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NOVEMBER/DECEMBER 2024
Volume 96, Issue 6

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MACHINE DESIGN (USPS Permit 323-980), (ISSN 0024-9114 print, ISSN 1944-9577 online) is published 6 times per year (January/February, March/April, May/June, July/August, September/October, November/December) by Endeavor Business Media LLC, 201 N. Main St., 5th Floor, Fort Atkinson, WI 53538. Periodicals postage paid at Fort Atkinson, WI, and additional mailing offices. **POSTMASTER:** Send address changes to Machine Design, PO Box 3257, Northbrook, IL 60065-3257. **SUBSCRIPTIONS:** Publisher reserves the right to reject non-qualified subscriptions. Subscription prices: U.S. ($139.00 per year); Canada/Mexico ($159.00 per year); All other countries ($199.00 per year). All subscriptions are payable in U.S. funds. Send subscription inquiries to Machine Design, PO Box 3257, Northbrook, IL 60065-3257. Customer service can be reached toll-free at 877-382-9187 or at machinedesign@omeda.com for magazine subscription assistance or questions.

From the Editor

By Rehana Begg, Editor-in-Chief

It's a Big Deal: Industrial Automation Acquisitions, Strategic Growth & Diversification

THE NEWS THAT Siemens AG acquired Altair Engineering Inc. was not as much a surprise as it was a flashback.

Earlier this year at Hannover Messe, Germany, a visit to Altair's booth got me thinking about how their computational science and AI solutions might really give Siemens a run for its money.

Little did I know that the two companies were already in deep discussions. The $10.6 billion deal signed in October was designed to solidify the German industrial conglomerate's trajectory towards higher margin, software-driven product lines.

The acquisition is a significant one for Siemens, which has progressively evolved beyond its traditional industrial customers. Altair's capabilities complement Siemens Xcelerator, creating a complete AI-powered design and simulation portfolio, according to Roland Busch, president and CEO, Siemens AG.

But if the endgame for Siemens is to transform into a leaner world leader in industrial-automation software and smart infrastructure, this acquisition is merely a milepost.

As we head towards 2025, technology-driven deals are at the forefront and likely will continue to have a ripple effect in the number of mergers and acquisitions we can expect this year. The emphasis is squarely on AI, machine learning and other emerging technologies.

Forward-thinking companies pursue acquisitions to capture the advantage of scale. The challenge for them is finding the best niche options and the ideal sequence to maximize value creation.

Blue-chip companies across industries—ranging from BMW, Swatch, Ducati and Red Bull to Porsche and KPMG—have historically embarked on similar global consolidation strategies. They were either dominated or surmounted when attempting to achieve a competitive edge while increasing market share.

And let's not forget the stealth of the "Magnificent Seven!" These companies—Alphabet, Amazon, Apple, Meta Platforms, Microsoft, NVIDIA and Tesla—are at the bleeding edge of AI, EV, cloud computing infrastructure and digital transformation. One deal of note for chipmaker NVIDIA was the closing of a $675 million transaction with AI startup Figure AI, which is in the process of commercializing industrial humanoid robots to address labor shortages.

Homing in on domestic industrial automation solutions, advisory firm Blue River Financial Group reported a rush of M&A activity in Q3 2024 that can be connected to demand for software-based automation solutions: Acieta acquired Capital Industries; Motion & Control Enterprises acquired Air Automation Engineering; THK Group acquired Liberty Robotics; The Timken Company acquired CGI; and Kubota acquired Bloomfield Robotics.

Analysts expect middle-market M&A activity to pick up once we enter 2025. When all is said and done, the best course of action for strategists will depend not only on economic resilience, the interest rate regime and political uncertainty, but success will also depend on their style of execution.

Reach out with questions and comments at rbegg@endeavorb2b.com.

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The Critical Role of Workwear in Enhancing Machine Safety: An Integrated Approach

Engineers who operate in manufacturing environments should be aware of the relationship between their workwear and machine safety.

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Beyond the Cab: Making the Case for Remote Controls

Understanding a few key points about remote controls will help determine the correct type for the application.

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Inspiring the Next Generation of Engineers

Tormach's 2024 Instructor of the Year Danielle Ward shares her approaches to STEM education, emphasizing hands-on learning and the integration of advanced technologies to prepare students for careers in engineering and manufacturing.

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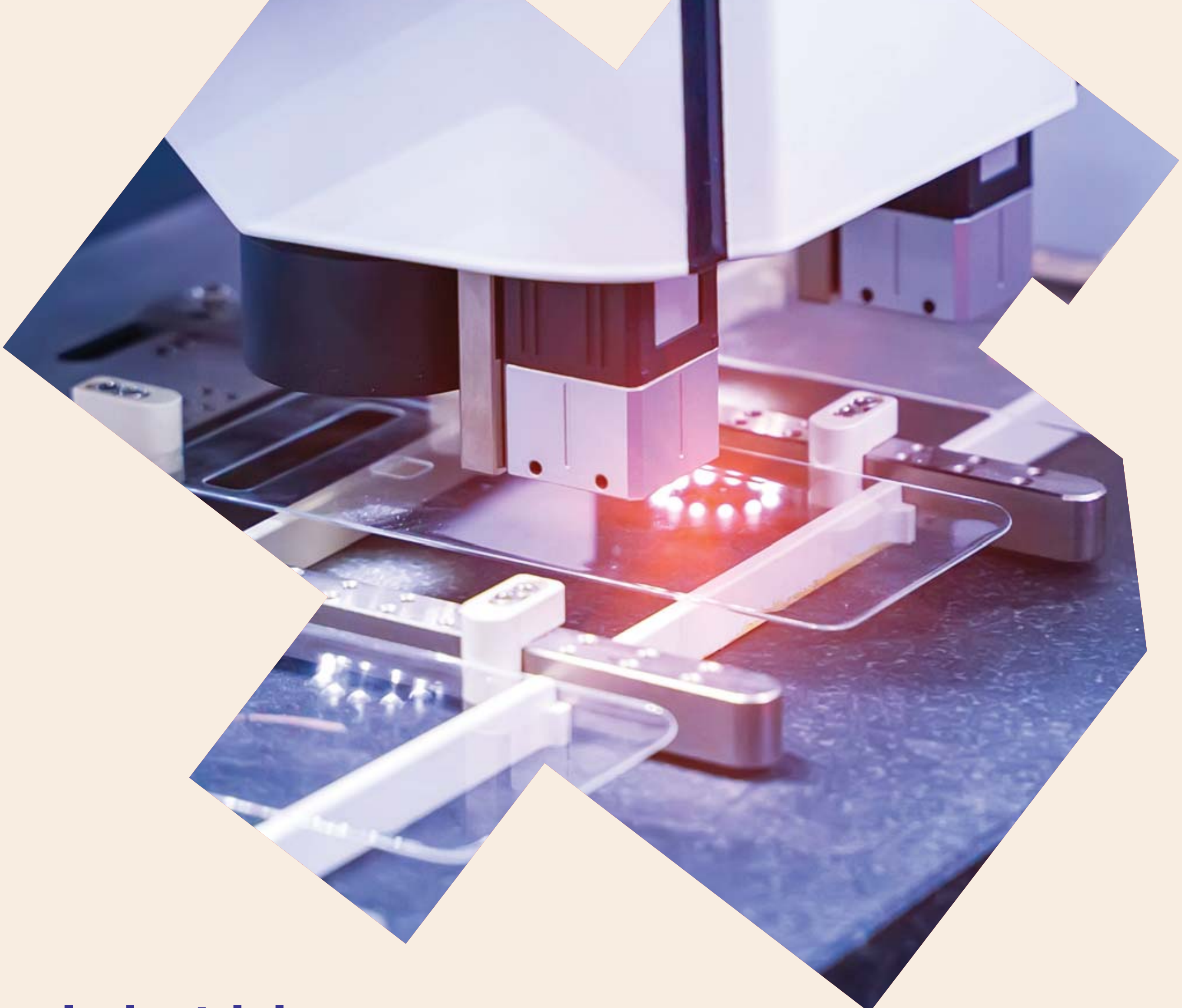


Aveva World Conference 2024:
Designing for a Connected Industrial Economy

The software provider's next breakthrough is set to be powered by "radical collaboration."

ATTENDEES TO AVEVA WORLD 2024 came away with a definitive message: Drive digital transformation and sustainability throughout the lifecycle of industrial assets.

Supporting partnerships and collaboration is a cornerstone in the company's portfolio-wide transition to a subscription-based business model, which leverages cloud, hybrid and on-premises solutions across the design-operate-optimize industrial lifecycle, said Aveva CEO Caspar Herzberg, who announced portfolio updates to 3,500 delegates who attended this year's conference in Paris (Oct. 14-17).

The traditional approach to securing customers by developing software specifically for industry has been surpassed by the call for open software, argued Herzberg. He said the promise of AI and digitization has paved the way for working with open-source software and open data. Without it, the promise of using AI and making a plethora of case studies work at scale won't work, pointed out Herzberg.

This perspective may seem counterintuitive because most companies prefer not to share information with rivals. For Herzberg, the benefits of doing so outweigh both the challenges of competitiveness and the fear of negative repercussions.

"Radical collaboration is about engaging the community at large industrial manufacturing with critical infrastructure to help solve these enormous problems we're all facing," said Robert McGreevy, chief product officer, Aveva. "The energy transition, the increasing demand for power, the need to manufacture goods at a rapid pace, distribute those in an interesting and sustainable way...the entire value chain of producing finished goods and manufacturing things requires this idea of radical collaboration. And 'radical' just means that it's going to take basically all elements of that value chain working together to achieve the demands of the future."

Aveva CEO, Caspar Herzberg, supporting a drive for partnerships and collaboration is a cornerstone in Aveva's portfolio-wide transition to a subscription-based business model. Joining him onstage at Aveva World 2024 is Jean-Pascal Tricoire, chairman of Schneider Electric, which completed a full acquisition of Aveva in 2023, and Matei Zaharia, co-founder and CTO, Databricks, a data and AI platform provider which focuses on bringing AI to the energy sector. *Machine Design*

Secure Data-Sharing with Multiple Stakeholders

Aveva announced two new strategic partnerships at the conference with Vulcan Energy Resources (VER) and Oxford Quantum Circuits (OQC). Other partnerships and use cases represented on the mainstage included Matei Zaharia, co-founder and CTO, Databricks, the data and AI platform provider bringing the power of AI to the energy sector, and Michelin CTO Bruno Batisse, who laid out how the French multinational tyer manufacturer is decarbonizing across their value chain.

At this year's event, Aveva showcased key capabilities of several products designed to further optimize operations and improve collaboration, including Industrial AI Assistant, United Engineering, Operations Control and PI Data Infrastructure.

Aveva's full suite includes simulation, engineering and design, asset information management, 3D asset visualization, enterprise asset management, unified supply chain, system platform and MES, Plant SCADA, production management, predictive analytics, and PI system.

The global software provider held its annual flagship software conference at the Paris' Palais des Congrès, bringing together 3,500 delegates, including senior leaders from 13 industrial sectors and 600 companies. Key industrial verticals included power, chemicals, minerals and food & beverage. ■

READ THE full report at machinedesign.com/55240491.

FABTECH 2024 Forged Ahead in Florida

The mid-October show in Orlando showcased the manufacturing industry's determination to move forward after Hurricane Milton, featuring more than 1,500 exhibitors and groundbreaking innovations in metal forming, fabricating and welding.

FABTECH 2024 TOOK place in Orlando, Fla. from Oct. 15-17, showcasing the resilience of the manufacturing industry even in the aftermath of Hurricane Milton. The event, which proceeded as planned despite the hurricane, was a significant gathering for industry professionals.

With more than 800,000 square feet of exhibits, the expo featured more than 1,500 exhibitors from a range of domains, including machine makers, software companies, contract manufacturers and service providers. This created an expansive platform for the latest innovations in fabricating and manufacturing. Key highlights of the event included cutting edge technologies tailored for industry. Attendees had the opportunity to explore advances in metal forming, fabricating, welding and finishing technologies.

