

Gill Sensors & Controls
has announced its Oil
Debris Sensor.
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MicroPower Direct has announced
its MHI200LRI8 series of high
isolation 2 W DC-DC converters.
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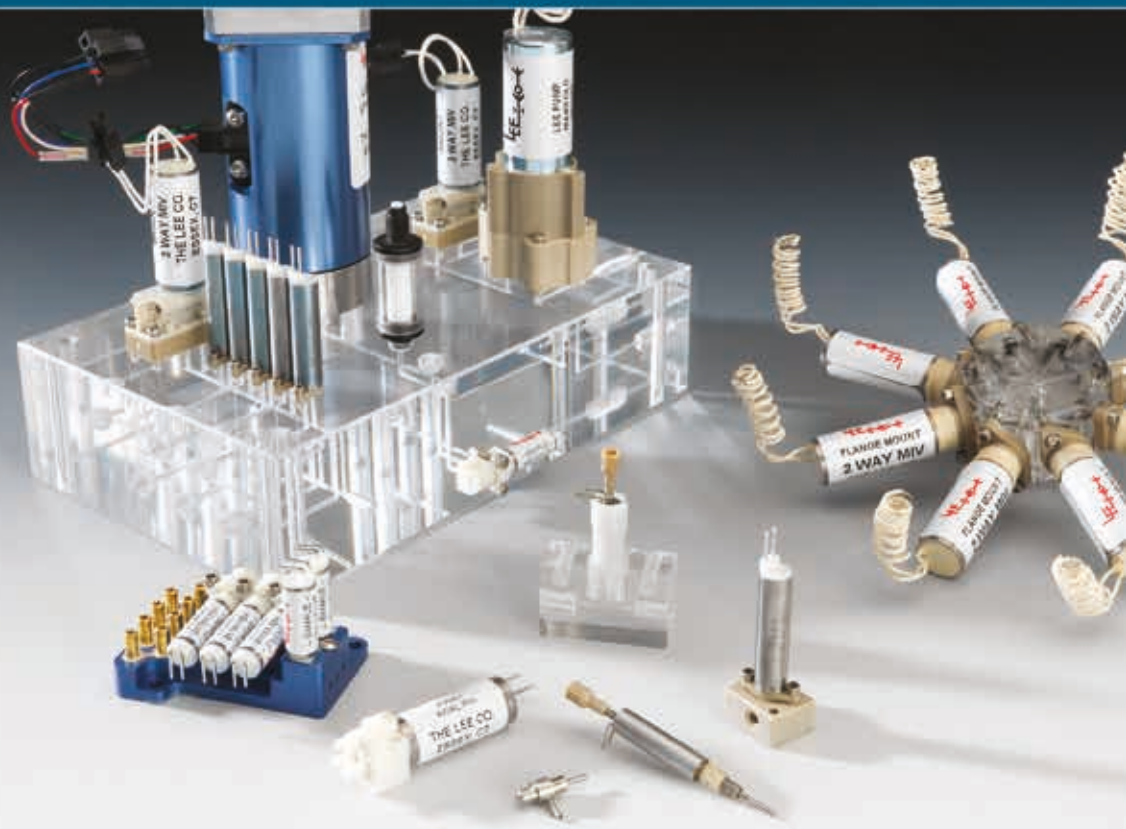


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Developing a New Material for Stronger 3D Prints

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PRODUCT DESIGN & DEVELOPMENT® (ISSN #1084-7278, USPS #445-920), is published monthly in Mar, Apr, Sept & Oct, bi-monthly in Jan/Feb, May/Jun & Jul/Aug, & Nov/Dec (8 times per year) by Advantage Business Media, 100 Enterprise Drive, Suite 600, Box 912, Rockaway, NJ 07866-0912. No part of this publication may be reproduced in any form without 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.

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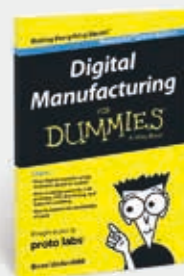
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At Issue

Lee Goldberg, Editor



Regardless of how you feel about climate change, you can take comfort in the fact that America's commitment to the goals of the recently-ratified Paris accords has opened up our nation to one of the biggest business opportunities we're likely to see in this century. Rather than rely on another war to drag us out of our current economic doldrums, the next boom could be fueled by the demand for clean energy, energy-efficient products, and the other tools we need to create a lower-carbon economy.

There are also many opportunities to capitalize on the steadily-growing global market for renewable energy systems and energy-efficient products. The demand is already high in Europe, where energy has traditionally been expensive, but there are also potentially huge markets for the advanced energy technologies throughout Africa, Asia, and Latin America. Some of these products can be manufactured at a good profit in domestic factories while others can be licensed for overseas production.

A Green Future & a Green Bottom Line

Even if you choose to ignore the environmental benefits, it's becoming increasingly clear that investing in a sustainable future yields higher and more sustainable returns. There are at least three advantages to adopting a green bottom line that even a hard-nosed entrepreneur can't ignore.

First, renewable energy liberates our economy from the wild cost fluctuations of fossil-based energy sources. While oil and gas will inevitably soar above the historically-low prices we've recently seen, the cost of solar, wind, geothermal, and bio-derived energy will continue to drop as the technology matures. And those savings don't even include the billions we won't have to spend protecting our off-shore fossil energy interests.

In addition, energy-efficient vehicles, equipment, and other products save money. Lower utility and gasoline bills can help the average family stretch their monthly budget further while the savings for businesses and manufacturers can add up to a significant bump in their bottom line. That's why energy-efficiency is becoming one of the key deciding factors when consumers, businesses, and governments make purchasing decisions for many products.

But don't take my word for it. Take, for example, the Regional Greenhouse Gas Initiative (RGGI, www.rggi.org), a cooperative effort among the states of Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont to cap and reduce CO2 emissions from the power sector.

According to a study (bit.ly/1I92nnC) conducted in 2015 by the Acadia Center, an advocacy group, the states participating in the RGGI enjoyed growth in their gross domestic product of more than 21.2 percent between 2009 and 2014. Meanwhile, non-RGGI states' GDP grew only 18.2 percent. At the same time, the participating states' emissions dropped by 35 percent, compared with 12 percent in other states. Surprisingly, the Acadia center reports that electricity prices in RGGI states tended to decline during the same time period.

The Paris accords have put us at a crossroads where we can choose to enjoy the rewards of leading the race towards a green economy or suffer the consequences of ignoring the direction most of the rest of the world is headed.

Comments? Questions? Tips on new green energy stories? Write me at Lee.Goldberg@advantagemedia.com.

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71st Year, Issue 4

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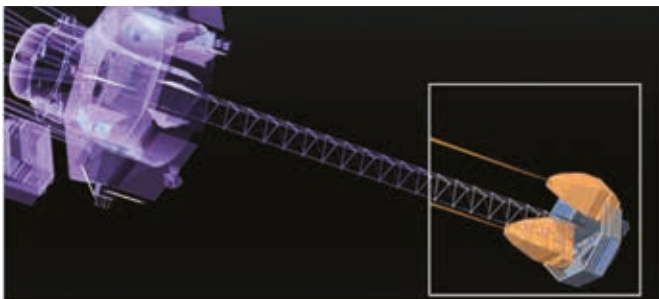
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Engineering Newswire 187: Treacherous Homemade Hoverbike Takes Flight



bit.ly/pdd16May01

The Mystery of the Hitomi Satellite, Solved



bit.ly/pdd16May02

Image credit: JAXA



Product Design & Development

An enormous tunnel-boring machine known as Bertha is being used to drill a two-mile-long underground tunnel in Seattle.



Photos of the Day: Seattle's Two-Story, Partially Completed Subterranean Highway

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eemerge 3D @eemergeit · May 17

How #3DPrinting is driving the growth of Small Businesses

ow.ly/piku300thA @kaylieandduffy interviews @JHornick3D1Stop - @PDandD



Kaylie Duffy @kaylieandduffy · Apr 28

Floating #solar power plants are possible with these novel platforms.
pddnet.com/news/2016/04/... via @PDandD #energy



Falcon 9 Completes Drone Ship Landing

SpaceX successfully landed the first stage of the Falcon 9 rocket on a drone platform in the Atlantic Ocean on April 8.



bit.ly/pdd16May04

Image credit: SpaceX



Design Concepts @design_concepts · May 3

Super thin solar cells in development could be cheaper, more versatile.
ow.ly/4nkHzX @PDandD



FirstLook

Universal Measurement Gage

Mahr Federal (Providence RI) has announced the Multimar 844 T Universal Measurement Gage. Built on a finely ground, hard chrome-plated column, and available in a range of sizes, the Multimar 844 T can measure ODs and IDs up to 2,500 mm with extreme sensitivity and accuracy. Features include:

- A precision guideway with ball bearings on the moveable arm.
- 3-point support for tilt measuring motion on the work piece.
- Heat isolating handles.
- A set of mounting stands to hold the gage when not in use.

Why Would I Specify?

- The Multimar 844 T can be fitted with any measuring indicator with an 8 mm mounting shank, including new wireless indicators for data collection with no cables.
- The stationary measuring arm can be moved along the column for coarse adjustment, and constant measuring force is applied due to a built-in measuring force spring.
- Both the direction of the measuring force and the measuring arms can be changed for either external or internal dimensions.

www.mahr.com



Twin-Wheel Casters

The Revvo Caster Company

(West Seneca, NY) has announced its T Series line of kingpinless fabricated steel, twin-wheel casters featuring wheel locks and directional locks. Designed for heavy-duty power towing (up to 4 mph), T Series casters can be used in adverse working conditions such as heavy loading, shock loading, and traversing poor floor surfaces. Feature include:

- A hand-operated wheel lock that sets the caster in a parked position.
- A four-station plunger directional lock that converts a swivel caster into a fixed (rigid) caster for straight-line travel.
- Availability in three sizes: 8, 10, and 12" wheel diameters with load capacities of 6,725, 9,350, and 10,285 lbs., respectively.
- Swivel casters fitted with octagonal top plates.

Why Would I Specify?

- T Series casters feature "Revvothane" (Vulkollan) Polyurethane tire on cast-iron wheels to provide high tear strength, abrasion resistance, and long service life.
- The Revvothane wheels offer low rolling resistance with floor-saving characteristics and repel floor debris (e.g. metal shavings).
- The cast-iron center withstands shock loading and side impact.

www.revvocaster.com



Self-Clinching Nuts

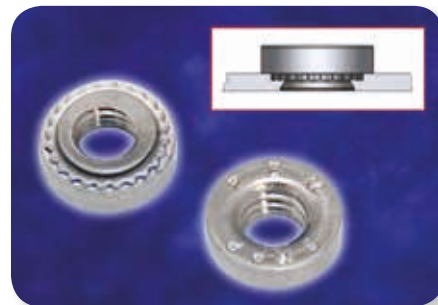
PennEngineering (Danboro, PA) has announced its PEM Type SMPP self-clinching nuts, which install permanently in ultra-thin stainless steel sheets and provide dimensionally suitable solutions for stainless assemblies where space for attachment hardware may be limited. Features include:

- A height of 0.065" (1.4 mm).
- A diameter of 0.220" (5.6 mm).
- Close-to-edge mounting capabilities for installation in stainless steel sheets as thin as 0.025" (0.64 mm).
- Corrosion resistance similar to 300 Series stainless steel.

