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Vol. 59 No. 10

Powering Military Vehicles for Modern-Day Warfare

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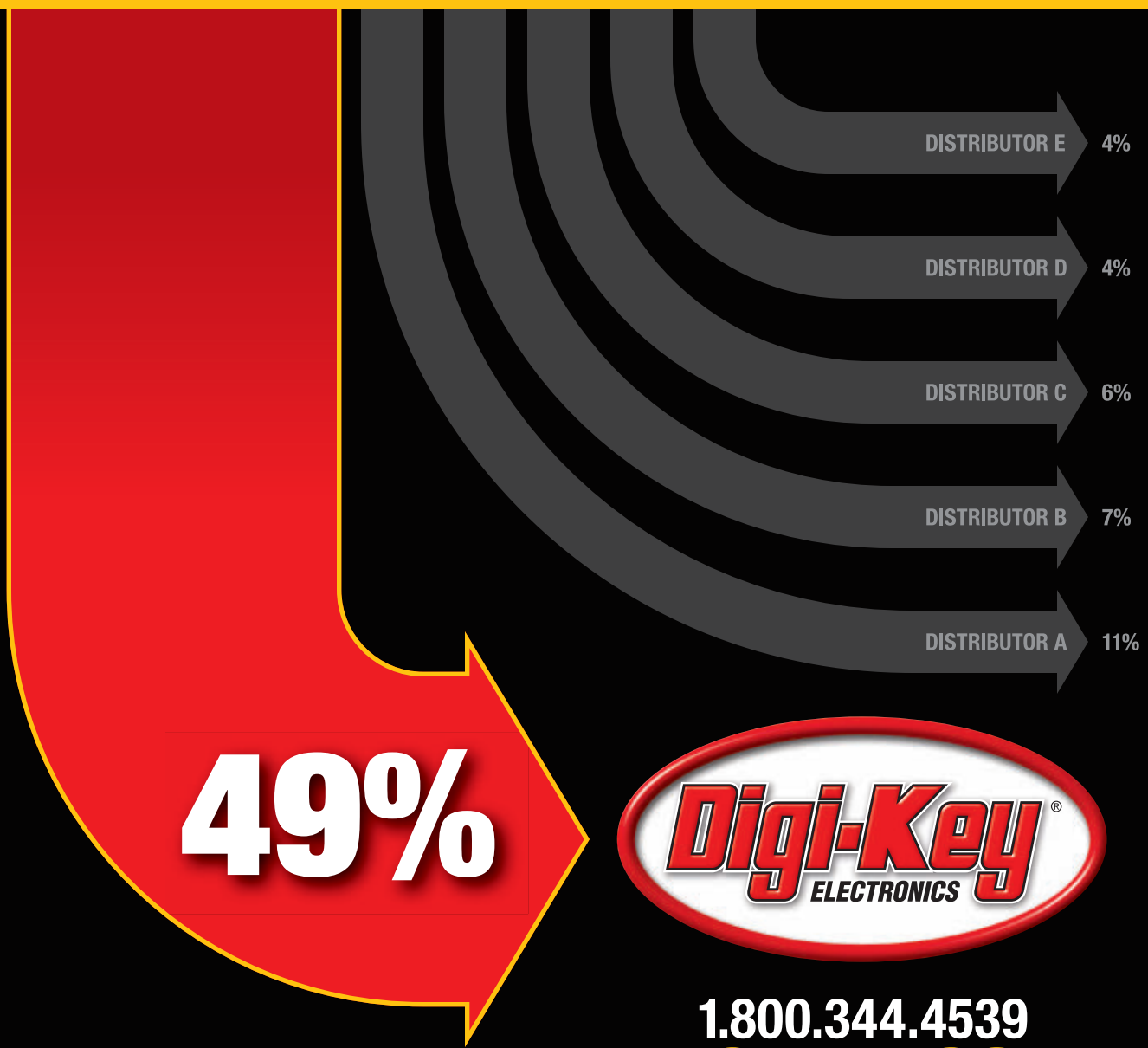

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The New Boogeyman

I'm going to make a request to the general public and readers of this magazine; we really need to relax about hacking.

I'm not saying hacking isn't a serious threat or that it's something that doesn't happen, but people throw around the word hacking so much it's simultaneously lost all meaning and become the boogeyman of the electronics world. I'd be willing to bet even Chicken "The Sky Is Falling" Little would be willing to tell everyone to just chill out for a minute.

Hacking is a thing that happens. We've seen instances of major websites falling prey as well as celebrity cellphone voicemail inboxes, credit card information, government databases, and a bunch of other examples. These are bad. These are why we need better security for our data.

But let's also be real.

Yes, it is possible for someone to hack your wireless pacemaker. Yes, it is possible for someone to hack your car. Yes, it is possible for someone to hack your smart home.

Yes, it is possible you could win the lottery. Yes, it is possible you will be trampled to death by a cow. (Fun fact: This is actually more likely to happen to you than for you to be killed by a shark.)

All of these things are possible, but they are not probable. It is not incredibly challenging to hack a cellphone or baby monitor, but to attempt to hack a car requires a high level of skill, patience, luck, and information not widely available to the public.

This is not to say that we should all kickback and enjoy our smart refrigerators without worry. Finding a way to secure the Internet of Things is an ongoing industry conundrum, but we're using the word hacking so freely and openly, it's overshadowing the opportunities we have to create an industry standard for security.

Yes, hacking is a serious problem, but by applying the term to everything we risk missing the really important things.

Until Next Time,

Kasey Panetta

Kasey Panetta
Editor
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New Scale Technologies announced a new developer's kit in its M3 micro-mechatronic product line. The DK-M3-RS-U-1M-20 is a complete piezoelectric mirror positioning system with a familiar galvo-scanner form factor, but a drastically smaller size: only 12 mm diameter including the embedded closed-loop controller.

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Engineering Update #126: A New Record for Electric Cars

- **Fighting Air Pollution With Artificial Intelligence**
  Beijing is surrounded by factories, many fueled by coal, that emit harmful particulates. But pollution levels can vary depending on factors such as industrial activity, traffic congestion, and weather conditions. Now engineers are bringing the battle to the lab.
- **How to Go Solar Without Panels**
  Solar power seems to be the next big thing in the U.S, but there are still limitations. Not everyone can go solar, especially if you're a renter or if you don't have the proper rooftop. But what if there was a way to "borrow" someone's rooftop? Well, thanks to Yeloha, a peer-to-peer solar startup, now you can, even if you're not a home owner or if your roofs blocked by a shady tree.
- **A New Record For Electric Cars**
  Tesla has just upped the bar with an announcement that they have a Tesla Model S,/ which has driven 453.8 miles on just one charge. It's a new world record, but it doesn't mean too much for the average Tesla driver.

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Is Drone Fishing the Next Big Thing?

By Jamie Wisniewski, Associate Editor, @JamieECNmag

People like to do crazy stuff with drones. Just take this guy, who catches a fish with his DJI Phantom 2.

In what's apparently his first try (though I'm guessing he practiced a little beforehand), the fisherman snags a fish straight out of the lake almost effortlessly and flies the drone back to shore.

50 percent

Percentage of auto recalls due to software bugs

Would This Aircraft (Designed by a Drunk Student) Actually Fly?

By Kasey Panetta, Editor, @kcpanetta

As it turns out, college kids aren't just using college as an excuse to get drunk and party, they're using it as an excuse to get drunk, party, and then come home and design an entire aircraft.

Or at least that's what one Michigan Tech student is doing.

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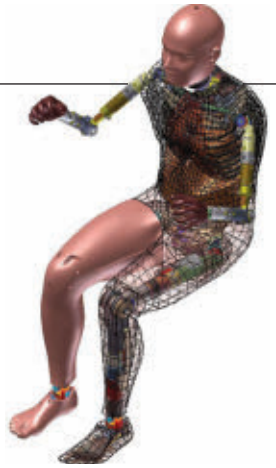
The Peculiar World of Military Blast Dummies



The unique test world of Anthropomorphic test devices.

By Kasey Panetta, Editor

Humvees in the hills. Tanks in the desert. Army trucks in a convoy. These vehicles are tasked with some of the most challenging and dangerous environments. They must be able to keep occupants safe against various attacks, including blasts from underneath the carriage.

Optimizing occupant safety in a Humvee or tank when encountering unexpected explosives—or bumps—in the road is one of the most important considerations, particularly when making vehicles bound for war zones.

