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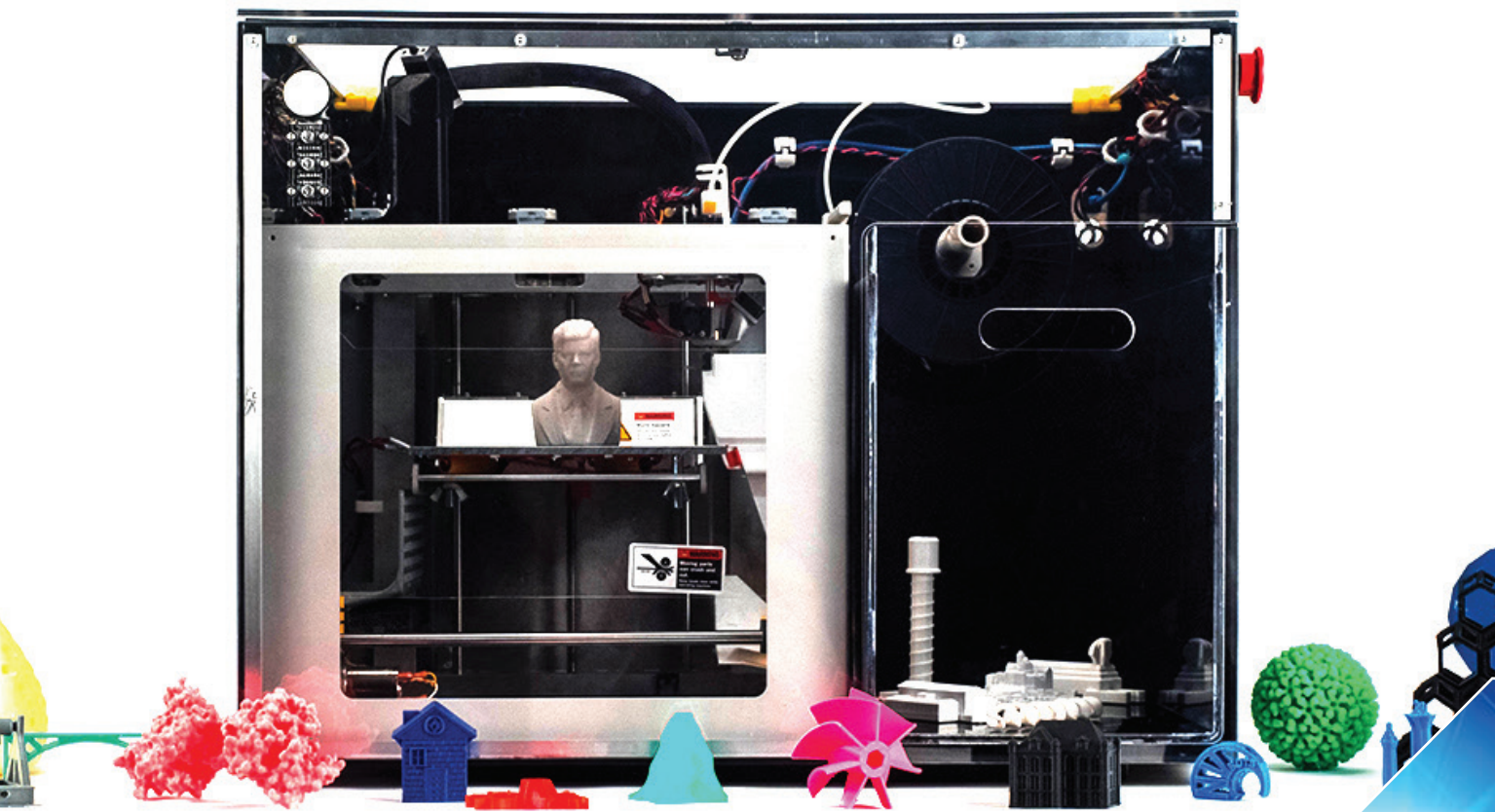
Vol. 59 No. 6

The evolution of 3D printing

The policies behind conflict materials

Securing all devices in the Internet of Things

Accessible Innovation:
An automated 3D printer



KASEY PANETTA | EDITOR
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Defining Innovation

Innovation. It's kind of an odd word because it has a very vague definition. Generally, it means to create something so different from what's been done before that simply calling it new isn't quite right. The fact that the definition of innovation seems to evolve with each new technological breakthrough doesn't make it any easier.

At *ECN's* IMPACT Awards ceremony at EDS 2015 in Las Vegas, Mike Rainone, founder and chief innovation officer at PCDworks, Inc., had a lot to say about innovation. In addition to criticizing an industry which no longer allows for true innovation, Rainone talked about the clash between the would-be innovators and the higher ups who have trouble understanding that it's difficult to innovate with a small budget and a large bureaucracy.

Rainone talked about amazing innovators such as Lockheed Martin's Skunk Works group led by Kelly Johnson. Johnson and his team are famous for their revolutionary plane designs like the U-2, SR-71 Blackbird (one of the world's fastest airplanes), and the P-38 Lightning. They were most recognized for their quick delivery times—the P-38 was finished in just six months—in an industry that doesn't lend itself to short time-to-market. Rainone attributes the success of the program to the way Johnson set it up, but also that Lockheed Martin leadership allowed Johnson to manage the program.

Rainone also talked about companies that didn't innovate very well, like Chevy with it's Aztec fiasco. You can read more about Rainone's ideas at www.ecnmag.com/everythinge.

I'll end with just a little bit of housekeeping. We've had quite a few new faces around the office lately, and you'll be seeing one of those faces pop up around ECN. The face in question belongs to our new associate editor Jamie Wisniewski, who joined the ECN team last month. Jamie replaced long time digital editor Jason Lomberg, who moved on to greener pastures on another publication at Advantage Business Media. He's still available by email, so feel free to wish him good luck (or good riddance).

Until next issue,

Kasey Panetta

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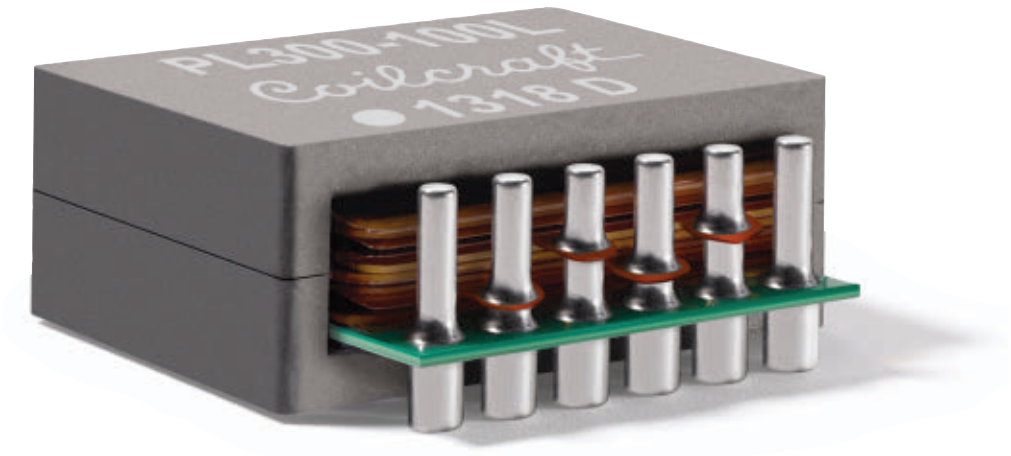
300 Watts. Zero Wait.



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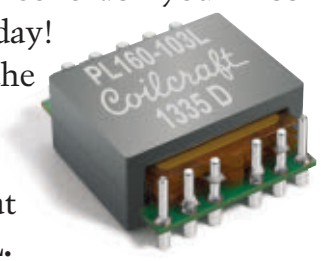

