ECN®

Advantage Business Media
JULY/15
ecnmag.com

SERVING THE ELECTRONIC DESIGN COMMUNITY SINCE 1956

Vol. 59 No. 8

Legislating power: Designing power supplies for the 21st century

Cooling for electronic systems

Harvesting and scavenging ambient energy

The mission of the synthetic diamond

WIN
YOUR DREAM BENCH
$141,000 of instruments and software*
www.keysight.com/find/DreamBench

One box. Many tools.

PERFORM A WIDE RANGE OF MEASUREMENTS WITH GREAT PRECISION.

The Keysight 34970A and the 34972A data acquisition switch units are compact, economical, one-box solutions for data logging, general-purpose switching and control applications. And with their built-in 6½ digit digital multimeter, they offer high-quality switching and ultra-low reading noise. So you can use them to accurately measure a variety of signals with precision in a variety of applications—even in extremely noisy electromagnetic environments.

34970A and 34972A Data Acquisition Switch Units
6½ digit (22-bit) with ultra-low reading noise (140 dB CMRR)
Built-in signal conditioning enables 11 measurement functions
Measure up to 60 differential channels, up to 300 DC/AC volts
Up to 32 MB readings of non-volatile USB memory
BenchVue software-enabled to control, view and analyze data

Data log and visualize with BenchVue software.

microlease

Learn more with our test challenge measurement briefs and videos at
www.microlease.com/keysight/daq
Buy from an Authorized Distributor 866 436 0887

KEYSIGHT TECHNOLOGIES
Unlocking Measurement Insights

Agilent's Electronic Measurement Group is now **Keysight Technologies**.

KASEY PANETTA | EDITOR
kasey.panetta@advantagemedia.com

Girls run the world?

As I sit at my desk listening to Beyonce's "Run the World (Girls)", I'm also reading an article about the U.S. Army finally opening up engineering positions to women for the first time. For those of you who aren't fans of the Queen Bee—honestly, it just came up on a playlist—the lyrics to the song are: "Who run the world? Girls (girls)" repeated over and over again. It's not exactly Chaucer, but that's not the point.

It's surreal background noise to listen to while reading an article that notes the U.S. Army, which has allowed women to join since 1942 with the establishment of the Women's Army Auxiliary Corp, *just* opened up over 20,000 engineering jobs to women that had previously been boys-only.

Now, women have been in combat roles since the Civil War. Sure, they were dressed as men, but they were doing the same role as men. How can girls run the world (or even be equals in it) when they don't have the same job opportunities as men?

The U.S. Army really just serves as a microchasm of society with more formalized rules about who can and can't be a leader or who can and can't serve in a particular role.

Women in STEM face a lot of similar challenges. Though the instances of overt sexism in engineering and science jobs are limited by laws and a general changing of societal attitude, it's the covert sexism that runs rampant. It's the people saying, "Girls don't like science because they're girls" or "girls and boys are biologically created so only boys will really want to pursue these careers." When you have a Nobel Laureate who opens a speech by saying girls don't belong in labs because they cry, or, worse yet, saying girls don't belong in labs because boys fall in love with them, you have a serious problem. That sound you hear while reading that is the simultaneous banging of heads against desks around the world. In 2015, a leader in the scientific field made a statement—which he later called a joke—about why all women shouldn't be in labs.

Everyone, boy or girl, needs encouragement to pursue a career in what can be a very challenging field. And if you're sitting in your office—perhaps also listening to Beyonce—thinking that you've never treated someone differently because she was a woman then that's great. But your job isn't done yet. Become a mentor or visit a classroom, show kids that STEM careers are great careers. Encourage everyone with an interest or aptitude to pursue STEM and slowly, we'll open the doors to everyone who wants to learn.

Until next issue,

Kasey Panetta
Editor
@kcpanetta
kasey.panetta@advantagemedia.com

TABLE OF CONTENTS

Departments

ECN
www.ECNmag.com

General Manager
Nick Pinto
nick.pinto@advantagemedia.com
973-920-7745

Editorial Director
David Mantey
david.mantey@advantagemedia.com

Editor
Kasey Panetta
kasey.panetta@advantagemedia.com

Associate Editor
Jamie Wisniewski
jamie.wisniewski@advantagemedia.com

Technical Contributor
Joshua Israelsohn
ECNjoshua@jas-technicalmedia.com

Regional Vice President of Sales, Midwest
Mike Francesconi
mike.francesconi@advantagemedia.com
973-920-7742

Regional Vice President of Sales, East
Glen Sundin
glen.sundin@advantagemedia.com
973-920-7038

CEO
Jim Lonergan

COO/CFO
Terry Freeburg

Chief Content Officer
Beth Campbell

List Rentals
Infogroup Targeting Solutions
Senior Account Manager, Bart Piccirillo,
402-836-6283; bart.piccirillo@infogroup.com
Senior Account Manager, Michael Costantino
402-863-6266;
michael.costantino@infogroup.com

Reprints
For custom reprints and electronic usage,
contact YGS Group;
1-800-290-5460
reprints@theygsgroup.com

For subscription related matters please contact: ABM@omeda.com. Or phone them at: 847-559-7560, or fax requests to: 847-291-4816

Advantage Business Media
Advantage Business Media
100 Enterprise Drive, Suite 600,
Box 912, Rockaway, NJ 07866-0912

BPA WORLDWIDE

PRINTED WITH SOY INK


Rapid Manufacturing with a Polite Disregard for Tradition
Tech-driven injection molding, CNC machining and 3D printing for those who need parts *tomorrow*
Proto Labs uses proprietary software and a massive compute cluster to accelerate manufacturing of prototypes and production parts for every industry.
Got a project? Get 1 to 10,000+ plastic, metal or liquid silicone rubber parts in as fast as 1 day.
Digital Manufacturing for DUMMIES
Request your free Digital Manufacturing For Dummies at go.protolabs.com/EC5TJ
ISO 9001:2008 Certified | ITAR Registered
Major Credit Cards Accepted | © 2015 Proto Labs, Inc.
proto labs®
Real Parts. Really Fast.™

TVS diodes suitable for aerospace applications

Littelfuse, Inc. has introduced six new series of high reliability TVS diodes that are upscreened for use in aerospace applications. The 5KP/15KPA/30KPA-HR and 5KP/15KPA/30KPA-HRA Series High-Reliability TVS Diodes are designed specifically to protect sensitive electronic equipment from voltage transients induced by lightning surges and other transient voltage events. They have been specially screened and sorted for use in DC line protection for applications that demand high reliability. Well-suited for robust DC power protection and ESD protection, these new TVS diodes series are designed for application in aviation electronics (avionics) like FADEC, airplane sensors, avionics computers, fly-by-wire flight control systems, cockpit electronic equipment, and airport landing aid systems. Other uses include industrial applications such as in the energy industry. **For more information, visit www.littelfuse.com.**

KEY FACT:
Military screening process flow ensures high reliability to meet the requirements of aerospace, military, industrial, and medical applications.

High brightness TFTs target outdoor environments

Industrial LCD manufacturer KOE has announced the introduction of three new TFT displays designed for use in outdoor environments. The 7.0-inch TX18D203VM2BAA, 8.0-inch TX20D200VM2BAB and the 10.4-inch TX26D200VM2BAB all feature high brightness, white LED backlights. All three displays have a brightness rating of 1500cd/m^2 which enables the displays to be used in environments with high levels of ambient light. KOE's high brightness LCD display modules are designed specifically for use under high ambient light conditions. The 1500cd/m^2 LED backlights ensure a high quality display image is maintained even under direct sunlight. **For more information, visit www.koe-europe.com.**

KEY FACT:
The new display modules also feature an anti-glare polariser coating which helps to disperse light in multiple directions effectively eliminating reflections.

Fluid-repellant sealant tape suited for belly fairings, engine nacelles, tail boom covers

W. L. Gore & Associates, Inc. (Gore) has enhanced its line of GORE™ SKYFLEX™ Aerospace Materials with a new aviation fluid-repellent tape. Available in various sizes, the new sealant tape is well-suited for use on belly fairings, engine nacelles, tail boom covers, fuel bladders and access panels. This gap filling material provides durable, reliable protection in the most demanding conditions, including wide temperature ranges, bending, flexing, and exposure to chemically aggressive aircraft fluids.

GORE™ SKYFLEX™ Aerospace Materials that repel aviation fluid consist of expanded polytetrafluoroethylene (ePTFE) — a proprietary material used in the construction that has been chemically modified to resist typical aircraft fluids. At the same time, these materials have non-hazardous properties that meet industry standards.

For more information, visit www.gore.com.

KEY FACT:
Unlike traditional two-component materials, the materials require no mixing, masking, curing, or cleanup after installation.

9,000

Number of utility generating plants operating on the North American electric grid.

Engineering Update #115: NASA's new deep space CubeSats

- **SpaceX hosts competition for the best Hyperloop pod design**
  SpaceX is holding a competition in June 2016 for students and engineering teams to design Hyperloop Pods.
- **A new app lets you drive your car with a smartphone**
  Jaguar Land Rover is testing a new system that allows drivers to remote control their vehicles using a smart phone app.
- **NASA's new deep space CubeSats**
  In 2016, NASA will launch its next mission to Mars and flying with it will be the first deep space CubeSats to hit the skies. Though the small modular spacecraft featuring off the shelf parts have been the talk of the industry for a while, they've mostly been relegated to missions that are a little closer to home.

20 percent

Amount of greenhouse gas emissions and oil use generated from medium and heavy-duty vehicles in the U.S.

TWEET

Pelonis Technologies @pelonistech

#FF We love reading @ecnonline's latest posts on #electronics!