That means before the vehicles are sent to do battle, they have to be battle-tested.

Creating the technology that improves vehicle safety is the job of engineers. They collect data from crashes and improve on systems—or create entirely new technology—to increase the chance that the occupants will walk away from a crash. But while they're crunching numbers and working at benches, someone—or something—is busy doing the dangerous work.

Enter the crash test dummy.

More specifically, the military blast test dummies, which are also called anthropomorphic test devices (ATDs). These high-tech dummies vary from traditional automotive dummies because they're designed to do different things. An automotive dummy is designed to measure either frontal or side impacts, since that is where the impact would be coming from in a regular car accident. A military-dummy is designed to measure—in addition to side and frontal impacts—the impact coming from underneath the vehicle during a blast event.

Where did military crash dummies come from? Current soldiers can thank their friend Sierra Sam, the original military crash-test dummy, for starting the trend of using human-shaped objects for testing. Sierra Sam, created by Alderson Research Labs and Sierra Engineering in 1949, was designed for the purpose of testing aircraft ejection seats. Traditionally, engineers used animal carcasses or other distinctly non-human objects to test safety.

However, in the pursuit of finding an even better human analog, the U.S. Army is designing ATDs more suited to their purposes, instead of using dummies designed for more traditional automotive purposes.

The WIAMan Project

The Warrior Injury Assessment Manikin (WIAMan), under the U.S. Army Research Development and Engineering Command, is a project with the express purpose of creating a Warrior-representative test dummy that would contain biomedically-validated injury assessment tools. The data from these dummies will allow the Army to design safer vehicles and better outfit soldiers.

This is important for four reasons, according to the WIAMan project. The new blast dummy will offer the ability to accurately measure accelerative loads caused by Under Body Blast testing, increased knowledge of Warrior

vulnerability in Under Body Blast testing, State of the art criteria, methodologies and metrics used to assess injuries from accelerative loading sustained during Under Body Blast testing, and [increased] potential for enhanced vehicle and soldier survivability.

Given that the Army is looking for vehicles to offer different types and increased amounts of safety than regular cars, WIAMan is taking data from injuries in Iraq and Afghanistan to create the new instrumented test dummy.

Testing for a Blast

Diversified Technical Systems (DTS), the prime contractor on the WIAMan project is engineering a complete new test solution including the dummy and the sensors and data recorders that will be inside the dummy. These devices allow researchers to collect that data from the accelerometers and load cells and use it to improve the vehicle safety.

DTS has a history of working within the unique world of the military. The company also works on vehicle black boxes that capture blast events, as well as internally mounted helmet sensors that capture impact data to assess soldier's injuries.

A key part of the dummy will be the sensors and data recorders, says Steve Pruitt, co-founder and President of DTS, which are "primarily accelerometers and load cells, greater than 100 channels per dummy"—similar to what is contained in an automotive dummy.

All the data is sampled from each sensor simultaneously at high rates and stored locally in flash memory, Pruitt says. The data acquisition system that will be inside WIAMan is based on DTS's innovative SLICE NANO, but is even more compact

But, as expected, designing for military environments is a difficult task. The harsh environment means shock, EMI, and cables that are cut are all frequent problems. Even cable management is an issue, considering a typical dummy may have as many as 100 channels.

To deal with that, DTS places their data recorders inside the dummy, since large cable bundles attached outside a dummy can impact positioning, free flight test dynamics, and even more logistical issues like the amount of time it takes to set up a test.

The Nerve-Wracking Test

There is no room for error even in the testing phase.

"Each test only lasts milliseconds and can cost millions, so loss of data is not an option," says Pruitt. It can take weeks to prep the dummies, vehicles and make sure all the sensors, cameras, and data acquisition systems are ready to go.

There is a lot that could go wrong during the tests. The vehicle—which has taken weeks to set up—is traveling down a track at high speeds and needs to stay on that track. Plus, in order for the test to be useful the lights, data recorders, and cameras all have to trigger at the correct time to collect what is likely a concussive impact lasting only a few milliseconds, according to DTS.

The WIAMan is being designed to be used in live fire testing, but it can be used to evaluate ground vehicles, including seats, as well. It will also be used to test armor and tactical gear. ECN

The new in-dummy data acquisition system DTS is developing for WIAMan is based on the proven architecture and form-factor of the SLICE NANO (pictured here with SILCE MICRO) system. NOTE: Products shown are not those used in the WIAMan project.

Powering Military Vehicles for Modern-Day Warfare

The importance of Li-ion systems in today's military world.

By Alex Bynum, Director of Space & Defense Sales, Saft

In a new generation of warfare, today's military vehicles will be tasked to, in effect, function as mobile power plants. That is forcing electronics designers to reevaluate the power architecture, and how a vehicle's emerging sensors and communication systems are powered on-board. Specifically, they're taking a look at – and questioning the effectiveness of – legacy Pb-acid (lead-acid) 6T batteries.

Previously, military vehicles only required enough power to support radios and electronic systems that could be operated for short time periods without starting the engine. However, today's vehicles feature sensors, jammers, communication, and control systems. More complex vehicles require higher power and more energy than Pb-acid chemistry can provide. The ability to generate significant amounts of electrical power is critical for the full technology spectrum of modern industrial, tactical, combat, and hybrid vehicles.

The NATO 6T battery format, the most common battery used in military vehicles around the world, is often comprised of 28VDC batteries with two 12VDC lead-acid batteries strung in series for ground vehicles. The batteries were originally used for just starting, lighting and ignition (SLI) loads, but as the complexity of vehicle integrated systems increased, the vehicle batteries were also used to provide higher power loads and cycled at up to 80 percent depth of discharge.

The increased strain on lead-acid 6T batteries causes

premature failure by excessive discharge, improper charging, and extreme internal temperatures. In turn, military operators must frequently stock and replace the batteries, resulting in limited trust by troops during deep-cycle applications. Another shortfall is that State of Charge (SOC)/State of Health (SOH) is difficult to detect, which could cause unexpected power loss, leading to engine start failures, inability to complete missions, and increased danger for soldiers.

The good news is that advances in lithium-ion battery technology have created new opportunities for the development of innovative power solutions capable of pushing outdated legacy technology and chemistry aside, allowing engineers to explore new possibilities with their on-board designs.

Li-ion technology offers many benefits over lead-acid, such as longer life, lighter weight, higher energy density, and lower total cost of ownership. Substantially longer battery life significantly enhances the capabilities of today's military vehicles, supporting extended silent watch operations (engine off mode), and a multitude of technologies on the vehicle that run on battery power.

What may be most encouraging related to adapting existing vehicles to Li-ion, is a drop-in replacement component that many Li-ion batteries feature.

One Li-ion battery provides the power equivalent of two lead-acid batteries at a quarter of the weight and half the volume with greater power and energy density.

In addition to the enhanced performance benefits, Li-ion power systems have proven successful in reducing the total cost of ownership for military vehicles. Li-ion battery packs reduce logistical burdens to stow, transport and distribute replacement batteries. This translates to over $200 million of potential savings in total cost of ownership for a fleet of 20,000 vehicles over a 20-year life. With a market size of 700,000 lead-acid batteries acquired per year by the military, the widespread adoption of Li-ion technology can return tremendous cost savings to the end user.

At the same time, size and scale of the U.S. military marketplace and the prospect of an across-the-board transition to a new battery class has represented a challenge. Until now, production costs have limited the availability and wholesale integration of the superior Li-ion systems. But that is changing.

The cost-efficient mass production of Li-ion batteries will mark a sea-change in the performance, reliability and safety of modern military ground vehicles. Along with advanced performance, logistical costs will be significantly reduced. Engineers are welcoming the arrival of this new battery technology, as are the military and service personnel it is designed to protect. ECN

The Increasing Adoption of Hybrid and Electric Vehicles

A look at popular types of hybrid and electric vehicles.

By Bruno Boury, Melexis

There are stringent legislative policies now in place across the EU to curb harmful emissions, ensuring future generations can enjoy cleaner air and preventing irrevocable damage to the environment. At the same time, increasing effort is being made to reduce dependency on the planet's dwindling oil reserves.

These dynamics both point towards a migration away from automobiles based on combustion engines alone and heavier use of hybrid and electric vehicles (HEVs). However, a series of obstacles have prevented widespread HEV proliferation from taking place. Recent technological breakthroughs have demonstrated the challenges are surmountable.