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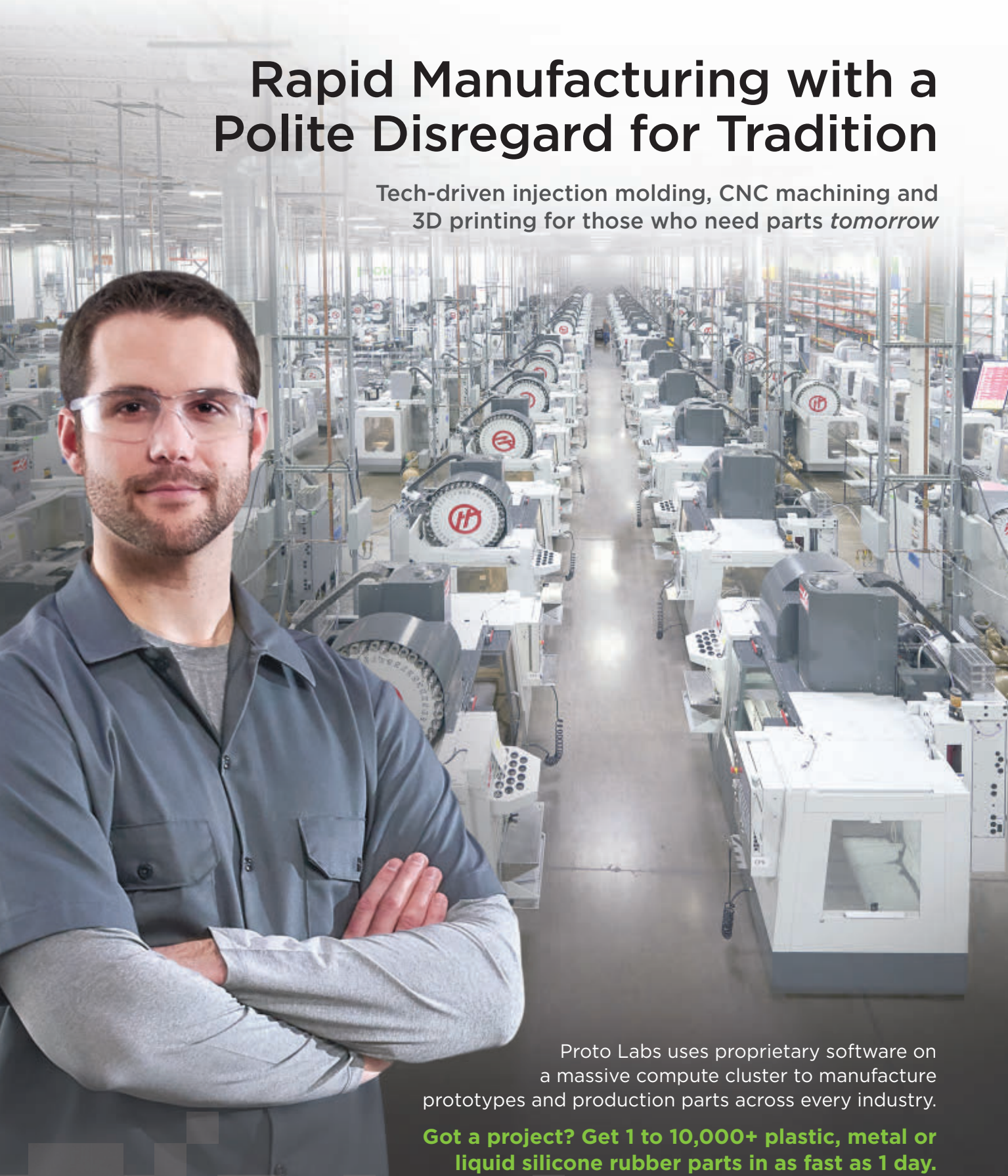

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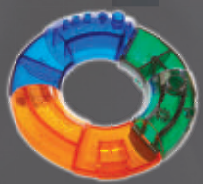

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KEY FACT:
Applications include the connection of IP cameras, public transport and railway infrastructure, broadcasting systems, industrial machinery and process equipment, automation packaging, and encoder solutions.

Enclosures suitable for touchscreen applications

OKW's multifunction INTERFACE-TERMINAL enclosures are now suitable for touchscreen applications. The cases can be ordered with a high quality glass panel fitted in the top to protect the touchscreen underneath. The enclosure is an extremely versatile range of configurable enclosures which can be used for handheld, desktop, wall or flush mounted applications by specifying different combinations of case components. Applications for the new touchscreen format include office electronics, controllers, communications, safety engineering, medical and laboratory technology, education, museums, healthcare, automation, and measurement.
For more information, visit www.okwenclosures.com.

KEY FACT:
The new touchscreen glass panels have been designed for use with the Version II base sections – either flat or high, to give designers a wider choice of internal space options.

Connector facilitates 10 GbE applications

ERNI Electronics, Inc. continues to expand its M12 connector product offerings. Recent additions to this popular form factor include an enhanced Gigabit Ethernet connector that facilitates 10 GbE applications. Providing reliable high-speed data transfer, the connectors are designed for reliable and rugged industrial data communications applications. The connectors feature an 8-pin design and are compatible with RJ45 network cabling. The interface is X-coded according to IEC 61076-2-109. EMC characteristics are supported by the 360° shielding and improved effectiveness that is complemented with shield to PCB and shield to panel conductor features.
For more information, visit http://www.erni.com.

KEY FACT:
Backed by a one-year warranty, FM series photoelectric sensors are cULus, CE, and RoHS approved.

Sensors ideal for food and beverage applications

AutomationDirect's FM series harsh duty photoelectric sensors are IP69K-rated sensors in three-wire NPN or PNP styles and are available in 27 washdown models. Ideal for food and beverage applications, the 10-30 VDC rectangular sensors are fitted with 316L stainless steel housings and are available in diffuse, diffuse with background suppression and polarized retro-reflective styles and through-beam models are sold as an emitter and receiver separately. The harsh-duty photoelectric sensors have either an attached two-meter output cable, or an M8 or M12 quick-disconnect. All models have a selectable light-on/dark-on output setting; sensing ranges are available up to 10 m.
For more information, visit www.automationdirect.com/photoelectric.

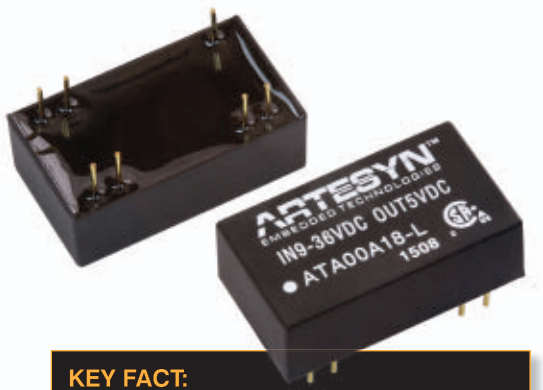
KEY FACT:
Wide input voltage range of 4.5 V to 60 V covers all standard input rails including 5 V, 12 V, 24 V, 36 V, 42 V, and 48 V.

Buck controller enables direct step-down conversion

Intersil Corporation announced the first 60 V synchronous buck controller able to bypass the intermediate step-down conversion stage traditionally employed in industrial applications. The ISL8117 synchronous step-down PWM controller's low duty cycle (40ns minimum on time) enables the direct step-down conversion from 48 V to a 1 V point-of-load. This technical achievement makes it possible for designers to reduce system complexity and solution cost in industrial, factory automation, medical and communications infrastructure applications. The component reduces solution footprint and simplifies design without compromising performance. Default design values for commonly used functions and wide Vin and Vout reduce the number of external components compared to competing solutions.
For more information, visit www.intersil.com.

Output DC-DC converters target low power applications

Artesyn Embedded Technologies launched its lowest power output DC-DC converters, targeting a diverse range of low power applications, including data communication, telecommunication and computer peripheral equipment, industrial automation and mobile battery-powered systems. The new Artesyn ATA series of 3 watt isolated DC-DC converters comprises 16 variants, each of which is available in a mini dual-in-line package for through-hole mounting or a mini surface-mount package. All ATA series converters feature ultra-wide 4:1 inputs; eight of the models have 9–36 V inputs and the other eight have 18–75 V inputs. Within each of these two categories, there is a choice of five single output models, offering voltages of 3.3 V, 5 V, 12 V, 15 V, or 24 V, and three dual output models offering +5/-5 V, +12/-12 V, or +15/-15 V.
For more information, visit www.artestyn.com.



KEY FACT:
Offering up to 80 percent conversion efficiency, the converters use 350 kHz fixed frequency switching to minimize the need for external EMI filtering.

KEY FACT:
The controllers primary-side regulated sensing methodology eliminates expensive and unreliable optocouplers, replacing them in the feedback loop with a simple transformer winding.

Reference design demonstrates industrial power supply

Power Integrations announced a new reference design (DER-479) demonstrating an industrial power supply using the company's LinkSwitch-4TM family of CV/CC primary-side regulated (PSR) switcher ICs with a 1200 V bipolar junction transistor (BJT). The design supports 440 VAC line inputs and features three outputs which combine to provide up to 11 W of highly accurate constant-voltage DC power. LinkSwitch-4 controllers feature an adaptive base and emitter switched drive scheme to boost switching performance and increase efficiency. The advanced switching technique is especially beneficial in high-voltage applications as it reduces slow turn-off switching losses and eliminates BJT failures due to secondary breakdown, improving the reverse-bias safe operating area (RBSOA) and system reliability.
For more information, visit www.power.com.

8%

Amount of California's self-driving cars in accidents since September

NASA's morphing-wing technology could make flying more ... tolerable

by Jason Lomberg, Digital Editor, @JasonECNMag

While NASA experiments with tiltrotor drones capable of switching from aircraft to helicopter mid-air, it's also testing a shape-changing wing that could save millions in fuel costs and improve the passenger experience.

Engineering Update #109: NASA's 10-engine tiltrotor drone

- **NASA's 10-engine tiltrotor drone**
  NASA's new 10-engine drone looks like someone Frankensteined together a C-130, V-22 Osprey, and a Harrier for good measure. So naturally, they dubbed it the GL-10 Greased Lightning.
- **Using 3D printing to prevent a rare pediatric disease**
  Researchers at the University of Michigan have designed a 3D printed piece that is capable of preventing an infant's airway from collapsing from a rare pediatric disease that affects one in 2000 children.
- **Eye-tracking technology that improves the driver experience**
  Jaguar Land Rover and Intel partnered with Seeing Machines to develop eye-tracking technology that could be used prevent drowsy driving.

