# Methods

Mouser's technology & solutions eZine

Volume 2, Issue 1

5G and Wireless Technology

Artificial Intelligence

Data Security

Maker and Open Source

## 2018 Look Ahead: Design & Technology

MOUSER ELECTRONICS

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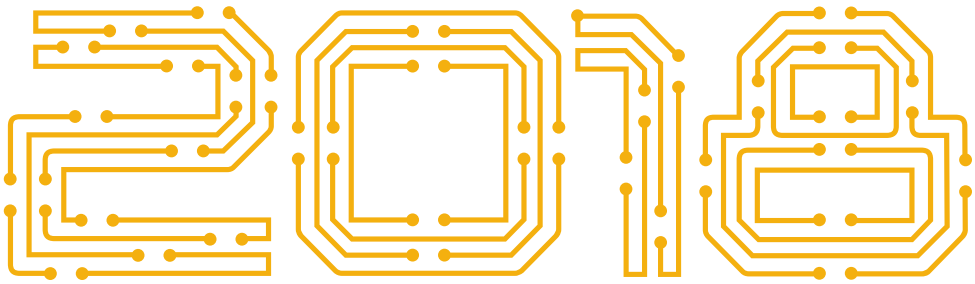


# Welcome from the Editor

It seems like we just wrapped up our "Best of 2017 Technical Content" special edition of Mouser's Methods eZine, and here we are already ringing in the new year!

As Sylvie Barak writes in the opening article: "While it's certainly a bummer that hoverboards are still not a thing," 2018 promises smarter homes, more connected cars, VR and AR, and better voice assistants, among other things. Advances in power management, 5G, and energy harvesting will bring new and better applications to the forefront. Hardware solutions will solve more and more data security vulnerabilities, and development platforms will continue to be at the core of innovation as well. Finally, open source hardware and the Makers Movement coupled with crowdsourcing will continue to expand and reach new industries and applications.

Some of the most useful and innovative changes to come aren't revolutionary per se, but are incremental advances that aim to bring stability and wider application of existing solutions.

Certainly, VR, AR, and AI aren't new in the alphabet soup of technologies; however, aspects of these and other technology areas have now evolved to the point that their potential is within reach. While truly disruptive technologies will be few and far between, we'll reap rewards and benefits of technologies maturing and gaps being filled.

Happy New Year! We look forward to bringing you technical content and publications in 2018 that inspire innovative designs and solutions, to bringing you the newest products from the world's leading suppliers, and to being a part of the applications and technologies to come.

*Deborah S. Ray*
**Executive Editor**

**Connect with us!**


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Deborah S. Ray

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# No Hoverboards, but Plenty of Awesome Tech in 2018

*By Sylvie Barak for Mouser Electronics*

While it's certainly a bummer that hoverboards are still not a thing and that the remake of BladeRunner pushes realistic humanoid AI interaction back from 2019 to 2049, that doesn't mean the next year is a total tech wash-out! So, what can we expect to happen in 2018? 5G, smarter homes, more connected cars, better voice assistants, AI, Machine Learning, new biometric interfaces, and more await!

## 5G Force

Most things in tech hinge on connectivity, and in 2018 connectivity is going to start improving with almost every chipset maker looking toward 5G. Current 4G speeds can hit 100MBps, which would allow you to download the HD version of a two-hour film in around six minutes; not bad, but not a patch on the 3.6 seconds it will take with 5G's blistering 10GBps potential speeds.

While downloading movies faster is quite cool, it's probably not life-changing. Life-changing, however, are the implications for critical infrastructure needed for autonomous vehicles, smart city, smart home, smart assistants, voice control, better Internet of Things (IoT), and a whole host of other applications that have sounded promising in the past, but have been gimmicky or unworkable due to slow speeds and bandwidth bottlenecks.

2018 won't automatically upgrade everyone to 5G, and indeed, most smartphones and tablets won't even support it yet; however, we can expect to see a plethora of chipset announcements and companies building around it starting this coming year and becoming the norm before 2022. The emergence of the next-generation Wi-Fi standard 802.11ax in 2018 will also help take a load off the bandwidth burden facing the IoT, while updated Bluetooth technology will support mesh networking to allow more many-to-many device communications and the creation of large-scale device networks.

## Smart Home Gets Smarter, Connected Car Turns a Corner, and Voice Recognition Improves

Smart homes, connected cars and voice recognition technologies are not new, and you may even be tired of hearing about them. In their first iterations, they were not very good, but that's about to change. Faster connectivity speeds, upgraded chipsets and better electronic architectural design will give all of these technologies a significant boost in 2018 and beyond.

The modern home is seeing an exponential increase in the number of sensors people are installing and connecting together, from video to audio, temperature, humidity, occupancy, air quality, bio-adaptive lighting and even sensors embedded into fabric that measure human bio data.

Meanwhile, real headway is being made in autonomous driving, and test vehicles are also getting increasing numbers and types of sensors. 2017 saw an explosion in terms of demand for automotive components and systems for processing traffic information and safety control, while car makers went all-in on radar modules, image sensors, automotive processors, automotive displays, advanced driver assistance systems and connected vehicle platforms.

In 2018, it's expected that most major automotive chip suppliers will begin shipping products that allow cars to achieve Level 3 automation and approach Level 4 automation. The combination of increased Level 4 hardware availability and a more accepting legislative framework means we're right on the cusp of true autonomy becoming a near-immediate reality. Combine that with increasing car connectivity and help from AI/Machine learning, and your car may soon be very smart indeed.

Voice assistants are also taking a much-needed boost from improvements in AI and Machine Learning, and 5G technology will come ever closer to passing the Turing test and becoming helpful in terms of understanding contextual conversations and providing self-aware assistance. Chipmakers are

already coming out with better AI focused chipsets, and the knock-on effects for robotics will also be something to look for this year.

## Open Doors with Your Face

Fingerprint recognition is so 2017! Biometric recognition is another key trend going into the next year with a major smartphone maker already offering facial recognition, with a slew of competitors to follow. Face ID is being touted as the next mainstream interface not just for unlocking phones, but also for mobile payments and activating or unlocking other things, both digital and physical through your phone, like your hotel room or even your own front door if you own a smart lock. Advanced biometric recognition technologies also use audio for voice recognition and can still also use fingerprint scanning.

New digital interfaces will allow for things like saved car settings that can recognize different drivers and adapt accordingly, or even smart homes that can adjust temperature and lighting based on personal preferences and room occupancy. The hardware is a little costlier than a simple capacitive fingerprint scanner, so these new interfaces may be restricted to the high-end for now, but they are here and will get cheaper.

## AR & VR Again, But Separate This Time

It's true that the promise of both Augmented and Virtual Reality (AR & VR) has been long touted and not well delivered, but as we move into 2018, mixed-reality is out, and standalone AR/VR technologies are back, for the better. More affordable VR headsets with better graphics and more freedom of movement are set to come out in 2018 making the technology more accessible and useable, while big handset companies are also coming out with better AR Kits to make that technology more useful. AR will also hugely benefit from 5G, enabling far more immediate interaction with one's environment, taking it from gimmick to useful.