Watch the first full-color HD videos of Earth from space

By Jamie Wisniewski, Associate Editor, @JamieECNmag

An HD camera mounted to the International Space Station (ISS) released its first videos of Earth from space. And they're pretty impressive.

This is the first time Urthecast, the satellite company behind the videos, has released footage taken from their color HD video camera, called Iris.

TWEET

ECNmag.com @ecnonline

Fun in the studio w/ @jamieECNMag @JMooneyWDD @kcpanetta + @ jonnyparmesan (not pictured) http://ow.ly/i/boD8N

This is the DoD's new hoverbike

By Kasey Panetta, Editor, @kcpanetta

Hoverbike is not a word you generally hear associated with the Department of Defense (DoD), but a recent announcement by U.K.-based Malloy Aeronautics at the Paris Air Show indicates that a partnership is in the works with Maryland-based SURVICE Engineering Co. to further develop the technology to suit the specific needs of the DoD. Together, the two companies are working on a contract with the U.S. Army Research Laboratory to develop the hoverbike to operate as a new class of Tactical Reconnaissance Vehicle.

Legislating power

Designing power supplies for the 21st century.

By Carol Pickford, ICCNexergy Technical Marketing Manager

In 2004, when California announced the first energy efficiencies mandates, other government entities were considering similar actions, but everyone seemed reluctant to take the first step. In the late 1990's, California recognized that energy demands were going to outpace the planned capacity of its power plants. At that time, studies showed that household proliferation of smaller external power supplies, such as those that powered cell phone chargers, internet connectivity devices, game boxes, cordless phones, portable audio equipment, laptop computers, etc., were not only already becoming a major contributor to the energy demand, but were expected to grow at an explosive rate. Particularly with cell phone chargers, due to low cost and high availability, it was not uncommon for users to have at least two devices. Both chargers were left connected to the grid 24/7, while most likely being used to charge the phone one-to-two hours per day. It soon became obvious that, while efficiency was important for external type power supplies, reducing energy consumption while they were idle, but still connected to the grid was even more important to reducing overall power consumption. Thus began the world's government bodies asking, and even insisting, the power supply industry build more efficient power supplies to reduce the waste in energy consumption.

After California declared legal requirements, the US government came out with the Energy Star program, a voluntary instead of mandatory requirement for efficiency. Once the EU declared minimum efficiencies, it was clear that the US was no longer a leader, but a follower in energy efficiency standards. In 2011, the US Department of Energy (DoE) began interviewing power supplies manufacturers, asking "If money was no object, what efficiencies could you achieve?"

When the DoE first came out with their proposal for the efficiency standards, the reaction from the power supply industry was enormous and severe. The new standard was to be 87 percent at 50 to 250 W, with a sliding scale of 85 percent to 87 percent between 18 W and 50 W, and a maximum 'no-load' input draw of 0.1 W for 0 to <50 W units, and 0.21 W for 50 to 250 W units. The previous requirements were also a sliding scale to 49 W, with 77.7 percent at 18 W, and 86 percent at <49 W to 250 W, and at 'no-load' condition, 0.3 W for 0 to <50 W units, and 0.5 W for 50 to 250 W designs. The biggest changes were expected in the lower powered units, nearly a seven watt improvement (almost 10 percent) at 18 W, where things like voltage drop through the output cable is a fixed loss without shortening the cable, or going to larger wire size. The lower the power level, the more the effect of fixed losses has on the overall efficiency of the power supply, making it even harder to reach the new proposed standards. On top of the overall efficiency, the no load power consumption was to drop to nearly one-third the current requirements. All of the changes needed to bring power supplies into compliance with the technology available at that time would require the loss of features that consumers wanted. This included things such as removing LEDs and shortening cables from the typical six feet to four feet or even as drastic as two feet. Even with those changes, power supply engineers were saying they could barely meet the requirements and still maintain a reasonable cost. Initial forecasts from the industry were showing a two dollar per unit increase in price to the consumer.

Based on all of the aforementioned comments, the DoE delayed the issuance of the ruling by a much-needed year. During that time, the LED industry made significant advances in their ability to provide reasonable brightness with considerably less power consumption. The designers of power supply control chips also took that time to finalize and bring into production new control chips that helped power supply designers achieve the higher efficiencies, particularly by boosting the efficiency levels seen when the power supply is at lighter load (~25 percent of full rated power). When the DoE released their requirements in 2014, although they were the same requirements as originally proposed in 2013, the industry now had better technology and components to comply with the new regulations.

Still the changes are not without cost. The two dollar power supply cost increase is no longer a concern, since the cost of power supply controllers have come down with more volume and improved efficiencies have allowed manufacturers to reduce box size. While these improvements offset much of the expected cost increases, there are other costs to the industry that come into play. As an example, let's say a company builds desktop supplies in the 18 to 220 W range and offers 10 standard power levels throughout that range. Of those 10 levels, one series is already compliant, six need only minimal changes to reduce no load power consumption, and three need redesign that will need to be submitted back through safety approval processes. For OEM customers of Information Technology Equipment (ITE) power supplies, roughly half of them will need to requalify their products. When customers perform a system evaluation and repeat their EMI testing, even with an external power supply, EMI must be tested with the entire assembly. While EMI profiles are usually expected to be close to old power supplies, they will not always be exact. If one of the peaks happens to shift a few dB so that is now at the same frequency as the system is generating, it could push the combined EMI at that frequency out of the allowed limits.

All power supply manufacturers must finish their design and agency approvals inside of two years, with enough time for their OEM customers to complete their evaluation and clear out their distribution inventory before the February 2016 deadline. There is a subsequent burden to OEM customers, who need to evaluate these new products and get them approved before the deadline so that power supplies shipped after February will meet their needs and expectations.

Reduction in cable lengths and elimination of LEDs were initial recommendations to increase power supply efficiency. (Photos courtesy of ICCNexergy).

As consumers ourselves, we appreciate the savings we will see in our own electric bills over time, in direct cost for energy saved in our homes and in indirect costs for future power plants that we will not have to support in our communities, but the industry as a whole has much work to be done in the coming months to prepare for the approaching deadline. ECN

The right power supply

Choosing the optimum power supply for test equipment.

By Paul Kingsepp, Product Manager, SL Power Electronics Corp.

The challenges in choosing the right power supply for new test equipment designs can be overcome by carefully choosing the right product for the application. When choosing a power supply, the basic starting point involves volts and amps, cooling requirements, size, and regulatory certifications, to name a few. If the criteria for choosing were only these parameters, an engineer's job would be easy. However, there are other important parameters that test equipment designers must consider when choosing the right power supply to integrate into their equipment. Electrical noise, in its many forms, is a major concern because the speed and accuracy of the equipment rests greatly on the ability to minimize noise and keep it away from the sensitive electronics, which sample and report the data that the equipment is designed to measure. Also important is the environment where the equipment can be used.

Noise

Electrical noise is a random or undesired fluctuation in the electrical signals or voltage source. It can be either differential mode (across power or signal lines) or common mode (between a power or signal line and a common ground) noise. Radiated noise is a form of electromagnetic interference (EMI) transmitted through the air by cables and components with AC voltages or currents. The radiated coupling can be very local; for example, between a transformer and a nearby wire or PCB trace, and become conducted noise. Differential mode noise (aka ripple and noise) can range from a few microvolts in linear type power supplies, up to hundreds of millivolts in switching types. The values for the levels of this noise are normally specified by the manufacturers in both rms and pk-pk, although the pk-pk noise is generally 10 times higher than the rms noise, and is potentially more troublesome to sensitive electronic circuits. Mitigation of the effects of this type of noise requires additional filtering, but since this noise is known when choosing the power supply, the effort required to minimize it is relatively easy.

Common mode noise (between power or signal lines and ground) on the output of a power supply is often overlooked and rarely specified on power supply datasheets. This may be due to lack of knowledge by power supply manufacturers of its impact on product performance, or that it may not be an issue for the types of applications that they target with their products. The power supply output, in some applications, is often shorted to earth or chassis in the end application. In this case, the common mode noise will likely not be an issue.

However, it can be instructive to understand the common mode currents that flow in the circuit while making their way to ground. If the output of the power supply is connected to chassis/earth ground somewhere on the load board (electronics circuitry), there can be common mode currents flowing through the board. In addition, if the PCB layout is not done properly, the current can flow through sensitive parts of the circuitry and cause it to malfunction.

All switching power supplies will have some level of common mode noise, the extent of which is dependent on many factors including power supply topology, filter designs and input-to-output isolation, to name a few. Since most power supply manufacturers do not specify the common mode noise performance on any of their documentation, the equipment designers are left in the dark when it comes to the common mode noise they will need to deal with. Power supplies that address common mode noise by minimizing it to practical levels, and also characterize the common mode noise profile of the units are worth serious consideration. Such power supplies will allow test equipment design engineers to determine the potential effects of this noise before spending hours or days characterizing this themselves.

Emissions, both radiated and conducted, are also a major concern when integrating a power supply into test equipment. Test equipment, like many other types of applications, needs to comply with certain levels of EMI. Both radiated emissions (RE) and conducted emissions (CE) need to be within either class A or class B of CISPR22/EN55022/FCC Part 15, depending on where the end equipment is meant to be used. Open frame power supplies typically meet class B for CE, and class A for RE. Power supplies are normally tested with resistive loads when certifying their performance to these standards. This sometimes presents a challenge to equipment designers in that once the power supply is integrated with the test equipment, the EMI profile will typically change, as other factors (cabling, grounding, etc.) can change the overall system performance to these standards. A power supply that is designed to meet these standards with some level of margin gives test equipment designers a better chance of maintaining compliance in their equipment. This minimizes development time and potential material cost to make the end system compliant.