Why Would I Specify?

- Upon installation, a serrated clinching ring prevents the nut from rotating in service and, ultimately, the fasteners will not loosen, fall out, or otherwise adversely affect the end-product integrity or performance.
- The nuts are made from age-hardened A286 stainless steel and recommended for use in stainless sheets with hardness of HRB 90/HRB 192 or less.
- Thread sizes for mating hardware range from #2-56 through #6-32 and M2.5 through M3.5.

www.pemnet.com



Direct Drive Linear Motor

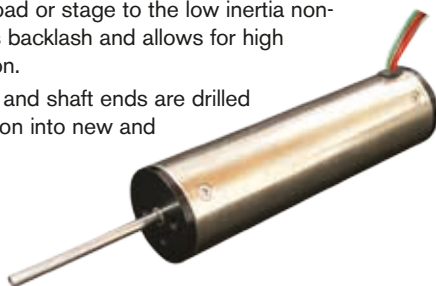
Moticont (Van Nuys, CA) has announced the SDLM-025-070-01-01 direct drive linear motor, also known as an electric cylinder. It has a built-in encoder, zero backlash, zero cogging, and provides users with high acceleration, high speed, high resolution, and long life. Features include:

- A resolution of 1.25 μm (0.000049").
- A diameter of 1.00" (25.4 mm).
- A length of 2.75" (69.9 mm).
- A stroke length of 0.500" (12.7 mm).
- A continuous force rating of 22.2 oz. (5.9 N) and peak force of 67.2 oz. (18.7 N).

Why Would I Specify?

- Inside the motor housing, the linear optical quadrature encoder is directly connected to the shaft for the greatest possible accuracy.
- Direct coupling of the load or stage to the low inertia non-rotating shaft eliminates backlash and allows for high acceleration/deceleration.
- Both ends of the motor and shaft ends are drilled and tapped for integration into new and existing applications.

www.moticont.com



Weight Processor

Hardy Process Solutions (San Diego, CA) has introduced the HI 6500-XP Extreme Weight Processor, an EtherNet/IP enabled weight processor that can process and output 300 updates per second of processed (stable) weight. A/D conversion, weight processing, and the communications port all update at 330 Hz, providing the PLC with the latest processed weight reading every 3 ms. Features include:

- A resolution of 1:30,000 even when exposed to mechanical vibration.
- Support for CLASS 1 (scheduled) EtherNet/IP data transfer.
- EtherNet/IP, Modbus TCP & RTU, Profibus-DP, and Analog 4 to 20 mA compatibility.
- UL, CUL, and CE compliance.

Why Would I Specify?

- A Set-Up Wizard and Rockwell Add-On Profile make the HI 6500-XP easy to install and calibrate.
- Hardy's C2 can be used for automatic system calibration without test weights, saving hours of start-up and maintenance time.
- Hardy's WSAVERSAVER+ technology suppresses vibration and mechanical noise, reducing scale settling time and increasing the speed of stable gross and net weight readings.

www.hardysolutions.com



Media Technology Cable

HELUKABEL (Elgin, IL) has announced its latest media technology cable – the HELUEVENT HYBRID. The cable combines video, audio, and electrical components and is highly flexible at the same time. The cable's primary use is for control desks and mixing consoles, but can also be used in cameras with multiple outlets. Features include:

- Two HELUKAT 200 cables for data transmission.
- One JZ-500 control cable for power supply.
- A 75 Ω 1.0/4.6 coax cable for the video signal.

Why Would I Specify?

- The HELUEVENT HYBRID is halogen-free as well as flame-retardant and can therefore be installed in buildings.
- It is resistant to oxygen, UV, and microbes.
- It can be employed in studios, on stages, or in building services and safety engineering, such as security cameras in trains.

www.helukabel.com

From the Cover



Oil Debris Sensor

Gill Sensors & Controls (Los Angeles, CA) has announced its Oil Debris Sensor that provides continuous real-time monitoring of particle contamination in hydraulic and engine oil lubrication systems. The sensor triggers either an immediate shutdown in cases of large particle build-up, or an early warning indication for needed maintenance. Features include:

- An operating temperature range from -40° to 302°F.
- The ability to work independently of oil flow rate, temperature, viscosity, oil color, or air and water content.
- Outputs from 4 to 20 mA, 0 to 10 V, and CANbus outputs.

Why Would I Specify?

- The sensor incorporates a powerful, high temperature neodymium magnet that collects debris and keeps it from recirculating through the system.
- There are two independent channels for particle detection – one for fine metallic debris and the other for larger metallic debris.
- Engineers receive unprecedented real time information on the health of the mechanical components that are most reliant on hydraulic lubrication systems.

www.gillsc.com

AC-DC Front-End Modules in VIA Package

Vicor (Lombard, IL) has announced that its high density PFM AC-DC front-end modules in the rugged VIA package feature a universal AC input range (85 to 264 VAC), power factor correction, and a fully isolated 24 or 48 VDC output. They also deliver 400 W of isolated, regulated, DC output power at efficiencies up to 93%. Features include:

- A power density of 127 W/in³ (8 W/cm³).
- A 9 mm thin VIA package.
- System functions including EMI filtering, transient protection, and inrush current limiting.
- Availability in chassis-mount and PCB-mount configurations.

www.vicorpower.com



Low Noise, High Efficiency DC-DC Converters

Polytron Devices (Paterson, NJ) has launched its TLB5 series of 5 W DC-DC converters for telecommunications, measurement equipment, industrial control systems, and other applications. The TLB5 power supplies deliver a low noise of 10 mVp-p and 89% power supply efficiency in one industry-standard DIP package of 1.25 x 0.80 x 0.40". Features include:

- A built-in EN55022 Class B filter for reducing electromagnetic interference.
- Overcurrent, short circuit, undervoltage, and overvoltage protection.
- 1,600 VDC input to output isolation.
- A 4:1 input voltage range.
- RoHS II and Reach compliance.
- Compliance with UL60950-1, EN60950-1, and IEC60950-1 safety standards.

www.polytrondevices.com



Infrared LEDs for Biometric Identification

Osram Opto Semiconductors (Sunnyvale, CA) has introduced infrared LEDs for biometric identification. The 1.6 mm high OsLux SFH 4786S infrared LED (IRED) is around one third thinner than its predecessor. Its direction of emission is slightly angled so there is no need for the usual mechanical aids to ensure correct geometrical alignment. Features include:

- A 8° tilt in the emission direction.
- A radiant intensity of typically 1,750 mW/sr at a current of 1 A.
- The emission of light with a wavelength of 810 nm.
- Chips of Nanostack design, which provides two emission centers per emitter.
- A thermal resistance of 25 K/W.
- An emission angle of +13°.

www.osram.com

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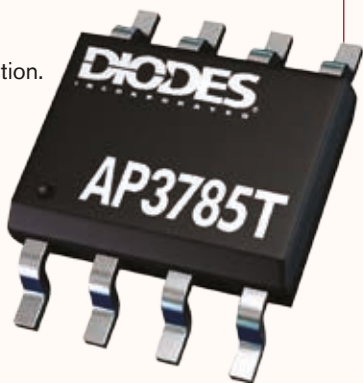
Extrusions
shown actual size.

Switch-Mode AC-DC Regulator

Diodes Incorporated (Plano, TX) has announced the P3785T AC-DC primary-side switched-mode power supply controller. The controller is aimed at 8 to 15 W, 5 V output USB chargers that necessitate ultra-low standby power. Features include:

- A no-load input power rating of less than 10 mW.
- Valley-on operation and a low VCS jitter specification.
- Multiple PWM/PFM control modes.
- Over-voltage protection, output short-circuit protection, and transformer saturation protection (via primary peak-current limitation).
- Internal temperature protection.
- A dedicated pin to support external temperature protection.

www.diodes.com

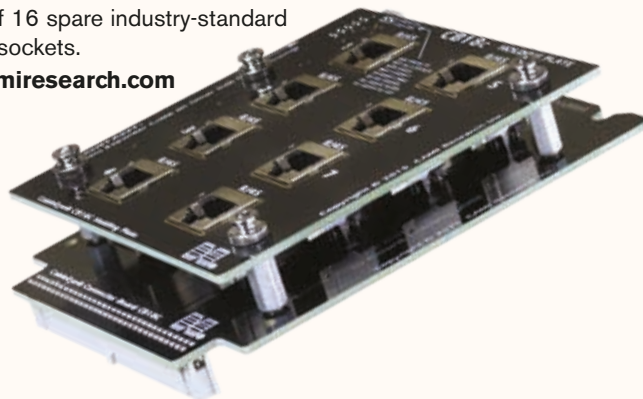


Connector Board

CAMI Research (Acton, MA) has announced a connector board for its CableEye cable and harness testing systems. Populated with eight, shielded RJ45 connectors, the boards may be used to test shielded or unshielded cables. Hipot rated to 500 VDC/350 VAC, the CB18C may be used on all CableEye models. Features include:

- A set of two boards with expander cable.
- The ability to accept eight shielded RJ45 connectors via quick-change, press-fit connectors.
- A kit of 16 spare industry-standard RJ45 sockets.

www.camiresearch.com

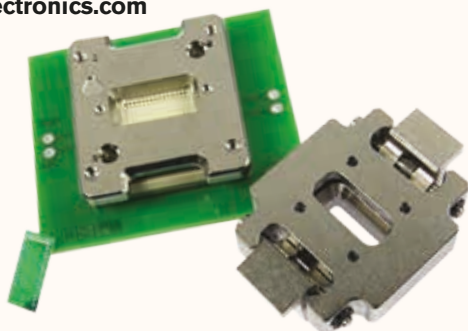


Production Test Socket for BGA30

Ironwood Electronics (Eagan, MN) has introduced a stamped spring pin socket addressing high performance requirements for testing BGA30 - CBT-BGA-7027. The contactor is a stamped spring pin with 31 g actuation force per ball and cycle life of 500,000 insertions. Features include:

- A contactor self-inductance of 0.88 nH.
- An insertion loss < 1 dB at 15.7 GHz.
- A capacitance of 0.097 pF.
- A current capacity of each contactor of 4 A at 40°C temperature rise.
- A socket temperature range from -55° to +180°C.
- A double latch lid.
- An integrated compression plate for vertical force without distorting device position.

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DEVELOPING A NEW MATERIAL FOR STRONGER 3D PRINTS

By Steven Kubiak, Manufacturing Engineer, Stratasys Direct Manufacturing

Although additive manufacturing is often called 3D printing, it's not literally "3-Dimensional" in that it's actually a series of two-dimensional layers stacked on top of one another to form a part. This layering process can create varying strength relative to the properties of each plane. In advanced applications where consistent strength throughout the part is required, the layering process creates anisotropy, or varying properties in different directions.

The layering process produces concentrated strength in the XY dimensions and weaknesses in the Z direction and as a result, engineers are forced to design around the lowest mechanical properties in Z. All additive manufacturing processes are susceptible to this deficiency that can inhibit design freedom. Dry-blended carbon fiber-filled materials for Laser Sintering (LS) in particular, although incredibly strong and dense, can exacerbate anisotropy.