## Killer Apps, Out; Incrementally Significant Progress, In

While it's true that one could scan this article and say they've heard it all before; the difference going into 2018 is people's expectations. Gone are the days when a new technology will instantly change the world, but perhaps more sustainably, the tech world has focused on making significant incremental improvements to existing tech to make it more efficient, user friendly, seamless, and useful. 2018 will see a lot of these improvements, and that means applications that have been long-promised are finally within reach of being delivered to the masses, which is something we can all be excited about.

***"Gone are the days when a new technology will instantly change the world. …"***

## Conclusion

I, for one, am still bummed that hoverboards aren't a thing, but am excited to see advances in 5G, home automation, autonomous vehicles, AI and Machine Learning, biometric interfaces, and other applications come of age as a result of steady, incremental improvements and continued innovation. Stay tuned to Mouser Electronics' 2018 technical publications and content, including the technical newsletter (arriving in your inbox every other week), the Applications and Technology website, and the Bench Talk for Design Engineers blog.



***"VR headsets with better graphics and more freedom of movement are set to come out in 2018"***

--Sylvie Barak


RANSOMWARE
RANSOMWARE
RANSOMWARE

# Achieving Security Requires Much More Than Just Robust Technology

*By Steve Evanczuk for Mouser Electronics*

***"Although systems developers can draw on robust security technologies, effective security requires a combination of technologies, practices, and policies—and acceptance by each stakeholder of their own role in maintaining security."***

News headlines about data breaches have become so commonplace that reaction to a massive theft of data one week is quickly overtaken the next week by accounts of an even more egregious security breakdown.

Hackers have stolen information from every type of organization—even three-letter government agencies once considered impenetrable. Throughout all of this, a useful lesson lies less in the notion that no one is immune and more in an important consideration: Security threats and their mitigation are a constant struggle involving not just cyber experts but everything and everyone that touches data. In 2018, one of the greatest gaps in data security lies in appreciating that security is an organizational problem that needs to combine technologies, practices, and policies at each level of the system, whether in enterprise IT or spread through a cloud-based IoT application.

Take data encryption, for example. Developers recognize the fundamental need for cryptographic methods to ensure the integrity of data and metadata passed across networks and stored on hosts. Technologies such as elliptic curve cryptography have gained increased acceptance with their ability to provide the same level of security as older crypto approaches but with much shorter key lengths and faster solutions—important considerations for resource-constrained IoT devices. Yet, even the most robust crypto algorithm cannot ensure security without accompanying policies for ensuring protection of crypto keys throughout the key life cycle, including key creation, device provisioning, and even key revocation.

Use of robust technologies, practices, and policies for cryptography are necessary for security but are by no means sufficient. The overall integrity of an application also requires assurance that data suppliers and consumers are authorized participants in the overall data workflow. This assurance takes the form of authentication protocols such as transport layer security, elliptic-curve Diffie–Hellman, and others in widespread use on the Internet and in web applications.

On the Web, authentication is typically limited to host authentication to assure users that they are in contact with the intended host. Although this one-sided authentication might be satisfactory for web applications, IoT applications typically require mutual authentication, where both IoT device and host each validate the identity of the other. Even so, developers need to combine authentication technologies with suitable practices. For example, authentication protocols might allow reuse of the same session key from session to session—a practice that exposes devices and hosts to man-in-the-middle attacks and session hijacking as recently documented by Carnegie Mellon University's Computer Emergency Response Team (CERT).

Proper encryption and authentication might still not be enough to ensure the validity of data generated by an IoT device, aggregated by an edge device, and eventually consumed by a cloud-based application. Bad actors can exploit device software update delays to install corrupted versions under their control. Thus, devices and hosts might be using recognized crypto keys and authentication practices but the software running on those systems might itself be untrustworthy.

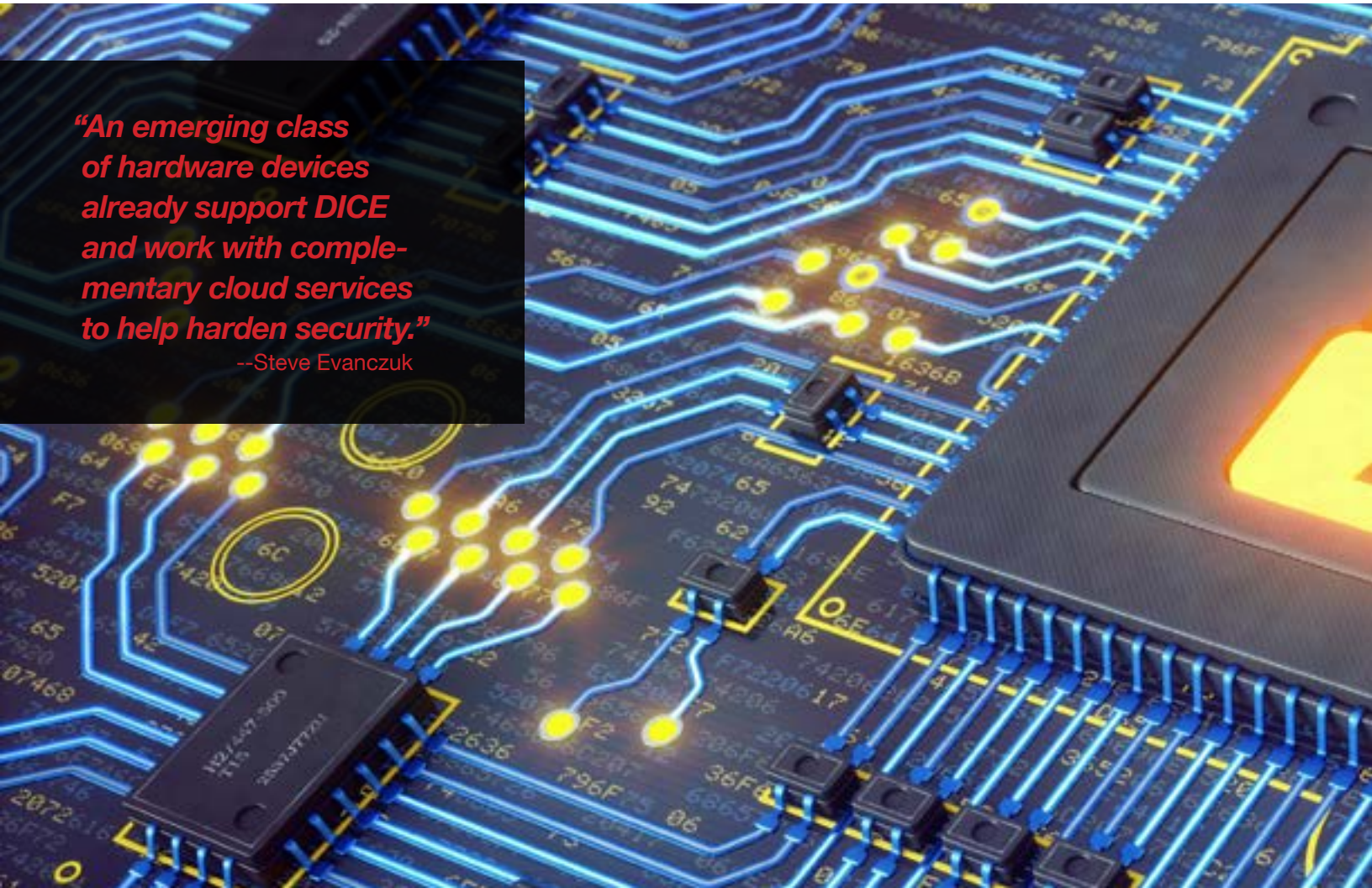
Secure over-the-air (OTA) updates and secure boot methods are meant to protect against these attacks but vulnerabilities can exist at each layer of the software stack. Ideally, developers employ sufficient security measures to ensure the use of valid software at each layer of the underlying software, thereby