Here are just a few of the new products that were on display at this year's event.

Automation Solutions from Cincinnati Machinery

Cincinnati Machinery showcased its latest advancements in automation and smart manufacturing technologies, focused on improving productivity and reducing operational costs. Addressing the challenges of skilled labor shortages and machine programming, Mark Watson, product consultant at Cincinnati Machinery, told *Machine Design* that the company is changing the way machines are managed to optimize efficiency.

Mark Watson, product consultant, and Bryant Downey, software business unit leader, at Cincinnati Machinery, explained to FABTECH attendees how the company is changing the way machines are managed to optimize efficiency. ***Sharon Spielman***

One of the key highlights of the company's offerings is an innovative automation solution that simplifies the management of multiple laser systems, Bryant Downey, software business unit leader, said. This technology eliminates the need for operators to manually track machine outputs, instead automating scheduling and load balancing to ensure optimal performance across all machines. "We're moving toward fully automated systems, freeing operators from the traditional clipboard tasks," Watson said.

Downey also talked about the importance of lights-out manufacturing, enabling machines to operate autonomously for extended periods. With advanced software tools, operators can monitor real-time machine performance through mobile applications, allowing for quick identification and resolution of issues. "Our technology provides insights into machine output and efficiency, ensuring operations run smoothly," he said.

Safety is paramount, Watson, added, and Cincinnati Machinery's introduction of cameras on machines is designed to maintain safe working conditions while enhancing operational monitoring. "We focus on overseeing production processes to ensure safety protocol adherence," he said.

Downey added that the company is integrating artificial intelligence (AI) and machine learning to empower machines to make intelligent decisions during operation, reducing the need for continuous human oversight, noting this will allow operators to concentrate on higher level tasks and strategic decision making.

igus Served Up a Burger-Flipping Cobot Robot and More

Visitors to the igus booth witnessed the company's latest advancements in automation and robotics, including a range of zero-lubrication, maintenance-saving solutions. A highlight was the igus ReBeL cobot robot, which captivated attendees by flipping burgers on a Blackstone grill as part of an interactive demonstration.

Alongside this display, igus showcased energy-efficient cable management systems, low-cost automation and drylin linear guides, emphasizing their commitment to sustainability and reducing downtime for manufacturers across industries. ■

Visitors to the igus booth got to be a part of an interactive demonstration of the company's ReBeL cobot robot that was flipping burgers on a Blackstone grill. ***igus***

READ THE full report at machinedesign.com/55243804.

Teaching an Old Sensor New Tricks

While LVDTs have been around for several decades due to their trademark toughness and reliability, they continue to be adapted with new capabilities to meet today's requirements.

by Michael Marciante, Applications Engineer, NewTek Sensor Solutions

LINEAR VARIABLE DIFFERENTIAL TRANSFORMERS (LVDTs) have been commercially used for more than 50 years. Originally developed as a laboratory instrument, LVDTs are now utilized in various industries such as computerized manufacturing, military, aerospace, subsea, oil and gas, power generation, packaging, robotics, and research and development for linear position measurement applications.

While advancements in manufacturing, electronic circuitry and construction materials have extended LVDT performance in a wider range of environments and applications over the years, the fundamental principles of its operation and key attributes such as dependability, toughness, sensitivity, accuracy, zero mechanical friction and long service life have remained unchanged. It is these trademark characteristics that have kept LVDTs relevant over the years and in demand by many industries.

What is an LVDT?

An LVDT is an electromechanical transducer that measures movements as small as ±0.010 in. (±0.254 mm) to ±10 in. (±254 mm) or longer in some cases. It converts linear motion into corresponding electric signals, which can be interpreted by operations and control systems.

In composition, LVDTs include two basic parts:

1. A housing containing a single primary winding coupled to two secondary windings, S1 and S2.
2. A movable core mechanically linked to the measured object.

The housing and core rely on magnetic coupling and have no contact. Typically, the LVDT housing is fixed to a stationary reference point, and the measured object is mechanically linked to the movable LVDT core. As the core moves, the change in magnetic coupling between each secondary coil S1 and S2 produces an output proportional to the position of the measured part. The LVDT's raw output can then be interpreted by a signal conditioner, which delivers an analog or digital output to a meter or logic controller. *(See Figure 1)*

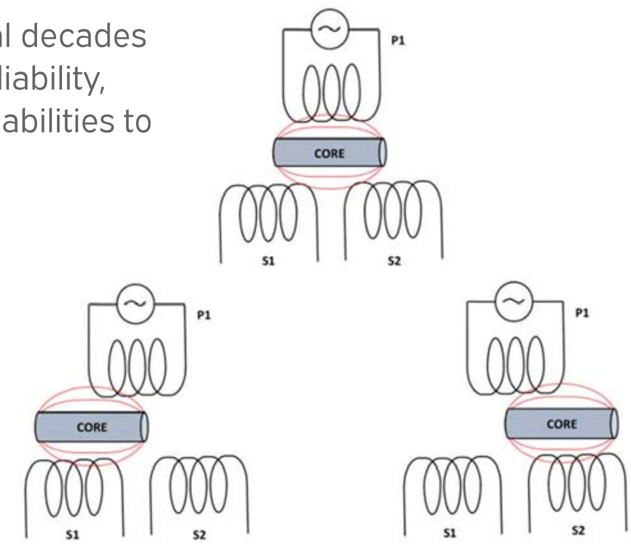


Figure 1: As the core moves over S1, the voltage output of S1 increases. As the core moves over S2, the output of S2 increases. The value of (S1 S2) and (S2 – S1) becomes a linear function of the core position. *Images courtesy NewTek Sensor Solutions*

Initially, LVDTs required external excitation from a signal conditioner to produce a digital output. However, modern LVDTs can now be built with internal signal conditioning modules, eliminating the need for external modulation, while still maintaining some beneficial characteristics of an AC-operated LVDT. AC units are still desirable in many applications with temperature extremes as they are not limited by the temperature limits of the internal electronics.

Why LVDTs Remain Popular

- LVDTs possess many traits that make them a "tried-and-true" technology for many applications.
- They are extremely rugged and durable. This has made LVDTs popular for decades in heavy industrial production applications such as paper mills as well as power generation stations.
- LVDTs are sensitive to very slight changes in position on the submicron level. Resolution is limited only by the signal conditioner. Precise feedback on infinitesimal movement is necessary for the optimal performance of different auto-

- mated processes and measuring parameters for dimensional quality, TIR and thermal expansion.
- The frictionless operation of an LVDT provides for near-infinite mechanical life. They are reliable over millions of cycles, which is critical for installations with inaccessible or unattended locations, or when replacing equipment or instrumentation is expensive and cumbersome. They also eliminate the threat of stiction errors with stationary surfaces.
- LVDTs are sometimes the only type of position sensor that works for a given application. For example, LVDTs are preferred in harsh environments like underwater and space and other areas with extreme environments. The absence of onboard electronics in AC-operated versions can tolerate high levels of moisture, chemicals, shock, vibration and extreme temperatures without affecting performance or life.

Modern LVDTs

LVDTs have been updated to make them more energy efficient, compatible with control systems and easier to fit into tight installations while offering greater performance characteristics.

Higher pressures. The use of high-strength alloys now allows LVDTs to be hermetically sealed to pressures of 20,000 psi, making them suitable deep subsea environments, downhole use near cutting tools for oil exploration and other extreme high-pressure applications such as pressure test vessels and hydraulic actuators. They serve as ideal replacements for load cells, pots and magnetostrictive sensors in underwater use. *(See Figure 2)*

Higher temperatures. New higher-temperature materials and ceramics enable LVDTs to operate at temperatures exceeding 1,000°F, making them suitable for applications with rugged environments such as power plants, engine control systems and autoclaves.

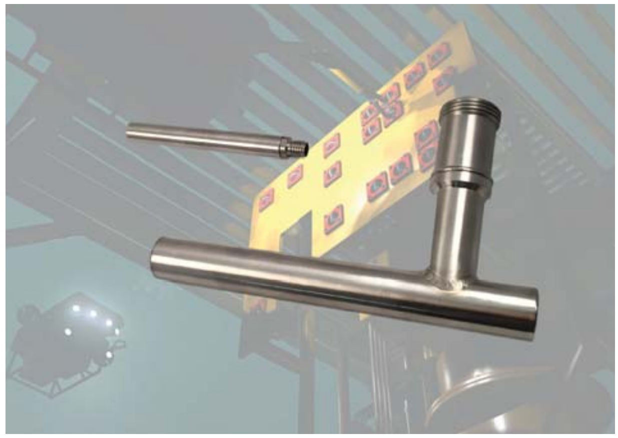


Figure 2: The higher content of nickel, chromium and molybdenum in the alloys used by NewTek to encase the LVDT assembly extends the corrosion resistance of its Submersible Position Sensors.

While advancements in manufacturing, electronic circuitry and construction materials have extended LVDT performance in a wider range of environments and applications over the years, the fundamental principles of its operation and key attributes such as dependability, toughness, sensitivity, accuracy, zero mechanical friction and long service life have remained unchanged.

Figure 3: Radiation Resistant LVDTs provide critical position measurements in autoclaves, particle accelerators, nuclear power plants, submarines, spacecraft and other applications with radiation exposure. Constructed of radiation-tolerant and hardened materials, these AC-operated linear position sensors operate continuously in demanding radiation environments without failure or decay.

Figure 4: Vented LVDT sensors equalize pressure inside and outside the LVDT to operate reliably in temperature extremes of −65°F to +400°F and operating pressures of 30,000 psi. Offering a lightweight, low-mass core and a compact 3/8-in. diameter, these miniature AC-operated position sensors are ideal for high-response dynamic measurement.

Radiation resistance. When LVDTs are now constructed using radiation-tolerant and hardened materials so they can operate in nuclear power plants, aircraft, submarines and other applications with radiation exposure. *(See Figure 3)*

Greater reliability. LVDTs can be constructed with special alloys such as Monel, Inconel, Hastelloy and Titanium to extend their reliability when operating in challenging environments like seawater and corrosive acids, as well as high/low temperatures and pressures.

Exotic alloys such as those that contain cobalt, nickel and chromium can deliver even higher performance from LVDTs where comparable technologies will not survive. For instance, a higher content of nickel, chromium and molybdenum extends chemical resistance to seawater in depths to 10,000 ft and external pressures of ~5000 psi.

LVDT construction materials are chosen based on parameters such as corrosion, pressure, and magnetic properties across the operating temperature range.

Convenient DC and digital outputs. PCBs with microelectronic processors allow for custom analog voltage, current and digital outputs directly from an LVDT or a remote-mounted signal conditioner. Digital outputs are critical for monitoring different assets in factory automation, especially as the industry moves to the IoT, smart factories and intelligent automation.

DC and digital outputs also offer convenience and higher reliability for laboratories to immediate process results with different third-party software. It also enables data to be saved in the clouds or shared with different partners.

Low power consumption. Modern LVDTs operate on lower voltages at 2.5 kHz – 10 kHz, making them resistive to noise created by electrical equipment and radio frequencies. They also consume much less power than legacy LVDTs that run on 120 V and 60 Hz that draw a lot of current. The lessened power consumption is critical in structural monitoring applications where measurements are made infrequently and paired with battery-powered electronics.

Smaller units. Computer-controlled winding machines allow for new coil designs previously not practical when LVDTs were wound by hand. This means LVDTs can be made smaller and lighter than ever before. Smaller, lighter LVDTs are of particular importance for spacecraft, robotics and where space is at a premium.

Vented. LVDTs can be designed with vented holes in the housing to equalize pressure inside and outside the unit to withstand a combination of high pressure, temperature, shock and vibration. Vented LVDT position sensors are ideal for high response dynamic measurement such as plastic injection molding machines, automatic inspection equipment as well as different robotic applications requiring displacement feedback to ensure proper machinery operation. *(See Figure 4)*

While LVDTs may have been around for a long time, many characteristics and operating benefits are just as relevant now as they were 50 years ago. The optimization of LVDTs with new performance and physical characteristics addresses even more modern applications, making them a cost-effective and more reliable choice than other sensor technologies on the market today. ■

Selecting the Right Sensor: A Guide for R&D and Electronics Design Engineers

This article details six essential sensors, along with four necessary questions a design engineer should ask before choosing which ones to use in their next design.

by Barry Brents, Field Application Engineer, Littelfuse

IN THE R&D and electronics design world, choosing the ideal sensor for your application goes beyond price and availability. Whether you're developing smart home appliances, building automation systems, automotive electronics or industrial equipment, sensors are the critical components ensuring your product functions as intended. When selecting a sensor, engineers must think holistically, considering performance, reliability, customization and the supplier's capabilities.

