AC and DC Loads

VISHAY INTERTECHNOLOGY is expanding its VOR family of hybrid solid-state relays with four new devices designed to deliver enhanced electrical characteristics for telecommunications, industrial, security system and metering applications. The relays are single-channel (VOR1121A6 and VOR1121B6) and dual-channel (VOR2121A8 and VOR2121B8) normally open SPST switches. A hybrid architecture enables fast typical turn-on and turn-off times of 0.20 and 0.03 ms and an ambient temperature range of -40°C to +100°C. A high-efficiency GaAlAs IRED enables low forward current on the input side. On the output side, high-performance MOSFET switches provide 12 Ω on-resistance to reduce power dissipation.

The VOR1121A6 and VOR1121B6 can be configured for dc-only operation to reduce the on-resistance. The VOR1121A6 and VOR2121A8 are offered in DIP-6 and DIP-8 packages, respectively, while the VOR1121B6 and VOR2121B8 are available in SMD-6 and SMD-8. All four devices offer a high isolation test voltage of 5,300 VRMS and load voltages of 250 V.

Typical applications include alarm and telecom switches, I/O cards, automation, battery management systems and automatic test equipment. Samples and production quantities of the new solid-state relays are available now in tape-and-reel and tube packing, with lead times of four to six weeks for large orders. Pricing starts at $60 each/100.

VISHAY INTERTECHNOLOGY

www.vishay.com

Scalable Dev Kit Produces Biometric Wearables

VALENCELL AND STMICROELECTRONICS are introducing a new, highly accurate and scalable SensorTile development kit for biometric wearables that includes ST's compact SensorTile turnkey multi-sensor module integrated with Valencell's Benchmark biometric sensor system.

The SensorTile, a 13.5 x 13.5 mm IoT module, integrates an STM32L4 MCU, a BLE chipset, wide spectrum of high-accuracy motion and environmental MEMS sensors (accelerometer, gyroscope, magnetometer, pressure sensor), and a digital MEMS microphone. With its on-board low-power MCU, the IoT module can be used as a sensing and connectivity hub for developing firmware and shipping in products such as wearables, gaming accessories and smart-home devices. The module integrates a complete BLE transceiver including a miniature single-chip balun on-board, along with a set of system interfaces. It can be plugged to a host board, and when powered, it streams inertial, audio and environmental data to ST's BlueMS smartphone app.

The Benchmark biometric sensor system delivers a complete Valencell PerformTek technology package, ready for integration into wearable devices. PerformTek sensor systems boast accurate, robust and flexible technology, giving wearable and hearable devices the ability to continuously and accurately measure blood flow signals, even during extreme physical activity or when the optical signals are weak.

VALENCELL, *www.valencell.com*

STMICROELECTRONICS, *www.st.com*

Top Capacity of VLP DDR4 Memory Modules Doubled

VIRTIUM HAS DOUBLED the top-end capacity of its VLP RDIMM and Mini-RDIMM DDR4 memory modules up to 64 GB. Additionally, they have increased the capacity on their DDR4 SODIMM modules to 32 GB. Virtium's own chip placement technology enables maximum density of chips placed in the smallest footprints. The small form factor RDIMM and Mini-RDIMM memory modules, featuring the PC4-2400 interface with 2,400 MT/s data transfer speeds, are designed to provide high-performance memory to height-restricted blade servers, 1U racks, SBCs, mezzanine cards and other networking and telecom applications with space constraints.

Industrial temperature rated at -40°C to 85°C, the memory modules include options for conformal coating and extreme-temperature accelerated-burn-in for zero-downtime applications. The new high-capacity VLP RDIMM and Mini-RDIMM memory modules will be available January 2017.

VIRTIUM

www.virtium.com

802.11ac SDIO Embedded Wi-Fi Includes Bluetooth

SILEX TECHNOLOGY'S LATEST embedded Wi-Fi module, the SX-SDMAC, is a dual-band, single-stream, 802.11a/b/g/n/ac plus Bluetooth Smart Ready module based on the latest Qualcomm Atheros QCA9377 SoC. The module delivers enterprise-grade, dual-band 802.11ac Wi-Fi connectivity with link rates up to 433 Mbps, while maintaining footprint compatibility with previous generation Silex SDIO modules. The radio is available in SiP, surface mount with chip antenna or external u.fl antenna port, connectorized, and plug-in SDIO card.