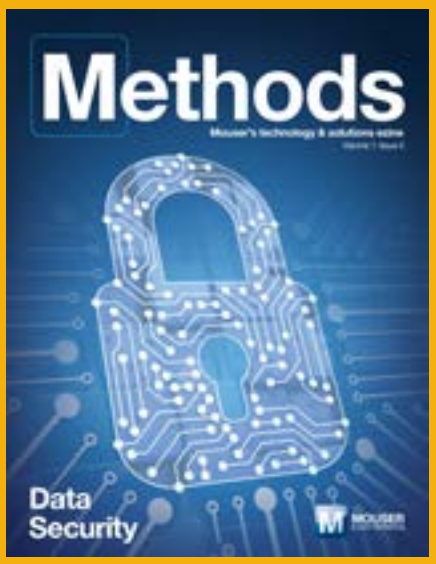
creating a robust root of trust for all other security features, software applications, and data operations. In practice, however, building this root of trust can fall short in IoT implementations due to a combination of factors ranging from limited device resources for performing security operations to limited understanding of proper security development practices.

With its Device Identifier Composition Engine (DICE) specification, the Trusted Computing Group proposes a multi-phase approach that uses secrets associated with each phase of the boot process to create a root of trust even in resource-constrained devices. An emerging class of hardware devices already support DICE and work with complementary cloud services to help harden security.

Cryptography, authentication, and trusted devices can serve as key enablers for security. Improperly executed, however, those same factors can present additional threat surfaces. Indeed, the development and deployment of any smart device presents multiple threat surfaces and more so when built into IoT applications. Few applications share the IoT's expansive development on separate communities of developers, technicians, and users. Each participant in the chain maintains a critical role in successful deployment and operation of these complex applications and holds responsibility for maintaining secure practices within their purview, including avoiding exposure to the social engineering-based attacks underlying the most infamous breaches.

The good news is that the industry is beginning to recognize the expansive and collaborative nature of system security. In its recent Security Manifesto, Arm calls for a shared sense of responsibility among technology users and providers alike for reducing the effectiveness of cybercriminals. In 2018, a deep appreciation of the implications of shared responsibility stands as a significant hurdle for achieving security. By approaching security as more than just a technological problem, the industry can begin creating an environment where bad actors find fewer opportunities for compromising securely connected systems.

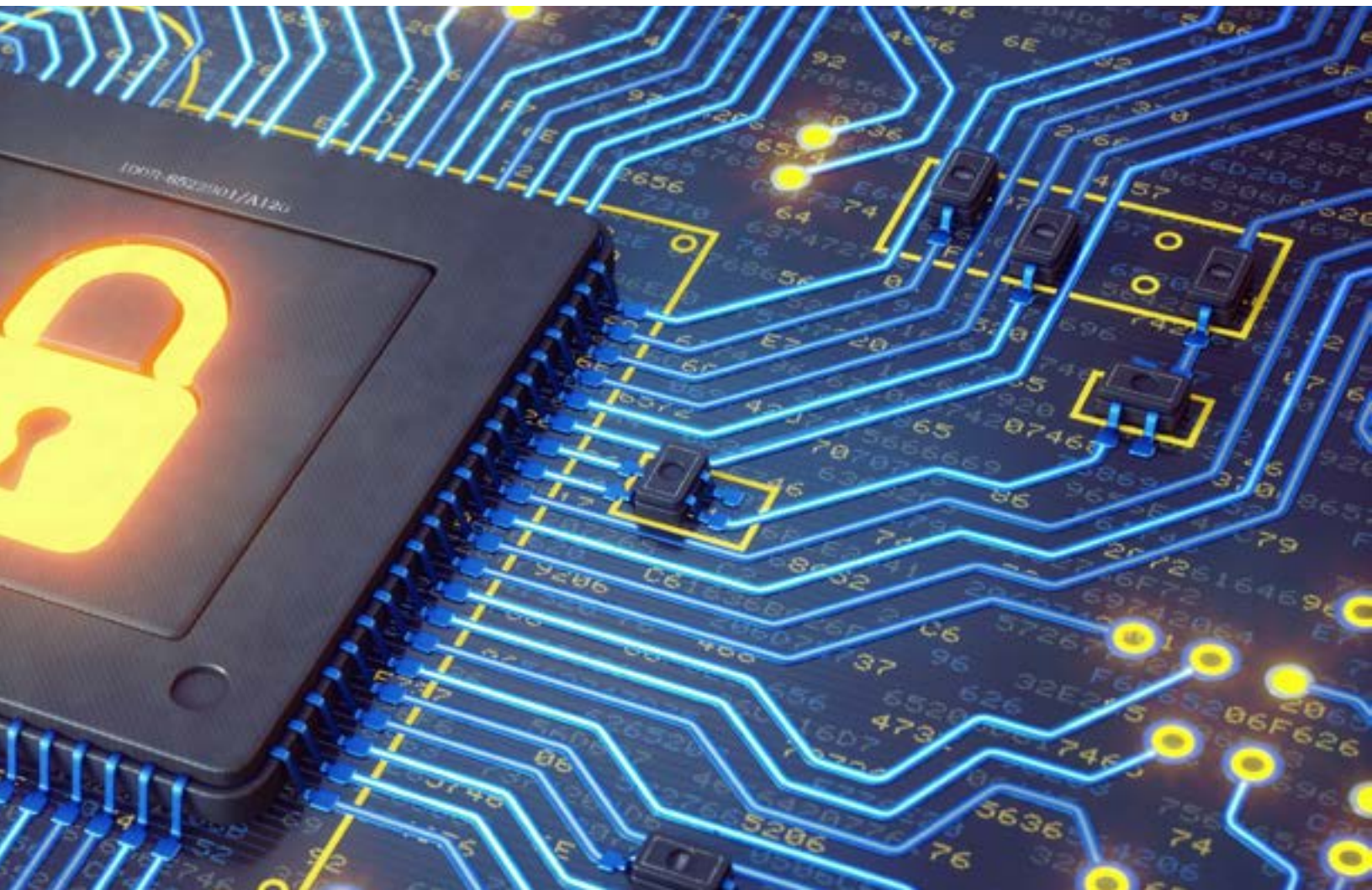





Check out Mouser's collection of Data Security content, including the "Think Like a Hacker" webinar, Mouser's hot-off-the-presses Data Security eZine, and a slew of articles and blogs—all available on the Applications & Technology site.


## A1006 Secure Authenticator

**mouser.com/nxp-a1006-secure-authenticator**



# **Development Boards for 2018:** Trends and Applications

*By Joseph Downing, Mouser Electronics*

Which development boards show the most promise to meet application trends in 2018? With so many technologies and applications ahead in 2018, it's hard to narrow the list to just a few; however, here are highlights of ones we expect to see make big impacts in the year to come that align with the most significant development needs and trends:

## Samsung Artik 710 IoT Module

Samsung's Artik 710 is a robust platform for IoT development. With multiple options available for wireless connectivity and a development kit allowing easy access through an I/O interface board, you are well on your way to an end solution.