Environment

Test equipment operates in many environments–production lines in factories around the world (both testing other products, and in the factories building the test equipment itself), design engineering labs, research labs, etc. Many remote environments present different challenges to the equipment designer, as the equipment must operate continuously and reliably in all geographies and environments the equipment is to be used. Unstable power sources, noisy (electromagnetic) environments, etc., can affect the operation of a power supply, and therefore, the system that it is used within.

In order to provide the best protection against external influences, compliance to the highest levels of Electromagnetic Compatibility (EMC) standards is needed. The typical standards are IEC61000-4-x, with the “x” being one of various numbers denoting a specific section of the standard. Most power supplies comply with various levels of certain sections of the IEC61000 standard, the following being the typical (figure 1).

IEC 61000-4-2 defines levels of Electrostatic Discharge (ESD) protection, using two different testing methodologies. Contact discharge involves discharging an ESD pulse directly from the ESD test gun that is touching the Device Under Test (DUT). Air discharge is the other, where an ESD test gun is brought close to the DUT until a discharge occurs.

- Levels 1 & 2 are reserved for equipment which is installed in a controlled environment and in the presence of anti-static materials.
- Level 3 is used for equipment which is sparsely, but not continuously handled.
- Level 4 is required for any equipment which is continuously handled.

Description	Section
Electrostatic discharge	IEC61000-4-2
RF Field Susceptibility	IEC61000-4-3
Electrical Fast Transients/Bursts	IEC61000-4-4
Surge Immunity	IEC61000-4-5
Conducted Disturbances induced by RF Fields	IEC61000-4-6
Power Frequency Magnetic Field Test	IEC1000-4-8
Voltage Interruptions, Dips, Sags & Surges	IEC61000-4-11

Figure 1. IEC61000 section descriptions. (All figures and images courtesy of SL Power).

For test equipment which comes in contact with operators regularly, level 4 (8kV contact, 15kV air) would provide the best protection for all environments.

IEC61000-4-5 relates to the immunity requirements, test methods, and range of recommended test levels

EN61000-4-11 Test Level and Durations for Voltage Dips

Class	Test Level and Durations for Voltage Dips (50/60Hz)				
1	Case by case according to the equipment requirements				
2	0% during 1/2 cycle	0% during 1 cycle	70% during 25/30 cycles		
3	0% during 1/2 cycle	0% during 1 cycle	40% during 10/12 cycles	70% during 25/30 cycles	80% during 250/300 cycles

EN61000-4-11 Test Level and Durations for Short Interruptions

Class	Test Level and Durations for Short Interruptions (50/60Hz)
1	Case by case according to the equipment requirements
2	0% during 250/300 cycles
3	0% during 250/300 cycles

Figure 2.

for equipment to unidirectional surges caused by over-voltages from switching and lightning transients. Several test levels are defined which relate to different environment and installation conditions. These requirements are developed for and are applicable to all types of electrical and electronic equipment, including test equipment. Areas around the world where unstable and unconditioned AC sources provide the power for test equipment–in labs, in factories, etc. will potentially subject the equipment to various surges that could potentially shut down, or even damage the equipment. Power supplies that are compliant to level 4 (4kV), will provide superior protection against high levels (2kV line-line, 4kV line-GND) of input surges.

IEC61000-4-11 defines the immunity test methods and range of preferred test levels for electrical and electronic equipment connected to low-voltage power supply networks for voltage dips, short interruptions, and voltage variations. This standard applies to electrical and electronic equipment having a rated input current not exceeding 16A per phase, for connection to 50Hz or 60Hz AC networks.

The standard describes three different tests:

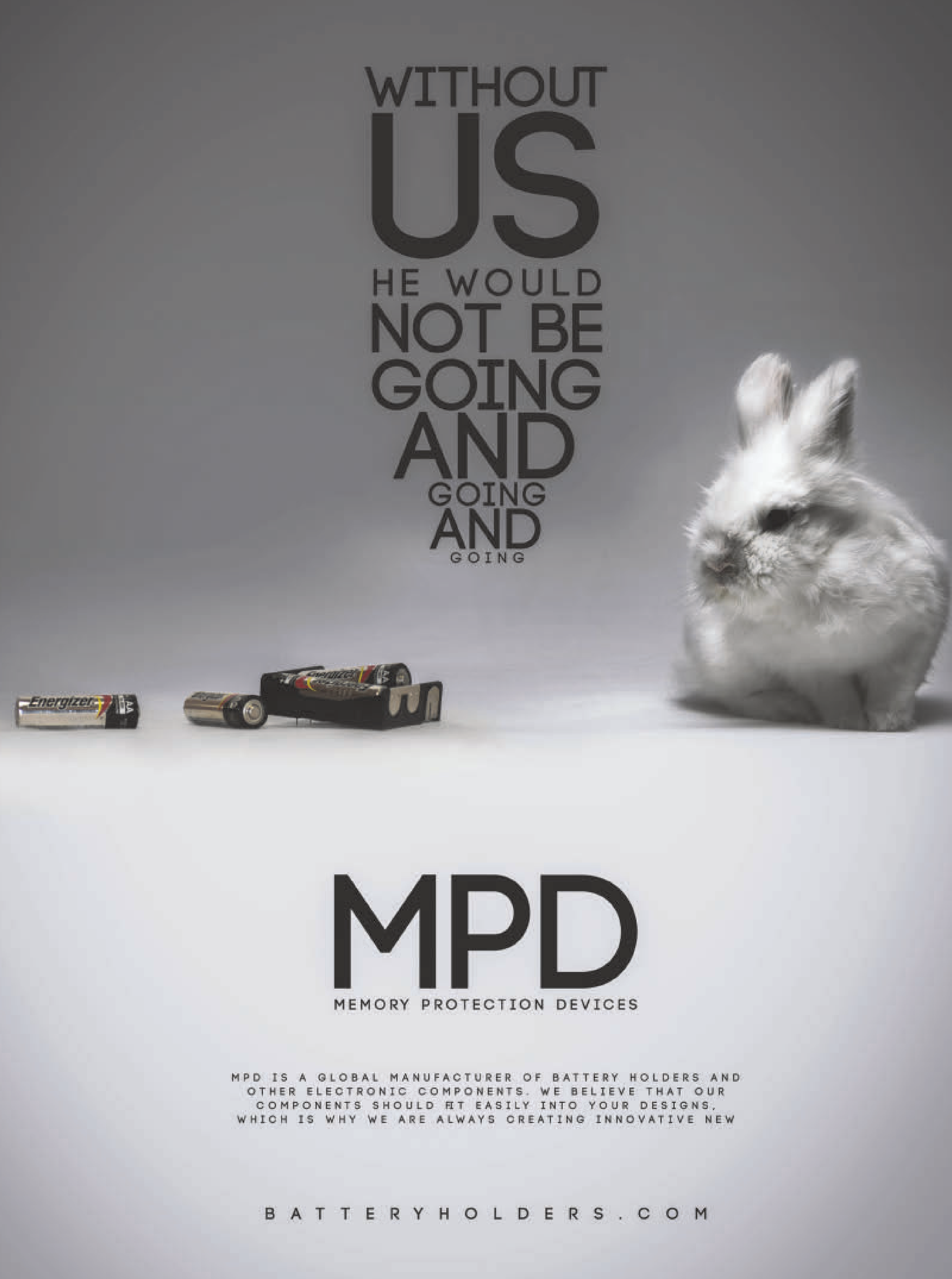
1. **Voltage dips** are defined as sudden reduction in voltage to lower voltages for a short period of time, followed by recovery to the original voltage.
2. **Short interruptions** are defined as a disappearance of AC voltage for a short period of time, typically not exceeding one minute, followed by recovery to the original voltage. Short interruptions can be considered as voltage dips to zero volts.
3. **Voltage variations** are gradual changes of the supply voltage to a higher or lower value than the rated voltage. The duration can be short or long.

The ability for a power supply to continue to operate during dips in input (mains) voltage and interruptions ensures that the equipment it is used in will also continue to function through these anomalies, minimizing any downtime. These voltage dips and interruptions vary in magnitude and length (figure 2):

Power supplies that have higher levels of hold-up time perform the best when subjected to these voltage dips and interruptions. They are able to ride through them, without output voltage deviation. Power supplies with short hold-up times will typically shut down and restart during these dips. The equipment designer will need to understand the operational nature of the equipment to determine if an intermittent shutdown is acceptable.

Engineers designing test equipment have many challenges to consider when choosing a power supply for use in their end equipment. External influences on the systems and circuits that perform the data sampling and measurement tasks in test equipment can adversely affect the function of those circuits, requiring equipment designers to spend a great amount of their development shielding these circuits from those influences. SL Power's TU425 series models (figure 3) were designed with these challenges in mind. The enhanced performance of these models to output noise, EMI, and EMC requirements will make the test equipment designer's development effort easier. ECN

Figure 3. SL Power's TU425 AC/DC 425 watt power supply is designed with the highest level of EMC and EMI protection.


WITHOUT
US
HE WOULD
NOT BE
GOING
AND
GOING
AND
GOING
Energizer
MPD
MEMORY PROTECTION DEVICES
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

The mission of the synthetic diamond

Synthetic diamond: superior heat spreader and enabler of next generation GaN transistors

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

As semiconductor devices continue to shrink and increase in power density, there is less area for heat to dissipate. As a result, heat fluxes are dramatically increasing, reaching temperatures as hot as five times that of the sun's surface, and more than half of all electronic failures are now heat related. Chipmakers are in need of new heat management solutions to continue the design and manufacture of next generation devices that consumers have come to rely upon and expect.