Following is a breakdown of sensor types, their applications and the key questions every engineer should ask before selecting.

Exploring Sensor Applications

Sensors play a crucial role in various applications, including:

Appliances. From small kitchen gadgets to large home appliances, sensors monitor conditions like temperature, humidity and proximity, ensuring safe and efficient operation.

Building and industrial automation. Sensors enable smart building features such as lighting control, HVAC optimization and security monitoring.

Automotive/electric vehicles (EVs). In modern vehicles, sensors are vital for safety, performance and user experience. They monitor parameters such as speed, tire pressure, battery temperature and proximity for parking assistance. In electric vehicles, sensors play a critical role in battery management and motor control, as well as ensuring efficient energy use, directly impacting vehicle range and safety.

Industrial automation. Sensors are the backbone of automated manufacturing and processing environments. They monitor temperature, pressure, flow rates and machine positioning, ensuring precise control and maintaining safety standards. In robotics, sensors enable navigation, collision avoidance and operational efficiency, driving advancements in smart factories.

A Look at Six Essential Sensor Types

Choosing the right sensor requires understanding the different sensor technologies available. Here's a detailed overview of the six main types used in electronics design.

Magnetic Detection Sensors for Proximity, Positioning and Control

Reed switches. Contain two ferromagnetic blades sealed within a glass tube filled with nitrogen gas to prevent oxidation. The sensitivity of a reed switch depends on the blade stiffness, gap and contact overlap. Activated by a permanent magnet or an electromagnet, reed switches operate

Reed Switches | Hall Effect Sensors | Reed Relays | TMR Switches | Thermistors | Pt-RTDs

Commonly used sensors for proximity, positioning, control and temperature sensing. *Images courtesy Littelfuse, Inc.*

without requiring external power, making them ideal for battery-powered devices.

Hall effect sensors. Constructed from semiconductor materials, these sensors generate voltage in response to magnetic fields. They require signal conditioning due to their microvolt/millivolt-level outputs, temperature compensation and electromagnetic compatibility (EMC) protection. Hall effect sensors are suitable for proximity detection and continuous linear or rotary positioning.

Reed relays. These consist of a reed switch and a control coil, providing galvanic isolation between the control circuit and the load. They offer advantages like high insulation resistance, low contact resistance and long life. Their compact size and high magnetic efficiency make them favorable for low coil drive power applications.

TMR switches. Integrating Tunneling Magneto Resistance (TMR) with CMOS technology, TMR switches offer high sensitivity and ultra-low power consumption. They feature on-chip voltage generators for magnetic sensing, amplifiers, comparators and noise-rejecting Schmitt triggers. Internal temperature compensation allows these sensors to operate across a wide supply voltage range.

Temperature Sensors

Thermistors. These are thermally sensitive resistors whose resistance changes predictably with temperature. Negative temperature coefficient (NTC) thermistors decrease resistance as temperature rises, while positive temperature coefficient (PTC) thermistors do the opposite. They provide high accuracy over a narrow range (−50°C to 100°C), making them ideal for precise temperature control applications.

Platinum Resistance Temperature Detectors (Pt-RTDs). Featuring near-linear resistance changes across a broad temperature range (−70°C to 500°C), Pt-RTDs are ideal for applications demanding wide-range temperature measurement and control. Their stability and uniform resistance change rate set them apart from other temperature sensors.

Four Critical Questions for Sensor Selection

When selecting sensors, asking the right questions can lead to better performance, reduced development time and enhanced reliability:

1. Does the supplier offer a wide-ranging product line of sensors and other components?

Partnering with a supplier that produces a variety of sensors means you're working with a team that has deep expertise in multiple technologies. This approach can be invaluable when customizing sensors to meet specific requirements. Additionally, sourcing various components from a single supplier simplifies the supply chain, helping to streamline operations and reduce vendor management complexity. A supplier with a broad portfolio is more likely to introduce innovative solutions to give your product a competitive edge.

2. Does the supplier offer application assistance?

Technical support from your supplier can save precious development time. Their expertise can help you select a suitable sensor and ensure you consider essential parameters such as temperature, vibration and electrical noise susceptibility. Supplier application engineers can guide you through installation and usage nuances, potentially identifying issues before they become costly problems in the field.

3. Does the supplier provide custom engineering?

Your design may have unique requirements, such as size constraints, enhanced sensitivity or specific connector types. A supplier with custom engineering capabilities can address these needs by creating a sensor tailored to your application. Suppliers focused solely on standard products may limit your design flexibility and hinder your project's long-term success. Look for manufacturers using advanced tools, such as simulation software and 3D CAD design, to accommodate custom sensor requests efficiently.

4. Does the supplier have the capacity to manage your order requirements?

Supply chain disruptions and long lead times can significantly impact revenue. Ensure your supplier has the manufacturing capacity to meet both your forecasted needs and unexpected large orders. This capability is crucial for maintaining product availability and meeting market demands promptly.

Custom sensor designers employ simulation software and 3D CAD design tools to create a new design or modify existing standard product packages.

The Advantages of a Capable Sensor Supplier

Working with a supplier that meets these critical criteria may mean a higher upfront cost for the sensor. However, the benefits—such as reduced development time, lower warranty expenses, enhanced product reliability and higher customer satisfaction—can lead to substantial long-term savings. Supplier selection is as vital as sensor selection itself, ultimately contributing to the success of your product in the market.

Final Thoughts

When choosing sensors, price and delivery time are essential, but technical capabilities, customization options, application support and supply chain management can significantly impact the overall product performance and market competitiveness. Make informed decisions to ensure your sensors meet and exceed your project's requirements. ■

IO-Link-enabled smart sensors are emerging as a leading technology for field-level applications, offering a future-proof solution that seamlessly integrates with both new and existing machine architectures.

Smart Sensors:
IO-Link Enables New Era for Strain Gauge Sensors

by Jeremy Cohen,
Managing Editor, *Machine Design*

THE DIGITALIZATION OF sensors for mechanical quantities represents the future in modern production and testing technology. Decentralized intelligence, data economy, failure-proof setup and efficient operation all go hand-in-hand with increased accuracy and greatly improved reliability in operation. Smart sensors with an IO-Link interface are set to be the predominant technological solution for sensors in the field-level, providing a future proofed solution that integrates with new and existing machine architectures in an easy, flexible and cost-efficient way.

Machine Design connected with Martin Schütz, product manager, Smart Sensors, Hottinger Brüel & Kjær, to help navigate the interface between smart sensors and IO-Link.

***Machine Design:* In which applications are strain gauge-based sensors typically used?**

Images courtesy Hottinger Brüel & Kjær

Martin Schütz: Strain gauge-based sensors are used in a wide variety of industrial and testing applications and fall into three main categories: force transducers, load cells and torque transducers. Measuring these mechanical quantities (force, load, torque) is at the heart of many mechanical processes in machines and production lines or in end-of-line testing applications. Typical applications are force joining processes; check weighing and torque measurements in end-of-line production; and testing and monitoring applications—just to mention a few.

***MD:* How do smart sensors evolve from the traditional measurement chain?**

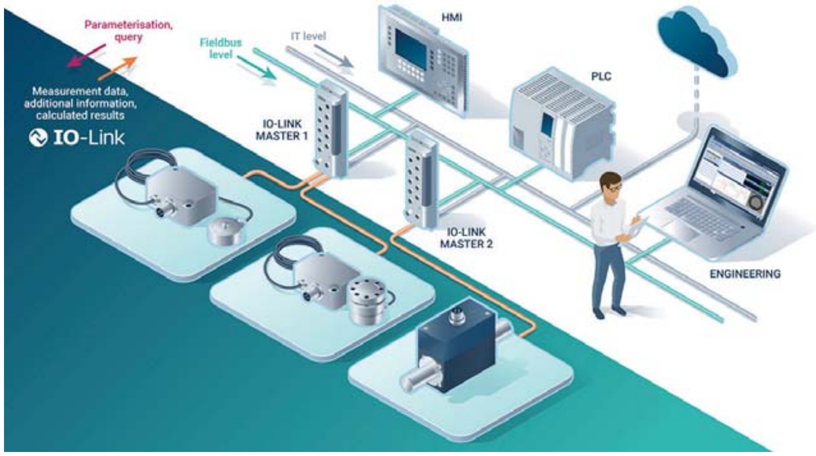
MS: Traditionally strain-gauge based sensors must be set up in a measurement chain, consisting of a passive sensor, high-quality, double-shielded cabling and an amplifier with the required output signal—that is, analogue (V, mA), serial Bus

(Profibus, CAN) or industrial Ethernet (Profinet, Ethernet/IP, EtherCAT, etc.). With the new line of smart sensors, we integrate the sensing element, the amplifier and a microprocessor as well as a communication interface into one single unit.

***MD:* What are key benefits of integrating electronics into the sensor?**

MS: With this approach, we can achieve higher sensor accuracy due to the internal linearization functionality and the possibility of compensating temperature influences on the sensor. With integrated, domain-specific algorithms offering statistical functions such as min/max value tracking, limit switches, a checkweighing algorithm or power calculation, engineers achieve the results needed for their underlying process rather than having to implement these by themselves in the PLC program.

Another groundbreaking advancement is the implementation of a sensor health monitoring feature, which allows the sensors to continuously track the applied load or temperature and compare with the sensor-specific limits. If these limits are overrun, the sensor sends out an alarm event notifying the PLC and higher-level applications about the issue.



***MD:* Why choose IO-Link as the communication interface?**

MS: There are many advantages to the IO-Link interface, and I want to highlight a couple of them. IO-Link unifies the sensor connector and cabling to a single standard allowing for simplification of sensor and actuator setup in the field-level. IO-Link was invented to be integrated into any common fieldbus environment, which is why there are IO-Link masters available for all common industrial Ethernet protocols.

***MD:* How does this solution benefit system architects designing state-of-the-art machines and processes?**

MS: This is a huge advantage in terms of system design and overall machine architecture because engineers can now design sensor and actuator setups in their machines without having to change a big part of the setup when switching the overarching PLC solution. Furthermore, with IO-Link standardized backup protocols and system setup and parametrization, procedures can be defined for all IO-Link sensors in a machine. This means a huge efficiency benefit in servicing and machine setup.

***MD:* How is an overall cost-efficiency benefit achieved with this solution?**

MS: Overall, the cost efficiency benefits can be divided into three categories. Firstly, due to the higher accuracy of sensors with integrated signal processing, applications benefit from using a single sensor for wider measurement ranges without having to buy multiple sensors with different measurement ranges to fit the application.

Secondly, the integrated amplifier and standardized cables and connectors reduce the initial hardware costs. Leveraging the integrated domain-specific algorithms for process control applications such as force limit detection or check weighing also allows for decentralization and means fewer engineering hours in programming these algorithms.

Lastly, the IO-Link protocol standard allows for a standardized sensor setup, which is failsafe, fast and efficient and is the same for all IO-Link sensors. No more different approaches are required—one parametrization solution works for all. This means that less special training is required for system setup and maintenance staff, which results in an overall gain in total cost of ownership (TCO). ■

A Partnership in Defense Engineering

Photos courtesy Element U.S. Space and Defense and Texas Tech University

Element U.S. Space and Defense and Texas Tech University are working together to drive innovation in defense technology.

by Sharon Spielman,
Technical Editor, *Machine Design*

A COLLABORATION BETWEEN Element U.S. Space and Defense and Texas Tech University's Mechanical Engineering department represents the potential for groundbreaking advancements in defense technology. Dr. John Granier, chief engineer of munitions and energetics at Element, and Dr. Michelle Pantoya from Texas Tech Combustion Lab, spoke with *Machine Design* about how understanding the ignition processes in a range of ammunition systems—from small arms to large tank rounds—will help improve the performance and safety of munitions.

