Navigating Electrohydraulic Disruption **23**

Danger From DDoS Attacks Grows **26**

Building A Safer Lithium Battery **32**

Machine Design®

THE PREMIER RESOURCE FOR THE MULTI-DISCIPLINED DESIGN ENGINEER

Additive Manufacturing (Finally) Has Its Moment **20**

If it's in your panel, it's at AutomationDirect.com...for less!

- Circuit protection including MCCBs, circuit breakers, and transfer switches (Circuit breakers starting at $15.00)
- Wiring solutions including cut-to-length cable, hookup wire, wire duct, conduit, terminal blocks, and cable entry systems (Wire duct starting at $7.50)
- Drives, soft starters, and motor control devices (Micro AC drives starting at $128.00)
- Enclosure lighting and thermal management (Thermoelecric coolers starting at $718.00)
- Industrial power supplies, transformers, and converters (DC power supplies starting at $20.00)
- PLCs, field I/O systems, motion controllers, servo and stepper systems (PLCs starting at $85.00)
- Industrial Ethernet switches, gateways, and VPN routers (Ethernet switches starting at $83.00)
- Safety products including safety controllers, safety relay modules, intrinsically safe isolators, etc. (Safety relays starting at $103.00)
- Modular and pre-fabricated enclosures (Modular enclosure kits starting at $875.00)

Plus motors, HMIs, pneumatics, a huge assortment of sensors and pilot devices, and so much more. All at great prices and with award-winning customer service and support.

Don't overspend elsewhere. With our everyday low prices you can build your panel for a lot less!

Research, price, buy at:

www.automationdirect.com

Huge Inventory for Fast Shipping

FREE Technical Support

30-day Money-Back Guarantee

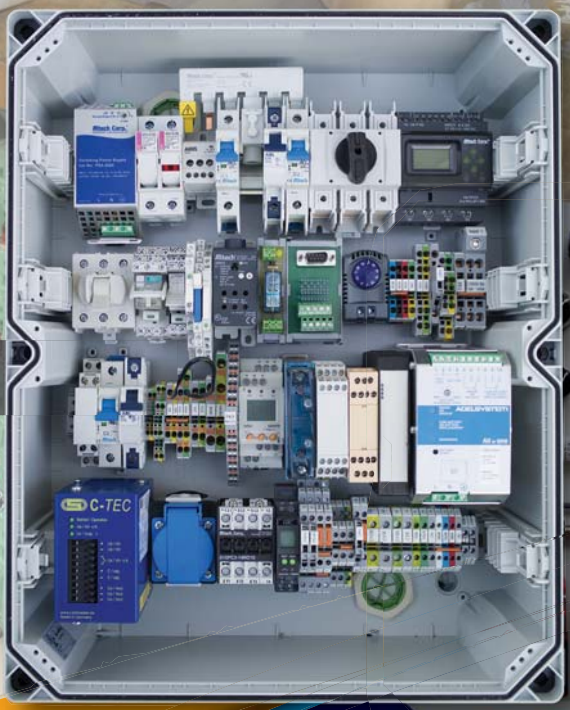
TOP RATED ★★★★★ BY CUSTOMERS

AUTOMATIONDIRECT.com

1-800-633-0405 the #1 value in automation

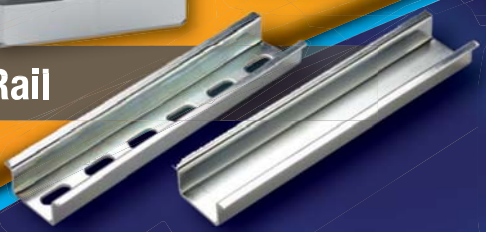
Altech®
Components & Assembly

Your Source for Automation & Control Components



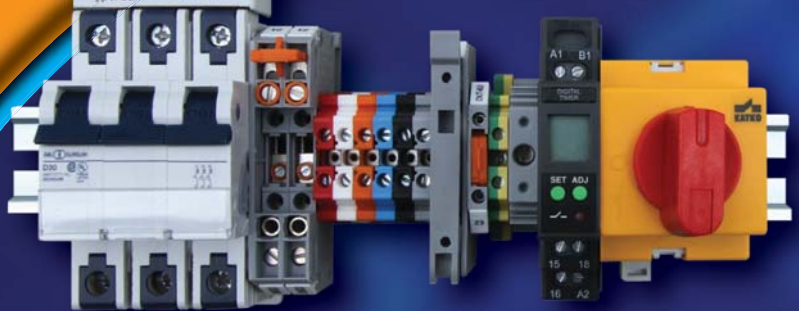
Broad Selection of Components

+ Enclosures & DIN Rail



Quality Components & Quality Assembly SOLUTIONS

= Altech Custom Assemblies



Altech Corp.®

Your Source for Automation & Control Components

info@altechcorp.com
908.806.9400
AltechCorp.com

INSIDE

MachineDesign
MAY 2022
Volume 94, Issue 4

"By printing parts on an as-needed basis at metal printing hubs, companies can prototype and iterate faster, scale up or down based on real-time fluctuations in demand, and get products to end-users more quickly without compromising their bottom lines during times of uncertainty."

COVER STORY

20 How Additive Manufacturing Takes Shape in 2022
When supply chain disruptions inhibited business operations in 2021, additive manufacturing offered a lifeline.
Image: Komgrit Pradissagul/Dreamstime and 3DEO

FEATURES

23 MECHANICAL & MOTION SYSTEMS
Electrohydraulic Disruption
With electrification on the upswing, new demands are being placed on the hydraulics industry.

26 AUTOMATION & IIoT
Digital Supply Chain
Cybersecurity report flags clear and present danger.

30 MATERIALS
Record-Breaking, Ultrafast Diodes Could Protect the Grid from EMPs
A new Sandia diode can shunt excess electricity in a few billionths of a second.

32 MATERIALS
Striving for a Safer Lithium Battery
Liquid electrolyte, solid electrolyte or a combination of the two: Which is safest?

COLUMNS

6 From the Editor
Supply chain woes may have provided the impetus for people to finally take additive manufacturing seriously.

40 One Last Thing...
Envelope tracking improves energy efficiency across communication networks.

DIGITAL EXTRAS

4 Machine Design Online
Stories, videos, exclusive articles and events. Visit the official website of *Machine Design:* ***www.machinedesign.com***

NEWS & NOTES

8 By Design
Industry news and briefs.

- Hannover Messe Preview: Industrial Transformation
- 3D Eyes its Big Breakthrough
- Hydraulic Hybrid Multicopter Design Takes Flight
- Design with the End-User in Mind

34 Featured Products

39 Ad Index

39 Classifieds

MACHINE DESIGN ISSN 0024-9114 (PRINT) AND 1944-9577 (DIGITAL) is published by Endeavor Business Media, 1233 Janesville Ave., Fort Atkinson, WI 53538. Machine Design is published monthly, except for combined issues in Feb/March and Aug/Sept. Rates: U.S.: $139/year; $199/two years. Canada/Mexico: $159/year; $239/two years; All other countries: $199/year; $299/two years. Cost for back issues are U.S. $10.00 per copy plus tax, Canada $15.00 per issue plus tax, and Int'l $20.00 per issue. OEM Handbook and Supplier Directory, $50.00 plus tax. Prepaid subscription: Endeavor Business Media (MACHINE DESIGN), PO Box 3257, Northbrook, IL 60065-3257. Periodicals postage paid at Fort Atkinson, WI and additional mailing offices.

Canadian GST #R126431964.

DIGITAL SUBSCRIPTION RATES: U.S.: $69/year. Canada/Mexico: $79/year. All other countries: $99/year. Print/Digital combo subscription rates: U.S.: $174/year; $249/two years. Canada/Mexico: $199/year; $299/two years; All other countries: $249/year; $374/two years.

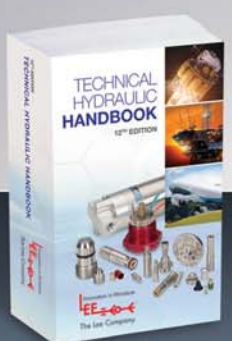
POSTMASTER: Send change of address notice to Customer Service, MACHINE DESIGN, PO Box 3257, Northbrook, IL 60065-3257.

THE LEE COMPANY

WHEN IT COMES TO PERFORMANCE, WE'RE YOUR WINGMAN.

PEACE OF MIND, SINCE 1948.

Count on The Lee Company for relentless support and unsurpassed reliability. That's been our approach for over 70 years, which has placed our field-proven Microhydraulic fluid control components on board every military and commercial aircraft flying today. So, whether you need a standard or custom-engineered solution, choose The Lee Company and relax. We've got your back.



Your Microhydraulics Flight Manual.
The Lee Technical Hydraulic Handbook has, for decades, served as the industry-standard engineering reference for hydraulic components. Request your free copy today at www.theleeco.com/new-hydraulic-handbook

The Lee Company **860-399-6281 • www.theleeco.com/aerospace**

WESTBROOK • LONDON • PARIS • FRANKFURT • MILAN • STOCKHOLM

MachineDesign

EDITORIAL
Senior Content Editor: **Bob Vavra**
bvavra@endeavorb2b.com

Managing Editor: **Jeremy Cohen**
jcohen@endeavorb2b.com

Senior Editor: **Stephen J. Mraz**
smraz@endeavorb2b.com

Senior Editor: **Rehana Begg**
rbegg@endeavorb2b.com

Senior Editor: **Marie McBurnett**
mmcburnett@endeavorb2b.com

Technical Editor: **Sara Jensen**
sjensen@endeavorb2b.com

ART DEPARTMENT
Group Design Director: **Anthony Vitolo**
tvitolo@endeavorb2b.com

Art Director: **Jocelyn Hartzog**
jhartzog@endeavorb2b.com

PRODUCTION
Production Manager: **Sam Schulenberg**
sschulenberg@endeavorb2b.com

Ad Services Manager: **Deanna O'Byrne**
dobyrne@endeavorb2b.com

AUDIENCE MARKETING
User Marketing Manager: **Debbie Brady**
dmbrady@endeavorb2b.com

Article Reprints: reprints@endeavorb2b.com

LIST RENTAL
Smartreach Client Services Manager: **Mary Ralicki**
mralicki@endeavorb2b.com

SUBSCRIPTION SERVICES
OMEDA: machinedesign@omeda.com
847-513-6022 or 866-505-7173

DIGITAL
Senior Digital Innovation & Strategy Director:
Ryan Malec rmalec@endeavorb2b.com

SALES & MARKETING
Patrick Carmody
pcarmody@endeavorb2b.com
AK, AR, AZ, CA, CO, HI, IA, ID, IL, IN, KS, KY, LA, MI, MN, MS, MO, MT, ND, NE, NM, NV, Western OH, OK, OR, SD, TN, TX, UT, WA, WI, WY, Western Canada

Brandy Bissell
bbissell@endeavorb2b.com
DE, MD, NC, NJ, NY, Eastern OH, PA, SC, VA, WV

Liz Stott
lstott@endeavorb2b.com
AL, CT, FL, GA, MA, ME, NH, RI, VT, Eastern Canada

Stuart Bowen
sbowen@endeavorb2b.com
Belgium, France, Luxemburg, Netherlands, Portugal, Scandinavia, Spain, United Kingdom

Diego Casiraghi
diego@casiraghi-adv.com
Italy

Helen Lai or Charles Liu
helen@twoway-com.com or liu@twoway-com.com
Pan-Asia

DESIGN & ENGINEERING GROUP
Electronic Design, Machine Design, Microwaves & RF, Power & Motion, SourceESB, Source Today, 3DX

EVP, Design & Engineering Group: **Tracy Smith**
tsmith@endeavorb2b.com

Group Content Director: **Michelle Kopier**
mkopier@endeavorb2b.com

VP of Marketing Solutions & Data: **Jacquie Niemiec**
jniemiec@endeavorb2b.com

ENDEAVOR BUSINESS MEDIA

Endeavor Business Media, LLC
331 54th Ave. N., Nashville, TN 37209 USA
www.endeavorbusinessmedia.com

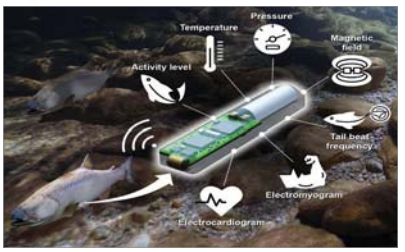
CEO: **Chris Ferrell**
President: **June Griffin**
CFO: **Mark Zadell**
COO: **Patrick Rains**
Chief Administrative and Legal Officer: **Tracy Kane**

MachineDesign.com

Plastic Bearings: The Pros and Cons

Here's some advice on when—and when not—to use them.

www.machinedesign.com/21239439



Wireless Sensor to Uncover the Secret Life of Fish

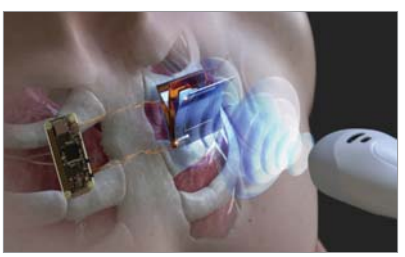
The new Lab-on-a-Fish "Fitbit" tracks a fish's location, heartbeat and tail beat, and even the temperature of the surrounding environment.

www.machinedesign.com/21238911

At Your Fingertips: Improving Dexterity Through 3D-Printed Skin

Fabricating a biomimetic fingertip that demonstrates human sensitivity using the transduction principles of human touch.

www.machinedesign.com/21238328



Battery Option: Applying Ultrasonic Waves for Wireless Charging

Triboelectric power generation can be used to charge batteries underwater or in body-implanted electronic devices.

www.machinedesign.com/21239371

FEATURED VIDEO

Why the Context of Your Mobile Device Matters to Productivity

Knowing where your workforce's mobile devices are affects both safety and productivity.

www.machinedesign.com/21237792

MachineDesignMagazine

@MachineDesign

Machine-Design-Magazine

Read Anytime, Anywhere!

