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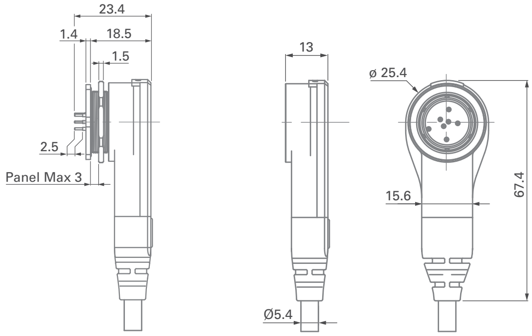
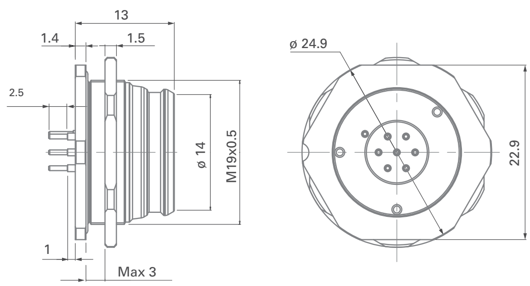


LP360™ RECEPTACLE - PANEL MOUNTED OR SEWN-IN

ACTUAL SIZE



ELECTRICAL DATA

Number of contacts	7
Rated voltage (rms)	≤ 250 V
Typical operating voltage	9-48 V
Max. current rating	3x 5A + 4x 1A
Max. wire size	AWG 24
Data protocols	USB 2.0 and Ethernet

ENVIRONMENTAL DATA

Characteristic	Performance	Standard
Corrosion resistance	1,000h salt mist	MIL-STD-883 Method 1009.8
Sealing	IP67 unmated	MIL-STD-810 Method 512.6
	IP68 mated -20m/24h	
Vibration & shock	9,26 rms	MIL-STD-202 Method 214 Condition I
EMI/EMC	360°	Protection by design

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Our annual survey reveals the trends
most impacting the electronics engineer's job **p12**

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WHEN YOU'RE CREATING ENERGY EFFICIENT DEVICES THAT SENSE, CONNECT AND CONTROL
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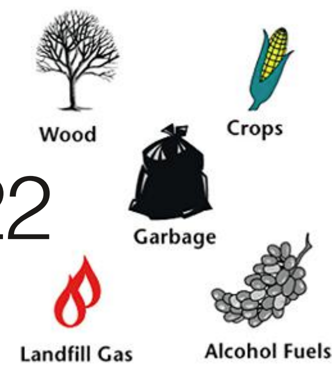
IN THIS ISSUE

FEATURES

12



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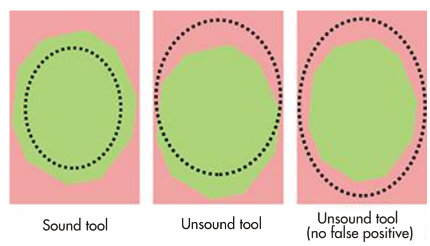

44

52

COLUMNS & DEPARTMENTS

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

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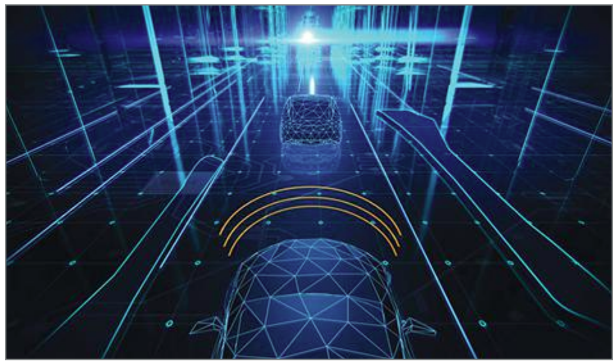
ON ELECTRONICDESIGN.COM

Optical Biosensing for Emerging Healthcare Applications

Biosensing has only scratched the surface of its potential. Using non-intrusive, inexpensive sensors as part of a larger information system could be paradigm-changing in terms of consumer wellness. Maxim Integrated's Ian Chen breaks it all down.

https://www.electronicdesign.com/analog/optical-biosensing-emerging-healthcare-applications



Testing the Unknown: The Real Problem with Autonomous Vehicles

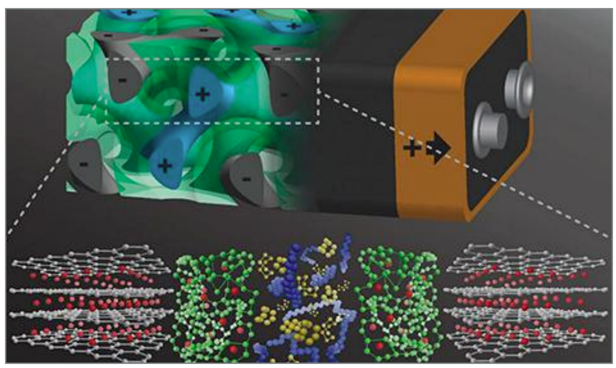
In his latest blog post, National Instruments' Jeff Phillips brings to light that regulations, architectures, and neural-network algorithms are among the unknowns facing autonomous-vehicle test engineers, and why that beckons the call for a test infrastructure to be put in place.

https://www.electronicdesign.com/automotive/testing-unknown-real-problem-autonomous-vehicles

SNN News: BrainChip Unveils Akida Architecture

Armed with approximately 1.2 million neurons and 10 billion synapses, the Akida Neuromorphic SoC (NSoC) spiking-neural-network chip developed by BrainChip takes on training and inference tasks.

https://www.electronicdesign.com/embedded-revolution/snn-news-brainchip-unveils-akida-architecture



Novel Techniques, Materials Cut Battery-Recharge Cycle Time

To overcome storage capacity and recharge-time limitations of conventional batteries, a Cornell team developed a self-assembling battery with twisted "ribbons."

https://www.electronicdesign.com/power/novel-techniques-materials-cut-battery-recharge-cycle-time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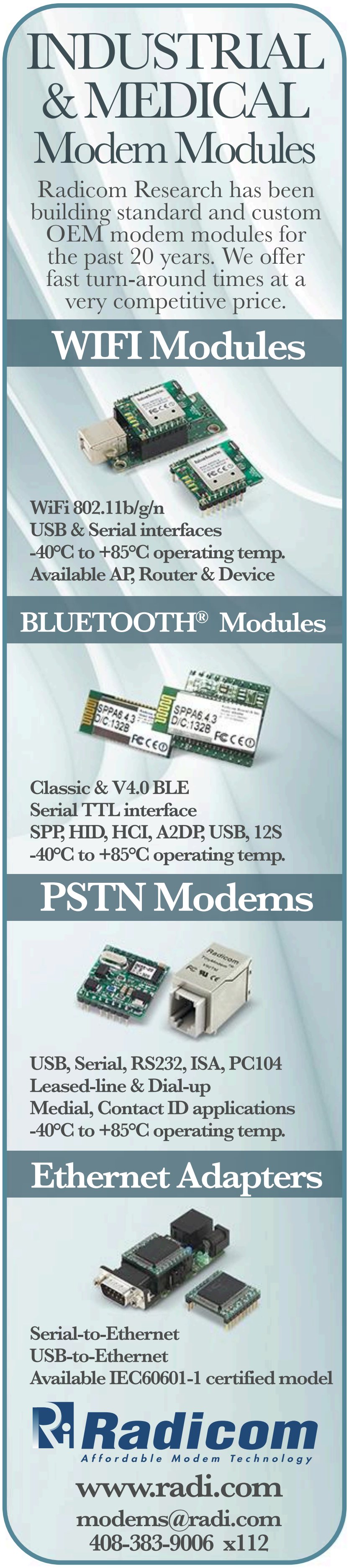

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EDITORIAL

EXECUTIVE DIRECTOR, CONTENT: **KAREN FIELD** karen.field@informa.com
ASSOCIATE EDITOR/COMMUNITY MANAGER: **ROGER ENGELKE** roger.engelke@informa.com
ASSOCIATE EDITOR/COMMUNITY MANAGER: **JEREMY COHEN** jeremy.cohen@informa.com
EMBEDDED/SYSTEMS/SOFTWARE: **WILLIAM WONG** bill.wong@informa.com
ANALOG/POWER: **MARIA GUERRA** maria.guerra@informa.com
ASSOCIATE CONTENT PRODUCER: **JAMES MORRA** james.morra@informa.com
CONTRIBUTING EDITOR: **LOUIS E. FRENZEL** lou.frenzel@informa.com

ART DEPARTMENT

GROUP DESIGN DIRECTOR: **ANTHONY VITOLO** tony.vitolo@informa.com
CONTENT DESIGN SPECIALIST: **JOCELYN HARTZOG** jocelyn.hartzog@informa.com
CONTENT & DESIGN PRODUCTION MANAGER: **JULIE JANTZER-WARD** julie.jantzer-ward@informa.com

PRODUCTION

GROUP PRODUCTION MANAGER: **GREG ARAUJO** greg.araujo@informa.com
PRODUCTION MANAGER: **JULIE GILPIN** julie.gilpin@informa.com

AUDIENCE MARKETING

USER MARKETING MANAGER: **DEBBIE BRADY** debbie.brady@informa.com

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AZ, NM, TX: **GREGORY MONTGOMERY** **T** | 480.254.5540 gregory.montgomery@informa.com

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LIST RENTALS/ SMARTREACH CLIENT SERVICES MANAGER: **MARY RALICKI** **T** | 212.204.4284 mary.ralicki@informa.com

DIGITAL

GROUP DIGITAL DIRECTOR: **RYAN MALEC** ryan.malec@informa.com

DESIGN ENGINEERING & SOURCING GROUP

EXECUTIVE DIRECTOR, CONTENT: **KAREN FIELD** karen.field@informa.com
VP OF MARKETING: **JACQUIE NIEMIEC** jacquie.niemiec@informa.com

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With mix and match capability, the FS735 can also be configured with 10 MHz, 5 MHz, Broadband, and CMOS Logic distribution amplifiers side-by-side for other applications. Multiple units can be daisy-chained for easy expansion.

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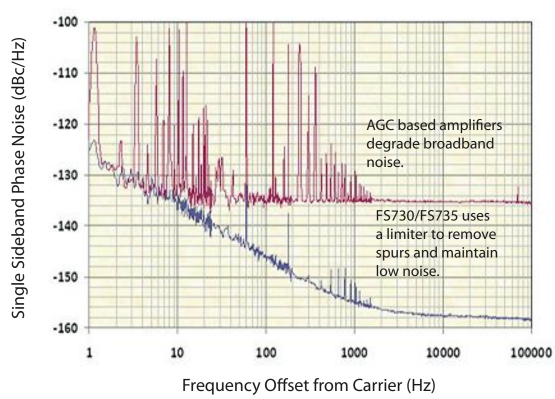

Additive phase noise in 10 MHz Distribution Amplifiers: Limiter vs. AGC Designs

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Editorial

WILLIAM WONG | Senior Technology Editor
bill.wong@informa.com

Cool Parallel-Processing Tech at Hot Chips Symposium

The Hot Chips Symposium is where the cutting-edge technology appears, and this year is no different. Parallel processing is the name of the game, especially when it comes to 5G and machine-learning (ML) solutions.

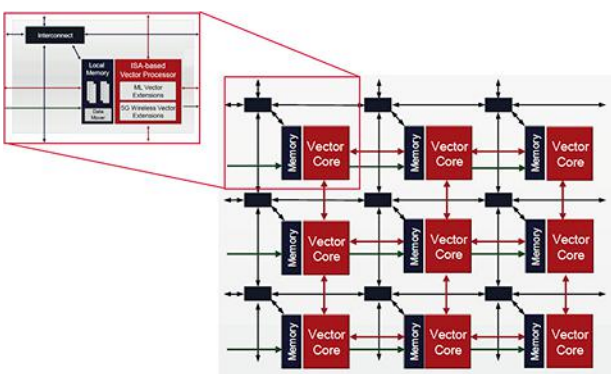
We got a more detailed glimpse at Xilinx's "Everest" adaptive compute acceleration platform (ACAP) that targets 5G and ML. ACAP is a tile-based architecture that's commonly found in high-performance computing and network processing *(Fig. 1)*. The non-blocking interconnect delivers over 200 GB/s/tile and adjacent cores can also share results. The instruction set includes integrated synchronization primitives. Like an FPGA, the system is scalable, allowing large arrays to tackle more ambitious projects.

Tachyum's Prodigy chip targets networking applications with a pair of 400-Gb Ethernet links to feed its 64-core chip *(Fig. 2)*. It's designed to address ML applications that are becoming increasing important in managing and delving into the contents of network traffic. The cores use out-of-order (OOO) execution courtesy of the compiler. It implements instruction parallelism by applying poison bits. All of the I/O is linked via a high-speed ring that also connects to the multicore fabric.

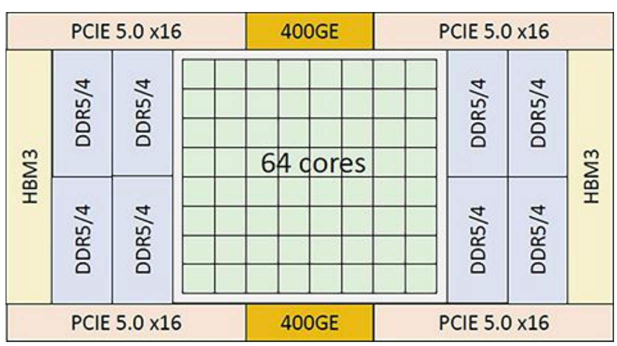
On another front, Arm lifted the veil more on its ML processor. It includes features like static scheduling, where convolution operations wait until data is DMA'd into memory, providing relatively predictable performance. Convolution output feature maps are interleaved across compute engines; weight and feature map compression support reduce data and power requirements.

Mythic explained its matrix multiplying flash-memory technology designed to deliver deep-neural-network support on the edge using a fraction of the power needed by alternatives. The hybrid digital/analog array performs calculations with in the memory array where the network weights are stored. ADCs are used to read a memory cell's voltage-variable conductance resulting in an 8-bit value rather than the one or two bits normally stored in a cell. The architecture is designed to support ML models like those developed using TensorFlow.

The integration of ML in almost every application space is placing demands on hardware and software. These and other technologies are rising to meet the demand. ed



1. Xilinx's adaptive compute acceleration platform (ACAP) is built around a tile-based network of parallel processors.



2. Tachyum's Prodigy chip sports a 64-core array with 400-Gb Ethernet support to handle networking tasks.

News

GlobalFoundries Suspends Work ON 7-nm TECHNOLOGY

GlobalFoundries has stated that it would cut short the development of new 7-nm manufacturing technology, highlighting how hard it now is to stay to stay on the leading edge of the semiconductor industry. The change of heart highlights the mounting challenges to etching smaller and smaller transistors onto the slabs of silicon inside everything from data centers and factories to smartphones and thermostats.

The announcement raises questions about whether there are still financial benefits to spending billions of dollars on the development of chips tattooed with transistors almost the width of a virus and the hundreds of millions on equipment capable of manufacturing them without the slightest defects.

For Thomas Caulfield, chief executive officer of GlobalFoundries, that stopped making financial sense with 7-nm production. The company just doesn't have enough customers to make it profitable. The strategy is to invest in current technology that could remain in use for years and matters more to its customers. But the move leaves Intel, Samsung, and Taiwan Semiconductor Manufacturing Corp. to fight over the most advanced technology.

"These nodes are transitioning to design platforms serving multiple waves of applications, giving each node greater longevity," Caulfield said, adding that GlobalFoundries would concentrate on the production of chips based on 14-nm and 12-nm FinFet. The company is focused on adding new components to chips, including embedded memories like magnetoresistive random-access memory (MRAM).

"The vast majority of today's fabless customers are looking to get more value out of each technology generation to leverage the substantial investments required to design into each technology node," Caulfield said. "This industry dynamic has resulted in fewer fabless clients designing into the outer limits of Moore's Law. We are shifting our resources and focus by doubling down on our investments in differentiated technologies across our entire portfolio that are most relevant to our clients."

The changes are intended to rebalance the world's second largest contract chip manufacturer, which employs around 17,000 people worldwide and serves customers including Advanced Micro Devices, STMicroelectronics, and Broadcom. The company's spokesperson, Jason Gorss, said that it would have to cut around 5% of the workforce after employees are reassigned to new product lines inside GlobalFoundries.

Halting development could have repercussions for some customers, blowing wind into the sails of the company's rivals. Mark Papermaster, AMD's chief technology officer, recently announced that the company would shift all 7-nm production to TSMC, while using GlobalFoundries to manufacture its current product line. "We do not expect any changes to our product roadmaps as a result of the changes," Papermaster said in a statement. ■

RENESAS BUYS INTEGRATED DEVICE TECHNOLOGY in $6.7 Billion Deal

RENESAS ELECTRONICS ANNOUNCED it would buy Integrated Device Technology (IDT) for $6.7 billion, looking to supply more comprehensive batches of automotive chips. The company said that the deal would give it radio frequency, interconnect, timing, and other chips that could be vital in building future automotive and industrial devices.