CVD diamond heat spreaders

Chemical vapor deposition (CVD) diamond heat spreaders have emerged as a leading thermal management technology, particularly for Gallium Nitride (GaN) RF power amplifiers. Diamond possesses a unique set of properties including the highest known thermal conductivity, as much as 2000 W/mK, of any commercial material at room temperature. Therefore, diamond is an excellent material for thermal management as it can significantly reduce overall package thermal resistance. Another strong advantage to CVD diamond is that it is engineered to have fully isotropic characteristics, enabling enhanced heat spreading in all directions. CVD diamond is also now readily available in commercial quantities and in different thermal gradients ranging from 1000 to 2000 W/mK; product prices depend on the thermal conductivity used.

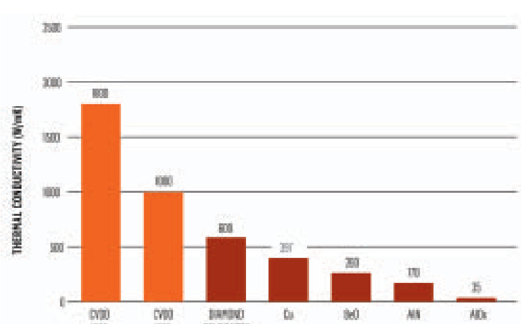


Figure 1: Comparison of thermal conductivity of CVD diamond and traditional heat spreading materials. [Source: "Integrating

Numerous studies and application examples demonstrate superior device performance when leveraging CVD diamond heat spreaders over other materials. In one example, a VDMOS power amplifier package was initially made with a Berillium/Oxide (BeO) heat spreader (7.50 x 3.00 x 1.00 mm) on a Copper/Molybdenum (CuMo) flange (34 x 10 x 1.60 mm). The end user was interested in lowering the overall thermal resistance of the system design and avoiding using BeO due to its toxicity. Thermal modelling was performed with parameters for heat-spreader thermal conductivity and thickness using an Indium/Tin based solder solution.

Out of 12 total design models, the model using CVD diamond with a thermal conductivity of 1000 W/mK and thickness of 0.30 mm had 30 percent lower thermal resistance compared to the original solution (See Figure 2). The almost horizontal, constant temperatures within the CVD diamond indicate that it's not even used to its full capability, yet the improved thermal resistance allows the device to function with better linearity in its RF performance and with improved reliability due to its reduced junction temperature, according to a 2006 Element Six internal thermal simulation.

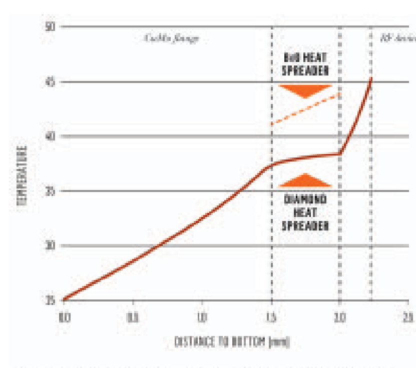


Figure 2: Predicted temperature profile as a function of height for an RF VDMOS power amplifier package having either a BeO or CVD 1000 heat spreader [Source: Element Six internal thermal simulation, C. Bibbe, 2006.]

Continued advancements

While CVD diamond heat spreaders have already proven to significantly reduce channel temperature and thermal resistance, researchers are continuing to explore new techniques and application processes for enhanced performance. Researchers have found metallizations to be an important aspect of CVD diamond package

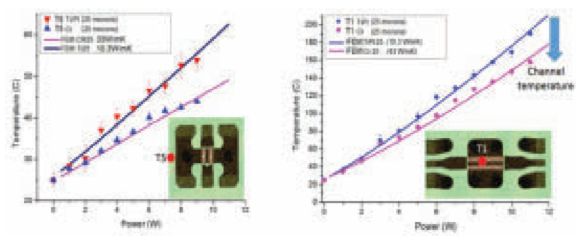


Figure 3: Temperatures as a function of power for different metallization schemed and solder thickness

integration to achieve optimal results. Typically, for adhesion and mechanical and thermal robustness, three-layer metallization schemes are used. A common scheme is titanium/platinum/gold (Ti/Pt/Au), often used in high-end devices because of its excellent stability and endurance characteristics. However, because the thermal conductivities of titanium and platinum are relatively low, researchers sought, and found, an improved material: chromium (Cr).

Chromium forms a carbide with diamond and is also readily used as a barrier layer, enabling it to perform both functions at a relatively high thermal conductivity of Tc=93.9 W/mk. To test the thermal effectiveness of chromium, samples were prepared at the Centre for Device Thermography and Reliability at Bristol University comparing a standard Ti/Pt/Au (100/120/500nm) metallization with this novel Cr/Au (100/500nm) configuration. Results showed the effective thermal conductivity of the Cr/Au metallization to be three to four times higher, compared to Ti/Pt/Au.

To demonstrate the advantages of a Cr/Au metallization compared to Ti/Pt/Au, high power GaN-on-Silicon Carbide (SiC) high electron mobility transistor (HEMT) devices were mounted to a CVD diamond heat spreader. To ensure comparable results, all samples were placed on a temperature stable platform also made from high thermally conductive diamond material. Results are shown in Figure 3. In the left diagram, the base temperature is plotted for increasing power output from the device. The temperature for the Cr/Au configuration is significantly lower, at 9 W device power output by about 10 °C. On the right hand side, the graph shows the temperature as measured on the transistor channel directly. In this case, the lower thermal resistivity of the Cr/Au metallization decreases the channel temperature by more than 20 degrees C at 9 W power output. The significantly lower temperature will result in as much as a four times longer device lifetime, or alternatively, will allow such devices to be packaged smaller and with higher power densities, according to a University of Bristol paper titled "GaN-on-Diamond High-Electron-Mobility Transistor – Impact of Contact and Transition Layers".

GaN-on-diamond wafers: The next step in improved device architecture

It's clear, from extensive research and positive results leveraging synthetic diamond heat spreaders, that there is room to continue modifying device architecture for improved performance. Engineers have long known the potential of GaN to help create a new generation of smaller and faster devices with greater power density.

Continued on page 19

Cooling for electronic systems

The importance of maintaining temperature in components

By Marc Caiola, Global Category Director, IT/Datacom, Pentair Electronics Protection (Schroff brand)

Processing power and the speed at which crucial networking equipment runs is steadily increasing to keep up with user application demands. Through technology advances, the size of these electronics is shrinking, resulting in greater board population density and higher power consumption. This yields increased heat generation throughout the data center where equipment is housed and operated. High heat levels can damage networking equipment and potentially eliminate a company's ability to effectively process, communicate, and store information. Implementing the proper cooling, airflow handling, and management solution will not only protect electronic systems from costly damage, but also ensure continuous access to company data and communications in an economically and environmentally responsible way.

Cooling solutions have become more sophisticated—providing new methods for improving cooling while enhancing overall efficiency to adapt to changing networking equipment and electronic systems designs. Design engineers can select and implement the ideal solution that adequately addresses individual cooling requirements by understanding the evolution of modern cooling solutions, along with their advantages and disadvantages.

The importance of efficient cooling

In the past, air optimization wasn't as critical as it is today. Most systems are designed with either front-to-rear or side-to-side cooling configurations. Each configuration utilizes high-powered fans to compensate for hot-running electronics, inefficient installation or leaks; these solutions may require noise dampening to minimize high fan noise emission from the system. Regardless of the selected configuration, or amount of heat generated by the system, airflow optimization is a key requirement to maximizing cooling efficiency.

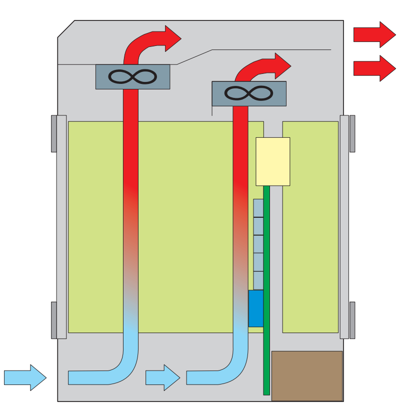


Figure 1: Pull configuration

Airflow optimization

Airflow optimization should be a design engineer's primary consideration from the earliest stages of system development. Board design has a direct effect on heat generation and airflow since heat sinks or densely populated boards create resistance. Cold air will naturally follow the path of least resistance. Thus, when combining high resistance and low resistance boards in a chassis, special consideration must be taken to optimize air flow.

To better control air flow, air baffles cover empty slots to ensure that air is directed where it is needed. For systems in which the board configuration does not change, a 'slot balancing' element may be used. This slot balancing element is a custom grille that redirects air to cards with greater resistance or heat dissipation and away from cards with lower resistance or heat dissipation.

Conventional fan cooling

Natural convection is the simplest and least expensive method of removing heat; however, it is only practical when the ambient temperature is significantly lower than the required internal temperature of the system. At a room temperature of 20°C or 25°C, convection can be used to remove 10 W per slot.

The most common method for convection cooling is forced air, which is sufficient for the majority of situations, and employed in the latest high performance systems. With forced air convection, natural convection is augmented with fans or blowers. Here again, the ambient temperature must be significantly lower than the specified system internal temperature. Typically, the temperature in the slot or chassis will be 10°Kelvin higher than ambient. Some individual components on the boards, such as processors, may be considerably warmer. In some cases, fan trays can be activated when the air resistance of the incorporated components reaches a predefined threshold.

Forced cooling techniques can be divided into three basic approaches: push cooling, pull cooling or a combination of push and pull. See side bar information.

