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SEPTEMBER 2016

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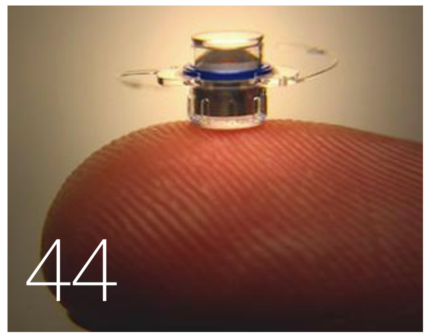

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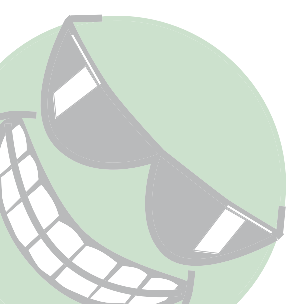

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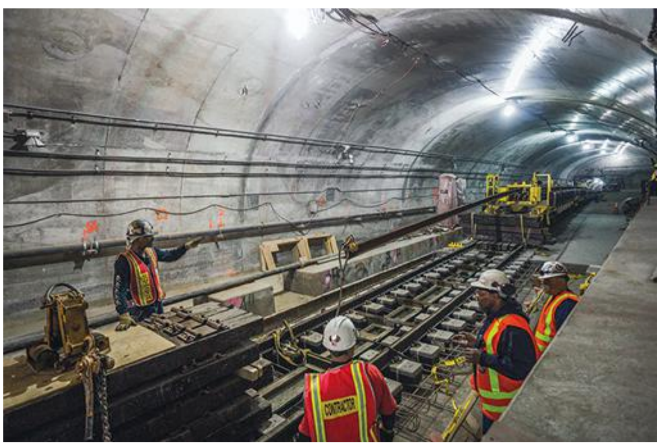
THE NERVOUS SYSTEM OF THE IoT

http://machinedesign.com/iot/nervous-system-iot

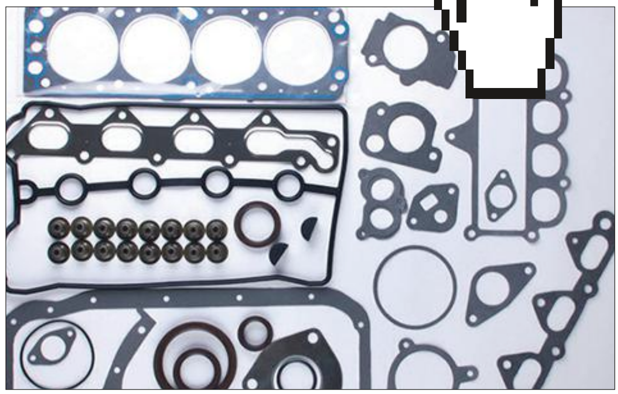
Most discussion of the Internet of Things centers around Big Data analytics and cloud computing, but sensors are just as much at the core of the IoT. *(Image courtesy of Thinkstock)*



THE FUTURE OF MASS TRANSIT AND SMART CITIES

http://machinedesign.com/iot/all-aboard-future-railroads-subways-and-smart-cities

The rise of the Internet of Things and smart cities will increase our reliance on the rail system and how modern rails and subways are being constructed.



10 TIPS FOR LEAK-FREE GASKETS

http://machinedesign.com/fasteners/10-tips-leak-free-gaskets

Gaskets usually stop liquids, often under pressure, from leaking out or getting in through the cracks between two mating parts. Here are 10 tips for ensuring the gaskets will indeed make the joint or connection leak-free. *(Image courtesy of Thinkstock)*

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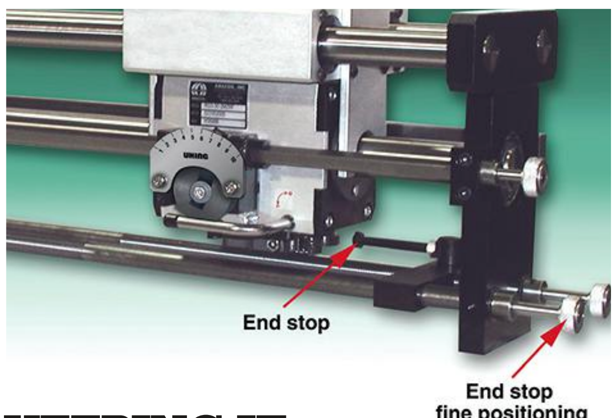

KEEPING IT SIMPLE WITH ROLLING-RING DRIVES

http://machinedesign.com/controllers/has-plc-met-its-match

Decentralized technologies like PAC can work with PLCs, but by offering more features for machine vision and IIoT, they may be in a state of diminishing return.

The Truth About Compressed Air!

If you think compressed air is too expensive and noisy - read this. The facts will surprise you!

Compare these Blowoffs

There are a variety of ways to blow the water from the bottles shown in the photo below, but which method is best? To decide, we ran a comparison test on the same application using four different blowoff methods: drilled pipe, flat air nozzles, Super Air Knife (each using compressed air as a power source), and a blower supplied air knife (using an electric motor as a power source). Each system consisted of two twelve inch long air knives. The following comparison proves that the EXAIR Super Air Knife is the best choice for your blowoff, cooling or drying application.

The goal for each of the blowoff choices was to use the least amount of air possible to get the job done (lowest energy and noise level). The compressed air pressure required was 60 PSIG which provided adequate velocity to blow the water off. The blower used had a ten horsepower motor and was a centrifugal type blower at 18,000 RPM. The table at the bottom of the page summarizes the overall performance. Since your actual part may have an odd configuration, holes or sharp edges, we took sound level measurements in free air (no impinging surface).

Drilled Pipe

This common blowoff is very inexpensive and easy to make. For this test, we used (2) drilled pipes, each with (25) 1/16" diameter holes on 1/2" centers. As shown in the test results below, the drilled pipe performed poorly. The initial cost of the drilled pipe is overshadowed by its high energy use. The holes are easily blocked and the noise level is excessive - both of which violate OSHA requirements. Velocity across the entire length was very inconsistent with spikes of air and numerous dead spots.

Flat Air Nozzles

As shown below, this inexpensive air nozzle was the worst performer. It is available in plastic, aluminum and stainless steel from several manufacturers. The flat air nozzle provides some entrainment, but suffers from many of the same problems as the drilled pipe. Operating cost and noise level are both high. Some manufacturers offer flat air nozzles where the holes can be blocked - an OSHA violation. Velocity was inconsistent with spikes of air.

Blower Air Knife

The blower proved to be an expensive, noisy option. As noted below, the purchase price is high. Operating cost was considerably lower than the drilled pipe and flat air nozzle, but was comparable to EXAIR's Super Air Knife. The large blower with its two 3" (8cm) diameter hoses requires significant mounting space compared to the others. Noise level was high at 90 dBA. There was no option for cycling it on and off to conserve energy like the other blowoffs. Costly bearing and filter maintenance along with downtime were also negative factors.

EXAIR Super Air Knife

The Super Air Knife did an exceptional job of removing the moisture on one pass due to the uniformity of the laminar airflow. The sound level was extremely low. For this application, energy use was slightly higher than the blower but can be less than the blower if cycling on and off is possible. Safe operation is not an issue since the Super Air Knife can not be dead-ended. Maintenance costs are low since there are no moving parts to wear out.

Facts about Blowers

Energy conscious plants might think a blower to be a better choice due to its slightly lower electrical consumption compared to a compressor. In reality, a blower is an expensive capital expenditure that requires frequent downtime and costly maintenance of filters, belts and bearings. Here are some important facts:

Filters must be replaced every one to three months.

Belts must be replaced every three to six months.

Typical bearing replacement is at least once a year at a cost near $1000.

- Blower bearings wear out quickly due to the high speeds (17-20,000 RPM) required to generate effective airflows.
- Poorly designed seals that allow dirt and moisture infiltration and environments above 125°F decrease the one year bearing life.
- Many bearings can not be replaced in the field, resulting in downtime to send the assembly back to the manufacturer.

Blowers take up a lot of space and often produce sound levels that exceed OSHA noise level exposure requirements. Air volume and velocity are often difficult to control since mechanical adjustments are required.

To discuss an application, contact:

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Cincinnati, Ohio 45249-1621
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Fax: (513) 671-3363
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www.exair.com/45/423.htm

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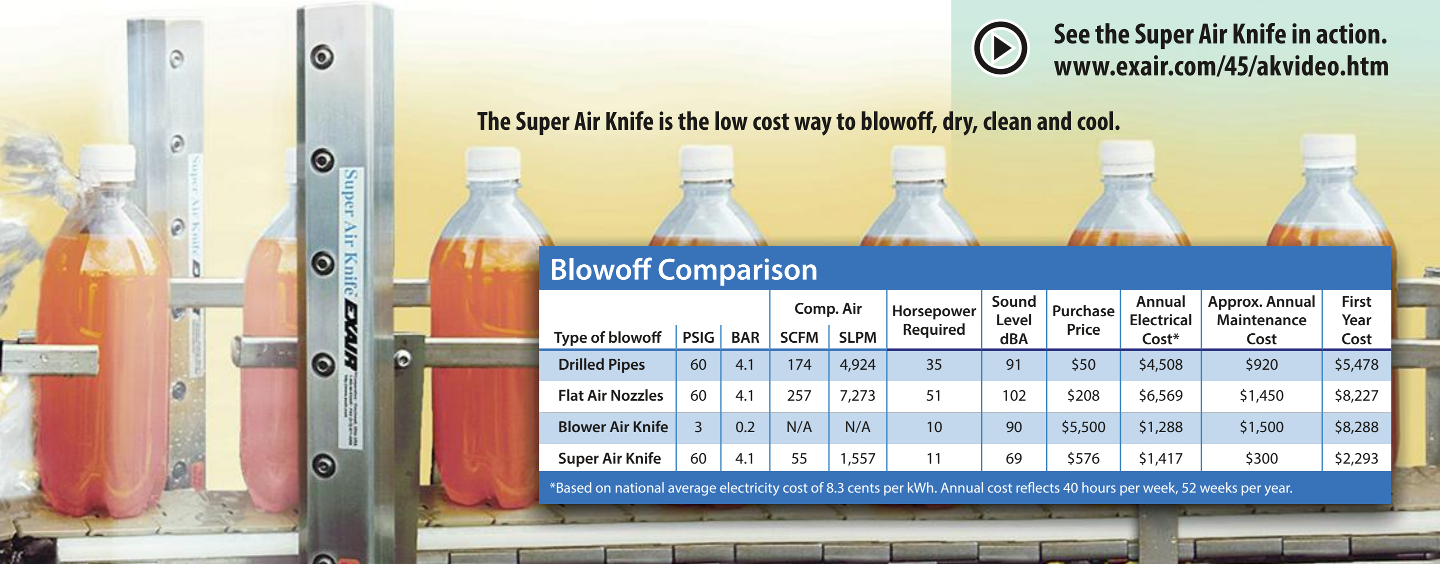
The Super Air Knife is the low cost way to blowoff, dry, clean and cool.