Carbon emission levels have been addressed through better air management and thermal management systems, which has allowed a certain degree of engine downsizing. The next major step toward reducing CO_2 output will be increased usage of electrification and hybridization. This reduces the load on the engine (through more on-demand systems), and optimizes the combustion engine efficiency.

Electric cars are becoming increasingly popular. They already form the basis of many established elements of modern automobile design. For example, the replacement of hydraulic steering mechanisms with electric power steering has led to significant reductions in CO_2 emissions (as much as 5 percent in some models). Through uptake of HEVs, things can be taken much further.

Though up until quite recently, automobile manufacturers doubted their validity, commercial acceptance of HEVs is taking place around the world. Industry analyst firm Freedonia has predicted that worldwide hybrid and electric vehicle (HEV) sales will more than double between now and 2018.

Currently, Japan leads the way with regard to the endorsement of HEVs (representing over 20 percent of its annual vehicle sales). This is followed by North America, then Europe —though in both of these cases the percentages are far lower. Various types of different HEV now exist, including micro hybrids, mild hybrids, full hybrids, plug-in hybrids, and electric vehicles. The options available stand as a testament to the popularity and importance of the HEVs.

Improving Energy Efficiency

Vehicle manufacturers are looking at different ways by which they can downsize engines and reduce emissions. Turbos have long been able to optimize the efficiency of conventional combustion engines as part of their air management function (with lower CO2/kWh figures resulting). Turbos use high temperature compressed exhaust gas to drive a secondary 'cold side' circuit, compressing the air intake for the next combustion cycle. Combinations of exhaust gas can be fed into the secondary side air intake in exhaust gas recirculation (EGR) systems, allowing compliance with the strictest of emission standards—such as those concerning nitrogen oxides (NOx), the other pillar in the cleaner air mantra. One of the handicaps intrinsic to turbos is the response lag caused because the turbo only works once a certain RPM threshold has been reached. Even with optimizations, such as variable geometry turbines (VGTs), which maintain the optimal aspect ratio as a function of the RPM, the lag can never be eliminated. One solution to this problem could be electric superchargers because compression of the air intake is not achieved via the exhaust gas's high pressure, but through an electric motor, which is effectively 'on demand', with no lag to worry about.

It is generally accepted that all cars will eventually, at the very least, have start/stop functionality. Nonetheless start/stop alone will not pave the full road to the 2020 targets being carved in legislation. The hybridization/electrification needs to be brought to the next level.

Full Hybrids

Full hybrids normally rely on a 40kW to 70kW electric motor, which works in tandem with the vehicle's combustion engine. Some of the most prominent examples of full hybrid vehicles are able to reduce CO2 emissions compared to equivalent combustion engine models by as much as 35 percent. The electric motor should be in operation for the whole time

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that the vehicle's engine is running, or at least up to a certain speed. This mandates the specification of a large, cumbersome, and expensive battery pack, to provide the high voltage required for high power electric motors that enable a fully electric drive. Additional on-board charger electronics are required for the plug-in hybrids and the associated energy storage necessary to cover an extensive mileage.

Mild Hybrids

Alongside full hybrids, plug-in hybrids and electric vehicles, a new category of HEV has started to appear—mild hybrids. Mild hybrids possess greater functionality than stop-start systems or micro-hybrids. In most respects, these vehicles have more in common with conventional combustion engine based vehicles than with HEVs. What differentiates a mild hybrid from a full hybrid is the electric motor is not responsible for propelling the vehicle on its own, with power ratings in the range of 5kW to 20kW. The vehicle's combustion engine takes care of this, with the electric motor just there to provide additional support, the so-called torque-assist. This approach offers improvements between 10 to 15 percent in fuel efficiency, whereas full hybrids can easily double that. With mild hybrids, car makers still have the goal of further minimizing engine size and delivering emission reductions. The benefits of lower wire harness weight, wire harness cost reduction and no longer needing to comply with the high isolation standards of high voltage batteries are to be derived and at the same time ensuring strong levels of performance are maintained and driving experience is unaffected. To this end it is necessary to deliver an electrical boost along with kinetic energy recuperation function on a lower voltage net than full hybrids. Typically systems known as integrated belt starter generator (iBSG), integrated motor assist (IMA) or belt-assisted starter (BAS) provides instantaneous boost upon acceleration. The kinetic energy recovery system (KERS) further increases overall efficiency by recharging the battery and/or powering the electrical loads.

Mild hybrids may not be able to deliver degrees of fuel efficiency comparable to full hybrids —they do, however, enable marked improvements on conventional combustion engine vehicles and also offer consumers more attractive price points. While a full hybrid will add at least $4,000 to $6,000 to the cost of vehicle model in a given category, a mild hybrid will only add around $1,000 —as it does not require the same quantities of battery power capacity and power in general. For this reason IHS Automotive predicts that by 2020, around 15 percent of all HEV production will be for mild hybrids.

Mild hybrids (along with micro-hybrids) have seen most traction in Western Europe. It looks likely for the next few years that the European market will constitute nearly half of the total global sales for this particular HEV category. If the power goals being set by mild hybrid inverters can be reached with a 48V system, there is no question that currents will be pushed way beyond the 200A mark.

The considerable expense of inverter hardware has, to some degree, restricted HEV adoption, with government subsidies or other incentive schemes—like the no road tax on hybrid vehicles in Japan and free license plates in Shanghai, which are otherwise valued at several thousands of dollars—being offered to add appeal to car buyers. The use of smaller inverters with lower power losses would make it possible to significantly reduce the costs. This would impact the commercial success of HEV models by lowering price tags, as well as reducing overall weight. It

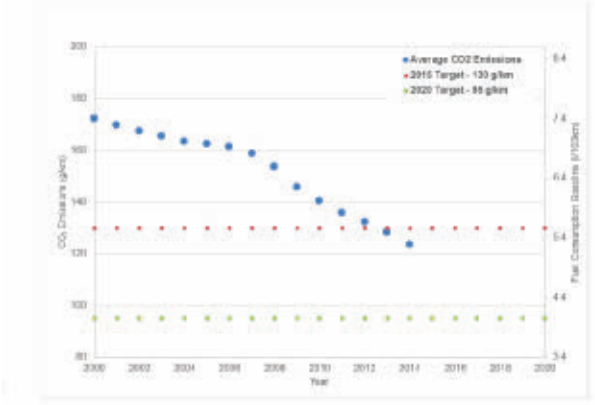

Figure 1: European Union's 2015 Target for Average Fleet Emission Levels (All figures courtesy of Melexis)

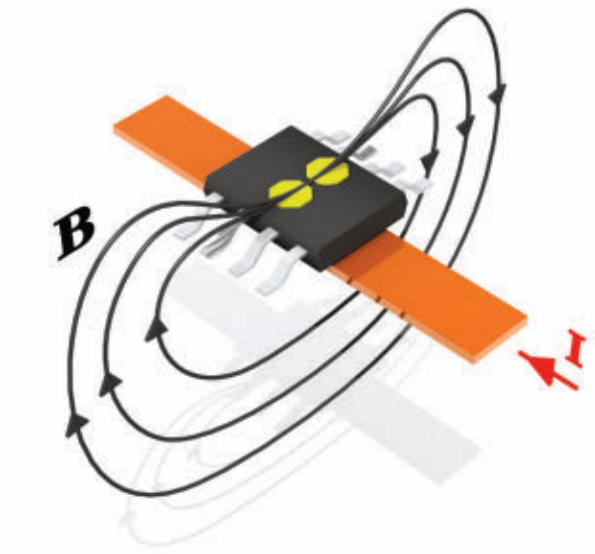

Figure 2: The IMC Structure Utilized by Melexis' Current Sensors

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would, in turn, mean that these inverters exhibit much higher power densities, which would have implications for the current sensing technology employed.