In this article, we explore causes of anisotropy in LS carbon fiber-filled materials, present solutions, and highlight a new LS material with isotropic properties being developed by Stratasys Direct Manufacturing, EOS, ALM, and The Boeing Company.

SOURCES OF ANISOTROPY IN CARBON FIBER-REINFORCED POLYMERS

LS builds complex parts directly from 3D CAD data using powdered thermoplastics. A laser melts and forms each layer of the part, the build platform slightly descends, a recoating blade sweeps a fresh layer of powder over the last layer, and the process continues until the model is complete. The part is built in self-supporting powder which is brushed off during post-processing. It is an affordable way to build durable, complex production parts in low volumes and is often used for robust aerospace, transportation, and oil and gas applications.

LS uses semi-crystalline polymers which exhibit a combination of high mechanical properties, high softening

temperatures, and high long-term stability. These semi-crystalline polymers are either pure unfilled nylons commonly used for concept modeling, non-functional prototypes, or small series productions. Nylons reinforced with functional micro fillers are commonly used for more advanced prototyping and production applications.

While LS is one of the most popular 3D printing processes for freeform fabrication, engineers still struggle with designing for the anisotropic process. Anisotropy in unfilled LS nylons can deviate anywhere from five to eight percent between XY and Z mechanical properties, while carbon fiber-filled nylons jump to much higher dimensional deviations of 30 to 70 percent between XY and Z properties. Although carbon fiber-reinforced LS nylons have high heat deflection, chemical resistance, and tensile strength, their properties vary between the X, Y, and Z axes. Engineers end up designing for the lowest mechanical properties in Z and have to take anisotropy within the XY plane into account.

The discrepancies between the properties in the X, Y, and Z orientations in carbon fiber-reinforced polymers is due to a combination of the material's properties and the LS recoating process. Standard polymer composites are produced through a dry blending process in which the plastic particles, fibers, and fillers are simply mixed together as shown in the microscopic image below (Fig. 1).

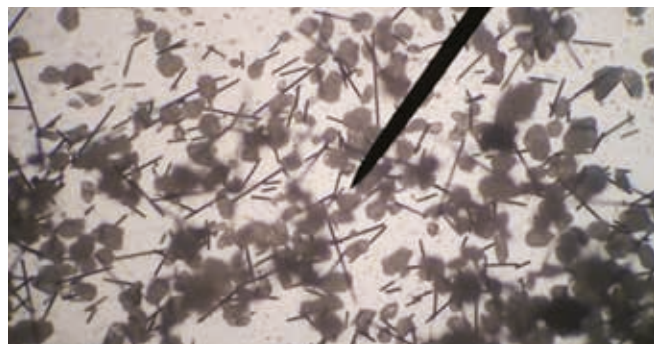


Figure 1: In this microphotograph of a dry blended LS carbon fiber composite, the plastic particles and fibers are clearly visible throughout the powder. Image courtesy of EOS.

Because the carbon fibers are long, thin, and separate from the plastic particles, they tend to align along the direction of the recoating blade as it pushes a new layer of powder over the top of the previous sintered layer. Since the fibers are predominantly oriented along one axis of the part, there is a greater percentage of anisotropy. The top half of Table 1 illustrates the differences between strength in the X, Y, and Z orientations for EOS

CarbonMide carbon fiber-reinforced LS composite, with a greater concentration of fibers aligned on the X axis.

In order to minimize the inconsistencies to move toward isotropic reinforcement, the orientations of the fibers need to be more evenly distributed throughout the part.

IMPROVING FIBER DISTRIBUTION

LS material developers are discovering new methods for producing LS carbon fiber composites that randomly orient the fibers throughout X, Y, and Z to achieve better isotropy. One method is encapsulating the fiber within the plastic particles which has shown significant improvements in fiber orientation distribution (Fig. 2).

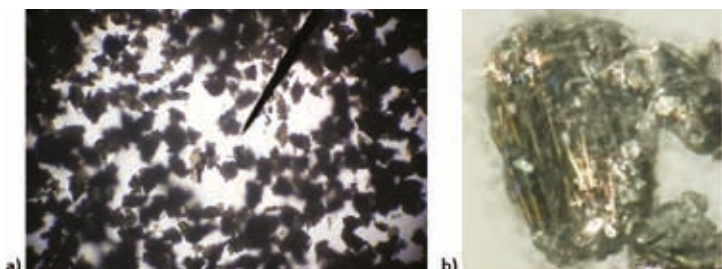


Figure 2: Encapsulated carbon fiber composite (a). A single powder particle with encapsulated carbon fiber (b). Images courtesy of EOS.

The carbon fibers are encapsulated in the plastic in varying orientations to prevent them from aligning with the recoating blade along the X axis. As the laser hits the powder, the particles are spread in every direction in the melt pool (Fig. 3a). A micrograph of a cross-section of a finished part reveals carbon fibers oriented randomly in and out of the plane (Fig. 3b).

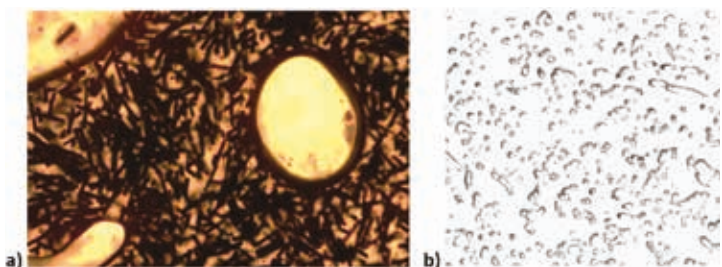


Figure 3: Encapsulated carbon fibers during (a) and after laser sintering (b). Images courtesy of EOS.

The result is more uniform reinforcement. The table below shows a comparison between EOS CarbonMide, a dry-blended carbon fiber-reinforced LS composite, and EOS HP11-30, an encapsulated carbon fiber-reinforced LS composite. While both materials use a Nylon 12 as their base polymer, the method of carbon fiber reinforcing creates a notable difference in mechanical properties.

	Tensile Strength (MPa)	Change from X (%)	Tensile Modulus (GPa)	Change from X (%)	Poisson's Ratio	Change from X (%)
CarbonMide						
X	82		7.6		0.41	
Y	58	-29	4.0	-47	0.20	-51
Z	33	-60	2.8	-63	0.14	-66
HP11-30						
X	56		3.3		0.37	
Y	56	0	3.3	0	0.37	0
Z	46	-18	2.6	-21	0.34	-8

Table 1: Courtesy of Stratasys Direct Manufacturing.

DEVELOPING AN ISOTROPIC HIGH-PERFORMANCE THERMOPLASTIC

While isotropy is universally beneficial for all applications, it's in high demand for functional end-use applications in aerospace, transportation, and energy. The Boeing Company recognized a gap in isotropic LS materials for advanced applications and approached EOS, a manufacturer of LS systems; ALM, the materials development arm of EOS NA; and Stratasys Direct Manufacturing, one of Boeing's additive manufacturing service providers. The companies formed a team to develop an isotropic reinforced high performance LS thermoplastic.

PEKK (polyetherketoneketone) is a semi-crystalline thermoplastic from the polyaryletherketone (PAEK) family with high heat deflection temperature, excellent chemical resistance, and strong mechanical properties. While most LS materials require a heavy molecular additive to achieve flame retardancy, PEKK is naturally flame retardant and lightweight.

ALM formulated PEKK for LS with encapsulated carbon fibers to run on a EOSINT P 800 machine. EOS provided hardware and software modifications to its standard EOSINT P 800 machine as well as optimized process parameters in order to process the carbon fiber reinforced PEKK and account for the unique material processing challenges. After EOS pinpointed the initial machine modifications, Stratasys Direct Manufacturing and The Boeing Company began testing the new material and process. The table below shows normalized data comparing carbon fiber encapsulated PEKK (HT-23), carbon fiber encapsulated Nylon 11 (HP11-30), and flame retardant Nylon 11 (FR-106). HT-23 exhibits isotropic properties combined with improved strength, stiffness, flame retardancy, and glass transition temperature.

Property (RT)	HT-23 (PEKK-CF)	HP11-30 (PA11-CF)	FR-106 (PA11-FR)
Ultimate Tensile Strength (XY)	1.6	1.2	1
Ultimate Tensile Strength (Z)	1.2	1	1
Modulus of Elasticity (XY)	3.5	2.5	1
Modulus of Elasticity (Z)	3	2	1
Glass Transition Temperature (Tg)	2.6	1	1
Flammability	Great	OK	OK

Table 2: Courtesy of Stratasys Direct Manufacturing.

The team is continuing to test and validate encapsulated carbon fiber PEKK for LS and has already used some parts for Boeing's ecoDemonstrator program, which tests new technologies to reduce aviation's environmental impact. **PDD**

This article was written in partnership with Andreas Pfister, Senior Scientist, EOS; Sybille Fischer, Material & Process Developer, EOS; Rick Booth, Chemist, Advanced Laser Materials; Brett Lyons, Product Development, Materials Integration, Boeing; and Chris Robinson, 3DSIM.

Clean Energy Jobs in AMERICA

According to a new report by *Environmental Entrepreneurs* (E2), more than **2.5 million** Americans work in the clean energy industry.

The report is based on information from the U.S. Bureau of Labor Statistics, the U.S. Department of Energy, and a survey of more than **20,000** clean energy businesses nationwide.



JOB SECTOR BREAKDOWN

ENERGY EFFICIENCY:

1,880,148 AMERICANS

Top energy efficiency industries:

- Traditional HVAC: **630,587** jobs
- Energy-efficient lighting: **328,288** jobs
- Advanced materials/insulation: **292,667** jobs



RENEWABLE ENERGY:

413,924 AMERICANS

Top renewable energy industries:

- Solar: **299,953** jobs
- Wind: **77,088** jobs



ADVANCED VEHICLES:

169,939 AMERICANS

Top advanced vehicles industries:

- Electric: **55,401** jobs
- Hybrid: **53,030** jobs



CLEAN DISTRIBUTION:

40,020 AMERICANS

- Storage: **27,140** jobs
- Smart grid: **12,880** jobs



FUELS: **32,792** AMERICANS

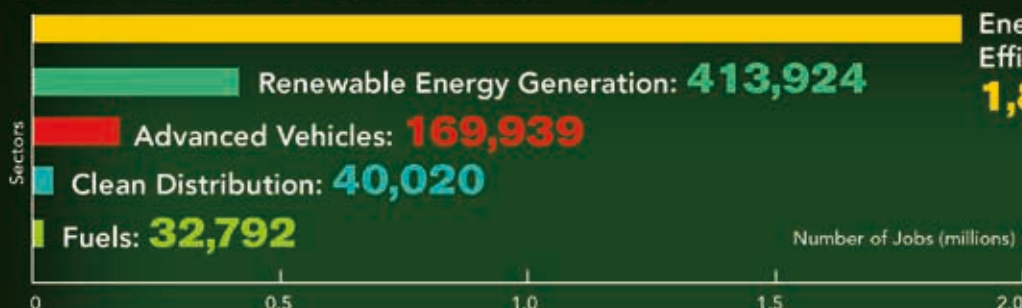
- Woody biomass: **18,031** jobs
- Other ethanol/non-woody biomass: **14,761** jobs



For more information, visit www.e2.org.