Blowoff Comparison

Type of blowoff	PSIG	BAR	Comp. Air SCFM	Comp. Air SLPM	Horsepower Required	Sound Level dBA	Purchase Price	Annual Electrical Cost*	Approx. Annual Maintenance Cost	First Year Cost
Drilled Pipes	60	4.1	174	4,924	35	91	$50	$4,508	$920	$5,478
Flat Air Nozzles	60	4.1	257	7,273	51	102	$208	$6,569	$1,450	$8,227
Blower Air Knife	3	0.2	N/A	N/A	10	90	$5,500	$1,288	$1,500	$8,288
Super Air Knife	60	4.1	55	1,557	11	69	$576	$1,417	$300	$2,293

*Based on national average electricity cost of 8.3 cents per kWh. Annual cost reflects 40 hours per week, 52 weeks per year.

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SEPTEMBER 2016

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Editorial

STEPHEN MRAZ | Senior Editor
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Time to Update Engineering Colleges

It's time engineering colleges took a look at their curriculums and majors and made some changes. There's already almost too much "essential" engineering knowledge these days to expect graduates coming out of traditional discipline tracks (EE, Mech E, Materials, even Civil E) to be productive in their first year or more in real engineering jobs. More co-ops couldn't hurt, especially if they emphasized hands-on time with modern manufacturing tools.

The concept of a core of engineering courses seems like a good one. It provides a common base of need-to-know information and gives all the engineering students something in common. But that core should be updated to weed out courses that are a waste of time and money. For example, one course that apparently could be tossed is differential equations. It was voted the most useless course in a landslide in an informal poll of our audience a few years ago. One retired electrical engineer explained that the course was taught mostly to keep math professors busy and employed. Required physics courses on quantum mechanics and special relativity also failed to prove useful in most engineering careers.

Some engineering schools require phys ed. The gyms, swimming pools, and playing fields are nice to have, but they don't add much to an engineering education.

The core courses should also be expanded to include topics every good engineer should be familiar with, such as intellectual property law, the economics of manufacturing, engineering ethics, and written and oral communications,. Then you can get rid of any requirements in humanities and social studies. The library has all students will ever need to know in those subjects.

Perhaps adding a few new majors might also make sense. For example:

Robotics Engineering: Students would learn about industrial robots and automating assembly, agricultural, and even service processes. Courses could focus on motion control (electrical and mechanical engineering), software, AI, sensors, manufacturing processes, and safety.

Test and Measurement Engineering: This discipline would prepare graduates for the various types of testing, data acquisition, and analytics needed across all industries and disciplines these days. Courses would cover statistical sampling and analysis, various quality tools (SPC, Six Sigma, FMEA), DAQ, CMM, and material/metal testing.

Fastening and Joining Engineering: Without engineers who know how to attach one part to another, the modern world would fall apart. But I can't recall any courses in my engineering education that touched on the multidisciplinary topic. Students should get a good grounding in screws, threads, bolts, rivets, pins, and joints, as well as adhesives and metal joining with soldering, brazing, and welding. Fastening techniques like hook-and-pile (i.e., Velcro), zippers, and others should also be touched on as well as gaskets and seals.

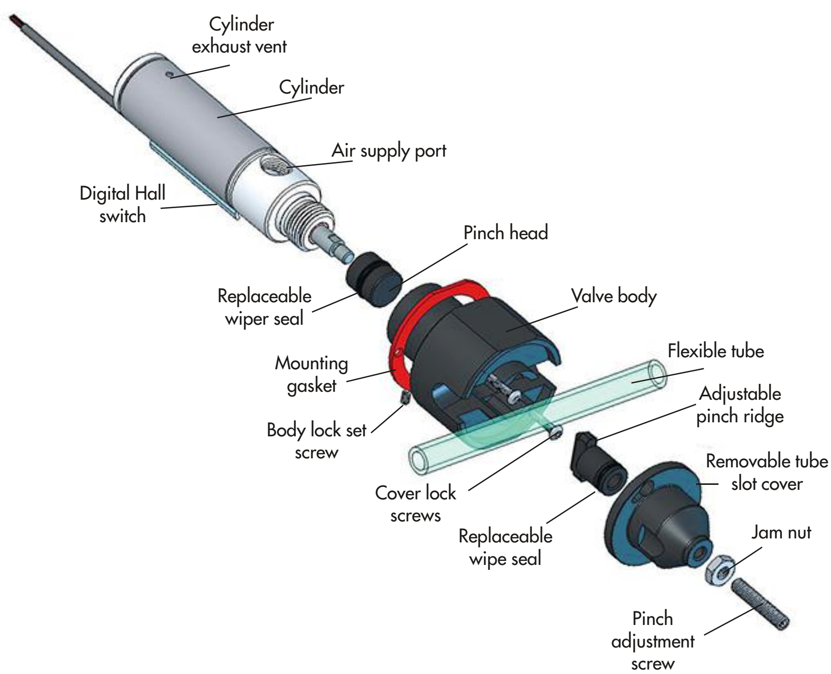
Any changes you would like see made to engineering college requirements? md

Pinch Valve Offers Compactness and Affordability

THE ACRO 600 Series of pneumatic pinch valves from Bimba Manufacturing Co. *(www.bimba.com)* eliminate media contamination and can withstand frequent washdowns, making them well suited for pharmaceutical, food and beverage, and adhesive applications.

The $165 valves are powered by 70 to 125 psi of compressed air, and consume about 0.25 in.^{3} per cycle. The valves can handle one cycle every three seconds. They use a black Acetal pinch head and ridge to exert about 24 lb of pinching force on the media. Pinch valves are control valves that use a pinching effect to obstruct the flow of fluid, gases, slurries, powders, or pellets in applications where the media must be completely isolated from any internal valve parts. Otherwise, corrosive media would degrade the internal workings of wetted valves, leading to frequent replacements. Pinch valves and disposable pieces of tubing eliminate these concerns and lower costs.

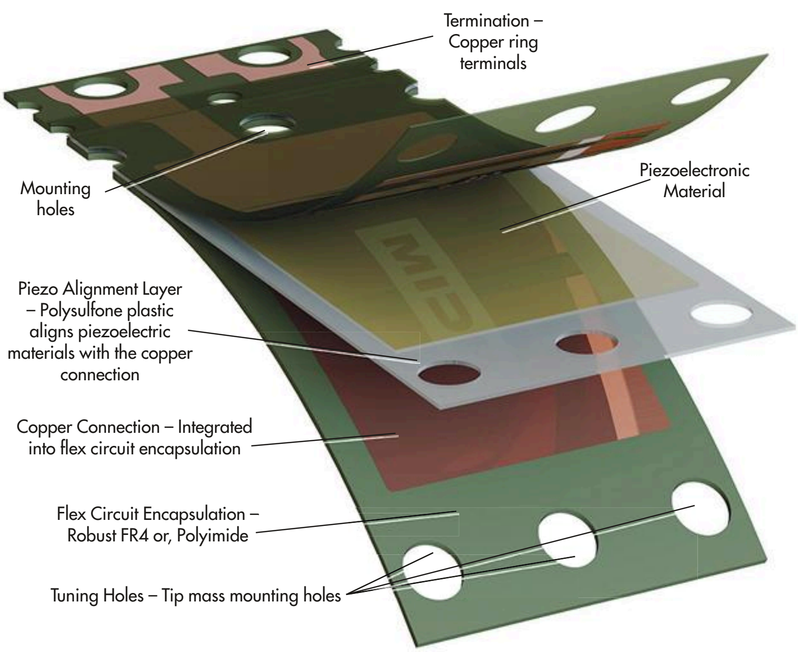
The valve comes in three sizes and they can ccommodate tubes ranging in size from 0.125 to 0.375 in. (OD), thanks to an adjustable pinch gap. The valves can be normally open or closed. Technicians can install the valves and have them fully operational within 10 minutes. The valves are also backed by an 18-month warranty. md



Piezoelectric Products Feature Flex Circuits

PIEZO CERAMICS ARE brittle, difficult to connect electrical leads to, and have no insulating protection to prevent electric shocks (piezos are often driven with 100s of volts). Mide's *(www.mide.com)* piezoelectric products offer piezo wafers sandwiched between thin flexible circuits to help solve these challenges. Called the **Piezo Protection Advantage** (PPA), Mide typically uses either FR4 (like those in a standard printed circuit board) or Polyimide for the flex circuits, but any circuit material can theoretically be used.