Advanced 48V hybrid systems, such as the ones discussed in this article, are destined to present modern society with a credible way by which to save fuel and lower vehicle emissions without requiring major financial investment by consumers. The relatively high cost of automotive inverters have traditionally limited wholesale HEV adoption. Consequently, there is heightened interest in finding ways in which inverters can be downsized. The emergence of the mild hybrid subdivision of the HEV sector is allowing car buyers to derive some of the benefits of hybridization without being exposed to the higher costs normally associated with it. Vehicle manufacturers can avoid the cost and weight penalties that come with full hybrid designs while still improving fuel economy. Through use of more compact electric motors and smaller less capacious batteries, these vehicles will be able to gain a competitive edge in the HEV market. The support of next generation component technology will allow the higher power densities and elevated temperatures that define such implementations to be attended to. ECN

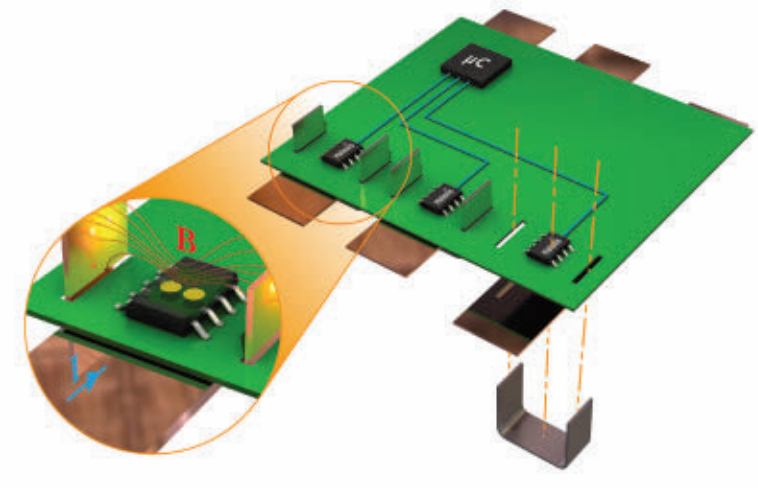
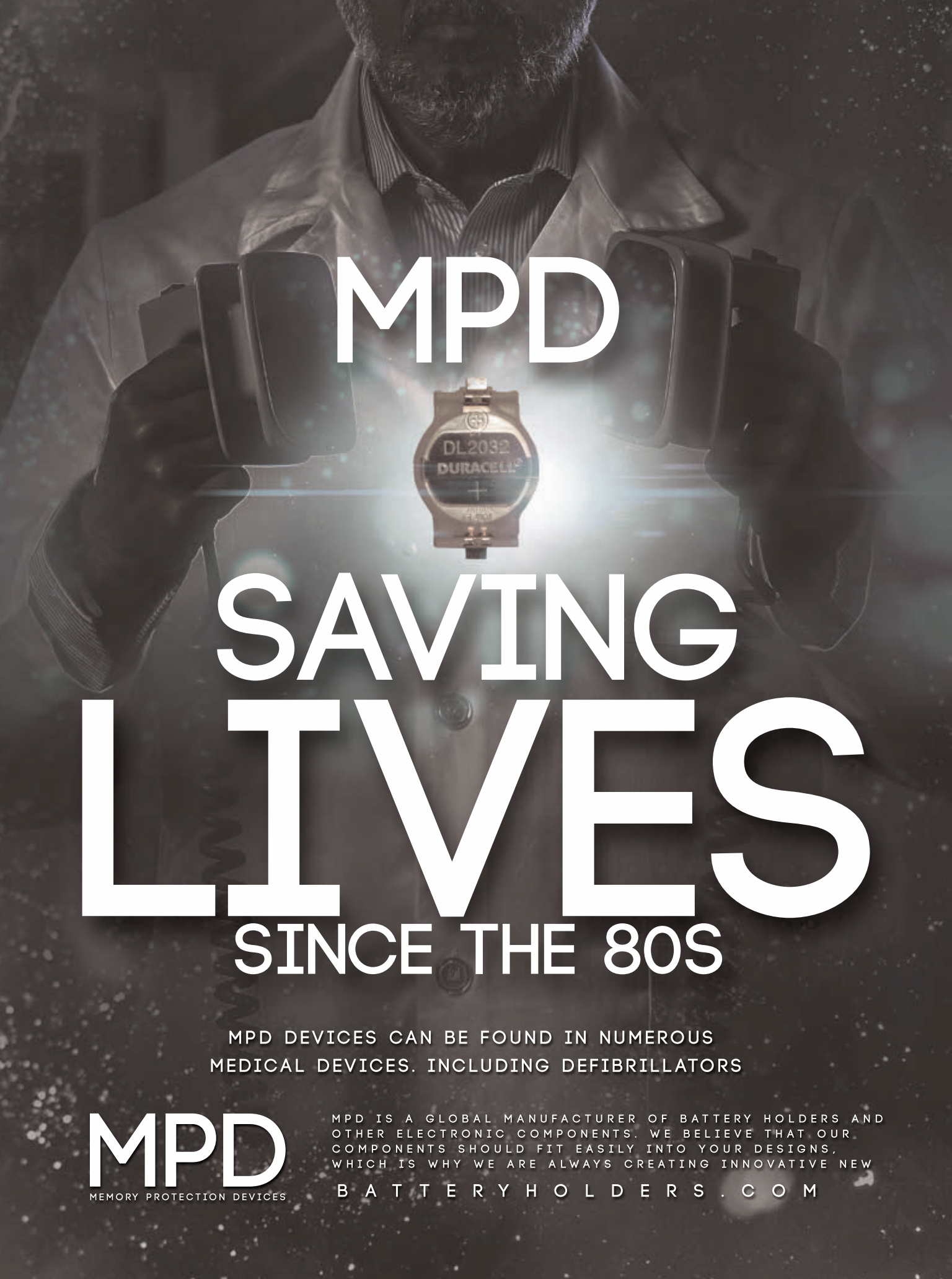


Figure 3: Melexis' MLX91208CAV Implemented into a 3-Phase Power System


MPD
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MPD DEVICES CAN BE FOUND IN NUMEROUS
MEDICAL DEVICES. INCLUDING DEFIBRILLATORS
MPD
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MPD IS A GLOBAL MANUFACTURER OF BATTERY HOLDERS AND
OTHER ELECTRONIC COMPONENTS. WE BELIEVE THAT OUR
COMPONENTS SHOULD FIT EASILY INTO YOUR DESIGNS,
WHICH IS WHY WE ARE ALWAYS CREATING INNOVATIVE NEW
BATTERYHOLDERS.COM

Ultra-Low Capacitance Steering Diode Provides Circuit Protection

ProTek Devices introduces a new ultra-low capacitance steering diode / transient voltage suppressor array (TVS array) targeting circuit protection in a variety of applications that include Gigabit Ethernet; smartphones and other portable electronics; and video card, USB and DVI interfaces. The SRV05-4-A is designed for electrostatic discharge (ESD) protection of > 25 kilovolts and offers protection for up to four lines.

The component can clamp the effects of electrical fast transients (EFT) on the power bus. It combines eight low-capacitance steering diodes for up to four individual data or transmission lines and one TVS diode for power bus protection. It has a rated stand-off voltage of 5.0 volts and minimum breakdown voltage of 6.0 volts. Its ultra-low capacitance is 3.5pF I/O to GND, 2.0pF I/O to I/O.

For more information, visit: www.protekdevices.com.

Surface-Mount RF Bandpass Filter for Cooperative Intelligent Transport Systems

CTS Corporation, through its subsidiary, CTS Electronic Components, Inc. introduces a surface-mount RF Bandpass Filter for use in Cooperative Intelligent Transport Systems (C-ITS) including 802.11p for Wireless Access in Vehicular Environments (WAVE) and Dedicated Short-Range Communications (DRSC). The CTS TCB001A Bandpass Filter supports 2W of average RF output power at the Antenna and is a necessary component to ensure compliance and non-interference to 3GPP for wireless infrastructure co-location/co-existence.

This newest filter addition to the CTS product portfolio is composed of a ceramic block plated with silver (Ag), measures 4.0x3.0x2.0 mm and weighs 0.14 grams. The filter delivers 45dB of rejection with insertion loss of less than 1dB and return loss of at least 16dB. Rated to handle input power of up to 3 Watt average and 30 Watt peak, at operating temperatures from -50°C to +150°C.

For more information, visit: www.ctscorp.com/components.

Sealed Subminiature Micro Switch Offers Reliable Option

Numerous process control applications depend on pressure switches to operate reliably. To convert a physical pressure differential into an electrical signal a mechanical switch inside is used.

Microprecision Electronics SA in Vouvry, Switzerland is now offering a new variation of its MP500 sealed subminiature micro switch for this type of application. Compared to the standard version with an actuating force of max 2.5N, the new MP520 has a lower actuating force of max 1 N. The differential force is only about 0.2 N. The differential travel of less than 0.05mm and a fast change over time of 5 ms is another important parameter for process applications.