SECTOR COMPARISON



From the Cover

High Isolation 2 W DC-DC Converters

MicroPower Direct (Stoughton, MA) has announced its MH1200LRI8 series of high isolation 2 W DC-DC converters in a miniature SMT case. The converters provide the noise immunity, high isolation, compact SMT packaging, and tight regulation required for a range of high power switching applications. Features include:

- Fifteen models operating from 5, 12, or 24 VDC inputs.
- Outputs of 5, 12, 15, ± 12 , or ± 15 VDC.
- An input/output isolation of 8,000 VDC.
- A line/load regulation of $\pm 1.2\%$ max.
- Reinforced insulation and continuous short circuit protection.
- A common mode transient immunity of 15 kV/Us.
- An isolation barrier with reinforced insulation.
- An MTBF (per MIL HDBK 217F) of greater than 2.0 Mhours.
- Approval to EN 6950.
- RoHS compliance.
- Packaging in a miniature, SMT case with an industry standard pin out.
- Availability on tape/reel.
- An operating industrial temperature range from -25° to $+80^{\circ}\text{C}$ with no heat sinking required.

www.micropowerelectronics.com

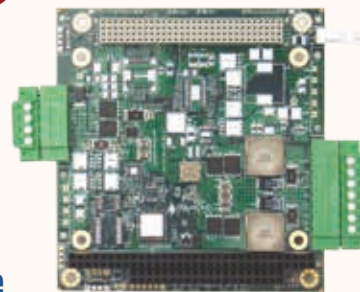


DC-DC Power Supply Module

Diamond Systems (Mountain View, CA) has unveiled the Jupiter-MM-5000 high-efficiency, high-precision family of DC-DC power supply modules. The I/O modules offer up to 196 W of ± 5 and ± 12 VDC power in either the compact PC/104 form factor or PC/104-Plus form factor. Features include:

- Complete DC-DC voltage regulator circuitry.
- An integrated thermal solution.
- Detachable screw terminal block I/O connections.
- PC/104 bus connectors.
- An input voltage range from 7 to 34 VDC.
- Compatibility with industry standard 12, 24, and 28 V inputs.
- Efficiency as high as 95%.
- An extended temperature operation from -40° to $+85^{\circ}\text{C}$.
- Compatibility with MIL-STD-202G shock and vibration specifications.

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Palm Trees Inspire Wind Turbine Design

By Kaylie Duffy, Associate Editor

A novel design for enormous 200-meter-long blades could help bring offshore 50-megawatt (MW) wind turbines to the United States. If constructed, the blades would be longer than two football fields and span two and a half times longer than any wind blades in existence.

The University of Virginia School of Engineering and Applied Science is currently researching the viability for a large Segmented Ultralight Morphing Rotor (SUMR), which is funded by the Department of Energy's (DOE) Advanced Research Projects Agency-Energy (ARPA-E) program.

Recently, the agency awarded a three-year \$3.56 million federal grant to a team led by Professor Eric Loth, Chair of the Department of Mechanical and Aerospace Engineering. His team will use the grant to build a small-scale prototype of the SUMR wind turbine.

The project also includes researchers from the University of Illinois, the University of Colorado, the Colorado School of Mines, Sandia National Laboratories, and the National Renewable Energy Laboratory.

"There are multiple aims of the project, the biggest one is driving down the cost of energy for offshore wind," explains Todd Griffith, lead blade designer on the project and technical lead for Sandia's Offshore Wind Energy Program. "The blade length we're proposing is 200-meters. By going larger, we anticipate the cost of energy will come down."

In theory, the ultralight segmented rotors could produce enough energy to power a small town. "One megawatt will power roughly 300 average U.S. homes; so a 50-MW wind turbine will power 15,000 average U.S. homes. A farm of these could power a sizable city," muses Griffith.



Eric Loth poses with a model of the SUMR wind turbine. Image courtesy of the University of Virginia School of Engineering and Applied Science.

A Palm Tree Design

Currently, a 50-MW wind turbine doesn't exist. The latest advancements only produce 8-MW and 10-MW with a standard three-blade design. If Loth and his team are successful, the DOE could attain its goal of providing 20 percent of the nation's energy from wind by 2030, as outlined in the recently updated Wind Vision Report.

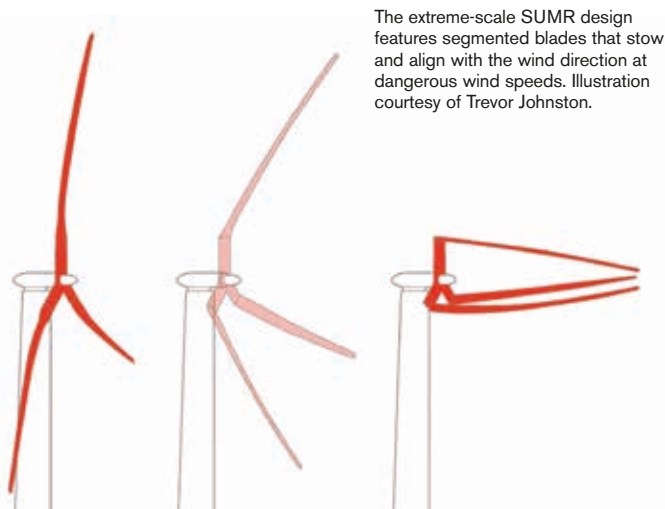
According to Loth, the U.S. will need to start taking advantage of its offshore wind resources to accomplish the DOE's objective. However, offshore installations are expensive, meaning turbines must become larger to capture energy at an affordable price.

"These turbines will be much bigger and more powerful than anything in production," says Loth. "Not ten percent more powerful, but ten times more powerful than the largest turbines in the U.S."

Unfortunately, at about 10-MW, weight and gravity becomes problematic, which forced the researchers to propose an outside-the-box design. Their solution, inspired by palm fronds, utilizes blades that face downwind and fold together in dangerous weather.

"Under storm loads – for example, hurricanes – the blades will fold up, similar to the way a palm tree will fold up under a hurricane," says Griffith. "I refer to this as a natural defense mechanism."

The concept incorporates a vertical plane geometry at below-rated speeds and then converts to a load-aligned downwind deflection between rated speeds and cutout speeds. The design relies on curvature and coning to balance gravity, aerodynamic, and centrifugal forces.



The extreme-scale SUMR design features segmented blades that stow and align with the wind direction at dangerous wind speeds. Illustration courtesy of Trevor Johnston.

Conventional wind turbine blades are usually located upwind of the tower, which causes the wind to push the blades back toward the tower in operation. Therefore, the downwind architecture of the exascale blades will prevent them from accidentally striking the tower.

Loth believes that the ability to fold the blades together will eliminate cantilever loads ten-fold, and will allow his team to use much lighter blades built in segments, which would reduce the cost of the turbine substantially.

Applying Lessons Learned

Back in 2009, Sandia started working on a design for a 13-MW system that uses 100-meter blades on which the initial segmented rotor designs are based. The project helped demonstrate that load alignment can dramatically reduce peak stresses and fatigue on the rotor blades.

In contrast, conventional upwind blades need to be stiff to avoid fatigue and eradicate the risk of tower strikes in strong winds. Thus, they are expensive to manufacture, deploy, and maintain beyond 10-MW to 15-MW. For the 50-MW turbine, Griffith proposes placing a trunnion hinge at the base of the blades, which can be controlled to fold up when winds exceed a high speed value, such as 100 mph.

Extreme scale turbine blades cannot rely on stiff blades due to the increased mass and gravity loads, which are also directly related to cost. The new blade design could be manufactured in simpler, more cost-effective segments, thus avoiding the massive equipment needed to transport and assemble the blades constructed as a whole entity.

"We did a couple of material studies in our 100-meter blade project. We started with fiberglass, which is typical, because they're much less expensive than carbon fiber," explains Griffith. "However, carbon fiber comes with a much higher cost, but the stiffness is much higher and its weight is much lower."

The researchers hope to use a fiberglass material for the bulk of the design, while adding the more expensive carbon fiber selectively where needed. Other alternative materials will be investigated over the course of their research.

A 20-Year Timeline

Many steps remain before designers and engineers can scale up to a 50-MW turbine. For the first year of the project,

Todd Griffith displays a cross-section of a 50-meter blade. Image courtesy of Randy Montoya, Sandia Labs.



the researchers will work on designing a 13-MW version of the SUMR turbine, with 100-meter-long blades.

Then, during the second and third year of the project, the researchers will design and construct a subscale version of the 13-MW turbine, with 20-meter-long blades. In addition, they will also perform a field testing demonstrator campaign to showcase the feasibility of the project. Afterward, Loth and his team can begin to move forward with the larger 50-MW turbine design.

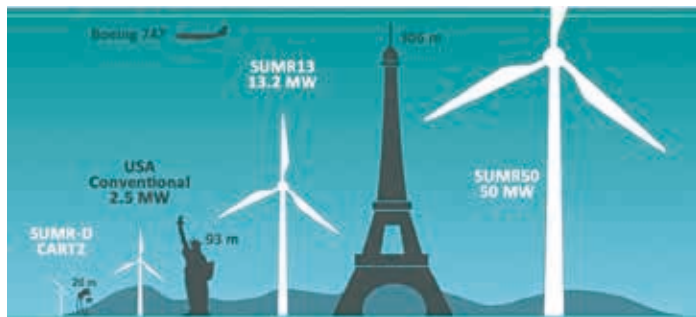
Throughout the first three years of the project, Sandia will also be responsible for developing an analysis tool to analyze aeroelastic stability, otherwise known as flutter. Griffith wants to avoid the potential galloping effect of blades under wind loading, similar to what poorly constructed bridges sometimes experience.

"One of the big focuses of ARPA-E is technology transfer and outreach, and we do have a plan from now until 2036 to advance this technology all the way to full-scale," explains Griffith. "If we meet all our milestones within the next 20 years, we hope to work with the industry to fully fund the project."

Griffith explains that the role of national laboratories is to try to get out in front of issues that the industry might face.

"Typically, we look for pathways to make technology work and to drive down costs, and we help the industry to adopt that technology," he says. "We're hoping to do that through this project as well – through the blade design work we're doing; through the controls work and development; and also through the technology demonstration we plan."

The next three years will determine the scope and feasibility of the project. If achievable, the extreme-scale wind turbines could revolutionize clean energy production in the United States and around the world. **PDD**



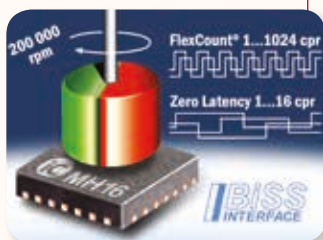
This image shows the sizes of various wind turbines, including the project sub-scale demonstrator (SUMR-D) to be tested in 2018 and the two extreme-scale designs (SUMR13 and SUMR50). Image courtesy of the University of Virginia.