The quantum dots revolution

by Jason Lomberg, Digital Editor, @JasonECNMag

Quantum dots are the most important technological development that no one has heard of. At least not when compared to the buzz about 4K, curved displays, the Internet of Things, or other Consumer Electronic Show (CES) titans. It's not exactly a new technology as scientists first discovered the tech back in 1981. This technology has made cameo appearances at SID Display Week and other optoelectronics events, but CES 2015 was the first to showcase quantum dots on so large a platform.

1,184

Number of offshore wind turbines around the coast of the UK

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The dying world of innovation

By Kasey Panetta, Editor, @kcpanetta

Innovation is a word that gets thrown around at a lot of companies, but nobody understand more about innovation than Mike Rainone, founder and chief innovation officer at PCDworks, Inc. And, according to him, all those companies tossing out ideas about how to innovate? They're doing it wrong.

Power inductors deliver high performance in small spaces

Coilcraft's XAL15xx Family of rugged, magnetically-shielded power inductors are offered in two versions – one providing saturation current ratings up to 111 Amps and the other offering inductance values as high as 33 μH – delivering the highest levels of performance in the smallest possible space.

The XAL1510 Series offers a unique combination of high inductance values (up to 33 μH) and current rating as high as 39.0 Amps, all in a compact package that measures just 15.4 X 16.4 mm and has a maximum height of 11.0 mm. For even higher current applications, the XAL1580 Series offers Isat ratings up to 111 Amps, with a 15.2 X 16.2 mm footprint and maximum height of 8.2 mm.

Both series offer very low DCR – down to 0.70 mOhms for the XAL1580 – and their soft saturation characteristics make them ideal for VRM/VRD applications. They feature RoHS compliant tin-silver (96.5/3.5) over copper terminations and offer a maximum reflow temperature of 260°C. The XAL/XFL inductors, the products feature a proprietary composite core that is not subject to thermal aging issues associated with other iron powder core inductors.

For more information, visit www.coilcraft.com.

Power supplies meet DTM165 standards

TDK Corporation announces the introduction of the TDK-Lambda medical certified DTM165 adapter power supplies. Suitable for a variety of hospital and healthcare applications, including diagnostic and monitoring equipment, the product also meets the required efficiency level V standards for medical equipment. The product is housed in a rugged, vent-free enclosure, measuring 170 x 85 x 44 mm. AC is applied using a standard IEC60320-C13 cable and DC provided through a four pin Power-DIN connector. Other connectors are available upon request. The adapters also feature over-voltage and over-current protection.

Accepting a 90 to 264VAC input, the 160 to 165W adapters are available with 12 V, 15 V, 19 V, 24 V, 28 V, 36V and 48V outputs and can operate in ambient temperatures ranging from 0 to +60oC (with derating). In addition to satisfying CEC, ERP and EISA requirements with an average efficiency of greater than 87 percent, the power supplies have an off-load power draw of less than 0.5W.

The DTM165 series conforms to the IEC 60601-1 3rd edition medical standard with 4kVac input to output isolation (2 x MOPPs) and 1.5kVac (1 x MOPP) between input to ground. Leakage current is less than 300μA. The series has been certified to ANSI/AAMI ES 60601-1, CAN/CSA-C22.2 No. 60601-1-08, EN 60601-1 and carries the CE mark. All models meet EN 55011-B, FCC Class B conducted & radiated emissions and EN 60601-1-2 immunity standards.

For more information, visit www.us.tdk-lambda.com.

Accessible innovation

Creating a 3D printer that anyone can operate.

By **Kasey Panetta,** Editor, @kcpanetta

3D printing has been making waves in almost all facets of the design engineering industry, from life-saving medical devices designed for preemie babies to parts for military airplanes. In fact, a recent industry survey by Tech Pro Research showed that though only 12 percent of companies are actively using 3D printing, 48 percent of companies were evaluating the printers. Of those companies, 19 percent planned to implement 3D printers in the next year. The market is growing so rapidly the McKinsey Global Institute predicts that in 10 years, the 3D printing industry will exceed $500 billion.

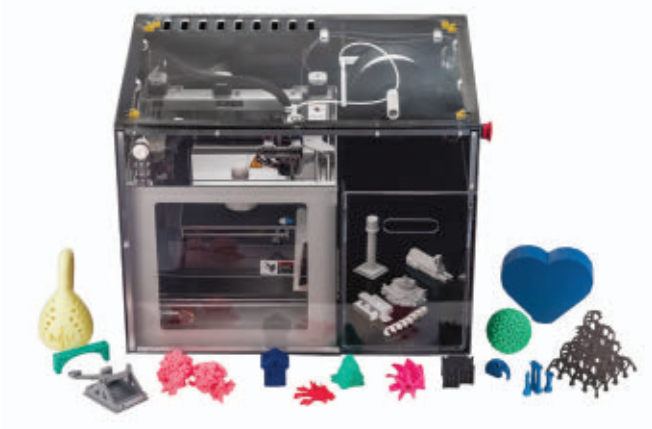
As companies start to recognize the benefits of 3D printing, such as faster time to market and lower costs, one company is trying to emphasize the educational benefits of this technology available in schools.

NVBots, a Boston-based company started in March 2013, has created a fully-automated cloud connected 3D printer with the idea that the set of technical skills necessary to utilize a traditional 3D printer should not be a barrier to receiving the creative and educational benefits of the technology.

The goal of the company, according to co-founder and CEO AJ Perez, is to create a technology that makes the design and 3D printing as ubiquitous as the code.

Essentially, the company created a 3D printer that anyone can use. Other printers have a knowledge threshold or other barrier that makes them difficult to implement in schools. As a result, students aren't learning how to think creatively because they don't have the technical knowledge to get started.

"Being able to augment the 3D world is more important than being able to augment the computer world, because these are things that we use and touch," says Perez. "People take for granted the idea that things just exist today, because we've built beautiful supply chains and people have no sense of what it takes to get that done. They have no say in the process."



NVBots leases schools the NVPro. (Photos courtesy of NVBots)

NVBots is looking to give students the ability to be involved in the creative design aspects without having to learn complicated coding or CAD programs. The goal was to make the manufacturing aspects of 3D printing so simple that students as young as six-years-old can use it and be able to focus on the creativity instead of the software.

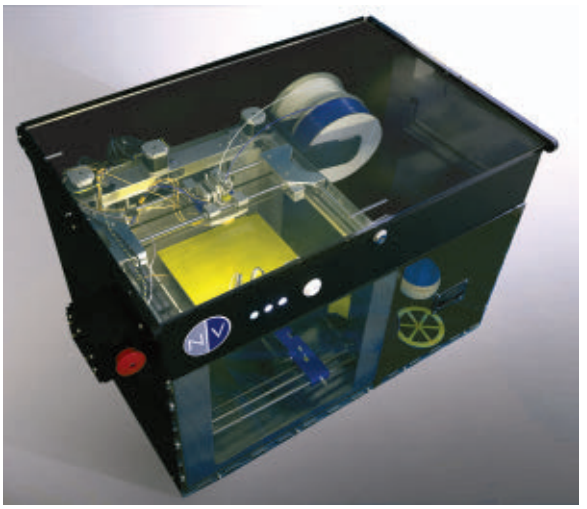
The challenges of 3D printers

Though 3D printers offer flexibility and creativity, most of them aren't classroom-friendly. Some of the printers, like those made by Stratsys or 3D Systems require an operator with a distinct skillset. Oftentimes, one person has total control over the machine since the operator will have painstakingly set certain parameters that will need to be reset if the project is interrupted. Other printers, like Formlabs' Form1+, require chemicals and post-processing and most of the printers require a person be physically near the machine to remove the printed part so that the next part can begin printing. None of these are problematic when it comes to corporations, but for a school where the system needs to be designed for multiple users and operate at least semi-independently, these challenges can seem impossible.

Because the NVBots 3D printers were designed with schools in mind—though corporate leases are available—the creators knew they had to design a system that was simple, easy to learn, automated, and innovative enough to be useful in a classroom. Because, after all, what's the point of introducing a technology like this into schools if it's not educational (and fun).

"You want the kids to be more creative, that's the goal, increasing creativity so the U.S. is more competitive," says Perez, who estimates the number of current users to be 500. "You can't do that if everyone has to be an expert at design, code, machine tools, and operating and maintaining a 3D printer."

NVBot printers are automated and can be observed, via a live video feed so no one has to be physically watching. Plus, it includes a robotic hand to remove parts once they're printed allowing the printer to work



NVBots estimates their user base to be in the mid-500s.

continuously. They're also designed for multiple users—NVBots recommends one for every 50 students—which makes them more appealing for a school that's catering to large class sizes.

3D printing innovation

Perhaps one of the most innovative aspects of the printer, and the one that makes it a valuable tool for educators, is the cloud-based component. Because the aim is to make the printers a useful option for teachers, the company offers up 3D printer-based curriculum and lesson plans so it can be integrated a classroom's day-to-day. The curriculum isn't entirely being created by the NVBot teams, but rather by the teachers who have figured out what works and what doesn't.