The Series MP500 is UL61058 and EN61058 approved for a power rating of 250 AC/ 5A with an operating temperature between – 40°C and 105°C. Termination options are PCB pins, solder lugs or cable. To adapt to special applications, the actuators can be custom designed.

For more information, visit www.wilbrechtledco.com.

Call for Entries

Advantage Business Media

YOUNG MIND AWARDS

Entries for the 2nd Annual Awards Are Now Open

Advantage Business Media's **Young Mind Awards** recognize inspired designs in science, technology, engineering, and math (STEM) from the next generation of inventors, scientists, and engineers.

The awards shine a spotlight on these future innovators, giving them the opportunity to demonstrate their passion and showcase their ability to tackle real-world challenges in STEM. It provides an excellent opportunity for educators to add STEM to their curriculum by having their students take on individual or team research projects. And all Middle School, High School, and Undergraduate students are eligible to apply.

A panel of distinguished industry professionals will review all submissions based on the core principles of creativity, comprehensiveness, clarity of expression, and demonstration. Students can submit a project in one of five innovation categories:

- Electromechanical/Mechanical
- Electronic Design
- Medical Device Design
- Research and Development
- Wireless Design

Join us in saluting the efforts and achievements of our future innovators!

For more information and to enter, visit www.youngmindawards.com.
Deadline to enter: May 31, 2016

Evergreen Sponsor: MPD

Rapid Prototyping Technology Expands Into Electronic Assemblies

By **Paul Pickering,** Technical Contributor

Manual prototyping by a skilled craftsman has been used for centuries, but has now been largely supplanted by Rapid Prototyping (RP) technology, also known as Additive Manufacturing (AM). RP produces three-dimensional objects by a process of layer-by-layer material deposition; the technique had its origin in the 1980s with the growth in Computer Aided Design and Manufacturing (CAD/CAM) technologies. The machines that generate these prototypes one layer at a time are known as 3D printers.

In recent years, RP technology has expanded far beyond its original applications to include electronic circuits, software networks, even human organs. In addition, the expanding technical capabilities and declining equipment and material costs mean that RP can now be used for low-volume production runs.

As a result, market research firm Canalys forecasts that the 3D printing will be a $16.2 billion market by 2018, up from around $2.5 billion in 2013, representing a CAGR of 45.7 percent.

The RP Process

The procedure for producing a 3D printable object begins with a 3D model – a mathematical representation of the object to be manufactured. A 3D model can be created with a computer aided design (CAD) package, by means of a 3D laser scanner, or via a digital camera and photogrammetry software.

The manual modeling process of preparing geometric data for 3D computer graphics is similar to plastic arts such as sculpting. 3D scanning is a process of analyzing and collecting digital data on the shape and appearance of a real object. Based on this data, three-dimensional models of the scanned object can then be produced.

There are many CAD packages available for generating 3D models, ranging from open-source offerings such as Blender or BRL-CAD to high-end packages such as Fusion 360, AutoCAD and Solidworks.

Regardless of the software used, the 3D model (often in .SKP, .DAE, .3DS or another graphics format) must then be converted to a format such as .STL (stereolithography) or .OBJ to be readable by the software which drives the printer.

3D Printing For Electronics

RP technology is no longer confined to purely mechanical components: multi-material 3D printers can now build up circuit boards and other electronic assemblies. The primary applications are flat panel display backplanes, EMI shielding, RFID tags, PCBs, electroluminescent lighting, and touch screens.

The materials needed to produce an electronic assembly are a thermoplastic for the base material and a conductive ink for the electrical connnections. Acrylonitrile Butadiene Styrene (ABS) was the most popular base material for 3D printing several years ago, but it required higher temperatures than biodegradable thermoplastics such as Polyactic Acid (PLA) a biodegradable polyester derived from renewable resources such as corn starch, tapioca roots, or sugarcane; other options include nylon and PET (PolyEthylene Terephthalate), which is widely used to make plastic bottles.

Given the fact that 90 per cent of plastic waste is not recovered, one hot trend is the use of recycled materials for the base material. Thermoplastics can potentially be obtained from many different places including milk bottles, plastic cups and even the insides of refrigerators.

Printable conductors - for traces, vias and pads - are made from a variety of exotic materials with resistivities ranging from 10 to <10-6 Ω-cm. Options include conductive polymers, carbon nanotubes, and silver micro-powder pastes, but metal nano-particle inks are most widely used. The ink contains nanoparticles (typically silver) of 5 - 6nm in size; the small particle size significantly reduces the melting temperature of the silver below the bulk melting point, allowing for very low processing temperatures for sintering the nanoparticles into conducting films.

Temperatures can be as low as 90°C, compatible with most plastic subtrates. The ink is also curable by laser or UV light at room temperature.

3D Printers Coming Down The Cost Curve

Traditional high-end multi-material 3D printers can run into hundreds of thousands of dollars, but lower-cost (under $10,000) printers are starting to make their appearance.

Nano-Dimensions' Dragonfly 2020 3D PCB printer, for example, converts standard Gerber files into fully-functional multi-layer PCB prototypes using a desktop unit. The printer can print traces of 80-100 μm, blind and buried vias, and interconnections of ~150 μm. The minimum layer thickness is 3 μm and the number of layers is limited only by the mechanical height z-axis. The maximum size of the pcb is 20cm x 20cm; a complex 10-layer board can take up to several hours to print.

The 3D assembly shown in figure 1 (a circuit based around the venerable 555 timer) is made by Voxel8, a spinoff from a Harvard materials science lab.

The device uses PLA and Fused Filament Fabrication (FFF), a popular technique in which the printer builds up an object by extruding multiple layers of melted thermoplastic material which almost immediately hardens.

The 250 micron traces are laid down by a pneumatic direct-write system that uses conductive silver ink with resistivity 5 x 10-7Ω-m and a curing time of 5 minutes. The resulting circuit is multi-layer, with vias and pads for surface-mount components. In the initial product, scheduled to be available at the end of 2015, mounting the components is a separate operation which can be done in situ, or by removing the build plate to give more room.

Future Developments

Even cheaper machines may be on the horizon, with the advent of a new breed of printers capable of depositing electrically conductive and insulating materials, the first step towards 3D printed electronics. Many are being developed by crowd-sourced startups: according to IDTechEx, customers funding such first-generation machines have spent over $800k on Kickstarter alone.

The company predicts that consumer-level machines will drive the hype, but next generation machines aimed at professional use will become the largest commercial markets over the next decade by servicing prototyping and manufacturing end users. ECN

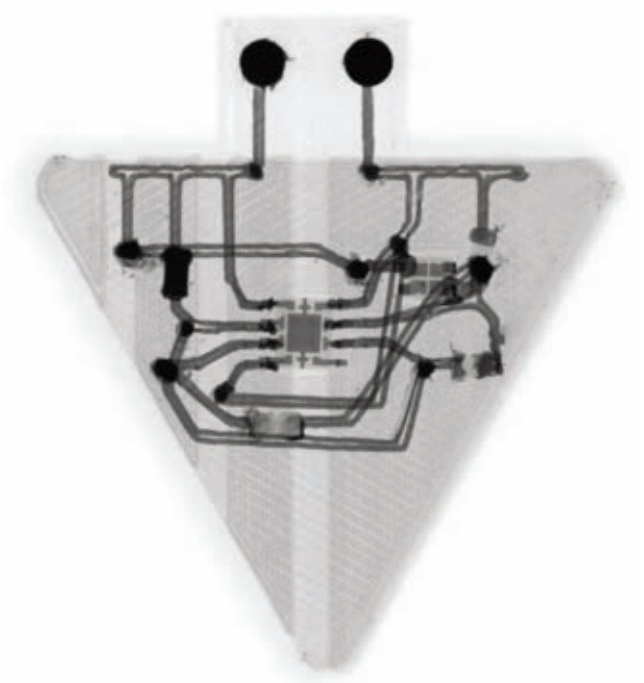


Figure 1: RP electronic assembly made by 3D printing (Source: Voxel8)

What Drains The Battery In Smartphones?

By Charles Limonard, Product Marketing Manager,
Dialog Semiconductor

Even in the fast-paced technology sector, few products advance as quickly as the smartphone.

In the past, functions such as navigation, enabled through the Global Positioning System (GPS), could easily be pinpointed as major consumers of power.

Similarly, WiFi represented a major battery drain, particularly if the RF conditions were poor or the home router or base station was working at the edge of its range.