The Artik 710 features an 8 core, 64-bit, Cortex A-53 processor with Wi-Fi, Bluetooth, and ZigBee built in. Built-in GPU, 1GB of RAM, and 4GB of flash allow for the development of Smart Home, Building Automation, and Multimedia control just to name a few possible example applications.


## Intel Movidius Neural Compute Stick

With AI and Neural Networks currently trending, the Intel Movidius NCS, of course, makes our list. This $79 USB form factor device allows for fast prototyping and deployment of Neural Network applications with supported frameworks such as TensorFlow and Caffe.

Powered by the Movidius low power, high-performance VPU (along with either a Linux box or Virtual Linux device running Ubuntu 16.04) and Movidius Neural Compute SDK, the Intel Movidius NCS platform can help get you started in applications around visual recognition.


## *Bluetooth*® 5 Wireless MCU

Bluetooth 5 is currently being included in many commercial and industrial devices such as the iPhone 8 and iPhone X. And what better way to jump on board than with NXP KW3xA and KW3xZ Kinetis MCUs.

NXP's new series of Kinetis Arm Cortex M0+ devices integrate BLE 5, supporting up to eight secure connections for multiple users in an automotive qualified AEQ Q100-Grade 2 package.

To help in development, NXP provides a Freedom Development board, FRDM-KW36 (coming soon), to get engineers off the ground and running to develop for automotive, industrial, and healthcare applications.

## PocketBeagle

Who doesn't love inexpensive development platforms? The PocketBeagle, coming in at just $25, comes equipped with the new Octavo Systems OSD3358-SM. This chip is integrated with the Texas Instruments Sitara AM3358 processor, TPS65217C PMIC, TI TL5209 LDO, and up to 1GB of DDR3 memory. What's more, it sits on a board the size of a key FOB. With a micro SD card (not included) and a copy of the Debian IoT image provided by BeagleBoard.org, you can be up and running within minutes.

By default, the PocketBeagle provides access to SPI, $I^2C$, 18 GPIOs, CAN, and PWM, providing plenty of features for any designer. The flexibility to increase the number of GPIOs makes this development platform very appealing.

## Conclusion

We expect to see many great applications come from these and other development kits in 2018. Of course, this only scratches the surface of what is currently available or upcoming. Several technology trends such as IoT and AI had a high impact through 2017 and should continue to see movement and growth into 2018.

# SiC Devices Usurp Si MOSFETs and Diodes in Servers, Motors, EVs

*By Bill Schweber for Mouser Electronics*

Our seemingly insatiable need for more power, delivered with increased efficiency, continues with no end in sight. Even as individual components reduce operating power levels, the systems that they support are expected to do more and more. As a result, aggregate power demands are increasing, easily outpacing the decrease in power needed by the individual component.

Certainly, a large part of the increase in power demands is due to huge installations such as servers and data centers. However, the causes are far more widespread. For example, electric motors are making major inroads in applications long dominated by hydraulic power or internal combustion engines. This includes electric vehicles and hybrid electric vehicles (EVs and HEVs) as well as large-scale robotics and heavy construction equipment.

The workhouse component for these electric power systems has been the silicon-based MOSFET along with the IGBT. Both of these power switches have seen significant improvements, with their capabilities extending to high voltage and power levels as well as reductions in both their static (RDS(ON)) and dynamic (switching) losses over the past decades. Now, though, these efforts have reached the point of diminishing returns versus R&D cost.

## A New Contender Gets Very Real

Fortunately, there's a disruptive technology that has been in development for many years, and it's already mature enough to be used in large-scale installations, reaching its market-adoption inflection point. Switching devices—both transistors and diodes—based on silicon-on-carbide (SiC) are redefining capabilities of power-related circuits. These offer far better efficiency and range than today's best silicon-only MOSFETs, IGBTs, and diodes, and are already in widespread use in top-tier data centers and server farms.

An August 2017 market report from Yole Développement, "Power SiC 2017: Materials, Devices, Modules, And Applications," puts some numbers on this situation. Their study maintains that, "SiC technologies adoption is going to accelerate with a tipping point in 2019." The report adds that "…the SiC power market (diode and transistor) is estimated to be more than $200 million (USD) in 2015 and forecasted to be more than $550 million in 2021, with a 2015–2021 CAGR of 19 percent. SiC diodes still dominate the overall SiC market with 85 percent market share…this leading position will not change for several years. In parallel, SiC transistors…should reach 27 percent market share in 2021."

Their adoption is having the usual beneficial ripple effect of driving down cost, increasing designer experience, creating more-comprehensive specifications, and validating reliability data. All power stages benefit, from those at high-voltage AC down to mid-range DC and even single-digit DC-rail voltages. (Note that there's a similar uptake, but not as large, in power devices based on gallium nitride.)

## SiC Advantages

SiC-based power MOSFETs and diodes are wide-bandgap (WBG) solid-state devices that are both similar to, yet different from Si-only devices. (Their bandgap is in the range of 2 to 4eV, while silicon's bandgap is in the range of 1 to 1.5eV.) Although the underlying physics are quite complex, WBG materials enable fabrication, at least in principle, of devices that operate at significantly higher breakdown voltages and temperatures (typically, 200° to 300°C), due to inherent characteristics of the material. They also achieve this in smaller, lighter packages and with higher efficiency.

While the virtues of smaller, lighter packages are obvious, why are higher voltages and temperatures also desirable? Higher voltages are attractive for the reasons they have always been: They enable lower current levels for the same amount of delivered power ($P = VI$) and, thus, reduce the unavoidable voltage drop ($V = IR$) and dissipative losses ($P = I^2R$) that occur as current passes through any resistance. Higher temperatures allow a power component and system to be pushed harder and, thus, deliver more output,

reducing the need to split the system into two or more smaller subsystems to deliver the same power.

Although the virtues of SiC have been known for a long time, translating theory into practical, cost-efficient, reliable devices has been a long-term challenge. Remember, though, that it took decades to "tame" silicon and make it do what it can today, especially in power devices where all imperfections and defects are magnified by heat and power levels. Similarly, bringing SiC technology to market as practical devices has taken years (and countless dollars) of basic physics research, innovative process development, unique device structures, and new fabrication techniques, supported by suitable packaging and millions of hours of test and reliability data.

## The Present and Future

Power device vendors with strong positions in silicon alone, as well as those with expertise in non-silicon materials and processes, see the immediate and long range potential of SiC and how it meshes with the demands for better, cheaper, and more efficient power. Among the active participants are Infineon Technologies AG, Microsemi Corporation, CREE, Inc. (Wolfspeed), General Electric, Power Integrations, Toshiba, ON Semiconductor, STMicroelectronics N.V., NXP Semiconductors, ROHM Semiconductor, and Renesas Electronics. Hundreds of released SiC-based MOSFETs and diodes are already integrated and installed in products. These products are supported by intensive, ongoing R&D efforts, putting SiC in an attractive position.