Hybrid cooling: Air and liquid

When convection cooling alone is not sufficient, other alternatives must be considered. One solution is to lower the ambient temperature. By lowering the ambient

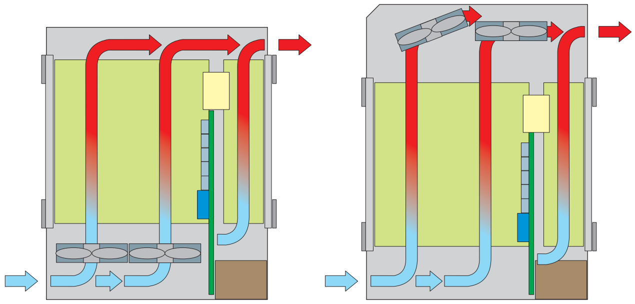


Figure 2: Push configuration

temperature to +25 °C, the maximum ΔT rises by 30 K from 10 K to 40 K, which makes it possible to cool four times as much heat. The ambient temperature can be adjusted by adding an air/water heat exchanger (AWHE) in the cabinet, with redundancy if high system availability is required.

Solutions with AWHEs at a system level rather than a cabinet level are also conceivable, as is the cooling of hotspots directly on the boards. However, it is important to evaluate the costs versus gains of each solution; the greater the complexity, the greater the cost. Energy costs should be considered for overall system design. Often the more complex water cooled systems will require less energy for ongoing operation. For example, by adding an AWHE, densely populated high-speed electronic systems only require a third or a quarter of the fan capacity.

Conduction Cooling

Conduction cooling is the method of using thermally conductive material to transfer heat from the PCB to a cold wall or heat sink. With a clamshell design, electronics are completely encapsulated, and thermal interface materials (TIMs) such as pads, paste, films, adhesives, and even solders are often used to improve the conductivity of the mating surfaces. Conduction cooling is typically used in rugged applications since it provides protection against environmental conditions such as shock, vibration, EMC and contaminants. While conduction cooling alone is limited on a system level, it can be used in conjunction with forced air or liquid cooling at the chassis level for a superior cooling solution. Conduction cooling is also used in environments where airflow is restricted (sealed chassis), or for environments such as in avionics where low-pressure air is not able to remove enough heat.

The demand for greater cooling is expected to continue. In order to continue to meet market demand, air cooling will be supplemented by fluid cooling at either the cabinet, system, or board levels. For a wide range of applications, it is still possible to provide adequate ventilation and fan capacity to handle excess heat generated despite growing power density per processor and dissipation loss per unit volume. When designing data center systems it is crucial to consult with a knowledgeable enclosure design partner, like Pentair, to ensure efficient heat management solutions that can mitigate the risk of costly performance disruption within the data center. ECN

Forced cooling techniques

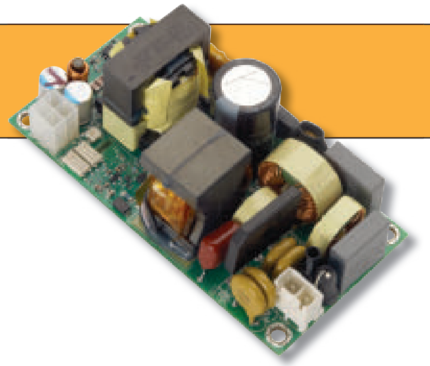
Push Cooling: Fans are positioned below the boards and the air is pushed over hot components. The fans in the push configuration are situated in a cold airstream and therefore not subjected to high working temperatures, so they tend to have a longer operational life. The push configuration generates positive pressure in the system, which helps to keep dust and other contaminants out of the chassis.

Pull Cooling: Fans are mounted above the boards, and they pull air up through the card cage. Fans are located at the top of the enclosure within a hot airstream, frequently resulting in a shorter fan life. In pull systems, radial blowers are often used which draw the air up from below and blow it horizontally out the rear of the chassis. Radial blowers typically eliminate the need for any redirection of the air, resulting in greater air flow, better air distribution and higher static pressure within the chassis.

Continued from page 17

By leveraging GaN-on-diamond wafers, which replace the typical silicon substrate and transition layers with CVD diamond, the diamond material can be brought within one micron of the heat generating gate junctions, according to a paper presented at the 2013 International Conference on Nitride Semiconductors. Initial users of GaN-on-diamond wafers for RF HEMT devices report as much as three times the power density when compared with similar GaN-on-SiC devices, which is currently the industry standard for advanced RF power devices, according to a paper presented at GOMACTech 2014. Leveraging GaN-on-diamond wafers also has also been proven to reduce thermal resistance by as much as 50 percent compared to GaN-on-SiC substrates.

While CVD diamond is not yet a mainstream semiconductor thermal management material, its use in high power density applications is rapidly increasing—especially as its thermal management properties become more advanced through improved synthesis and processing. As consumer demand and industry standards call for smaller and more powerful electronic devices, CVD diamond will become increasingly prevalent in design architectures. ECN



Portable instrument enclosures now customizable

New customization options are now available for METCASE's UNIMET-PLUS desktop and portable instrument enclosures. UNIMET-PLUS is a high quality range of robust metal cases for laboratory and communications equipment, medical and wellness devices, test and measurement, industrial control, peripherals, interfaces and switchboxes. METCASE – the metal enclosures division of OKW – now offers UNIMET-PLUS in custom sizes, complementing the existing six standard sizes (1.969" x 9.055" x 7.598" to 5.905" x 13.779" x 10.354"). Enclosures are available in custom heights, widths and depths. That also applies to 'H' versions of UNIMET-PLUS which feature a tilt/swivel bail arm that can be inclined to double as a desk stand. The bar of the bail arm is extruded so it can be easily manufactured in custom lengths. Installing PCBs is easy – they slide in on clip-in guide rails. Four polyamide guides are supplied as standard but extra positions can be punched into the chassis on demand to accommodate more guides.

For more information, visit www.metcaseusa.com.

AC-to-DC power supplies for space-constrained applications

GE's CLP0224FP and CLP0112FP are the latest addition to its open-frame, Compact Low Power (CLP) family of AC-DC power supplies. These new solutions complement the already released CLP0212FP solution, a 200-W, 12-volt AC-to-DC solution.

The CLP0224FP, 200-watt (W), 24-volt power supply delivers efficiencies of greater than 90 percent in a compact, high-density 2-by-4-inch footprint at 18W/inch3. The CLP0112FP offers similar leading efficiency levels in a comparable footprint but at 150-W and 12-volts.

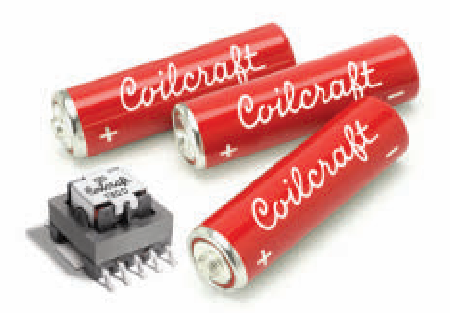
For more information, visit www.geindustrial.com.

Controller system controls motion on multiple axis

Velmex VXM Controller Systems are integral components of the power systems that efficiently drive motorized Velmex products including UniSlides®, BiSlides®, XSlides™ and Velmex Rotary Tables. The VXM Controller is a 2-phase, unipolar stepper motor controller that has the capability to drive and control precise movements, multi-axis and velocity. Velmex's VXM Controller System is capable of controlling to 4 motors, 1 motor at a time. Also two motors can be controlled simultaneously for coordinated motion. The VXM Controller's advance design delivers high, consistent performance and insures they are very efficient, reliable and easy to program.

For more information, visit www.velmex.com.

Current sense transformers detect switching current up to 40 Amps



Coilcraft is launching its new CST2010 Series of current sense transformers. The devices detect switching current up to 40 Amps over a frequency range of 50 to 500 kHz while also isolating circuits electrically, resulting in up to 10X lower power dissipation than current sense resistors. This makes them ideal for switched-mode power supply applications, including feedback control, overload detection, and load drop/shut down detection. The compact, surface mount CST2010 Series has a 14.55 X 19.91 mm footprint with a maximum height of 10.50 mm. Coilcraft offers eleven turns ratios (primary-to-secondary) within the series ranging from 1:20 to 1:200. The CST2010 Series also offers 500 Vrms isolation between windings and very low primary DC resistance (0.00036 Ohms). It features RoHS compliant tin-silver, over tin, over nickel, over phos bronze terminations and has an ambient temperature rating of -40°C to +125°C. **For more information, visit www.coilcraft.com.**

High input VVAs suitable for repeaters, wireless backhaul

RFMW, Ltd. announces design and sales support for a series of voltage-controlled variable attenuators (VVAs) from Skyworks Solutions. The SKY1223x series of attenuators is suitable for applications such as repeaters, wireless backhaul and wireless infrastructure. The four attenuators in the series, SKY12232-21, SKY12233-11, SKY12235-11 and SKY12236-11, are optimized for low distortion and centered at 1.95, 2.60, 3.15 and 3.8GHz respectively. Together, the attenuators cover operation from 1.45 to 5.0 GHz and have control voltages ranging from 0-5 V. Typical insertion loss of ~1.5 dB offers improved system efficiency and attenuation >25dB provides excellent receiver protection. All four attenuators are packaged as 4.9x3.2x1mm multi-chip modules. **For more information, visit www.rfmw.com.**

Harvesting and scavenging ambient energy

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

Energy harvesters have only enjoyed mainstream support from commercial power-management IC manufacturers for less than a decade. Yet this broad class of transducer, known for nearly two centuries, takes advantage of a wide variety of technologies and has been welcomed in a surprisingly broad range of applications.