The partnership between Element and Texas Tech is rooted in a shared commitment to address national security challenges. Pantoya sees the importance of integrating the expertise of seasoned professionals with the energy and creativity of students—a collaboration that not only improves the educational experience for graduate students but also bridges the gap between theoretical research and practical applications.

From Propellant Ignition to Advanced Diagnostics

One prominent project stemming from this partnership involves the study of propellant ignition processes. By focusing on the early heat transfer mechanisms during ignition—an essential aspect in the functionality of various military systems—the team aims to develop more reliable and efficient propellants.

The collaboration allows them to explore innovative methodologies for quantifying energy conversion processes, which are necessary for optimizing propellant formulations. These advancements not only offer improvements in performance metrics—including velocity, range and accuracy of weapon systems—but also improve safety by identifying conditions that could lead to failures.

The Role of Advanced Technologies

A part of their research uses sensor technologies designed to capture critical data in real time. One of the breakthrough methodologies they use is digital tomography, which utilizes high-speed cameras equipped with filters and software to analyze temperature distribution. This approach allows researchers to visualize and quantify temperature changes in the ignition process that occur at incredibly rapid timescales.

These sensors can capture data at rates of up to 200,000 frames per second, providing temporal and spatial resolutions. This allows for a deep understanding of the energy dynamics during ignition, shedding light on how heat transfers between gases, solids and other phases in a confined system.

The use of filtered light emission analysis facilitates the extraction of temperature data based on Planck's law of black body radiation, Pantoya explained. This method involves collecting multiple intensity measurements at discrete wavelengths, enabling precise quantification of thermal emissions. Consequently, this provides insights into the energy transfer mechanisms within the combustion environment, which is important for optimizing propellant formulations.

Emerging technologies like artificial intelligence (AI), robotics and advanced materials are also a part of the partnership's efforts. While current projects focus on fundamental research using state-of-the-art diagnostics, the data generated will ultimately serve as a foundation for future AI and machine learning applications.

As both Granier and Pantoya point out, the high-speed cameras employed in their experiments allow for unprecedented data capture at varying temperatures and conditions. This capability significantly enriches the datasets necessary for developing predictive models that can influence future material development.

Additive Manufacturing Allows for New Geometries

The research team employs additive manufacturing (AM) techniques to rapidly prototype components tailored to their specific experimental needs, helping to accelerate the design process and increase the precision of their studies.

AM allows for the creation of geometries previously unattainable using traditional methods, which can improve the performance of propellants through optimized designs. Granier says this technology enables rapid prototyping and iteration, accelerating the timeline from concept to deployment.

Pantoya echoes this sentiment, noting that the ability to quickly produce tailored components can greatly enhance experimental design. "In academic environments, additive manufacturing is essential for swiftly adjusting our experimental apparatus to meet specific needs," she said.

Overcoming Engineering Challenges

The journey from design to prototype includes several challenges. Both Granier and Pantoya acknowledged that iterative design is necessary to address the complexities of their experiments. Every trial yields new insights, leading to refinements and experimental setups, which are necessary to uncover the underlying physics of combustion and propulsion systems.

A significant aspect of their work lies in isolating variables during experiments to better understand how different materials and geometries affect propellant performance. Testing protocols at element are stringent, particularly due to the unique nature of defense products where each prototype often represents a one-of-a-kind asset. Granier explained they must ensure the reliability of results from the outset to minimize risk during critical tests. The timeline is often tight, and they aim to collect valuable data within those constraints, he said.

Future Trends in Defense

Looking ahead, the integration of emerging technologies such as machine learning and advanced visualization techniques promises to further enhance the capabilities of defense applications. This information will enable more sophisticated modeling and predictive analytics in future propellant formulations.

Pantoya reiterates that the data generated from their experiments will contribute to larger datasets that can inform the application of AI in optimizing defense technologies. By breaking down the complexities of combustion physics, they aim to pave the way for innovations that not only meet stringent defense standards, but also improve the overall safety and effectiveness of military operations.

The partnership is not just about technological advancements, it is also about cultivating the next generation of defense engineers. Engaging students in meaningful research contributes to their education while simultaneously addressing defense challenges. By fostering an environment conducive to collaboration, knowledge sharing and mentorship, this alliance not only prepares students for careers in defense engineering, but also plays a role in developing the advanced solutions necessary to meet the future challenges of national security. ■

BE SURE to check out our five-part interview series with Dr. John Granier and Dr. Michelle Pantoya at *machinedesign.com/55232924*.

Q&A: Advanced Sensor Technologies Promote Safer, More Efficient Manufacturing Processes

Metsen's Vaibhav Modi explains why sensors backed by custom software benefit continuous casting processes across industries.

by Jeremy Cohen,
Managing Editor, *Machine Design*

ADVANCES IN SENSOR technology have transformed manufacturing processes across various industries by enhancing precision, efficiency and safety. Sensors measure and monitor typical parameters like temperature, pressure and humidity. Industrial manufacturers also use them in more advanced applications like measuring vibrations, chemical compositions and capturing real-time data for better control of production processes.

Sensor technology helps manufacturers detect process deviations and anomalies as soon as they occur, minimizing waste and rework. They facilitate predictive maintenance, which reduces downtime. Advanced sensor systems also improve workplace safety by monitoring environmental conditions and detecting hazardous situations promptly.

With the emergence of Industry 4.0 and its focus on leveraging robots and smart machines to optimize performance, manufacturers need sensor systems designed to support automation. IoT, artificial intelligence and big data are common themes within the industrial automation mix. These and other developments are paving the way for future innovations in smart manufacturing and the new Industry 5.0 initiatives that are gaining momentum, which focus on the human aspect of technology applications.

In this Q&A, Vaibhav Modi, technical sales representative for Metallurgical Sensors Inc (Metsen), provides insights on some manufacturing processes benefiting from advanced sensor technologies. He also talks about trends impacting emerging and future industrial sensor systems.

***Machine Design:* What kinds of industrial sensors does Metsen design and implement?**

Vaibhav Modi: Metsen designs and implements extreme vision camera systems for harsh environments; vibration and optical slag detection systems to identify the waste matter in molten metal; endoscopes for checking smelting furnace conditions; a system for high-precision rhomboidity measurement of billets, blooms and bars; and hydroweigh systems for molten metal weight measurement in the ladle and bucket. Each system involves advanced sensor technologies customized for the customer's primary need.

***MD:* What industrial manufacturing processes benefit from Metsen's sensor systems?**

VM: Metsen's core sensor solutions benefit continuous casting processes in steel mills, smelter operations in metal processing plants, automotive, food and beverage, pharmaceutical, pulp and paper, oil and gas, aggregates, robotics and general surveillance environments. They are used by companies globally.

For example, within the automotive production assembly environment, many sensor technologies are used for everything from precision welding and painting to safety performance testing before vehicles are delivered to customers. Industries with highly noxious encapsulated environments—such as petrochemicals, aggregates, food and beverage, and pharmaceuticals—can also benefit from integrating sensor technologies that allow safer process monitoring.

***MD:* Are there any universal issues or challenges that advanced sensor systems address across the process industries?**

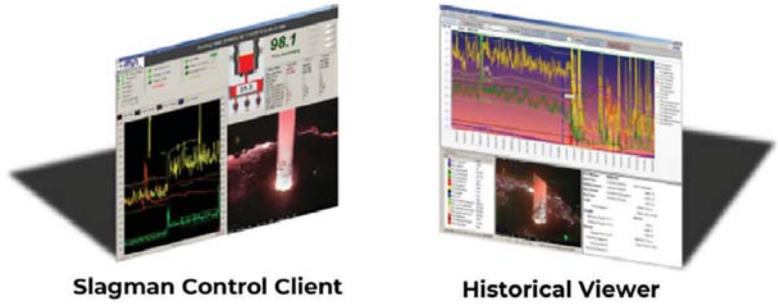
VM: All industries are united by three common objectives: safety and compliance, energy efficiency and process optimization, driven by best-in-class quality control. Advanced sensor systems uniquely address each objective. Sensors backed by custom software designed to monitor environmental conditions can ensure compliance with safety regulations. When hazardous conditions emerge, alerts are generated to ensure safe working conditions for employees.

Regarding energy efficiency, sensors can monitor energy consumption in manufacturing processes, analyzing energy usage patterns. This allows manufacturers to implement energy efficiency strategies, reducing costs and minimizing environmental impact. As for process optimization, analytics from sensor data can identify inefficiencies or bottlenecks in the process, allowing manufacturers to fine-tune operations, improve workflows and enhance overall efficiency.

Quality control sensors provide real-time data for continuous product quality monitoring. With the right sensor system in place, deviations from set standards can be promptly identified for immediate corrective actions to maintain best-in-class quality standards throughout production.

***MD:* Can you share a success story or a specific project using your sensor technology to improve existing machine operations?**

VM: Major global companies in the iron and steel processing environment use our Slagman vibration slag detector (VSD) system to improve the safety and life of the steelmaking tundish, improve the quality of the yield they produce and reduce downtime. In the steel industry, downtime can cost as much as $10,000 per hour, so if advanced sensor systems can help save as little as 15 seconds off a critical process, more than $100K can be saved each month by not having to slow down the machines. A large steel company had a caster producing high-quality billets focused on improving tundish life. The average tundish permanent (safety) lining life was 150 heats. A better refractory was tested, which increased the life to 250 heats. After implementing the VSD system, the life of the lining increased to 1,000 heats and the average tundish working-lining life doubled. Despite tundish slag decanting practices, there were two to three tundish breakouts (or hotspots) per month. After implementing the VSD system, tundish breakout was reduced to zero and the tundish decanting practice ceased. Zero breakouts are the safety goal of every steel mill operation. The tundish drain-down design target in another steel plant was 4,536 kg (about 10,000.16 lb), but production averaged 5,443kg - 6,803kg (11,999.74 lb – 14,998.05 lb), even with tundish slag decanting practices. After implementing the VSD system, a significant drain-down average of 2,722kg (about 6000.98 lb) was achieved, and decanting ceased. Previously, the production crew used 90 to 95 tundishes on average per month with a throughput of 500 to 520 heats.



Vhaibav Modi noted that "software sits at the heart of the sensor system's effectiveness." It is responsible for collecting, integrating and visualizing data in real time. *Images courtesy of Metsen*

After implementing the VSD system, the caster reduced tundish consumption to an average of 65 per month and increased throughput from 600 to 630 heats monthly. The return on investment (ROI) was less than one month from start to finish and the safety benefits were an added value. Since each manufacturing environment has different criteria for improving production and quality, we consult with customers to design sensor systems to meet their unique needs and customize the system to fit their process.

***MD:* What R&D innovations are you developing to advance sensors for greater machine efficiency?**

VM: The companies we talk to and work with daily are pushing the implementation of new technologies, such as automation, artificial intelligence and cloud-based solutions for data storage. Metsen is innovating its EVCam series of extreme vision systems by using artificial intelligence in many ways, such as enabling the capability to learn from the images and data collected through the software.

Our systems can also be implemented with cloud technology and, as we move into Industry 5.0, we continue to embrace the interaction and collaboration between humans and technology. These kinds of developments we see taking shape will impact the development of industrial sensor systems.

MD: Is there anything else our audience should know about advanced sensor technologies?

VM: Software sits at the heart of the sensor system's effectiveness, collecting, integrating and visualizing data in real time, so ensure the system you choose is designed to fully integrate with your plant's production processes. Also, keep predictive maintenance in mind, which requires analytics to monitor equipment performance continuously. Maintenance can be scheduled proactively by detecting early signs of wear or potential failures based on sensor data patterns, minimizing costly unplanned downtime and repairs.

Finally, work with a team of highly skilled professionals who can provide you with top-notch customer service support from start to finish and provide continued support utilizing a remote monitoring management system. ■

Things to Consider When Selecting an **Industrial Photoelectric Sensor**

This article compares three types of photoelectric sensors—through-beam, retroreflective and diffused—used in industrial applications to detect object presence.