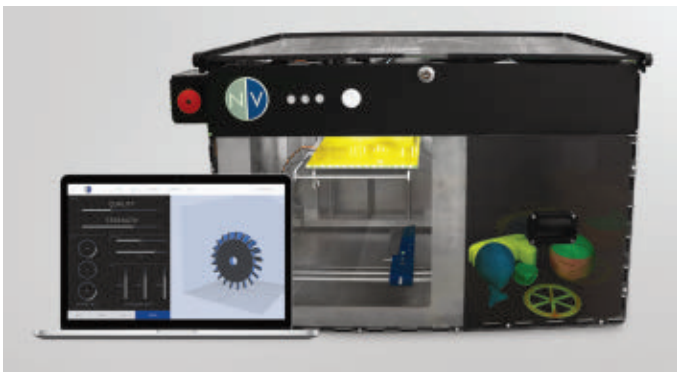
Basically, the team is working to create a group of Master teachers, who are established experts in a particular field, and who will take a look at any curriculum submitted by other teachers. If that's approved, the plans will be sent to the marketplace and be accessible to anyone with a printer.

While the NVBots team may have a great way to integrate the printer in to a particular subject—Perez says he's okay with physics or chemistry but he's "not your guy" for biology—a teacher might have a creative way to use the printer for a completely different purpose.

For example, Perez didn't think there was any way to use the printer for math lessons, but one teacher proved him wrong. The teacher went over the concept of volume with the class. The students were then told to come up with the dimensions for a box to hold a certain volume of water. Then the teacher used those dimensions to physically print the box and actually fill it with water.

"The teacher turned volume and design thinking into an experiment and math concept," says Perez.

The next phase is to increase the number of schools that are leasing the product and build up the Masters network. In the future, Perez is also hoping that the marketplace evolves into something that will allow one to share ideas that might change the world.



Packaging mockup.

"My hope is that this is a way for people around the world to share practices so schools in developing companies have access and vice versa," says Perez. "There's so much we can learn from each other but there's no means to communicate that." ECN

The evolution of 3D printing

Technology advances driving new training demands.

By **EJ Daigle**, Dean of Robotics & Manufacturing, Dunwoody College of Technology

3D printing has become a very buzzy term, even though as it's been in development since the 1990s. Part of the reason for that buzz is simple. The incredible pace of advancements in recent years and what technological progress now promises has placed us at a crossroads marked by great opportunity and an urgent demand for the skills to meet it.

I recall a recent trip to Boston. As my wife and I walked the streets after dinner we came across a store front with that distinctive MakerBot™ "M" logo. As we walked inside it looked like a strange combination between a cell phone store and microbrewery. Needless to say, they weren't selling phones or brewing beer. Instead you could bring in a CAD design to print and/or buy the printer you printed it on. For fifty bucks, you could 3D scan your bust and print out a very unique mantel piece. As we looked around the store, we saw MIT students working on class projects next to yuppies printing their wedding cake-topper.

This isn't the first far-reaching technology-shift in the manufacturing industry. It wasn't that long ago technology redefined the norm for manufacturing workers. As baby-boomer machinists retired, they were replaced by CNC programming gurus who brought with them the ability to program five and six-axis mill-turn machines using CAD/CAM software. The productivity of the machinist suddenly increased exponentially allowing for parts to be made in a single set up at lightning-fast speeds.

As we examine the future for 3D printing, we see similar technological advances driving staffing and training changes. In the past, a plastic part design would be sent to a mold shop where the mold-maker could spend upwards of a month building the mold to form the part. The modern day 3D printer can work with multiple polymers, huge work envelopes and superb precision. This allows the 3D printer not only the ability to create plastic parts, but also to print tools used to make other plastic parts. Imagine low-volume injection molds printed using high temperature polymers to mold low temperature polymers. One thing is certain, we must train our students, technicians and young people to understand and embrace this capability not for today but for what's coming.

Immense Possibility

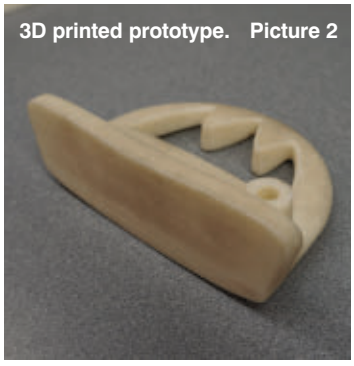
We are living in an age when the 21st Century CAD designer now has the ability to go from CAD model file to stereo lithography file with just the click of a button. I spent 10 years serving aboard US Navy submarines. As the submarine went to sea, we took a crew, food, fuel and spare parts for every subsystem onboard. Today a submarine crew or even an astronaut on the International Space Station could bring CAD files and a 3D printer to digitally manufacture on-demand repair or replacement parts needed.

Although many still view a 3D printer as purely a rapid prototyping machine, applications for these plastic parts have far outgrown this stereotype. In addition to protyping, 3D printers have found new applications in machining, molding, casting, inspection and even digital dentistry. (Picture1) shows a student-designed putter

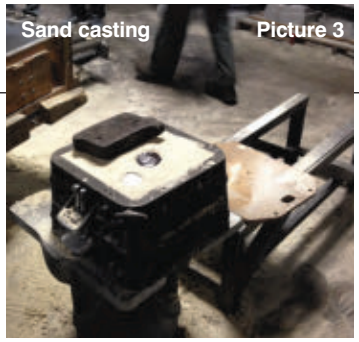
Picture 1

A student-designed putter prototype.
(All images courtesy of EJ Daigle.)

prototype that was modeled using Solidworks ™ software and printed on a Stratasys Fortus 250 3D printer. (Picture 2) shows the 3D-printed prototype used as a pattern for sand casting. (Picture 3) shows the sand casting just after the aluminum poured into the mold cavity formed by the 3D-printed pattern. From this casting process we get the final form (Picture 4) which has been cleaned up and painted for use on the golf course. The best part, all of this was done by two engineering design students with only two semesters of training.


3D printed prototype. Picture 2

The largest and most versatile printers such as

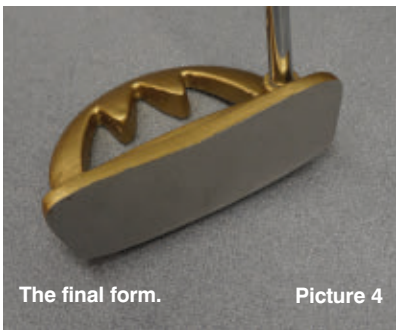

Sand casting Picture 3

the Stratasys Fortus 400 increase capabilities even more. The traditional ABS plastic part now has polymer siblings such as; acrylonitrile styrene acrylate (ASA), polycarbonate (PC), polyphenylsulfone (PPSF), Ultem™ and Nylon™. These new polymers solve many problems related to strength, surface finishing and weather resistance. Post build processing such as vapor smoothing, bead blasting and electroplating also allow parts to go from prototype to end use part. FDM printing has also given way to new additive printing processes using photopolymers with UV light and even laser metal sintering. It seems we may be only a few years from the ability to print anything.

Evolution of training

Modern engineers and technicians must prepare themselves by adding these tools to their arsenal. Although 3D printing will not replace traditional manufacturing processes, many of these processes can be greatly leveraged using the 3D printer. This means students need to expose themselves to both the old and the new. Traditional training in measurements, materials, machining and mathematics needs to be supplemented by hands-on training in GD&T, CAD, CAM and 3D printing. The ability to think in three dimensions is critical as slice toolpaths not only determine build time, but also part strength.

The combination of a 3D printer with a tensile/shear tester provides college professors the opportunity to provide unique training on statics, strength of materials and polymer engineering. Applying force perpendicular to the FDM tool path results in a very weak specimen, while applying force in-line with the FDM tool path results in a much stronger part. In addition to orientation, considerations on core structures such as solid, sparse and material selection also provide students training on strength to weight ratios. Application-based engineering programs and polytechnic universities have a unique opportunity to combine historical foundations in manufacturing with visionary software and tools that advance productivity, quality and performance across many industries. ECN


The final form. Picture 4

Challenges and solutions for thermocouple signal conditioning.

By John Austin, Product Marketing Manager,
Analog and Interface Products Division,
Microchip Technology Inc.

The thermocouple is one of the oldest and most widely used components for measuring temperature. Thermocouples are generally found in applications that require temperature measurements in hostile environments, such as boilers, ovens, and automotive and petrochemical applications, to name a few. A thermocouple is capable of measuring temperatures in the range of -200°C to +2500°C, and rapidly responding to changes in temperature than other sensors. Shock and vibration immunity is another reason why thermocouples are so broadly deployed.

What is a thermocouple? A thermocouple consists of two wires made of dissimilar metals, joined together at one end. The joined end is typically referred to as the "hot" junction, while the open end is called the "cold" junction. The differential voltage between the two wires is used to calculate the temperature at the hot junction, as shown in Figure 1.

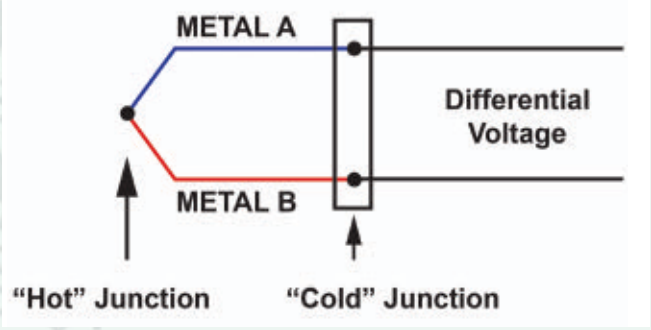


Figure1: Simplified Thermocouple Diagram. Images courtesy of Microchip Technology Inc.