"This acquisition will bring us complementary, market-leading analog mixed-signal assets," said Bunsei Kure, chief executive officer of Renesas, which holds around 30% market share in automotive microcontrollers. "IDT's products combined with our MCUs, SoCs, and power-management ICs will enable Renesas to widen its product offerings as well as to expand its reach into areas such as the growing data economy-related space."

(Continued on page 48)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ElectronicDesign

2018 SALARY & CAREER REPORT

JAMES MORRA | Senior Content Editor

Taking the Good with the Bad in Electrical Engineering

Salaries are booming and satisfaction remains high, but many professionals harbor concerns about working conditions, ongoing education, shortsighted management, and outsourcing. Mounting demand for engineering talent could change all that, though.

Electrical engineers are increasingly having to take the good with the bad. Even though salaries, satisfaction, and employment continue to rise, professionals still worry about working conditions, ongoing education, shortsighted management, and outsourcing and offshoring, according to 1,300 respondents to *Electronic Design's* latest subscriber survey. Many respondents wonder whether tightening deadlines, long hours, and endless studying are worth it.

Despite everything, the survey results show the profession remains in high spirits. Almost 90% of respondents say that they enjoy their current jobs, while two-thirds acknowledge that employers pay them what they deserve. But around 40% of respondents admit that they have considered moving onto another less stressful or more profitable profession. Respondents report working an average of 50 hours per week, not including time on call.

Salaries are booming. The survey shows that the profession's average salary is currently $113,624 compared to $105,040 last year and $97,644 five years ago. The average bonus amounts to $4,492 with a median of $3,000 as opposed to the $3,870 average and $1,000 median five years ago. More than 60% of respondents expect their total compensation to exceed what they brought home last year, with a median jump of 4% in compensation.

Contrast that with the 30.8% of electrical engineers who expect total compensation to remain the same versus last year. In addition to boosting salaries, many companies are ramping up other forms of payment as the Trump administration curtails corporate taxes. Over the last year, the percentage of respondents rewarded with stock has grown from 14% to 17%. One-fourth say their employer shares profits, an increase of 4% since 2014.

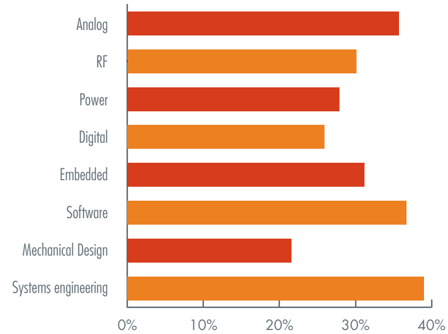
Generally, respondents can't shake the feeling of the grass being greener on the other side. Around 37% say that their pay compares with what other engineering employers are paying. Only 13.5% of respondents say their earnings are somewhat more competitive—less than half of the 31.5% that say their pay is somewhat less competitive. The results also show that 12.5% feel their pay is much less competitive than at other companies.

Over one-third of respondents sense that their employers are shortchanging them. The consensus among these

(Continued on page 20)

IS YOUR COMPANY HAVING DIFFICULTY HIRING? IF YES, FOR WHAT SPECIALTIES?

YES 62%
NO 38%



WOULD YOU RECOMMEND ENGINEERING AS A CAREER PATH TO YOUNG PEOPLE?

YES 90%
NO 10%

DOES YOUR ORGANIZATION EXPERIENCE CHALLENGES HIRING WOMEN FOR ENGINEERING ROLES?

YES 33%
NO 67%

HAVE YOU BEEN CONTACTED BY A HEADHUNTER IN THE LAST YEAR?

YES 67%
NO 33%

DO YOU BELIEVE THAT AN ENGINEERING SHORTAGE EXISTS?

YES 63%
NO 37%

ARE YOUR FEELING INTELLECTUALLY CHALLENGED BY YOUR CURRENT PROJECTS?

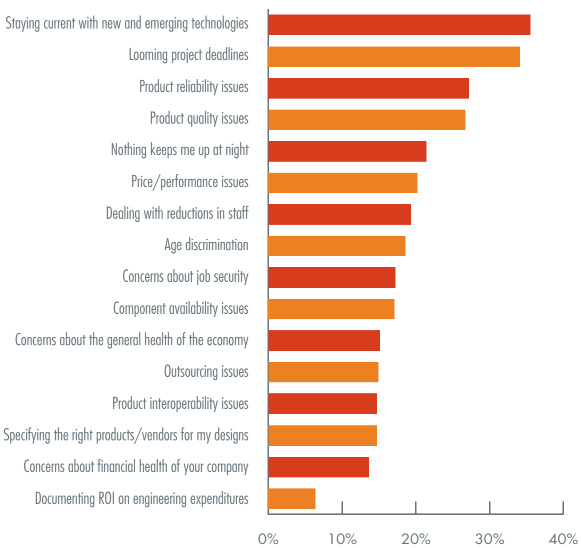
YES 59%
SOMEWHAT 32%
NO 9%

MOST IMPORTANT FACTORS IN JOB SATISFACTION

8.01	Researching potential design solutions
8.01	Challenges that accompany the design of new products
7.73	Compensation you receive for the work you do
7.62	Opportunity to design products that can benefit society
7.41	Your company's culture and values
7.11	Working in team situations with peers
6.67	The pressures associated with solving design problems
6.83	The recognition you get from others for the work you do

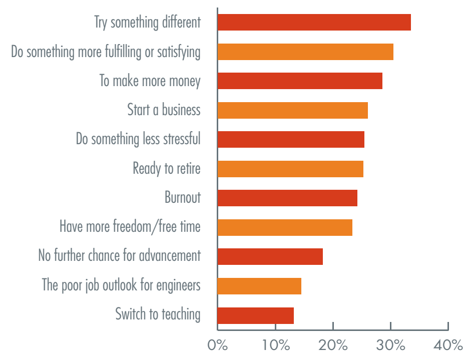
[Based on a scale of 1 to 10]

WHAT PROFESSIONAL ISSUES KEEP YOU UP AT NIGHT?*



WOULD YOU LEAVE THE PROFESSION? WHY?*

YES 40%
NO 60%



Respondents were allowed to pick more than one answer.

HOW SATISFIED ARE YOU IN YOUR JOB?

EXTREMELY SATISFIED	VERY SATISFIED	SATISFIED	NOT VERY SATISFIED	NOT AT ALL SATISFIED
21%	32%	36%	9%	2%

ElectronicDesign 2018 SALARY & CAREER REPORT

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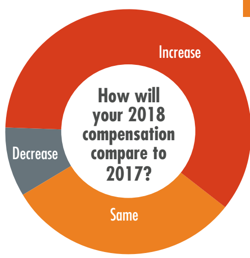
SALARIES

BY CAREER

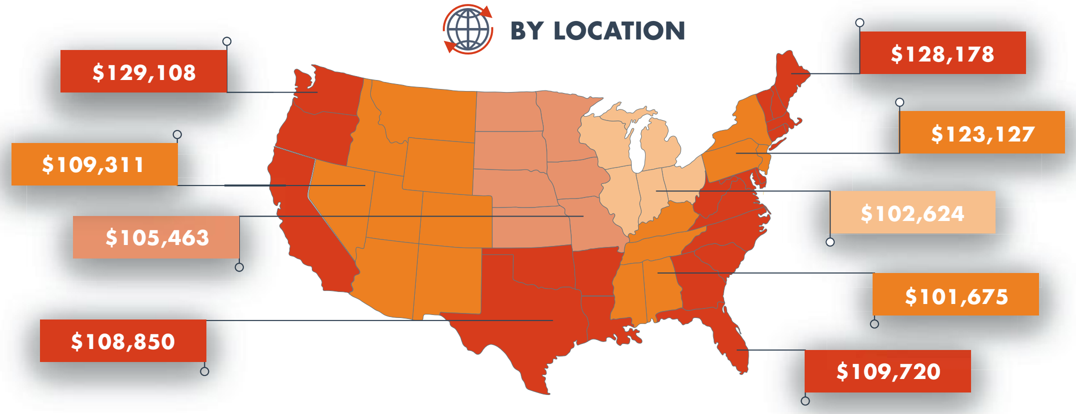
Executive/operating management	$132,212	1
Engineering management	$129,376	2
Design & development engineering	$113,999	3



AVERAGE SALARIES

Average Base Salary	$113,624
Average Bonus	$4,492
Median Bonus	$3,000
Average Stock Options	$2,764

BY LOCATION



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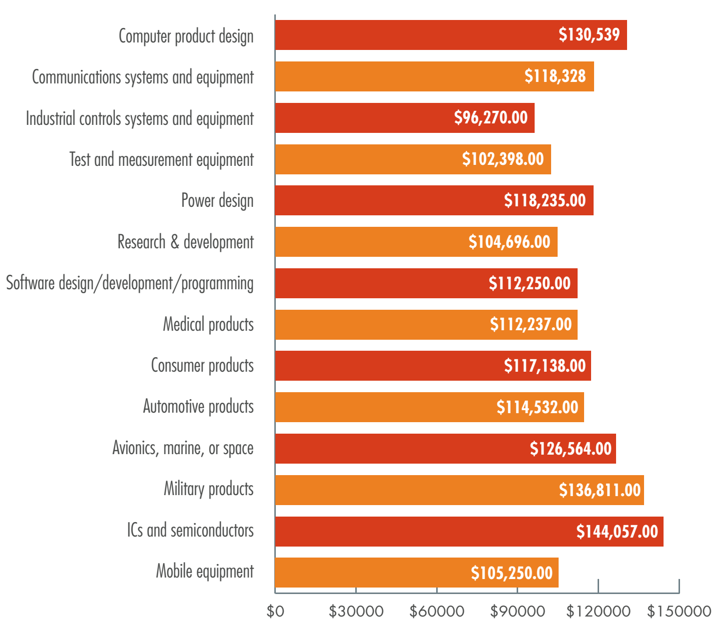
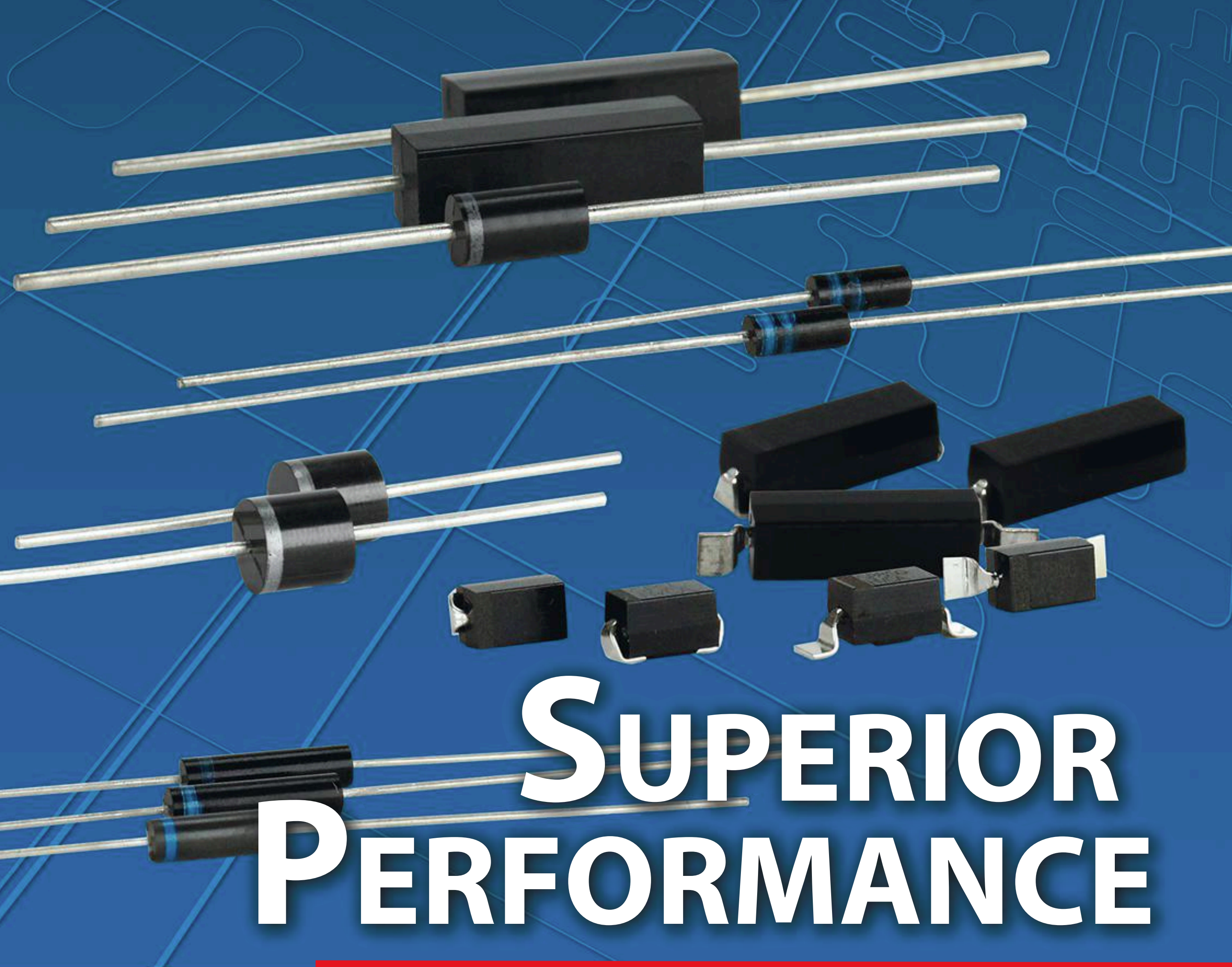


BY EXPERIENCE

40 years or more	$114,984
35–39 years	$122,071
30–34 years	$126,416
25–29 years	$124,167
20–24 years	$122,758
15–19 years	$117,129
10–14 years	$113,924
5–9 years	$91,224
1–4 years	$72,014
Less than 1 year	$57,682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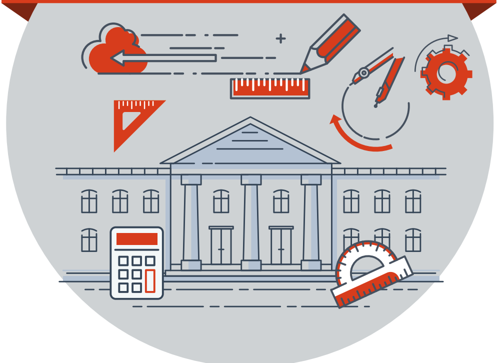
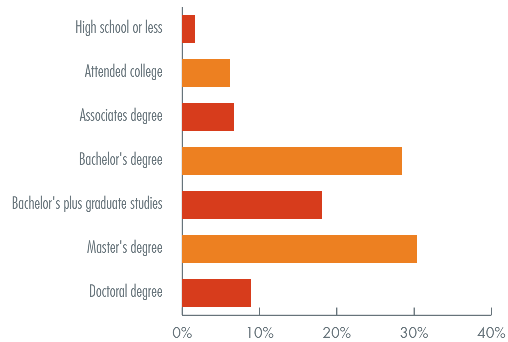
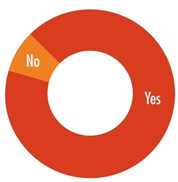
EDUCATION



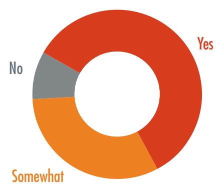
WHICH ONE OF THE FOLLOWING BEST DESCRIBES YOUR HIGHEST LEVEL OF EDUCATION?



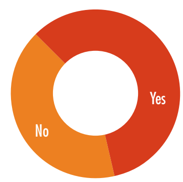
SHOULD ENGINEERS BE MULTI-DISCIPLINED?



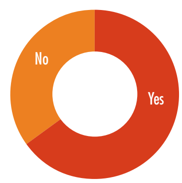
ARE YOU ARE BEING CHALLENGED INTELLECTUALLY?



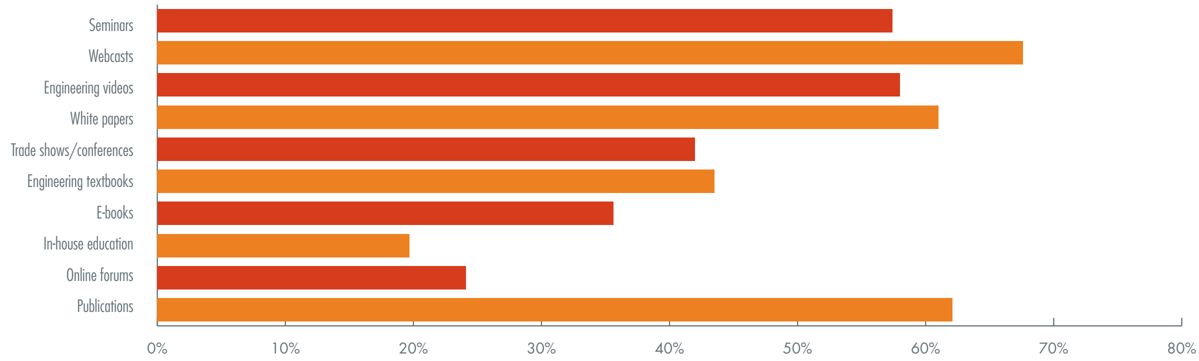
IS IT DIFFICULT FINDING QUALIFIED CANDIDATES?