Photoelectric sensors are indispensable tools in modern industrial automation, offering reliable and versatile object detection capabilities. *Credit: kynny_1383386662 | iStock / Getty Images Plus*

by Eric J. Halvorson, Senior Marketing Technology Manager for Automation and Control, DigiKey

SIMPLY PUT, SENSORS are the eyes and ears of industrial automation. Regardless of the application, automation is simply not possible in today's manufacturing process without sensors. There are many different ways in which we measure our environment through sensors. Whether that is vibration, object detection, temperature or humidity, speed, strain or a hundred other different sensing technologies, sensors enable the world of industrial automation. One of the many different sensor technologies available is photoelectric sensors.

Photoelectric sensors are used in industrial applications to detect object presence. There are three types: through-beam, retroreflective and diffused. Depending on the sensor type, they can be used to detect materials such as wood, plastic, metal and glass.

Through-beam sensors utilize a transmitter node and a receiver node. The transmitter will be on one side of the beam, the receiver on the other. These two must be in alignment without obstructing the beam to work. With retroreflective, the sensor contains both the transmitter and receiver in the same unit. The sensor emitter projects the beam to a reflector. The reflector is aligned to reflect the beam back into the receiver.

In a diffused reflective sensor, the sensor again contains both transmitter and receiver in one unit. However, instead of needing a reflector to return the beam to the receiver, the sensor is directed at an object and the light returns to the receiver.

There are advantages and disadvantages to each sensor type. With a through-beam sensor, longer range, reliability and higher accuracy can be achieved. Areas such as wide door openings (e.g., garage doors or wide conveyors) can be monitored. This is due to light only needing to travel in one direction.

There are some disadvantages as well. For example, the cost is higher due to the need for multiple components being able to detect through thin, clear objects due to light refraction. With the need for two modules, setup can be more difficult as well. Factors like mounting space requirements, cable management and alignment can prove to be a challenge, depending on the application.

With retroreflective, the cost is lower and setup is easier, having only one module and a reflector. There is no need for additional cabling and power and alignment is easier, but distance becomes shorter. Applications for retroreflective include baggage conveyors at airports, vehicle detection at toll gates and some material handling applications.

The disadvantage of retroreflective photoelectric sensors is the reflector. When the detected object is highly reflective, the sensor may fail to read the object. This can be avoided by adjusting the angles, but it is something to be aware of. With the beam being bi-directional, the detection distance is also shorter.

Depending on the sensor type, photoelectric sensors can be used to detect materials such as wood, plastic, metal and glass. *Credit: zorazhuang_1326958893 | iStock / Getty Images Plus*

The diffuse photoelectric sensor is cheaper and there is only one point of installation. However, the detection distance is much shorter. Rather than relying on a reflector to bounce back the beam, the sensor relies on objects passing in front of the beam. The other downside is that depending on the material and color of the object being detected, the sensor may struggle to detect it.

What to Consider

When selecting the right photoelectric sensor for your needs, there are several things to review before deciding on one type over another. The following are a few points you should consider:

Location. The sensor's location plays a significant role in the type of sensor technology you can use. What is the detecting range for your application or, to put it simply, how far away from the sensor is the object to be detected? Is there sufficient mounting space for the sensor module and bracket, and is cabling required for power and connectivity? What are the environmental conditions where the sensor(s) will be mounted? What level of ingress protection will the sensors need?

Beam size. Select a sensor with a beam size appropriate for the size of the target you are looking to detect. The target must be big enough that it will break the beam and trigger detection.

Sensor output. Two-wire sensors and three-wire sensors provide different outputs. In a two-wire sensor configuration, the sensor acts as a switch and will toggle the output on or off. With three-wire configurations, logic is required. In this case, the sensor triggers an event with a connected PLC using sourcing or sinking currents (PNP vs. NPN).

Output configuration. You will need to determine whether your sensor application would require a light-on, dark-on, light-off or dark-off configuration. Depending on the configuration needed it will help to select the proper sensor.

The circuit function will help to identify the type of sensor you need. Through-beam, retroreflective and polarized retroreflective sensors are all capable of light-off and dark-off output configurations. In contrast, diffuse reflective sensors are capable of light-on and dark-on configurations.

Excess gain. Excess gain is the measure of the minimum light energy needed to ensure proper triggering of the sensor. When selecting your sensor, you need to ensure there is sufficient excess gain to allow for proper detection. This will be especially important in dirty industrial environments.

When researching your sensor options, most manufacturers will provide an excess gain curve chart for both non-polarized and polarized sensors. These charts will provide maximum distance vs. maximum receiver gain based on a clean environment. There are levels to consider based on the cleanliness of the air in which the sensor will be operating.

Here are some examples to help explain the level of air contamination and how it impacts sensor operation and object detection.

- *Clean air* — ideal conditions, perfectly clean air
- *Slightly dirty air* — non-industrial areas
- *Low contamination* — warehouse, light manufacturing
- *Moderate contamination* — milling operations
- *High contamination* — heavy particulate, extreme washdown environments
- *Extreme contamination* — coal bins

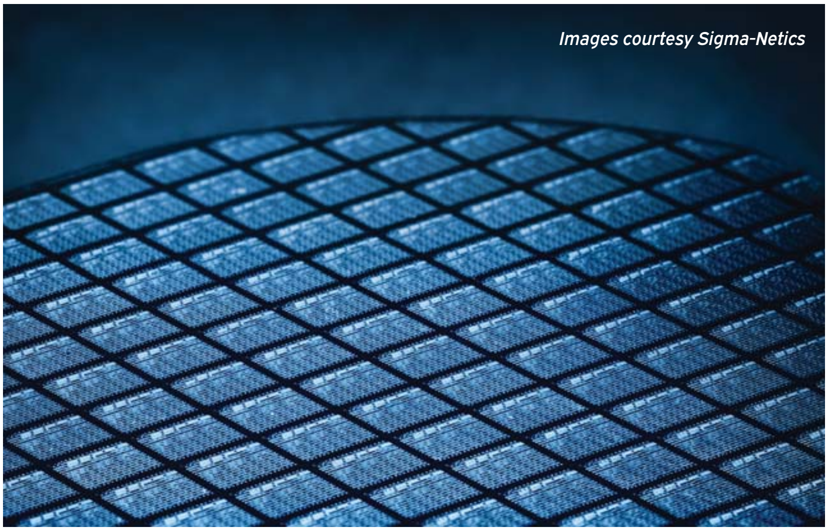
Photoelectric sensors are indispensable tools in modern industrial automation, offering reliable and versatile object detection capabilities.

Photoelectric sensors are indispensable tools in modern industrial automation, offering reliable and versatile object detection capabilities. Understanding the nuances of through-beam, retroreflective and diffused sensors is crucial for selecting the optimal solution for specific applications.

By carefully considering factors such as location, beam size, sensor output, output configuration and excess gain, engineers can ensure the successful integration of photoelectric sensors into their automation systems. The judicious choice of these sensors contributes significantly to enhanced efficiency, productivity and quality control in various industrial settings. ■

Custom Pressure Transducer Delivers High-Temperature Accuracy

Sigma-Netics designed a sensor for the demanding performance requirements of a semiconductor application. Discover how they balanced thermal performance with package size.



Images courtesy Sigma-Netics

by Sean Gregory, Director, Engineering Applications & Sales, Sigma-Netics

DESIGNING HIGH-PERFORMANCE pressure transducers can be a technical balancing act. While it's relatively simple to design an accurate low range transducer with high output sensitivity, it is difficult to couple that with low thermal errors at extreme temperatures. Add in additional requirements—like a smaller form factor or lower mass—and the design challenge becomes even more difficult.

Basic physics limits many pressure transducer design and performance combinations that tend to be mutually exclusive in commodity sensors, including low-range accuracy, thermal performance and size. Striking a balance between these attributes is possible but requires a significant amount of custom engineering along with a deep understanding of pressure transducer components and calibration strategies. Traditional sensing technologies offer a few of these options in combination, but not all.

For example, bonded gauge sensors offer high accuracy at low pressures with excellent thermal performance and survivability, but they sacrifice size, requiring a significant strain field and room to bond. MEMS sensors offer high accuracy at low pressure ranges, high signal output and small size, but they perform poorly or even fail to survive at extreme temperatures, typically limited to under 200°F. Exceptions exist but can then be cost-prohibitive.

For a glimpse at what's possible when a sensor is designed for demanding performance requirements, rather than bought as-is from a catalog, consider a model we recently created for a semiconductor application. This customized 0–100 PSIA sensor measures pressure as part of a semiconductor gas flow monitoring and control system. Performance requirements included an accuracy of 0.35% FSO TEB, frequent excursions to temperatures as high as 428°F and a high output signal of 100 mV.

Designed for flush-mount installation within the gas flow system, the sensor also needed to be small, with just a 12.7-millimeter (mm) diameter and 13.5-mm height. Conventional COTS solutions could not meet these application requirements.

The Problems With Accuracy, Heat and Size

Achieving this level of accuracy is not an issue for high-performance pressure transducers. Most of our off-the-shelf pressure transducers, for instance, offer a standard accuracy of 0.25% FSO static accuracy (not TEB) and can optionally reach accuracies better than 0.1% FSO static accuracy for operating temperature ranges between −65° and +250°F.

High temperatures, however, affect the sensor's circuitry and strain gauges, introducing errors that reduce accuracy across the entire span. A typical high-temperature sensor operating at 428°F could exhibit a thermal error as high as 2.0% with standard thermal compensation techniques. Many off-the-shelf high-temperature models can't achieve 428°F at all—at least not for long-term exposure—without limiting output options or requiring thermal isolation methods that increase the final product's complexity.

Our new sensor design, by contrast, has a total error of 0.35% FSO TEB across a wide temperature range—from room temperature to 428°F. That total error includes linearity, hysteresis, repeatability and thermal effects on zero and span.

With this sensor, the combined features of low-range accuracy and high-temperature thermal performance don't come at the expense of package size, where the three requirements tend to compete. Nor does it require traditional thermal wells or standoff tubes that require extra room within the sensor location.

In high-temperature applications, it is usually necessary to protect against heat either by using a standoff tube to "bleed" the temperature, adding mass to use as a heat sink or separating the electronics module to isolate the components that can't tolerate high temperatures. Similarly, internal space is required to allow for the additional thermal compensation sensors. In addition, with low-range sensors, diaphragm thickness is limited by the outer diameter of the sensors: traditional diaphragm or beam designs yield to machine tooling pressures before desired thicknesses are reached, and media-isolated designs require complex geometries, further impacting the size, mass and number of internal components.

How It's Done

Pushing the envelope on the compact low-range sensor's thermal performance while minimizing its package size did not come down to an individual technical breakthrough. Instead, the improvements are rooted in careful application of known, but difficult, sensor design, manufacturing and calibration methods.

In particular, we paid close attention to materials used throughout the sensor, avoiding lower melting-point solders in favor of gold, using proprietary bonding techniques and selecting only heat-tolerant materials throughout the sensor. Likewise, we selected high-temperature electrical components for the signal conditioning circuitry.

To ensure total error band accuracy across such a wide thermal range, we took the extra step of thermally matching the sensor's individual strain gauges. Thermal matching boils down to a time-consuming process of identifying resistors with a similar Temperature Coefficient of Resistance (TCR)—and then creating the Wheatstone Bridge circuitry using these matched resistors. This technique reduces one of the key causes of thermal error: strain gauge performance variability. Strain gauges in a single lot "move" differently from one another as temperatures change due to variations in material conditions, starting resistance and TCR. Our process reduces this critical source of thermal performance uncertainty, allowing traditional techniques to further enhance performance.

Rather than thermally matching the strain gauges, the standard practice in the sensor industry is to compensate for the differences in strain gauge TCR with additional resistors or through a digital compensation board. These compensation methods include well-known active and passive measures that would not have allowed us to meet the 0.35% FSO TEB accuracy specification at high temperatures without adding size or additional components or impacting the sensor's operating temperature capabilities.