All thermocouples measure microvolt-level signal changes. The most common thermocouple types are J, K, and T, and their room-temperature voltages vary at 52 μV/°C, 41 μV/°C and 41 μV/°C, respectively. Because their voltage signal is very small, it can be difficult to extract from the system noise. Also, the thermocouple output is not linear over temperature, requiring the use of high-order equations to accurately calculate the temperature. Furthermore, a thermocouple measurement is only as accurate as its cold-junction temperature measurement, adding more complexity to an already complex system. Generally, thermocouple signal conditioning is the largest investment in a thermocouple solution.

Measurement options

The differential voltage generated at the cold junction is dependent on the temperature differential between the hot junction and cold junction. Therefore, in order to obtain an accurate overall temperature reading, one must know the temperature at the cold junction. This is known as cold-junction compensation (CJC). The overall temperature accuracy of the thermocouple solution is limited by the temperature accuracy of its CJC.

Today, there are many solutions for measuring the cold-junction temperature, such as RTDs, thermistors and silicon-based IC temperature sensors. Thermistors have fast responses and small packages, but they require linearization and have limited accuracy over wide temperature ranges. They also require current for excitation, which can produce self-heating and increases power consumption, thus limiting their use in many portable or battery-powered applications. Resistance temperature-detectors (RTDs) are accurate, stable and reasonably linear devices. However, package size and cost restrict their use in many applications. Silicon IC temperature sensors now have temperature accuracies better than 0.5°C. Silicon ICs are simple devices, and require minimal external circuitry or thermal design knowledge to implement. This simplicity, along with improved temperature accuracy, has increased the popularity of these devices in recent years.

Generally, discrete thermocouple solutions use an instrumentation amplifier (INA) to extract the thermocouple voltage, and the INA rejects voltages that are common to each input of the device. Since most of the noise will be common to each thermocouple lead, the INA effectively filters the noise.

There are a variety of instrumentation amplifiers available today. The traditional INA topology utilizes two operational amplifiers, for the gain stage, which then feed into a third operational amplifier configured as a differential amplifier, as shown in Figure 2.

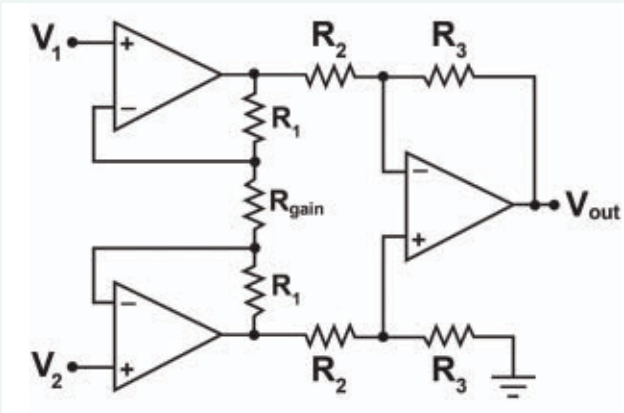


Figure 2: 3 Op Amp Instrumentation Amplifier

The gain of this circuit is set with a single resistor Rgain. Though this topology can achieve common-mode rejection (CMRR) above 80 dB at DC, the CMRR dramatically degrades as frequency increases. This can be an issue if one of the objectives for this device is to reject high-frequency noise. There are considerations for using the single-resistor approach. The internal resistors are trimmed to a ratio, rather than an absolute value. Not knowing the absolute value of the internal resistors makes it difficult to determine the gain of the circuit. The temperature coefficients of the monolithic resistors versus the external gain resistor will be different, causing additional gain error over temperature.

Newer architectures sum currents rather than voltages, improving common-mode rejection at higher frequencies. An example of this is Microchip Technology's MCP6N16, which is shown in Figure 3. This architecture generates currents that force a voltage across RG equal to the differential voltage from VIP to VIM.

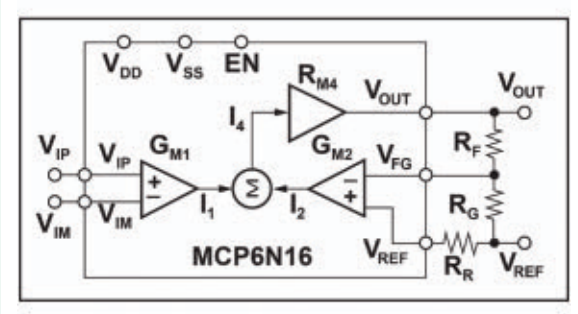


Figure 3: MCP6N16 Instrumentation Amplifier Functional Diagram

Vout = (VIP - VIM)*(1 + RF/RG)

Notice that the gain is set using two external resistors, eliminating the previously mentioned concerns with the single-resistor approach. Thermocouple signal conditioning is more complex than that of other temperature-measurement systems. Modern INA architectures and the advancement of silicon-based IC temperature sensors have addressed many of the historical design challenges associated with thermocouples. Additionally, several silicon-IC manufactures have integrated many analog, mixed-signal and temperature-sensing devices for CJC, further minimizing design efforts while improving overall system performance. ECN

Flare gas monitoring in the upstream oil field

Tighter flare gas regulations require companies to more closely monitor the total flow of gas on their sites.

By Scott Keller, CEO/CTO, SignalFire Remote Telemetry

The release of gas at a well in upstream oil and gas operations is a common occurrence, primarily conducted for safety and/or economic reasons. When oil is extracted from a well, any present gas is separated from the oil and either routed to a pipeline or flared (burned) at the site. As the gas is less valuable than the liquids in many cases, collecting it is economically unfeasible or the required pipeline infrastructure is yet to be built out. In these situations, oil producers choose to burn gas in a flare system to dispose of it. This is known as gas flaring.

Gas flaring or venting also ensures that natural gas can be disposed during an emergency or shutdown situation. Even a well that sends gas to a pipeline may need to flare it if the pressure in the pipeline exceeds a threshold value. This scenario occurs if the processing plant at the end of the pipeline shuts down for some reason. In this case, the pipeline will "back up" and wells will need to flare the gas locally or shut-in. Where gas cannot be stored or piped, the risk of fire and explosion must be reduced by either flaring or venting.

State and governmental regulations for gas emissions

In April 2012, the U.S. Environmental Protection Agency issued federal rules requiring companies to create a plan to monitor and control emissions by January 2015. These regulations are aimed at newer (hydraulically fractured) wells.

States (notably Wyoming and Colorado) also have local requirements on gas emission monitoring and control. While not every operation is in compliance, more and more companies are moving toward monitoring the amount of gas flared or expelled.

As gas is considered a greenhouse source, these regulations are being passed in order to capture and understand the amount of gas being flared to the atmosphere. The concept is that monitoring will eventually lead to a better understanding of the amount of gas flared to the environment by different companies in certain regions of the country. Results will be used to put more pressure on capturing this gas and use it as an energy source.

Monitoring methods

Different challenges exist when measuring and/or monitoring flare gases related to changing gas composition, flow variation, and hazardous locations. EPA regulations

also require a 5 percent measurement accuracy. These challenges must be taken into consideration when determining which technology to use for monitoring gas flow. Several technologies can be used:

- **Thermal Mass Flow Meter** introduces heat into the gas flow stream (usually an insertion probe), and measures how much heat dissipates using one of more temperature sensors. As the mass flow increases, more heat is dissipated thus the flow can be determined.
- **Ultrasonic Flow Meter** measures the time-of-flight of a pulse and calculates velocity from the timing.
- **Optical Flow Meters** use laser beams to measure gas flow by sensing the velocity of microscopic particulates in gas.
- **Pressure Differential** (such as Orifice Plate, Venturi, Pitot Tube) use pitot tubes to measure gas pressure (like an airplane's airspeed indicator) or the differential pressure across a restrictor plate.

Each of these has these technologies has its own benefits and issues.

Flow Meter Technology	Cost	Pros	Cons
Thermal	Medium	Easy installation, accurate enough, adequate range, measures mass flow	Composition change and moisture = inaccuracy
Ultrasonic	High	High accuracy, large range, immune to composition of gas	Cost, complex installation, need pressure sensor to compute mass flow
Optical	High	Easy to install, good accuracy, large range, immune to gas composition	Cost, relies on particles in gas stream
Delta P	Medium	Common technology used on other flow applications	Restrictor plate is not recommended for safety applications like this
Pilot/Venturi	Low	Cost	Low accuracy, low turndown, not good at low flows

Table 1: Pros and Cons of Different Technologies Used to Monitor Flare Gas Flow

Continued on page 23

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Securing all devices in the Internet of Things

Why IoT security is critical to the success of the technology.