The graphic illustrates a PPA uni-morph (using one piezo) configuration (bi-morph and quad-morph are also available) where a layer of high-temperature polysulfone plastic is used to align the piezo wafers to the copper connections in the flex circuits. The flex circuit then runs the piezo connection out to a convenient electrical termination (connector or solder pads). Finally, a high temperature epoxy is used to adhere all the layers together in the packaging process to encapsulate the high-performance piezo ceramics between copper-clad insulating materials creating a robust, hermetically sealed, electrically insulated transducer with easy connection. md

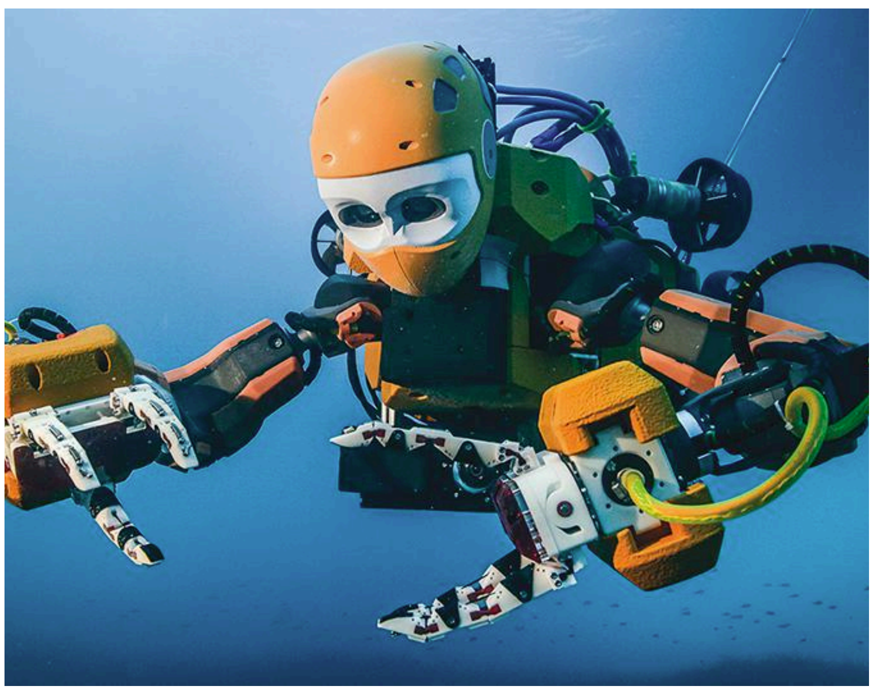


News

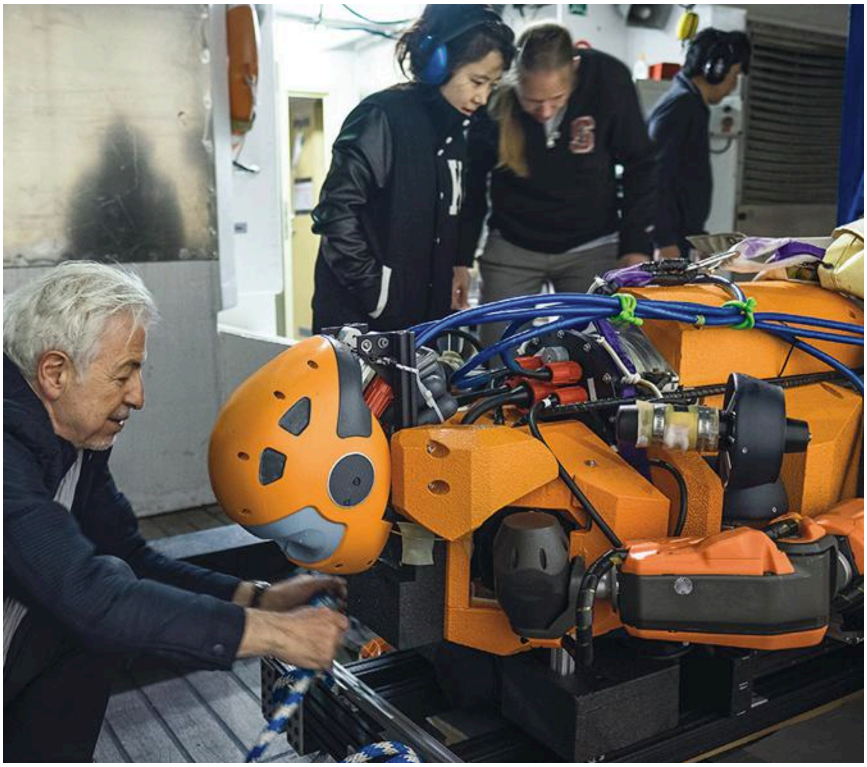
HUMANOID ROBOT HANDLES DELICATE, Difficult Deep-Sea Missions

When it comes to very delicate underwater tasks, teams of remote-controlled human robots may be the next go-to in lieu of human divers.

To test the capabilities of underwater humanoid robots in delicate underwater tasks, Stanford University scientists sent a prototype robot diver, OceanOne, to retrieve an artifact from *La Lune*, the flagship of King Louis XIV. Capsized in 1664, the ship lies 100 meters below the Mediterranean Sea, 20 miles off the coast of France.



OceanOne's sleek humanoid design makes it more dexterous than most current underwater remote-operated vehicles (ROVs), which tend to have a boxy design equipped with job-specific end pieces and appendages.



OceanOne has been the passion project of Stanford University Professor Oussama Khatlib for the past few years. *(Courtesy of Frederic Osada and Teddy Seguin/DRASSM)*

During its mission, OceanOne sent real-time video footage to researcher Oussama Khatib, who used a joystick to control it from a boat. While handling the artifact, Khatib received haptic feedback from force sensors on Ocean One's wrists so that he could gauge the strength of the grip without breaking the object.

OceanOne's sleek humanoid design makes it more dexterous than most current underwater remote-operated vehicles (ROVs), which tend to have a boxy design equipped with job-specific end pieces and appendages. In the future, the humanoid design may also enable controllers to communicate with other divers and camera-equipped ROVs via hand gestures.

CUTTING-EDGE FEATURES

OceanOne propels itself through the water using eight tiny multidirectional thrusters. It leverages calibration hardware to adjust to turbulence for seamless travel to its destination. OceanOne is immersed in oil, thus making it waterproof up to 2000 meters. It has series elastic arms with 7 degrees of freedom and wrists with force sensors. Future prototypes are expected to include haptic sensors on each finger.

The head houses a majority of the electronics and balance sensors, in addition to a vault on the back. It also contains a stereovision camera, while the underside has a wide-angle camera for navigating and environmental mapping.

OceanOne's success in handling a delicate artifact marks its potential for other sensitive missions that are too dangerous for human divers. Soon, robots like these will be used to explore the Red Sea in depth. Future mission plans include exploration of delicate mesophotic coral reefs, which are too deep to be reached by scuba divers, but tend to be shallow enough to qualify for deep-sea programs. The robot may also be used to neutralize underwater disaster zones. ■

CLOTHES THAT CLEAN THEMSELVES

in the Sun?

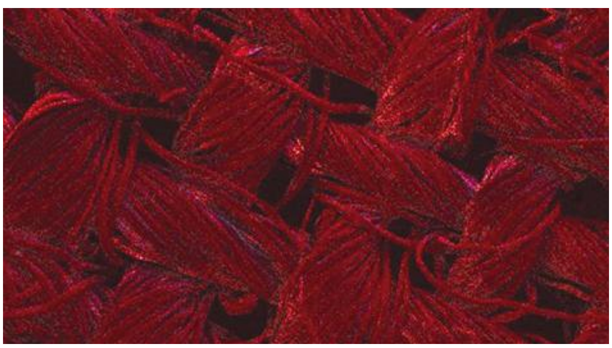
A "HOT-ELECTRON" DESIGN textile could change the way people do laundry. Researchers at RMIT University, Melbourne, Australia, incorporated silver and copper nanoparticles into the textile's composition, allowing it to release heat in the presence of visible light as oscillating electrons at the surface of each nanoparticle gain kinetic energy. This heat can be used to degrade various organic materials, including stains and dirt, so that a person's shirt can come clean as soon as they step out into the sun.

> **PUBLICATIONS ABOUT PLASMONS** and plasmonic devices have increased exponentially since the quasiparticles were discovered in the 1950s. "Hot electrons" on the surface of metals are widely investigated as energy-efficient heat sources to drive chemical reactions or induce current in the presence of visible light.

The scientists chose to use copper and silver nanoparticles (two species of noble metals) because their free electrons become excited by light on the visible spectrum. As resonance-frequency light hits the nanoparticles scattered within the textile, their free electrons begin to oscillate at higher intensities, releasing quantized packets of energy called plasmons. Like particles, these quasiparticles have momentum and position, and can transfer between carrier sites in a lattice.

Noble-metal nanoparticles have already been extensively researched for light-activated self-cleaning textiles. However, RMIT's fabric is specially designed so that its wettability, absorbency, and porosity allow for the transfer of plasmons from the electrons in the nanoparticles to the rest of the fabric.

The team grew the nanostructures by dipping the textile into various solutions. Their process is a form of electroless deposition, which simply means that none of its reactions required energy from an outside electrical source. Not only did this reduce the cost of deposition, but it took a mere 30 minutes—the shortest production time achieved in self-cleaning textile research.



Silver nanoparticles in this textile release heat in the presence of visible light to degrade dirt and stains. *(Courtesy of RMIT)*

The scientists are still researching textiles that will be effective for removing red wine and other more stubborn stains. Thus far, their product has been able to eliminate more neutral stains in a mere six minutes.

These advances could benefit more than those consumers who don't want to wash their clothes. They could also lead to a range of 3D plasmonic devices that efficiently generate heat to drive chemical reactions within a substrate and produce electric currents in the presence of light.