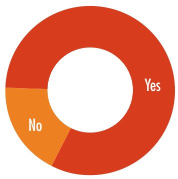
ARE STUDENTS LEARNING THE RIGHT SKILLS?



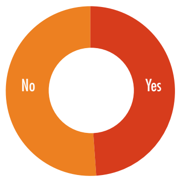
HOW DO YOU MAINTAIN YOUR EDUCATION?



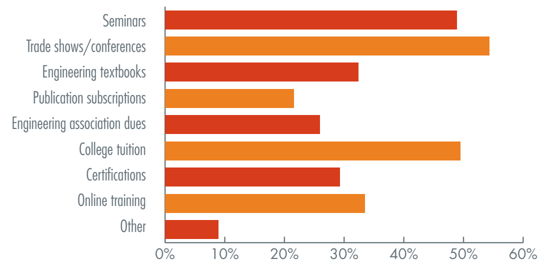
NEED FOR STRONGER FOCUS ON STEM EDUCATION EARLY ON?



DO WORKERS RIGHT OUT OF SCHOOL BRING NEW SKILLS?



FOR WHICH FORMS OF EDUCATION DOES YOUR COMPANY REIMBURSE COSTS?



The Unique AKIII Enclosure ....

The patented Air Ventilation elements avoid condensation while preserving the high protection class IP65. Occurring condensation is transported out of the enclosure immediately via air exchange.

The continuous and high air exchange allows the interior air to mix constantly with the environmental air and moves the moisture outward.

Even environments with nearly constant humidity and temperature possess air exchange, since the air on the interior of the enclosure warms due to the fittings. The individual components of the ventilation elements mainly consist of the rotating cover (rear side of box) and the 10µm filter element integrated on the inside of the box.

E254144
UL TYPE 3R, 12, 12K

EU

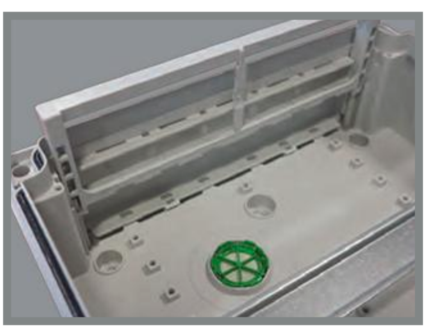
PROTECTION IP65

WINNER
DESIGN AWARD

Advantages of Air Ventilation Elements

- Prevention of condensate water while preserving the high protection class IP65
- High air exchange rate
- 100% pressure compensation
- Foreign object protection
- Maintenance-free

Combination flange / flange end walls



Closed wall

Knockout flange

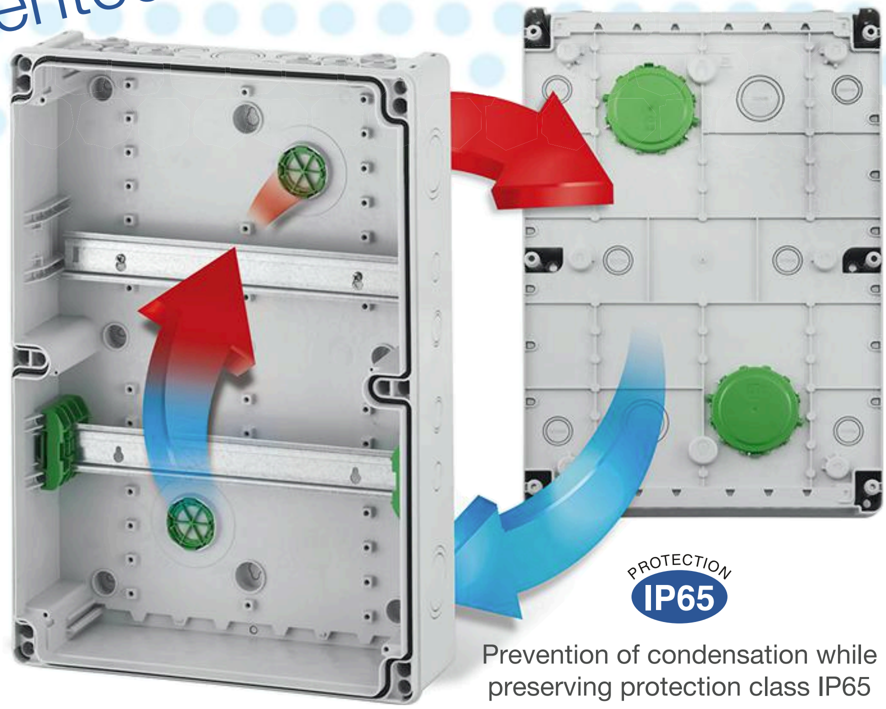
Knockout flange

Combination flange

...with Patented Air Ventilation System

Patent No.
WO 2015/063057 A1

Accessories available including air ventilation element for use in other enclosures.



Prevention of condensation while preserving protection class IP65

Integrated Air ventilation elements

Wide Range of Features:

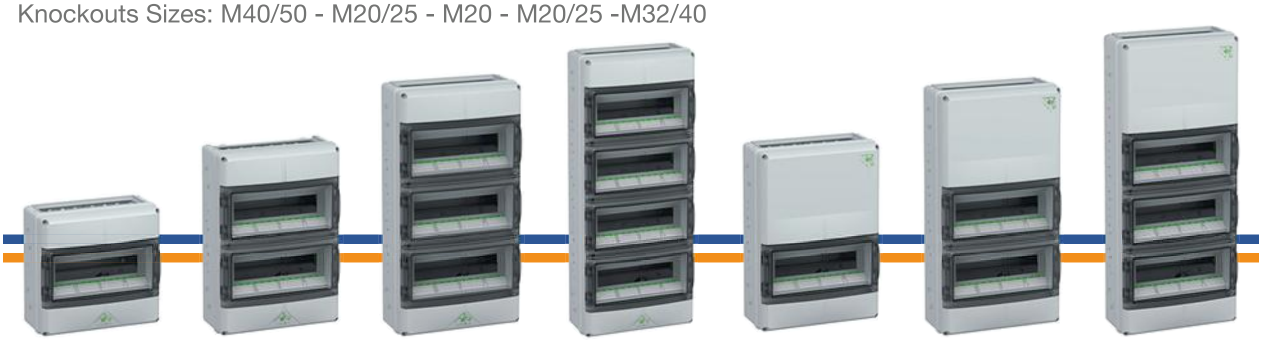
- Integrated air ventilation
- Top/bottom interchangeable flange endwalls
- Height-adjustable mounting rail
- 150 mm rail spacing
- Optimized hinged window
- Combinable
- Multiple installation options
- DLG focus test: Ammonia resistance
- Indoor and outdoor installation
- Free of halogen, PVC and silicone

Free of halogen, PVC and silicone

Highly flame-retardant

The AKIII Enclosure Family

Enclosure Size Range: 315 x 300 x 155 mm (12.4 x 11.8 x 6.1 in) to 315 x 750 x 155 mm (12.4 x 29.5 x 6.1 in)
Knockouts Sizes: M40/50 - M20/25 - M20 - M20/25 -M32/40



(Continued from page 12)

respondents is that 20% higher pay on average would bring them to market value. In addition to higher compensation, respondents report that employers are slowly improving health benefits, retention bonuses, and other incentives to fill open engineering positions with more than journeymen and contractors.

But electrical engineers are changing jobs more often. The survey showed that the number of respondents who have worked for their current company less than four years increased from 26% to 38% over the last five years. Only one-tenth of respondents are actively looking for new jobs, while 30% say they would follow up if they heard about an interesting opportunity. Nearly 32% indicate they would listen if personally offered a position.

More than two-thirds of respondents said a headhunter has contacted them within the last year. All told, the number of electrical and electronics engineers is projected to grow from 318,300 to 347,000 over the next decade, according to the U.S. Bureau of Labor Statistics. Around 40% of respondents said that their company is going to boost engineering staff over the next year and 50% say that staffing will stay the same, with the remainder foreseeing cuts.

That suggests mounting competition for engineering skills, putting pressure on professionals to teach themselves about the latest technology and integrate it into increasingly complex and compact products. Many express that they struggle to devote enough time to continuous education. Only around 54% say that they are compensated for trade conferences. One-third indicate that they are reimbursed for online training, up from around 25% in 2014.

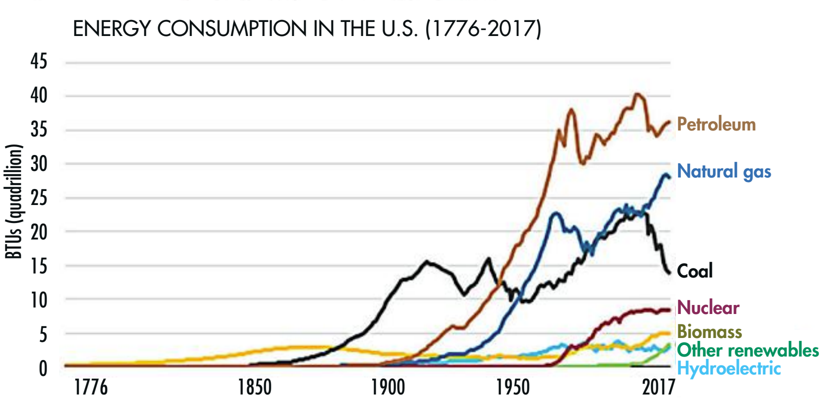
Some respondents feel that employers are unwilling to train new engineering hires. Others argue that the qualifications for many new jobs are unreasonably broad, giving companies ground to hire contractors or start outsourcing. Two-thirds say that their companies are having trouble filling open engineering positions. That could be why the number of respondents who believe in an engineering shortage has jumped from 51% to 63% over the last year.

Despite the challenges and sacrifices of an engineering career, more than 90% would recommend the profession to young people. Even though the number of engineering students entering the workforce is falling, many respondents say that the future of the profession looks bright. More than half agree that recent graduates are bringing new skills to their company, while almost two-thirds say that engineering students are learning the right skills to succeed. ed

BONNIE BAKER | BB@ATW, LLC

Is RENEWABLE ENERGY Ready to Topple Fossil Fuel's Domination?

Heavy dependence on oil, gas, and coal may dissipate sooner than you think as the infrastructure matures around alternative sources like wind and solar.



1. Renewable fuels, at below 5 quadrillion BTUs, collectively rank a little more than nuclear fuel. *(U.S Energy Information Administration)*

It seems like, in the near future, renewable-energy source technologies such as solar and wind power have a chance to surpass traditional fossil fuels in terms of usage. I mention solar and wind power because these energy generators seem to be more visible than other types of renewable energy. Being born and bred in Arizona, I'm certain that solar energy sits at the top of the list. After all, it seems like almost every other week I see the occurrence of a new solar-panel installation, and there's no shortage of annual sunshine in my neighborhood.

But, let's step back and look at the big picture. According to the U.S. Energy Information Administration, renewable energy sources in 2017 collectively had a minor impact on the energy consumption in the United States *(Fig. 1)*.

Fossil fuels such as petroleum, natural gas, and coal account for at least 80% of energy consumption in the United States. But, enough about this evil global-warming, climate-modifying fuel. For those that argue that natural gas isn't a threat to global warming, they may be wrong. Natural gas emits less carbon dioxide than fossil fuels and coal to be sure. There's a widespread effort to replace other fossil fuels with natural gas. The pitfall with this movement is that the by-product of methane or natural-gas combustion is water and carbon dioxide. Ouch.

Let's concentrate on the future of renewable fuels *(Fig. 2)*. Five renewable fuels are ahead of the pack in today's energy creation and consumption landscape. The origin of these fuels is from biomass energy, hydropower, wind, solar, and geothermal.

BIOMASS ENERGY

The most prevalent renewable energy today involves biomass. The production of biomass energy comes from recently living organic matter like plants. This is a nice renewable resource because plants can be quickly regrown, and a

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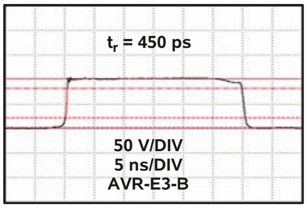
AV-156F-B: 10 Amp current pulser for airbag initiator tests



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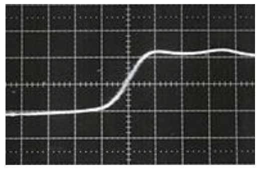

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100 V	300 ps	0.02 MHz	AVI-V-HV2A-B
50 V	500 ps	1 MHz	AVR-E5-B
20 V	200 ps	10 MHz	AVMR-2D-B
15 V	100 ps	25 MHz	AVM-2-C
15 V	150 ps	200 MHz	AVN-3-C
10 V	100 ps	1 MHz	AVP-AV-1-B
10 V	50 ps	1 MHz	AVP-3SA-C
5 V	40 ps	1 MHz	AVP-2SA-C

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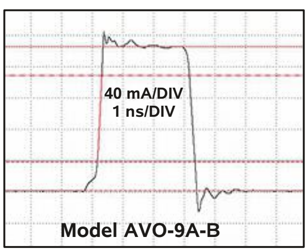

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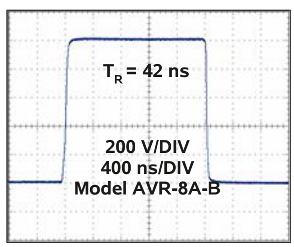

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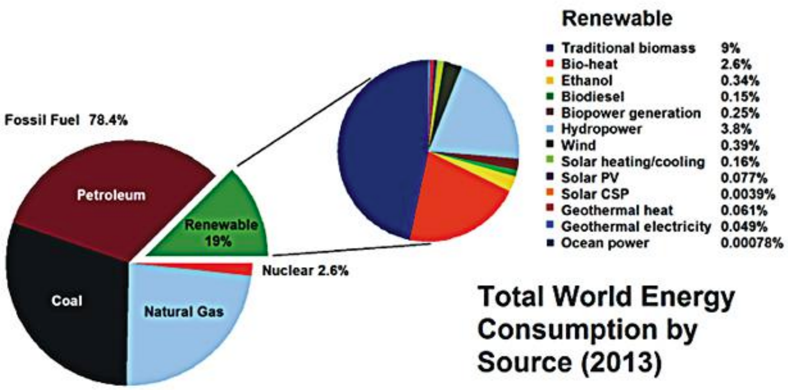
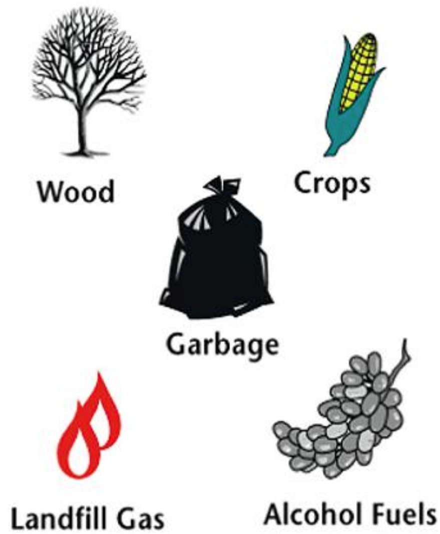
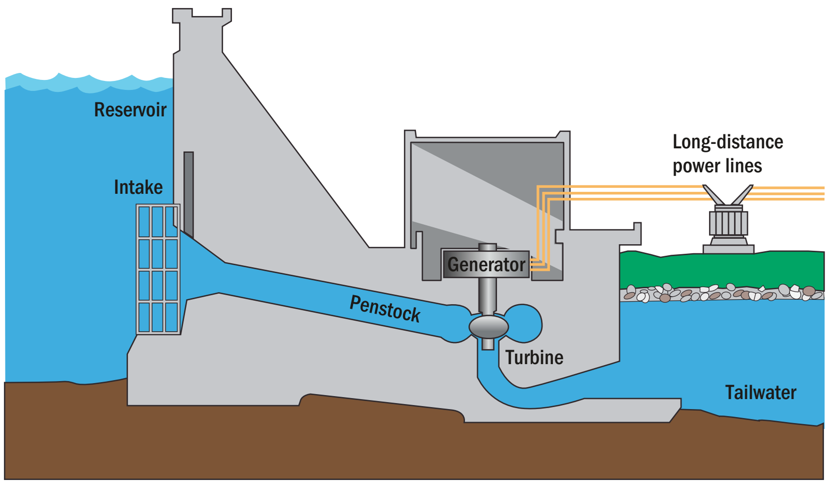


2. A worldwide view of renewable fuel in 2013 highlights bioenergy at the front of the pack. *(Credit: Wikipedia)*



3. Plants and waste are natural biomass energy makers.



4. With this dam, steeper drops generate more water power and thus energy.

main source of energy for them is water, CO_2, and solar.

I can remember that the craze a while ago was using biomass fuels to replace the petroleum fuels in cars or trucks. At that time, I had an image in my mind of a confused truck driver at a truck stop feeling like he was a cattle magnet. Gosh darn, that corn-based biomass fuel.

The creation of bioenergy comes from wood (largest biomass), miscanthus, switchgrass, hemp, corn, poplar, willow, sorghum, sugarcane, bamboo, eucalyptus, palm oil, etc. *(Fig. 3)*. Biomass fuel's contribution to carbon is somewhat of a wash. Harvesting and burning plants for energy produces carbon. However, the generation of new plants require time, water, and the consumption of carbon dioxide. I guess that's what makes it a wash.