By Gil Reiter, Director, strategic marketing, Wireless Connectivity Solutions, Texas Instruments (TI)

The Internet of Things (IoT) connects billions of devices and brings a huge opportunity for business to grow; it can also enable efficiency improvements, better consumer services and a greener environment. However, billions of new connected devices also bring billions of new opportunities for hackers to steal intellectual property (IP), compromise users' property and invade their privacy. While awareness for Internet security grows as more security breaches at large companies are revealed to the public, secure Internet communication has advanced to a level that provides reliable and safe online banking, e-commerce and government services. State of the art Internet security relies on advanced cryptographic algorithms, powerful computers and collaboration between major Internet companies and users.

Assets and threats

IoT security matters because connected devices are difficult to secure, but hold assets we want to protect as increasing threats can compromise these assets. This can include information stored in the IoT device, such as manufacturer IP and private user information, but also credentials that unlock access to cloud services and other devices on the network.

To attack an IoT device, a hacker (or a threat-agent) needs to gain access to the device. Figure 1 illustrates different entry points for unauthorized access. On the far left side, the threat agent has physical access to the bare chip inside the device and can reverse-engineer its content. This level of access is fairly complex and requires technology and tools typically available only to large corporations and agencies. On the far right side, the threat-agent accesses the device remotely over the Internet. Attacking a device's assets remotely from the Internet could be more limited compared to physical attack, but on the other hand it can be easier and less expensive, therefore more common. In fact, because so many new devices are being connected to the Internet, the number of attack opportunities on these devices from the Internet increase dramatically.

The building blocks of Internet security

Internet security has matured since the late 1990s and today provides a robust and reliable infrastructure for critical day-to-day transactions in e-commerce, banking and government. The common security capabilities available to Internet applications today include the following:

Figure 1 – Evaluating threat-agent access levels. All images courtesy of TI.

- **Private communication** – Information exchanged between parties is encrypted, such that an eavesdropper cannot understand it.
- **End-point authentication** – Communicating parties confirm each other's identity prior to any information exchange to prevent attackers from using a false identity to access information and gain unauthorized control of a remote device.
- **Information authentication** – Critical information including transaction data and software updates are digitally signed to authenticate its origin and prevent malware installation.

These security capabilities largely rely on a few fundamental building blocks, including:

- Stable **cryptographic ciphers** such as the Advanced Encryption Standard (AES), Secure Hash Algorithm (SHA2), and the public key ciphers RSA and ECC. When used properly with an adequate key size, these ciphers have no known practical attack – even with projected advances in computer power in years ahead.
- The **Transport Layer Security (TLS)** protocol, superseding its predecessor Secure Sockets Layer (SSL) protocol, provides the framework for establishing a secure communication channel between two parties. It handles both information encryption and end-point authentication, and relies on the cryptographic ciphers mentioned above.

- **Public Key Infrastructure (PKI)** provides the building blocks for authentication and trust through a digital certificate standard and **Certificate Authorities (CA)** such as Symantec and others.

The benefit of using these widely deployed ciphers and protocols in IoT applications is two-fold. First, it relies on proven technology that is widely deployed and tested at mega-scale. Second, it allows harnessing the power of already deployed Internet services (e.g. email, social media sites) as well as the public key infrastructure provided by CAs.

Although Internet security technology is widely available, recent research from Symantec Security suggests that many deployed IoT devices have not implemented adequate security measures. There are likely multiple reasons for this security gap, but vendor awareness, software complexity and implementation cost are probably at the top of the list.

Securing low-end IoT devices

Many IoT devices are based on low-end microcontrollers (MCUs) that have low processing power and memory. Some devices don't have a user interface and many are designed by OEMs with little to no experience in Internet security. This brings about one of the biggest challenges in IoT today - enabling robust security for low-end devices and making implementation easy for OEMs.

There are multiple commercial and open-source TLS libraries available in the market today. These libraries typically consume more than 100 KB of code and data memory, which is not a lot for a smartphone, but can be quite significant for a thermostat or a smoke detector. Some of the commercially available TLS stacks require developers to have knowledge of the TLS protocol to properly use their API. Integrating these TLS stacks into a simple embedded product can be quite challenging.

Moreover, the cryptographic ciphers used by TLS consume significant MIPS and present a major computational task for MCUs. Table 1 shows a few examples of algorithms used in TLS and their related performance when run on a mid-range 32-bit MCU and a low-end 16-bit MCU. As can be seen from the table, running these algorithms on MCUs will result in low data rates and slow connection and authentication times.

Algorithm	Performance Impact	32-bit MCU 80 MHz	16-bit MCU 24 MHz
AES-128	Maximum data rate	3 Mbps	900 Kbps
RSA-2048	Authentication time	2 Sec	7 Sec
DH Key exchange	Connection time	1 Sec	3 Sec

Table 1: TLS performance compared across two microcontroller architectures.

Even if a low data rate is acceptable in an IoT product, it can result in a longer active time – hence more power consumption and a shorter battery life. Long authentication and connection times can result in a poor user experience in some applications and also lead to longer active time and a shorter battery life.

To overcome these shortcomings, some semiconductor

Algorithm	Performance Impact	32-bit 80 MHz MCU	
		Traditional	With CC3100
AES-128	Maximum data rate	3 Mbps	10 Mbps
RSA-2048	Authentication time	2 Sec	200 mSec
DH Key exchange	Connection time	1 Sec	100 mSec

Table 2: performance using CC3100 compared against two 32-bit MCU software implementations.

manufacturers are starting to offer highly integrated IoT ICs that include the TLS stack integrated on-chip with highly abstracted and easy-to-use APIs. These devices often include on-chip hardware cryptographic accelerators that perform the complex computational tasks swiftly and efficiently. One example is TI's SimpleLink Wi-Fi CC3100 network processor that can add secure Internet connectivity to any MCU by completely offloading the TLS implementation from the microcontroller.

Table 2 shows achievable TLS performance when a mid-range 32-bit MCU is attached to the CC3100 MCU vs. running the TLS stack on the MCU in traditional solutions. A 10X reduction in connection and authentication time, and a 3X increase in secure data throughput are achievable without any Internet security knowledge from the embedded software developer.

POODLE, Heartbleed, and other attacks

POODLE and Heartbleed are two SSL and TLS attacks that made news in 2014. Looking closely at these two examples, a TLS fallback to the old SSL 3.0 protocol for backwards compatibility enabled the POODLE attack. The Heartbleed vulnerability was a result of a bug in the implementation of the popular OpenSSL open source stack.

One could argue these attacks indicate that TLS is not secure and should not be used in IoT applications. On the contrary, the relatively rare discovery of these attacks compared against the widespread implementation of TLS, in addition to the quick corrective actions are evidence for the amount of industry-wide effort invested in testing the TLS technology, finding possible attacks and fixing them.

The lesson for IoT developers is simple – security is never perfect; more attacks will likely be discovered in the future. To mitigate the next attack, IoT devices need ways to download security patches, either physically or over the network, to revoke compromised certificates and install fresh certificates when available. These capabilities need to be simple and easy to use to ensure OEMs can and will implement them in new IoT devices.

Summary

Securing Internet communication to IoT devices is vital. While TLS is the most deployed security protocol in the Internet, its implementation requires significant processing power and memory. Many IoT devices are low-end and low-power and cannot afford traditional TLS implementations. On-chip cryptographic hardware accelerators and TLS engine can completely offload the MCU in low-end IoT devices and bring the power of TLS to any IoT device. ECN

Continued from page 18

While there is no one ideal technology that addresses every situation, in general, flare applications where a modest amount of gas is expelled and cost is an issue, thermal sensors are often the best choice. In larger flow applications where cost is not as much of an issue, ultrasonic sensors are often used. In these cases, the sensors can have custody accuracy.

Whatever technology is used, the monitoring system needs to be able to totalize the daily gas amount (Standard Cubic Feet) over a settable contract (24 hour) period, so a settable real-time clock should be part of the equipment. See Pic 1 for an example of how a module can be used to provide instantaneous totals of gas flow rates to help address flare gas regulations.

While most small (well pad) flare systems currently are not monitored, regulations will accelerate the need to monitor gas flow. In turn, it is likely that gas flow monitoring will drive the push for capturing this gas as it has value. While a number of technologies exist for monitoring flare gas (with thermal being the most prevalent), the push for monitoring compliance will, most likely, stimulate the growth of more technologies to address this application. ECN

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The PE46120 is a monolithic phase and amplitude controller (MPAC) designed for precise phase and amplitude control of two independent RF paths. Covering a frequency range of 1.8 to 2.2 GHz, the PE46120 integrates a 90-degree hybrid splitter, 5-bit digital phase shifters and a 4-bit digital step attenuator along with a low-voltage, CMOS serial digital interface. It can cover a phase range of 87.2 degrees in 2.8-degree steps and an attenuation range of 7.5 dB in 0.5 dB steps. Ideal for optimizing dual-path dynamically load-modulated amplifier architectures such as Doherty power amplifiers, the monolithic RF controller offers high linearity, high isolation, high power handling and maximum phase-tuning flexibility compared to multi-chip, gallium arsenide-based solutions. **For more information, visit http://www.psemi.com.**

The policies behind conflict materials

by **Joshua Israelsohn**, Director, JAS Technical Media

Since the end of World War II, the commercial sector of the electronics industry has operated with comparatively little influence due to geopolitical conflicts. Meaningful shifts in international markets for electronic finished goods most often derive from innovation or changes in countries' international policies based on relatively peaceful co-existence, not combat.