Flexible Magnetic Position Sensor

iC-Haus (Naperville, IL) has announced the iC-MH16, a one-chip solution for magnetic sensor applications in fast motor control units. Combined with a diametrically magnetized permanent magnet, the device in a QFN28 5 x 5 mm package can be used to create a universal encoder for motor commutation and positioning. Features include:

- A Hall sensor array with signal amplification control.
- A FlexCount interpolator delivering incremental (ABZ) and latency-free commutation (UVW) signals.
- Integrated RS422 line drivers.
- A serial SSI/BiSS interface.
- An incremental edge rate of 16 MHz.
- A rotation speed of up to 200,000 RPM.
- UVW commutation signals available for any pole pair count ranging from 1 to 16.
- A supply voltage of +5 V ($\pm 10\%$).
- An operating temperature range from -40° to $+125^{\circ}\text{C}$.

www.ichaus.us



2,400 RPM Permanent Magnet EC Motor

NovaTorque (Fremont, CA) has introduced 2,400 RPM versions of its 3 to 15 hp models, with rated efficiencies of 93.5 to 95%. In many cases, the motor will be one full frame size smaller than the alternative AC induction motor, reducing weight, cost, and possibly VFD size. Features include:

- A 30 to 50% reduction in motor losses and 5 to 20% reduction in energy usage when compared with NEMA Premium induction motors.
- Compatibility with all leading VFD brands.
- Production in NEMA dimensions.
- An all-ferrite (versus rare earth) magnet design.

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Rigid Shaft Couplings & Shaft Adapters

Stafford Manufacturing (Wilmington, MA) has announced a full line of rigid shaft couplings and shaft adapters for OEM and MRO applications. Stafford Rigid Shaft Couplings & Shaft Adapters are designed to join shafts of different sizes and configurations, extend shafts, and provide different mating options. Features include:

- Availability in a variety of configurations made from steel, stainless steel, aluminum, and brass.
- Rigid shaft couplings available in one-, two-, and three-piece designs with or without keyways.
- Shaft adapters offered in step-up and -down configurations with or without keyways.
- Shaft extensions, which can be round, square, hex, D, threaded, keyed, and tapered.

www.staffordmfg.com



EtherCAT Drive Module

ACS Motion Control (Bloomington, MA) has launched a series of EtherCAT drive modules for servo, step, and voice coil motors. Featuring a dual/quad-axis universal drive, the UDMSD Series is designed for motors with a continuous power range of 10 to 100 W (200 W peak). Features include:

- Support for up to four digital incremental encoder channels and up to two absolute encoder channels.
- A Serial Peripheral Interface (SPI) to support other feedback devices.
- The ability to operate under any ACS EtherCAT Master Motion Controller.
- The ability to manage networks with up to 64 axes and thousands of I/O points.
- Availability with currents of 1.25/2.5 A and 2.5/5 A (cont./peak).
- Power via a 12 to 48 VDC drive supply voltage and by a separate 24 VDC $\pm$ 20% control supply.

www.acsmotioncontrol.com

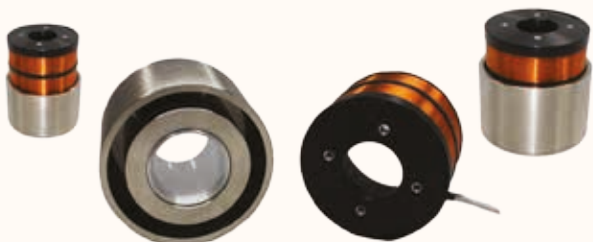


Linear Unhoused Voice Coil Actuators

BEI Kimco (Vista, CA) has introduced a family of linear unhoused Voice Coil Actuators (VCAs) with aperture sizes of 15, 20, and 24.9 mm. The through-hole design allows an OEM assembly to pass directly through the middle of the actuator, resulting in reduced weight, fewer parts, and a more compact product overall. Features include:

- Availability in three standard models.
- Capabilities for low out-gassing.
- Actuator sizes that measure as small as 1.5" (38.1 mm) in diameter and 1.56" (39.6 mm) in length (at mid-stroke).
- Total strokes ranging from 0.25 to 0.45".
- Peak forces from 14 to 45.2 lbs., respectively.

www.beikimco.com

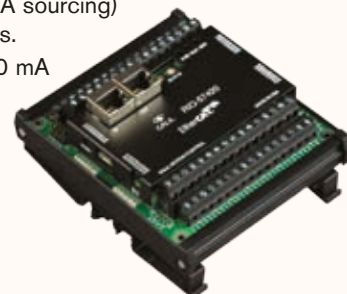


EtherCAT Slave I/O Controller

Galil Motion Control (Rocklin, CA) has announced its new EtherCAT slave I/O controller. The RIO-574x0 is packed with digital and analog I/O to be used remotely in an EtherCAT automation system. Although the RIO-574x0 can be used with any generic EtherCAT master, it is designed to integrate into an EtherCAT system with Galil's DMC-500x0 EtherCAT master. Features include:

- Sixteen opto-isolated digital inputs.
- Sixteen high-power (500 mA sourcing) opto-isolated digital outputs.
- Eight analog inputs (4 to 20 mA option available) and eight analog outputs.
- Dimensions of 4.24 x 4.81 x 2.35".

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BLAST TEST DUMMY IMPROVES WARFIGHTER SAFETY

By Randy Boss, Program Manager, DTS

Testing in a world of weapons, tanks, and tactical gear takes on a new level of intensity when “getting it right” has potentially life or death consequences.

The goal of taking physical measurements is to predict how a test article, in this case a proxy for the warfighter, will respond to real-world events. It begins with meticulous laboratory and simulation testing, but ultimately requires real-world field testing to validate those findings.

The analysis of the data from these efforts will lead to new innovations to improve warfighter safety in a multitude of ways.

The First Blast Test Dummy

The human factor always needs to be at the forefront, and one new high-tech development is the world’s first “warfighter” blast test dummy. A blast test dummy is a full-scale anthropomorphic test device (ATD) that simulates the dimensions, weight, proportions, and articulation of the human body that has been instrumented to record data about its dynamic behavior during testing.

The current test dummies in use have been adopted from the automotive safety industry; however, they are limited in their usefulness as they had been designed to measure frontal or side impacts, not the vertical forces coming from under the vehicle and occupant in a blast event.

The U.S. Army has chosen Diversified Technical Systems (DTS), a privately-held, California-based manufacturer of miniature data recorders, as the prime contractor for both the dummy and instrumentation aspects of this important project. The result is WIAMan – the Warrior Injury Assessment Manikin. Specifically, the WIAMan in its current form is designed to assess the potential for skeletal injury from underbody blasts, particularly with regards to the legs, spine, and pelvis.

This multi-phased project for the dummy began in 2011 and is anticipated to extend through 2020, when production



WIAMan is the world’s first blast test dummy designed to assess the potential for skeletal injury from underbody blasts. All image credit: DTS and U.S. Army.

for the U.S. Army is anticipated to be initiated. The Department of Defense will be using WIAMan to conduct live fire explosive testing and evaluation on ground vehicle designs and associated equipment.

The biofidelic data collected from the WIAMan ATD will assist in improving vehicle designs, seats, restraints, padding, body armor, and tactical gear and support the development of new concepts like interior airbags – anything that can be used to minimize injury modes for the warfighter. This state-of-the-art blast dummy is a major step forward, and will have been the culmination of a significant effort and partnership between the U.S. Army and industry.

Overcoming Space Constraints

A significant challenge to military vehicle testing is understanding how to fit all of the test instrumentation into the vehicle. From the outside, a vehicle such as the Mine-Resistant Ambush Protected (MRAP) is a massive beast. But inside it’s packed tightly with tactical gear and equipment, leaving little space for the warfighters, who end up in very close quarters side-by-side and knee-to-knee.

Traditional dummies require extensive external cabling, sensors, data recorders, and power supplies. The reason being is that the average dummy is instrumented with 64 to 100 channels of data collection instrumentation, but WIAMan can have upwards of 200 channels. The general trend toward higher channel count tests allows engineers to get an even more robust picture of what’s happening.

It’s a combination of several factors that drives this trend. First, more sensors are added to areas of interest. Second, different types of sensors are added. Typically, it’s load cells or accelerometers, but angular rate sensors may be included to capture rotational velocity, like that seen in whiplash.

Each sensor that’s embedded inside the dummy represents a data channel. The sensor cables are routed outside the dummy to an external data recorder. This large bundle of cables, or umbilical, not only adds significant weight (50 to 60 pounds), but it can also alter test dynamics and the precise pre-determined position of the dummy.



It's All Inside

In 1997, an official ISO Task Group was established to create the first international, regulation side impact dummy. DTS was awarded the data acquisition system (DAS) contract for that project. The dummy, called WorldSID, became the centerpiece of a new standard which for the first time included putting data recorders within the dummy itself (in-dummy DAS). DTS co-founder and president, Steve Pruitt, remembers those days clearly. "DTS pushed the importance of making WorldSID with in-dummy DAS from the beginning," he recalls. "It just didn't make sense to develop a new dummy that wasn't forward-thinking, only to have to retrofit it later for in-dummy DAS."

WIAMan will feature the next generation in-dummy DAS. Unlike the WorldSID system which has two to five small 32-channel DASs that fit in the spine and legs, WIAMan will have a multitude of tiny, six channel DAS blocks distributed throughout the entire body. Along with the data recorders, the sensors, cables, and even batteries will all be within the dummy.

One Chance to Get It Right

Another challenge has been ensuring there's viable test data once the dust settles. For years the U.S. Army has been testing



With "in-dummy DAS" (left), all the sensors, cables, and data acquisition system fit inside, eliminating the mass of sensor cables exiting a traditional test dummy (right).

troop armored personnel vehicles with DTS black boxes that are bolted into a protective cage on top of the vehicle during explosive testing. Rugged enclosures with shock-hardened components are being incorporated directly into the WIAMan data acquisition system design.

DTS's ability to do this has been proven in its projects with the U.S. Military, such as providing miniature recorders capable of surviving a 20,000 g impact, the highest g-rating available, which fits right into the test missile for hard-target testing. Other systems have been developed that can capture up to one million data points per second.

For destructive testing that may be over in literally milliseconds, it's not only critical the data is retrievable, but it must be accurate as well. Higher sampling rates mean more data points yielding better details and ultimately a better understanding of the blast event and its consequences.

Helmet Smart Sensors

In addition to quality, there is also quantity. Good testing relies on repeatability and validation. In an effort to better understand what's happening to individual warfighters in the field, DTS has developed a combat helmet smart-sensor to assist in tracking hard to identify or recognize mild traumatic brain injuries (mTBI).

Over 58,000 combat helmet smart-sensors were manufactured and delivered by DTS for use by the U.S. Army in Iraq and Afghanistan. This tiny data recorder, with its built-in sensors, fits seamlessly inside the top of a helmet. This device was a BAE Systems contract for the U.S. Army and is used to continuously monitor the warfighter for up to 12 months in order to capture any suspect events they may have experienced.

Thresholds are set so it knows the difference between a drop on the ground and an impact from combat, crashes, or an explosion. Analyzing the correlation between head motion and mTBI will be critical to understanding the long-term care needs for what has become one of the signature injuries of recent wars.

Safety can be a moving target. But with ongoing testing, research, and advances in technology – improvements in soldier safety are definitely a reality in progress. "It's always rewarding knowing that the work we do helps save lives," says Pruitt. **PDD**



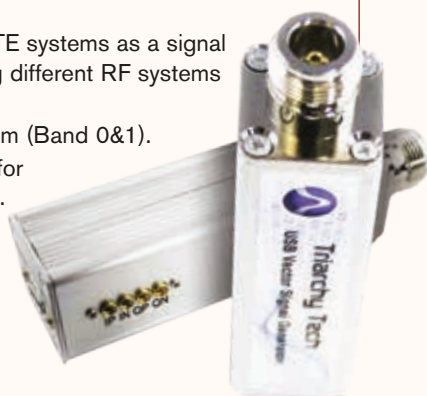
Over 58,000 combat helmet smart-sensors were manufactured by DTS for use by the U.S. Army in Iraq and Afghanistan.