While moving around, frequent handovers between cellular base stations would increase traffic to and from the handset, again leading to a significant power demand. As handover would often happen on the edges of cells, those signals would also need to be boosted, which means more power being supplied to the RF power amplifiers. Because 2G signals are more efficient under these conditions at low data rates, a common piece of advice was to force the device to avoid using 3G or 4G communications.

Until recently with Bluetooth® Smart, there had not been any major changes to the core protocols that influence power consumption. The increasing use of apps that communicate in the background have made the traditional advice of turning radio subsystems off impractical. Instead, smartphone and tablet manufacturers have made the firmware that controls these subsystems much smarter. The firmware analyses conditions in real time and continually adjusts how the device responds.

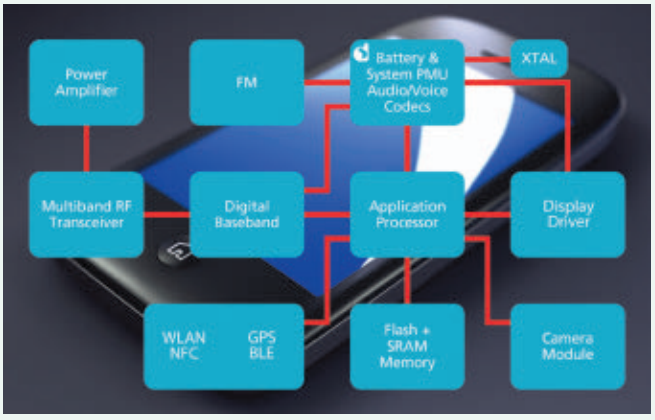
The firmware will prevent unnecessary cellular handovers and only activate the GPS decoding engine when the software decides it needs a new position reading, based on changes since the most recent fixes. A phone that has been stationary for a while does not need to update nearly as often as one on a dashboard in a moving car.

The conditions that lead to higher than expected battery drain are now increasingly more subtle, making them harder to identify. Apps now provide the key influence over long-term energy consumption. Some ask for information from the firmware more often than is required and do not give the firmware the opportunity to optimise battery drain. This means that one app that asks for permission to see your location in real time, even when running in the background, may have little impact on power while another similar app is far more power demanding. This is one reason why there is an emergence of apps that sample system state at regular intervals to find likely power hogs.

Still, not everything has changed. The display remains one major power consumer on smartphone platforms. To make the screen readable under the brightest of ambient lighting conditions, the LEDs in the backlight, which form the actual pixels in the case of OLED displays, are designed to be able to operate at high intensity. This can rapidly drain the battery if the screen is set to not power down after inactivity.

Tests have shown that doubling the brightness of a backlight increases the power consumption approximately four-fold. At maximum brightness, the backlight can easily consume twice as much as the average power demand of the applications processor and its memory subsystem while it is running. However, even here greater attention to power efficiency has taken hold, with ambient light sensors used to tune the backlight's output to a level appropriate to the conditions, while the efficiency of the white LEDs has increased significantly leading to lower power at the same intensity.

Bluetooth is an example of how the emphasis on power efficiency has shifted to ambient intelligence around the mobile device. Bluetooth Smart increases the already impressive energy efficiency of the protocol to the point where a sensor device can run for over a year on a lithium



**The display remains a major consumer of power, but there are many others in today's smartphones .
(Image courtesy of Dialog Semiconductor.)**

button cell. As a result, Bluetooth Smart is key to the design of a growing list of wearables, including step counters and heart-rate monitors. These devices feed a stream of information to smartphones and can do so without significantly draining the battery of either device. This is a testament to the way that mobile-device design has reacted to power-consumption issues.

The most successful of these devices employ a divide-and-conquer strategy to ensure the most appropriate and energy-efficient method for dealing with data is used at any one time. At other times, a processor that is less power hungry runs many functions, letting the larger core power down.

The sensor hubs in many of the latest smartphones take this philosophy even further. These devices are based on simpler implementations of the ARM architecture, such as the Cortex-M0+, rather than the Cortex-A53. The M0+ device intercepts many of the messages from sensors, storing their data ready for the applications

processor when it wakes up. If a message shows a sudden change, it can interrupt one of the higher-performance cores that are able to turn the appropriate software. Very often the phone can make huge improvements in battery life by intercepting these packets of data.

Emerging applications such as voice activation also make use of these techniques. The first and lowest-power layer of processing looks for noises, the second, whether it's a voice and finally whether or not it sounds like a command. The voice-recognition software is only deployed when it is absolutely needed. This division of responsibilities means the phone is always ready to obey voice commands but it has negligible impact on power.

The complex mixture of processors and memory within the phone has driven a corresponding revolution in power management. The power management integrated circuits (PMICs) that control how electricity is delivered to each part of the phone, from the microphone to the processor array to the displays, now have tens of voltages lines with each one individually controlled in real time. Their I/O pins are as numerous as those found on the SoCs they power.

The PMIC has to carefully orchestrate power to each electronic device in the smartphone. Not only are they switched on and off at different times, the voltages they receive need to be carefully tuned. The LPDDR3 memory that holds data for an applications processor may only differ by 0.1V from that used by the processor core and may need to be powered up before the core is activated. The order is often critical to avoid damage, so they need different, precisely controlled voltage rails.

The efficiency targets for the PMICs have also shifted. Traditionally, power supplies have been optimised for efficiency at high load. This helps ensure mobile devices do not heat up excessively when performing intensive operations. But in an always-on environment where data is continually being processed in the background, broad-spectrum efficiency is now the requirement. The PMIC uses sophisticated digital techniques to deliver efficiencies of more than 90 per cent from low to high loads across the many voltage rails.

The spread from low to high load can be orders of magnitude; from a few milliamps in a device that is idling to sudden peaks of well over 10A as a processor starts up and begins to work through data as quickly as possible. This happens before dropping to a few hundred milliamps for sustained video decoding or a series of Facebook updates. As a result, the power subsystem has become the key for ensuring that a smartphone can survive for more than one day on a single charge without demanding that users disable the functions for which they bought the device. ECN

DISTRIBUTION

A special section

Moving from a Linear to Networked Supply Chain Model for Electronic Products

Jesse Laver, VP Global Sector Development, Technology at Exel

The technology supply chain has unique requirements compared to other industries. These requirements stem from both the nature of the products moving through that supply chain and the markets being served.

The products themselves often have high-value that increases the need for security and are the subject of continuous innovation that shortens life cycles and contributes to dramatic shifts in demand. The ability of the supply chain to respond efficiently to these shifts can mean the difference between capitalizing on volatility and becoming a victim of it.

Further contributing to the supply chain challenges of the technology marketplace is its global nature. Where other industries have regional production facilities that serve regional markets, technology companies often serve global markets from a single manufacturing location or region.

The traditional supply chain is not well suited to meet these unique requirements as it is subject to latency and visibility gaps between each stage of the process that limit the ability to quickly respond to change.

The alternative is to develop a highly adaptive supply chain that can quickly align across global markets to deliver value to the company and to its customers. This can best be accomplished by the networked model.

The Network Model

In the networked model, manufacturers and their suppliers move components and finished products in a way similar to how information moves across a network. This allows organizations to align manufacturing, distribution, sourcing and sales to achieve horizontal process orchestration. Demand drives activity and real-time visibility into demand is synchronized across all parties in the supply-production-delivery ecosystem to eliminate latency.

No single stage of the process moves any faster; however, the increased visibility allows better decisions around the inbound and outbound material flow that can cut days or weeks out of the supply chain.

This operational agility represents a significant differentiator for technology companies and is enabled by an asset light supply chain that can deliver fully qualified capacity when and where it is needed. This is best accomplished through a partnership with a third-party logistics company, which serves in the role of lead logistics provider (LLP), manager of a shared services model, or provider of pre-sales support and postponement.

Lead Logistics Provider (Llp) Outsourcing Model

Partnering with a third-party logistics firm to take the lead in managing all supply chain activities provides a single point of contact and responsibility for managing global logistics activities.

The LLP sits atop the supply chain 'control tower', and employs real-time visibility tools to constantly monitor and assess the condition and performance of the supply chain. Using alerting systems, the LLP can identify and address potential problems proactively before they disrupt or delay the supply chain.

This visibility can extend across multiple tiers of suppliers, where significant risk of disruption exists in the technology supply chain. It can also provide visibility into multiple echelons of global inventory, enabling management to make better decisions as to amount, positioning, quantity and type of inventory.