The markets for certain source materials useful in electronics component and assembly manufacturing, however, are a different matter. In particular, four elements—tin (Sn), tungsten (W), tantalum (Ta), and gold (Au)—derive from mineral deposits found in, among other places, the conflict zone in the eastern provinces of the Democratic Republic of the Congo (DRC). Sales of these materials, mined in and around the conflict region, have helped finance armed groups, perpetuate regional violence and human rights violations, and exploit area populations.

Background

In an effort to make financing hostilities in central Africa more difficult, the United States Congress passed the Dodd-Frank act in 2010 that, among many other things, added a requirement for manufacturing companies that file certain reports with the Securities and Exchange Commission (SEC). Pursuant to section 1502 of the Dodd-Frank act, the SEC issued its Conflict-Materials rule in August of 2012.

Subject companies must determine their sources of tin, tungsten, tantalum, and gold—the so-called 3TG elements—as being DRC conflict-free or not DRC conflict-free. Minerals are not conflict-free if mined in the DRC or any of its surrounding covered countries (Angola, Burundi, Central African Republic, Republic of Congo, Rwanda, South Sudan, Tanzania, Uganda, and Zambia) unless a diligent review of the mineral's chain of custody determines that the materials did not benefit armed groups. The SEC required that reporting companies make their conflict-materials Form SD special disclosure reports public and update them at least annually.

A sense of magnitude

A number of interesting things have happened since the SEC rule issued. First, the additional scrutiny may have improved the mineral mining reporting overall. For example, The United States Department of the Interior US Geological Survey (USGS) Mineral Commodity Summaries 2012 report does not show any of the covered countries as meaningful providers of tungsten in 2010, the year Dodd-Frank passed but before the resulting SEC rule went into effect. The 2015 Mineral Commodity Summaries indicate that, by 2013, the reported tungsten output from covered countries was 1,560 metric tons—a little less than 2% of the worldwide annual yield.

It's possible that mining concerns in the DRC and Rwanda—the two covered countries producing the most tungsten-bearing ore—entered the tungsten market during

that interval. Another explanation is that the accounting process for tungsten sources in central Africa produced more complete information than in prior years. Either way, tungsten continues to be an important constituent in alloys for cutting tools, filaments, and semiconductor manufacture, and its reliable source, therefore, is important to the industry.

USGS data doesn't make clear the extent to which covered countries' are sources of gold. Listed countries include those producing 1.7 percent of the worldwide supply or more, with nearly a quarter attributed to "other". What is noteworthy here is that in the five years from 2010 to 2014, inclusive, China's gold production increased nearly eleven-fold. In the same period, production in Canada, Russia, Mexico, and Brazil grew 76 percent, 28 percent, 26 percent, and 21 percent, respectively, versus a worldwide gold production increase of 12 percent. Additionally, worldwide gold reserves are roughly 19 times annual production with particularly large reserves in Australia and South Africa. It's unlikely that source-market shifts could raise the covered countries to prominence in the gold-metal supply chain over the near term.Unfortunately, from a humanitarian perspective, covered countries prominence in gold-supply markets for the electronics industry isn't the sole relevant issue. Due to the high price gold fetches, gold is an attractive commodity for corrupt government officials and fighting factions. A 2012 report from the Southern Africa Resource Watch notes exploitation of gold miners in conflict countries, particularly east of the DRC. So even though conflict countries are not going to rock our gold supply, we might consider if ethical business practices impose a moral obligation to maintain a clean supply chain for gold in industrial applications, independent of government mandates.

With the data I have available, I can't assert that the Dodd-Frank act has caused the source-market shifts that USGS reports, but it is interesting to note that the DRC production of tin-bearing ore fell 55 percent from 2010 to 2014. Production in Rwanda made up a little more than half of the difference, ignoring the extent to which some of the 2014 total reflects the benefit of additional sourcing scrutiny; that is to say simply better counting. Still, covered countries accounted for only 1.7 percent of 2014 worldwide tin production, down from 2.5 percent five years earlier. This is good news in light of the fact that virtually every solder alloy that the electronics industry uses—leaded or lead-free—depends largely on tin. Tin has also shown potential [sic] in the manufacture of lithium batteries. For example, Sony used a Tin-Cobalt alloy in its Nexelion battery, although, at this point of their evolution, the metal is not key to most mainstream Li-Ion chemistries.

Where the covered countries are more likely a concern to electronic-industry materials-sourcing markets is in tantalum—an important element in the manufacture of

capacitors and certain types of glass. African nations produce about 2/3 of the world's tantalum-bearing ore and about 2/3 of that comes from the DRC and Rwanda. Historically, even before the conflicts in central Africa, worldwide tantalum shortages have caused tantalum-capacitor prices to spike and supplies to run short enough to interfere with finished-goods production. Instability in the supply chain due to military or paramilitary action does not yield to international trade negotiations or other good-will efforts and are, therefore, all the more potentially perilous to the industry.

That said, tantalum remains attractive as a material in capacitor manufacture. Tantalum capacitors offer good volumetric efficiency at moderate voltages compared to either aluminum electrolytic or ceramic. They also offer a low temperature coefficient of capacitance, on the order of X7R ceramic but with a monotonic temperature characteristic as opposed to ceramic's concave-downward temperature curve.

Are we conflicted?

In April last year, the US Appeals Court for the District of Columbia Circuit struck down the public disclosure requirement while upholding the supply-chain monitoring obligations specified by the SEC's conflict-minerals rule. The suit, brought by business lobbying groups including the National Association of Manufacturers, the US Chamber of Commerce, and the Business Roundtable, claimed that the rule was overly burdensome.

Yet the portion of the rule that the Appeals Court struck down was the piece that offered reporting companies the best customer-relations opportunity to present themselves as good corporate citizens of the world. Allow a comparison:

Early in 2010, press reports told of child labor and harsh workplace practices at Chinese assembly plants with which Apple Computer had manufacturing contracts including Foxconn. Similar allegations surfaced in 2013 regarding conditions and practices at Pegatron, among others.

As harmful as those reports were to Apple Computer's image, the company appears to have turned the situation around to a net public-relations positive by disclosing the extent to which they've taken corrective action and instituted programs that help assure compliance with the company's code of ethics.

Interestingly, although it has not been legally bound to disclose publically its conflict-mineral sourcing status since the US Appeals Court decision, Apple Computer chose to publish its 2015 Form SD. The disclosure documents the extent to which the company has improved its supply-chain conformance to DRC-conflict-free goals, in essence telling the world of investors and customers alike that Apple Computer is a better corporate citizen of the world this year than last as it strives for further improvement for the future. You can't buy that kind of PR, especially couched in officialdom, not flashed across the screen in a glitzy image-selling video.

For the product design community, focused thousands of miles from either raw-material source markets or product assembly lines, the conflict mineral issue we might be most vulnerable to and able to affect most directly is our use of tantalum. To the extent that our companies and suppliers have made their tantalum supply chain public, we can see to what degree our designs face supply side risk due to central-African conflicts.

Some applications can exploit circuit methods or topologies take reduce the size of capacitors, which in some cases can allow designs to shift from one dielectric to another. For example, control methods that allow faster switching frequencies in power stages also facilitate reductions in the size of reactive components, both capacitive and magnetic. Another example in power-conversion applications, Vicor's sine-amplitude-converter (SAC) topology allows designers to move output capacitors to the converter's input port where they can be smaller by the conversion voltage ratio squared. For example, a 48- to 12-V converter with a 10 μF capacitor appears to the output like a 160 μF part. If supplying a 1-V output, the same topology reflects a 1 μF input cap as 2300 μF to the load. ECN

Small electronic enclosures offer rounded edges

TEKO has launched REMO-TEK small electronic enclosures – a fresh new design with rounded edges for superior ergonomics.

REMO-TEK offers electronics designers a smart modern standard enclosure for a wide range of applications including remote controls, mobile USB systems, compact measurement devices, pulse generation for ultra-sound and infra-red, mobile data recording and wireless communications. These stylish enclosures are available in four types: either 'compact' or with one, two or four buttons. Features include a choice of protection bumpers (either solid plastic or polished chromed metal) plus an LED light pipe on the cover to indicate operation.

Installing a PCB is quick and easy thanks to internal pillars. Each enclosure can accommodate a CR2032 button cell and can be closed with just one screw. They are available in one size, 2.81" x 1.55" x 0.45" and molded from Novodur P2H-AT, a standard impact strength, easy flowing, high gloss plastic which contains an antistatic additive, or P2H-AT/ZA4C1.

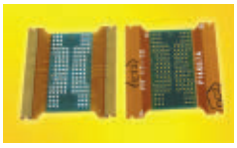
For more information, visit www.tekoenclosures.com.

Outdoor cooler improves cellular coverage

Laird releases the new AA-480 Series Outdoor Cooler which improves the reliability of cellular coverage, keeping people connected during a power outage by protecting the emergency batteries used in wireless base stations. When the power to a cellular antenna tower goes out, emergency batteries in the base station turn on to provide power for up to six hours. But battery life is significantly reduced by exposure to temperatures outside the optimal range. That is why many wireless base station operators take measures to ensure that emergency batteries are kept at the proper temperature extending the life of those batteries and ensuring more reliable cellular coverage during power outages. Laird's new AA-480 Series Outdoor Coolers protect these critical batteries by providing greater cooling power and increased reliability compared to other units currently on the market. The AA-480 accomplishes this using less energy and taking up less space compared to similar units.