The good news is that we humans have a huge repository of wasted trash that often happens to be renewable organic waste. The origin of renewable natural gas (RNG), or biomethane, is from organic wastes that have a moisture content. Cities, towns, and businesses around the country already use RNG to manage local waste and power vehicle fleets. And one innovative company in Fair Oaks, Ind.—a dairy farm company—powers milk delivery trucks with cow manure RNG. On the plus side, this saves them $2.5 million in annual fuel costs, while at the same time reducing 24,000 tons of CO_2 emissions.

California is at the forefront for passing a bill that targets 100% renewable energy by 2045. The claim is that this initiative bill creates new jobs and powers homes, businesses, and cars with clean, zero-carbon energy. The actual date may not be achievable; however, the state's direction is clear.

HYDROPOWER

Hydropower or water power has been an effective resource for humans since the beginning of time. Basically, this power comes from falling water. When harnessed, it takes on various energy-producing forms: watermills for irrigation, waterfalls for electricity, or stored water in dams—the water from a released dam flows as kinetic energy through turbines to produce electricity. This style of renewable energy generates 19% of electricity worldwide.[1]

Most hydroelectric power plants are located on a river at a high elevation, with a dam to hold back the water in a reservoir *(Fig. 4)*. The water flows through a penstock pipe into the dam. It then pushes the turbine, which turns an electric generator.

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WIND

An engineer can easily consider wind a form of solar energy. Differences of temperature at the Earth's surface, when lit by sunlight, creates an atmospheric movement. This is because the sun causes uneven heating and cooling events in the atmosphere. The sun owns part of the changing wind conditions as does the earth rotation and other topographical factors.

Extremely large fans or windmills, with turbines, convert the wind to electricity *(Fig. 5)*. In this manner, wind can cut business or home electrical costs. Commercial-grade wind-powered generating systems presently meet the renewable-energy needs of many organizations. Single wind turbines generate electricity as a supplement to an organization's existing electrical supply.

5. Wind turbines in Lamar, Colo. make up a 162-MW Colorado green wind farm. Each turbine produces 1.5 MW of electricity.

When the wind blows, power generated by the system offsets the need for utility-supplied electricity. The electricity purchase of utility-scale wind farms is in the wholesale power market, either contractually or through a competitive bid process.

SOLAR

So now it's time for me to come back to my hometown of Tucson, Ariz. The Davis-Monthan Air Force Base in Tucson has installed quite an array of solar panels *(Fig. 6)*.

"For a minimal investment in manpower, projects like this provide sub-

> "The Davis-Monthan engineers found that in the first 10 months of operation, the array produced 33,083,404 kWh of electricity, enough to power over 3,600 homes. This amounts to a $500,000 per year savings for Davis-Monthan and the Air Force."
>
> *—Lt. Col. Brian Stumpe*

stantial savings," says Lt. Col. Brian Stumpe, the 355th Civil Engineer Squadron commander. "The Davis-Monthan engineers found that in the first 10 months of operation, the array produced 33,083,404 kWh of electricity, enough to power over 3,600 homes. This amounts to a $500,000 per year savings for Davis-Monthan and the Air Force."

Now, renewable-energy projects like the Davis-Monthan array are part of the Air Force's overall strategy to provide energy resiliency, reliability, and security, as well as cost savings. Power systems located on secure installations deliver necessary predictability, and dollar savings free up resources that can be reallocated to other mission priorities.

GEOTHERMAL ENERGY

Another form of alternative energy is geothermal electricity. Barring any property investment on Hawaii's Big Island, this energy is usually sustainable and reliable. Magma conduits, hot springs, or hydrothermal areas provide Earth's heat energy to spin turbines or heat buildings *(Fig. 7)*.

One drawback to geothermal energy is the limitations of location. Only a small number of places allow for the cheap harnessing of this energy. However, in certain areas of the world, such as Iceland, Indonesia, and other regions with high levels of geothermal activity, it's an easily accessible and cost-effective way of reducing dependence on fossil fuels and coal to generate electricity.

LOCATION, LOCATION, LOCATION

One problem with renewable energy is the limitations that ensue due to the dependence on nature. A secondary issue is the expense of alternate energy compared to traditional sources such as oil and natural gas. Until very recently, running coal-fired or oil-powered plants was cheaper than investing mil-

6. Solar panels on 170 acres of underutilized land collect sunlight energy. *(Credit: U.S. Air Force /1st Lt. Sarah Ruckriegle)* lions in the construction of large solar, wind, tidal, or geothermal operations. Ongoing improvements make solar cells, wind turbines, and other equipment viable energy competitors. All over the world, nations and communities are making efforts to hasten the evolution toward cleaner, more sustainable, and more self-sufficient methods.

7. The Krafla is a geothermal power station located in Iceland. *(Credit: Wikipedia Commons/Ásgeir Eggertsson)*

GALLOPING INTO THE FUTURE

Are the days of coal and oil domination winding down? Some say yes, or at least Californians would say absolutely. There are several ways to generate power from biomass, hydro, wind, solar, and geothermal sources. These renewable-energy source alternatives to fossil fuels are already becoming an important part of our power-generation mix. So, what do the years in the future hold? Or a better question is: "When will the renewables dominate?" ed

REFERENCE

1. http://water.usgs.gov/edu/wuhy.html

SIDDHARTH MISHRA | Senior Research Analyst, Information, Communication, and Next-Generation Technologies, Grand View Research

IoT's Next Revolutionary Shift Through Analytics

A closer look at the top IoT use cases today in the business-to-business and business-to-consumer sectors can help determine the growth potential for the analytics of things.

The exponential rate of growth in the Internet of Things (IoT) has of course led to more and more things, from wearable devices to factories, becoming embedded with technology. Consumers, as well as enterprises, are increasingly realizing the full potential of IoT, ultimately reducing cost and leveraging more robust data analytics.

Regardless of all the technological advances, end-users and businesses haven't yet completely tapped into the vast possibilities of the IoT. One of the reasons for this is that today's users lack the knowledge on how to collect and utilize data from the connected devices. Though it's theoretically possible to collect and analyze more data than ever before, the actual implementation still lags behind.

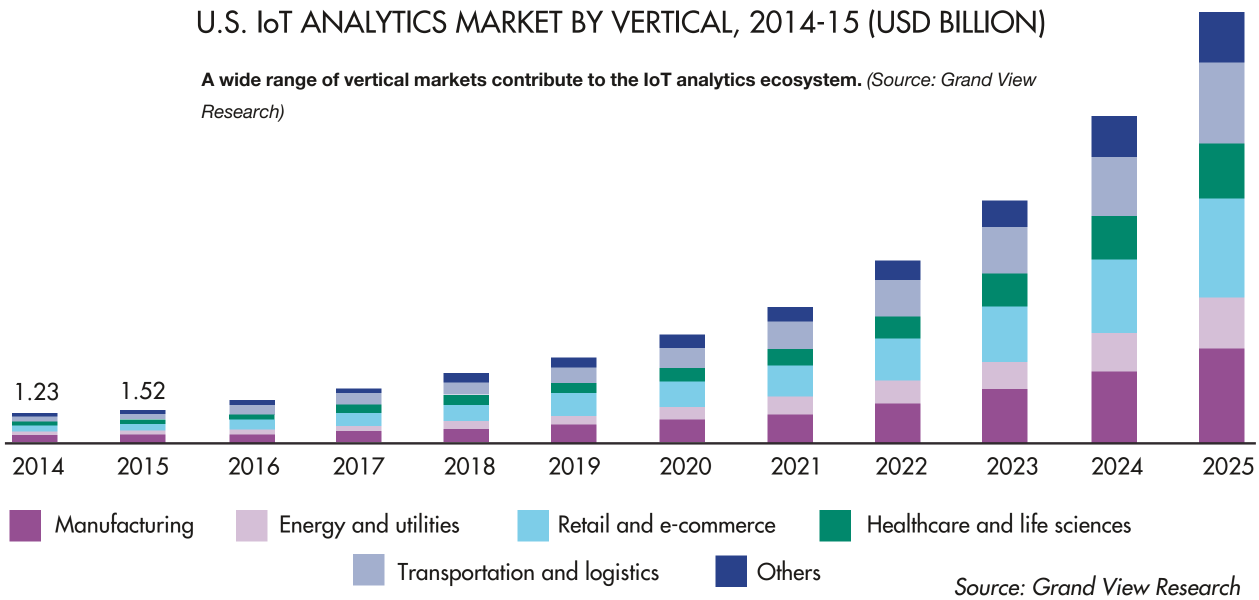
There's an ever-increasing need to think about the relationship between connected devices and the optimum utilization of data in various analytics use-cases. Companies that haven't yet started leveraging the abundance of data are missing the IoT bus.

As per the estimations made by Grand View Research, the global IoT analytics/analytics of things market size is expected to reach USD 57.3 billion by 2025, following a CAGR of over 29% from 2017 to 2025. Increasing demand for cost-effectiveness and advanced technologies has boosted the adoption rate of analytics of things among enterprises. IoT analytics is helping enterprises and individuals gaining real-time insights, thereby optimizing the decision-making process.

The *figure* depicts the U.S. IoT analytics market size estimates and forecasts, broken down by various verticals including manufacturing, energy and utilities, retail and e-commerce, healthcare and life sciences, transportation and logistics, and others. Manufacturing is expected to be one of

U.S. IoT ANALYTICS MARKET BY VERTICAL, 2014-15 (USD BILLION)

A wide range of vertical markets contribute to the IoT analytics ecosystem. *(Source: Grand View Research)*



the most lucrative segments, while healthcare and life sciences will likely emerge as the fastest growing vertical over the forecast period.

DEVELOPING IoT ANALYTICS USE-CASES

Industries: Shift Toward Optimization

Manufacturing, power generation, oil & gas, and logistics & transport are becoming a perfect breeding place for IoT advancement. Most of these industries have become extensively automated, which offers boundless potential for data collection. The companies are increasingly struggling to remain competitive in the market by achieving the best results at the lowest possible costs. Businesses worldwide are looking forward to collecting more and more data by establishing a connected ecosystem.

Though many industries have automated their business processes, they still have a long way to go to fully harness the capabilities of IoT analytics. Automation has allowed the enterprises to process and ship orders faster than ever before. However, the implementation of IoT analytics in order tracking and machine performance is anticipated to help the enterprises better optimize their manufacturing and inventory processes.

The implementation of IoT can help various industries analyze the data collected from almost every single part of their inventory, manufacturing, and distribution processes, thereby reducing wastage, quickly optimizing their operations, and predicting accurate time for machine maintenance.

Smart Cities: Improving the Quality of Urban Life

The transformation toward a smart city is already on its way in many urban areas around the world. Something as simple as an electronics sign informing passengers when their bus is supposed to arrive, or giving its current running status, is an example of IoT solving problems in smart cities.

Navigation is one of the biggest hassles in megalopolises. Tracking the real-time location of trains, buses, metros, trams, and subways is expected to help commuters overcome significant difficulties related to public transportation. Moreover, municipalities can utilize this data to schedule their maintenance or repair activities for public transport and infrastructure, aiming toward the least disruptive time for work and allocating the most efficient workforce for the same.

IoT data has the potential to significantly improve the quality of life in cities, particularly where public facilities are involved. For instance, Barcelona, Spain has started utilizing sensor-equipped trash cans to help city management regulate the service routes, keep the trash can empty, and decrease traffic.

Future applications of IoT analytics in smart cities is limitless in scope. With more objects in cities becoming a part of the IoT, city planning is expected to be shaped from effective utilization of analyzed IoT data, in order to optimize public relationships with the urban environment. New bus or train routes could be strategically planned by using years of traffic data. City power grids in most metropolises have already started tracking the power consumption, so we foresee the development of solutions, such as blackout prevention, that will effectively manage city power consumption and supply.

Customer-Driven Innovation

The buzz about IoT has now become a roar in the retail industry. Retailers are increasingly leveraging the benefits of IoT to upgrade their customer experience, provide new services, and enter new markets. Data collected from IoT devices and sensors not only help retailers attain an enhanced management of energy usage and store assets, but also enhance in-store marketing efforts. IoT-delivered data provides real-time insights into employee productivity and inventory management.

The majority of the advances in the retail industry are primarily focused on the customer's journey of selecting items through the store. For instance, several retailing giants have started utilizing smart check-out stations, which are designed to weigh, scan, and automatically complete all check-out procedures within a smart cashier-less checkout station.

All of these examples represent how the retail sector is implementing IoT analytics to enhance the customer experience by alleviating the worst parts of shopping, like waiting for items to ship or waiting in line. Furthermore, some innovative startups are working on the development of new IoT data use-cases, which are expected to reveal a better analysis of buyer interaction during the purchase process. The analysis is primarily based on the following parameters:

- How are customers moving in the store?
- How long are they in dressing rooms, waiting in queues, and/or looking at products?
- What type of difficulties do they face while shopping?
- What is influencing them to move to brick-and-mortar stores?

IoT Analytics Shaping Human Habits

Wearable technology is one example of how IoT analytics is being used to shape human habits. Consumers increasingly use fitness trackers and smartwatches for their self-improvement. These devices allow a user to analyze his/her behavior by tracking steps traveled, miles run, sleep, or minutes without any motion.

The advent of IoT in the human ecosystem has led to the development of smart refrigerators, allowing users to remotely check the inside of the fridge (with the help of interior cameras) and notify them when food is about to expire. We believe that it's only a matter of time before a smart fridge will be

Design Note

SEPIC, Boost, Inverting, and Flyback Controller Solves the Voltage Drop Problem of High Impedance, Long Length Industrial Power Lines

Victor Khasiev

Introduction

The LT®8710 is a versatile DC/DC controller that supports boost, SEPIC, inverting, or flyback configurations, and is widely used in automotive and industrial systems. The LT8710 includes features that enable use in applications with high impedance power supplies, or where input current must be limited.[1] For example, long power lines in industrial plants and warehouses add significant input source resistance as well as a significant voltage drop from converter to load. This value can change as equipment is relocated, further complicating regulation. Solar panels also have a high impedance input, with a peak power output and a narrow voltage range. This design note demonstrates how the LT8710 can solve the problems of high impedance and current limited input sources, through the example of a lithium-ion battery charger.

Circuit Description and Functionality

Figure 1 shows a charger solution for a 20V lithium-ion battery, commonly used in portable power tools. The voltage source, V_{SRC}, is 24V via a high impedance power line, resistor R_{LN}, resulting in the voltage V_{IN} at the charger input terminals. The voltage source could be considered as a popular 12V solar panel with 22V to 24V open-circuit and 18V to 19V optimum operating voltage. The charger is based on a synchronous non-coupled SEPIC topology and controlled by the LT8710. The power train consists of discrete inductors L1, L2, transistors Q1, Q2, decoupling capacitors between the inductors, and input/output filters. Resistor R_{SC} sets 2A of charge current, I_{CHRG}; resistor $R_{V(FL)}$ sets the float voltage of 21V. The resistor divider R_{IN1}, R_{IN2} sets input voltage regulation level which is 18.6V in this example.

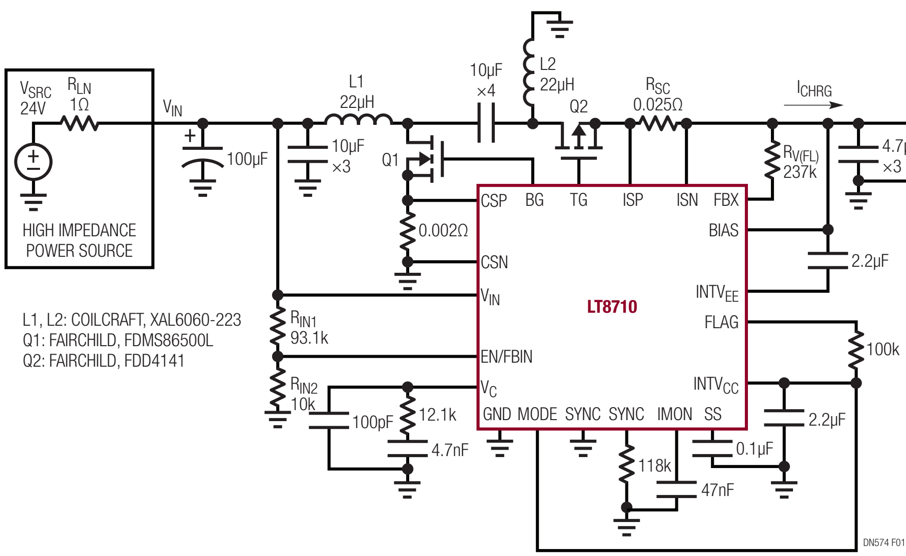


Figure 1. Electrical Schematic of LT8710 Li-Ion Battery Charger In High Impedance Input Lines

Figure 2 illustrates the functionality of the charging solution over time. When V_{IN} and power source voltage V_{SRC} are above 19V, the LT8710-based SEPIC charges the lithium-ion battery to the programmed 2A, I_{CHRG}. As V_{SRC} drops below 20V, the value of V_{IN} drops correspondingly. When V_{IN} reaches the input voltage regulation level, the LT8710 reduces the charging current, I_{CHRG}, to maintain V_{IN}, even as V_{SRC} continues to decline. The horizontal axis represents normalized time, which can be hours for a solar panel, or minutes, or seconds for power supplies in complex industrial systems.