View the digital edition of *Machine Design* at:

www.machinedesign.com/magazine

INDUSTRIAL AUTOMATION eXCHANGE BY CSIA

CSIA Exchange
Find a system integrator here: https://www.csiaexchange.com

THERMAL CONDITION MONITOR

Provides 24/7 monitoring for predictive maintenance and reduced downtime of equipment.

More Automation Options...And Growing.

digikey.com/automation

1.800.344.4539

Digi-Key ELECTRONICS®

DIGI-KEY ELECTRONICS & AUTOMATION®

Your source for the latest electronic components and automation devices worldwide

By Bob Vavra, Senior Content Director

A Second Look at 3D Printing

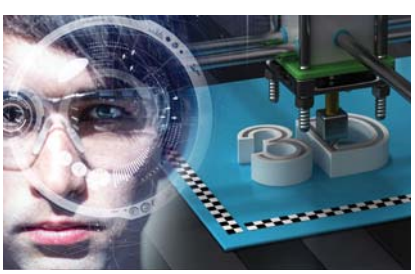
Supply chain woes may have provided the impetus for people to finally take additive manufacturing seriously.

IT'S PROBABLY TOO CLICHÉ to suggest additive manufacturing is entering a new dimension. The promise of 3D printing as a prototyping tool was quickly realized by manufacturing managers. The evolution to production-level quality products and materials turned 3D printing into a powerful took for precise geometries and customized production solutions.

The solutions were more easily identified, but the industry still was slower to embrace the potential of 3D printing as more than a design tool. Then came a global supply chain crisis followed by a global pandemic, and design and production teams began to rethink the way 3D printing could be useful.

As *Machine Design* reports this month, 3D printing was a valuable tool to deal with a badly mangled supply chain. By using in-house machines, parts could be produced in hours instead of waiting days for the supply chain to untangle itself. For commodity parts, they could be produced in bulk and on site, saving in transportation costs while being able to control inventory management.

At a presentation at last month's MD&M West Show in Anaheim on advanced manufacturing, 3D industry experts said the combination of supply chain value, a more sustainable solution from creation to procurement, and greater control over the production process should make 3D printing an essential element for manufacturers looking to expand their competitive advantage.



The barrier that remains is the confidence that 3D printing can scale all of these operational and production obstacles. Matt Sand of 3DEO, who also authors this month's *Machine Design* lead article, told the audience at MD&M West that some manufacturers still are cautious about 3D's potential value.

"The challenge is convincing people [3D printing] is real," said Sand. "There have been so many hype cycles to the industry. The important messages is that it is really happening this time. We're on the precipice of a big breakthrough."

Even so, Tim Heller of Stratasys reminded the attendees that there are limits to what manufacturers should expect from 3D printing. "Additive doesn't change the supply chain," Heller noted. "It's a piece of the puzzle."

But 3D printing can be a fit for those manufacturers who can identify ways to take full advantage of its scale and precision. It requires a second look at 3D printing to understand how technological advancements can be of value to the single-site shop or the global manufacturer. ■

One Cutout NEMA Outlets From Interpower®

product design simplified

Interpower offers four NEMA snap-in sockets which include 5-15, 5-20, 6-15, and 6-20 sockets with one common panel cutout to help you simplify product design. Each socket type has four different configuration options—choose from quick disconnect tabs with or without wire-binding screws or solder tabs with or without wire-binding screws.

Snap-in Mount

The snap-in mount style has tabs on the outer surface of the component setting just under the mounting flange. As the component is inserted through the cutout hole, the tabs slide back until they clear the panel surface. The tabs snap back into the original position. This holds the panel between the tabs and the mounting flange.

Screw-Mount

Screw-mount style has an enlarged flange on the sides providing a place for mounting holes. The panel is drilled for screws or tapped for bolts. The mounting screws fasten the sockets securely in place.

- **Same day shipping on in-stock cord sets & components**
- **No minimum order or dollar requirements**
- **World-class customer service**

interpower®

Order Online! www.interpower.com

Business Hours: 7 a.m.–6 p.m. CST

INTERPOWER | P.O. Box 115 | 100 Interpower Ave | Oskaloosa, IA 52577 | Toll-Free Phone: (800) 662-2290 | Toll-Free Fax: (800) 645-5360 | info@interpower.com

Hannover Messe Preview: Industrial Transformation

The international trade fair has elected a theme aimed at stimulating innovative and efficient approaches to production and climate protection.

Hannover Messe, one of the world's largest trade fairs, will stage a physical trade show in Hannover, Germany, from May 30 to June 2, 2022.

This year's theme, "Industrial Transformation," places the focus on how connected production facilities can work toward sustainability by operating more efficiently and conserving resources. The theme responds to the current energy supply debate, which brings the topic of hydrogen to the forefront.

Dr. Jochen Köckler, CEO of Deutsche Messe, set the tone for the upcoming event by acknowledging the impact of current political events. "Today, we can really appreciate how 'normal' everything was before the pandemic," Köckler said at a press preview on March 16. "Now we have learned, due to the condemnable war of aggression against the Ukraine, that we have had to return to another crisis mode."

While this will not lead to postponing Hannover Messe, he said, the topics will be fine-tuned. "At the heart of the matter is how we can ensure security of supply and growth in a dynamically changing world—politically, environmentally and economically—while counteracting climate change," said Köckler. "Innovative technologies will play a key role in this."

To this end, many companies are paving the way with concrete solutions. "In Hannover, more than 200 companies—including Iberdrola, Saint Gobain, Emerson, ElringKlinger, Plug Power, Siemens, Phoenix Contact, Enapter, Bosch, Hexagon Purus, Nel Hydrogen, Hydrogenious and GP Joule—present solutions for a sustainable energy supply based on hydrogen derived from renewable energy sources," Köckler said. As an example, Hannover Messe exhibitor Bosch created a hydrogen cycle at its Industrie 4.0 facility that produces green hydrogen for industrial processes.

In 2019, EU leaders expressed support for the objective of achieving a climate-neutral EU by 2050. This endorsement followed the commitments made by the EU and member states on signing the Paris Agreement in 2015. This means that companies have set ambitious goals and are in the process of converting their production and services.

AT A GLANCE:

- Hannover Messe 2022 is designed for audiences interested in Industrie 4.0 and its contribution to sustainability.
- With innovations in automation, digitalization, electrification and energy efficiency, the electrical and digital industry is steering the industrial transition to a climate-neutral circular economy.
- Portugal is this year's partner country. An explicit goal is to encourage German companies to minimize risk by investing in Portugal for their supply chain needs.

Energy supply security and climate change are at the forefront of problems in need of solutions at Hannover Messe 2022. *Images by: Hannover Messe*

FESTO

Innovate today
for a new tomorrow

Realize your vision with Festo‘s approach to smart automation for automotive manufacturing. Partner with Festo today.

Industry Leadership

Superior Quality Products

Global Training & Support

www.festo.us

Digitalization, Automation and AI Against Climate Change

Exhibitors at the trade fair display state-of-the-art machinery and equipment and solutions that are not only resource-conserving and energy-efficient, but boost innovation and reduce greenhouse gas emissions around the world, noted the organizers.

Recording the CO2 footprint across entire supply chains is often the first step towards climate neutrality. For example, Siemens, an exhibitor, developed software that captures emissions data along the supply chain and combines this with data from the company's own value chain to determine a product's actual carbon footprint, noted a conference brief.

Some 2,500 companies display their technologies for the factories and energy systems of the future at the Hannover Exhibition Center.

Portugal's Problem Solvers

An integral part of the Hannover Messe formula is to showcase a partner country. This year's consort, Portugal, is supported by AICEP—Portuguese Trade & Investment Agency in partnership with AIMMAP—Association of the Portuguese Metalworking Industries and the Portuguese-German Chamber of Commerce and Industry.

The Portuguese contingent will have a strong on-site presence, with product and solution displays for digital transformation, energy transition and reliable supply chains. The goal is to encourage German companies to minimize risk by investing in Portugal for their supply chain needs.

Portugal has a sizable global footing in the Engineered Parts & Solutions segment (15,277 companies and 198,698 employees in 2020), covering sectors such as mechanical engineering, metal, mobility and automobile, aeronautics, and space. This sector of Portuguese industry exported goods and services worth more than $19.6 billion (€17.8 billion) to more than 200 countries. Metal works, machinery, tooling and transport equipment represent 32% of total Portuguese goods export

At the preview event, Luís Castro Henriques, president, AICEP, made that case for Portugal's digital ecosystem as one of the most vibrant areas for entrepreneurship and investment in Europe. Two other markers of distinction, noted Henriques, are that the country's energy solutions rank ninth in global contribution and climate in the Good Country Index, and that Portugal is committed to achieving carbon neutrality by 2050.

Henriques also pointed out that the country has the third-highest rate of engineering graduates in Europe, and nearly 30% of the country's graduates are from ICT, engineering, math and science disciplines.

> *"At the heart of the matter is how we can ensure security of supply and growth in a dynamically changing world—politically, environmentally and economically—while counteracting climate change. Innovative technologies will play a key role in this."*

Coronavirus Ordinance

As of March 4, 2022, trade fairs can take place without being subjected to new restrictions. The ordinance is in effect until March 19, 2022. Thereafter, coronavirus-related restrictions are expected to be eased, barring any resurgence in infection and hospitalization rates. Hannover Messe organizers noted that participants who are vaccinated, recovered or tested have access to exhibition grounds and the exhibition halls. In addition, FFP2 masks are mandatory in indoor areas.

Exhibiting Companies

Some 2,500 companies display their technologies for the factories and energy systems of the future at the Hannover Exhibition Center. Exhibiting companies include corporations such as Siemens, Bosch, Schneider Electric, Schaeffler, Microsoft, SAP and Service Now. Medium-sized industrial enterprises include Beckhoff, Festo, Harting, Pepperl+Fuchs, Phoenix Contact, Wago and Ziehl-Abegg. Accompanying them are major research institutes, such as Fraunhofer and Karlsruhe Institute for Technology (KIT), as well as about 100 startups that find Hannover Messe an ideal platform for networking with industry.

Four conference stages will cover topics in the following categories: Automation, Motion & Drives, Digital Ecosystems, Energy Solutions, Logistics, Engineered Parts & Solutions, Global Business & Markets and Future Hub.

The complete program will available to visitors, but will also stream simultaneously via the Hannover Messe website at https://www.hannovermesse.de/en/. ■

Best under pressure

*The pressure-resistant **AxiEco** series.*

The brand new AxiEco 630-910mm axial fans have air performance curves with a maximum pressure of over 2.8 in.wg. This exceeds existing axial fan designs, while at the same time lowering the overall noise level and providing impressive static peak efficiencies of well over 50%. The axial fan range consists of three new sizes with impeller diameters of 630, 800 and 910 mm, (24, 31 and 35 inches) with a maximum airflow of more than 25,000 CFM of free air.

ebmpapst

engineering a better life

Images: Sergiy Palamarchuk/Dreamstime and Bob Vavra

3D Eyes its Big Breakthrough

WHILE A LARGE AMOUNT of the focus in additive manufacturing is about the machines and materials, speakers at the panel discussion on "The Promise of Additive Manufacturing for Production" at the MD&M West trade show in Anaheim on April 13 said there also should be focus on how to gain and maintain control of the 3D printing network.