Check out Mouser's articles and resources for Power Management on our Applications & Technology site.

Check out Mouser's articles and resources for Power Supply on our Applications & Technology site.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# A Look Forward at the Trends Shaping Artificial Intelligence

*By Paul Golata, Mouser Electronics*

2018 looks to be a year in which Artificial Intelligence (AI) will continue to be increasingly integrated into businesses to transform them into new marketing solutions and increased efficiencies. IBM's Watson, the company's famous supercomputer, is expected to touch and make an impact in over one billion people's lives. Within 10 to 15 years, AI is expected to generate an economically beneficial impact on the world economy, exceeding 15 percent of the world's current economic output. China, North America, and Northern Europe are expected to be the primary geographical regions receiving economic benefits. It is estimated that they may receive up to 80 percent of the beneficial economic impacts.

New marketing solutions are expected to provide the highest level of economic benefits, perhaps 60 percent of the total, through increased consumer demand. Greater efficiencies spurred on by labor productivity improvements enabled by AI taking over roles currently held by humans will provide the bulk of the remaining economic benefits.

Accenture, a global management consulting and professional services company, identifies the following industries as benefiting with the largest economic growth:

- Manufacturing
- Professional Service
- Wholesale & Retail
- Public Services
- Information & Communication

Businesses are quickly working to ensure they are taking full advantage of what AI has to offer. Let's take a look at some of the areas they are working on to make their business more competitive and responsive to their customers.

## Chat-Bots

Chat-bots are artificially intelligent computer programs that dialog with humans—typically customers calling in with questions or in need of help with ordering—by providing responses that are similar in feel and behavior to chatting with a person. In the same way that the touch-tone telephone provided the ability to bypass the human switchboard operator, the chat-bot provides businesses with the opportunity to automate many of their customer service functions. Similarly, virtual agents can go one step further: Customers will be able to engage with an interface that takes away the need to engage with a human.

AI enables less effort, time, and money to be expended to handle human relationships and customer service. In the course of writing this article, my phone popped up with a message about an upcoming flight to New York City. With the push of a button, I am now checked in. This technology has existed on our phones for the past few years, but businesses will be significantly expanding the capabilities that customers have to quickly and efficiently engage with their company.

## Decision-Making

Advertisers are also using AI to improve their decision making. AI can assist with generating a greater variety of adverting options as well as assist key decision makers by providing insights about customer preferences based on customer inputs and feedback. This ability to efficiently handle Big Data quickly and efficiently is not just of benefit for advertisers; many businesses are looking at how to take vast amounts of information they have available and use it to improve decision making and marketing.

AI technology provides benefits because, like humans, it can be highly adaptable according to the situation. Whether it is interacting with humans in a customer support fashion, where the specific dialog cannot be well known in advance, or sifting through medical imaging files to detect illnesses and suggest a course of treatment, AI can be enabled to provide feedback that is appropriate to the context of the circumstance.

AI technology is also increasing its ability to learn. Immediate feedback incorporated with Big Data provides the ability for AI to minimize

mistakes as it moves forward, while maximizing its ability to achieve its goals.

## Electronics

The increasing development of new electronic components and systems continues to advance technology so that humans and businesses have more powerful technological capabilities within their grasp than ever before. Last night, my Samsung Galaxy 4 phone dropped from a bench onto a hard floor, cracking its glass screen—something that we can all probably relate to. This morning I was looking at replacing it with the Samsung Galaxy 8, with its contextually-aware AI Bixby. Across the board, companies are making it so that AI is closer to their customers and interfacing with them more often and more conveniently.

## Conclusion

Many people have raised concerns about what AI may mean for human employment. In this context, people and governments naturally fear for their jobs and economic lifestyles. It is inevitable that there will be a transition in shifting humans away from jobs that require high data computational capabilities toward other possibilities. In the past, seismic transformational changes in society brought about by technology have always required people to adapt. As time proceeds, the necessity to respond to changes happens faster. For our part, we need to change and adapt to meet the reality of the future, in which AI technology emerges as more and more integral to the world in which we live.

It doesn't take knowledge of the future to see that, in 2018 anyway, we do not yet have to fear machines rising up to completely replace humanity.

***"For our part, we need to change and adapt to meet the reality of the future in which AI technology emerges as more and more integral to the world in which we live."***

ANALOG DEVICES

## EVAL-ADICUP3029 Development Platform

mouser.com/adi-ltc3871-controllers

DIGI

## XBee® Cellular NB-IoT Embedded Modem

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intel


## Movidius™ Neural Compute Stick

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Texas Instruments


## CC2640R2F/CC2640R2F-Q1 SimpleLink™ Wireless MCUs

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# Emerging Applications Put Microwave Technology to the Test

*By Barry Manz for Mouser Electronics*

RF and microwave design engineers inhabit a mysterious world where circuits that "should" work don't, where simulation tools get you just so far, and where signal propagation varies with the time of day, the weather, and yes, the phase of the moon. This year, the vagaries of the ether will test the best minds in the business of "fields and waves," as applications will need their talents more than ever. There's much to be done, a limited time to do it, and none of it will be easy.


The fifth generation of cellular, 5G, is a terrific example because it's the most wide-ranging change since wireless visionary Martin Cooper made the first cellular call using a handheld phone in 1973 (**Figure 1**). Since then, cellular networks have moved up in frequency from UHF to microwave, but 5G will take them more than an order of magnitude higher, to millimeter wavelengths, where almost everything about communications becomes more difficult and more expensive.

A signal "up there" travels only as far as the first thing it meets, whether it's a tree, sign post, or building. After that, the signal is scattered and thus severely reduced in strength as to be almost undetectable. But this is where cellular is headed, as little spectrum remains at lower frequencies to accommodate the huge bandwidths required to transfer the zettabytes of data generated by streaming video, gaming, and virtual reality. To make millimeter-wave networks a reality, designers will need all available tools, from higher-order modulation techniques to multi-user "massive" MIMO, to phased array antennas, currently the exclusive domain of defense radar systems.

***Figure 1:*** *Dr. Martin Cooper poses with the 1973 DynaTAC prototype, the first cell phone. (Source: Rico Shen/CC BY-SA 3.0)*

They will also have to avail themselves of the few semiconductor technologies that work at these frequencies, primarily silicon germanium (SiGe) and RF CMOS, both of which remain to some degree works in progress. That is not just in the base stations; smartphone designers have the onerous task of incorporating massive MIMO in a pocket-sized device, along with even more frequency bands and the seemingly impossible problem of keeping a user's hand from absorbing a millimeter wave signal.

Speaking of works in progress, there's the IoT, to which RF and microwave technology is linked at the hip. The challenge here is not high frequencies, higher data rates, or obscure technologies; just the opposite. IoT networks operate at much lower frequencies, minimize data rates and channel bandwidths, and use existing technologies to create dirt cheap "edge devices" the size of a matchbook that can operate for up to 10 years on a coin cell battery.

This might be less a technical challenge than operating at frequencies in the wilds of the millimeter-wave frontier, but it's not trivial. The designer's tasks are compounded by the fact that too many competing solutions exist for connecting edge devices, and to no one's surprise, those are

mostly incompatible. Regardless of the connectivity solution, such as Bluetooth 5, Zigbee, or the other dozen competitors, a mesh network will be required that lets them communicate with each other.