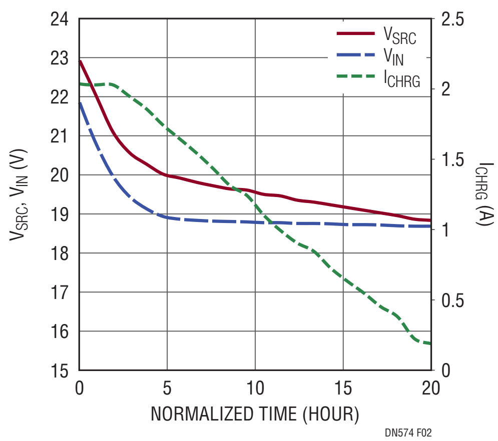


Figure 2. Graphs of Charging Current (I_{CHRG}) as a Function of the Voltages Power Supply (V_{SRC}) and Charger Input Terminals (V_{IN})

Another way to control the load for converters based on the LT8710's input current is to monitor voltage of the capacitor from the IMON pin. Select resistor R_{SC} to provide a voltage close to 50mV at the maximum current. A corresponding voltage is reflected across the IMON capacitor. If there is no current flow and the voltage across the ISP and ISN pins is zero, then the IMON voltage is approximately 0.616V. If the ISP–ISN voltage is 50mV, it reflects the IMON voltage as 1.213V. This feature, as well as many others, can be evaluated using our demonstration circuit DC2067A[2] and corresponding LTspice models[3].

Conclusion

The LT8710 is a versatile and flexible controller that supports synchronous SEPIC, boost, and inverting converter topologies. Along with a wide range of input voltages and switching frequencies, it includes advanced features, such as the ability to regulate the input voltage and output current based on input current or voltage. These features make the LT8710 ideal for industrial, solar panel systems and other current limited applications.

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Data Sheet Download
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	Company	2017 Global Revenue
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3.	Avnet *	$17.44 billion
4.	Future Electronics Inc. **	$5 billion (EST)
5.	Digi-Key Electronics	$2.33 billion
6.	TTI	$2.25 billion
7.	Electrocomponents plc/Allied Electronics & Automation	$1.87 billion
8.	Smith & Associates	$1.5 billion
9.	Mouser Electronics	$1.34 billion
10.	Premier Farnell/Newark	$1.195 billion
11.	Rutronik Elektronische Bauelemente GmbH	$1.17 billion
12.	DAC/Heilind	$857.4 million
13.	Fusion Worldwide	$525 million
14.	Sager Electronics	$272.9 million
15.	Master Electronics	$245.2 million
16.	America II Electronics	$238.2 million
17.	PEI-Genesis	$215 million
18.	Advanced MP Technology	$189 million
19.	Bisco Industries Inc.	$156.95 million
20.	The Powell Electronics Group	$138.1 million
21.	Richardson Electronics, Ltd.	$136.9 million
22.	Electro Enterprises Inc.	$127.4 million
23.	RFMW Ltd.	$119.4 million
24.	NewPower Worldwide	$107.3 million
25.	Flame Enterprises	$102 million
26.	Steven Engineering, Inc.	$99.15 million
27.	Hughes Peters	$98.5 million
28.	Classic Components Corp	$90 million
29.	CoreStaff Co., Ltd.	$70 million
30.	Crestwood Technology Group	$56 million
31.	Marsh Electronics	$52.7 million
32.	Edge Electronics, Inc.	$48.4 million
33.	IBS Electronics, Inc	$47.7 million
34.	Symmetry Electronics, Corp.	$44 million
35.	NRC Electronics, Inc.	$41.6 million
36.	SMD Inc.	$39.4 million
37.	Air Electro Inc.	$29.48 million
38.	ASAP Semiconductor	$28.9 million
39.	Area51-ESG, Inc.	$24.96 million
40.	House of Batteries	$24.84 million
41.	Diverse Electronics	$24.5 million
42.	March Electronics, Inc.	$22 million
43.	Powertech Controls Co. Inc	$21 million
44.	CTrends, Inc.	$19.5 million
45.	Cumberland Electronics Strategic Supply Solutions Inc (CE3S)	$18.65 million
46.	Kensington Electronics	$18.5 million
47.	PUI (Projections Unlimited Inc.)	$18.47 million
48.	Gopher Electronics Company	$16.1 million
49.	Marine Air Supply	$14.8 million
50.	Advantage Electric Supply	$13 million

*In October 2016, Avnet closed its acquisition of Premier Farnell and the company's total includes Premier Farnell's revenue for fiscal year 2017. Source Today also lists Premier Farnell's global revenue separately
**SourceToday estimate of Future Electronics global revenue

developed that would be able to precisely track the way a user eats, wastes, and buys food.

Personal betterment with IoT is simply the process of automatically collecting the behavioral data and using it to modify the way an individual behaves. Increasing sophistication of wearable devices is likely to support the trend, i.e., self-improvement with IoT. With many consumer/individual items becoming a part of the IoT system, market incumbents are expected to stay focused toward optimizing the utilization of IoT data.

INTERSECTING IoT ANALYTICS WITH CONNECTED WORLD = HUGE ROI POTENTIAL

Be it improving machine behavior, or resource management, or enhancing personal routine, IoT analytics has the potential to significantly revolutionize the way we achieve our goals. The intersection of IoT analytics with the web of things will likely open the door to myriad business opportunities.

Grand View Research predicts there will be almost 100 billion devices connected to the internet by 2025. These include everything from smart-home devices to industrial equipment and critical machine tools to driverless cars. The growth in the IoT devices is anticipated to lower the cost required to embed almost any item with a sensor and permit real-time transfer of the data collected from sensors over cellular, wireless, or other networks. ed

SIDDHARTH MISHRA is a consultant with Grand View Research and is responsible for the company's syndicate and consulting market research across the Information, Communication, and Next-Generation Technologies domains. His primary focus is on disruptive and emerging technologies and solutions delivered to multinationals, enterprises, government agencies, and SMEs across the globe. His key areas of interest include the IoT, Industry 4.0, smart factories, and other emerging technologies shaping the new-age industry. He completed his Master of Business Administration in Marketing (2013-2015) after Bachelors of Electronics & Communication Engineering (2008-2012). Siddharth has extensive experience in the Internet of Things (IoT) industry and worked mainly with the global and regional technology providers, system integrators, and wireless connectivity service providers, helping them make better business decisions. For the last couple of years, he's been involved in the continuous monitoring of the Analytics of Things Market, thereby keeping a tab on all emerging and latest trends and developments in the industry worldwide.

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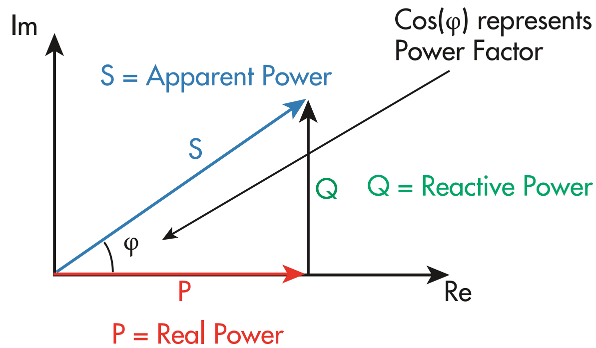
How Does Power Factor Correction Impact Your Utility Bill?

Reactive power elements such as capacitors and synchronous generators and motors can help overcome issues involving low Power Factor values.



1. The "power triangle" includes Real Power, Reactive Power, and Apparent Power.

Your utility Power Factor is the ratio of the system's Real Power and the Apparent Power (Eq. 1). This unitless factor ranges from −1 to 1. The Power Factor ratio aptly describes the type of storage elements in the circuit and the stability of the current-to-voltage relationship. More importantly, for utility companies, this ratio provides insight into a user's power consumption habits, enabling them to apply fees related to lower value Power Factors (usually below 0.80 or 0.85).

Power Factor = Real Power/Apparent Power (1)

Inductive or motor-control environments are most apt to impact the system's Power Factor. Consequently, many industrial processing facilities are piquing the interest of utility companies due to their typically low Power Factor numbers. These facilities have a large number of induction motors that drive pumps, conveyors, and other machinery in the plant. Induction motors, with their inductive elements, cause low positive Power Factors.

POWER FACTOR

The three elements of the Power Factor diagram are Real Power, Reactive Power, and Apparent Power. In *Figure 1*, the graphical relationship of these powers conveniently uses a right triangle, where the Pythagorean theorem of $S^2 = P^2 + Q^2$ becomes very helpful.

A wattmeter measures Real Power (P) (also known as Working Power, Actual Power, or Active Power), providing a value with units equal to watts (W). The Real Power or P actually powers the equipment that performs useful work.

The Apparent Power (S) measurement is equally simple to perform. For the S value (Eq. 3), multiply the total voltage by the total current to provide a value with units equal to VA. The Apparent Power or S is the "vectorial summation" of Real Power (S) and Reactive Power (Q).

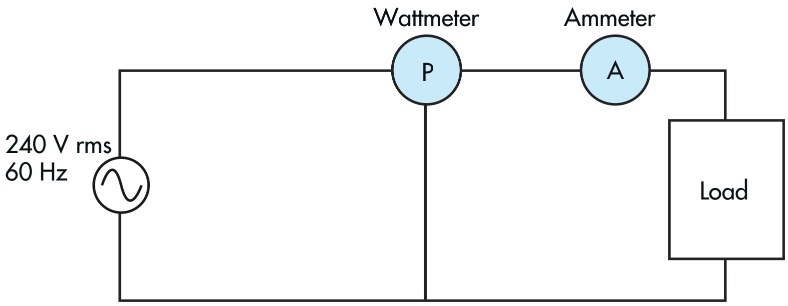
The Reactive Power (Q) derivation uses the P and S in the Pythagorean theorem (Eq. 2). The Q units are equal to VAR. With a positive Power Factor value, Q is the power that magnetic equipment (transformer, motor, and relay) needs to produce the magnetizing flux. With a negative Power Factor value (Eq. 4), Q is the power that a capacitive element needs to produce an electric field.

$$Q = 1/(S^2 – P^2) \quad (2)$$

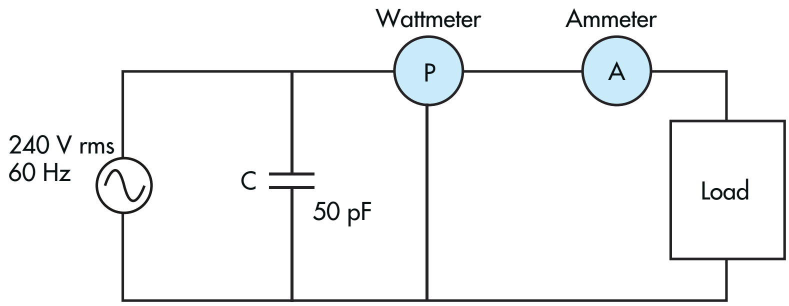
To help illustrate these points further, *Figure 2* shows a 240-V ac model driving an inductive load. In the figure, V = 240 Vrms; I = 9.515 A rms; and P = 2.0 kW.

$$S = V \times I = 240\text{ V} \times 9.515\text{ A rms} = 2.284\text{ kW} \quad (3)$$
$$\text{Power Factor} = P/S = 2.0\text{ kW}/2.260\text{ kVA} = 0.88 \quad (4)$$

As discussed earlier, the industrial processing facilities run the risk of running a facility with low Power Factor values. In turn, many electric utility companies acquire a low Power Factor penalty. This incentive drives factories to design-in higher Power Factors by adding power-factor-correction (PFC) elements.



2. In this block diagram of a 240-V ac model driving an inductive load, the wattmeter measures the total Real Power of the system and the ammeter measures real-time system current.



3. This circuit with power factor correction uses a 50-pF capacitor.

POWER FACTOR CORRECTION

The key contributors to Power Factor reduction are transformers, induction motors, induction generators (windmill generators), and high-intensity discharge (HID) lighting. To battle the facility's low Power Factor values, there are reactive power elements that increase Power Factor, including capacitors, synchronous generators (utility and emergency), and synchronous motors.

An electric motor load creates a lagging (inductive) or positive Power Factor. Typically, installed capacitors decrease the magnitude of Reactive Power (VAR), thereby increasing the Power Factor. The correct capacitor of appropriate size, wired in parallel, solves the low Power Factor problem *(Fig. 3)*. We will use the Reactive Power value to calculate the capacitor size (Eqs. 5 and 6):

$$XC = 1/(2 \times \pi f \times C) \quad (5)$$
$$XC = V/Q \quad (6)$$

where Q = Reactive Power; V = system supply voltage = 240 V rms; XC = capacitive reactance agent; f = system frequency (60 Hz); and C = new capacitor in farads.

From Equation 5, XC = 52.26, and from Equation 6, C = 50.7579 pF or 50 pF.

LOW POWER FACTORS

Power Factor challengers claim that there's no system penalty for low Power Factors. This may be true to a point for a typical home power user who may never see the impact of a low Power Factor regarding increases in electrical bills or home electronic performance. There's no benefit for such users in terms of PFC. For the utility and industrial users, this claim is markedly not true.

A low Power Factor indicates an imbalance that manifests itself as a phase shift between the voltage and current signals in a power supply. This may or may not be an issue. However, it's possible that the power supply may dip, and for the heavy motor user, the utility company may not respond in kind. ed

LEE SMITH | Vice President, Advanced Packaging Products, UTAC
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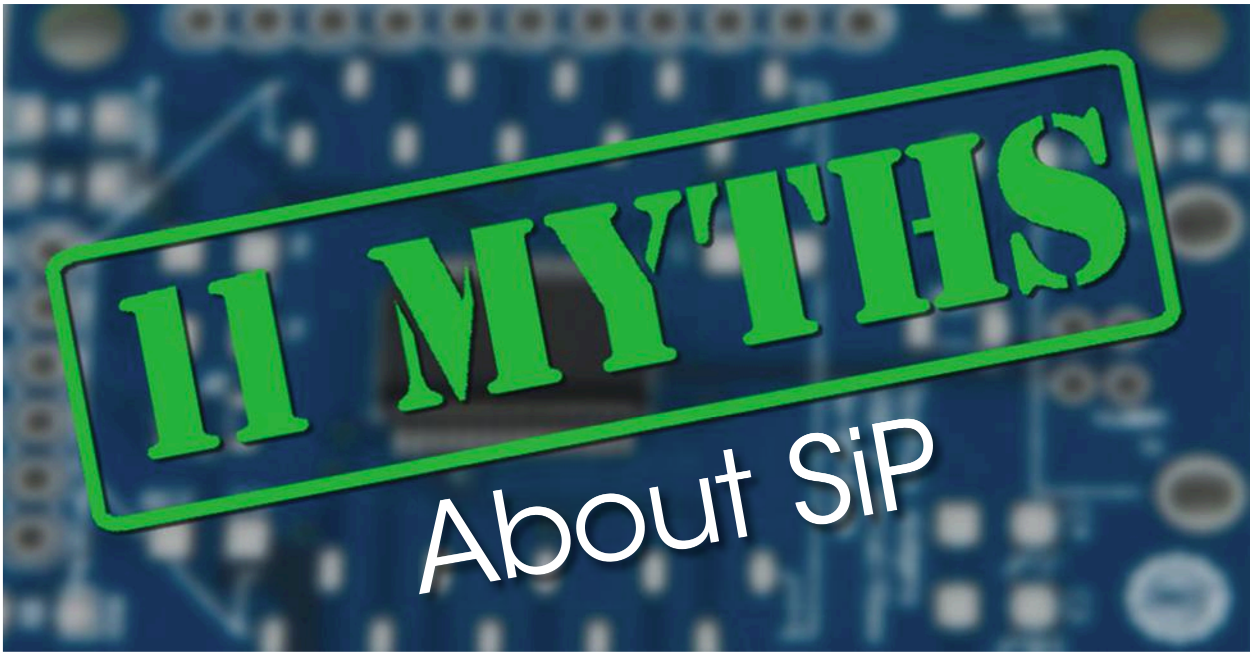

The prevalence of system-in-package technology in a host of different applications has invariably led to myths about it. UTAC's Lee Smith dispels some of these fallacies.

System in package (SiP) is an invaluable tool for delivering compact silicon solutions. It allows different technologies to combine into a single package, reducing the bill of materials (BOM) of a system while increasing the reliability. It can also lower system design costs since more complex components are combined within a SiP.

There are many SiP implementations, so it's not surprising that a few myths about this technology may be floating around.

1. There's no industry agreement on the definition of system in package.

The definition of SiP varies so widely that the first chapter of TechSearch International's recent SiP report[1] includes a list of over 20 definitions, contributed by a range of SiP suppliers and users. To establish the basis for the report and forecasts, the chapter provides the following definition:

"System-in-Package is a functional system or subsystem assembled into a standard footprint package such as LGA, FBGA, QFN, or FO-WLP. It contains two or more dissimilar die, typically combined with other components such as passives, filters, MEMS, sensors, and/or antennas. The components are mounted together on a substrate to create a customized, highly integrated product for a given application. SiPs may utilize a combination of advanced packaging including bare die (wire bond or flip chip), wafer-level packages, prepackaged ICs such as CSPs, stacked packages, stacked die, or any combination of these."