"It's not just a hardware solution. You need to have very good on control with your software," said Matt Karesh of Velo 3D during the panel presentation. "Repeatability, scalability enables true production—not just with a single machine, but in a distributed supply chain."

The vision of an 3D printing system integrated not just with production but also with supply chain management is part of the promise of additive manufacturing. As speakers noted, the reality of current systems are still a distance from fully realizing that promise.

"The challenge is convincing people [3D printing] is real," said Matt Sand of 3DEO. "There have been so many hype cycles to the industry. The important messages is that it is really happening this time. We're on the precipice of a big breakthrough."

Added Tim Heller of Stratasys, "Additive doesn't change the supply chain, it's a piece of the puzzle." The size of that puzzle also is a factor, as Heller noted. "When you do analog-to-digital transformation, you ask people to think differently."

Another consideration is the size of the organization. Because 3D printing depends on a CAD model as the single point of reference, that model can be tweaked, replicated and distributed across a local network or distributed around the world.

"You could have a couple of development machines at a centrally located technical center where you can vet out components and then, once ready, send the file out to where it needs to be printed," said Karesh.

"Distributive is where I think we want to go," said Heller. "If we're going to talk about distributive, we need to see it's an enabling device. Right now, it's not about printing a product; it's printing a part. There's a lot more that has to happen end-to-end to get to distributive."

> *"The challenge is convincing people [3D printing] is real. There have been so many hype cycles to the industry."*
> *—Matt Sand, 3DEO*

Speakers speculated that distribution centers also could become a contract manufacturing center, printing parts on-demand rather than carrying inventory waiting for an order. The same model also is possible within a manufacturing plant. Either way, the potential for 3D printing is huge, and early adopters may gain an edge.

"Customers have got to figure out what's real," San said. "It's happening now in a small way that can be hard to see. People are putting a lot of money in quality, in repeatability. People taking advantage of that now are going to have a huge competitive advantage." ■

FOR MORE on Additive Manufacturing, see page 20.

HEIDENHAIN

The **KCI 120 D*plus*** **Dual Encoder**
High-Accuracy Robot Motion

The new KCI 120 D*plus* dual encoder from HEIDENHAIN combines motor feedback and position measurement in a single compact rotary encoder. Both benefits can be applied to every robot axis, correcting inaccuracies such as gearbox backlash and work-induced reaction forces. The HEIDENHAIN KCI 120 D*plus* thereby turns a typical articulated robot into a high-accuracy manufacturing system and dependable cobot.

Contact us today for details

HEIDENHAIN CORPORATION, 333 East State Parkway, Schaumburg, IL 60173 847-490-1191 www.heidenhain.us

Hydraulic Hybrid Multicopter Design Takes Flight

AMONG THE DIZZYING NUMBER of drone videos shared on YouTube, there are few that we're willing to share. But when the R&D engineers at Flowcopter Ltd. reached out to glean interest in doing a story on their hydraulic hybrid multicopter, something was different.

The founders of Flowcopter were involved in developing the underlying digital displacement hydraulic pump (DDP) technology at an Edinburgh company called Artemis Intelligent Power (AIP). Danfoss acquired the company in 2021 and has been using DDP technology to disrupt the hydraulics market. The technology is touted for delivering greater efficiency and increased productivity, particularly in off-highway applications.

The Flowcopter team, led by a group of 2015 MacRobert award winners (the UK's most prestigious prize for engineering innovation), set out to commercialize DDP technology for the aerospace industry. Their heavy-lift drone is intended to be a workhorse platform, targeting applications traditionally requiring manned helicopters, said Calum Arnott, one of Flowcopter's R&D engineers. This includes precision agriculture, reforestation, offshore logistics, search and rescue, rural delivery and law enforcement.

Flowcopter's engineers noted that DDP technology can be driven by either a liquid fuel IC engine or a more conventional battery-electric combination. For the multicopter, they envision using an IC engine for long-endurance flight, with a backup electric motor to cover short distance flight.

"At its core, [DDP] is a very efficient, multi-outlet, digitally controlled pump with fast control response," explained Arnott. "This enables us to independently control the flow rate to each of the four hydraulic motors driving our propellers. The DDP transmission provides control bandwidth necessary for our multicopter, in which fast and precise control of each propeller is essential for stable flight."

The world's first hydraulic hybrid multicopter was designed by Flowcopter. *Image: Flowcopter Inc.*

We had a few more questions for the engineers: Was battery-electric power considered? What are the advantages of using DDP? What is the multicopter's range?

Their responses, which follow below, have been condensed and edited for clarity.

What advantage does DDP have over conventional hydraulics and pure electric transmission?

Whilst much of the recent multicopter development has been focused on battery-electric power, hydraulics are not new to the aviation industry. Every day, seven million people fly on aeroplanes, which use hydraulic technology for control surfaces, landing gear, brakes, flaps and more. Hydraulics are chosen for their high power density/specific power and reliability. For example, Eaton's hydraulic engine-driven pumps are used in Airbus A330, A340 and A380 platforms with an average reliability exceeding 50,000 hours MTBF.

The DDP provides a highly efficient method of power transmission to our hydraulic motors. Our Hydro Leduc motors have an extremely high specific power output. Each one is capable of producing 96kW continuous output power whilst weighing only 5.5kg. Hydraulic motors are also inherently robust and capable of withstanding tough environmental use cases—they are most often found powering outdoor all-weather industrial equipment such as excavators and salt-spray spreaders.

By taking hydraulically powered heavy-lift multicopters to the sky, Flowcopter can target applications that have traditionally required helicopters whilst reducing O&M cost and improving personnel safety through autonomous, unmanned flight.

How were you able to improve the range to six hours?

We are able to have long-range flight by making use of a liquid fueled type-certified aircraft engine. This allows us to run on liquid fuel with significantly greater energy density/specific energy than batteries. Our goal is to run on net zero carbon synthetic fuel. This involves extracting hydrogen from water by using energy generated from renewable sources, before combining it with carbon dioxide captured from the atmosphere.

GETTING YOUR ATTENTION is our job.

LOUD & BRIGHT attention-getting devices.

AN-450 Announcer

Floyd Bell offers an Extensive and Diverse Line of Products

Announcer	Programmable Speakers in both panel-mount and stand-alone styles. **Up to 115dB!**
NEW! ***CAN Alarm***	A large, super-loud intelligent alarm that can be controlled on any **CAN J1939** network.
Audiolarm	The most widely-used industrial piezo alarm in the world.
M-80	The original high-output piezo alarm in a **small footprint**.
Turbo	Small, front-mount panel alarm that is half-the-size and twice-as-loud as industry counterparts.
Turbo Light	High intensity panel LED indicator available in **5 different colors**.
Ultra	A rear-mount piezo alarm that is **12 dB louder** and **1000 Hz lower** than industry counterparts.
Twin Turbo	A panel mount lighted piezo alarm that combines **bright light** with **loud sound**.

For our complete line of products, visit **www.FloydBell.com** or call **1-888-FLOYD-BELL**

Floyd Bell Inc

Please explain why the choice was made to go with the IC engine/liquid fuel combination for this drone. Why would battery power alone not work?

Battery-electric propulsion is an amazing method of reducing CO2 emissions, provided the batteries are charged from renewable energy sources. However, batteries have significant drawbacks that become apparent once you try to use them as an energy source to fly. One of these is low specific energy. This means they are heavy. The combination of an IC engine and liquid fuel can deliver 15 times the energy amount to the rotors per pound (kilogram) than batteries. The second limitation to batteries is the degradation of their performance under aggressive discharge cycles, which would be required to fly a heavy industrial drone. This results in the regular requirement to replace such packs.

We feel a net zero emission synthetic fuel offers a significantly better strategy than regularly replacing degraded battery packs.

What can you tell us about decisions made regarding light-weighting? Were there any special considerations or trade-offs?

The test platform in our videos is intended to prove our control bandwidth. Our next article is substantially closer to a finished product.

Our hydraulic motors are significantly lighter than the equivalent best-in-class electric motors with their speed controllers, and when used in heavy-lift high power applications, electric motors need to be liquid cooled, adding significantly more weight.

This reduction in system weight means we can avoid more costly carbon fiber components while still providing superior range and payload than an equivalent electric hybrid system.

Are there any regulatory hurdles you'll need to overcome?

Like all other large drones, depending on where you wish to fly them, we will need some certification. This will involve working with the likes of the CAA in the UK, FAA in the U.S. or EASA in the EU.

The Flowcopter drone can fly for more than six hours, up to 900 km. Hydraulic motors are sealed, and are proven workhorses in offshore environments. *Images: Flowcopter Inc.*

What's next in your process?

We want to do significantly more flight testing to tune the initial system. Following this we want to proceed to free-flight testing of a demonstrator drone, whilst developing our production-ready model in parallel.

Do you have any interesting backstories you want to share with our audiences of design engineers and with the hydraulics industry?

The founders of Flowcopter are hydraulics experts, having spent most of their careers developing the digital displacement technology from its conception at Artemis Intelligent Power. They have worked previously on applying the technology to projects ranging from 7MW offshore wind turbines to the America's Cup Foiling Catamarans. With a focus on practical innovation, they now bring their relentless energy to showing the aerospace industry the capability of a digital displacement hydraulic power transmission. ■

> *"We want to proceed to free-flight testing of a demonstrator drone, whilst developing our production-ready model in parallel."*

SEPT. 12-17, 2022 • MCCORMICK PLACE, CHICAGO

FIND IT

IMTS2022

INTERNATIONAL MANUFACTURING TECHNOLOGY SHOW

DIGITAL MANUFACTURING. IMPLEMENTED.

EXPERIENCE EASY-TO-DEPLOY **COBOT AUTOMATION**

COLLABORATIVE ROBOTS. FANUC AMERICA.

Unload preconceived notions about cobots. They weld, dispense, pick, place, inspect, tend, lift, finish, and more. Cobots program using drag-and-drop icons, deploy in hours, and go years without maintenance. Discover how cobots like the FANUC CRX make automation easy at IMTS 2022.

REGISTER NOW AT **IMTS.COM**

Design with the End-user in Mind

DESIGN WORKS BEST when applied in its widest form. Here are six ways to use design in the industrial sector to create results that go beyond the traditional idea of design as merely an aesthetic exercise..

1. Design for Usability and Safety

Usability, or ergonomics, looks at machines from the point of view of the people who use them. How efficient is it? Is it effective? Is it safe? With so many physical stress factors such as noise, increased danger levels and the challenging environments industrial machines operate in, mistakes can have serious consequences. That's why designers must always start with the user, an approach known as human-centered design. The better the user's needs are understood, the safer, the more functional the result.

A clean design with an ordered component distribution creates a safer work environment for the operator. When working for Tederic, the Chinese producer of plastic injection molding machines, the Design Group Italia team spent days in their production facility in Hangzhou City, China observing the operators to really understand how they use the machines. By teaming with Tederic's R&D team, a clean, minimalist design language with easily accessible HMIs, indicators and inspection areas was developed to best serve the users.

2. Design as Communication

Companies buy industrial machines to perform clear functions. Trustworthiness, credibility and level of innovation of the machinery are key drivers in the purchasing process. Beyond the logo or brand identity, a well-designed machine is the most important vehicle of the brand, bringing considerable competitive advantage and communicating the technological capabilities of the manufacturer.

What the machine design communicates depends on the company. The woodworking machinery producer SCM Group already had a strong brand but wanted to create a new line that would be the reference point for the entire category. The resulting L'Invincibile communicates top-of-the-line quality, technological excellence and exclusivity.

3. Design that Creates Economies of Scale

Designers play a crucial role in optimizing machinery for production and upkeep costs. For the die casting machine producer Idra Group, similar modules were used for multiple types of machines in the product family, which dropped production costs and made replacing parts and keeping product stocks easier.