Supporting Wave 2 MU-MIMO (Client), which increases the overall WLAN system performance by 3X compared to 11n, and sporting a small form factor, rich features, and low power, the module is particularly suited for portable devices. The SX-SDMAC is modular certified for North America, Canada, Europe, and Japan. Additional certification services for regions not covered are also offered.

SILEX TECHNOLOGY

www.silexamerica.com

42-in. ePaper Display Meets Digital Signage Demands

E INK IS DEBUTING the latest addition to its Pearl product line of ePaper displays, a 42-in. active matrix ePaper display module designed for use in the digital signage market. Exhibiting qualities such as readability and visibility in various lighting conditions, the display utilizes E Ink's signature bi-stable technology, which allows the display to retain images and text even when removed from a power source. The display also demands minimal power requirements and features the ability to function with a standalone power system.

The module's ultra-wide viewing angle can be viewed in both landscape and portrait modes. Its 4:3 aspect ratio is identical to that of real paper, making digestion of information similar to when it is written on regular paper. At 658.6 × 884.3 × 1.64 mm, the display offers a resolution of 2,160 × 2,880 and 85 dpi. The 42-in. ePaper module will be in production by the end of Q1-2017.

E INK

www.eink.com

Compact IoT COM Express Optimizes Graphics

THE COME-CAL6 COM Express Type series of compact modules from Kontron is based on the latest generation Intel Atom, Pentium, and Celeron processors. The highly scalable series covers the entire range of Intel's latest IoT-ready embedded processors and extends the existing Intel SoC-based COM Express portfolio to embrace especially powerful compact variants with full COM Express Type 6 I/O support including PCI-e, LAN, USB and digital display interfaces. Target industries include POS/POI and kiosk systems, digital signage, gaming and medical PCs, as well as HMIs and controllers in industrial machinery and equipment.

The new Intel Gen 9 HD low-power graphics integrated on the SoC with up to 18 execution units provides 4K encode/decode algorithms supporting HEVC, H.264 and VP8/VP9. The COMe-cAL6 supports three independent displays and memory is laid out as dual-channel DDR3L SODIMMs. The module comes with two SATA II 300 Mbps interfaces and optional eMMC memory up to 128 GB.

KONTRON

www.kontron.com

FPGA Carrier Designed for ASIC Emulation and Sensor Processing

VADATECH'S NEW FPGA module, the AMC596, is based on the Virtex UltraScale XCVU440 FPGA in a FLGA2892 package with an on board Power PC P2040. Compliant to the AMC.1, AMC.2, AMC.3, and/orAMC.4 specifications, the module provides 20 SERDES lanes on tongue 2, providing high-bandwidth connectivity to another module at high speed (where supported by appropriate chassis). The use of the tongue 2 connector complies with the AMC.0 specification. The on-board, re-configurable FPGA interfaces to the AMC FCLKA and TCLKA-D via a MLVDS cross bar switch. The FPGA has interface to one 64-bit wide DDR4 with 8 GB total memory, allowing for large buffer sizes to be stored during processing and for queuing the data to the host.

VADATECH

www.vadatech.com

Ultra-Compact Embedded PC Handles Unmanned Systems

ADL EMBEDDED SOLUTIONS' new ultra-compact ADLEPC-1500 is a full-feature embedded PC targeted for UAV and UUV unmanned systems, industrial control and camera systems, robotics, data logging, wearable computing, traffic management, digital signage, kiosks, IoT gateways. The PC measures 1.3 in. × 3.4 in. × 3.2 in. and features a voltage input of 20-30 Vdc, 24 V nominal, and a -20°C to 50°C standard temperature range or an extended temperature range of -40°C to 70°C when direct mounted for conduction cooling. Based on the ADLE-3800SEC Edge-Connect embedded SBC, the computer includes: an Intel E3800-series Atom processor with onboard 4 GB DDR3 RAM; onboard DisplayPort, USB3.0/2.0, M.2 KeyB 2242 SATA and two LAN ports; and an integrated Intel HD Graphics engine with support for DirectX 11, Open GL 4.0 and full HD video playback.