The Seebeck, Peltier, Thomson, and photovoltaic effects were all first observed between 1821 and 1851. The piezoelectric effect was first observed only a few decades later in 1880. However, with a few exceptions, such as with photovoltaics, devices based on these 19th-century discoveries in electro-physics could not serve as either primary or supplemental power sources until relatively recently.

Reasons are several fold:

- Until recently, functional loads dissipated far too much power to operate from ambient sources.
- Lacking one or more market-driving applications, energy transducers had yet to realize economies of scale, often rendering them too expensive for adoption as sources.
- Without market rationale for transducer R&D investment, many harvester technologies delivered only marginal transduction efficiencies.
- Truly wire-free nodes require wireless communication and suitably low-power technologies for that critical function were not in evidence either.
- Efficient power-conversion ICs compatible with energy-harvesting transducers' output characteristics were not available.
- Dense, economical energy-storage options were limited.

In the last decade, disparate engineering disciplines have contributed independently to resolving these six issues. Note that these developments were not specifically to make electronics that operate on ambient energy, but instead to resolve technical challenges affecting mainstream applications.

For example, IC process, device, and circuit-design advances have enabled low-power measurement AFEs, small microcontrollers with various on-chip analog and digital peripherals, and standards-based short haul radios that can form flexible networks. Transducer improvements in photovoltaics have received wide notice and metallurgy determines thermocouple performance, but other transducers have benefitted from less-well-publicized technology improvements.

What has changed less dramatically are product-design methods, which need to accommodate the source-energy limitations imposed by small systems operating on ambient energy. Specifically, energy budgeting is a critical part of the design process on both the source and load side, whereas normally, source energy is not so stringent a limitation.

Unlike systems powered from mains or battery connections, power budgets for ambient-powered products must include both average dissipation and an assessment of instantaneous energy use versus time through complete use cycles. The latter helps designers ensure that at no moment does the time integral of energy use drive the available energy store below the minimum operating voltage. Think capsule power-up sequence from the 1995 Ron Howard film Apollo 13.

Harvesters versus scavengers

During the earliest days of modern energy-harvester IC commercialization, I had the opportunity to interview a good number of engineers in both the power management and end-application spaces. It became readily apparent that, applications fell into two distinct categories with regard to source energy.

From this, one can draw a distinction between energy harvesting and energy scavenging. In this comparison, energy harvesters convert energy from sources directly associated with the application. An example of harvesting in this view would include a machine design that uses an autonomous monitoring node to measure, say, the temperature of a motor's stator winding, with that node converting energy from mechanical vibration or heat emanating from the monitored motor. In this case, the node's energy source is the very machine that the node monitors. By relying on the application to provide the node's energy, the designer can characterize the node's energy source with better confidence than if the node depended on an unrelated and uncorrelatable source.

By contrast, a scavenger would be an energy converter

for which the source and load are unrelated. Most ambient-RF-based power converters fall into this category. Systems that depend on energy scavengers require greater design effort to characterize potential sources, and likely depend more on local energy storage with continuous or near-continuous replenishment by the scavenger for a, typically, ultra-low-duty-cycle load.

I admit that the nomenclature failed to catch on within the industry at large. One obvious weakness is that the word scavenger strikes some as derogatory no matter what explanation follows. Few manufacturers are likely to embrace that association (although I've noticed that the U.S. Department of Energy—less concerned with subtle implications of commercial speech—uses it freely). For designers, however, the concept is useful: If your energy source is tightly associated with your ambient-powered function, your source-characterization task is simpler and likely more reliable than if your source is independent of your application.

Harvesters and Scavengers versus Generators

In discussions with industry experts more recently, I've found another distinction worth making for some applications: harvesters and scavengers versus generators. In this view, the design of harvester- and scavenger-based power subsystems proceed to support specific load energy-use characteristics whereas generator-based power-source specifications are not so closely associated with the behavior of a given load. This perspective allows differentiation between cases using similar energy acquisition technologies but demanding different design procedures with regard to energy budgeting.

Photovoltaics offer numerous examples. Compare, for example, the precision with which future energy acquisition assessments must proceed for a large-scale solar farm, rooftop mounted solar panels, and the solar-electric transducer for a multi-space parking kiosk, as shown in figure 1.

The solar farm and rooftop panels require pre-construction energy acquisition assessments as part of a site evaluation to justify their required investment. Seasonal performance fluctuations are included in the process of setting expectations.

The kiosk-mounted solar panel, however, must scavenge sufficient energy to keep the kiosk operating year round including during winter months when the solar angle is low, daylight

Figure 1: Municipalities increasingly enjoy lower maintenance and collection costs after switching from traditional per-space parking meters to solar-powered multi-space kiosks such as this VenSTATION with battery backup from VenTek International. (Photo courtesy JAS Technical Media; used by permission)

hours are short. The cost of overestimating source energy is system failure.

As do many applications, the parking-kiosk example benefits from the happy accident that most of its in-use hours coincide with daylight hours. Transactions typically take a minute or less and, although the system cannot control the time between transactions as it can in many data-collection applications, one can derive typical and worst case numbers from traditional meter-use data. Between uses, the system can shut down leaving only a low-power microcontroller to look for a user key press and the power subsystem to charge the battery.

The choice is yours

At present, power management ICs are available for a wide variety of transducer types and some accommodate multiple transducers, increasing the opportunity for systems to operate without battery backup. For those that can, eliminating batteries reduces system cost, eliminates one source maintenance expense, and increases system reliability. For those that do require a secondary electro-chemical energy source, battery chemistries have been improving their cost, density, and charge-cycle count performance.

Potential ambient-energy transducers for harvesting or scavenging include kinetic, thermo-electric, solar, mechanical stress, and RF. If triboelectric transducers and their power converters become practical, we may see a resurgence of corduroy in the wearables market but, until then, your wardrobe remains safe.

Of course, not all ambient energy sources are created equal. Available energy, be it for harvesting or scavenging, is available in quantities that, across all source types, vary over six orders of magnitude, as figure 2 shows. **ECN**

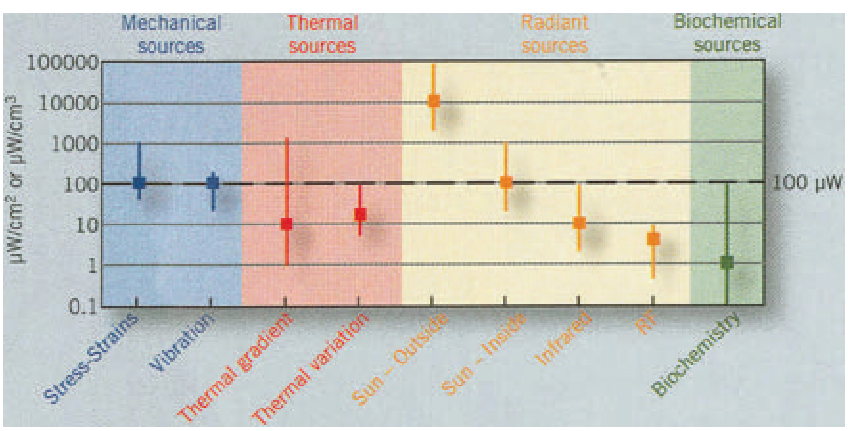


Figure 2: A comparison of ambient energy sources (before conversion). (Data source: CEA-Leti; graphic source: Linear Technology; used by permission)

Acknowledgements:
The author thanks Tony Armstrong of Linear Technology and Peter Dipo-Ajayi of Texas Instruments for sharing their insights.

Choosing the right processor for synthetic aperture radar

By John Warner, Dan Wang, Murtaza Ali, Texas Instruments

Synthetic Aperture Radar (SAR) is a radar technique involving moving the radar platform to create the effect of a large antenna and thus achieving high-resolution remote sensing imagery. SAR image formation algorithms rely heavily on digital signal processing techniques such as FFTs (Fast Fourier Transform) and matrix manipulations. Additionally, processing the data effectively through the signal processing chain requires rearrangement of data in memory. SAR systems thus use processors that can efficiently handle both computations and data manipulation. This article discusses these requirements and provides an example of multicore digital signal processor (DSP) processor for SAR image formation.

SAR System

A SAR system, carried by a space borne or airborne platform moving along a fixed track, gathers signals reflected from the targets at different positions at different times (Figure 1). The antenna transmits a short chirped waveform with a given pulse repetition frequency (PRF). The reflected echoes from the scene are collected, digitized and stored for processing. In order to create a focused image, the raw data passes through a chain of signal processing steps. Here, we will focus on the most widely used method known as range-Doppler (RD) algorithm.

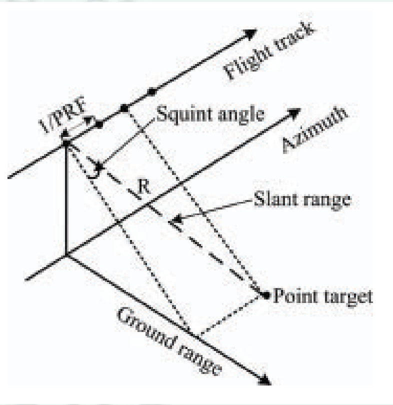


Figure 1: geometry of SAR data collection

RD algorithm

The main steps involved in the RD algorithm are: range compression, matrix transpose or corner turning, range cell migration correction (RCMC) and azimuth compression (Figure 3). Range compression compresses the received pulse along the range direction to concentrate the main energy into a narrow duration. This compression is achieved with matched filtering implemented as complex multiplication in the frequency domain, involving FFT, multiplication with a reference and IFFT (inverse FFT). Matrix transpose is purely memory access operation to arrange the range compressed data so that it can be read and processed along the azimuth direction. Range migration is caused by the range variations due to the platform movement. RCMC adjusts distance at each radar position. Azimuth compression can then be conducted along each parallel azimuth line.