"The advantage of textiles is they already have a 3D structure, so they are great at absorbing light," says Dr Rajesh Ramanathan from Applied Sciences. In this case, the inherent 3D characteristics of fabric are beneficial for speeding up the process of degrading organic matter."■

CAPTURING PHASE TRANSITIONS
in Alloy Processing at Near Atomic Level

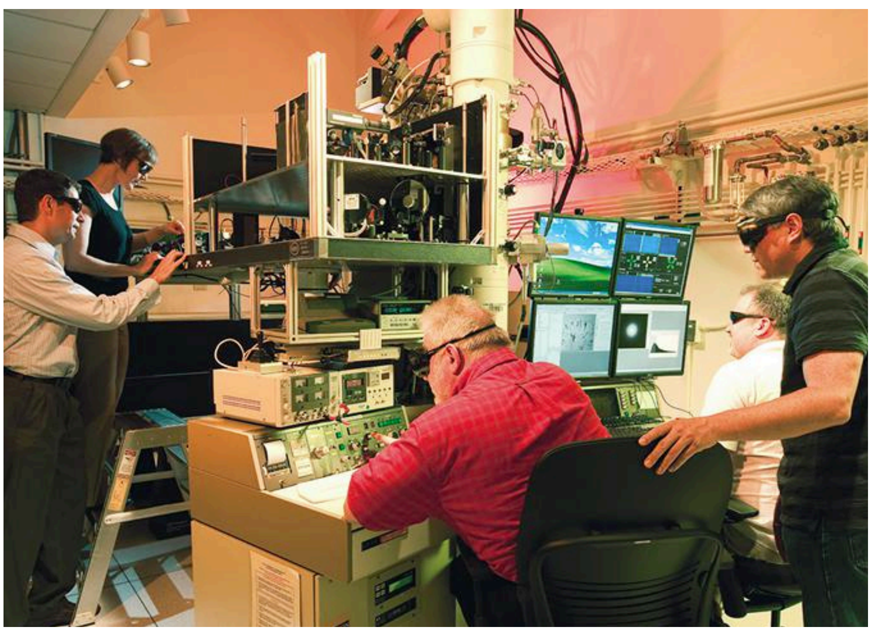
UNDER A $500,000 grant from the National Science Foundation, engineers at the University of Pittsburgh will use the Dynamic Transmission Electron Microscope (DTEM) at Lawrence Livermore National Laboratory (LNLL) to observe rapid phase transitions in aluminum alloys under laser and electron-beam processing. The study is expected to deliver valuable data and computer-modelling capabilities to the metal-additive manufacturing industry.

Characteristic to transmission electron microscopes (TEMs), the DTEM allows scientists to observe objects to near atomic level, down to the order of a few angstroms. Synonymous to the way light microscopes observe scales limited by the wavelength of a photon, a person can use a TEM to view objects as small as the wavelength of an electron. (The De Broglie wavelength of an electron at 1-eV kinetic energy is about 1.23 nm—1000 times smaller than that of a photon.)

Perhaps the most outstanding feature of the DTEM, though, is its high temporal resolution. While scientists are better inclined to determine the beginning and end products of catalytic and multistep reactions, they often remain ambivalent about the state of reactants during intermediate steps. With nanosecond and microsecond temporal resolution, the DTEM will enable the university's engineering students to observe various rapid transitions of aluminum alloys during welding, joining, and other processes.

Joe McKeown, LLNL materials scientist, explains, "DTEM allows you to see the interface between the solid and liquid during rapid solidification, which is extremely hard to do."

Students will begin to use the DTEM at LLNL this fall. "Prior to the advent of the DTEM, we could only simulate these transformations on a computer," Wiezorek said in a news release. "We hope to discover the mechanisms of how alloy microstructures evolve during solidification after laser melting by direct and locally resolved observation."■



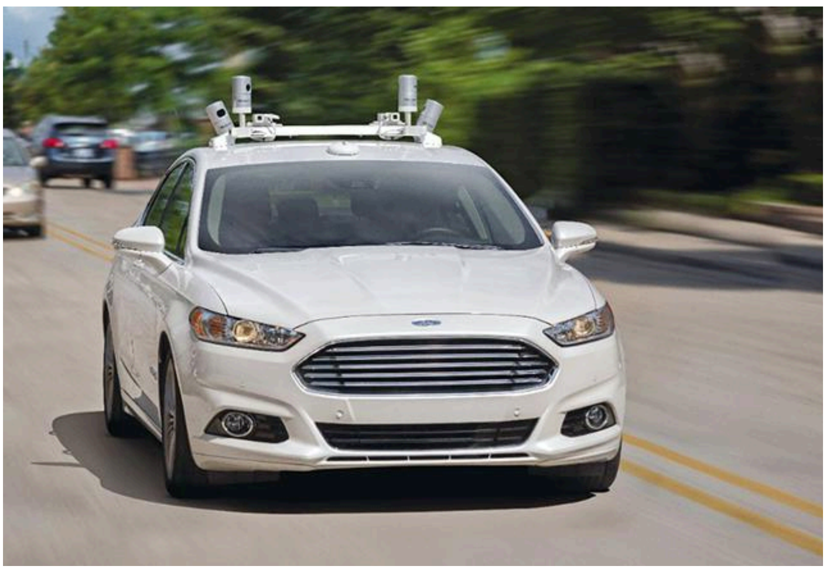
The DTEM has proven useful for capturing rapid intermediate steps in reactions found in chemistry, biology, and materials science.—

FORD PROMISES FULLY
Automated Vehicles by 2021

IN 1913, FORD implemented the first moving assembly line for automobiles, building its Model T automobile in a little over two and a half hours. Their success was seen as a milestone for creating thousands of assembly-worker jobs, changing the conduction of car manufacturing in the U.S., and extending the use of cars to the middle class.

Last month, Ford Motor Company officially set the deadline to make its next contribution to automobile manufacturing. The automaker promised to mass produce fully automated vehicles by 2021. Its design will not include a steering wheel, gas pedals, and any other features that accommodate human drivers, according to Mark Fields, the chief executive of Ford.

To follow through on that goal, Ford is building up its Silicon Valley R&D team. The company said that it will add two more buildings across the street from its Research and Innovation center and nearly double its staff working on self-driving cars. Engineers, technologists, designers, and other workers will design more efficient sensors, AI frameworks, and systems so that the next generation of cars will be affordable to mass produce.



Ford's planned fully automated vehicles will not include a steering wheel, gas pedals, or any other features that accommodate human drivers.

Ford is also investing in several companies and partnerships, including one with Light-Detection and Ranging (LIDAR) sensor developer, Velodyne. It also announced plans to acquire SAIPS, an Israeli startup that develops frameworks for machine learning and AI. This acquisition will build up Ford's expertise in video processing, proximity sensing, and deep-learning neural networks—a subset of machine learning where computers store various responses to ambiguous inputs like images, and then weigh the value of these outputs to choose the best response to a specific situation.

Ford also is forming a licensing agreement with Nirenberg Neuroscience, which was founded by a neuroscientist that decoded neural signals for transferring visual information to the brain. She incorporated this neural code into software for prosthetic eyes, and plans to help Ford incorporate these into a visual processor for its cars. Finally, Ford chooses to invest in Civil Maps to create and 3D maps of its surroundings. ■

3D PRINING DEPOSITION

Method Augments Sensor Durability

ADDITIVE MANUFACTURING CAN be a powerful weapon in producing durable outer protection for sensors used in high-pressure environments, such as pipelines in the gas and oil industry. These coatings significantly improve sensor useful life despite sheer stresses and pressures on the magnitudes of hundreds of bars.

O.R. Laser's powder nozzle and laser head can deposit alloy coatings onto sensors without damaging them.

One company that takes the additive-manufacturing route is O.R. Lasertechnologie. To create such coatings, the company's R&D team invented a powder nozzle that deposits Stellite, a cobalt-chromium-based alloy, onto the sensors. Using a compact EVO mobile laser welding system, they deposit Stellite powder coaxially with the laser beam at deposition rates as high as 5000 mm^3/h.

Stellite is traditionally difficult to machine onto sensor surfaces—the intense heat during layer deposition causes the sensor material and the Stellite to melt together, impacting the integrity of the sensor. But by applying a powder-based laser cladding method called direct metal deposition (DMD), the team melted Stellite onto the sensor with a low-power laser as low as 200 W. In addition to the low laser temperatures, the coating was melted to the sensors at only a few scattered points to minimize melting of the sensor material.

The Stellite-powder grain sizes are between 45 and 90 µm for undistorted, crack-free coating, and track widths between 200 µm and 2 mm for precise deposition. DMD was also done in a chamber of the noble gas argon, to prevent the coating's reaction with the atmosphere during deposition and the generation of gas bubbles. ■

DETAILED SCANNING SUPPLEMENTS

Museum Tours with Virtual 3D Models

USING 3D-SCANNING TECHNOLOGY from Creaform, experts from the Milwaukee School of Engineering (MSOE) invented a way to let visitors observe ancient Egyptian artifacts up close. Over the course of three days, they scanned over 30 items at the Milwaukee Public Museum (MPM), including a life-sized sculpture of King Tutankhamun on his horse-drawn carriage, so that visitors can observe astonishing details on 3D virtual models from their tablets.

One of the museum's first permanent exhibits in ten years, Crossroads of Civilization serves to "explore how the ancient civilizations of Africa, Europe and Asia came together to form an epicenter of complex culture," according to the MPM website. It includes over 200 artifacts and two mummies supplemented by CT scans of their faces. It has a special focus on King Tut, who ruled in Egypt in the mid-1300 BC starting at the age of nine.

Based off of CT scans on his mummy, MPM's sculpture accurately portrays Tut's body type and facial structure. Embellishments on his armor and horse-drawn carriage are true to artifacts found in his tomb. Using the Go!SCAN 20 and the Go!SCAN 50, Vince Anewenter and Jordan Weston from MSOE's Rapid Prototyping Center (RPC) scanned clothing and riding gear layer-by-layer. The Go!SCAN 50 was used to create a general contour map by recording the way the sculpture reflects light.

Based off of CT scans on his mummy, MPM's sculpture accurately portrays King Tut's body type and facial structure. Embellishments on his armor and horse-drawn carriage are true to artifacts found in his tomb.

The specialists then switched to the Go!SCAN 20 in its "Natural Features" mode to capture more intricate details at a higher resolution and in full color. After scanning, the experts resolved any holes in the image using post-treatment software called VXmodel. They then transferred the watertight color image to multimedia software, and projected the 2D image onto a 3D model.

In addition, a "matching point" feature on both scanners ensured continuity as the experts switched between scans of individual layers of clothing. By setting reference points on a pre-saved base model, the experts could keep track of the orientation for each layer.

The "matching point" feature also enhanced the Go!SCAN 20's abilities for scanning very thin artifacts by matching up the position of engravings on opposing sides. The Go!SCAN 20 captured even the faintest engravings, including hieroglyphics on one artifact that could previously not be deciphered.