RF Vector Signal Generators

Saelig Company (Fairpoint, NY) has announced the availability of Triarchy Technologies' VSG2G1 and VSG6G1 RF Vector Signal Generators – USB-connected portable, pocketable RF signal sources with capabilities that provide features and functions comparable to full-size analog RF signal generators. Features include:

- Frequency ranges up to 2.2 (VSG2G1) or 6.2 GHz (VSG6G1).
- The possibility of frequency sweep, frequency hopping using I&Q modulation, and arbitrary signal generation.
- The ability to generate most RF signal modulations that RF engineers might need.
- The ability to operate in ATE systems as a signal source module, simulating different RF systems for test purposes.
- Output levels up to 10 dBm (Band 0&1).
- A built-in pulse generator for creating pulse modulation.

www.saelig.com

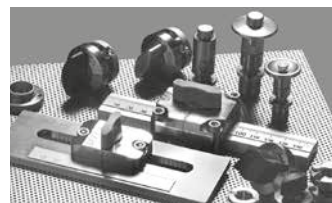


Submersible LVDT Position Transmitter

TE Connectivity (Pennsauken, NJ) has announced a Macro Sensors SSIR 937 submersible LVDT position transmitters with a CANopen interface compliant with CiA 443 for subsea instruments. The transmitter offers more interoperable and standardized communications to network with devices from different manufacturers used on the ocean floor. Features include:

- The ability to withstand external pressures up to 7,500 psi in excess of 1 million hours mean time between failure, when encased in special alloys.
- Suitable repeatability (error less than 0.01% of full range), regardless of offsets due to pressure and/or temperature.
- The ability to measure the extension of structural members of oil platforms to a fraction of a microstrain.

www.macrosensors.com

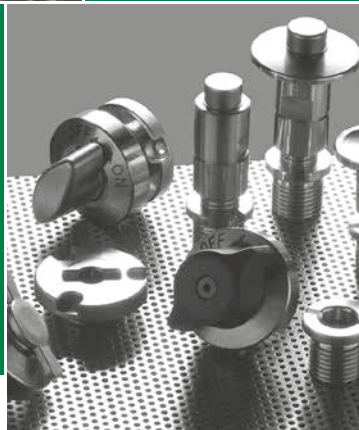


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Supercritical Fluid Extraction & Processing System

Supercritical Fluid Technologies (Newark, DE) has introduced a new generation of the SFT-150 Supercritical Fluid Extraction (SFE) System. Developed to investigate the application of supercritical fluid techniques to various analyses and processing situations, the SFT-150 SFE is a full capability, research grade extractor. Features include:

- Fully integrated waterless chilling technology to cool the CO₂ liquid prior to pumping.
- A back pressure regulator for precise CO₂ flow control.
- A stainless steel vessel capable of containing supercritical fluids at pressures up to 10,000 psi.
- The ability to be configured with hand-tight sample vessels ranging in capacity from 100 mL to 2 L.
- An air regulator which controls the amount of air supplied to the pump.

www.supercriticalfluids.com



Current Transducer

NK Technologies (San Jose, CA) has introduced the AT/ATR-MS Series AC Current Transducer, combining a current sensing element and signal conditioner into a single package. The large split-core design allows for installation over existing conductors without the need to disconnect the load, even in applications with multiple conductors per phase. Features include:

- An industry standard output of 4 to 20 mA, signal proportional to the AC current.
- A loop powered design.
- A sensing window, which provides space for bus bar, single, or multiple conductors.
- Factory calibration.
- UL, CUL, and CE approval.

www.nktechnologies.com



High Precision Platform Tiltmeter

Jewell Instruments (Manchester, NH) has announced the A601-2 tiltmeter series as the latest installment to the electrolytic sensor family for geophysical and geotechnical applications. The model replaces the 520M geodetic platform tiltmeter. Features include:

- A dual-axis sensor with built-in micrometer leveling legs.
- An absolute gravity referenced electrolytic sensor.
- Precision of up to <25 nanoradians with virtually no thermal drift.
- High and low gain ranges offered with outputs of ± 8 DC voltage (single-ended) and ± 16 VDC (differential).
- An IP50 seal rating.

www.jewellinstruments.com



www.pddnet.com

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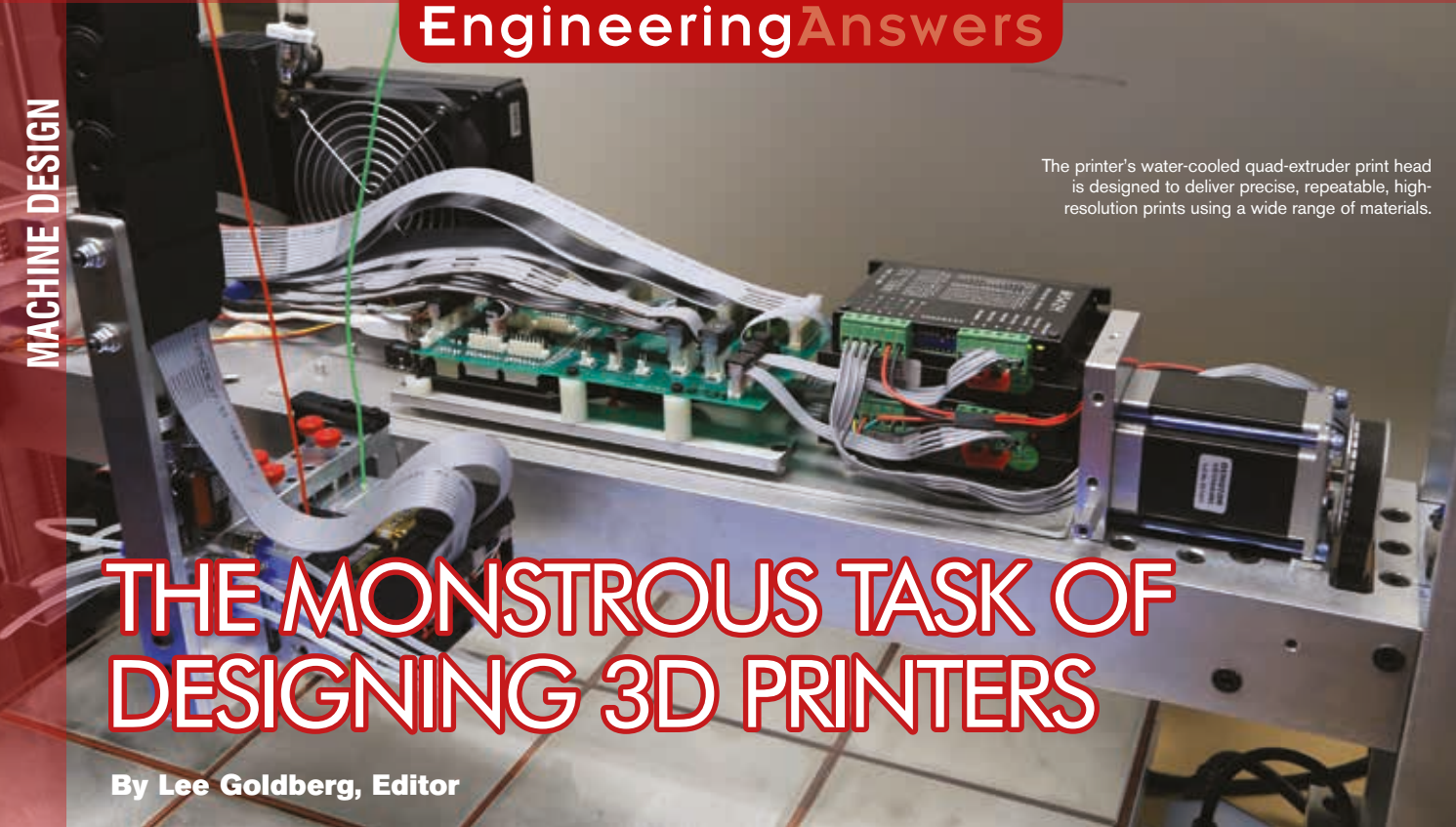
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The printer's water-cooled quad-extruder print head is designed to deliver precise, repeatable, high-resolution prints using a wide range of materials.

THE MONSTROUS TASK OF DESIGNING 3D PRINTERS

By Lee Goldberg, Editor

Supporting a quad-extruder, liquid-cooled print head, a working volume of up to eight cubic feet, and industrial-grade quality at prosumer prices, 3DMonstr's 3D printers occupy a unique space within the market.

Ben Reytblat, 3DMonstr's CEO and lead designer of the T-Rex 3D series is as unique as the printers he creates. The son of a Russian physicist, inventor, and amateur rocket scientist, Reytblat is a renaissance geek, equally comfortable piloting a CNC milling machine, a software development suite, or a sailboat.

In designing his printer, Reytblat set out to fix many of the big and small deficiencies he noted in the machines already on the market, something that he quite frankly admits was a formidable, perhaps even "Monstrous" task.

He is also quick to point out that, despite the delays it caused, re-thinking every aspect of 3D printing resulted in a much better product, and taught him some valuable lessons he'll be applying to the next generation of 3DMonstr products. In this exclusive interview with PD&D, Reytblat generously agreed to share some of those hard-won insights with our readers.

PD&D: What were the design goals which drove the development of the T-Rex 3D series of 3D printers?

Reytblat: We wanted to build a machine that was two steps beyond anything on the market at the time. So it had to be really large (up to 8 cubic feet of build volume); it had

to have more extruders than anyone else at the time; and it had to be able to work with more materials than anyone else at the time. We think we've succeeded in doing just that. In some areas, we've even exceeded our own expectations. For example, the multi-zone heated bed on our printers is much more efficient than anyone else's on the market. Because you can control each of the 6 x 6" zones individually, you don't need to heat the universe with a full 960 watts of power, saving energy and reducing costs of operations.

PD&D: The extruder mechanism is one of the most unique aspects of your machine. What does it offer the end user and what were some of the challenges involved with designing it?

Reytblat: There are two major advances embodied in our extruders: a very precise drive mechanism we call our GentleDrive, and a much more sophisticated thermal system which uses liquid cooling and components made out of titanium to manage the temperature within the extruder. Combined, these technologies give excellent print quality across a very large range of materials, from PLA to Nylon, from ABS to Polycarb, from HIPS to paraffin wax. Yes, our machines can print with a specially manufactured paraffin wax filament. This allows our users to go directly from a 3D model to a foundry-ready wax plug. Just print it and ship it to a foundry to be cast into metal using the old reliable lost-wax casting technology. I'm not aware of any other machine on the market that can offer that.

On top of that, our extruders are very compact and light-weight. Our entire extruder, all up, weighs in at just 310 g – less than most NEMA17 motors that are used in conventional extruders. And this allows us to mount all four of them in the space and weight limits of two extruders on any other machine I know.



3DMonstr printers undergoing assembly at the company's main plant, located in West Windsor, N.J. All image credit: 3DMonstr.