Industrial designers need to work closely with engineers to facilitate easy and efficient

(Continued on page 38)

FREE WEBINAR

May 19, 2022 | 2pm EDT (11am PDT)

Registration URL: https://www.machinedesign.com/webinars/webinar/21238249/designing-piezoelectric-acoustic-transducers-with-simulations

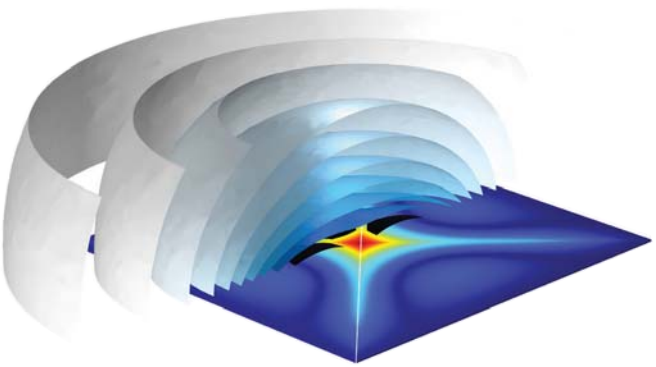
Designing Piezoelectric Acoustic Transducers with Simulations

Piezoelectric transducers generate and receive acoustic signals in applications that range from small speakers to medical devices and sonar arrays. The trend to miniaturize these devices presents significant challenges. For example:

- Piezoelectric devices within mobile speaker applications need to be able to generate high-quality sound.
- Many noninvasive medical diagnostic devices operate at highly specific frequencies. Thus, the piezoelectric devices must operate at a precise frequency.
- Sonar applications often require that piezoelectric devices generate high-power signals to propagate long distances without attenuating below detectable levels.

In each case, product design engineers must develop designs that meet the required specifications within ever-smaller packages.

These electroacoustic transducers are inherently multiphysics in nature. Thus, designers must have a platform that allows them to calculate the multiple physics within their products, such as multiphysics simulation.



Multiphysics simulation has the features needed for developing product designs more effectively and simulating the designs within operating conditions. In addition, the simulations may include the entire ecosystem, from the control circuit to the piezoelectric transducer to the surrounding acoustic environment.

In this presentation, guest speakers Kyle Koppenhoefer and Joshua Thomas from AltaSim Technologies will discuss the development of an acoustic device that operates on piezoelectric transducers within an underwater environment. The webinar will also include a live demonstration using the COMSOL Multiphysics® software, as well as a Q&A session.

Hosted with

MachineDesign

COMSOL

SPEAKER:

Kyle Koppenhoefer is the president of AltaSim Technologies. He and his business partner founded AltaSim 20 years ago. He works with customers to identify how computational analysis can be used to provide solutions to their products and manufacturing processes. Prior to cofounding AltaSim, Kyle worked for the Department of Defense and the Edison Welding Institute. He holds a PhD in civil engineering from the University of Illinois.

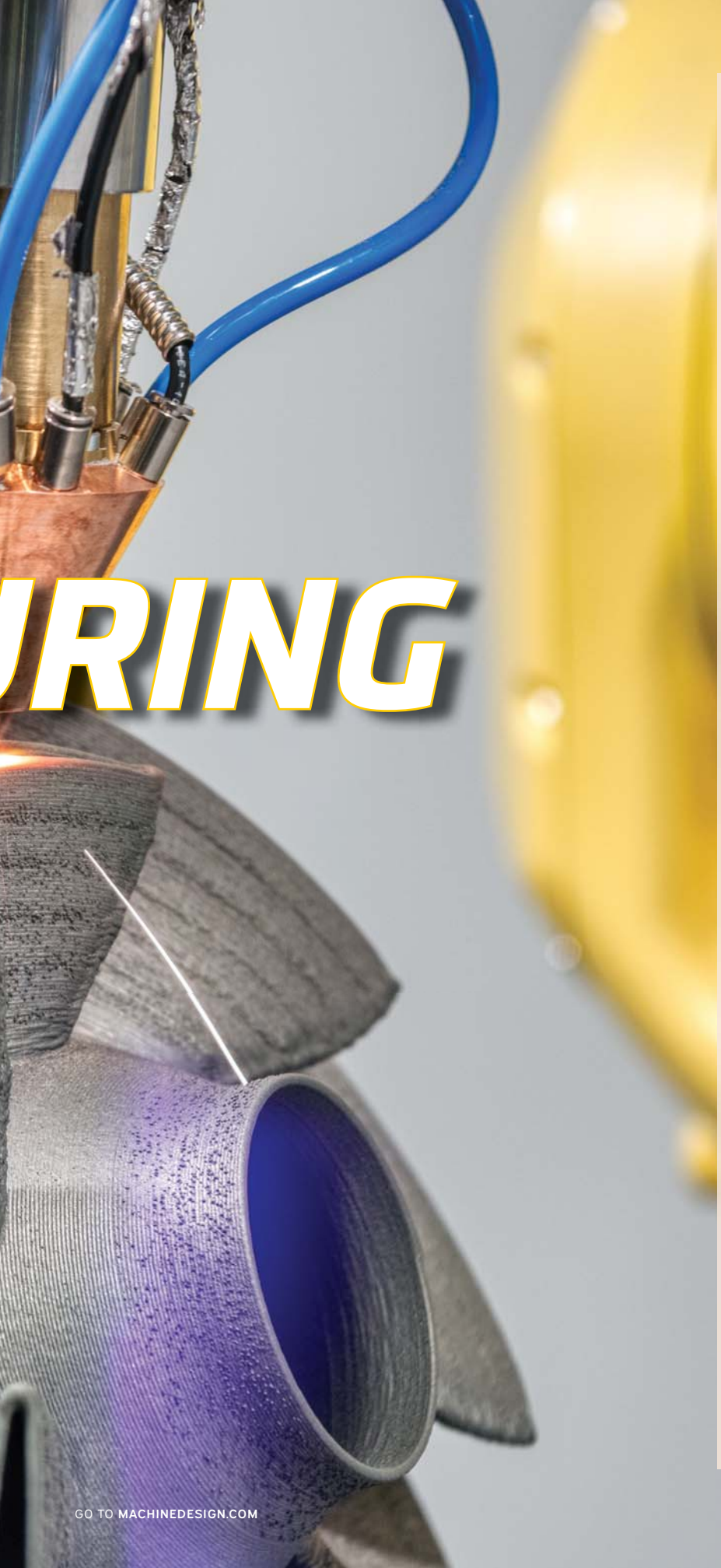
SPEAKER:

Josh Thomas is a senior engineer at AltaSim Technologies. He has provided consulting and training support in COMSOL Multiphysics® over the last 10 years. He is a lead instructor in many of AltaSim's classes and has worked extensively with structural mechanics problems and multiphysics problems involving thermal and structural analysis. Josh received his bachelor's degree in aerospace engineering and master's degree in mechanical engineering from The Ohio State University.

How ADDITIVE MANUFACTU Takes Shape in 2022

When supply chain disruptions inhibited business operations in 2021, additive manufacturing offered a lifeline.

188352140 / 3D Metal Printer © Nordroden | Dreamstime.com



URING

by Matt Sand, Co-Founder and President, 3DEO and Co-Author of *The Agile Startup*

After a year fraught with supply chain and environmental crisis, the industrial world is being incentivized to adopt technological solutions, such as additive manufacturing, that improve the way we design and ship products.

In 2021, the global supply chain was roiled by the COVID-19 pandemic while the environment sent disastrous warnings of the planet's fatigue with our inaction on climate change. The common refrain from manufacturers was "I can't get parts to make my products," or "My product is stuck at the port and I have no idea when to expect it."

As these problems escalated—deeply affecting people, companies and economies—3D printing proved to be an important part of the supply chain solution. By giving companies more autonomy over the way their products are designed, produced and shipped, and enabling them to return production back to their home markets, OEMs began 3D printing their way to streamlining supply chains while reducing their footprint on the environment.

In 2022, however, we expect these three areas to converge rapidly as 3D printing—or the additive layering of materials on one another to create a product in a machine—unlocks an attractive alternative to traditional manufacturing, even in mass production.

Alleviating Supply Chain Headaches

Helping to usher in this new industrialization are companies such as California-based 3DEO, a leader in mass production of metal 3D-printed parts that is creating localized production hubs.

In one example, one of 3DEO's customers was in a bind. The company was short one component in its products, which led to more than $500,000 in inventory that it could not ship. 3DEO started producing this component and, within four weeks, this customer was back in business.

3DEO uses patented metal 3D printing technology to produce parts and bring production closer to end-users. *Image: 3DEO*

Soaring demand over the past 12 months has led to a six-fold increase to 3DEO's manufacturing floor space. Last summer, the 2016-founded company surpassed its one-millionth part printed and shipped to a customer—a staggering 566% year-over-year improvement—as its machines were rapidly at work producing parts for everything from medical surgical robots to airplane engine parts for Fortune 500 companies based in the U.S.

New patents that enable higher-volume production from industrial metal-printing machines are enabling faster and more efficient processes, tipping the scales toward localized manufacturing. OEMs have long had to ship metal parts from around the world to build complex metal products, forcing OEMs' dependency on the global supply chain that proved cost-prohibitive and unpredictable during the backlogs of 2021. Supply shortages were up 638% in the first half of 2021 because of the pandemic, according to data from Resilinc, while dozens of cargo ships were stranded off the coast of San Diego through mid-October.

By printing parts on an as-needed basis at metal printing hubs, companies can prototype and iterate faster, scale up or down based on real-time fluctuations in demand, and get products to end-users more quickly without compromising their bottom lines during times of uncertainty.

3D Printing Offers Sustainable Solutions

The cherry on top of this efficiency is how it is impacting the way companies are contributing to climate action and meeting their environmental, social and governance (ESG) goals.

A whopping 90% of companies' impact on the environment comes from their supply chains, according to a report by McKinsey. But with Earth's temperatures rising and scientists urging global leaders to take steps toward sustainability, companies are being pressured to adopt sustainable solutions to reduce their carbon footprint.

A typical consumer company's supply chain accounts for more than 80% of greenhouse gas emissions and more than 90% of the impact on air, land, water, biodiversity and geological resources, compared with the company's own internal operations, noted McKinsey. But 3D printing is being recognized as an attractive alternative to help them lower CO2 emissions.

By localizing manufacturing with printing hubs, companies can distribute production so that products are built much closer to the end-user, returning jobs to OEM home markets, automating processes, and reducing both costs and CO2 output. In a 2014 report, MIT researchers predicted that 3D printing had the potential to cut total supply chain costs by about 50% to 90%, with the biggest savings coming from transportation as production shifts local.

The additive nature of 3D printing also produces far less material waste than the traditional subtractive methods of CNC, which can produce up to 95% excess material. It's the difference between using the bare minimum material required, versus subtracting from an existing metal block. Metal printing additionally invites more advanced, environmentally friendly materials, such as the cobalt chromium ceramic alloy used to print a jet engine nozzle. This can help companies comply with regulations that will undoubtedly arise in coming years.

California has already banned carmakers from selling brake pads containing "more than trace amounts" of copper and other heavy metals, and has taken a lead on banning toxic materials that are expected to disproportionally affect metal injection molding (MIM).

Look Forward to More Control, Better Designs, Improved Efficiency

3D printing enables companies to be flexible with industrial design, which can help to minimize waste by consolidating many assembled parts and processes into one. This can lead to much more efficient designs that benefit both the planet and the end-user.

The Additive Manufacturer Green Trade Association (AMGTA), a 2019-launched nonprofit promoting the environmental benefits of additive manufacturing, reports that one of its members, 3D printing company ExOne, has reduced material waste to less than 5% and is now delivering end-use products that are 30-40% lighter because of additive manufacturing. GE used metal 3D printers to reduce a turboprop engine from an 855-part assembly to the only 12-part Catalyst engine with improved power and fuel efficiency, according to an AMGTA white paper.

By tweaking designs online through platforms such as the 3DEO Manufacturing Cloud, companies can quickly scale production based on their exact needs, thus reducing wasted time and material in inventory. They can imagine innovative solutions to antiquated designs, create exotic new parts never before possible and be rewarded with a new sense of logistical freedom.

As we move through 2022, 3D metal printing will continue to revolutionize the supply chain for metal components on a scale not seen since the last Industrial Revolution. ■

Electrohydraulic Disruption:

New Technologies Steer the Way Forward

With electrification on the upswing, new demands are being placed on the hydraulics industry.

by Rehana Begg, Senior Editor

AT A GLANCE:

- In the energy debate, hydraulic systems are framed as inefficient energy hogs.
- Newer advancements, including electrohydraulic technologies, are well-suited for certain uses.
- OEMs are targeting new hydraulic system architectures that can incorporate electronics in off-highway equipment for increasing efficiencies and maximizing effectiveness.