Creaform offers its 3D scanning technologies for a range of different applications from industry to biomechanics. It hopes to partner with other museums to enhance their exhibits with virtual 3D models of intricate artifacts. ■

Wired vs. Wireless in the IIoT

Dr. Shipeng Li, CTO of IngDan, talks about IIoT networks, and offers his take on the ideal system.

Interview by JEFF KERNS

Dr. Shipeng Li is the CTO of Cogobuy Group and IngDan Technology , which has locations in Silicon Valley, San Francisco, Shenzhen, Beijing, Chongqing, Hong Kong, Tel Aviv, Rome, Kyoto, making it the largest "Uber-like" Internet of Things (IoT) innovation platform serving entrepreneurial communities worldwide. A Deputy EiC of IEEE Transactions on Circuits and Systems for Video Technology and a Fellow of IEEE, Dr. Li is an influential and leading expert on multimedia and the internet, holding 178 U.S. patents and 330 refereed papers.

Dr. Li obtained his Ph. D. in electrical engineering in 1996 from Lehigh Univ., Bethlehem, Pa. He founded IngDan Labs in 2016. Previously, Dr. Li co-founded Microsoft Research Asia in 1999, which soon became recognized as the world's "hottest" computer lab by *MIT Technology Review*. Among other positions, he was a partner of Microsoft Corp. and the Research Area manager/Principal Researcher for Microsoft Research before joining Cogobuy/IngDan.

How can sensing and connectivity be integrated into existing network lines?

Assuming existing lines such as phone lines, power lines, coax cable lines, or Ethernet, sensing in the IoT world essentially involves digitizing the analog world, then transmitting the data to other devices or processors through data networks. On the other hand, control essentially changes our world through quantified signals.

There are mature technologies that can convert existing lines into high-speed data networks. Therefore, if a sensing/control device happens to be co-located with a terminal of existing lines, it can easily communicate through the data networks over these existing lines.

However, the network interface devices of existing lines tend to be bulky and expensive. In addition, not every sensing/control device would be most effective at the terminals of existing lines. Therefore, most IoT devices tend to communicate wirelessly, not through existing lines.

What are key factors to figuring out if there is a positive ROI in retrofitting? For instance, high downtimes, supply-and-demand bottlenecks, etc.

The problem with retrofitting is not an economic one, but a technical one. My comments to the previous question partly address this issue. There are solutions, but it's still a hybrid wireless-to-wired solution. Data terminals over existing lines could have a wireless data hub attached, be it Bluetooth, ZigBee, or Wi-Fi. Only through wireless connectivity to IoT devices could these devices be freely installed at their most effective locations.

Existing lines could serve as the backbones of the data networks. However, once again, since expensive equipment is involved in leveraging existing lines (except Ethernet lines, but existing Ethernet lines are only popular in newer houses), most IoT devices still prefer to use Wi-Fi connectivity to directly hook up with a data network.

Are PC or PAC systems only necessary when you need to process more data, as in motion control or machine vision?

The power of IoT systems is not simply an aggregation of a bunch of IoT devices. Rather, it is derived from the intelligence amassed through the sharing of data among different devices and the collaboration between them. If we want to enable natural user interactions with the IoT system, we no doubt will deal with constantly big data from visual, speech, audio, and other digital sensors. On the other hand, we could not transmit everything to the cloud to process, or have enough time to process.

For example, if we are using computer vision technology to process human interaction with IoT devices, we need to put at least a significant part of processing on local computers. It saves bandwidth to the cloud, but more importantly, significantly lowers the response time. However, PCs or PACs may not be necessarily the only form factor we could use to process the data; other computing forms may be more convenient or

pleasing, such as an Echo-like speaker with sufficient processing power.

Can you provide a detailed list of how to connect an Ethernet to a PC, or achieve wireless cloud connectivity?

Depending on what a user is looking for when setting up a wireless router—just like a router they might have at home—it would be easier to configure a wireless network to achieve cloud connectivity. If a user is connecting to IoT devices, such as some human-machine interface (HMI) to their desktop, and they have wireless connectivity such as Bluetooth or ZigBee, they need to have a Bluetooth or ZigBee to Wi-Fi adapter to bridge the data to an Ethernet or Wi-Fi network. Once data connection is established, it should be easy to achieve wireless cloud connectivity.

What are some of the differences in the IoT around the world?

IoT is a new market with huge growth opportunity worldwide. Almost every country has started efforts to move forward to grab this opportunity. In developed countries such as the U.S., developers tend to focus on only a few high-value products, and customers tend to be more educated on what they think are useful to them. Some of the IoT products tend to be mandated by building codes for energy-efficiency purposes, for example. Data privacy or security carries more weight than other things.

On the other hand, in developing countries such as China, developers tend to rush into already-proven markets. Customers generally pick more cost-effective IoT solutions. Many regulations or codes are not yet in place. As a result, with a lack of commonly agreed-upon standards, we see a much more scattered market with many more varieties of devices. Data privacy and security in China has not yet been seriously addressed, though it is improving over time.

> IoT is a new market with huge growth opportunity worldwide. Almost every country has started efforts to move forward to grab this opportunity.
>
> —Dr. Shipeng Li, CTO of IngDan

What are the positive and negatives of these differences?

The pursuit of cost-effective solutions and competition in a few hot areas could lower the price of IoT devices, thus accelerating IoT adoption. But let's hope there is no security breach before these companies become big enough to have resources to secure possible loopholes in their products. Countries such as China have huge supply-chain support compared with the U.S., therefore it will help Chinese entrepreneurs to quickly iterate on their product to adapt to customer needs and market trends. IngDan is helping entrepreneurs of other countries take advantage of this huge supply chain in China as well, by providing an internet platform to bridge the supply and demand of the IoT industry worldwide.

What would you say is the ideal system, and why? What are the key factors of this system?

The ideal system in my eyes would have the following elements:

Data from different IoT devices, even from different manufacturers, could be shared by the whole system and each other's devices. There are five levels of connectivity that needs to be addressed

1. *Physical connectivity:* Make sure that devices can communicate with each other.

2. *Data connectivity:* Data with a compatible format that can be shared with security and confidence.

3. *HMI connectivity:* HMI can be shared among devices.

4. *Knowledge connectivity:* Knowledge about the user and his/her environment could be shared.

5. *Service connectivity:* Service control and device status can be shared.

Control of data should be put in the user's hands—the user owns the data—as should control of who/what device can access/use his/her data for how long in what services, etc.

Above all, the system should fuse the data, HMI, knowledge, and services provided by each IoT device, be it a sensing device or controlling device. The ultimate artificial intelligence (AI) that understands the user and help his/her life is only possible with the data fusion from all devices. An ideal system should be able to provide all levels of AI from notification to perception, to cognition, to prediction, to decision from these fused data and services.

Physical connectivity is just one small first step to fully explore the potential of an IoT system. Therefore, instead of calling the ideal system as IoT, I would prefer to call it SoT (Society of Things), where devices can interact with each other at different levels and behave like a social society.

What else do you think adds value to an IoT sensing and controls network?

Protocols and standards are key to the success of IoT systems. Regulations are also necessary to enable ultimate data and privacy protection, and security. When thinking of building an IoT device, we need to think how this device could fit in such an IoT system. Randomly building incompatible hardware will only lead to failure. md

CARLOS M. GONZALEZ | Technology Editor
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What's the Difference Between Engineering Degrees?

The plethora of engineering degrees available to students today allows them to work in a multitude of different disciplines.

Today's engineering education is an open playing field. Many engineers are being hired into positions that a few years ago would be considered a non-traditional profession. You can find engineers in human resource departments, in accounting firms, editorial staffs, and medical settings. You also see cross-engineering jobs where mechanical engineers, for example, work in civil engineering or electrical engineering. To understand the opportunities available to engineers, let us break down from the main disciplines to the concentrated ones the differences between them.

THE BIG FOUR

The following engineering disciplines account for 67% of all engineering bachelor degrees according to *DedicatedEngineers.org*: civil, computer, electrical, and mechanical engineering. According to the American Society for Engineering Education (ASEE), in the scholastic year 2014-15, 106,658 engineering bachelor degrees were awarded. Out of that total, 25,436 were in mechanical engineering, 11,900 were in civil engineering, 11,385 were in electrical engineering, and 10,970 were in computer engineering. Based on the same study, in the incoming freshman class of 2014-15, mechanical engineering saw the largest enrollment of 138,437, electrical/computer was second with 102,519, and civil placed third with 53,486.

Mechanical Engineering

Mechanical engineering is considered the broadest of engineering disciplines. This is due to the fact that it overlaps into many other existing engineering disciplines, which include civil and chemical engineering.

Areas of primary specialization are:

• Solid Mechanics: Analyzing the behaviors of solid bodies subjected to loads, stress, and/or vibration and to design and construct based on that analysis.

• Fluid Mechanics: Analyzing the behaviors of liquids and gases. Designing machinery and systems that include pumps, fans, turbines, and piping systems based on that knowledge.

• Thermodynamics: Analyzing the conversion of energy from one form to another. Design energy conversion devices and develop systems such as power plants, engines, heating, ventilations, and air condition.

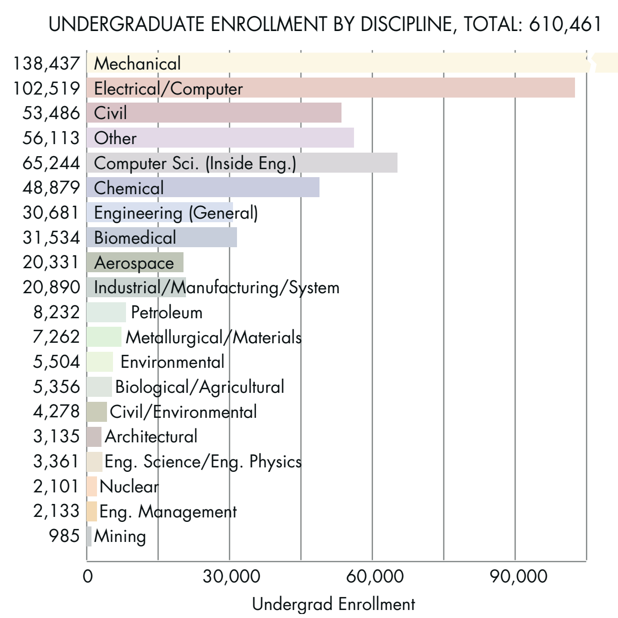
According to *Payscale.com*, the average starting salary in 2016 for mechanical engineers is $62,527 and the mean annual salary for all mechanical engineers is $88,190 according to the Bureau of Labor Statistics (BLS) in 2015.