The Value of Custom Designs

While engineered for a specialized semiconductor application, this high-temperature low-range sensor does highlight the value of custom sensors for all difficult applications. The same design, manufacturing and calibration principles can be tailored to the requirements of other applications whose thermal performance, accuracy and package space requirements are not well-served by commodity sensors—including space exploration, aircraft, subsea vehicles, downhole oil and gas, high-temperature process industries, and more. ■

This customized 0-100 PSIA sensor measures pressure as part of a semiconductor gas flow monitoring and control system. Performance requirements included an accuracy of 0.35% FSO TEB, frequent excursions to temperatures as high as 428°F and a high output signal of 100 mV.

Applying Low-Noise Solid-State Relays to Limit EMI: A Comprehensive Guide

A comprehensive look at low-noise solid-state relays and ways to limit electromagnetic interference.

by **Jesus Miranda,** Product Manager, Crydom Solid State Relays, Sensata Technologies

ELECTROMAGNETIC INTERFERENCE (EMI) is a pervasive challenge in the realm of modern electronics, influencing the performance, reliability and compliance of numerous devices. As industries continue to push the boundaries of electronic innovation, the need to mitigate EMI becomes increasingly critical. Solid-state relays (SSRs) offer unique advantages over traditional electromechanical relays (EMRs), but also present distinct challenges related to EMI.

This comprehensive guide explores the application of specialized low-noise SSRs to limit EMI, delving into their features, benefits and specific use cases.

The Role of Solid-State Relays (SSRs)

In a traditional EMR, a low-power circuit energizes a coil, creating a magnetic field which then physically closes the contacts and allows the high-power circuit to flow. Solid-state relays are electronic switching devices that use semiconductor components to switch on or off when an external voltage is applied.

Unlike EMRs, SSRs have no moving parts, which provides several benefits:

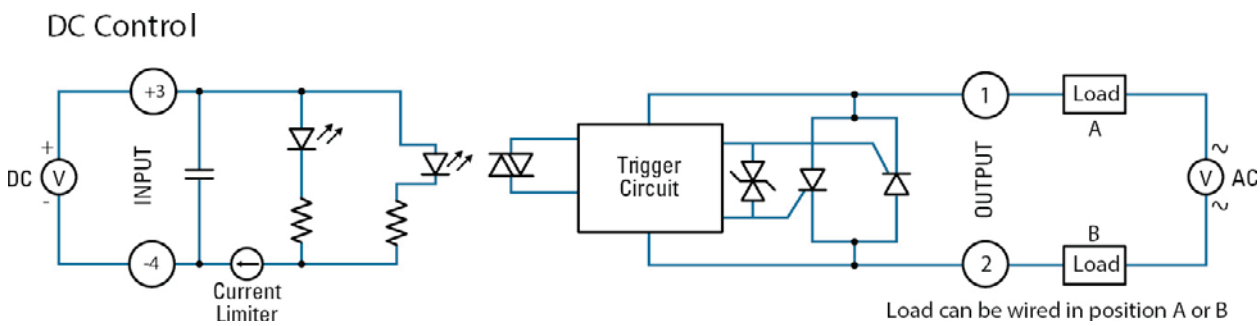
- **Increased reliability.** With no mechanical parts to wear out, SSRs typically have a longer lifespan. SSRs are known to last for millions of operations while EMRs often last in the range of 100,000-500,000 operations or slightly above when heavily derated. Obviously, the life expectancy of EMRs depends on the quality of materials and can be further increased at an additional cost. A frequent practice to increase life expectancy of EMRs is oversizing the ratings of the contacts, which in turn increases cost of the part as well.
- **Faster switching speeds.** SSRs can switch much faster than EMRs, which is crucial for many modern applications. Instantaneous turn-on solid state relays and contactors respond to a control signal in less than 100 µs.
- **Shock and vibration resistant.** Because they are not reliant on any moving components, solid-state switching solutions are not susceptible to erratic or unreliable operation when operating under tough environments.
- **Silent operation.** Solid state switching solutions make no acoustical noise when the output contacts change state. This is highly desirable in many commercial and medical applications.
- **No arcing.** SSRs generate no sparks arcs when opening or closing, and do not bounce electrically or mechanically, making them well-suited for hazardous environments.

One of the drawbacks of SSRs is driven by their nature as a semiconductor—specifically in terms of heat. When the SSR is on, resistance within the circuit causes power dissipation and heat build-up, which—depending on the application—may necessitate the inclusion of a heat sink, thus increasing the size of the solution. Many SSRs are sold with integral heat sinks, which helps reduce the complexity in managing heat dissipation across a specific application.

The fast-switching nature of SSRs can also generate high-frequency noise, contributing to EMI. This is where specialized low-noise SSRs come into play.

Understanding EMI and its Impact

EMI is the disturbance generated by an external source that affects an electrical



The author explained that SCR-based relays have the advantage of a faster dv/dt characteristic when compared with a triac relay. Sensata's LN series of relays is an example that incorporates a low noise trigger circuit. *Sensata Technologies*

circuit. This interference can degrade the performance of the circuit, lead to data loss or cause total device failure.

EMI can originate from various sources, including power lines, radio transmitters and even other electronic devices. In industrial settings, the consequences of EMI can be particularly severe, affecting precision machinery, communication systems and sensitive medical equipment.

Key Features of Low-Noise SSRs

To mitigate the EMI generated by fast switching, low-noise SSRs incorporate a variety of approaches, such as shielding and filtering. But the circuit design itself plays a significant role.

First, using relays with a silicon-controlled rectifier (SCR) output is an initial step in looking to minimize EMI. But when looking to meet standards such as IEC 60947-4-3, additional steps may be needed.

SSRs with zero-crossing detection are designed to deliver lower noise levels for resistive loads. This feature allows the relay to switch at the point where the AC voltage waveform crosses zero volts. Switching at this point eliminates inrush current and voltage spikes, significantly reducing EMI. For inductive loads, so-called random-switching SSRs are preferred. When the switch is activated, they switch instantly, rather than waiting for the AC supply to reach zero.

SCR-based relays also have the advantage of a faster dv/dt characteristic when compared with a triac relay—especially when the relay is not activated. By way of comparison, SCRs have a dv/dt of around 500 volts/microsecond (volts/µs)—compared to 10 volts/µs for a triac—and will not conduct after the zero-crossing point. Because the components are also spread wider within the device, they will generally deliver slightly better heat dissipation.

An example of these types of SSRs can be seen in Sensata's LN series of relays, which incorporate a low noise trigger circuit designed to help use of additional EMI filter.

The LN Series offers ratings up to 75 Amps at 528VAC in standard panel mountable hockey-puck style device with integrated input/output overvoltage protection. It is also available with standoffs for PCB mounting if needed, and is UL recognized and TUV certified.

Some key applications where the LN series has been well-suited include commercial ovens, household appliances and medical equipment.

Benefits of Low-Noise SSRs

The implementation of low-noise SSRs offers several benefits across various industries where EMI is most challenging, such as medical devices, telecommunications or industrial automation equipment.

While more expensive than EMRs, solid state relays deliver the wear-free operation needed in today's digital electronic landscape. By reducing EMI, these SSRs also ensure that sensitive electronic equipment operates more reliably and efficiently and potentially deliver an extended lifespan as impacts on components are minimized.

Using low-noise SSRs can also help reduce or eliminate the need for an external filter, reducing cost, design complexity and space.

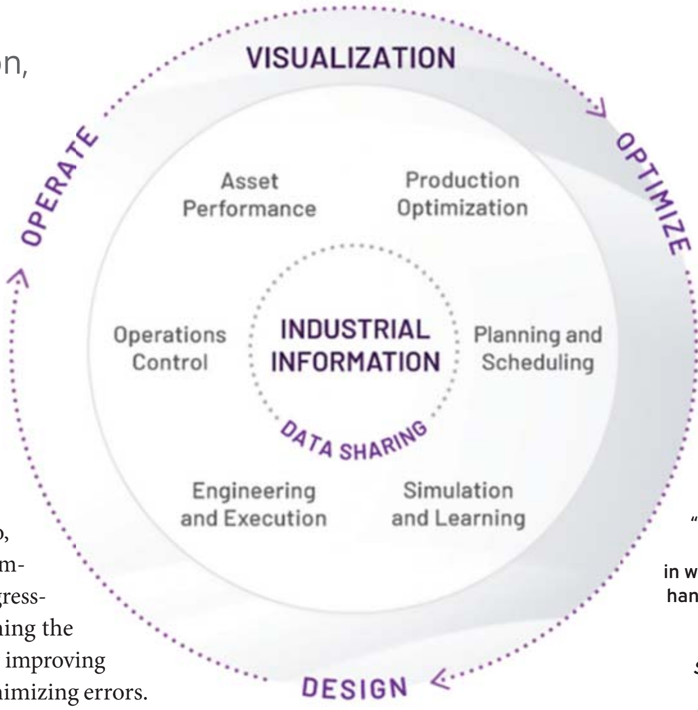
The application of specialized low-noise solid-state relays is a critical strategy for limiting EMI in various electronic systems. By incorporating features such as snubber circuits, zero-crossing detection and advanced shielding, these relays help ensure the reliable and efficient operation of sensitive equipment. As industries continue to demand higher performance and stricter compliance with EMI standards, low-noise SSRs will play an increasingly significant role in the design and implementation of modern electronic systems. ■

Sensata Technologies' LN Series offers ratings up to 75 Amps at 528 Vac in a standard panel mountable device with integrated input/output overvoltage protection. *Sensata Technologies*

How Digital Transformation, Virtualization and Software-Defined Automation are Reshaping Industrial Operations

Why engineers are making software defined automation, digital twins, soft PLCs and other agnostic tools part of the manufacturing automation toolkit.

by Ali Haj Fraj, SVP, Digital Factory, Schneider Electric



Industrial digital transformation arguably changes the industrial "design, optimize, operate" cycle in ways that improve hand-offs, maximize efficiency and minimize errors. *Schneider Electric*

CHANGE IS HAPPENING at record speed. More technologies are arriving, while many more are quickly becoming obsolete. For manufacturers that rely on systems designed and installed decades ago, this is particularly impactful. Today, for example, industrial digital transformation is progressing at pace. It is fundamentally transforming the industrial "design, optimize, operate" cycle, improving hand-offs, maximizing efficiency and minimizing errors.

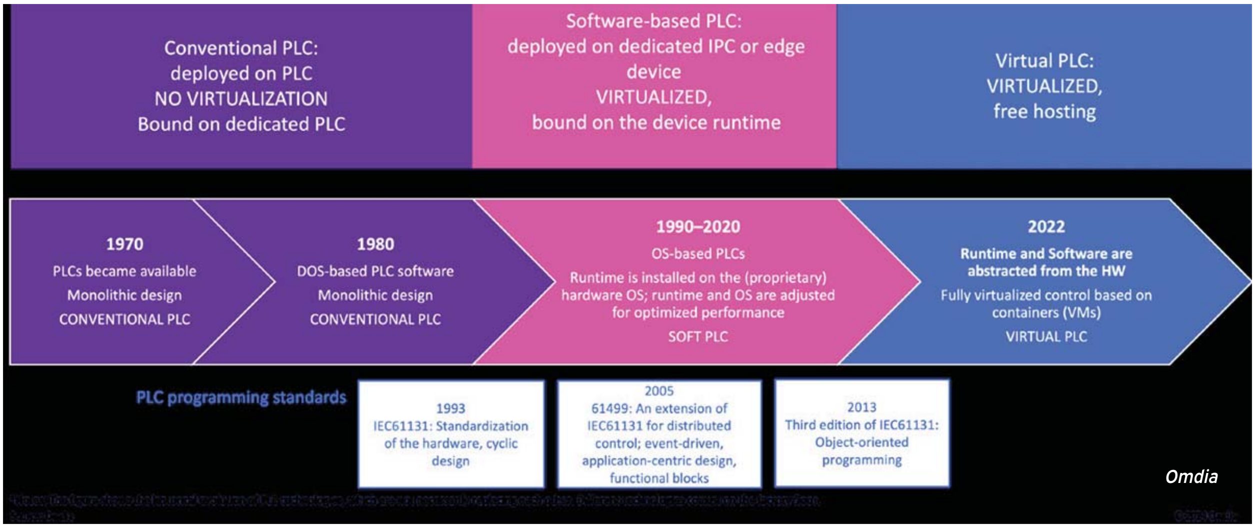
The consequential need to merge data and the flow of digital information with the operation of physical processes and machinery is also forcing convergence between IT and OT domains. This results in a sharing of cultures, expectations and engineering techniques such as virtualization, object-based programming and the ability to select a hardware platform based solely on application performance requirements.