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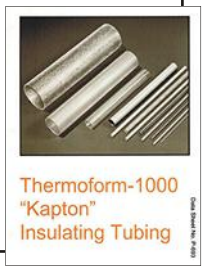
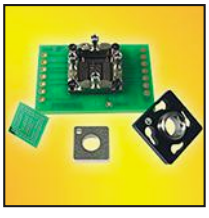


75GHz Clamshell Socket for NXP's BGA141

Ironwood Electronics has recently introduced a new BGA socket design using high performance elastomer capable of 75GHz, very low inductance and wide temperature applications. The GT-BGA-2061 socket is designed for 10x10 mm package size and operates at bandwidths up to 75GHz with less than 1dB of insertion loss. The socket is designed to dissipate few watts using compression screw and can be customized up to 100 watts with a modified fin design.



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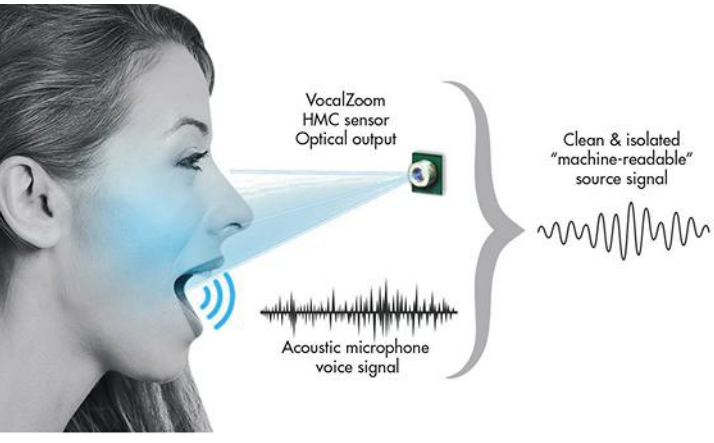
Improvements in Sound Technology

The 2017 Consumer Electronics Show was home to a host of new audio technologies.



1. VocalZoom uses an infrared range finder to measure skin vibration when speaking to implement a high-precision microphone that is essentially unaffected by ambient noise.

If you think there has not been much change in audio technology recently, then you missed the 2017 Consumer Electronics Show where a host of new technologies and products were on display. This is in addition to the plethora of Bluetooth earbuds that use wireless charging in addition to wireless connectivity.

One new technology was hidden in a corridor at Honda's booth. VocalZoom was showing off its Human Machine Communications (HMC) sensor *(Fig. 1)*. This high-precision microphone uses optics instead of sound vibrations through the air as with conventional audio microphones. The optical system implements an infrared range finder that detects skin vibration of a person speaking. This is most apparent around the throat, but much of the face provides sufficient feedback for the sensor.

The sensor does need to be aimed at the face, but this is easy with many application scenarios from tracking a car driver's voice to someone using an automated teller machine (ATM). A head mounted approach could also be used. The advantage of this approach is that only the voice-related vibrations are recorded, so noise cancellation is not required. The sensor is not applicable to all voice command input applications, but the ability to essentially eliminate ambient noise from the input is hard to overlook.

2. Conexant's tiny CX20988 is a low-cost, single-chip link between a USB Type-C host and headphones/earphones.

Another key change in mobile audio is the use of USB Type-C connections instead of a headphone jack as with the latest Apple iPhone. Many have complained of the lack of a headphone jack, but the approach offers a range of advantages from a thinner device because of the Type-C connector to a digital audio interface. A USB audio device also provides better control and more information about the device to the operating system and applications using the device.

Conexant's tiny CX20988 *(Fig. 2)* is a low-cost Type-C audio CODEC that does not require a crystal, allowing it to fit into a very small package. It is available in a 3.09-mm^2 WLCSP package. It delivers 24-bit stereo feedback with a 48 kHz sample rate and a five-band equalizer. It has a 1.5mA suspend current to minimize power requirements. It supports four-conductor headset jacks with auto-headset detection. It has multiple LED and button interfaces.

The slightly larger (5 mm^2) CX20888 CODEC adds noise cancellation with features like a wake-on-voice trigger. It uses a 100 MHz, dual core, 32-bit DSP that utilizes a pair of PDM digital microphone interfaces (DMICs).