When major automakers announced a pivot to electric vehicles last year, their collective declaration marked an inflection point.

GM demarcated its shift toward wide-scale EV production with a corporate logo change. The new logo featuring the letters "gm" in lowercase, noted the automaker, ushers in a new vision for "a world with zero crashes, zero emissions and zero congestion." The letter "m" was purportedly underlined as a nod to the company's Ultium battery cell platform.

More than a shift in tone, electrification is playing a pivotal role in the transformation of mobility. Many OEMs have set end dates for internal combustion engine (ICE) vehicles. In the U.S., new regulatory targets aim for an EV share of at least 50% by 2030.

Electricity use is expanding at twice the rate of any other form of energy and drives an imperative to deliver smart, safe and sustainable transport systems and solutions. As emission standards around the world grow more stringent, the pressure mounts to create more efficient electric and hybrid vehicle solutions. The recently enacted infrastructure bill is allocating more than $7 billion in funding across the battery supply chain for battery materials refining, processing and components manufacturing.

Yet, despite the all-out push for electrification, practical and technological hurdles

Cat 651 Wheel Tractor Scraper re-enters the market with upgrades to the powertrain, controls, hydraulics and structure. *Image: Caterpillar*

continue to hamper EV sales, including the limited range on these vehicles and the dearth of charging infrastructure. In 2020 there were roughly 25,000 Level 2 fast-charging stations in the U.S., compared to 115,000 gas stations.

Consider the zero emissions equation. Even if 50% of vehicles are electric by 2030, the obvious query remains: What happens to the remaining 50%?

Fluid power experts tell us that the ambition and demand required from regulatory emissions targets still outpace the speed at which the industry can optimize returns from electrification. In a recent interview with *Power & Motion* (https://powermotiontech.com/21214394), Eric Alstrom, president of Danfoss Power Solutions said the trend is encroaching on all segments. "What we've learned during the pandemic is that, especially now with significantly increasing supply chain costs, it makes perfect sense both for our flexibility but also from a cost perspective to be more local," he said.

With electrification moving to the forefront in the coming years, decision-makers will be critically assessing product portfolios for components that see slowing demand in the face of continuous improvement and costs, and opt instead for technologies that deliver cleaner and greener options.

Hydraulics Hold a Trump Card

Even as electric power transmission is proving to be cleaner and more efficient, and as electronic controls integrate with existing technologies, hydraulics remains unsurpassed when it comes to power density, pointed out Mitch Eichler, a business development manager at Parker Hannifin's Motion Systems Group. "It's hard to beat the power ratio of hydraulics," he said. "High-force, high-demand applications still are largely done by hydraulic valves."

The good characteristics need to be weighed against the bad in each application, Eichler said.

"In some applications, components are going more electromechanical for its motion control capabilities. But with all the energy that it consumes, it would be size- and cost-burdensome to drive everything this way."

Volvo's ground-breaking electrohydraulic system achieved radical improvements in energy efficiency. *Image: Volvo Construction Equipment*

Prototyping and Use Cases

While some OEMs plan a wholesale overhaul of their product lines, others are phasing in new hydraulic system architectures that can incorporate electronics in off-highway equipment for increasing efficiencies and maximizing the effectiveness of hydraulic technology. Examples in the field are becoming ubiquitous.

Electrohydraulic upgrades. Consider Caterpillar's self-propelled Cat 651 Wheel Tractor Scraper (WTS). This new single engine was big news at CES earlier this year, and has re-entered the market with upgrades to the powertrain, controls, hydraulics and overall design.

Its single engine design features the Cat C18 engine powering the tractor with 469 kW (629 hp) and meets EU Stage V/U.S. EPA Tier 4 Final emission standards. Advanced Productivity Electronic Control System (APECS) fully integrates the transmission and engine drivetrain to provide smooth and responsive shifts. The scraper can load 104,000 lb of material in 30 sec. (In the U.S., the 651 scraper is usually tandem pushed by a D10-sized tractor for optimum payload and cycle times.)

Caterpillar noted that improvements to the hydraulics include an electrohydraulic implement system for improved multifunction capability and a short throw for the T-handle implement control. And, with a high-pressure steering system that requires significantly less steering effort—therefore reducing fatigue—efficiencies to the work cycle and operator experience have been enhanced.

Energy recovery. A Volvo Construction Equipment team unveiled a groundbreaking new system architecture for excavators last year. Aimed at reducing energy losses in hydraulics, the new system architecture was being tested in the field. The machine's work functions are connected to a hydraulic energy storage via a common pressure rail, comprised of two or more pressure lines. The energy storage (hydraulic accumulators) enables energy-efficient recovery of kinetic energy and peak power supply.

For cylinder-driven functions, so-called "smart actuators" are used to achieve energy-efficient conversion from hydraulic power to a variable force and speed, noted Volvo's team. The system can recover energy and increase performance of the machine's rotating loads, such as the swing function through the introduction of variable hydraulic machines. With more power available, cycle times can be reduced (for example, when loading a truck), which contributes to both efficiency increases and cost benefits for users.

> *"It is digital hydraulics for the digital age. It is going to be a very creative phase for the whole industry as we learn how to apply the technology to solve a myriad of problems that customers have."*
>
> *— Niall Caldwell, Director, Danfoss Digital Displacement*

Danfoss Digital Displacement Pump lowers energy losses. *Image: Danfoss*

Improved duty cycle. When Danfoss engineers analyzed the energy flow in excavators, they discovered that 70% of the useful energy made by the engine disappeared as waste heat. Danfoss has developed its Digital Displacement (DDP) technology to help address this by simply swapping out the conventional pump. Replacing a standard pump with a single- or multi-outlet 96cc Digital Displacement Pump can significantly increase the productivity of hydraulic machinery, enhance control and reduce energy consumption, they noted.

According to Danfoss, DDP technology can cut fuel consumption in excavators by 25-30%. The technology uses a radial design, which enables pistons in real time, using ultra-fast mechatronic valves controlled by a dedicated controller.

"It is digital hydraulics for the digital age," said Niall Caldwell, director, Danfoss Digital Displacement. "It is going to be a very creative phase for the whole industry as we learn how to apply the technology to solve a myriad of problems that customers have."

Regaining ground. This new generation of hydraulic fluid power solutions shows that OEMs and vendors alike are open to innovative design considerations and developing competencies aimed at optimizing performance of hydraulic systems in tandem with electrified powertrain architecture. With new ways of thinking and systems approaches, they're able to carve a niche for hydraulics that promises to be more efficient, flexible and reliable. ■

Digital Supply Chain:
Cybersecurity Report Flags Clear and Present Danger

AT A GLANCE:

- Throughout the pandemic, cyber perpetrators exploited vulnerabilities created by rapid digitization.
- A Netscout Threat Intelligence Report that focused on the second half of 2021 reported a 606% increase in attacks against software publishers, a 162% increase in attacks on computer manufacturers and a 263% increase against computer storage manufacturing.
- An analysis showed that attackers are centering their efforts on the digital supply chain.

High-profile distributed denial-of-service (DDoS) attack campaigns emerged in 2021, placing greater emphasis on extorting victims in specific industry verticals.

by Rehana Begg, Senior Editor

If the data in a newly released cybersecurity report holds sway, it means that cyber extortion attackers are innovating by devising new techniques to block technologies that allow users to get on the internet. What's especially troubling is that they adapting those techniques to go after a specific group of manufacturers.

A Threat Intelligence Report prepared by Netscout, a cybersecurity, service assurance and business analytics solution provider, showed that during the second half of 2021, the digital supply chain experienced an upsurge in distributed denial-of-service (DDoS) attacks.

Those associated with software publishers and computer manufacturers are increasingly vulnerable. According to the bi-annual report, cybercriminals launched 606% more attacks against software publishers, 162% more attacks

against computer manufacturers and 263% more attacks against computer storage manufacturers.

DDoS attacks refer to malicious breaks in normal traffic of a server or distributed network. The attackers exploit the target's infrastructure (e.g., computer systems and other IoT devices such as smartphones, headphones and cameras). Unlike ransomware attacks, a DDoS ransom attack does not encrypt a company's systems; they aim instead to knock users offline.

DDoS attacks are saturating the internet. According to the report, the 9.7 million attacks levied in 2021 is a 14% increase over the number of attacks that occurred in 2019 and represents a DDoS attack every three seconds.

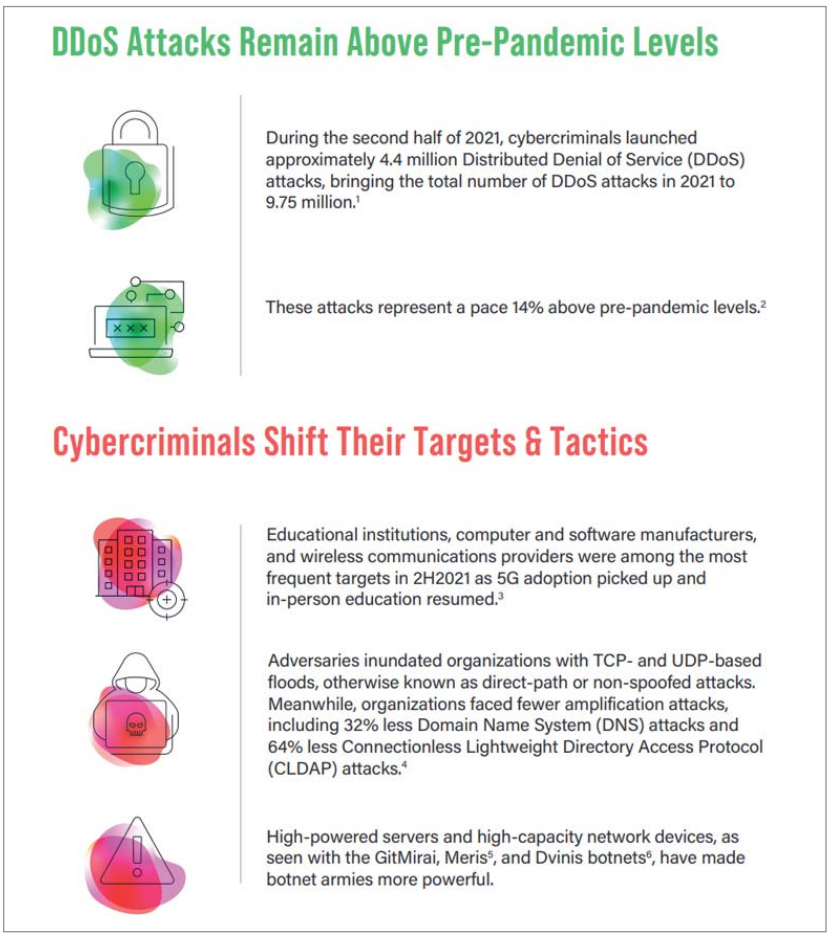
Richard Hummel, a threat research lead at Netscout and lead author of the report, pointed out there's a strong likelihood that enterprises have already had latency issues or experienced periods when the internet went offline due to DDoS attacks. "If you use the internet, you are absolutely impacted by DDoS attacks," Hummel said.

Adversaries are going after VPN or DNS servers or internet exchanges—the networks that allow us to communicate. "They are going after this fundamental layer of what allows us to get on the internet and are specifically going after these manufacturers," he said.

Telecommunications verticals tend to be a popular target for attacks, but saw fewer attacks in the latter part of 2021, reported Netscout. However, a notable exception occurred in the wireless telecommunications space, "where a likely increase in wireless hotspot gaming and the rapid adoption of 5G fueled increased attacks."

Many companies went through rapid digitization during the pandemic months. This reality sharply increased their attack surfaces if their IT was not sufficiently secured against attacks, explained Hummel.

Work-from-home didn't help either. A spike in DDoS attacks coincided with the period during which people started working from home and when schools closed, and it persisted until about September of 2021, when "the world started returning to normal."



The intimation, according to Hummel, is that remote work forced people to adapt their lifestyles and engage in recreational activities, such as gaming. "One thing that a lot of people don't realize about the DDoS world is that 80% to 90% of all DDoS attacks are related to gaming of some sort—related either to individual gamers, gambling associated with that gaming and professional gaming," he said. "Adversaries will launch attacks to knock their opponents offline."

Disruptive Maneuvers

To understand the ramifications of a DDoS extortion attempt, look no further than the attack launched by a group known as Lazarus Bear Armada (LBA). The perpetrators unleashed an extortion attack on the New Zealand Stock Exchange in August 2020. "They stock market was offline for several days, and the service provider was having issues," said Hummel. "LBA found a weak link and the target organization (NZX) was not entirely prepared to handle some of the attacks that were coming in.