By this definition, multichip packages (MCP) and multichip modules (MCM) aren't considered a SiP, although various suppliers would disagree—this increases the challenge of analyzing and forecasting the SiP market. Many MCPs are combinations of devices that are like stacked-die chip-scale packages (CSPs), where flash and RAM are combined in a die stack supplied in high volumes. MCPs are also similar to MCM or modules, where the solution is a custom assembly format that's not a standard package platform, like a fine-pitch ball grid array (FBGA).

2. SiP competes with system on a chip (SoC).

They are more complementary than competitive. SoC has long been an effective strategy to integrate established IP blocks for high-volume applications that can absorb the significant complementary metal-oxide-semiconductor (CMOS) design and mask costs (which can exceed $300M) associated with a SoC.[2]

However, in today's system, semiconductor designers are looking for heterogenous integration solutions for SiP that have:

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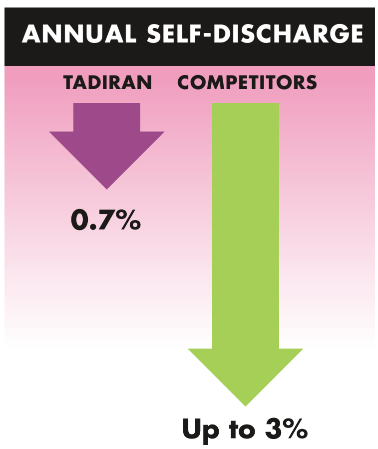

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- Faster time to market.
- Lower design, non-recurring engineering (NRE) and development costs (rarely exceed $100k).
- Can integrate semiconductor devices (active and passive) that don't scale well in CMOS.

3. SiP requires known-good die (KGD).

KGD isn't required, but may be necessary. Many SiP products are assembled with die that rely on the same wafer probe test coverage as used in a single-chip package. KGD may be the right quality and reliability strategy for a complex SiP that requires a costly substrate or component bill of materials (BOM). For high-volume SiP assembly, die is supplied in wafer form. Thus, defining the best probe flow (which could include burn-in or voltage screening) is critical in developing your KGD strategy and supply chain.[3]

4. Heterogeneous integration (HI) will replace SiP.

HI should be seen as the big-picture view for semiconductor technology road-mapping beyond Moore's Law. In contrast, SiP is the integration of various semiconductor devices within a given package platform. The International Technology Roadmap for Semiconductors (ITRS) is transitioning from a concentration of roadmaps for semiconductor fabrication scaling to outlining the roadmap challenges and requirements for heterogeneous integration technologies.[4]

5. SiP requires a printed-circuit-board (PCB) laminate substrate.

Due to strong demand for passive integration (primarily capacitors and inductors) in power-management applications, leadframe-based SiPs are seeing strong growth. Prismark Partners forecasts that 3.5 billion leadframe-based power SiP will ship by 2021.[5] Leadframes provide low cost and high thermal conductivity, making them a strong SiP platform for lower I/O and higher power requirements.

Laminate-based SiPs in land-grid-array (LGA) and ball-grid-array (BGA) configurations (primarily assembled in strip formats) serve the widest range of SiP applications; laminates support higher-density interconnection requirements with wide design flexibility, due to the wide range of laminate fabrication technologies. Wirebond, flip chip (FC), stacked die, embedded die or passives, and high-density SMT are all readily enabled through laminate substrates.

Emerging high wiring density applications are shrinking conductor line and space widths below 12 microns with roadmaps below 5 microns. This is driving adoption and development of new SiP platforms such as FanOut wafer, panel-level CSP, and the use of silicon or glass-based interposers with high-aspect-ratio through vias.

6. SiP is a planar 2D assembly.

With the growth in die stacking, package-in-package assembly, package-on-package (PoP) stacking, and embedded die technologies, 3D package architectures are providing size and performance advantages over 2D planar assemblies. 3D SiP solutions offers the following performance advantages:

- 3D SiP not only provides package footprint reduction on a printed-circuit-board assembly (PCBA), it also enables an increase in semiconductor content-to-package ratio through 3D integration technologies. The increased semiconductor content includes 3D integration of both active and passive devices.
- Reductions in package footprint can improve package warpage control, PCBA assembly, as well as second-level solder-joint reliability.
- Improved electrical performance through short vertical interconnects that can reduce circuit delays.
- Enable electromagnetic-interference (EMI)/radio-frequency-interference (RFI) shield isolation between semiconductor devices for radio-frequency and digital integration requirements.

7. The SiP architecture, process technologies, and materials are more critical than the supply-chain business model.

The supply-chain business model can make or break the success of a SiP in the market. A SiP solution can have 100 components in the electronic bill of materials (eBOM), but if one component isn't available due to delivery or quality problems, it stalls SiP manufacturing.

SiP solutions require advanced microelectronic package assembly and test capabilities. With the strong trend to outsource manufacturing services in the semiconductor and electronics industry over the past 50 years, outsourced semiconductor assembly and test (OSAT) providers have been the leaders in developing and scaling up of advanced packaging technologies.

The OSAT business model as a contract package assembly test provider to their semiconductor customers has been based on the consignment of wafers. OSAT supply chains have focused on equipment, circuit carriers (leadframe, substrate, etc.), and materials requirements. The growth in SiP has been driven by smartphone applications over the past 15 years, which has required OSAT supply chains to develop sources for electronic components. However, OSATs procure a very small percent of electronic components (estimated at 1%).

In a difficult business environment for electronic components (due to escalating component prices and lead times), demanding a full turnkey business model could adversely impact a SiP's cost and time to market. Thus, SiP customers should team with OSAT suppliers in defining the optimum business model:

- *Consignment model:* Where the SiP customer procures and consigns the eBOM, which is managed by the OSAT provider.

• *Pass-through-pricing (PTP) model:* Where the SiP customer has contractual agreements for key components and establishes supply terms for pass through pricing for the OSAT to procure at the contractual terms. This is common when custom components are specified or customers have a limited source of components qualified.

• *Full turnkey model:* Where the SiP customer requires the OSAT provider to source and manage the eBOM.

• *Combination business model:* Where certain key components may be consigned or managed, as PTP and standard components need to be procured by the OSAT or contract manufacturer.

8. There are no new business models in the semiconductor industry.

With the record number and value of mergers and acquisitions in the semiconductor industry over the past three years,[6] industry analysts and trade editors have focused on the trends and consequences of strong market consolidation. Due to the high cost of entry into the slowing and highly competitive semiconductor industry, analysts speculate that the industry is nearly closed to new entries and new business models. There's speculation that the following business models will continue to dominate the industry going forward:

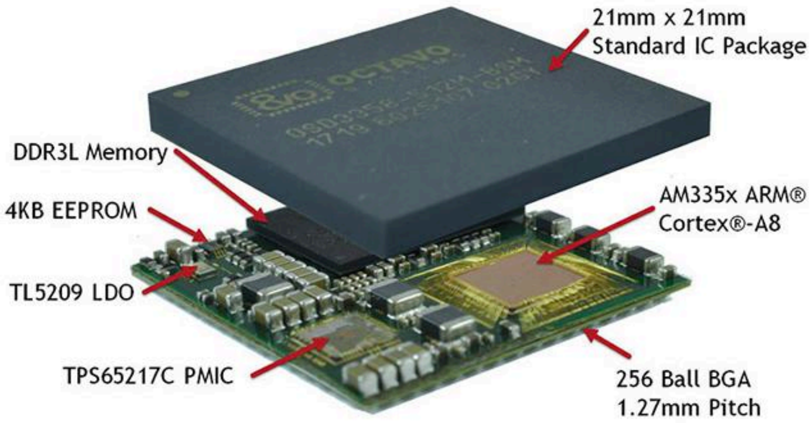
• *Integrated device manufacturers (IDMs):* Own and maintain semiconductor fabrication factories.

• *Fabless device suppliers:* Focus on design and IP, and rely on contract manufacturers to fabricate, assemble, and test their devices.

• *Foundry suppliers:* Provide contract semiconductor fabrication services to fabless and IDM suppliers.

However, SiP technology is enabling a new semiconductor industry business model to emerge—an electronic systems integration provider. An electronic systems integration provider relies on advanced substrate and microelectronic assembly technologies to design a system or subsystem solution by integrating various semiconductor devices, delivered in a SiP format. Octavo Systems is an example of this emerging business model.[7] The *figure* illustrates the semiconductors (bare and packaged ICs) used in Octavo's OSD335x-SM product delivered in a 21- × 21-mm, 256-ball BGA SiP solution.

The Octavo Systems website features information on the trends and solutions available through SiP as a systems integration platform. To understand the potential of this new business model, companies will need to explore the product innovations and new services emerging for Internet of Things (IoT) applications. New IoT applications are being developed across all industries, including banking, manufacturing, retail, healthcare, transportation, utilities, and government. The revenue



Shown are the semiconductors used in Octavo Systems' OSD335x-SM BGA SiP-based product.

potential for IoT-based products and services is forecasted to approach $270 billion by 2020.[8]

9. SiP is only used for miniaturization.

Miniaturization is a key advantage of SiP, but performance and system optimization are equally important in today's thrust for higher levels of integration. Many original equipment manufacturer (OEM) system suppliers have added engineers with strong microelectronic packaging experience to help them better define system architectures and new supply chains to expand their use of SiP and module solutions. These suppliers have support from electrical, thermal, and mechanical design/simulation teams who have the tools needed for system performance or reliability optimization. Semiconductor and OSAT suppliers have also expanded their engineering and design/simulation teams to apply a broader range of advanced packaging technologies to develop new SiP solutions.

In addition, semiconductor foundries and electronic manufacturing service (EMS) providers have added skills and capabilities to provide highly integrated solutions like SiP or modules. The use of SiP is quickly expanding in lower-performance applications like IoT connectivity and high-performance systems like 5G networks.

10. SiP is limited to a sole-source supply chain.

Multi-sourcing is a common requirement for high-volume applications. A wide range of OSATs have advanced package assembly capabilities and offer broad SiP services. If multi-sourcing is required for high volume or assurance of supply requirements, it's recommended to develop supply-chain strategies to address the following:

- Copy exact or copy equivalent requirements. Copy equivalent allows suppliers to apply their qualified material sets, as well as enable alternate sources for passive components.
- Multi-source qualification.
- Market-share agreements for sharing of volumes and maintaining capable sources of supply.
- Open sharing of design or manufacturing cost and quality improvements.
- End-of-life product management.

11. SiP is only economical for low-performance applications.

SiP solutions aren't limited to low-performance requirements and are in production across a diverse range of applications. Computing, gaming, communications, and networking require high performance for challenging electrical, thermal, and mechanical requirements with long product lives. Along with 3D SiP architectures, SiP solutions can enable miniaturization and semiconductor integration to enhance system performance by increasing bandwidth, lowering power, enabling increased functionality, and integrating mixed semiconductor process nodes—in smaller product footprints with increased time to market.[9] ed

LEE SMITH is Vice President of Advanced Packaging Products at UTAC. He has broad expertise in microelectronics and strong network within the electronics industry. As a thought leader in advanced and 3D packaging, Lee is recognized for driving the technology and market development for package on package (PoP). Lee also possesses a strong passion for growing business and helping customers succeed in bringing products to the market.

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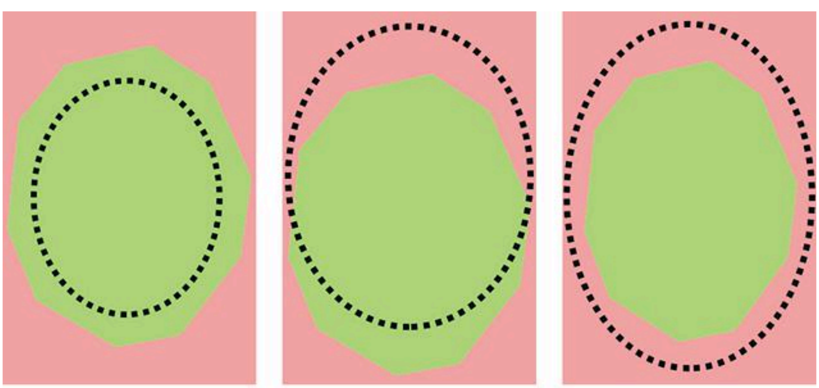
What's the Difference Between Sound and Unsound Static Analysis?

Timeliness and cost are two main factors for code verification, which separates sound from unsound. But recent advances are closing those gaps.



1. Shown are green and red areas that indicate correct programs and those that have a defect, respectively, when using sound and unsound tools.

Static analysis has established itself as a "must-have" for the verification of critical software. Notably, it can find problems that are hard to uncover by testing, such as concurrency issues and security vulnerabilities. Many static analyzers can now associate CWE entries (for Common Weakness Enumeration,[1] a well-known classification of security vulnerabilities) to their messages, to help users review all messages related to a given vulnerability. For example, CWE-120 is the classic buffer overflow.

But, in general, there's no guarantee that the code is immune from classic buffer overflows even after reviewing all messages associated with CWE-120. Indeed, most static analyzers are "unsound" in their verification; that is, unable to report all potential problems. This has led projects to use a combination of static analyzers to detect as many security vulnerabilities as possible. For example, Mozilla uses Clang Analyzer, clang-tidy, their own checkers, and Coverity on its C/C++ code.[2]

But this still doesn't provide any guarantee that a given vulnerability has been fully covered. Enter sound static analysis. Some static analyzers are "sound" in their verification and can guarantee that a given vulnerability isn't present in some piece of software. In practice, sound static analyzers output an exhaustive list of places where the vulnerability could occur, most of which are false alarms or "false positives" that need to be reviewed.

While more demanding for users, these static analyzers make it possible to achieve higher levels of confidence than is possible with their unsound counterparts, which makes them attractive in a security context. A recent workshop at NIST focused on "Sound Static Analysis for Security"[3] with presentations from providers and users of such tools showing the maturity of that field. In this article, we draw on that workshop's results and our experience building both sound and unsound static analyzers to explain why their difference matters—and when you should use which tool.

DEFINITION OF SOUND ANALYSIS

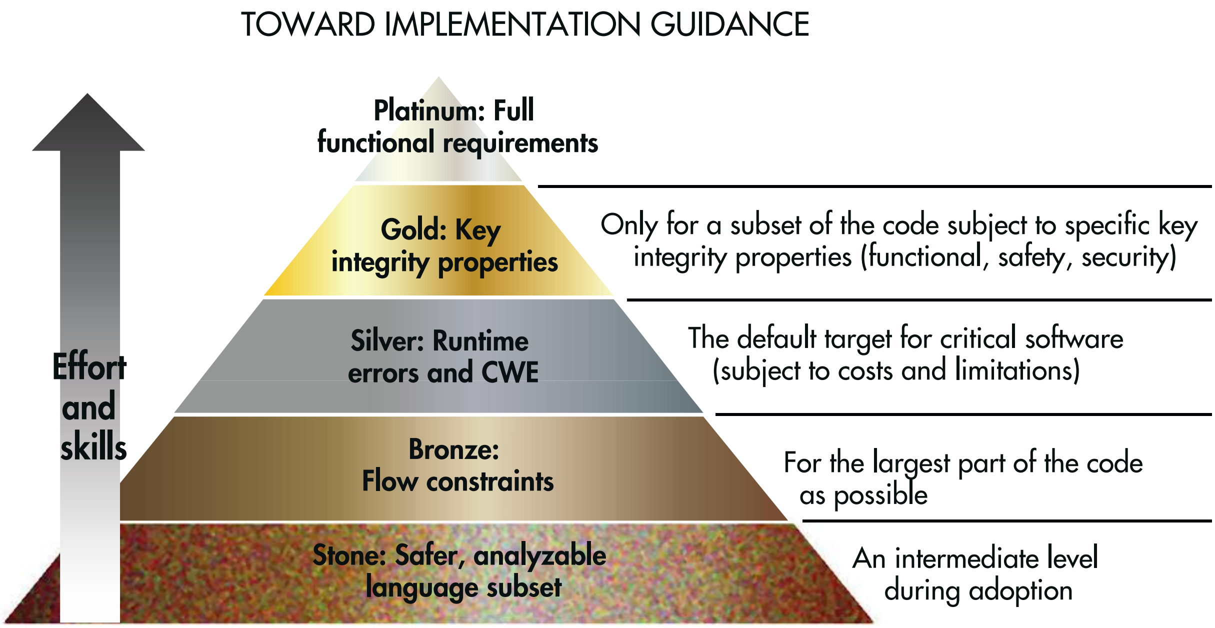
A sound analyzer is correct with respect to a class of defects it can detect in a safe and exhaustive way. It offers the guarantee that it will detect any such vulnerability occurring during run-time. This is in contrast with an unsound analyzer, which might not flag faulty code lines (in order to limit the number of warnings returned to the user).

In addition, a sound analyzer is guaranteed to be exhaustive, at the expense of possible false positives: warnings emitted on code for which no problem actually occurs at execution time. As explained by David Wheeler in his talk about verification of legacy software,[4] exhaustiveness is a large commitment, which can hardly be made by any other verification technique.

This difference between sound and unsound tools is shown in *Figure 1*. The green space represents the programs that are correct, the red part those that have a defect. In each illustration, a circle represents the answers provided by a tool, with the programs inside the circle being reported as correct and the programs outside the circle reported as potentially buggy.