The data that devices generate must be transferred to a gateway where the data is aggregated, minimally processed to reduce its bulk, and sent onward to the Internet via either cellular networks or Low-Power Wide Area Networks (LPWANs). This is difficult enough in a modest home automation system, but throughout a smart city, 5,000-acre farm, or manufacturing facility, it becomes a massive challenge.

We also can't fail to mention the frenetic pace of autonomous vehicle development that combines the aforementioned challenges with mobility and the need to provide extraordinarily precise, near-real-time vehicle situational awareness. Vehicles need to communicate with each other and with external sensors, such as cameras mounted on "street furniture," ranging from street lights to traffic signals. As governments, automakers, and device manufacturers are eager to make driverless cars a reality, a communication solution that all stakeholders can agree on must be found, and soon.

Ideally, this would be a simple process: Allocate frequencies, wireless access methods, and other communication specifications, and move forward. Reality being far less than ideal, two camps are now duking it out to reign supreme. The government has its 18-year-old commitment to Dedicated Short-Range Communications (DSRC) for which spectrum at 5.9GHz was allocated in 1999. It requires a dedicated communications infrastructure and "roadside units," neither of which currently exists. The cellular industry has ubiquitous infrastructure and advanced data communications already available, and considers DSRC archaic. The cellular industry will probably win this war, but not easily.

***"The cellular industry will probably win this war, but not easily."***

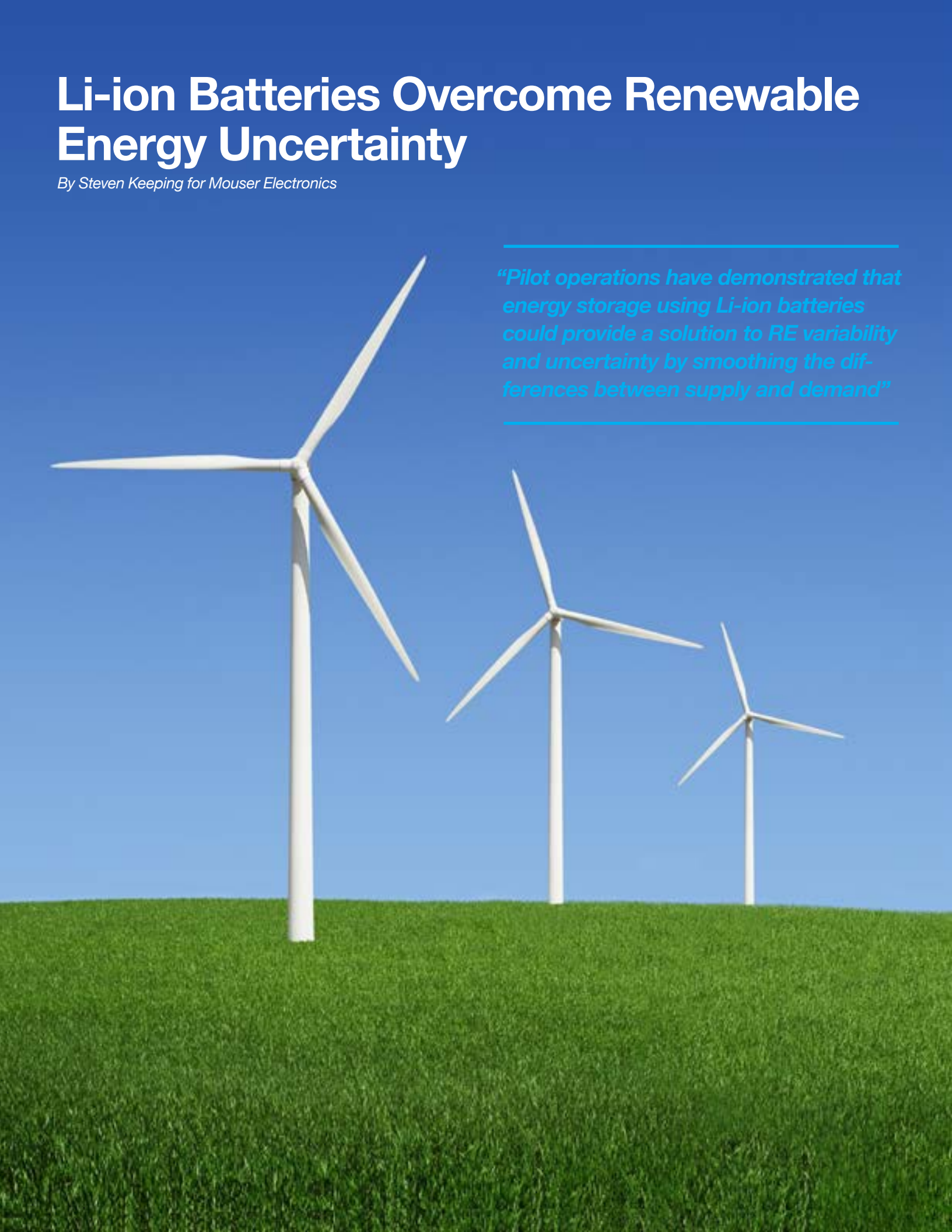
IoT, 5G, and autonomous vehicles share another immense communications challenge as well: Reducing latency to near the vanishing point. Latency is the round-trip elapsed time between when a signal is sent and when it arrives at the desired destination. This isn't simply a matter of advancing the state of the art; it pits designers against the immutable laws of physics. That is, latency over a given path can be reduced only so much, which is fundamentally dictated by the distance between the two points. This means that to achieve the 1ms latency proscribed by 5G and needed by some IoT applications, the communication path must be very short, necessitating the use of enormous numbers of small base stations (small cells). That will be extremely expensive and exceedingly complicated.

These are just some of the problems that the engineering, scientific, and academic communities must solve for 5G and IoT to meet their fantastic promises, and for autonomous vehicles to function in an unpredictable world while keeping us safe. There are many others in which RF and microwave technology play a less prominent but still important role. In short, big technological gaps exist that must be filled, and the stopwatch is running.

Check out Mouser's articles and resources for RF Wireless on our Applications & Technology site.

# Li-ion Batteries Overcome Renewable Energy Uncertainty

*By Steven Keeping for Mouser Electronics*



***"Pilot operations have demonstrated that energy storage using Li-ion batteries could provide a solution to RE variability and uncertainty by smoothing the differences between supply and demand"***

Renewable energy (RE) promises much, but it has yet to make a significant impact on world demand. In 1973, the world's total primary energy supply (TPES) amounted to 6,101 million tonnes of oil equivalent (Mtoe), of which just 0.1 percent was made up of "other" sources—primarily geothermal, solar, wind, tide/wave/ocean, and heat. Fossil fuels (oil, gas, and coal) made up 86.7 percent.

Forty-two years later (2015, the latest year for which figures from the International Energy Agency are available), TPES had more than doubled to 13,647Mtoe, but renewables still made up only 1.5 percent of demand (with fossil fuels making up over 81 percent). The positive spin on these figures is that renewables have risen from 6.1Mtoe to 205Mtoe in a little over four decades, but the slow rise shows there is still much to do.