"They weren't necessarily novel attacks or new vectors that had never been seen before," he continued. "It wasn't super-high volumes. It was that the provisions were not in place to be able to handle some of these attacks."

The attackers' persistence at finding a weakness in an enterprise's network is at the root of many DDoS attacks. In general, cybercriminals send their targets an email warning of the imminent attack unless a ransom is paid in cryptocurrency. If the demands are not met, the attackers repeatedly crash company websites or IT infrastructure by overwhelming them with

volumes of online traffic. DDoS attacks succeed precisely because enterprises do not make provision for all the potential attacks or because they don't have enough bandwidth to handle the influx.

"The LBA gang capitalized on that [weakness] and kept hammering and hammering and hammering and resulting in four days of downtime," said Hummel. "And that cost a lot of money—a lot of revenue loss, the stock market was impacted, the organization lost face and their brand took a hit."

Another notable attack in 2021 was the work of a group masquerading as REvil, the notorious ransomware operation that purportedly made more than $100 million from ransom payments by the first half of 2021. The copycat group launched an extortion campaign by sending their targets emails threatening to hold systems hostage and to continue DDoS attacking until their demands were met. Retail and wholesale VoIP providers in the UK were targeted first before attacks followed against VoIP operators in Western Europe and North America.

Unfortunately, the copycat group was successful. "One particular VoIP provider said they filed with the U.S. Securities and Exchange Commission (SEC) for between $9 million and $12 million worth of revenue lost," Hummel said. "It didn't just impact them as an organization—every single user of their service could no longer make phone calls." Aside from subscriber losses, reputation hits and the cost of recovering the services added to the collateral damage.

Not only have these cyberattacks crystallized assault capabilities, but Hummel warned that, across the board, industries can also expect to see more DDoS extortion campaigns and ransomware events. The number of attacks swell each time an event is brought up in the media, Hummel said. "The more times you see success stories in the criminal world, the more criminals you're going to have trying to adopt that success," he said.

The Netscout report pointed to industry data that shows the average cost of remediating a ransomware attack more than doubled in the past 12 months. Remediation costs, including business downtime, lost orders and operational costs, grew to $1.85 million in 2021 from an average of $761,106 in 2020. That sets the recovery cost at 10 times the size of the ransom payment on average.

Play Defense

If there's one goal of the report, then, it is to build awareness about the array of threats going after critical infrastructure and how these attacks can potentially cripple a digital supply chain, said Hummel.

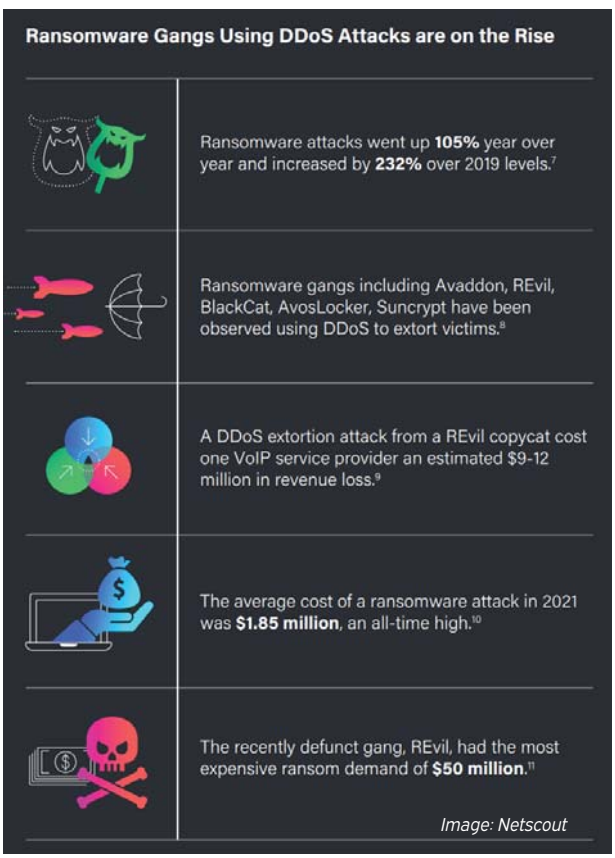
The Colonial Pipeline incident serves as another object lesson. On May 6, 2021, hackers gained entry to the largest fuel pipeline in the U.S. The breach occurred through the company's business network account. Even though Colonial's operational systems were not directly affected, the billing system was hit with ransomware,

according to Zero Day, and the decision was made to shut down the entire gasoline pipeline for the first time in its 57-year history.

"[The Colonial example illustrates] why you must have proper segmentation and permissions in place," said Hummel. In that instance, a ransomware attack impacted the entire workforce. Hummel argued that if Colonial had instead isolated different parts of their business and created fallbacks, the need to shut down the entire plant might have been avoided.

While DDoS attacks are ever-present and adversaries constantly innovate and develop new attack strategies, said Hummel, it is possible to stop 90% of DDoS attacks from being launched with minimal effort through mitigation efforts, including blocking IP address spoofing and controlling inbound traffic, as well as implementing current best practices and leveraging intelligent DDoS mitigation solutions.

The concluding remarks in the latest *Netscout Threat Intelligence Report* is a word to the wise: "In many cases, attackers are targeting organizations and service providers that have been lulled into a false sense of security because they aren't the usual targets. But just because attackers haven't focused as much attention on a particular vertical in the past in no way signals that they won't do so in the future." ■



RELATED VIDEOS AT MACHINEDESIGN.COM

Cybercrime Mitigation: Is Your Critical Infrastructure Secure?
Cybersecurity: DDoS Attacks Knock Organizations Offline
Report: DDoS Cyberattacks Pile Pressure on Critical Manufacturing Sector

Record-Breaking, Ultrafast Diodes

Could Protect the Grid from EMPs

A new Sandia diode can shunt excess electricity in a few billionths of a second.

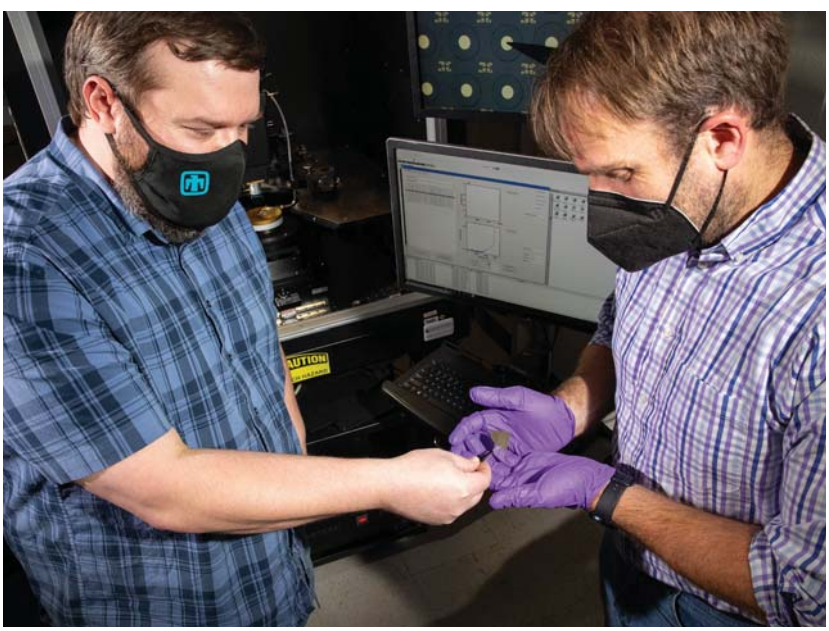
by **Stephen J. Mraz**, Senior Editor

Engineers at Sandia National Laboratories have developed a small electronic device that can siphon off excess electricity and send it to ground in just a few billionths of a second while operating at a record-breaking 6,400 V. This should be a significant step towards protecting the nation's electric grid from electromagnetic pulses. The team's ultimate goal is to provide protection from voltage surges, which could lead to months-long power interruptions, with an upgraded version of the device that operates at up to 20,000 volts.

Electromagnetic pulses (or EMPs) can be caused by natural phenomena, such as solar flares, or human activity, such as a nuclear detonation in the atmosphere. An EMP generates huge voltages in a few billionths of a second, potentially damaging electronic devices over large swaths of the country.

Although EMPs are unlikely, according to Bob Kaplar, manager of a semiconductor device research group at Sandia, if there were one that damaged the huge transformers that form the backbone of the U.S. electric grid, it could take months to replace them and re-establish power to affected regions.

The new device is a diode, much like the diodes found in nearly every electronic device. They act as one-way valves, letting electricity flow in one direction, but not the other. They are commonly used to convert AC power into DC power.



Luke Yates (left), a Sandia National Laboratories electrical engineer, passes Jack Flicker, a grid resiliency expert, a gallium nitride wafer with an array of diodes that can shunt a record-breaking 6,400 volts of electricity within a few billionths of a second. *Image: Rebecca Gustaf*

"There's a limit to how much current can flow through our diode," says Kaplar. "It cannot block an infinite voltage. However, our device uses the point at which the diode can no longer block the high voltage, holds the voltage to that level, and shunts excess current through itself to the ground and away from the grid equipment in a controlled, non-destructive fashion."

The voltage surges caused by EMPs are a hundred times faster than those caused by lightning, so experts don't know if devices designed to protect the grid against lightning strikes would work against an EMP, says Jack Flicker, a Sandia electric grid resiliency expert on the team.

"The electric grid has a number of different protections," Flicker explains. "They range in timeframe from very fast to very slow, and they're overlaid on the electric grid to ensure an event cannot cause a catastrophic outage of the electric grid. The fastest protection typically found on the grid reacts against pulses at one millionth of a second to protect against lightning. For EMPs, we're talking 10 billionths of a second, a hundred times faster."

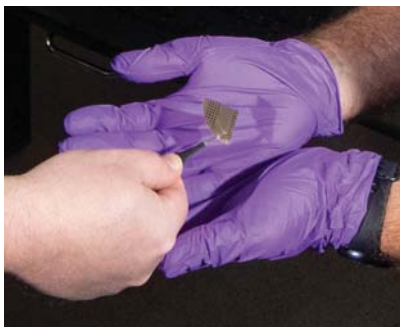
The new Sandia device can react that quickly.

The diode is made from gallium nitride, the same material used in LEDs, Kaplar

said. Gallium nitride is a semiconductor, like silicon. But because of its chemical properties, it can hold off much higher voltages than silicon before it breaks down than silicon. The material also responds quickly, which makes it a good candidate for delivering the fast response needed to protect the grid from EMPs.

The Sandia team made the devices by growing gallium nitride semiconductor layers using chemical vapor deposition. In the process, they heat a commercially available gallium nitride wafer to around 1,800°F and then add vapors that include gallium and nitrogen atoms. These chemicals form layers of crystalline gallium nitride on the wafer.

By tweaking the ingredients and the "baking" process, the team can build layers with different electrical properties. By creating the layers in a specific order, combined with processing steps such as etching and adding electrical contacts, the team produced devices with the performance they needed.



A close-up of the array of record-breaking gallium nitride diodes created by a team of Sandia National Laboratories scientists. These diodes are a step on the path to protecting the electrical grid from EMPs.
Image: Rebecca Gustaf

"A major challenge of constructing these very high voltage diodes is the need to have very thick gallium nitride layers," says Mary Crawford, a Sandia scientist leading diode design and fabrication for the project. "The drift regions of these devices have thicknesses of about 50 µm, or 1/6th of a sheet of notebook paper. This may not sound like a lot, but the growth process we use can have growth rates of only 1 or 2 µm per hour. A second major challenge is maintaining very low densities of crystalline defects, specifically impurities or missing atoms in the semiconductor material, throughout the growth time to get devices that work at very high voltages."

For the team to build diodes that operate at 20,000 volts, it will need to grow the thick layer even thicker with even fewer defects.

To test the diode, the engineers used specialized equipment capable of applying a high voltage pulse and measuring the electric pulse reflected back from the diode to accurately determine when the device turns on in less than a billionth of a second.

Beyond protecting the grid from EMPs, the diodes could also protect the electronics that convert electricity from rooftop solar panels into power that can be used by household appliances, and even electric car charging equipment. ■

Striving for a Safer Lithium Battery

Liquid electrolyte, solid electrolyte or a combination of the two: Which is safest?

by Stephen J. Mraz, Senior Editor

Solid-state batteries, currently used in small electronic devices such as smart watches, could be safer and more powerful than lithium-ion batteries for electric cars, storing energy from solar panels and other applications. However, several technical challenges stand in the way of solid-state batteries becoming more useful.