Civil Engineering

Civil engineers mainly focus on public works, infrastructures, and the construction of buildings and structures. Examples of public works and structures could be designing roads, dams, bridges, buildings, and canals. Due to their knowledge in materials and the environment, civil engineers are used to help analyze problems like coastal erosion or protect buildings from earthquakes.

Areas of primary specialization:

• Construction Management: Combining engineering knowledge with management skills and training to complete construction projects



The bar graph above highlights how many engineers are enrolled in undergraduate degrees based on engineering discipline for 2014-2015. Mechanical and electrical/computer lead the way with 40% of undergraduates. *(Source: American Society for Engineering Education)*

• Geotechnical Engineering: Analysis of rock and soils to support engineering projects such as building foundations, earthen structures, dams, tunnels, etc.
• Surveying: Measuring and mapping the earth's surface to support engineering designs and projects.
• Transportation Engineering: Designing types of transportation facilities and systems such as streets, highways, and other mass transit such as railroads and airports.

The average starting salary in 2016, according to *Payscale.com* was $55,995 and a mean annual salary of $87,940 according to BLS in 2015.

Electrical Engineering

Electrical engineering focuses on all things electrical or electronics-related. This includes electronic devices, electrical systems, electrical energy, etc. Electrical engineers design, develop, and with electrical systems. This could be to help develop efficient power methods and performance applications to help improve electronic system performance.

Areas of primary specialization are:
• Communications: The transmission and processing of information via either wires, cables, fiber optics, radio, wireless communications, satellites, etc.
• Digital Systems: Engineering geared toward digital-based communication and control systems.
• Electric Power: Generation, transmission, and/or distribution of electric power. Electric circuits deal with electricity movement but have no design-making or processing capability.
• Electronics: Engineering toward electronic devices and electrical circuits for producing, detecting, and controlling electrical signals for a variety of applications. These types of electronic circuits process signals to interpret or provide instruction to perform a designated task.
• Robotics and Control Systems: Controlling or performing automated processes via machines and electronic systems.
Starting salary for electrical engineers is $64,981 in 2016, according to *Payscale.com*. The mean annual salary in 2015 according to BLS in 2016 is $97,340.

Computer Engineering

Computer engineering bleeds into electrical engineering a little, but its main focus is to design and integrate computer systems, combining the worlds of hardware and software components. Computer engineering is an evolving field and those with this degree are among the most-sought-after engineering professionals today. With the important role computers and mobile devices are playing in our world, the demand for them is high.

Areas of primary specialization are:

• Hardware Engineering: Developing complex microprocessors, computer circuits, and printed circuit boards.
• Software Engineering: Writing, designing, developing, and testing software applications for a variety of businesses. The software can be for personal computers, industrial computers, or mobile devices. This also includes designing computer instruction sets and combining electronic or optical components to yield computing systems.
• Artificial Intelligence: Developing computers that can simulate learning and reasoning abilities. This includes advancements in computerized personal assistants like Siri or Alexa.
• Information Technology: Developing and managing information systems to support a business model or organization.
• Operating Systems and Networks: Designing and writing basic software for computers to use so they can supervise their own networks and communicate with each other independent of human input.
• Robotics: Construction of computer-controlled robots for performing repetitive industrial tasks.
• Software Applications: Applying computer software to help develop solutions for problems outside of the computer field environment such as in education or medicine. This would be the key example for the Internet of Things.

The starting salary for computer engineering in 2016 according to *Payscale.com* was $66,238 for hardware engineers and $68,510 for software engineers. The mean salary in 2015, according to BLS, was $114,970 and $108,760 for hardware and software engineering respectively.

NARROWING THE ENGINEERING FIELD

The next 20% of engineering degrees is comprised of aerospace, biomedical, chemical, and industrial/manufacturing engineering. According to the ASEE, 9,090 students graduated with a degree in chemical engineering, 5,683 with a degree in biomedical engineering, 5,291 with degree in industrial/manufacturing engineering, and 3,803 in aerospace engineering in the scholastic year of 2014-15.

Chemical Engineering

The focus of chemical engineering is applying chemistry in manufacturing based method for commercial production. This includes the production of fuels, plastics/polymers, pharmaceuticals, paper products, ceramics, electronic materials, industrial chemicals, and agricultural chemicals.

Areas of primary specialization are:

• Biotechnology: Engineering geared toward agricultural, food, and medical applications.
• Petroleum and Natural Gas: Refining crude oil and natural gas as a source of fuel for many motorized vehicles and devices.

• Polymers: Designing and focusing on the production of plastics, synthetic rubbers, fibers, films, and composite materials.

Starting salary according to *Payscale.com* is $67,006 in 2016 and the mean annual salary according to BLS is $103,960 in 2015.

Biomedical Engineering

Biomedical engineers focus on applying engineering applications to the fields of medicine and life sciences. Examples of this are artificial replacements like a hip or knee replacement, plastic components for hearts and veins, artificial limbs, and the use of electronics in the human body for monitoring purposes. As we get more specific in the field of engineering, we can see where the basis for that field comes from. Biomedical engineers overlap with mechanical, electrical, and chemical engineering depending on the specialty area.

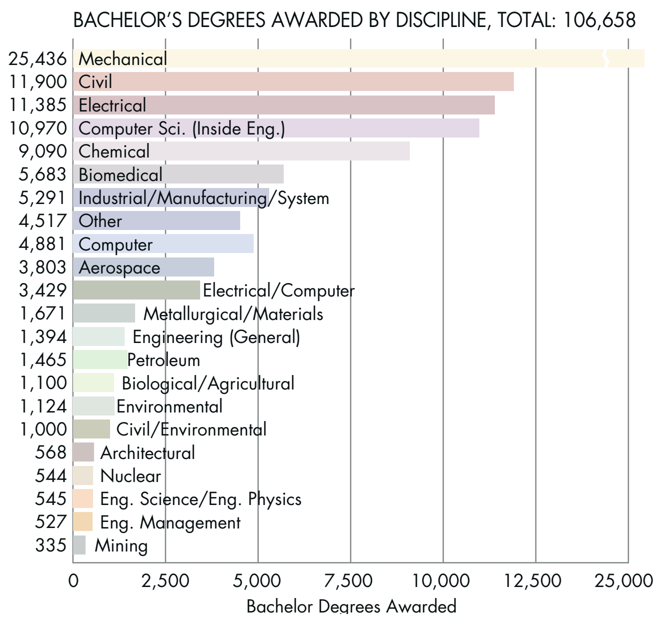
Areas of primary specialty are:

• Biomaterials: Designing of living tissue and artificial materials for implants.
• Biomechanics: Designing implants or artificial tools based in mechanical principals to help solve medical problems or handicaps, i.e., artificial limbs and implants.
• Biotechnology: Development and production of pharmaceutical products.
• Medical Devices and Equipment: Development of diagnostic equipment like X-rays, CAT scans, MRIs, etc.

Starting salary according to *Payscale.com* is $61,288 in 2016 and the mean annual salary according to BLS is $91,230 in 2015.

Industrial/Manufacturing Engineering

Industrial/Manufacturing Engineers focus on how to organize, implement, and operate production factors in the most



Above are the numbers of bachelor degrees awarded in 2014-2015 based on engineering discipline. *(Source: American Society for Engineering Education)* efficient manner possible. This involves the development of processes involving materials, equipment, people, information, and energy. The world of the Internet of Things is greatly affecting the role of the industrial engineer and how the scope of their profession.

Areas of primary specialty are:

• Ergonomics: Developing a better workplace environment to accommodate human abilities and behaviors to yield efficient operations with fewer injuries or accidents.

• Facility Design: Designing the work environment to operate efficiently while accommodating workers, equipment, robotics, moving vehicles, products, etc.

• Quality control: Analysis based on sampling products to assess and maintain quality of yield and services.

• Work Design and Worker Productivity: Defining the jobs of workers and setting work standards to optimize the facility work methods.

Starting salary according to *Payscale.com* is $63,509 in 2016 and the mean annual salary according to BLS is $86,990 in 2015.

Aerospace Engineering

The focus of aerospace engineering deals with flight vehicles and systems for both space flight and sub-space flight. This includes airplanes, helicopters, missiles, rockets, and spacecraft. Aerospace engineers also work on land vehicles as the principles of aerodynamics apply to both.

Areas of primary specialty are:

• Aerodynamics: The study and designing of external surfaces to move efficiently through fluids.

• Structural Design and Material Selection: Designing parts based with the specific materials based on the required operation. Examples would be ceramics on spacecraft vehicles for heat resistance or fiberglass on racing cars for weight savings.

• Propulsion Systems: Designing with fuel mixtures or chemicals for propelling objects into the atmosphere or space. Examples would be solid-state chemical rockets or fuel mixtures for space shuttle rockets.

Starting salary according to *Payscale.com* is $78,544 in 2016 and the mean annual salary according to BLS is $110,570 in 2015.

SMALLER AND SPECIALTY DISCIPLINES

The list of engineering degrees goes on and on. You have many subsets of engineering; for example, petroleum engineering and materials engineering could be considered subsets of chemical engineering, while many aerospace engineers start off as mechanical engineers first. Environmental engineers can be divided even further down to agricultural, mining, or ocean engineers. This smaller subset of engineering disciplines accounts for 15% of all engineering degrees available. The trend appears to be that the more specific engineers' degrees become, the higher in salary they are and the smaller the amount of employed engineers in the field becomes. md

VICTORIA FRAZA KICKHAM | Distribution Editor

Global Distribution: MEXICO

Distributors focus on growth in Mexico and beyond, as automotive, lighting, technology and solar markets hold promise.