Shared Services Model

The shared services model, in which the LLP manages the activities of multiple companies sharing supply chain assets and processes, such as warehousing, transportation

and information systems, offers a significant opportunity to reduce costs, spread risk and improve agility.

In this case, the 3PL handles multiple manufacturers' products in a shared facility, and spreads the costs of technology, infrastructure, services, people and expertise across multiple customers. This enables customized solutions for inbound, storage and outbound processes to be delivered at a more favorable cost/service structure to technology customers.

This solution works for inbound to manufacturing, outbound to customers and reverse logistics. The logistics provider is able to fluidly shift the work force from one activity or customer to another. This can be particularly effective in the consumer technology sector where manufacturers often have customer overlap in the form of large retailers that receive goods from the same grouping of manufacturers. The shared services model eliminates the duplication of supply chain assets, resources and costs across the companies serving these customers.

Postponement Solutions

For the tech sector, pre-sales support and postponement is a key customer satisfaction differentiator, and offers new profit potential. Technology companies can outsource postponement to a 3PL to create supply chain flexibility while reducing complexity. Moving these services into the supply chain delays final product differentiation until closer to the point of sale. The process can involve a layered approach to production with product from the primary manufacturing hub shipped to configuration centers close to the point of consumption. Once the product is closer to the actual demand, the product is customized with market-specific elements such as packaging, documentation, configuration or kitting.

Customizing product closer to consumer demand can significantly reduce inventory levels and obsolescence. It also increases the flexibility to serve customers by providing exactly the products the market wants without compromising the ability to leverage low-cost production environments.

Conclusion

Solving for volatility, uncertainty and ambiguity in the technology sector takes innovation, visibility and collaboration. The most competitive technology supply chains have abandoned the traditional linear supply chain approach and migrated to a networked model, fueled by real-time visibility, to increase speed and ensure resiliency. This eliminates the visibility black holes that add unnecessary time and cost to business operations.

This transition is being supported by relationships with third-party logistics companies in the role of lead logistics provider, shared supply chain services manager and postponement services provider to gain the agility and efficiencies required to remain competitive.

3 Trends in Design Services

By Cliff Ortmeyer, Global Head of Solutions Development, Newark element14

To survive in today's market, hardware distributors are beginning to act as a one-stop-shop for engineers looking to take their projects from design through to production. The reality is that today's engineer doesn't just buy hardware. In fact, a large portion of projects, and even the decisions made prior to starting a project, are related to the software and accessories available to them. As designers are required to take on more parts of the design process, the importance of finding the right development, test and simulation tools – dsa as well as EDA tools – has never been more important. With these components of the design process now as prevalent as the hardware itself, distributors are playing a key role in fulfilling this part of an engineer's design needs.

To best address those needs, it's important to first

continues on p.32

Executive Q&A

Steve Newland, Senior Vice President of Americas Sales and Global Sales Operations

MOUSER ELECTRONICS

Q: What is the primary focus when serving the design engineer?

We put the needs of our customers first and specialize in answering the component needs of the design engineer and buyer by providing them with the newest semiconductors and electronic products from more than 500 manufacturers. Mouser is the industry NPI leader. We make it a priority to stock and distribute the newest products to give our customers a speed-to-market advantage.

Having the newest, most advanced technologies to develop prototypes avoids costly redesigns, manufacturing delays or even the termination of a project. It also leads to a design edge in delivering more product features, capabilities and longer lifecycles. That's why we work in close partnership with all our manufacturer partners to provide the fastest, easiest access to the industry's newest technologies.

Q: What value-add services do you offer?

Every customer gets full and complete service every time. Our goal is to provide excellent customer service along with technical support for buyers and engineers worldwide.

In addition to being the new product leader, we provide our customers with the latest life cycle status on components. Also, at Mouser we have no minimum order quantity.

We offer several services and tools online that help customers through their buying process. Our advanced BOM tool allows customers to upload their bill of materials and receive real time pricing and delivery. Our Project Manager, Cart/Project Share make it simple for engineers and buyers to save projects and share instantly.

One major resource to further help our customers are our MultiSIM BLUE tools, introduced in partnership with National Instruments. Available via download at Mouser.com, MultiSIM BLUE is a fully-integrated circuit design tool to provide engineers with a simulation environment using Mouser's wide selection of products.

Q: What protection do you offer against counterfeit components or those made with conflict materials?

At Mouser we take great pride in providing our customers with the newest, genuine authorized parts. We are an authorized distributor for every component stocked from more than 500 manufacturers. All of our components are obtained directly from the original manufacturer or through authorized channels.

Mouser is an AS9100C certified distributor, earning the industry's top standard for quality and control, providing design engineers and buyers the assurance that their orders are traceable and genuine.

Q: How do you address time-to-market challenges?

We stock the widest selection of products and all are ready to ship that same day. At our state-of-the-art warehouse, many orders are processed within minutes of receiving them. We provide same-day shipping on most orders with delivery in one to three days.

For convenience, we offer easy online ordering and product documentation on the web, plus we have 21 Customer Support Centers worldwide, staffed with local representatives. For customers who prefer to call, we offer personal technical and sales support in local time zones, local language and local currency.

Q: What does your company offer in terms of design tools?

Online, Mouser has several places that engineers can quickly go and research new products and applications & technologies – www.mouser.com/new or www.mouser.com/applications. The Mouser Newest Products site provides detailed, technical information that can be viewed by category, manufacturer or by week.

We provide access to the latest essential technical data and industry applications through our Application and Technologies sites. These easy-to-navigate sites are an essential resource for reference designs to give engineers a quick start on their latest project. Product data sheets, application design notes, white papers, and other solution-based content are all designed to give our customers a technological edge.

Finally, engineers can take part in our exciting new Empowering Innovation Together program with celebrity engineer Grant Imahara of Mythbusters fame. There are video spotlights, design challenges and many more ways for engineers to engage and share design ideas with Grant and one another. It's just one of the many ways we are serving our customers.

For more information, visit **www.mouser.com**

Steve Newland is Senior Vice President of Americas Sales and Global Sales Operations at Mouser Electronics, Inc. He has over 30 years of experience in manufacturing and distribution, and is currently responsible for leading Mouser's customer support teams including: customer service, training, technical support, quotations, service quality, and sales operations. Newland holds degrees in Industrial Distribution from Texas A&M University and an MBA in Business Management from The University of Dallas.

continued from p.29

understand the three distinct trends in design services driving the electronics industry today and how those trends are impacting every player in the production cycle.

Trend 1: Component Sourcing

Traditionally, design engineers bringing their schematics to life were forced to rely on external sources to produce a prototype board. Today, design engineers are being given more and more opportunities to play a direct role in the production of prototypes in large part because of software. Solutions like CadSoft Eagle and Altium Circuit Studio allow engineers to integrate component sourcing with full design support – all built into one software package. Where once the prototyping process was broken up into three separate segments – finding the parts, finding a supplier to fabricate the PCB and then having the board built and tested – distributors are bridging the gap with software stores and design centers complete with full PCB fabrication, schematic design, layout and prototyping services.

Helping customers to piece together the complex software ecosystem through technical support and online community experts are one way distributors are moving into the space and helping engineers make better-informed purchases. Complex designs require complex tools, and the right decision can be a difficult one for engineers to make alone. The need for fully supported software solutions is only going to accelerate.

Trend 2: Single Board Computers

A second trend we're seeing is the proliferation of more open-sourced, hobbyist-oriented single board computers (SBCs) like Raspberry Pi and BeagleBone Black in the professional engineering space. Engineers using these products at home or in their spare time to develop personal projects are applying those same tools and techniques to the professional workplace – and for good reason. With SBCs, designers don't have to start a prototype from scratch. SBCs are increasingly serving as the base for a design in which they can modify the solution through open source software and incorporate whatever additional features they need most. As a result, fewer engineers are being challenged to design an entire circuit board on their own.

The ability to add on to or modify those SBCs – from memory capacity to sensors – saves engineers not only the time required when starting from scratch, but it also saves on development costs. Designers can reuse the software they've already developed on a platform with the same sourced parts to reduce the time to market for any particular new prototype. There is also a significantly lower risk involved when using SBCs. Many of the complicated pieces are already laid out – memory and other high-speed interfaces, etc. – and can be reused.

Congratulations to the 2015 Young Mind Awards Finalists!