Recent developments in software-defined automation (SDA) have rapidly transformed the traditional industrial automation model. This new approach, brought along with industrial digitalization, allows devices and equipment to be freely connected across architecture layers regardless of manufacturer. Hardware and software can be selected independently of each other, and this fundamentally changes the approach to automation and design.

Much like the IT world, users are free to develop applications based on their business needs, then deploy them on the hardware platform that meets their performance needs. Because applications are portable in this model, it's possible to develop and share best-in-class "apps" between users (i.e., the app store model). One such platform is UniversalAutomation.org, a community of automation users, technology vendors and universities organized around an independent non-profit association.

The shift to open, interoperable methodologies and tools is now well underway and manufacturer-dependent options are quickly becoming a thing of the past. SDA allows customers to quickly adapt to changing regulations as well as market and customer demands. The approach better supports the needs of industrial customers rather than getting in the way of them.

Manufacturers and engineers are constantly seeking new and innovative ways to enhance efficiency, productivity and flexibility. They want technology that helps reduce costs while offering agility to meet ever-changing market demands and prepare for a smoother transition into the digitalized future. Emerging technologies enabled by digital transformation afford designers the freedom to build control applications from libraries of



application objects in a drag-and-drop manner, and then select automation hardware based solely on performance requirements.

Digital twins extend this concept to industrial process design by allowing machines or entire lines to be designed from libraries of asset objects, then simulated virtually before they're built in the real world, reducing errors, saving both cost and time.

But what does it look like in practice? To answer this question, let's breakdown some of the steps manufacturers can take to enhance efficiency and productivity by adopting some of these new approaches.

1. SDA Gives Rise to Automation "Virtualization"

When automation hardware is decoupled from software, it allows automation functionality to be deployed on any platform of choice. The diagram on the facing page shows how this approach has evolved over time.

In the traditional IT sense, the term "virtualization" is commonly used to describe a scenario where several virtual machines (VMs) are set up on a single server. When this term is used in the context of industrial automation it has various meanings, but the premise is much the same—a move from physical to virtual. The software defined automation model allows automation (e.g., PLC) functions to run on various platforms instead of being tied to proprietary hardware. This has given rise to "soft PLCs" and the capability to use almost any available computing resource to execute automation functions.

Manufacturers and engineers can leverage this virtualization to streamline many standard processes such as consolidating programmable logic controllers (PLCs), human machine interfaces (HMIs) and industrial PCs (IPCs) on one hardware platform, but this only scratches the surface. Beyond operational benefits, virtualization of automation in this way also allows businesses to reduce both operating and capital expenses.

It's a similar principle to the IT world where hardware costs are significantly reduced by running multiple virtual machines on a single server. Fewer physical servers also mean less hardware to maintain, operate and repair—boosting productivity and freeing up staff to focus on more hands-on activities. Additionally, this process of virtualization goes a long way towards boosting sustainability. The consolidation of computing and storage resources into a set of central services reduces an industrial company's total energy use and Scope 2 greenhouse gas emissions.

2. Transitioning to Soft Programmable Logic Controllers

Traditionally, PLCs are the primary type of automation used for machine control. Enabled by software defined automation, the virtualized PLC approach described above offers access to a new way of automating machines and processes—a soft PLC, or a hardware-agnostic, software-based controller that can be run on any Windows or Linux server, industrial PC (iPC) or microcomputer, no matter the supplier. Multiple instances of these virtualized controllers can be installed on the same piece of hardware and configured, deployed and maintained both simultaneously and independently from one another.

This approach also offers the ability to make changes to processes without stopping production—minimizing downtime, reducing costs and providing the all-important flexibility and agility required to thrive in the demand-driven, dynamic consumer landscape of today. It makes deploying new processes or replicating and modifying existing ones much easier. Building automation application programs from proven, reusable engineering significantly reduces time-to-market, increases engineering efficiency and can offer an edge over the competition.

3. Introducing Digital Twins into Your Automation Toolkit

Industrial businesses should also look to model processes and machines virtually with digital twins to boost operational efficiency. Put simply, a digital twin is a virtual model of a real-world object designed to accurately mirror a physical object or process. This approach allows new processes and machines to be validated in the virtual world before they are built in the real world, reducing errors, saving both time and money.

When part of the flow of industrial data, they can also be used to model real-world processes while those processes are running. Opportunities for improvement can be identified and potential improvement activities validate in the virtual world to make sure they work as expected in the real world.

By leveraging digital twins, process designers can design production systems from libraries of asset-based objects (e.g., a robot, multicarrier transport system, etc.) using a drag-and-drop approach. They can then optimize, test and validate digital models of real machine solutions in the same virtual environment before they are built and commissioned in the real world. This enables workers to plan and test changes to the digital twin and then observe how performance would be affected when they are applied to the organization for real.

This makes continuous improvement activities far more efficient and effective. It is why researchers predict that by 2025, "80% of industry ecosystem participants will leverage their own product, asset and process digital twins to share data and insight with other participants."

Using the digital twin approach manufacturers no longer need to experiment with physical hardware to achieve optimized results. This can significantly increase efficiency as engineers can experiment with tools digitally instead of taking the traditional lengthy, costly manual approach. They are free to get on with more fulfilling, valuable work, saving time to market by up to 50% and commissioning time up to 60% when compared with traditional approaches.

Real-World Deployment

Software defined automation, virtual PLCs and the use of digital twins provide large industrial companies with another significant benefit: scalability. Once a design is proven to work in one plant or application it can easily be deployed in all their similar applications and plants worldwide. Asset management is simple; changes to one standard set of corporate designs are easily deployed globally without the vendor-specific constraints of proprietary hardware.

Continuous improvement and good ideas can easily be deployed globally to maximize economies of scale. Selecting the right automation partner with an extensive global footprint can help further streamline deployment by ensuring the appropriate support is available wherever and whenever it's needed.

In today's fast moving technological landscape, traditional tools are quickly becoming obsolete, outshined by new technologies that are consistently proving their ability to save time, money and resources, driving industrial growth and competitiveness. These digitalized, virtualized smart manufacturing approaches will continue to set new standards in interoperability, ease and efficiency and shape the future of industrial operations.

Companies like the machine and plant manufacturer GEA are using open, software-centric automation to optimize complex processes. The business develops solutions for centrifugal separation technology, and utilizing Schneider Electric's EcoStruxure Automation Expert, has automated applications independently of hardware. This can reduce engineering efforts by over 50% and increase throughput by over 5%.

By leveraging Software Defined Automation tools, GEA has been able to decrease product time-to-market and increase flexibility to meet the needs of critical industries such as food and beverage and pharmaceuticals. Additionally, EcoStruxure Automation Expert has provided them with more time to innovate by automating low-value work and eliminating task duplication across tools.

Automation is the heart of industrial operational technology. It optimizes the use of resources, and is a driver of industrial productivity, competitiveness and environmental sustainability in today's markets. But most of all, it is a key enabler of successful industrial digital transformation. Businesses that embrace digitalization will reap its rewards, being well prepared for Industry 4.0, but those who fail to get onboard with digitalization will fall behind competitors and get lost in the race to the workplace of tomorrow. ■

T-Slot Aluminum Extrusion:
Versatile Solutions for Modern Applications

T-slot extrusion, a modular framing system consisting of aluminum profiles, is popular in various engineering applications, from automation to medical laboratories.

by Erin Reilly, Buyer, Motion Automation Intelligence

A POPULAR TOY throughout the 20th Century, Erector Sets consisted of metal bars with regularly spaced holes allowing connections with nuts and bolts. Did you ever wonder what would happen if someone made a similarly adaptable system on an industrial scale? Welcome to the wide world of T-slot extrusion, a modular framing system consisting of aluminum profiles with T-shaped slots in one or more sides of the bar.

The slots allow easy assembly of structures using nuts and bolts. Sometimes marketed as an "Industrial Erector Set," it is well suited to applications like automation, medicine and laboratories due to its adaptability, durability and ease of use. Profiles come in various sizes and configurations, catering to different load-bearing requirements and aesthetic preferences.

Number of T-slots in Bar	Representation	Suggested Uses
One Slot		Framing for panel material to create doors, or as a stand for signage.
Two Slots (Adjacent)		The corner of a table or cabinet enables the panels to extend out from the corner while maintaining a clean, aesthetic finish.
Two Slots (Opposite)		A center support in a cabinet or table, allowing for connections on either side while maintaining a closed profile face toward the outside for a polished appearance.
Three Slots		The center upright of a table or cabinet requires a central crossbar. This profile may connect in three directions, while a closed profile faces the outside of the unit.
Four Slots		For attachments and panels where the final design is uncertain or if maximum utility takes priority over aesthetics. Four open profiles allow the greatest flexibility.

Measurement Profiles

There are two primary measurement systems of T-slot extrusion: imperial and metric. Imperial profiles are typically used in North American markets, while international markets or science-centered companies usually choose metric profiles for their structures. Because matching lines of hardware are available for each system, it is important to know which style will be preferred or is already in use.

While some hardware is interchangeable between imperial and metric, not all are compatible. The nuts and bolts for 1-in. and 25-mm bars will typically work for the T-slot size. However, the difference is enough that external fasteners like brackets, gussets and mounting plates will not precisely match the width when moving between metric and imperial. This can lead to an unsightly finished product where something looks slightly "off" or is hazardous. For example, if a joining plate designed for a 40-mm bar were used to connect two 1.5-in. bars, the resulting protrusion over the edges would create an opportunity for something to snag on it.

The number and orientation of T-slots on the extruded bars vary depending on the profile's design. Profiles may feature one, two, three or four slots, strategically placed along the length of the bar with applications suited to each:

Finishes and Weights

Certain manufacturers offer extrusion that is either smooth or produced with grooves in the exterior faces. The advantage of grooved profiles is that they can be aligned during assembly to ensure the bars match properly. Smooth extrusion profiles are particularly suitable for industries like biotechnology, where cleanliness is paramount. Some manufacturers may not offer these finishes for metric and imperial sizing options.

Aluminum is naturally corrosion-resistant, allowing it to be placed in environments where iron or steel would succumb to rust or contamination. Combined with appropriate panel materials and HEPA filtration, aluminum extrusion can even be used to create clean rooms.

There are also many different weights of T-slot extrusion for various applications. For large, load-bearing structures, bigger frames (e.g., 1.5 in. or 40 mm) in the manufacturer's standard weight are ideal. They offer the best strength and stability for building a raised stage or a laboratory table to support heavy equipment and remain stable. When social distancing protocols were in place, frames of either ultra-lightweight extrusion or the smaller 1-in. or 25-mm models were popular to hold up plastic paneling.