Conexant also demonstrated an impressive smartphone application that works with the chip. It had the ability to disable noise cancellation and feed ambient sound into the headset so I could hear a person speaking to me without having to take off the earphones. It also provides significant listening and noise cancellations adjustment profiles. ed

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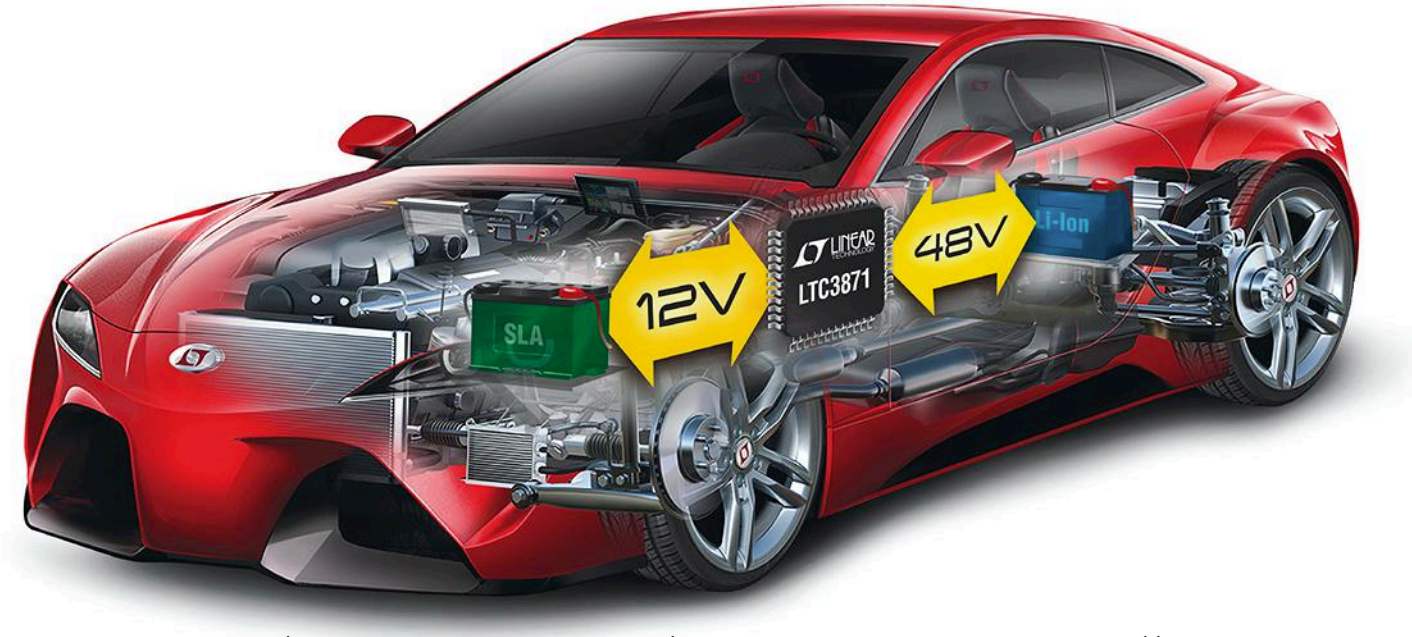

Single IC 48V/12V Dual Battery Power Controller

The LTC3871 bidirectional two-phase synchronous buck or boost controller brings a new level of performance and simplicity to 12V/48V automotive dual battery systems. Using the same external components for buck and boost modes significantly reduces complexity and solution size. Up to 97% efficiency can be achieved, and the maximum current delivered in either direction is controlled. Four control loops, two for current and two for voltage, along with overload protection in either direction provide a robust solution. 6kW to 8kW can be supplied in either mode with a 12-phase design.

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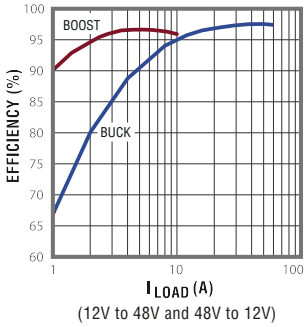
Efficiency Buck & Boost Modes



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