A team of researchers at Sandia National Laboratories is tackling one of these challenges—the assumption that adding some liquid electrolyte to improve performance would make solid-state batteries unsafe. After studying the issue, the team found that in many cases solid-state batteries with a little liquid electrolyte are safer than lithium-ion versions. It also discovered that solid-state batteries, once thought to be extremely safe, will put out dangerous amounts of heat if they short-circuit.

Solid-state batteries are somewhat like lithium-ion batteries. Both have lithium ions moving from one side of the battery to the other while electrons flow through a circuit to power the device. But in lithium-ion batteries the liquid electrolyte helps the ions move quickly.

Unfortunately, current liquid electrolytes are flammable and can cause battery explosions or fires, especially when batteries are damaged.

In solid-state batteries, the liquid electrolyte is replaced by a solid electrolyte.

Alex Bates (front) and John Hewson, Sandia National Laboratories engineers, examine a lithium-ion battery in front of a specially designed battery testing chamber. *Image: Rebecca Gustaf*

It also helps lithium ions move quickly, but although ions move quickly in the solid electrolyte, they have a hard time moving to and from the electrolyte to the electrodes.

To speed up this "direct shuttling," which shortens battery charging times speeds and improves performance, scientists have added a little bit of liquid electrolyte to the battery's positive side.

"However, there has been a lot of controversy in the solid-state battery research community about the safety of adding liquid electrolyte to 'grease the wheels,'" says Yuliya Preger, a Sandia battery reliability expert. "Some scientists say adding any amount of liquid electrolyte is unsafe. So, we did the calculations to see what the actual effects of liquid electrolyte."

To determine just how safe a solid-state battery with a little liquid electrolyte would be, the team first calculated how much heat could be released in a lithium-ion battery, an all-solid-state battery and a solid-state battery with varying amounts of liquid electrolyte. All batteries tested had equivalent amounts of stored energy. Next, the researchers looked at three different failure modes and the heat that would be released in each type of failure.

"We started by determining just how much chemical energy is in the three kinds of batteries," says John Hewson, a Sandia heat-release calculation expert. "There's only so much energy that can be released which will heat up the battery a certain amount if there's a chemical reaction."

The first failure mode the team studied was what could happen is if the batteries caught on fire. In these cases, the researchers found that the solid-state battery with a little liquid electrolyte in it generated about one-fifth of the heat of a comparable lithium-ion battery depending on how much liquid electrolyte it had. The solid-state battery without liquid electrolyte didn't produce any heat under this scenario.

The second failure mode was repeated charging and discharging causing the lithium metal to form a "spike" called a dendrite. These dendrites can puncture the membrane that keeps separates the two sides of the battery and creates a short-circuit. These failures led all three batteries to put off similar amounts of heat, which depended on how much lithium metal was in the batteries.

The third failure mode was the solid electrolyte breaking in a solid-state battery. This could happen if the battery was crushed or punctured or formed built-up pressure during operation. It lets oxygen from one side of the battery react with lithium metal on the other side. In these cases, the solid-state battery without liquid electrolyte could reach temperatures near that of the lithium-ion battery, which the team found surprising.

One of the promises of solid-state batteries is that they are safe because the solid electrolyte is unlikely to break. But if it does, the temperature rise could be about as much as when lithium-ion batteries fail. This underscored the need to ensure the separating membrane be made too strong to fail.

The researchers then made similar calculations with other solid electrolyte materials and conducted experiments to validate the new and original calculations.

"We found if the solid-state battery has lithium metal, it could be dangerous, regardless of if it has liquid electrolyte or not," says Bates. "There's a definite trade-off between performance and safety, but adding a bit of liquid may greatly increase performance while only having a small effect on safety."

"Solid-state batteries have the potential to be safer, and they have the potential for higher energy density," said Alex Bates, a Sandia researcher. "This means, for electric vehicles, you could go farther in between charges, or need fewer batteries for grid-scale energy storage. The addition of liquid electrolyte may help bridge the gap to commercialization, without sacrificing safety." ■

"There's a definite trade-off between performance and safety, but adding a bit of liquid may greatly increase performance while only having a small effect on safety."

Liquid Pump Can be Used in Hazardous Areas

The UFK 1.1100 EX is a low-pulsation, high-flow liquid pump for hazardous location (HazLoc) areas. The UFK 1.1100 Ex provides performance required by oil & gas, extraction and cooling circuit applications. The robust, adjustable pump is offered with chemically resistant materials. The robust, adjustable pump is offered with chemically resistant materials.

KNF Neuberger, Inc.

www.machinedesign.com/21239549

Cabinet Cooler Calculator Finds The Right Solution

The Cabinet Cooler Calculator simplifies the process of choosing the correct Cabinet Cooler System by asking the customer to answer a few simple questions. By providing certain information like size of the enclosure, NEMA rating needed and environmental conditions, our new calculator will sort through our large selection of ready-to-ship Cabinet Cooler Systems and provide instant feedback on the best cooling solution for any applicable electrical enclosure. Taking the guesswork out of the equation, the Calculator library ensures the customer that they can be confident in selecting the correct product for their unique specifications.

EXAIR

www.machinedesign.com/21239545

Controller Reduces Hardware, Set-up Time

The industrial-grade PFC200 controller features an integrated cellular modem. This all-in-one PLC controller and cell modem eliminates extra hardware and, by using the controller's web-based management configuration software to initiate the cell modem, reduces set up time. This new controller has the ability to deliver information directly to Cloud servers and send or receive SMS messages. The parameters from the PLC controller can be directly communicated to devices via wireless technology, allowing users running edge of network applications to collect data, control machine functions and connect to Cloud servers without adding traffic to wired networks.

WAGO

www.machinedesign.com/21239551

Drive Component Features Safety Function

The podis MS 5HP is a compact drive component with an integrated STO (Safe Torque Off) function. The safety function disconnects the power supply from the emergency stop circuits completely. As a result, the STO circuits no longer need routing through a central distributor and assignment to a specific energy branch. The system is less susceptible to interference and the installation work is more easily planned and carried out. The combination of starter functions allows for the decentralized assignment of all of the energy of the STO circuits in the field. Several STO circuits can operate from one power supply.

Wieland Electric

www.machinedesign.com/21239553

Power Suppliers Cover a Wide Input Voltage Range

The PS3V Series power supplies adds new features like push-in connections for simplified installation. The PS3V power supply family accepts a wide input voltage range from 85 to 264 VAC, and it provides an output of 5, 12 and 24 VDC with capacities ranging from 15 to 150 W, both depending on the model. Output voltage is user adjustable ±10%, and the 24 VDC versions deliver efficiencies ranging from 83 to 88%. A metal housing protects the PS3V power supply, and it can be mounted in four orientations by direct panel mount or DIN rail bracket. Models are available with traditional screw terminals, or with safe and efficient push-in terminals for rapid one-step wiring. A wide operating temperature range from –25 to +70°C ensures these power supplies work in the most challenging environments.

IDEC Corporation

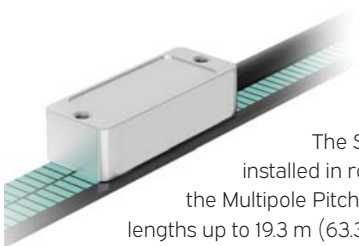
www.machinedesign.com/21239555

Braided Hose Coupling Line Expands

The braided hose coupling line has expanded to more than 740 styles and sizes. These compression-style hydraulic hose fittings feature RoHS-compliant plating that makes them ideal for a variety of industry applications and deliver superior performance, durability and quality. The braided hose couplings are available with many different end configurations, including SAE, metric and other styles. Available from ¼ in. I.D. to 1¼ in. I.D., the available variety will make it easy to find the right size and style for virtually all hydraulic applications.

Kurt Hydraulics

www.machinedesign.com/21239552



Bearingless Encoder Useful in Rotary, Linear Applications

The SMA3 bearingless absolute encoder can be installed in rotary and linear applications and integrates the Multipole Pitch Technology. It is designed for linear measuring lengths up to 19.3 m (63.32 ft) and shaft diameters greater than 6 m (19.685 ft) in a rotary application. The Multipole Pitch Technology enables the SMA3 to have a pole pitch that can be adjusted in width. The SMA3 is designed in a compact IP67 protected readhead. Installation is easy thanks to the wide mounting tolerances larger than 1 mm. Working speed is up to 20 m/s. It is also equipped with a diagnostic LED.

Lika Electronic

www.machinedesign.com/21239558

Vision System Provides Easy Set-Up, Deployment

The In-Sight 2800 series vision system puts the power of a full-featured vision system into an easy-to-use package that gets applications running in minutes. In-Sight's EasyBuilder interface guides users through the application development process step-by-step, making it simple for even new vision users to set up any job. Experienced users will appreciate how In-Sight's intuitive, point-and-click interface simplifies more complex application development and keeps operations moving fast. The combination of deep learning and traditional vision tools gives users the flexibility to solve a broad range of inspection applications; operators simply select the tool designed to deliver the highest possible accuracy for their task. Tools can be used individually for simple jobs or chained together for more complex logic sequences.

Cognex

www.machinedesign.com/21239543

Contactless Switching System Also Features Colors

The TTS RGB adds technical finesse to the original TTS switch series introduced in 2021. The TTS series provides contactless switching, highly precise operation and now customizable colors. With the new RGB ring illumination, the TTS switch series adds a multicolor palate to its existing bi-color options. The TTS series uses the highly precise Time-of-Flight (ToF) sensor technology, whereby light is emitted by a transmitter and reflected by one or more objects. The reflected light beams are then detected, and the distance is determined from the Time of Flight.

Schurter

www.machinedesign.com/21239546

Position Transducers Use MEMS Technology

Gefran inclination sensors use cutting-edge MEMS technology (micro-electromechanical devices integrated onto a single silicon chip) to provide reliable and precise tilt angle measurement with respect to gravity. The sensors are rugged and suitable for the harshest environments. They come in an encapsulated thermoplastic housing with a high IP67/69K rating and are available with an integrated cable or M12 quick-disconnect; M12 quick-disconnect models are fully redundant, having two sensors in one housing.

AutomationDirect

www.machinedesign.com/21239554

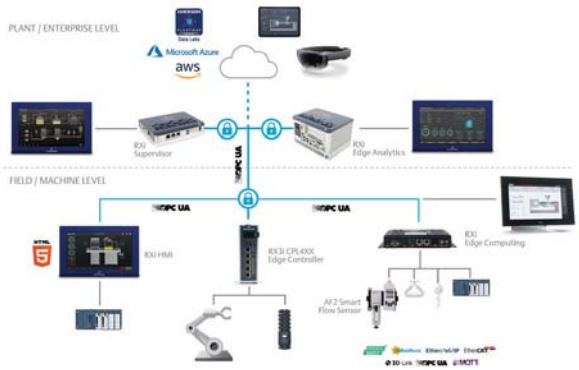
Robotic Alignment Software Increases Speed, Accuracy

The High Speed Alignment software offers manufacturers the ability to increase the speed of 6-axis robots by 70% and accuracy by 50%, which will reduce time-to-market while increasing accuracy levels. The PC-based software includes Visual Serving technology using one or more cameras, combined with a computer vision system, to control the position of the robot relative to the workpiece. Minimal programming experience required.

ABB Robotics

www.machinedesign.com/21239548

Edge Solution Package Simplifies Integration Time



The PACSystems Edge Solutions is a new portfolio of turnkey industrial edge hardware and software solutions. Edge Solutions simplify selection and deployment, helping OEMs, systems integrators and end-users significantly reduce the time spent integrating, developing and validating digital transformation projects. From low footprint connectivity and computing to plantwide analytics and supervision, the portfolio delivers a scalable range of edge capabilities in fit-for-purpose packages. The solutions allow personnel in food and beverage, industrial machinery, renewable energy and other industries to easily collect and visualize critical data and analytics locally, right where they work, enabling them to optimize and proactively maintain operations for maximum uptime and efficiency. Individual fit-for-purpose PACSystems Edge Solutions seamlessly interconnect, unlocking easy scalability across the entire platform. Organizations can start with one application and build as future needs grow, easily expanding the value of solutions already in place.