RCMC is often treated as part of azimuth compression. After carrying out FFT in Azimuth, a delay interpolation filter is applied in the range direction for correcting range migration. Since data is now arranged in azimuth direction (needed for efficient azimuth FFT), RCMC interpolation operates with discontinuous memory access. The range corrected frequency domain azimuth is then multiplied by an azimuth compression reference and a final IFFT is performed to create 2-D focused image.

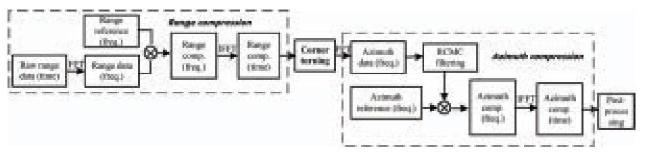


Figure 3: Details of range Doppler algorithm for SAR image formation

Mapping RD algorithm to a processor

Modern day processors employ multicore paradigm to increase processing capability while maintaining low clock rate to reduce power dissipation. They also use memory hierarchy to allow processing of a large amount of data with limited on-chip memory. Moving the data through this memory hierarchy to and from the processing core often becomes challenging and limits the actual realization of the processing capabilities in the processor. The ratio of compute capabilities to external memory interface bandwidth becomes a more important parameter than the absolute raw processing power of a processor.

The range Doppler algorithm is dominated by FFT operations. The large SAR data will be on external memory accessed via the memory interface, e.g., DDR3. The data needs to be in on-chip memory for efficient FFT. The access of the data can be through cache or through direct memory access (DMA) mechanism. The DMA allows data transfer and computations to be performed in parallel through a ping-pong buffering mechanism as illustrated in Figure 5. Data is transferred between external memory and ping buffer while FFT is being performed on pong buffer. The functions of the ping and pong buffers will be switched in the next step.

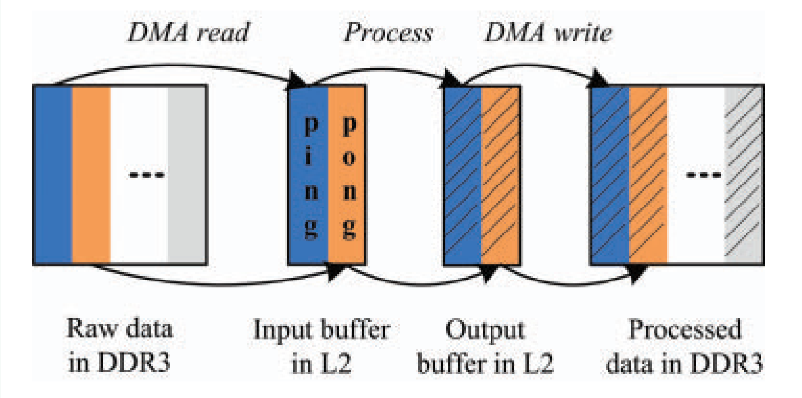


Figure 5: ping pong buffer scheme for overlapping of data transfer with computations

The corner turning poses a special challenge since memory access in one direction is strided causing poor memory interface efficiency (memory interface is most efficient when data are accessed sequentially). To improve this efficiency we can take the approach shown in Figure 6 that brings in a 2-D sub-block in on-chip memory, transpose it and then push it back to DDR3. For best performance, the processor needs to provide the capability to gather a 2-D sub-block from external memory to internal via DMA and then scatter it back to external memory.

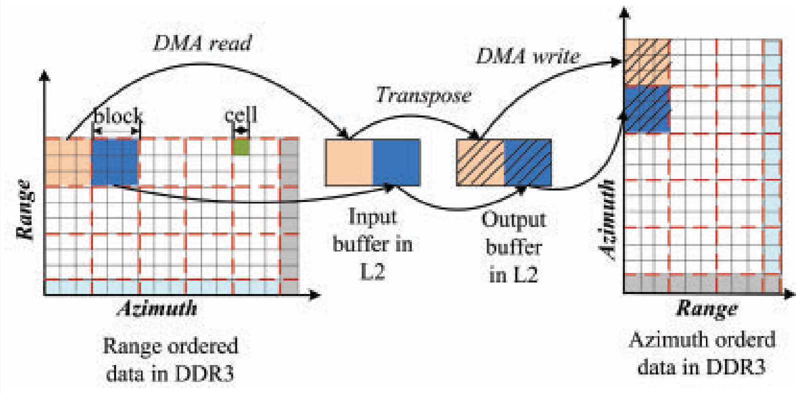


Figure 6: corner turning with ping pong buffering

Synthetic aperture radar system requires intense computational effort due to the large data size and complicated processing procedures. While choosing the right processor for such a system, designers need to consider often competing requirements:

- Power efficiency
- Computational capability
- Efficiency in data transfer between internal and external memory

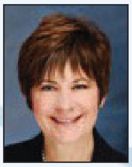
The new generation of multicore DSPs provides an excellent choice as a computational platform for SAR implementation. The DSP instructions allow power efficient implementation of FFT operations and various matrix manipulations. The computation tasks can be easily distributed to multiple cores and process the data in parallel. In addition, the direct memory access mechanism allows overlapping data transfer with computation, thereby, reducing overhead in data transfer among memory hierarchy. ECN

BRAINSTORM

MODERATED BY KASEY PANETTA
EDITOR

A question to ECN's Editorial Advisory Board:

Q: What is the most interesting thing happening design engineering?



Stacey M. DelVecchio, Additive Manufacturing Product Manager, Caterpillar Inc.

Well that has to be topology optimization as applied to additive manufacturing. Topology optimization sounds terribly complex, but basically, it means that you design something in the most optimal way to meet the function of what you need. Using this technique, you can find the best concept design that meets the design requirements. You don't have to worry about how to make; you just design it to be perfect. Nature has mastered this concept. If you need a photovoltaic cell, all you need to do is look at a leaf. If you need a strong foundation, look to the roots of a 100 year old oak tree. While software does exist to facilitate these kinds of designs, we've historically been stuck with the obvious obstacle that once designed, you have no way to manufacture your design.

Enter the world of additive manufacturing or 3D printing. With additive manufacturing, we now have the ability to actually create some of these amazing designs that we never dreamed were possible. Gone are the days where we have to design for manufacturability. Now we can just print it. While I'm making this sound super easy, there is still a lot of engineering that goes into printing these incredible designs, but the key here is that it's possible. Advances in 3D printing machines and materials are happening every day, making this technology faster and cheaper and more reliable. And that means we're getting closer and closer to not only being able to manufacture that design that looks like a leave, but we're also be able to make them as a viable production source.

The future is now. Embrace it.

Jeff Bader, VP Embedded Business Unit, Micron Technology, Inc.

The era of IoT and Smart Connected devices presents an interesting opportunity for embedded designers. Historically, embedded applications allowed designers to focus on functionality and performance based on a relatively fixed product definition. With every device connected to the Internet, embedded designers need to consider future-proofing components. They must not limit the scope of design based on today's functionality, but take into account the ability to field upgrade their devices to meet future requirements.

IoT embedded functionality is expanding from the device to include analytics software in the cloud. This presents an opportunity to change the scope of functions performed by the device itself. While these capabilities offer unprecedented benefits, it also open doors for hackers to exploit these always connected devices. Security is currently considered one of the biggest barriers to growth of IoT.; these devices must be designed from the ground up with security in mind across hardware, firmware, and communication stack.

As companies race to capitalize on the IoT trend, consumers demand delivery of the IoT promise of integration and interoperability. This requires a shift in mindset from when hardware features defined the device to a "Software Defined Device" era; and requires designers to rethink their hardware, memory and storage choices and budgets. Managing these future needs with today's costs and power constraints is the new balancing act for embedded designers, and a phenomenal opportunity.

Advertisers Index

ECN® (ISSN #1523-3081,USPS #172-060), (GST Reg. #844559765) is a registered trademark of and published monthly except semi-monthly in June (13 times per year) by Advantage Business Media, 100 Enterprise Drive, Suite 600, Box 912, Rockaway, NJ 07866-0912. All rights reserved under the U.S.A., International, and Pan-American Copyright Conventions. No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, mechanical, photocopying, electronic recording or otherwise, without the prior written permission of the publisher. Opinions expressed in articles are those of the authors and do not necessarily reflect those of Advantage Business Media or the Editorial Board.
Periodicals Mail postage paid at Rockaway, NJ 07866 and at additional mailing offices. POSTMASTER: Send return address changes to ECN, P.O. Box 3574, Northbrook, IL 60065. Publications Mail Agreement No. 41336030. Return undeliverable Canadian addresses to: Imex/Pitney Bowes, P.O. Box 1632, Windsor Ontario N9A 7C9.
Subscription Inquiries/Change of Address: contact: Omeda Customer Service, PO Box 3574, Northbrook, IL 60065-3574, 847-559-7560, Fax: 847-291-4816, email: abecn@omeda.com. Change of address notices should include old as well as new address. If possible attach address label from recent issue. Allow 8 to 10 weeks for address change to become effective. Subscriptions are free to qualified individuals. Subscription rates per year are $93 for U.S.A., $112 for Canada, $175 for Mexico & foreign air delivery, single copy $8 for U.S.A., $12 for other locations, prepaid in U.S.A. funds drawn on a U.S.A. branch bank.
Notice to Subscribers: We permit reputable companies to send announcements of their products or services to our subscribers. Requests for this privilege are examined with great care to be sure they will be of interest to our readers. If you prefer not to receive such mailings and want your name in our files only for receiving the magazine, please write us, enclosing your current address mailing label. Please address your request to Customer Service, P.O. Box 3574, Northbrook, IL 60065-3574.