PD&D: You also experimented with several different technologies for controlling the stepper motors used to drive the printer and extruders. What were the problems you encountered and how did you finally overcome them?

Reytblat: This was a long journey, and was ultimately the cause of a large portion of the delay we've experienced in bringing our machines to market.

Our goal was to build a machine with four extruders and with larger than usual motors (NEMA23 vs. NEMA17), so we could achieve reasonable printing speeds with a much heavier printer. From the outset, we knew this would be difficult.

At the start, we designed our machine around an existing off-the-shelf Arduino compatible micro-controller. The board was great, and the company behind it was even better. Alas, after many months of trying we had to give up on it. We couldn't solve the problems of wiring, due to how the connectors were laid out. It was far too expensive to produce, and it just couldn't be maintained in the field.

So the next approach we tried was to go completely in the opposite direction. We partnered up with a great little custom electronics house right here in New Jersey to design and manufacture a complete, from scratch, fully integrated custom controller that would have all the functionality we needed, including all motor drivers, all on one board. That also took many months, but in the end had to be abandoned as too ambitious.

Finally, we ended up with a combined architecture which gave us the best of both worlds. Our main controller is a large custom Shield sitting on top of a standard, off-the-shelf Arduino Mega micro-controller board. This gives us the best of both worlds: a well-known, cost-effective, reliable central processor with plenty of memory and I/O and a large-area custom board which allowed us to organize our connectors and other peripheral circuitry just the way we wanted.

In particular, it allowed us to drastically simplify and reduce the costs of all the wiring in the system, and at the same time improve our ability to support our customers for a long time to



Ben Reytblat, 3DMonstr's CEO, poses with his creation.

come. In the future, the modularity afforded by this approach will enable us to upgrade the electronics over the years with excellent backward compatibility and easy field installation. And our partner company can still make it reliably for us right here in New Jersey.

PD&D: Your extruder's design enables it to handle a very wide range of materials, but you've already hinted at developing other extruders which will allow your machines to print even more exotic stuff. Can you comment on what types of materials you're aiming for and when you expect to roll out those capabilities?

Reytblat: We have very high ambitions. We think we've figured out how to 3D print with metal and with glass at a much lower cost than possible today. We've already filed for a patent on the former, and are working on the patent application on the latter. If we're successful in developing this technology, I think it will revolutionize the industry by reducing the cost of metal and glass 3D printing to a level unheard of before. Stay tuned!

PD&D: There are rumors that you originally decided to design a 3D printer to help you build a new type of rocket engine. Are those rumors true? And will any of the new extruders you'll be working on be related to your rocketry venture?

Reytblat: That is indeed how we started on this journey. The metal extruder is exactly what needed to do that. However, as so often happens, the journey became the goal in and of itself. And so these days rocketry is a hobby, and 3D printing is the main focus of what we do. When the metal extruder is done, I'll certainly try printing a rocket engine. But I think 3D printing is now in my blood, so we'll stay focused on it for a very long time – it's just too much fun! And in particular, the approach we're taking to it, enabling people to print things they can't print any other way, is very satisfying. I really enjoy coming to work every day and taking on the challenges of engineering and manufacturing. And I love our crew!



3DMonstr's T-Rex 3D series offers build volumes of up to 24 x 24 x 24".



THE BRAINSTORM

In the *Product Design & Development* Brainstorm we talk with industry leaders to get their perspective on issues critical to the design engineering marketplace. In this issue, we ask:

What are some of the key technology trends that will shape the evolution of the wearables market?



Karen Lightman, Executive Director, MEMS & Sensors Industry Group

My friend Mark DiPerri, a business management developer at Toshiba, told me years ago: The most successful wearable will be the one we are not aware we are wearing, seamless in its ability to track and modify our behavior.

MEMS & Sensors Industry Group's (MSIG) membership is at the forefront of delivering intelligent sensing technologies that track our daily behavior and improve our lifestyle without our having to think about it. Valencell uses a combination of MicroElectroMechanical Systems (MEMS)/sensors and algorithms to deliver clinically validated accuracy, continuously monitoring numerous biometrics via an optomechanical sensor module tiny enough for an ear bud.

Other MSIG member companies use MEMS and sensors to quantify fitness/exercise and even sleep. The fitness tracker Jawbone UP3 is a sleek, low-profile wristband that captures resting and passive heart rate, and automatically detects detailed sleep stages (like Deep and REM) and workouts through an advanced multi-sensor platform. The multi-sensor platform includes a tri-axis accelerometer, bioimpedance sensors, and skin and ambient temperature sensors. Using this technology, UP3 delivers resting and passive heart rate, and will capture even more health data over time.

WiseWear houses the accelerometer in a beautiful bracelet that functions as an activity monitor and adds one more compelling feature: by tapping the bottom half of a WiseWear bracelet, the device sends a distress signal via text to a pre-selected group of contacts.

While such wearables have the potential to improve our quality of life by giving us insight into our personal health and well-being, there remain some challenges to the wearables market:

- Keeping data private and secure is a critical issue. We users will demand that data collected from our wearables (or any smart device) belongs to us, and only we users decide with whom (or what) to share our data.
- Proprietary devices fly in the face of the trend toward interoperability of what Apple, for example, is creating: a silo for tracking and monitoring data with its Watch. Having a wearable that is more universal and "open source" in the way that it captures and relays data could prove to be beneficial to users.
- Short battery life is a barrier to the growth of wearable technology. Yet, MicroGen Systems is aiming to alleviate this huge problem. Its novel piezoelectric MEMS (piezo-MEMS) vibrational energy harvester (pVEH) and piezo-sensor platform

technology are at the core of its Micro-Power Generator (MPG) products (provide variable AC electricity output) and Power Cell products (offer AC to DC conversion and configurable fixed DC voltage electronics, and various types of energy storage). These MicroGen Systems' products can power rechargeable batteries in wearables and other Internet of Things/wireless sensor applications. Plus, at just about 0.3 cm³ in size, MicroGen's MPG devices are like low-cost miniaturized onboard "gas stations."

As we move beyond batteries to energy harvesting modules and other emerging technologies that will free us from having to constantly power-up wearable devices, we are going to see a groundswell of activity in new wearables. Ultra-low-power electronics that hold their charges longer and transmission protocols that leverage ambient RF signals to power wireless devices will ease the power consumption issue with wearables.

Ultimately, we will see more self-powered, user-modifying wearables that are private, secure, and interoperable.



Dr. Steven LeBoeuf, President & Co-Founder, Valencell

1. Wearable PPG for medical use

Decades of research on wearable PPG (photoplethysmography) has shown the ability to non-invasively track cardiovascular disease progression and to detect impending exacerbation, but only recently (via the advent of Valencell's PerformTek sensor technology) has wearable PPG sensor technology achieved high enough accuracy and user comfort, and low enough power consumption, for use in consumer medical wearables. With this classic peanut butter + chocolate mixture of high-performance PPG sensing + established PPG assessments, the first round of seamless medical-grade consumer wearables will be entering the marketplace in the next three to four years.

2. "Periodic" biometric wearable use cases

The reality is that wearables do not need to be worn 24/7 in order to generate important user content that can be used for health assessments or assessing consumer behavior. For example, a "good enough" biometric sensor on the handle of a coffee pot can be used to determine how often one drinks coffee by sensing: a) who the person is, b) how often they pour coffee, and c) how their body responds to this behavior. The important aspect is not 24/7 use but rather reliable, routine, high-compliance touch-points with the wearable device. Biometric hearables – wearables worn at the ear – are likely to benefit the most from use cases that require simple routine touch-points throughout the week or month to

reliably and seamlessly collect just enough data-points to make important health or behavioral assessments.

3. Battery/energy-harvesting technology

Notable startup and academic efforts have been directed towards low-power digital processing, shrinking batteries, energy harvesting, and safely increasing the energy density of batteries. On the academic front, the NSF + industry-funded ASSIST program, headquartered at NC State University, is driving innovation in all of these areas. And in the startup world, uBeam recently made headlines for yet another round of venture funding, now totaling more than \$25 million, directed towards energy harvesting ("wireless charging") via ultrasound.

4. Flexible, high-integration technology

Before the advent of wearables, most consumer electronics were boxy in nature, and rectangular electronic components and circuit boards were aptly suited for the job. But the most desirable wearable devices must frequently be curvy, thin, and pliable in order to accurately measure biometrics while remaining comfortable for the user, often requiring flexible components or interconnects. Flexible electronics have been commercially available for decades, but scalable flex solutions have remained too expensive for mass consumer markets. FlexTech Alliance, was recently granted \$75 million from the U.S. Defense Department with the goal of making electronics more suitable, "stretchy," and affordable for wearables.

5. Sophisticated speech recognition

Like flex technology, speech recognition technology has been commercially available for decades. But only now has this technology become sophisticated enough at a reasonable price point to not be so annoying. Hearables will exploit this technology to the fullest, as the ear sports the best location for not only biometric monitoring but also speech recognition and human-computer communication. With several recent announcements of major R&D and marketing investments in the area of hearables, look to Jabra (a consumer brand of GN Netcom) for leadership in this category.



Stephen Breit, VP Engineering, Coventor

Low-cost, durable sensors are essential to the wearables market. Coventor supplies software tools for designing MEMS-based sensors to companies and R&D organizations. From our customer engagements we see three trends emerging: commoditization of MEMS sensors, denser package-scale integration of MEMS, and the entry of mainstream CMOS foundries to the MEMS business. These trends bode well for the wearables market. Developers will be able to count on an established ecosystem for producing and integrating MEMS-based sensors that meet the form factor, performance, cost, and reliability requirements of wearables.

MEMS sensors are fabricated on silicon wafers using equipment and methods derived from large-scale CMOS manufacturing and therefore, have similar advantages over conventional macro-scale sensors including: lower cost, smaller size, lower power requirements, and better performance (all desirable advantages, especially for wearables). Over the past two decades, shipments of MEMS sensors have grown from negligible to consumer electronics volume, due mainly to mobile devices, most of which now have at least a 6- or 9-axis inertial measurement unit (IMU) and one or more MEMS microphones. MEMS suppliers have, in some sense, become victims of their own success. MEMS market analyst, IHS,

reported in late 2015 that total dollar revenue for MEMS pressure and motion sensors had actually fallen despite increasing unit shipments. This is clear evidence of a commoditization trend in MEMS, which is hard news for MEMS suppliers but great for MEMS consumers.

The widespread use of MEMS in mobile devices has created strong demand for denser integration of heterogeneous technologies such as MEMS, CMOS logic, memory, RF, and power conditioning. This is the second trend we see. Suppliers today offer highly integrated 6- and 9-axis IMUs. To see where this is going, we need only look at a ChipWorks' teardown of the Apple Watch. It reveals that Apple integrated more than 30 die into a single package. Notably, a 6-axis MEMS IMU is one of the few components not included in that package. One can easily imagine that the IMU functionality will be more tightly integrated in a future version of the Apple Watch. The integration trend can only be good news for the wearables market, where form factor can be a make-or-break proposition.