Political and regulatory hurdles aside, the key technical hurdles for greater adoption of renewables are:

- Variability: Change of generation output due to fluctuations of wind or sun, for example
- Uncertainty: The inability to predict the timing and magnitude of changes in generation output

Both make it impossible to guarantee RE resources will be available when peak demand occurs.

However, pilot operations have demonstrated that energy storage using Li-ion batteries could provide a solution to RE variability and uncertainty by smoothing the differences between supply and demand. For example, since 2012 the Hawaii Electric Light Company has been relying on two containerized Li-ion battery systems from Saft to smooth wind power variability on the Big Island. The systems store 496kWH, feature a two-hour runtime, and can be charged during lulls in demand from RE sources. These developments point to 2018 as the year this technology takes off on a commercial scale.

## Hedging Bets

Unreliable supply spooks utility managers because of harsh financial penalties if the lights go out. While virtually all utilities understand the merits of green energy, investment in the technology is often accompanied by back-up investment in highly reliable conventional sources. For example, in recent years the U.S. increased conventional reserves by nine percent to back-up its investment in wind power. While the utilities can hardly be blamed for protecting their bottom lines, this conservative approach isn't going to reduce overwhelming reliance on fossil fuels any time soon.

The solution to the technical challenge is to store any excess energy from RE sources when the sun shines and the wind blows for release when the elements don't cooperate. The electricity generation industry is well-versed in energy storage to smooth peaks and demands. For example, hydroelectric schemes typically use excess energy at times of low demand to pump water uphill. The potential energy in the upper reservoir is then released exactly when it's needed.

Some utilities have taken this a step further by teaming wind turbines with hydroelectric schemes. The wind turbines fill the upper reservoir whenever there's a breeze, enabling energy storage even if all the main plant's electricity is being used to meet consumer demand. The technology is popular: Oak Ridge National Laboratory research revealed that in 2014, 97 percent of utility-scale storage was in the form of pumped water.

The disadvantage of hydroelectric schemes is that they rely on

favorable topology and suitable sites—especially those close to population centers—which are thin on the ground. And even if a site is identified, there's no guarantee that construction on what is often a sensitive site will be given the go ahead.

## Batteries Solve Outages

Batteries are purpose-designed for electricity storage and overcome the geographical restrictions of hydroelectric installations because they can be placed virtually anywhere.

While other battery technologies exist, few can compete with Li-ion technology's energy density, number of recharge cycles, and reliability. In addition, continuity of supply and a robust distribution chain are assured, in part due to Li-ion technology's widespread adoption in consumer electronics products and electric vehicles (EVs). Such advantages have seen Li-ion technology adopted for pilot energy storage schemes; the Hawaiian example is just one of many pilot plants around the world. Smart grid technologies are easing the on and off switching of stored energy by making it simpler and more efficient.

According to Scientific American, Li-ion storage technology is set to expand from pilot plants after 2018 because solar and wind power are becoming more abundant and cheaper—accelerating the shutdown of older coal- and gas-fired power plants that can no longer compete. Because this transitional period is haphazard, Li-ion storage is filling the inevitable gaps in generation capacity that occur.

A perfect case study is South Australia (SA). The region turns to wind power for around 40 percent of its power generation, but the rush to RE has been made at the expense of reliability. Now that old coal-fired power stations have been removed from the generational mix, the Australian state suffers widespread power outages when the weather calms. EV maker Tesla has offered a solution in the shape of the world's largest Li-ion battery—situated in Jamestown and to be employed when SA's wind turbines can't cope. The unit is rated at 129MWh, enough to supply 30,000 Australian homes for just over an hour in the event of other sources going offline. Power to charge the batteries comes from the next door Hornsdale Wind Farm.

More ambitious plans are afoot. Scientific American reports that, by 2021, a Long Beach gas-fired "peaker" power station—so-called because it comes online in the afternoons to help baseload stations meet peak demand—will be replaced by a 400MWh Li-ion electricity storage system. The installation is big enough to supply nearly 50,000 homes for two hours and will comprise 18,000 modules, each the same size as a Nissan Leaf EV's power pack. In a novel twist, the battery will be charged by solar energy in the mornings to cater for the afternoon peak and by wind power during the night for the early morning peak.

## The Slow Pace of Change

Although 2018 will see much greater use of Li-ion storage, the technology will take time to become ubiquitous. Recently, Citibank estimated that the cost of power from pumped hydroelectric sources was about five percent of the cost of grid-scale battery-stored electricity. Others say that a shortage of lithium (and cobalt, which is used for Li-ion battery electrodes) will limit future battery supply.

But as additional sources of manufactured Li-ion cells come to exist, prices for the batteries will drop and other market sources will come into play. For example, cheaper RE will push out fossil fuel capacity, encouraging greater investment in storage technology. Long-term material shortages are likely to disappear as Li-ion technology succumbs to battery technologies with greater promise, built from less exotic materials and with much higher energy densities.

Check out Mouser's articles and resources on renewable energy on our Applications & Technology site.


# Organizations and Events Shaping the Maker Movement in 2018

*By Mike Parks for Mouser Electronics*

The human spirit of incessant innovation and wonder has long driven our technological and artistic pursuits. The Maker Movement is the latest manifestation of this spirit. But the past is now prologue, and 2018 is shaping up to be an amazing year for makers around the world. Here is a look at some of the organizations and events that are helping to make this happen:

## Maker Faire

Maker Media, Inc. publishes *Make*: magazine and hosts Make Faires around the globe. The first Maker Faire of 2018 will be held in Bangkok from January 20–21, 2018. The flagship Bay Area Maker Faire will once again be hosted at the San Mateo Fairgrounds from May 18–20, 2018. If you can't make it to California or Bangkok don't fret. Chances are there is a local Maker Faire that you can attend.

## SXSW Create Conference

If you happen to be in Austin, Texas between March 10–11, 2018 then you might want to swing by SXSW for their annual SXSW Create conference. Create is their maker-oriented portion of their overarching annual festival held in the Lone Star State.

## NoMCON Conference

The beauty and power of the Maker Movement is in its diversity both in terms of its global inclusiveness of people and support from all types of organizations. The huge support base can be a double-edged sword, however, as it can be quite a challenge to gain consensus on

the direction of the movement. The necessity of such consensus is crucial if the Maker Movement wants to grow beyond being a hobbyist community and instead become a true global force for good. This is the hope of the recently formed nonprofit Nation of Makers. Part of their vision is a belief that "...the maker movement has significant implications for manufacturing, economic and workforce development, education, healthcare innovation, community revitalization, and technology advancements."

To initiate a dialog on their vision and determine better ways ahead, Nation of Makers is looking to host an inaugural conference (NoMCON) in 2018. NoMCON is still in the planning stages, but they have announced the event will take place June 9–10, 2018 in Santa Fe, New Mexico. For those interested in keeping abreast on the conference, be sure to check out their planning page.

### Maker City Project

The Maker City Project is an effort to help public-private ventures adopt the principles of the Maker Movement to help revitalize communities and spur economic growth, improve education, and develop a 21st century workforce.

### Fab Foundation

One of the foundations of the Maker Movement is universal access to makerspaces, hackerspaces, and fabrication laboratories (FabLabs). The Fab Foundation is a nonprofit that grew out of MIT's Center for Bits and Atoms Fab Labs Program. Their stated mission is "...to provide access to the tools, the knowledge, and the financial means to educate, innovate, and invent using technology and digital fabrication to allow anyone to make (almost) anything, and thereby creating opportunities to improve lives and livelihoods around the world."