Though sound tools will never report a buggy program to be correct, they may report potential errors on correct programs (false positives). Unsound tools will typically generate many fewer false positives, but will not detect some erroneous programs. Unsound tools are sometimes even complete (they report no false positives), making them very easy to use—every reported bug is a real problem and should be fixed. (In literature, the term "precision" is sometimes used to refer to a static-analysis tool's ability to avoid false positives. Thus, a complete tool is one that's absolutely precise.)

An example of a shortcut used by an unsound tool to produce fast, mostly noise-free outputs is to entirely ignore large or difficult-to-analyze functions. Likewise, calls to functions of external libraries may be skipped. To be fast, such analyses are sometimes flow- and path-insensitive, meaning that they don't



2. In the SPARK analyzer adoption process, benefits (and costs) increase as the project ascends to higher levels.

depend on exactly what the function did "before" the source code line that's being analyzed. As this usually results in poor precision, unsound tools will filter their outputs aggressively, using heuristics to determine which messages are likeliest to be correct.

In contrast, a sound tool is usually more accurate, albeit slower and less selective (higher rate of false positives). Still, even though they aim at detecting all occurrences of some kind of defect, the guarantees offered by a sound analyzer are subject to certain assumptions.

First, most analyzers work on the source code, as opposed to, say, the final executable. Discrepancies may be introduced by gaps between the logic semantics used for the verification and the actual execution of the program on the platform (because of bugs in a tool used in the compilation process for example). Second, a sound analyzer might not properly support certain language constructs which are too complicated, resorting to approximations to handle them.

Finally, to keep the analysis tractable and to increase the precision of the tool, a sound tool may choose to treat in an unsound way some particular language features. For example, it might assume that calls to completely unknown functions don't modify variables, or it might ignore attempts to manipulate the stack through setjmp/longjmp, etc.

In contrast with unsound tools, a sound tool usually reports the assumptions it makes, so that they can be verified by others means. As explained by Roderick Chapman, this is part of the soundness case of a sound static-analysis tool, and helps to build trust in the tool.[5] The need for such a gap with "full" or "ideal" soundness has been recognized by the research community in the soundiness manifesto.[6]

Please note an important point of terminology. *Sound* is sometimes used also for unsound tools! In that context, it usually means that all findings are real bugs, i.e., that no false positives are ever emitted. This is what we called *complete* above. Hence, care must be taken when reading that a tool is sound. In this article, we always use "sound" in the sense of "no false negatives"; in other words, all possible bugs are reported.

COSTS AND BENEFITS OF SOUND AND UNSOUND ANALYSIS

Sound and unsound analyzers bring different benefits for different costs. The first benefit of a sound analyzer is that it guarantees absence of a certain class of defects—notwithstanding a set of assumptions more or less easily reviewable. In addition, while unsound analyzers generally aim at detecting bugs, sound analyzers can be used to verify that the software has some "good" properties in a larger sense. These good properties naturally include absence of certain defects, but aren't limited to that. Some examples of good properties targeted by sound analyzers include:

- *Correct data flows:* Each function only accesses the data it's allowed to access, and its output values only depend on the input values from which they're allowed to depend. This is particularly interesting for security applications, to ensure that secrets don't leak.
- *Absence of some class of defects:* Initialization errors, run-time errors, concurrency errors.

Unsound static analyzers allow developers to quickly find defects in a large code base. Sound static analyzers guarantee finding all defects of a given kind, albeit with additional effort.

- *Verification of key safety or security properties:* Preservation of safety invariants, unreachability of bad states, etc.
- *Functional correctness:* The program conforms to its high-level specification. In these last two cases, required properties should be manually expressed by the user in a dedicated formal language.

The major benefit of unsound analysis, on the other hand, is its cost. Since they require little or no annotations, and will focus on limiting the number of false alarms they generate, unsound analyzers are generally easy to apply. In fact, they may produce quick gains even when applied blindly on large existing code bases. Conversely, sound analyses often take more effort to apply. Depending on the technique used, they may require code changes, user-supplied annotations, or reviews of numerous false alarms.

To alleviate this cost, a project can take a step-by-step approach to the adoption of sound tools, achieving increased benefits with each step. A scale of confidence levels for the TrustInSoft Analyzer was presented by Benjamin Monate.[7] An example of this approach is the adoption process for the SPARK analyzer, which was accomplished as a joint effort between AdaCore and Thales.[8] It defines five levels of assurance, offering increasing benefits (and costs) as a project ascends to higher levels *(Fig. 2)*.

Each level builds on the previous ones—the higher levels require more work to achieve, but also provide more gain. To reach the bronze level, no user-provided annotation is needed, even though some work is already required to identify parts of the code that should be analyzed, possibly rewriting them to comply with tool-imposed restrictions. Reaching this level already ensures total absence of some defects, like uninitialized data, aliasing of parameters, or data race conditions.

The platinum level, at the other end of the spectrum, requires writing the full functional requirements as specification in the code, as well as providing intermediate specifications and possibly other annotations when required by the tool. But code verified at this level is guaranteed to be free from most runtime errors, and to conform with its supplied specification.

As discussed by Stuart Matthews, the level to aim for on a specific project is a difficult question.[9] It may depend on the level of integrity required by the project, on the high-level objectives discharged by the analysis tool, as well as on the kind of code and properties that are envisioned. Different levels may even be targeted on different parts of the same software; for example, depending on their relative criticality or the features that they use (such as floating point numbers, nonlinear arithmetic computations etc.).

CONCLUSION

Unsound static analyzers allow developers to quickly find defects in a large code base. Sound static analyzers guarantee finding all defects of a given kind, albeit with additional effort. As emphasized by Paul Black in his introduction to the workshop,[10] there are different static-analysis techniques for different use cases, which all have their strengths and weaknesses. They complement each other well, and the appropriate technique(s) should be chosen depending on the use case.

Thanks to its ease of deployment, unsound static analysis has become a standard tool in serious software development. It's used in most large software companies, and advised by best practices. Due to its higher cost, sound static analysis has long been the domain of experts. However, with the recent progress in verification techniques, sound static analysis is used in more and more projects, and is becoming part of the standard development process when strong safety or security requirements are needed. In the years to come, sound static analysis may become a standard tool for critical software development. ed

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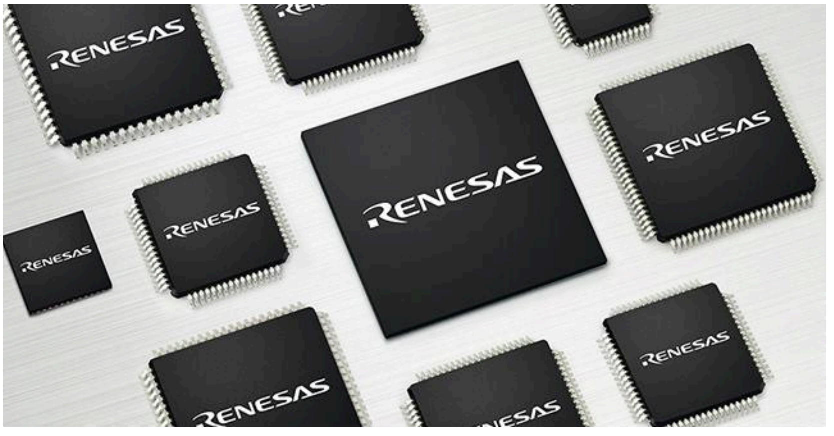
News *(Continued from page 10)*

The acquisition is the latest bet that the autonomous car of the future will resemble the inside of a data center. It combines two companies in different businesses: Renesas is the second largest maker of microcontrollers used to control systems ranging from windshield wipers to collision avoidance in cars, while IDT targets data centers and wireless communications. The deal is expected to close in the first half of 2019.

IDT's technology includes timing integrated circuits that act as the time keepers inside electronic devices, which could have increased importance to enforce the lower latency required for automatic collision avoidance and other functions. The company's RapidIO and PCI Express interconnects are used to move information inside servers and could be repurposed to connect cameras, radar and other sensors to support high-reliability sensor fusion.

"Renesas acquired IDT to broaden its reach in analog and wireless," said Kevin Mak, an automotive analyst with Strategy Analytics. "IDT's position sensors and signal conditioning devices would be complimentary to Renesas and so there should be some immediate expansion of its automotive portfolio. There may also be significant IP from other areas that will become more important to automotive, such as IDT's clocks and timers."



Renesas, which reported profits of $1.2 billion and revenue of around $6.95 billion in 2017, has bought its way into new businesses before. Last year, the second largest supplier of automotive chips bought Intersil for $3.2 billion to move into analog semiconductors and other chips increasingly required to manage battery levels in electric and hybrid vehicles. The chips can also be used to boost the efficiency of industrial controls systems and robotics. ■

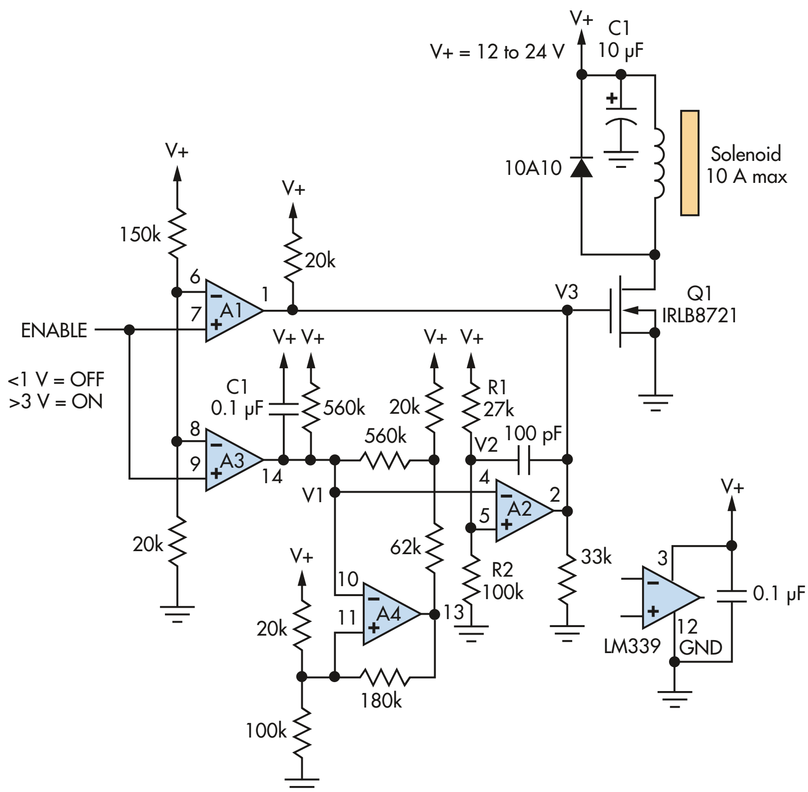
Enhanced Circuit Yields Versatile, Efficient Switch-Mode Solenoid/ Relay Driver

W. STEPHEN WOODWARD | Technical Consultant

SEVERAL YEARS AGO, Paul Rako, in collaboration with the late, great Bob Pease, wrote a terrific article about the finer theoretical and practical points of electromagnetic solenoid-driver circuits.[1] It noted that most solenoids need less power to sustain actuation after the plunger is pulled in than is needed to actuate them in the first place. Important power saving and heat reduction without loss of mechanical performance are therefore possible if drive voltage starts out high for pull-in, then backs off to a lower value for hold.

Bob's method for power reduction (see the first figure of Paul's discussion) was elegantly simple, consisting merely of a resistor and capacitor connected in parallel with each other and in series with the solenoid coil. Transient pull-in power is supplied by the capacitor, while steady-state hold current flows through the resistor, chosen to be 60% to 70% of the resistance of the coil. Hold current is therefore reduced by ~40% and coil heat production is cut by more than 60%. That's a pretty impressive reduction in solenoid-coil power dissipation. However, that series resistor consumed power, too: 70% as much as the solenoid.

The circuit presented here *(Fig. 1)* takes the same power-reduction principle to the next logical level by eliminating the series voltage-dropping resistor and replacing it with efficient switch-mode. (Note that the design applies to driving relay coils and contactors.)



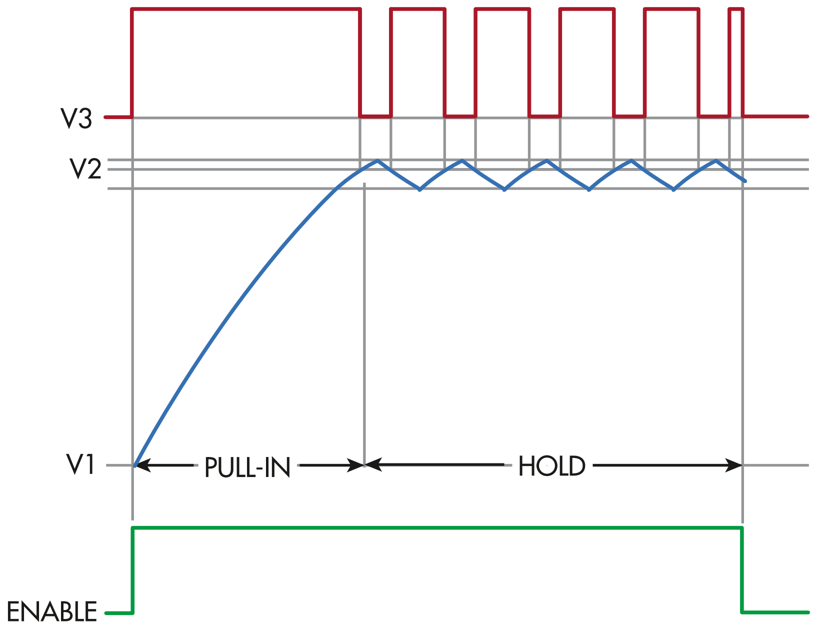
1. This switch-mode solenoid-drive circuit maximizes hold-mode power savings by using comparators to efficiently manage drive waveforms.

Driver topology is organized around the four analog comparators that comprise an old "friend," the LM339 quad IC (A1 through A4) that combine to control a power FET (Q1) in response to the logic-level ENABLE input. Solenoid actuation begins when ENABLE activates A1, turning on Q1 and A2, starting the drive cycle *(Fig. 2)*.

The V1 timing ramp generated by A3 rises at a rate determined by C1 (pull-in time $T_{pull\text{-}in} = 5 \times 10^5 \times C1 = 50$ ms for C1 = 0.1 µF) and the associated resistor network, generating the initial full-voltage (V+) PULL-IN pulse V3 at Q1's gate. This continues until V1 arrives at the V2 threshold of drive modulator A2 (set by R1 and R2), initiating reduced-power

HOLD mode. Modulation of V3 and Q1 conduction is driven by the A4 oscillator, which starts up when V1 rises to A4's threshold, and imposing a triangular ripple in V1. This cyclically switches A2, thereby establishing a ~70% duty factor on Q1's conduction. Subsequently, it reproduces the hold-mode solenoid power-dissipation savings described in the Pease/Rako article, while avoiding the inefficiency of a voltage-dropping resistor.

The versatility of the resulting driver is enhanced by its ability to accept a power source from 12 to 24 V, and to accommodate solenoid current demand up to 10 A (i.e., up to 240 W), so that this single circuit can serve in a wide variety of solenoid-drive applications. Hold-mode power consumption is reduced by 60%, and overall efficiency easily exceeds 90%. Reset of the C1 timing capacitor takes less than a millisecond.



2. The drive-sequence timing controls the solenoid pull-in and subsequent hold operation to conserve power.

STEVE WOODWARD has authored over 50 analog-centric circuit designs. A self-proclaimed "certified, card-carrying analog dinosaur," he is a freelance consultant on instrumentation, sensors, and metrology freelance to organizations such as Agilent Technologies, the Jet Propulsion Laboratory, the Woods Hole Oceanographic Institute, Catalyst Semiconductor, Oak Crest Science Institute, and several international universities. With seven patents to his credit, he has written more than 200 professional articles, and has also served as a member of technical staff at the University of North Carolina.

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Ad Index

JOEL WOODWARD | Strategic Oscilloscope Planner at Rohde & Schwarz in Munich

7 TIPS for Better Power-Integrity Measurements

Today's ASICs, FGPAs, and off-the-shelf ICs have increasingly stringent power requirements. These requirements result in the need to test power rails with decreasing voltages and tighter tolerances.

For power-integrity tests, users rely on oscilloscopes. However, with more precise requirements, measurement errors that approach the required measurement value are problematic. Every millivolt of measurement error is critical; for example, when measuring a 1.5-V power rail with 2% tolerance. In addition, high-speed digital signals and other sources can couple onto power rails, requiring gigahertz of bandwidth to identify. Below are seven tips on how to quickly and accurately characterize rail noise and identify coupled signals.

1. Start with a low-noise oscilloscope.

Measurements will never be better than the noise of the measurement system. Every oscilloscope contributes internal broadband noise to measurements. Choosing a scope that has lower noise ensures a better measurement *(Fig. 1)*. For example, if you're trying to measure a 1.8-V rail with 2 % tolerance, having 10 mV of scope and probe noise is problematic, since this will be additive to the signal you're measuring.