United States Postal Service

Statement of Ownership, Management, and Circulation **(Requester Publications Only)**

1. Publication Title: Machine Desgin
2. Publication Number: 323-980
3. Filing Date: 09/30/2024
4. Issue of Frequency: Bi-Monthly
5. Number of Issues Published Annually: 6
6. Annual Subscription Price: Free to Qualified
7. Complete Mailing Address of Known Office of Publication (Not Printer): Endeavor Business Media, LLC, 201 N. Main Street, Ste. 5 — Contact Person: Debbie Bouley, Telephone: (603) 891-9372
8. Complete Mailing Address of Headquarters or General Business Office of Publisher (Not Printer): Endeavor Business Media, LLC,30 Burton Hills Blvd., Ste. 185
9. Full Names and Complete Mailing Addresses of Publisher, Editor, and Managing Editor - Publisher: Michelle Kopier, 30 Burton Hills Blvd., Ste. 185; Editor: Rehana Begg, 30 Burton Hills Blvd., Ste. 185; Managing Editor: Jeremy Cohen, 30 Burton Hills Blvd., Ste. 185
10. Owner - Full name and complete mailing address: Endeavor Media Holdings I, LLC, 905 Tower Place, Nashville, TN 37204; Endeavor Media Holdings II, LLC, 905 Tower Place, Nashville, TN 37204;Resolute Capital partners Fund IV, LP, 20 Burton Hills Blvd, Suite 430, Nashville, TN 37215;RCP Endeavor, Inc, 20 Burton Hills Blvd, Suite 430, ,Nashville, TN 37215;Northcreek Mezzanine Fund II, LP,312 Walnut Street, Suite 2310,Cincinnati, OH 45202;Invegarry Holdings, LP,44235 Hillsboro Pike,Nashville, TN 37215;Everside Fund II, LP,155 East 44th St, Suite 2101 - 10 Grand Central,New York, NY 10017Everside Endeavor F1 Blocker, LLC, 155 East 44th St, Suite 2101 - 10 Grand Central, New York, NY 10017;Everside Endeavor International Blocker, LLC, 155 East 44th St, Suite 2101 - 10 Grand Central, New York, NY 10017;Everside Founders Fund, LP, 155 East 44th St, Suite 2101 - 10 Grand Central, ,New York, NY 10017;Suncap Endeavor Blocker, LLC,155 East 44th St, Suite 2101 - 10 Grand Central,New York, NY 10017;
11. Known Bondholders, Mortgagees, and Other Security Holders Owning or Holding 1 Percent or More of Total Amount of Bonds, Mortgages or Other Securities: None
12. Tax Status (For completion by nonprofit organizations authorized to mail at nonprofit rates) (Check one)
The purpose, function, and nonprofit status of this organization and the exempt status for federal income tax purposes: N/A
13. Publication Title: Machine Desgin

	Average No. Copies Each Issue During Preceding 12 Months	No. Copies of Single Issue Published Nearest to Filing Date
14. Issue Date for Circulation Data: September/October 2024		
15. Extent and Nature of Circulation		
a. Total Number of Copies (Net press run)	36,233	36,270
b. Legitimate Paid and/or Requested Distribution (By Mail and Outside the Mail)		
(1) Outside County Paid/Requested Mail Subscriptions stated on PS Form 3541. (Include direct written request from recipient, telemarketing and Internet requests from recipient, paid subscriptions including nominal rate subscriptions, employer requests, advertiser's proof copies, and exchange copies.)	23,016	21,436
(2) In-County Paid/Requested Mail Subscriptions stated on PS Form 3541. (Include direct written request from recipient, telemarketing and Internet requests from recipient, paid subscriptions including nominal rate subscriptions, employer requests, advertiser's proof copies, and exchange copies.)	0	0
(3) Sales Through Dealers and Carriers, Street Vendors, Counter Sales, and Other Paid or Requested Distribution Outside USPS®	518	612
(4) Requested Copies Distributed by Other Mail Classes Through the USPS (e.g. First-Class Mail®)	0	0
c. Total Paid and/or Requested Distribution (Sum of 15b (1), (2), (3), and (4))	23,534	22,048
d. Nonrequested Distribution (By Mail and Outside the Mail)		
(1) Outside County Nonrequested Copies Stated on PS Form 3541 (include Sample copies, Requests Over 3 years old, Requests induced by a Premium, Bulk Sales and Requests including Association Requests, Names obtained from Business Directories, Lists, and other sources)	11,834	13,741
(2) In-County Nonrequested Copies Stated on PS Form 3541 (include Sample copies, Requests Over 3 years old, Requests induced by a Premium, Bulk Sales and Requests including Association Requests, Names obtained from Business Directories, Lists, and other sources)	0	0
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(4) Nonrequested Copies Distributed Outside the Mail (Include Pickup Stands, Trade Shows, Showrooms and Other Sources)	74	95
e. Total Nonrequested Distribution (Sum of 15d (1), (2), (3), and (4))	11,908	13,836
f. Total Distribution (Sum of 15c and 15e)	35,442	35,884
g. Copies not Distributed	791	386
h. Total (Sum of 15f and g)	36,233	36,270
i. Percent Paid and/or Requested Circulation (15c divided by 15f times 100)	66.40%	61.44%
16 Electronic Copy Circulation		
a. Requested and Paid Electronic Copies	-	-
b. Total Requested and Paid Print Copies (Line 15c)+ Requested/Paid Electronic Copies (Line 16a)	23,534	22,048
c. Total Requested Copy Distribution Distribution(Line 15f) + Requested/Paid Electronic Copies (Line 16a)	35,442	35,884
d. Percent Paid and/or Requested Circulation (Both Print & Electronic Copies) (16b divided by 16c x 100)	66.40%	61.44%

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17. Publication of Statement of Ownership for a Requester Publication is required and will be printed in the issue of this publication. Nov/Dec 2024

18 Date

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PS Form 3526-R, July 2014

This DIY shelf features a 1 × 3 in. grooved extrusion with black endcaps and hinges. Image courtesy of 80/20. *Motion Automation Intelligence*

Specialty and Safety Applications

In the ever-growing automation industry, T-slot extrusion provides a stable base for robotic arms and other automation equipment, enhancing precision and efficiency. Profiles can also accommodate mounts for accessory equipment such as monitors, keyboard trays and control panels. This enables the creation of ergonomic workstations where operators can monitor and control automated processes efficiently, and adding casters can create rolling carts with equipment for hospitals and clinics.

Some advanced profiles include a central channel capable of delivering pressurized gases. While the central cavity of the extrusion cannot typically handle ultra-high pressure, this feature is favorable for applications that need pneumatic capabilities, including laboratory installations.

T-slot aluminum extrusion is also widely used to construct safety guarding for automation systems. Profiles can support the installation of polycarbonate or mesh panels, providing protective barriers around automated machinery. These panels safeguard workers from pinch points, moving parts and flying debris.

Some guarding will protect from active injury, such as in a conveyor system, where nip points are at roller convergence, or a belt terminates at the end of a path. These can be guarded by solid material at the conveyor's edge to keep body parts from entering dangerous areas.

Other guarding is relatively passive but still important. Plastic and mesh panels protect workers from sparks and shrapnel from cutting, lathing and welding. T-slots can accommodate panels for applications where the clarity of acrylic is required, or polycarbonate's oil and acid resistance is needed. Because T-slot width varies between different extrusion sizes and manufacturers, a thinner panel can be used where a lightweight application is necessary.

However, if impact resistance is a concern, a larger bar with a wider T-slot can accommodate a thicker panel where the strength is needed. For mesh panels inserted into T-slots, a gasket material is commonly used to secure the panel material in the channel.

Enclosing hazardous areas with sturdy frames and transparent panels helps industries adhere to safety regulations without compromising operational visibility. Amputations are debilitating workplace injuries and ensuring proper guarding minimizes the risk of an employee experiencing such a tragic event. Employee safety comes first and protecting these valuable workers is crucial.

A Versatile and Reliable Solution

T-slot aluminum extrusion offers a versatile and reliable solution for constructing frameworks in diverse industrial applications. Its modular design, corrosion resistance and adaptability to various environments make it indispensable in manufacturing and biotechnology sectors. By leveraging T-slot extrusion systems, industries can enhance productivity, ensure workplace safety and streamline automation processes effectively.

Explore how T-slot aluminum extrusion can transform your industry's framework needs. Whether you are designing automation systems, conveyor assemblies or safety guarding, the versatility and robustness of T-slot profiles provide endless possibilities for innovation and efficiency. Engage your inside team or a qualified third party to start embracing the future of modular framing with T-slot aluminum extrusion. ■

Get a Sense of the IoT Sensors Market

WITH AN INCREASING internet penetration rate, the Internet of Things (IoT) is finding applications in a range of markets, including agriculture, automotive, transportation, retail, consumer electronics and other verticals. According to a Markets and Markets report, "IoT Sensors Market by Sensor Type, Network Technology, Vertical and Region—Global Forecast to 2029," the increasing number of Internet users worldwide is expected to drive the demand for high-speed, low-cost IoT technology-based devices such as radio frequency identification (RFID) tags, barcode scanners and mobile computers, which would result in an increased demand for sensors.

The industrial IoT vertical—which looks to enable the interconnection of sensors, machines and IT systems across the value chain of manufacturing companies beyond a single enterprise—holds a significant share of the IoT sensors industry, according to the report.

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WORD SEARCH, HIDDEN THEME

Find all the words in the list and then fill in the blanks with the unused letters beginning in the top left to reveal the hidden theme.

Find puzzle answers here: machinedesign.com/55243932

A	T	I	N	D	M	A	C	O	N	N	E	C	T	I	V	I	T	Y	S
U	E	U	S	T	R	A	E	T	S	I	A	L	I	N	T	I	E	C	G
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ACTUATOR	INCLINATION	PRESSURE
AEROSPACE	INTERCONNECTION	PROXIMITY
AGRICULTURE	INTERNET OF THINGS	RFID
AUTOMATION	LEVEL	SCANNERS
AUTOMOTIVE	LIMIT	SENSORS
CONNECTIVITY	MACHINE	TECHNOLOGY
DESIGN	MANUFACTURING	TEMPERATURE
EDGE	PHOTOELECTRIC	WIFI

DID YOU KNOW?

KEVIN ASHTON, an innovator and consumer sensor expert, coined the term "Internet of Things" in 1999.

ANOTHER FUN FACT:
The first IoT device was a Coca-Cola vending machine at Carnegie Mellon University in the early 1980s.

Source: www.facts.net

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Interface Relay Modules

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Quick Turnaround
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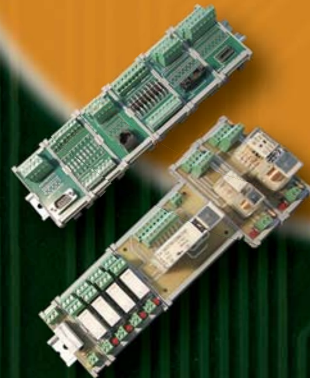
Value Added Capabilities

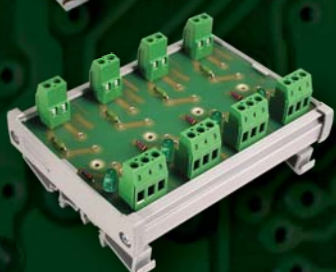


Connector-to-Terminal Block

Compact and reliable transitions between high density connectorsand high quality screw-cage clamp terminal blocks.

- FBK Ribbon Cable, up to 64 poles
- Subminiature - D, up to 50 poles

Diode Modules& Component Carriers



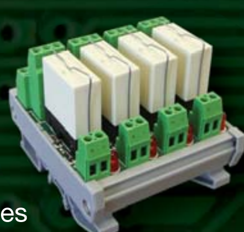
Use our Diode Modules to build lamp test circuits, decouple signals, etc.. Mount your own components into our Component Carriers (supplied without electronic components). Or, tell us what you need and we'll install it for you.

- DM Diode Modules have series connection 1A or 3A diodes, and 1A diode gates with common cathodes or anodes, providing commonly used diode arrangements
- BSM Component Carrier has factory installed fork and eyelet soldering posts in each series trace
- CCA Component Carrier consists of a printed circuit board with four in-line and two bus-connection through-holes to solder pads in each trace, complete with terminal blocks

Miniature Relays

Traditional relay and safety relay modules in a high density package.

- Protect equipment
- Provide insulation
- Control motors, solenoid and valves
- Safety relays for emergency stop, safety gate and two-hand stop



Custom Interface Modules

Altech offers complete engineering, prototype and production services for custom modules. Our staff has the ability to take your design or requirements and manufacture your custom module. Custom module production generally includes engineering, PCB layout and prototypes, packaged in Altech extrusions for mounting on panels or DIN Rail. In many industrial control systems, customized designs are the solution for many problems.

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Automation & Control Components

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