Emerson

www.machinedesign.com/21239557

Rotary Encoders are Explosion-Proof

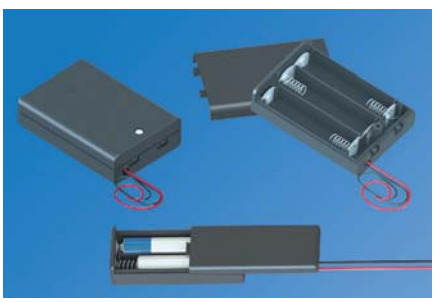
The explosion-proof IXARC rotary encoders have been certified to comply with ATEX/IECEx directives for Category 3 electrical products. These devices are suitable for use in Zone 2 and Zone 22 conditions (potential exposure to hazardous levels of explosive gases and flammable dust) and are ideal for oil and gas installations, chemical plants, woodworking operations and grain handling facilities. Certification documents cover multiple encoder configurations and were issued by an organization with special competency in ATEX and IECEx testing and certification. The ATEX/IECEx-certified series of encoders feature aluminum or stainless-steel housings designed to eliminate electrical hot-spots or sparking that could ignite an explosion. These encoders are available in both incremental and absolute variants and are offered with optical or magnetic measurement systems. Optical encoders are suited for high-precision applications, delivering up to 16-bit resolution and excellent dynamic response.

Posital

www.machinedesign.com/21239556

Plastic Battery Holders Now Include On/Off Switch

The Densi-Pak covered plastic battery holders now include a built-in On/Off switch. The switch eliminates the need for additional components in designs using AA and AAA batteries, which is ideal for self-contained powering components in a variety of applications. These high-performance battery holders are made with an ABS Plastic case and nickel-plated coil spring steel contacts for a reliable, low-contact resistance battery connection. The Densi-Pak, snap-on cover design protects and secures the batteries within the compartment to prevent shorting or damage. These switched battery holders are available to accommodate two or three AA or AAA batteries. They also are available are IP65 water and dust resistant versions to accommodate two, three or four AA cells.



Keystone

www.machinedesign.com/21239550

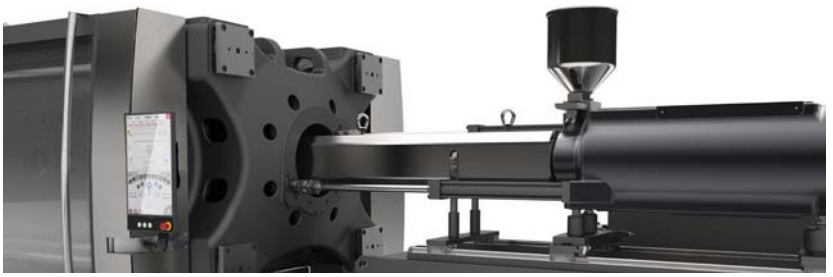
(Continued from page 18)

production. And not only with engineers: The Design Group Italia team believes in working in multidisciplinary teams as often as possible. When everything from HMI to logo to colors, materials, finishings and the physical product design is signed off by the same team, including industrial designers, engineers and digital designers, the process results in more than efficiency. Each aspect of the final product will be coordinated, curated and created faster as one team—not multiple agencies—works on the entire extended solution.

4. Design That Aligns and Integrates

Companies can have complex structures with many stakeholders involved in the decision-making for industrial equipment. Sales, technical officers, leadership and operators all come with different vertical expertise and views. The designer doesn't just shape the machine; he finds a shared direction that connects the dots for the bigger picture to unite marketing for the brand expression and engineering on how it is constructed and produced. When done well, it results in a market offering with innovative technology and immediately perceivable quality.

ABB, for example, had grown through acquisitions to manage a mixed portfolio of products. A powerful design system helped integrate its offering and capitalize on the ABB brand.



Form and function both can be important considerations in machine design. Sleek lines and functional, useful displays are not mutually exclusive. *Image: Design Group Italia*

5. Design to Make the Most out of Data and Industry 4.0

Rapid developments in technology and digital transformation have brought complex challenges and exciting opportunities to the industrial sector. Now, increasingly complex HMIs allow users to track massive amounts of data not only for operating the machines but also for supervising predictable issues. Designing easy, intuitive and user-friendly dashboards that facilitate the new needs is crucial and incredibly challenging.

Challenged with designing a UX system encompassing hundreds of parameters for the injection molding machine supplier Negri Bossi, the Design Group Italia team's intuitive design uses multitouch and new touchpads. With the swipe of a finger, operators can control the 11-meter-long machine and its 850-ton press.

6. Design as a Change Maker

Alongside innovation and evolution to the industry, digital transformation has brought a faster-paced, deeply digitally minded culture to a traditionally mechanical context. When working on software, updates and changes can be made with a click of a button, while the lifetime of an industrial machine is counted in decades.

Digital, technical and industrial specialists are all needed to develop futureproof functional solutions. However, it's people, not technological solutions, who will bring about true transformation. Speaking both traditional and the new digital languages, designers can serve as change agents, translators and facilitators in bringing forth the digital transformation processes in companies. ■

CONTRIBUTED BY Design Group Italia and authored by Edgardo Angelini, managing director; Andrea Desiato, digital product design director; Martin Franzen, product design director; and Pasquale Cirulli, lead industrial designer.

Ad Index

ALTECH CORPORATION 1
AUTOMATIONDIRECT . . . . . IFC
CLIPPARD INSTRUMENT LABORATORY, INC. . . . . BC
COMSOL INC. 19
DIGI-KEY ELECTRONICS 5
DURA-BELT 37
EBM-PAPST 11
ENCODER PRODUCTS COMPANY 31
ENM COMPANY 33
FAULHABER MICROMO 25
FESTO CORPORATION 9
FLOYD BELL INC 15
HEIDENHAIN 13
IMTS - INTERNATIONAL MANUFACTURING TECHNOLOGY 17
INTERPOWER CORPORATION 7
KEPNER PRODUCTS COMPANY 36
METAL POWDER INDUSTRIES FEDERATION 33
OGURA INDUSTRIAL CORPORATION 37
PI PHYSIK INSTRUMENTE L.P. 38
SCHMERSAL INC. . . . . IBC
SEIFERT SYSTEMS 18
SMALLEY STEEL RING CO. 29
SPIROL INTERNATIONAL INC. 6
THE LEE COMPANY 3
TRIM-LOK 28

Migrating to 5G: The Envelope Tracking Power Solution

by **Philip Lechner,** Avnet Abacus

While the telco industry is well advanced down the road of migrating from LTE to 5G, there are plenty of challenges remaining—not the least of which is the specific power requirements involved in 5G networks. The scale of the challenge is only set to grow in the coming years, with a recent IDC report predicting that worldwide, 5G and LTE router/gateway markets alone will grow to about $3.0 billion by 2024 from about $979.3 million in 2019. One specific power-related technology that is enjoying a day or two in the sun is envelope tracking.

What is Envelope Tracking?

Envelope tracking (ET) can be traced back to 1952, when one Leonard Kahn proposed a technique called envelope elimination and restoration (EER) to improve the efficiency of SSB transmitters. Envelope tracking has fewer drawbacks than EER, but offers similar efficiency enhancements. In spite of this, ET was not implemented for some years due to its complexity—especially in wide bandwidth signal scenarios. However, ET is increasingly popular among mobile phone designers as a method to improve power amplifier efficiency.

This efficiency is derived from the fact that most modern wireless communications standards such as 5G, LTE and 802.11ac Wi-Fi have a high peak to average power ratio (PAPR). A fixed supply power amplifier (PA) must use a supply voltage high enough to support that peak power, but is only operating at maximum efficiency at the very peak, with the voltage being higher than needed the rest of the time, resulting in unnecessary heat generation in the PA—not only wasted energy, but a design challenge to remove it. ET ensures that the PA is running at an optimum level by dynamically adjusting the supply voltage according to the instantaneous amplitude of the signal.

Battery Power Efficiency and ET

While the basis of ET techniques might not be brand-new, there are plenty of examples of ET in current 5G networks, and indeed the concept is a core part of some of the latest and most cutting-edge hardware in the public domain. For example, Qualcomm's newest fourth-gen Snapdragon X65 Modem-RF System has been in the headlines as a frontrunner in breaking the 10 Gbps barrier—a key tipping point where mobile broadband can genuinely match the speed of terrestrial fiber.

Qualcomm's latest announcement breaks the 10 Gbps barrier with the Snapdragon X65 Modem-RF System, which incorporates a seventh generation wideband envelope tracker QET7100. This ET delivers 30% better power efficiency compared to the best alternatives (according to Qualcomm), a potentially valuable saving for designers. Qualcomm points out this "enables reduced board footprint"—a key concern for all implementations, but particularly for IIoT scenarios, where battery life is often a key concern.

Pushing the Envelope

Of course, power efficiency concerns are not limited to battery-powered environments. Even with the peak efficiency of modern switch mode power supplies (SMPS) sitting comfortably between 85% up to 95%, efficiencies are still welcome, not least in higher output power scenarios (more than 150 W), where the need for forced-air cooling may become a necessary part of the design.

Solving this challenge in a 5G context is front of mind for many engineers—so much so that the U.S. Department of Defense has awarded the University of Houston's Power Electronics, Microgrids & Subsea Electrical Systems Center a $1.7 million grant to develop enhanced envelope tracking for 5G networks, a research project dubbed "5G comet," in partnership with New Edge Signal Solutions.

As the university states: "[5G] roll out in the U.S. and elsewhere has been stymied by gaps in available technology that could operate at the high frequencies required by 5G." The solution, according to the researchers, is to develop a 5G-specific envelope tracking power supply that can operate with a bandwidth of 100 MHz or higher—considerably greater than current envelope bandwidth in commercial applications.

Efficiency Crucial to a Connected Future

The road to 5G and beyond contains many hardware challenges, which will require pushing existing concepts to their limits, as well as originating entirely new techniques to manage spectrum, power and heat challenges. Clearly envelope tracking is set to play a significant role in the future of our communication networks, especially as pressure on efficiency in both physical size and power use will continue to grow.

In addition, the likely application of improved envelope tracking and related power efficiencies will have trickle-down impact and spur innovation in different vertical industries, such as medical power supplies and many more. Truly, this is one area where the phrase "pushing the envelope" moves beyond figurative language into a pragmatic statement of fact. ■

SCHMERSAL
THE DNA OF SAFETY

Schmersal Safety Light Curtains with Bluetooth interface

Schmersal SLC440 safety light curtains are now available with an integrated Bluetooth interface for data sharing with smartphones & tablets.

The SLC440 BLE uses the Bluetooth Low Energy system for secure data transmission, up to 5 meters. The data transmitted from the safety light curtains is accessible by the Schmersal **SLC Assist App**, available for Android and iOS smartphones and tablets.

The SLC440 offers many integrated functions including fixed blanking, floating blanking, fixed blanking with movable edge region, double reset, contactor control (EDM), automatic mode, re-start mode, and beam coding.

This unprecedented access to the operational data of the Safety Light Curtain has many advantages:

- The app serves as an installation alignment aid as it displays the signal strength of each beam.
- Real time monitoring of the active operation mode, the status of the OSSD outputs and the status of the protective field provides the information necessary to quickly resolve faults.
- The app can provide documentation on the light curtain, either emailed or saved to the smartphone or tablet.
- Additionally, you can see which functions have been enabled and their parameterized settings.

Contact us to learn more about this innovation in safety light curtains
www.schmersalusa.com | 888-496-5143 | salesusa@schmersal.com

Take Control with Cordis

ELECTRONIC PRESSURE REGULATION

- Resolution ≤5 mV
- Accuracy ±0.25% of full scale
- Real-time adjustable PID control
- Integrated 0 to 10 VDC, 4-20 mA signal, or 3.3 VDC serial communication
- 0 to 10 VDC feedback pressure monitor
- Virtually silent
- No integral bleed required
- Multiple pressure ranges from vacuum to 150 psig
- 2.7 to 65 l/min flow control

The future of proportional control has arrived—and it's digital. The **Clippard Cordis** is a revolutionary microcontroller primed for escape velocity from a proportional control market that has grown stagnant.

With unparalleled performance and flexibility not possible with current analog proportional controllers, the Cordis makes everything from calibration, to sensor variety, to future development opportunities more accessible and less complicated.

Precise, Linear Digital Pressure Control

Contact your distributor today to learn more about how the Cordis can provide precise, real-time control for your application, or visit **clippard.com** to request more information.

Clippard

877-245-6247

CINCINNATI • BRUSSELS • SHANGHAI