Oscilloscope manufacturers characterize and publish ac rms noise at each vertical attenuation setting, and this generally is a good first step in choosing a low-noise scope. For power integrity, though, the worst-case peak-to-peak voltage matters. It's easy to check this value with the scope you're using. With no inputs connected, measure the peak-to-peak amplitude at the vertical setting you will be using.

Many newer scopes offer 10- and 12-bit vertical resolution. However, the additional resolution is almost always

1. **Low-noise, high-bandwidth scopes like the 8-GHz R&S RTP enable fast and accurate characterization of dc rails. Specialized probes designed specifically for power-rail measurements, such as the 4-GHz R&S RT-ZPR40 power-rail probe, have a number of attributes to produce high-accuracy measurements.** *(Source: Rohde & Schwarz)*

obscured by noise unless averaging or high-resolution mode is used. For oscilloscopes on the market today, front-end noise hasn't caught up with advances in vertical resolution. Noise is a better indication of measurement accuracy than bits of resolution.

2. Use the 50-Ω path.

Many oscilloscopes offer 50-Ω and 1-MΩ paths. The 50-Ω path generally has lower noise. In addition, if using an active probe for power-integrity measurements, the probe will use the 50-Ω path. Measuring peak-to-peak noise of the oscilloscope with the probe you're using on the 50-Ω path will indicate how much measurement error you will have.

3. Use the most sensitive vertical setting possible.

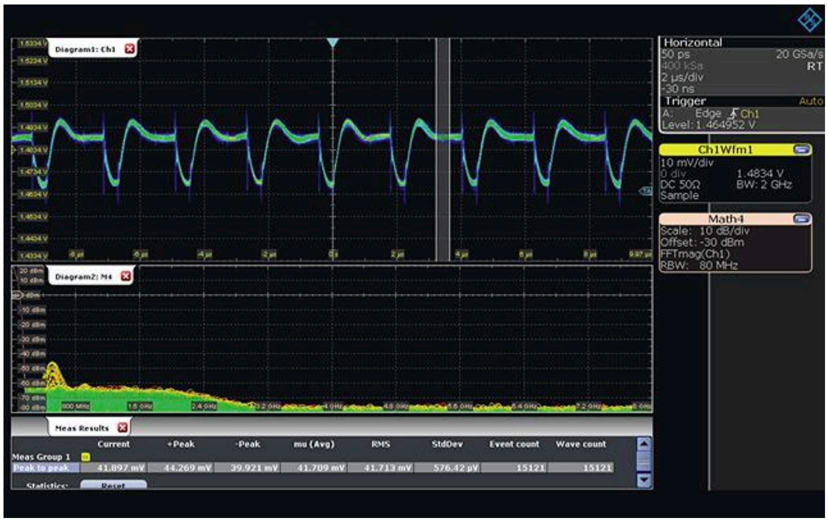
Oscilloscope noise is a function of vertical attenuation settings. Smaller settings have less noise than larger settings. Most oscilloscopes don't have sufficient offset to use large vertical gain. For example, at 10 mV per division, the oscilloscope may only offer 120 mV of internal offset. This forces users to choose a lower vertical setting to get the signal on the display, and therefore will result in a less accurate measurement.

There are other ways to compensate for limited internal offset. A blocking capacitor removes dc offset, which solves the problem of insufficient offset. But, it eliminates the ability to see low-frequency drift that can occur when subsystems turn on and off. The ac coupling on scopes also provides dc blocking. However, ac coupling has the same limitation of eliminating the ability to see low-frequency drift, and for many scopes is limited to the 1-MΩ path.

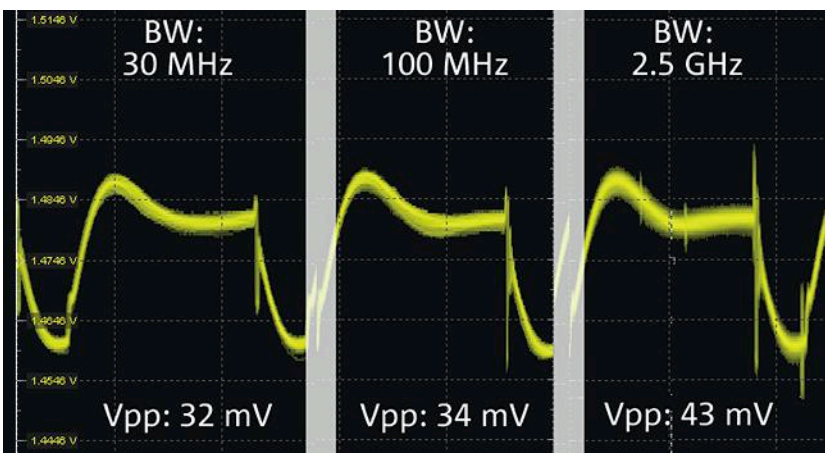
4. Use a high-bandwidth scope and limit the bandwidth to reduce measurement noise.

Higher-bandwidth scopes are becoming increasingly useful, since they allow teams to see coupled signals such as high-speed clocks riding on the power rail. Because scope and probe noise has linear noise density over broadband frequencies, using maximum bandwidth will result in over-reporting power-rail noise values.

In the absence of high-frequency coupled signals, limit oscilloscope bandwidth to reduce broadband noise. This technique significantly increases measurement accuracy. A common question is "How much should you reduce measurement bandwidth?"



2. Using an FFT and a high-bandwidth solution, such as the RTP oscilloscope and RT-ZPR40 power-rail probe, enables teams to quickly determine both coupled sources and the degree to which they can limit bandwidth while retaining signal content. *(Source: Rohde & Schwarz)*



3. Peak-to-peak voltage measurements using an RTP oscilloscope and RT-ZPR40 power-rail probe show the impact of bandwidth-limiting at three different values. The 2.5-GHz bandwidth setting visually shows coupled signals that are attenuated and ultimately missed with lower-bandwidth limit settings. *(Source: Rohde & Schwarz)*

Power integrity continues to grow in significance as FPGAs, ASICs, and standard device rails become smaller and tolerances become tighter. Choosing the right measurement tools enables fast and accurate characterization of each rail.

Experienced users often view the fast Fourier transform (FFT) to determine how much bandwidth reduction is possible while still capturing periodic and random disturbances on the power rail *(Fig. 2)*. When viewing the FFT, bandwidth can be reduced to the point where no higher-frequency tones are present. Another method is simply to look at the signal. If the signal shape changes at all when you reduce bandwidth, you've reduced the bandwidth too much *(Fig. 3)*.

5. Use a power-rail probe.

Most oscilloscope manufacturers offer specialized probes crafted for power-rail measurements. They include a number of capabilities not found in other probes. Large built-in offset compensates for lack of built-in oscilloscope offset. This enables users to choose the lowest vertical attenuation setting for reduced noise. Power-rail probes typically have 1:1 attenuation ratios, meaning they will produce significantly less noise than probes with 10:1 attenuation ratio. Power-rail probes have high dc impedance, typically 50 kΩ, which is significant, since rail impedances are typically in the milliohm range.

Power-rail probes come with a variety of connection methods, including a 50-Ω pigtail coax for the highest-quality measurements, as well as a probe browser where flexibility is paramount. Use of an SMA pigtail connector requires some forethought, since they work best when designed in. Browsers are more flexible, but don't have the accuracy of SMA pigtails.

Power-rail probes should have sufficient bandwidth to capture coupled signals. Users can achieve a low-noise probe with a passive probe that has 1:1 attenuation ratio. However, the probes have bandwidth limits of less than 40 MHz. While this approach is good, since it uses the higher-impedance 1-MΩ path, bandwidth-limiting inherent to the probe eliminates critical signal content and will under-report peak-to-peak voltage measurements. Some manufacturers specify guaranteed power-rail probe bandwidth, while others provide the typical value. For example, the R&S RT-ZPR40 power-rail probe has a typical 3-dB rolloff of 4 GHz.

Check with your oscilloscope vendor to determine which scope models are supported with their power-integrity probes. For some companies, the probes will work across all models that have a probe interface, while for other companies, the probe may only work on a subset of models. Worse, insertion of the probe in unsupported models may run the risk of damaging the scope's inputs.

6. Use high dc impedance.

Getting accurate dc values requires low measurement loading. If you connect the scope's 50-Ω path directly to a power rail, the 50-Ω loading will change the dc level of the rail. To mitigate this effect, higher measurement impedance is required. The 1-MΩ oscilloscope path has a sufficiently high impedance level at dc, but unfortunately there's more noise and it isn't the path supported with power-rail probes. Power-rail probes typically have dc impedance of 50 kΩ, greater than a million times more impedance than the rail itself. This means that the dc rail voltage will be only very minimally impacted during measurement.

7. Choose a scope with fast update rate.

Even the fastest digital oscilloscopes are blind more than 90% of the time. Between each acquisition, the scope must process the waveform before acquiring the next waveform. Infrequent events—in the case of power rails, this means potential worst-case peak-to-peak voltages—can be missed. To compensate, users turn on infinite persistence, automated measurements, and wait until the highest amplitudes are found.

How long should a user wait? It depends on the target system. Scopes with a fast update rate will show the overall noise envelope faster, and users will see a better graphical view of the dc rail signal behavior. For an oscilloscope that updates 1000 waveforms per second with automated measurements, users will achieve measurement results 20 times faster than an oscilloscope that updates 50 waveforms per second with automated measurements enabled.

Instead of waiting for measurement values to converge over 20 minutes with the slower scope, a user of the faster scope can accomplish the same task in just one minute. Since systems incorporate an ever-larger number of power rails, each of which requires verification, the scope update rate is becoming more and more important.

Power integrity continues to grow in significance as FPGAs, ASICs, and standard device rails become smaller and tolerances become tighter. Choosing the right measurement tools enables fast and accurate characterization of each rail. ed

WILLIAM WONG | Senior Technology Editor
bill.wong@informa.com

Going Mobile in the Lab

Technology Editor Bill Wong takes a look at AT&T's IoT Starter Kit and Gumstix AeroCore 2 for NVIDIA Jetson.

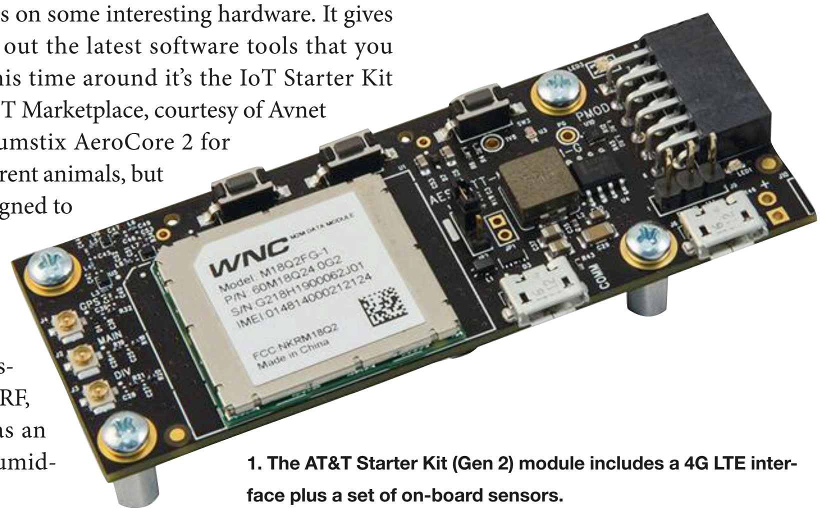
Occasionally I get my hands on some interesting hardware. It gives me the chance to check out the latest software tools that you use most of the time. This time around it's the IoT Starter Kit *(Fig. 1)* from the AT&T IoT Marketplace, courtesy of Avnet and STMicroelectronics, as well as the Gumstix AeroCore 2 for NVIDIA Jetson *(Fig. 2)*. These are very different animals, but do have one thing in common: They're designed to get you started quickly.

I actually started work on the earlier version of the AT&T IoT Starter Kit, which is a two-board set including an Arduino-compatible 4G LTE shield and STM32L4 Discovery IoT node with BLE, NFC, sub-GHz RF, and 802.11b/g/n WiFi support. It also has an array of sensors including temperature, humidity, 3-axis accelerometer, 3-axis magnetometer, 3-axis gyro, a time-of-flight and gesture sensor, and microphone. It incorporates a Pmod connector and runs Arm mbed.

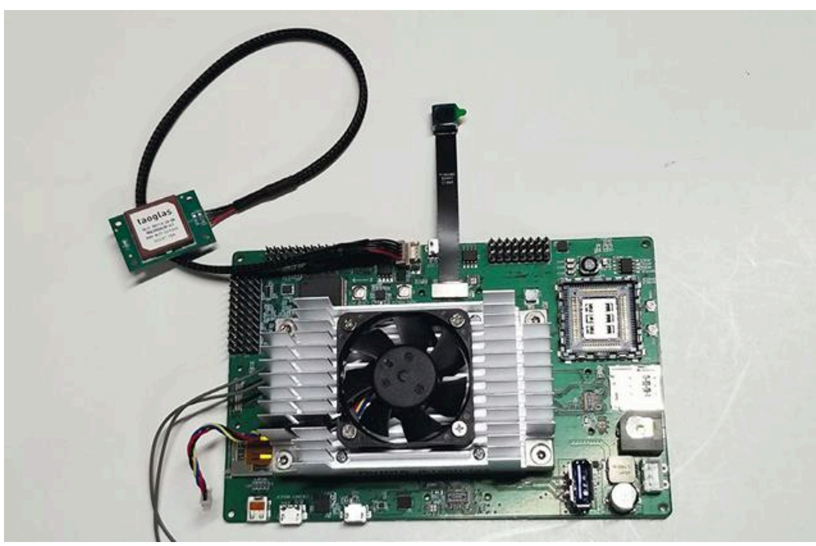
The Gen 2 version is a single module with a quad core Cortex-A7 running embedded Linux. It has GPS on-board plus a Pmod connector for attaching additional sensors. The module features a connector on the bottom, allowing it to plug into a carrier board.

Both come bundled with a six-month IoT data plan that can be extended. Setting up the accounts takes longer than getting the software up and running. They hook into AT&T's cloud services that feature a range of management tools and analytic services.

The platforms are supported by AT&T's M2X Data Service and Flow



1. The AT&T Starter Kit (Gen 2) module includes a 4G LTE interface plus a set of on-board sensors.



2. I attached the GPS module and a 4K video camera to the Gumstix AeroCore 2 for the NVIDIA Jetson, which is also host to my Jetson TX2 module.

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(1) Outside County Paid/Requested Mail Subscriptions stated on PS Form 3541. (Include direct written request from recipient, telemarketing and Internet requests from recipient, paid subscriptions including nominal rate subscriptions, employer requests, advertiser's proof copies, and exchange copies.)	40,605	41,290
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g. Copies not Distributed	572	574
h. Total (Sum of 15f and g)	43,199	43,949
i. Percent Paid and/or Requested Circulation (15c divided by 15f times 100)	99.24%	99.54%
16 Electronic Copy Circulation		
a. Requested and Paid Electronic Copies	-	-
b. Total Requested and Paid Print Copies (Line 15c)+ Requested/Paid Electronic Copies (Line 16a)	42,305	43,175
c. Total Requested Copy Distribution Distribution(Line 15f) + Requested/Paid Electronic Copies (Line 16a)	42,627	43,375
d. Percent Paid an/dor Requested Circulaltion (Both Print & Electronic Copies) (16b diveded by 16c x 100)	99.24%	99.54%

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17. Publication of Statement of Ownership for a Requester Publication is required and will be printed in the: September/October 2018 issue of this publication.

18 Debbie Brady, Manager, User Marketing — Date 9/5/18

I certify that all information furnished on this form is true and complete. I understand that anyone who furnishes false or misleading information on this form or who omits material or information requested on the form may be subject to criminal sanctions (including fines and imprisonment) and/or civil sanctions (including civil penalties).

PS Form 3526-R, July 2014

Designer. They are a great way to get started with an LTE-based IoT solution.

The Gumstix carrier board is designed for drones and robots but it can be used for other applications where bringing the compute power of the Jetson TX1 or TX2 to bear can be invaluable. The nice thing about the Jetson is that the applications that ran on the development board work well with the Gumstix platform. The major change is the peripheral complement. The Jetson module only has some built-in peripherals like the wireless support. The carrier board also has a socket for an LTE radio along with a SIM card socket.

The Gumstix board supports up to four cameras. I have that many, but started with just one that matches my Jetson TX2 development board. Getting applications to work was simply a matter of configuring the drivers. The NVIDIA module has its own storage in addition to a multicore ARM-compatible processor and an NVIDIA GPU.

I did not exercise all of the features of the Gumstix board yet, but I did plug in the GPS module. Having it on a cable allows the antenna to be positioned away from the processing module. I left the fan on because I still occasionally use the module on the development board. I didn't use it with the Gumstix board, although it runs a little slower to keep cool. I plan on utilizing it with the iRobot Create 2 vacuum turned robot.

The challenge is board placement, since the camera placement can be an issue and my board mounting is for a Raspberry Pi. The Gumstix board would fit into the carrier, although it would rattle around.

One thing I have yet to do is exercise STMicroelectronics' STM32F427 on the Gumstix board. This controls the servo headers and some peripherals. It includes the open-source, PX4 flight controller autopilot software. This comes in handy for aircraft, but can also be used for other robots. I'm hoping the techs at Gumstix get it working with the Create 2 before I need it. ed