Economists trimmed their outlook for the Mexican economy earlier this year, citing soft global economic conditions and low oil prices that are hurting an already sluggish industrial sector. Forecasts call for growth of between 2% and 3% this year and next, however, reflecting the steady growth the region has seen recently—and ensuring that it remains a focus for North American companies in the electronics supply channel.

"The market is expanding and our business has been growing," says Esteban Polanco, strategic sales director, Mexico, for Florida-based global distributor America II Electronics, which has been focused on growing its business in Latin America, especially Mexico, over the last few years.

A recent report from researcher Focus Economics predicts 2.4% growth in Mexico this year, accelerating to 2.7% growth next year.

"The consensus view among analysts is that economic growth will be supported by private consumption this year," the company wrote in a July report. "However, Mexico's difficult adjustment to low oil prices and the fact that monetary and fiscal tightening come at a time of softening economic activity are casting a shadow on the outlook."

But distributors such as America II are still banking on growth in the region, and elsewhere in Latin America, especially over the next two to three years for a variety of factors. Based in Guadalajara, Polanco says he sees growing activity in automotive and lighting markets in particular—especially in the central and northeastern parts of the country, where investment is strong. He points to a new Kia Motors plant in Monterrey, which opened earlier this year, along with growing design activity among small and mid-sized lighting manufacturers. Lighting is a key market for

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America II as it seeks to expand its relatively new focus in the Mexican marketplace.

"We have seen quite a bit of growth and our focus has been, over the last year, developing more products we can sell to the lighting market," says Polanco, adding that Mexico has been "ahead of the curve" in making the switch to energy-efficient lighting, and LEDs in particular. "This has been and will be a big area for us."

Cities and towns across Mexico continue to invest in energy-efficient lighting projects, and large and small lighting manufacturers have responded with a presence in the region that is driving design activity, Polanco says.

"You have really big OEMs that are building lighting, but you also have smaller and medium-sized [companies] that are down here focused on doing their own products. So from a design perspective, business is growing," he explains, pointing to a greater amount of electronic content in energy-efficient lighting as a key reason behind the growth.

Design activity is also growing in other areas, including the Internet of Things and automotive-related markets as demand for "smart" products accelerates. Polanco points to smart metering in gas and utility markets and tracking devices that can be used on everything from cars to vending machines as hot areas.

"There is a lot of push for design in different areas and by different sizes of customers," he says, adding that the lower cost of an engineer in Mexico compared to the United States is also contributing to the trend.

TECHNOLOGY, SOLAR MARKETS HOLD PROMISE

Polanco says he expects America II's business to grow beyond Mex-

America II's Esteban Polanco says growth continues in Mexico, as the company focuses on the lighting market throughout the region.

ico, especially as demand picks up for better technology infrastructure in places such as Brazil and Argentina, where changing political climates may open the doors for foreign investment.

"It is good timing, especially for us, to focus on those countries," he says. "There will be investment, [because] they have been backed up with technology [needs], especially."

Solar energy is another growing industry across the region. Researcher IHS Markit reported in July an increase in public tenders for photovoltaic (PV) projects throughout the region, spurring optimism for market growth. Latin America is expected to reach 2.7 gigawatts of installed PV module capacity this year, led by Chile, which will account for 44% of new installations, the researcher said. Honduras is the second-largest market in the region, but is set to be overtaken by Mexico, where new projects are emerging. As one example, northern Mexico is home to the first large-scale solar power project in the country, Aura Solar I, which began operations in 2013.

"Recent record-low bid prices—as low as $48 per megawatt-hour in Mexico—are attracting the interest of governments," according to Josefin Berg, senior analyst, solar demand, IHS Markit. "Meanwhile, these bid levels raise the pressure on suppliers, as the procurers will be squeezing the total system costs to make the projects viable."

IHS goes on to say that while tenders spur optimism regarding market growth, actual project deployment often takes longer than planned, as developers struggle with administrative barriers or seek to postpone construction to benefit from declining component prices.

"Planned tenders also risk delays, as most recently shown in Brazil where the power auction scheduled for July 2016 has not yet been set," according to IHS.

Nonetheless, such potential opportunity across Latin America is fueling an already-interested supply channel that is looking for new growth avenues in what continues to be a cautious global climate.

"The market is steadily growing, and there is investment in many different areas," Polanco adds, pointing to aerospace and medical industries in addition to automotive, technology and energy-related fields. "So, there is a quite a bit going on, which makes [the region] very appealing." ■

JEFF KERNS | Technology Editor
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REPLACING METAL With Plastic

Plastics can make parts lighter and stronger, but that is only the tip of the iceberg.

In a famous scene from the movie *The Graduate*, the young hero is advised that "there's a great future in plastics," a prediction that echoed reality. Now, plastic is aiding the driving force to make products lighter, stronger, easier to process, and available in more complex shapes—specifically in the form of composite and high-end polymers. In other words, plastics are still the future..

HISTORY

Bakelite, developed in 1907, was considered the first full-synthetic polymer. While other thermoplastics were around before this, Bakelite was a thermoset. Thermosets form strong bonds that cannot be remolded and can provide relatively strong parts, but are difficult to recycle. One option to recycling a thermoset is to simply grind it up and use it as an aggregate in a new part. Adversely, remolding is possible with thermoplastics (mostly known, but not limited to, economic polymers numbers 1 through 7). Being able to re-form the material has been associated with reduced strength. Plastics strengths have been improving for over 50 years and even replacing metal parts. Currently, new specialty polymers, composites, and processes have increased properties to a point where some engineers are not aware of the potential benefits plastics can provide.

Material	Ultimate Tensile strength (ksi)
Celazole (Source: Plastics International)	20
Grey cast iron	25
Annealed Copper	32
Aluminum 6463-T6	35
FR-4/G10	45
AISI 1040 hot rolled steel	76
Annealed stainless steel	85

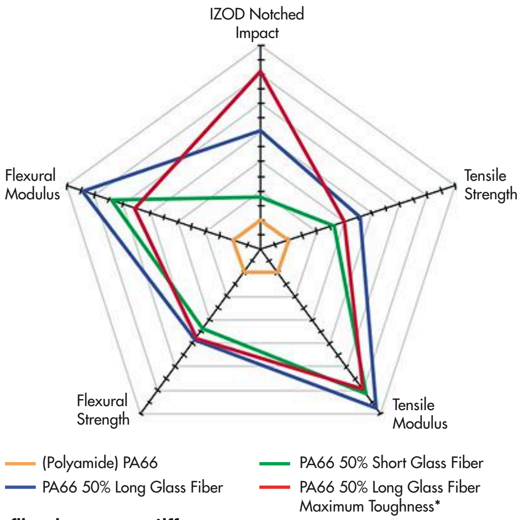
Environment and other properties will need to be considered when considering the use of plastics. For example, plastics may not rust, but water could potentially absorb into the plastic to act as an elastomer. This weakens the bonds in the material causing a part to fail.

Plastics over several decades slowly made their way from toys and jewelry to include serious aerospace and military applications. Plastic can be an easy choice when trying to save weight and cost. In September 2013, *the American Society of Mechanical Engineers* estimated, "in general, companies can expect to achieve an overall cost savings of 25% to 50% by converting to plastic parts." Plastics can offer indirect benefits as well. A simple example is plastic grocery bags. Shipping one truck of plastic bags rather than four trucks of paper bags, for the same quantity, can save fuel, time, and storage space. However, plastics might not seem as likely a choice in higher-stress applications.

One of the challenges in using thermoplastics to replace metals is that many structural parts need to be stiff and offer high impact strength. These properties were indirectly related in thermoplastics until about 50 years ago, when glass fiber was added to the polymer. This would help carry a load over a greater surface area and increase the flexural strength, stiffness, modulus, tensile, and impact strength by as much as 300% to 400%, according to Ron Hawley, the chief science officer of Integrated Composite Products Inc. (ICP). So began the age of thermal plastics.

Until the 1970s, glass was typically added during an extrusion process. There are a great deal of shear stresses involved in getting the glass fibers into the resin and making sure it is fully mixed—or wetted out—into the polymer. This would cause the glass fibers to break into relatively short lengths (typically under a millimeter). To work as reinforcement and improve performance by 300% to 400%, the fiber should have an aspect ratio of the length to diameter of about 20 to 1.

By late 1979, plastics manufacturers started producing long fiber with a drawing process. Fibers up to 12 mm could be produced in pellet form. During an injection-molding process, there are shear forces that break long fibers. But post-process lengths in excess of 8 mm are normal.



Long fiber increases stiffness, strength, and wear properties. *(Data courtesy of PlastiComp)*

**Maximum Toughness is a proprietary blend from PlastiComp.*

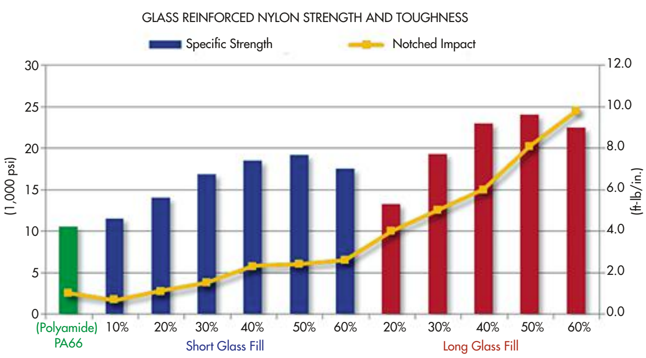
WHEN PLASTIC TAKES OVER

Longer fibers increased the strength of plastics, making it more competitive with metal. For example, Celazole is a polybenzimidazole (PBI) non-fill polymer; its tensile strength is about 20 ksi (138 MPa) according to Plastics International (testing with ASTM D638). FR-4/G10 is a composite with a fiberglass cloth that works well for plastic fasteners. It boasts a tensile strength of 45 ksi (310 MPa), according to CrafTech Industries. While metals can achieve higher strengths (see Table 1), composite polymers are competitive and stronger than some grades of metals.