Optical shaft measurement systems designed to provide fully automatic measurement of smaller shafts

Mahr Federal has introduced a new addition to their growing family of optical shaft measurement systems. Competitively priced and designed to provide fast, accurate, fully automatic measurement of smaller shafts and turned parts directly on the shop floor, the MarShaft™ SCOPE 250 plus features a highly accurate matrix camera with four million pixels. The system measures parts up to 250 mm in length and 40 mm in diameter with an accuracy that is previously unknown in this market segment. An MPE (Maximum Permissible Error) of less than 1.5 microns + L/40 when measuring diameter and an even more impressive 3 microns + L/125 when measuring length is significantly more accurate than other systems using line cameras.

One key to the system's speed is the state-of-the-art, high-resolution CMOS matrix camera with a live image field of view of 40 x 24 mm, enabling it to capture an entire part diameter in a single view. With Z-axis positioning speeds of up to 200 mm/second and an image acquisition rate of over 120 images per second, measurements are performed faster than the blink of an eye. Zoom functions allow measurement of the smallest details such as chamfers and radii, which can be difficult and in some cases even impossible to test, with conventional measuring methods.

For more information, visit www.mahr.com.

Mars Curiosity Rover

By Kasey Panetta, Editor

The day the Mars Curiousity Rover landed was a landmark day for NASA.The robotic rover, tasked with exploring the Gale Crater, landed on August 6, 2012 after a long journey from Earth.

CURIOUSITY (Mars Science Laboratory)

Length: 10 feet
Width: 9 feet **Height:** 7 feet
Weight: 1,982 pounds
Robotic arm: 7 feet long
Power: Multi-mission radioisotope thermoelectric generator

the LAUNCH

Launched: Nov. 26, 2011, 10:02 a.m.
Launch vehicle: Two-stage Atlas V 541
Distance from Earth to Mars at launch: 127 million miles
Program: $2.5 billion
Total time in air: 254 days

MARS

the MISSIONS:

- **Assess habitability**
- **Learn about past environments**
- **Study the modern environment**
- **Scientific objectives:** 8

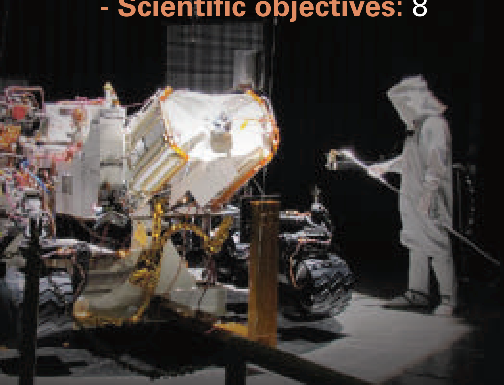


Image credit: NASA/JPL-Caltech

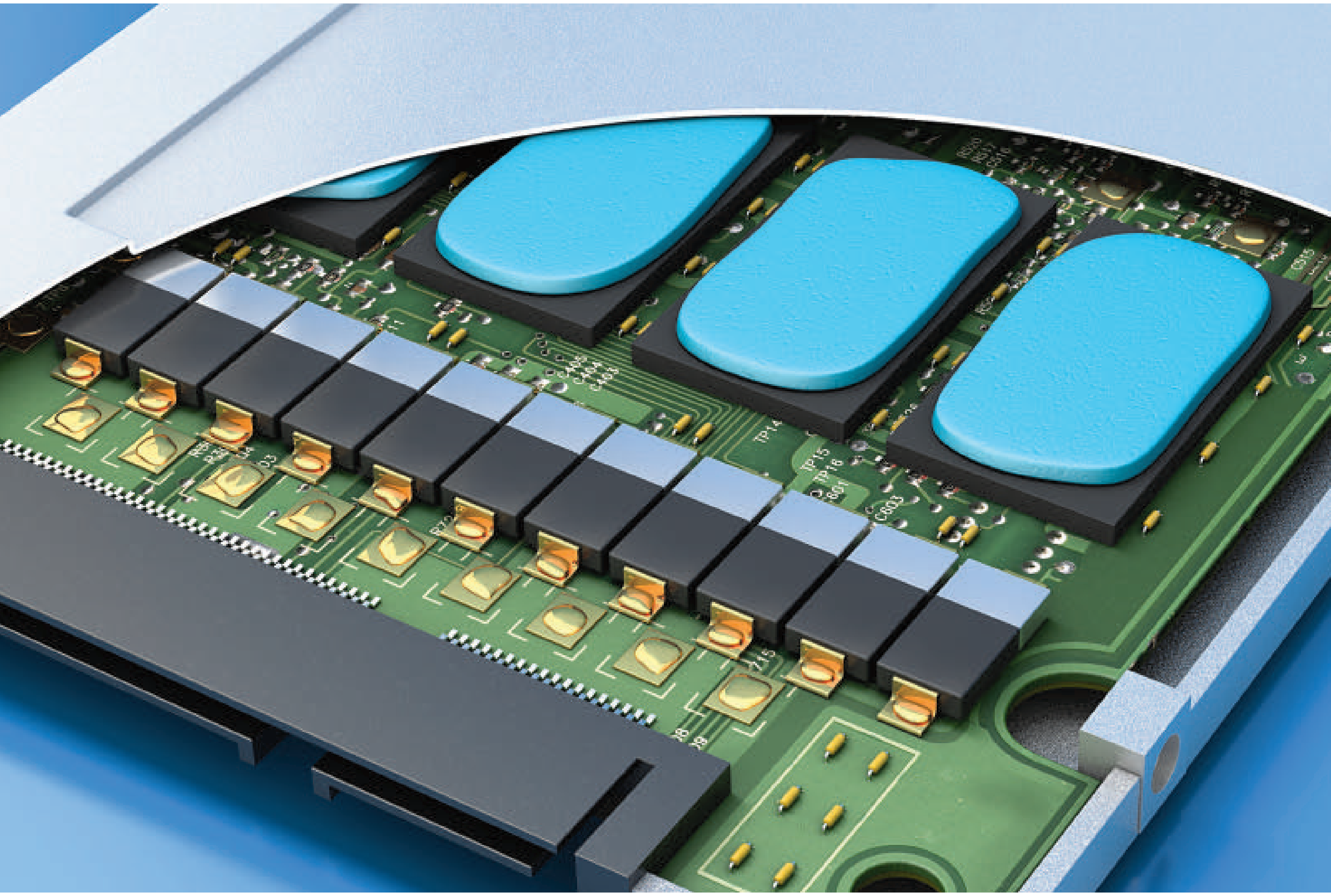
the PLANET

Named for the Roman god of war, agriculture, and the state
Average temp: -64°F
Atmosphere: 95% Carbon; 3% Nitrogen; 2% Argon
Moons: Phobos and Deimos (irregularly shaped)
Day: 24 hours, 39 minutes
Revolution around sun: 687 earth days

the LANDING

Landing site: 4.6 degrees south latitude, 137.4 degrees east longitude
Speed on approach (Martian atmosphere): 13,200 mph
Distance from Earth to Mars on landing: 154 million miles
Landing: 3 p.m. (Local time)
Mission life: 98 weeks (1 Mars Year)

designed by Larry Corby, Digital Artist



Bergquist Highly Engineered Liquids Give You Complete Flexibility Over The Design And Delivery Of Your Thermal Solutions.

Our full line of liquid polymers make it easy to customize your material, pattern, volume and speed.

Henkel's Bergquist brand consists of advanced liquids that are specifically designed to support optimized dispensing control with excellent thermal conductivity. Dispensed in a liquid state the material creates virtually zero stress on components. It can be used to interface and conform to the most intricate topographies and multi-level surfaces. The material remains in place after dispensing and prior to cure. Unlike pre-cured materials, the liquid approach offers infinite thickness options and eliminates the need for specific pad thicknesses for individual applications.

Whether automated or hand dispensed, Bergquist liquid materials have natural tack and precisely flow into position for a clean final assembly with little or no stress on components.

Less stress, reduced application time with minimal waste.

Either manual, semi-automatic or automated dispensing equipment offers precise placement resulting in effective use of material with minimal waste. Boost your high volume dispensing needs by capitalizing on our expertise. Bergquist can help customers optimize their delivery process through its unique alignment with several experienced dispensing equipment suppliers.

Visit us for your FREE liquid samples.

Take a closer look at the our line of liquid dispensed materials by getting your FREE sample package today.Simply visit our website or call us directly to qualify.

Request your FREE Liquid TIM Dispensed Sample Card

Call **1.800.347.4572** or visit **www.bergquistcompany.com/liquiddispense**

www.bergquistcompany.com **1.800.347.4572**

9 5 2 . 8 3 5 . 2 3 2 2 f a x 9 5 2 . 8 3 5 . 0 4 3 0

18930 West 78th Street • Chanhassen, Minnesota 55317

BERGQUIST

Thermal Materials • Thermal Substrates • Fans and Blowers

Who will drive the future of the transportation industry?
You and NI will. From passenger vehicles to rail systems, the transportation industry is struggling to deal with increased electronic complexity, higher demands on safety, and accelerated time-to-market requirements. See how NI helps simplify rapid control prototyping, in-vehicle data logging, and a variety of other critical applications at ni.com.
NATIONAL INSTRUMENTS™
©2014 National Instruments. All rights reserved. National Instruments, NI, and ni.com are trademarks of National Instruments. Other product and company names listed are trademarks or trade names of their respective companies. 18586