For more information, visit www.lairdtech.com.

Probe adapter allows for high-speed testing



Ironwood Electronics' PB-BGA132E-NANDFLASH-01 Probe Adapter which allows high-speed testing of Nand Flash while accessing the signals using testers via test pads. Features of the PB-BGA132E-NANDFLASH-01 include shortest possible trace length for maximum speed, low inductance, low capacitance, blind and buried via PCB design technology. This probe adapter is designed to interface 1mm pitch Ball Grid Array packages to SMT pads on the target PCB while bringing the signals out for probing.

Ironwood's PB-BGA132E-NANDFLASH-01 Probe Adapter consists of rigid flex PCB with solder balls on the bottom side. The probe adapter can be soldered to the target system board in place of BGA132, 1mm pitch, 11x17 array, 12 mm X 18 mm body using standard BGA soldering methods. Nand flash can be soldered on the top side of probe adapter that employs a flex wing design to deliver all data, address, control, and other signals to test pads on 0.4 mm centers. The flex wing test pads are interfaced to logic analyzer or other test equipment using appropriate cable connector. Alternatively, this probe adapter can be used inside a BGA socket for solderless solution.

For more information, visit www.ironwoodelectronics.com.

BRAINSTORM

MODERATED BY KASEY PANETTA
EDITOR

Q: What is the next big thing in LEDs?

David Somo, Vice President of Corporate Strategy & Marketing, ON Semiconductor

There are a numerous dynamics that we expect to have huge influence on the electronics industry this year allowing marked improvements in energy efficiency, with LED lighting being just one of these. Already within the automotive sector, LED lighting creates a longer lifespan and a higher degree of design flexibility. Many vehicles are becoming fully reliant on LEDs for all their illumination activities - front lights, read lights, sidelights and interior lighting.

This year car manufacturers are looking to utilize more sophisticated lighting technologies. A great example of this being employed is the LED laser light, which is featured in the latest version of the Audi R8 and the i8 from BMW. Laser light offers greater energy savings and lighting range than is possible with standard LEDs.

Other exciting new technologies such as Matrix and Pixel-Light will enable shaping of the vehicle's front beam via the turning on, off or dimming discrete LED emitters. This means that sections of the light beam can be blocked out to reduce potentially dangerous glare for vehicles travelling in the opposition direction. The beam can also move direction and angle positions to accommodate the road terrain ahead including bends, bumps and slopes. Using these will mean that there is no longer any need to include bending motors within the design thus creating a lighter weighted vehicle and a lower BOM.

Paul Scheidt, Leader of product marketing, LED components, Cree, Inc.

The LED lighting industry has made great progress in providing tangible value to customers and end users, including quick payback, low total cost of ownership, improved performance and high-quality illumination. The first major wave of LED adoption was driven by lumens-for-lumens replacement of traditional lighting, in similar form factors – from troffers to bulbs. However, recent LED level technology innovations enable new form factors and performance levels that were previously not possible. With more progressive design both in form and in function, light becomes more intelligent and a conscious choice to enrich, engage and enable better user experiences.

Ushering in the next generation of LED lighting begins with lowering overall system cost to allow manufactures flexibility to innovate and achieve new designs and performance levels. Lowering system cost can be attained a number of ways – from leveraging LEDs that pack more lumens into a smaller space, to reducing the amount of material needed in each design. Featuring significant advancements in epitaxial structure, chip architecture and an advanced light conversion system optimized for best thermal and optical performance, Cree's SC5 Technology Platform, for example, allows LEDs to have new levels of lumen density and longer lifetime at higher operating temperatures, while lowering the amount of other materials needed (drivers, heat sinks, etc.).

With smaller LEDs that have higher reliability, lumen output and design flexibility, even hard-to-reach applications are now addressable. Most recently, we saw this when the stadium for the 2015 "Big Game" was lit by LED for the first time. We also demonstrated the first LED technology capable of replacing 35W CMH, using quality and quantity of light in the right form factor. Through smart and innovative design, and the simplest function and operation, next generation LED lights will deliver rich experiences for end users while pushing the boundaries of what was previously thought possible.

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Sagar Jethani, Head of content, Element14

Recent innovations in LED technology are blurring the lines between lighting and software. For example, instead of just installing special "grow lights" in a greenhouse, you can now run alongside it a code which will illuminate your plants with the precise color temperature needed to stimulate growth for a particular species. Not to mention there is now technology that can intelligently phase the light's intensity to mimic natural solar patterns, among other more advanced software-driven LED applications.

Smart LEDs are also being used as a means of communication. Philips' line of HUE products is a prime example of this. The Philips HUE can adjust the intensity of your light to convey specific information – like whether or not your train is running late or whether or not you should carry an umbrella because rain is in the forecast. The marriage of LEDs and intelligent software is unlocking a myriad of new applications daily that are challenging conventional norms around lighting design.

The third "next big thing" in LEDs is UV. Ultraviolet LEDs are becoming more and more powerful and are now being used in a variety of innovative applications – from curing resins and killing germs found on food to detecting counterfeit currency. High-power UV LEDs, like software applications and smart LEDs, are forcing engineers and consumers alike to rethink how lighting can make day-to-day tasks easier, more intelligent and more intuitive.

Dan Herrmann, CAE Manager, Synopsys Optical Solutions Group

There continues to be extensive research into how to improve LED performance, such as how to enhance light extraction efficiency to improve LED efficacy, package- and module-level beam shaping to drive down size and cost for LED lighting applications at the system level, and package-to-system-level color tuning to improve LED color consistency and lower cost.

LED chip and package engineers are now incorporating sophisticated techniques into LED die and package designs, such as patterned substrates, polarization-sensitive gratings, back reflectors, surface textures, photonic lattices, and phosphor down-conversion. LED technologies, especially those with patterned or textured surfaces, contain geometric features that vary in size over orders of magnitude – ranging from large photonic elements to nanostructured surfaces. Because of the complexity of these LED designs, it is increasingly necessary for design and simulation software tools to use a variety of numerical techniques to completely analyze and improve LED die, package and module performance. A mixed-level simulation approach in optical design software is emerging as an effective way to develop these LED technologies.

Rigorous electromagnetic (EM) wave-based tools, rather than geometric optics ray tracing techniques, must be used to completely characterize scattering from nanostructured LED surfaces. The characteristics predicted using EM wave-calculations can then be incorporated into geometric ray tracing software to obtain overall LED die or package-level performance. As an example, Synopsys' Optical Solutions Group has recently developed an approach using either the RSoft™ DiffractMOD™ or FullWAVE™ tools to generate bidirectional scattering distribution function (BSDF) information for a patterned LED surface with feature sizes near the scale of the wavelength of emitted LED light. This BSDF information, which contains full polarization data, can then be incorporated into a geometric ray tracing tool such as LightTools®, permitting full analysis of the LED chip, package and module performance. This multi-simulation approach to LED design provides comprehensive, accurate modeling that is not possible through other methods, and can be used in a wide variety of applications aside from LEDs, including OLEDs, color filters, and photovoltaics.

This approach of using EM wave calculations with geometric raytrace simulations is very likely to increase in the future for developing new LED (and OLED) technologies.

David J. Donovan, VP Sales, America's, Plessey Semiconductors

The ubiquitous LED is poised to become much more than a passive p-n junction that emits light. Today's LEDs are built on various substrate materials, and together with advances in semiconductor physics, drive higher efficacies and efficiencies while lowering costs.

However, the real long term value is not found in honing these metrics, but in the next big thing in LEDs; silicon based monolithic integrated lighting solutions.

Lighting systems are made up of numerous autonomous electro-mechanical components, and as such are subject to the vagary and inefficiencies of the marketplace. The next generation of LEDs will be part of a Smart Lighting and Control system that integrates many of the electronic components. The most cost effective approaches to implementing these systems will take advantage of incumbent silicon technologies to incorporate various Smart Lighting features such as environment sensing, control and communications, power optimization, dynamic light intensity and energy savings.

Silicon wafer fabs are ideal for fostering this next big thing as mature foundry operations can integrate passive functions such as photo sensing diodes and temperature sensors together with the LED onto a silicon sub-mount. Adding Chip Scale Optics (CSO), Chip Scale Packaging (CSP) and/or Wafer Scale Packaging (WSP) makes the silicon based lighting solutions more cost effective.

In addition, the same silicon wafer fabs can produce the ancillary building blocks that make up a lighting system such as the power driver, control system and analog front ends.

The White Board

Consumer Wearables

By Kasey Panetta, Editor

Wearables are a $20 billion market in 2015, but by 2025 experts estimate the market will rise to $70 billion with healthcare wearables representing the bulk of the products. Wearables on the market today can record your biometrics, ensure your correct posture, and even track an unborn baby's heartbeat. In the future, researchers are hoping to reduce burdens on hospitals by offering at-home medical care options and offer the ability to better track patient's overall health.

designed by Larry Corby, Digital Artist

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