The third trend is the entrance of mainstream CMOS foundries into the MEMS manufacturing business. This is partly a consequence of consolidation of the semiconductor industry as the investment needed to stay at the leading edge of CMOS technology has grown into the billions of dollars. Semiconductor manufacturers have a growing pool of older fabrication facilities that are potentially well-suited for MEMS manufacturing. These foundries see MEMS manufacturing as an attractive opportunity that leverages existing assets to address a new, higher growth market. Further, they believe they can address demands for increasing integration by offering one-stop shopping for multi-technology foundry services including CMOS, MEMS, and other technologies.

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3-Axis Industrial 3D Printers

Titan Robotics (Colorado Springs, CO) has announced its Atlas and Atlas 2.0 3D printers. They are the standard models of Titan's 3-axis industrial 3D printers. The two standard build sizes are 30 x 30 x 45" and 36 x 36 x 48". Features include:

- Feed rates over 400 mm/s.
- A repeatability of +/- .003".
- A precision CNC machined steel frame.
- A 1,500 W bed.
- An optional 2,250 W heated enclosure.
- Yaskawa closed loop AC servos.

www.titan3drobotics.com



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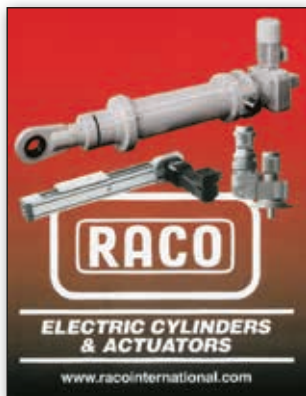
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Slim Safety Relay Unit

Omron Automation and Safety (Schaumburg, IL)

has introduced the G9SE Safety Relay Unit, a slim size safety relay unit that reduces installation and troubleshooting time for machine builders. The unit's screw-less push-in terminal allows for fast installation. Features include:

- A slim design (17.5 or 22.5 mm) to save mounting space.
- The availability of modules with two or four safety contacts and OFF-delay timing.
- Front-side wiring using screw-less terminals.
- A 15 ms maximum response time.
- A safe OFF delay function up to PLe.
- Certification for lift standards EN 81-1, EN 81-2.

www.omron247.com



Game Style Pendant Controller

APEM (Vista, CA) has announced its PC Series, an ergonomic game style pendant controller. The handheld device accommodates APEM's TS Series miniature proportional joystick and provides either analog voltage or USB output. The PC Series is suitable for controlling unmanned vehicles, robotics, and other remote controlled applications. Features include:

- High-impact, glass filled nylon.
- A modular design to provide OEMs the ability to configure the device as needed.
- The ability to specify standard, off-the-shelf configurations with miniature Hall effect joysticks, snap action pushbuttons, and USB interface.
- The ability to be environmentally sealed up to IP67.

www.apem.com





High-Speed USB 3.0 Microscope Cameras

ZEISS (Pleasanton, CA) has introduced two digital microscope cameras. ZEISS Axiocam 702 mono and ZEISS Axiocam 512 color complement the current portfolio of high-speed USB 3.0 microscope cameras. With ZEISS Axiocam 702 mono, ZEISS for the first time introduces a microscope camera with a scientific CMOS sensor.

ZEISS Axiocam 702 mono features:

- Low read noise, low light sensitivity, and high speed for live cell imaging and acquisition of fast processes.
- A 1/1.2" (13.3 mm diagonal) sensor with a resolution of 2.3 MP.
- High-speed USB 3.0 connections and active thermoelectric cooling.

ZEISS Axiocam 512 color features:

- The acquisition of large sample areas in one high resolution, true color image.
- A 12 MP CCD sensor with a size of 1" (16 mm diagonal).
- High-speed USB 3.0 connections and active thermoelectric cooling.

www.zeiss.com

10" Touch Display Kit

Avnet (Phoenix, AZ) has announced its 10" Touch Display Kit, providing engineers in markets including portable instrumentation, consumer kiosks, embedded systems, and industrial automation all the elements needed to develop interactive GUI applications with touchscreen capability using Xilinx Zynq-7000 All Programmable SoC evaluation and development boards. The Avnet-designed AES-ALI3-AMPIRE10-G kit features:

- A 1280 x 800 WXGA TFT-LCD display.
- A PCAP touch sensor overlay.
- An I2C touch controller.
- LED backlight supply.
- A haptic feedback driver.
- A 3-axis accelerometer.
- All the necessary cables for connecting to a development board.

www.avnet.com



Handheld Barcode Verifier

Microscan Systems (Renton, WA) has announced the LVS-9570 handheld bar code verifier designed for offline verification of bar codes to ISO/IEC standards. The LVS-9570 is able to verify linear (1D) and two-dimensional (2D) codes; autodiscriminate the symbology, narrow bar width, and aperture to be used to evaluate the code; and highlight trouble spots in the code. Features include:

- The ability to inspect all nine of the ISO (ANSI) parameters.
- Color coded analysis to show where the problem is located within the bar code.
- Sensor technology, allowing for more detailed analysis of the bar code.
- Numerous verification options.
- ISO bar code grading on various label sizes.
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www.microscan.com



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Universal Nozzle Cylinder

PHD (Fort Wayne, IN) has announced its Series BCZUS Universal Nozzle Cylinder for the plastic bottle blowing industry. Series BCZUS Universal Nozzle Cylinders are direct replacements for Sidel Universal Cold Set Machines. The cylinders mount into the same space and bolt patterns, provide longer service life, and reduce maintenance and downtime in stretch blow molding applications. Features include:

- The ability to operate for 20 million cycles.
- Drop-in replacement for OEM.
- FDA-approved materials.
- No lube in both high pressure and low pressure sections.
- A composite, high wear resistant, rod scraper.
- An available tooling kit for in field re-build.

www.phdinc.com



Aluminum Block Mounted Ejector

Piab Vacuum Products (Hingham, MA) has introduced its aluminum block mounted ejector, VL206, which is dimensioned to emulate a popular ejector format, making it able to install into many existing systems. Features include:

- A capacity that is twice that of the company's inline ejectors.
- Energy savings of up to 28% compared to similar ejectors.
- A design with no flap valves.

www.piab.com



Atomizing Spray Nozzle

EXAIR (Cincinnati, OH) has announced the 1/4 NPT internal mix deflected flat fan atomizing spray nozzle, which atomizes fluid and sprays at a right angle to the nozzle orientation. This allows spray to be placed precisely where it is needed when the mounting and work areas are limited. Features include:

- Liquid flows from 1.8 to 6.9 gallons per hour.
- The ability to coat, cool, treat, and paint a variety of products using compressed air and liquids with a viscosity of up to 300 cP.
- A stainless steel construction.
- Availability with 1/4 and 1/2 NPT connections and in a variety of sizes and shapes.

www.exair.com



Ultrasonic Flowmeter

KROHNE (Peabody, MA) has introduced the OPTISONIC 8300 ultrasonic flowmeter for superheated steam, which delivers 1% measuring accuracy, high repeatability, and a large measuring range with maintenance-free operation. The two-beam ultrasonic flowmeter is capable of handling high flow rates of superheated steam. Features include:

- A full bore flow sensor without moving parts or obstructions.
- No cables or sensitive parts exposed.
- The ability to maintain measuring accuracy without maintenance or subsequent calibration for up to 20 years.
- Availability in nominal sizes ranging from DN 100 to 1,000 (4 to 40").
- A rating for pressure up to 200 bar (3,625 psi).
- An operating temperature range up to 540 °C (1,004°F).

www.krohne.com

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Has America Finished Growing?

Karl Stephan, Professor of Electrical Engineering, Texas State University

A week before the 1980 presidential election, Ronald Reagan famously asked a debate audience "Are you better off than you were four years ago?" Though political circumstances change, the question remains: are we in the U.S. better off than we were in the past? Can we expect to be better off in the future? And, most important for the readers of this column, what role will design engineers play in future improvements to the U.S. standard of living?

Economist Robert J. Gordon has pondered these questions most of his life, and has delivered his answers in the form of a 762-page book called *The Rise and Fall of American Growth: The U.S. Standard of Living Since the Civil War*. The book confirms something that I have long suspected, and makes hard-data-based predictions that engineers need to bear in mind.

Gordon's basic message is simple. The period 1940 to 1970 – the economic golden age when a U.S. citizen with only a high-school education could get a good job, marry, have children, and afford a new house and a new car – was very likely unique, and will never return. Gordon judges its uniqueness by a measure he calls "total factor productivity" or TFP.

You have probably heard of gross national product, or GNP, which is basically the total output of a nation's goods and services. As I understand it, TFP is the amount of economic output for a given input of labor and capital. Any innovation that lets someone produce more value (a widget or a service) with fewer people or fewer dollars invested in capital equipment will increase TFP. And a growing TFP is what makes an economy attractive to live in. It opens up good employment opportunities, encourages productive investment, and makes life easier in general.

As Gordon shows in near-exhaustive detail, that is just what happened in the U.S. as the nation shook off the effects

of the Great Depression in its all-out effort to out-produce the Axis during World War II. Once the great engines of production got going during the war, they managed a smooth transition to making the peacetime abundance of consumer goods that characterized the 1950s: cars, TVs, air conditioning, computers, and all the rest. But once that wave of innovation ended, things slowed down again.

To quote data from just one of the hundreds of graphs and charts in the book, in the period 1890 to 1920, TFP in the U.S. rose at an average rate of 0.5 percent a year. From 1920 to 1970, it sped up to about 1.8 percent a year. And from 1970 to 2014, TFP fell back down to only about 0.6 percent per year. In a numerical nutshell, that is the story Gordon tells.

Couldn't it happen again? Not in the U.S., Gordon says. Barring some unanticipated universal disaster, you can wire a nation for electricity and pipe it for indoor plumbing and air-condition its buildings only once. The profound technological innovations that made everyday life and work much more pleasant now than for the preceding several thousand years took place in the U.S. largely between 1920 and 1970. It is very hard to imagine any comparable future innovations that could make as much of a positive difference to the everyday lives of most people as automobiles, clean water, sanitary sewers, electricity, and air conditioning have made already.

But what about the rapidly increasing pace of innovations that design engineers face every day? Product life cycles that used to be measured in years are now measured in months or weeks, which is why designers are so busy keeping up with the competition and taking advantage of new components and software.

Gordon distinguishes sharply between the pace of innovation, which he admits

is speeding up, and the impact of innovation. Yes, smart phones, Facebook, streaming TV shows over the Internet, and other such innovations

have wrought huge and rapid changes in some industries. But these communications-technology innovations have not contributed to TFP nearly as much as the innovations of the earlier twentieth century did.

Fortunately, there will always be something for design engineers to do. But it may be more along the lines of changes in style than of fundamental improvements in the quality of life. Volkswagen's New Beetle and Chrysler's PT Cruiser may be the shape of things to come: products that embody forms from the past, but with updated technology. Up to now, engineers have rarely thought like dress designers, who face the perennial problem that there are only so many ways to clothe the naked human body, but manage to come up with new styles every season.

If Gordon is right, the future of engineering design may look more like fashion design: a constant reshuffling of the same basic ingredients. In such a world, there will always be novel products for engineers to design. But if Gordon is right, novelty, rather than fundamental improvements in the standard of living, will be the main reason that people buy them.

Do you think the best years of American economic growth are behind us, or do you think there will be another technological advance that will surpass what happened in the 1940 to 1970 period? Send your response to kdstephan@txstate.edu.



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