## Virtual Communities

If you do happen to live any significant distance from a makerspace there are online alternatives to find a virtual community of like-minded makers. Some of the more popular sites include:

- YouTube
- Twitch
- Instructables
- Thingiverse
- GitHub
- Hackaday
- Hackster

Autodesk is aggressively going after the maker market, as they recently added electronics tinkering tools to their online 3-D design application TinkerCAD.

## Niche Maker Organizations

### Humanitarian Organizations

The Maker Movement has been instrumental in making the world a better place to live. Two organizations that exemplify the humanitarian nature of the movement include:

- Tikkun Olam Makers: a community that leverages technology to improve the livelihoods of people suffering with disabilities.
- Field Ready: a nonprofit group of makers that leverages their skills and tools to serve those suffering from natural or man-made disasters around the globe.

### Education Organizations

Similarly, hands-on education of youth has been another key issue for the Maker Movement, filling in gaps as schools have shut down art, home economics, and technology education programs. This has not gone unnoticed by many youth service organizations that one wouldn't typically equate with the Maker Movement. 4-H has adopted maker and STEM education, and it's given it an agricultural and environmental flavor. 4-H will be hosting an Agri-Science Summit in Washington D.C. from January 12–15, 2018.

Another group, the Boy Scouts of America, launched STEM Scouts in 2014 as a pilot program serving youth in 3rd through 12th grades. Next year will see an expansion of the co-ed program into more locations across the U.S. And for those scouts wanting to study past and current technology in the great outdoors, the BSA's Philmont Scout Ranch will be holding two 12-day STEM Treks programs in the summer of 2018.

### Robotics Competition

Lastly, the 2018 FIRST Robotics season kicks off January 6, 2018. The competition will bring together over 90,000 students for weeks of designing and building autonomous robots that will compete for glory at 160 events all around the world. The best of the best will earn the right to compete at the 2018 FIRST Championships. The first will be held April 18–21, 2018 in Houston, TX. The second event will be held April 25–28, 2018 in Detroit, MI.

# 2018: A Year for Open Source

*By Bruce Byfield for Mouser Electronics*

Open source technologies and products are major influences in applications ranging from super-computers to cloud computing and containers. In 2018, this influence is likely not only to continue, but also to expand into open hardware, especially in areas such as security, power supplies, and the autonomous car. If anything, envisioning future technological developments without open source is becoming increasingly impossible.

In the first decade of the millennium, the mainstream open source movement was slow to participate in new technology fields, partly because it lacked the software licenses that fit the conditions of circumstances such as cloud computing. However, in the second decade, it has more than made up for its slow start.

Today, for instance, 498 out of 500 super-computers operate on Linux. This near-monopoly is due partly to open source's support of the widely-used arm processor, which is more mature than that of Windows. However, when asked to explain their use of Linux on super-computers, project directors consistently cite its modularity, scalability, and low cost—advantages that are obviously going to continue into the future.

Commercially, the story is much the same. It began in 2010 when OpenStack—the open source cloud computing platform—consciously modeled itself after traditional open source areas such as Linux development. As a result, OpenStack has quickly grown into one of the leading cloud platforms, with contributions from such companies as Cisco, HP, IBM, Red Hat, and VM and with each of its regularly scheduled conferences attracting ten to twelve thousand attendees each. The same is true in the field of containers, where the open source Kubernetes has become the main tool for deploying and managing containerized applications.

Admittedly, some aspects of this dominance are still under development. For example, universal packages—essentially modern versions of static tarballs that include all required dependencies—are being developed in Canonical's Snap project and Red Hat's Flatpak as a substitute for Linux's traditional .deb and .rpm package management systems. Although both projects are aimed at embedded systems in particular and could become widely used in IoT devices, they are still in their infancy and may provide less security than their developers claim. All the same, with 2017 marked by Canonical Software de-emphasizing the development of Ubuntu Linux in favor of container and cloud technologies and with Red Hat planning to emphasize the same areas at its 2018 Summit, open source's domination seems only likely to grow.

## Open Hardware and Security

The next year should also see the proliferation of open hardware—that is, physical devices with public specifications that run on open source firmware. Combined with crowdfunding, open hardware promises to halve the usual time to market for new products. Already, it is helping small engineering companies create new products. Open hardware is also creating a generation of small-time developers-turned-engineers who are going into business to realize ideals that would have been improbable even a decade ago.

So far, such companies are insignificant economically, confined to niche space in their markets; however, as a source of innovation, they seem poised to have an indirect influence, particularly in new products. Keyboardio, for example, is developing a high-end, programmable keyboard that is also physically customizable. Similarly, Input Club, another small distributor of programmable keyboards, is considering turning its attention to mouses (or mice? Can't find an official answer) and trackballs—devices that have changed little for over a couple of decades. If these efforts are successful, established companies are sure to release their own versions of such innovations from small entrepreneurs. Already, less than two months after Purism,

a small maker of secured laptops, crowdfunded its plans to produce a Linux-based phone, Samsung has announced plans to produce its own Linux phone—which might be dismissed as coincidence, except for the timing.

Open software and hardware appear to be in a particularly strong position to bring security practices to general users. Qube OS, for example, is one of the first to make different levels of security accessible to any user by integrating them into the desktop environment. In the same way, the social purpose corporation Purism has made its name by selling computers that ship with secure setups. In fact, Purism's planned Librem 5 phone will be one of the first to emphasize security rather than the size of its app store. With security constantly making headlines these days, and no similar innovations coming from longer established companies, it requires no clairvoyance to predict that larger vendors will soon be following such examples.

In the past, open hardware devices have been handicapped by the fact that computer chips generally include proprietary firmware. However, even that is already changing with the release of the open source RISC-V open instruction architecture for chips. First developed at the University of Berkeley in 2010, RISC-V chips are now being developed by a number of small vendors, and are the subject of a regular conference. With the development of RISC-V, yet another barrier to open hardware's success next year has been removed.

## Coming Attractions

All these developments demonstrate how ubiquitous open source has become. Yet some of the areas where open source is most influential go mostly unnoticed—although a reliable indicator is often the crowdfunding campaigns on Kickstarter and the code repositories on GitHub. Even though open source is seldom mentioned, investigation soon reveals that open source is currently instrumental in the transition from silicon-based MOSFETS to Silicon-carbide switches in power supplies. In the same way, research into the autonomous car by major manufacturers is largely based on open source projects. For example, the 2018 Camry is the first vehicle to incorporate aspects of Automobile Grade Linux, and others are sure to follow.

Perhaps the most convincing indicator of how influential open source is likely to become in 2018 is the fact that it is so seldom mentioned. Just as Google re-brands Linux as Android, manufacturers are bootstrapping development with open source projects and releasing the results without mentioning how they were developed.

True, like so many years before it, 2018 is unlikely to be the long-deferred Year of the Linux Desktop. However, such a milestone seems increasingly irrelevant when open source is quietly providing the basis of so many key modern technologies.

Check out Mouser's articles and resources on open source hardware on our Applications & Technology site.