The Young Mind Awards (YMA) mission is to inspire students with an analytical mindset to challenge themselves and follow their dreams in STEM. A global competition, the YMAs encourage students at the middle school, high school, and undergraduate level to pursue their passion and bring forth design engineering and research and development as desirable education and career options for scholars. The YMAs recognize outstanding achievements and efforts of students who design and build a project in one of five innovation categories: electromechanical/mechanical, electronic, medical, research and development, and wireless.

Undergraduates

- Xiaopeng Bi
- Daniel Campbell
- Iman Chalabi
- Mahavir Dwivedi
- Christopher Hoolihan
- Emily King
- Maggie O'Connor
- Sean Salmon
- Paul Spaur
- Tajh Thompson
- Linh Vu

High School

- Caroline Blanchard, Emily Blanchard, Abigail Hancock, Sarah Maxson
- Eamon Bracht
- Julia Cocco
- Shana Gershbaum
- Michael Huang
- Zubair Khan
- Olivia Li
- Ray Liu
- Patrick McKee, Tanabodin Saengnark
- Zeynep Ozgur
- Sonia Sachar
- Sloane Sambuco
- Daleth Sendin
- Kaushik Tandon
- Maya Varma

Middle School

- Rylie Gray
- Rahul Guda
- Seshan Jayapregasham
- Terrance Li
- Kanav Mittal
- Isha Mohapatra
- Jahan Razavi
- Sanjana Shah
- Robert Walker

We'd like to thank our 2015 Young Mind Awards partners for their support:

- Allied Electronics
- Memory Protection Devices
- OKW Enclosures, Inc.
- API Technologies

= Electronic = Electromechanical/Mechanical = Medical = Research and Development = Wireless

SBC support is a natural extension for distributors like Newark element14 who already manufacture these boards for semiconductor suppliers. The familiarity and expertise with these distributors have with complex layouts, design, production and testing enable them to provide engineers with exactly what they need when building a board. The response among our customers has been overwhelmingly positive and, much like components sourcing, this trend is only going to continue.

Trend 3: More Accessories

The third trend we're seeing is a direct result of the proliferation of more SBCs in the professional setting. As more engineers use more SBCs for professional prototyping, more accessories have been made available to seamlessly support the boards and their operating systems. Those accessories are bringing engineers closer to the finished prototype now more than ever before.

In recent years the electronic components industry has seen a stronger emphasis placed on accessory boards that help users integrate added functionalities into their base platforms. This demand has given rise to some of today's most popular board accessories. The BB View is a portable LCD solution with touchscreen capabilities for BeagleBone boards, while Explore NFC is a high-performance, fully NFC-compliant expansion board compatible with the Raspberry Pi. The Cirrus Logic Audio Card is one example of an audio application for Raspberry Pi, and the PiFace Digital for connecting and controlling Raspberry Pi add-ons is now in its second iteration.

These add-ons and more are speeding up the parts selection and design process for engineers, which in turn is cutting down on development costs, minimizing the margin for error and reducing the time to market. Distributors and semiconductor suppliers will be challenged with continuing to provide the latest add-ons and accessories that support the full spectrum of board functionalities in both a personal and professional setting.

These three trends have developed in large part because of the rising demand for more complex and software-differentiated products like those used in user interface, as well as an expansion of wirelessly connected and general IoT applications. These features were once too expensive and too complex to incorporate into standard designs, but a sharp decrease in the cost of the microprocessors enabling these functions have made them accessible to more engineers' designs. This can be seen in the influx of IoT-enabled products like smart thermostats or smart refrigerators. This, in turn, has sparked a new demand for additional design services that suppliers and distributors are now starting to meet in full force. ECN

BRAINSTORM

MODERATED BY JAMIE WISNIEWSKI
ASSOCIATE EDITOR

Q: What's the best thermal management solution for electronics in harsh environments?

Bruce Bolliger, Head of Sales and Marketing, Element Six Technologies Group

Studies have shown that more than 50 percent of all semiconductor failures are due to heat. Place hot semiconductors in harsh environments where ambient temperatures, moisture, vibration and even radiation can by themselves cause failures, and adequate thermal management of semiconductors becomes extremely important to providing high reliability. Under these circumstances, synthetic diamond heat spreaders provide superior thermal management solutions.

Diamond has the highest room-temperature thermal conductivity of any material. Using chemical vapour deposition (CVD) technology, diamond can be synthesized with a thermal conductivity greater than 2000 W/mK, five times greater than copper. In addition, diamond is inert, making it robust in humid environments and with aggressive chemicals. Furthermore, due to its well-known strength, diamond offers a superb, stable platform impervious to most sources of vibration. Finally, diamond is radiation hard, which can be important for space applications.

Take RF power amplifiers, particularly the highest power gallium nitride (GaN) devices, as an example. These devices have small hot spots with heat fluxes that can be at temperatures higher than the sun's surface, thus representing an extreme thermal management challenge. These RF power amplifiers are often used in the harshest of environments, from outdoor cellular base stations that experience significant temperature swings and humidity to military airborne radar applications that experience very high vibration. GaN devices are even used in space in communication satellites. In addition to harsh environments, these applications also all require small form factors and light weight. Diamond heat spreaders meet all of the requirements for this application, having high thermal conductivity in three dimensions to rapidly take the heat away from the hot spot; are inert and stiff and thus impervious to both humidity and vibration; and are also radiation hard and light weight.

Thermal management of Nd:YVO4 crystals for disk lasers is another example where CVD diamond is an excellent choice. The most powerful disk lasers can have extreme heat densities with their output power often limited by over-heating. Since disk lasers are normally used for cutting and welding metals, output power and reliability are key determinants of the lasers' productivity. These lasers are normally used in heavy industrial, vibration-prone environments. Thus, a diamond heat spreader not only cools the laser crystal, but also provides a very stiff platform to eliminate vibration to enable excellent laser beam quality.

As these two examples demonstrate, CVD diamond can indeed be an excellent thermal management solution for electronics and lasers in harsh environments.

Guy Moxey,
Senior Director of Power Products, Cree, Inc.

Harsh environment applications typically impose several mechanical restrictions on power electronics systems. These restrictions typically affect a system's size, weight, airflow, circuit layout, and enclosures, which creates real challenges for system-level cooling. A common approach to solving thermal management issues in such applications is to develop a workaround thermal design through conventional or even creative cooling systems and heatsinking. However, the more effective and efficient approach is to reduce the overall system losses, and hence reduce the system's absolute dependence of thermal management.

By replacing incumbent (and

inefficient) silicon switches with advanced performance silicon carbide (SiC) devices, which have lower static and dynamic losses, engineers can remove a substantial part of the problem—which, in this case, is semiconductor device heat resulting from switching and conduction losses—and its resulting effects, making thermal management much less of a challenge despite the system's mechanical constraints. A power conversion circuit using SiC devices in place of silicon can either run cooler and more efficiently for a reduced thermal budget, or run at higher power density for the same thermal budget.

Electric planes, electric vehicles, and down-hole drilling are just a few of the harsh environment applications in which any power conversion system will face size, power density, and cooling constraints. Addressing the root cause of the thermal management issues such applications experience at their fundamental source—semiconductor device losses—by incorporating smaller, cooler, and all-around better performing silicon carbide power devices automatically mitigates these issues, preventing the systems from ever experiencing enough switching and conduction losses to result in unwanted heating and, thus, from requiring additional components, board space, and budget to solve thermal management issues.

Eric Vanlathem,
Senior Application Engineer, Electronics, Dow Corning

One thermal management solution for electronics in harsh environments is the use of silicone-based materials. These materials are best suited for optimum performances in both thermal management and harsh environment conditions.

For example, with automotive design trending toward smaller engine compartments, increased exhaust gas recirculation and decreased air flow the high-end

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temperatures in underhood environments are climbing. More importantly, it is driving the performance requirements for materials used in these applications to extremes not previously required. Silicone materials can be used in almost all of the automotive electronics application, including and especially in under the hood modules where thermal management is key.

The ultimate performance of silicone materials is a direct heritage from its unique non-carbon chemistry. On top of the thermal management that these material can supply they have other key strengths that are necessary for material performance in harsh environments. They can be used as thermally conductive fillers or as adhesives, which greatly expand design options for electronics by enabling strong bonds to a wide variety of substrates, durability and protection.

Last but not least, rheological properties of materials used in these types of applications need to be tuned to the application process. A small defect linked to the application or the materials used can cause module failure, especially in harsh environments. Silicones can be uniquely formulated to meet the needs that the customer is looking for so that their product will perform to its highest quality. ECN

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By Kasey Panetta, Editor

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