With stronger plastics and ease of processing, thermoset and thermoplastics can save production time and energy compared to making parts from metals. Engineers might take advantage of the benefits of processing plastic because reducing production time might be necessary to complete orders and stay competitive. ICP's Hawley offers the following example: "Imagine the first four-wheeler. It was probably made with a lot of metal. Its maker may have had access to a mill and some bending equipment, so it seems logical. However, as sales increase, you need to make things faster to keep up with demand. If milling a part takes 20 minutes, molding it with a thermoset might take five minutes. In this example, it wasn't necessary to save weight or cost, it was imperative to fill orders. That is when plastic takes over."

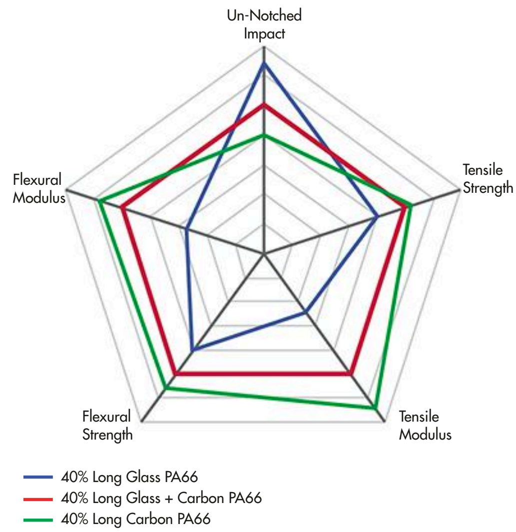
If you are making 200K parts per year, however, it might not be possible to do so with thermosets. With the example above, you only have about 100,000 five-minute cycles in a year. "Thermoplastics are good for mass production," says Hawley. "Quick manufacturing of thermoplastics can reduce hold and set times. Many parts are able to be molded in less a minute."

Markets moving from metals or thermosets to thermoplastics tend to need rapid manufacturing, notes Hawley. "Small personal watercrafts are a perfect market for a thermoplastic process." he says. This is exactly what Jordan Darling, founder/CEO of Free Form Factory—a personal watercraft manufacturer—has done.



(Data courtesy of PlastiComp)

According to Jordan, "Fiberglass manufacturing is costly, labor-intensive, and it releases volatile organic compounds (VOCs) that are toxic to the people manufacturing the parts.



Composites can be costly, but manufacturers are finding new ways of cutting costs. For example, using a blend of 20% carbon and 20% glass fibers reduced cost by 37% when compared to the 40% carbon fiber. *(Data courtesy of PlastiComp)*

By thermoforming with a proprietary material that contains no glass—it is not a composite—we are able to manufacture 10 times faster than we would using traditional methods.”

Jordan continues, “It can take 225 man hours from raw material to being ready to ship to make a hull. But our hull only takes 20 hours. And as we scale up, we can cut that time in half. While manufacturing is a large reason for using this manufacturing technique, this method also yields a 3.5 times increased impact strength compared to fiberglass products.”

Fiberglass products can also be hard to repair or recycle. By using a modular design with thermoplastics, it is possible to produce a non-VOC-generating product that is relatively easy to maintain and recycle. As regulations on VOCs and sustainable practices are growing, high-performance polymers and thermoplastics will continue to replace metals and thermosets—especially if they can handle higher stresses while making it possible to easily manufacture parts.

PROCESSING

Although Free Form Factory in particular is not using composites, composites are finding new ways to increase strength while considering ease-of-manufacturing. ICP, for example, is using a new process to add thermoplastics infused with long glass fibers that are strategically placed in areas of high stress. By being able to add continuous fiber to a specific area, the company can replace metal running boards on a vehicle. A polyolefin running board is now half the weight and cost of the previous metal part. In addition, a 3-point bending test showed that the plastic running board supported three times the load at the same deflection of the metal part. Another inherent benefit to using a polymer is chemical stability—it won’t rust—and, depending on the composite used, could offer higher fatigue strength.

“We are targeting beam applications,” says ICP’s Hawley. “They are flat on one side and there are ribs on the other side to increase strength. When those designs fail, the edge of the rib is the first area that cracks. That crack will propagate and eventually causes the part to fail. We improve the tensile strength by making continuous-length tension members at the bottom of the rib, where the failures occur. The continuous reinforcing fiber is about 60 times stronger than the base molding compound. You place continuous glass fibers that are already infused with plastic into the molds before it closes. As the mold opens and ejects that part, you can simply throw in some more of these rods before the mold closes for the next shot.”

Using different fibers can help improve properties and help polymers make further inroads into the metal market. When evaluating metal versus plastic, it is key that engineers are aware of how changing the resin, fiber, or how the fiber is used (length, orientation, etc.) alters the processing and economics as well as the properties. Sure, keeping lengths as long as possible can increase stiffness and impact strength. But engineers unfamiliar with long-glass injection molding might produce insufficient parts.

Think of it this way: A glass fiber is made up of around 4,000 glass filaments. As more energy is added into a process, it will break filaments, thereby reducing the strength of the final part. Reducing processing properties such as backpressure will help. However, this must carry over into the mold design. Smaller sprues, runners, and gates will increase stresses and the energy needed to push the material past these points, all of which will break fibers and thus reduce the part's strength.

Designers are starting to look at other processes when using composites to maintain fiber length. They also are trying to control the fiber orientation more effectively. Compression molding reduces pressures, and the need for material to pass through sprues and gates. This keeps fibers longer and potentially allows for better fiber orientation. Using compression molding can also improve the life of a mold. Injecting glass fibers with sharp ends can scratch molds. If the material has fewer ends—from either using longer fiber or not pushing the materials across the mold via a process like compression molding—the life of the mold can be increased.

A mold's lifecycle is important, as tooling cost is high for some processes. "Injection molding requires complex higher-cost molds," says Free Form's Darling. "With thermoforming, we can simplify the design and how the molds are manufactured to reduce tooling cost. Injection molding is good for smaller components produced on a large scale, but the cost increases tremendously. Thermoforming can scale while keeping cost low."

Additive manufacturing (3D printing) and aluminum molds are other growing trends in reducing tooling cost. 3D printing molds and fixtures can help improve the time to produce parts. This can increase the amount of iterations that can be tested before investing in more robust tooling—if needed.

For 3D printing, high-performance polymers and composites are eliminating molds. 3D printing with PEEK, ULTEM, and other high-performing polymers might take longer with a fused filament fabrication than molding. But printing assemblies as a single part without a mold can reduce assembly times, tooling costs, and help to automate production.

In some applications, it might be possible for 3D-printed and aluminum molds to handle short production runs. Key factors in how long a mold will last will depend on the material being molded, processing temperature, and the complexity of the geometry.

APPLICATIONS IN AEROSPACE

Whether it's a mold or part, a big advantage in using a composite is controlling fiber orientation. This is an advantage over metals as they are isotropic. As a result, the heat associated with processing would make it difficult to add fibers to metal parts. Controlling fiber orientation in composites will optimize the weight-to-strength ratio, but often increase cost and labor, too. In some industries, such as aerospace, the benefits generally outweigh the higher cost.

The wingbox is on the underside of this plane between or connecting the wings. This is the first time a composite has been used for this structural design.

"We used a unidirectional 'dry' tape for the box structure of the skin, stringers, and spar of the wingbox for the MC-21 Russian plane that rolled out June 8," notes Frank Nickisch, global strategic projects director for aerospace at Solvay. "Our TX1100 textile is a dry, unidirectional tape that was cut into ¼-inch (6-mm) strips. It is able to be placed by a tabling machine. Controlling fiber direction with automated equipment, such as the tabling machine, is the next step in the fiber or textile design and fabrication for composites. The entire lay-up is then injected with PRISM EP2400, a toughened infusion resin."

Aviation Week noted the airplace material trends around the choice of MC-21: "United Aircraft Corp. (UAC) has bet high on lighter-weight materials: an all-composite high-aspect-ratio supercritical wing has been designed for maximum aerodynamic efficiency in cruise flight. Other composite components include the center wingbox as well as the vertical and horizontal fins. The wingbox and the wing panels are produced using

vacuum infusion technology at AeroComposit in Ulyanovsk, another UAC subsidiary."

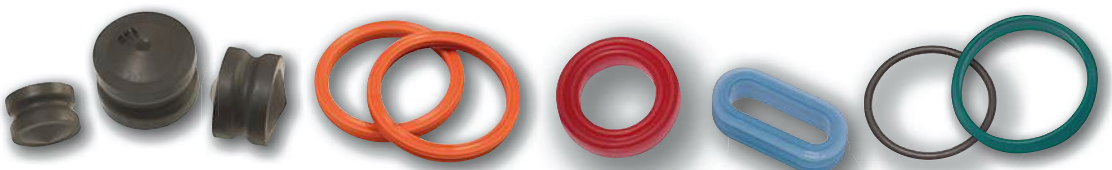
According to Nickisch, "The focus now is to make composite part fabrication more affordable. Innovations have improved the weight to strength ratio by about 20%, but nothing has really changed much in making the processing more affordable in the last 20 to 25 years. This means improving cycle times. For example, a standard autoclave cure is more than eight hours. If you can change the resin chemistry to cure faster and at a lower temperature, combined with a vacuum bag process—and without giving up mechanical performance—it is a real step forward. With the knowledge in both resins and processes, we are able to reduce processing times, thus increasing production greatly."

Unidirectional tape could take more time or labor compared to textiles or cloth composite. However, it offers strength to weight benefit desired by higher-end applications; for example, in performance racing and the aerospace industries. *(Data courtesy of Solvay)*

Solvay, for example, produces Cycom 5320-1, which can be processed using a vacuum-bag technique. This product has eliminated the comparatively expensive autoclave. In addition, the vacuum-bag process enables a broader supplier base, as ovens are more common than autoclaves. Solvay is also continuously working on resins for infusion processes. Nickisch says, "It is still tough, but we have come up with a good balance with PRISM EP2400. It is a thermoset resin with a comparable mechanical performance of toughened prepreg products, but still very easy to process."

When selecting materials, engineers must consider that they can't design metals the same way they would design a plastic part. There is rarely a direct apples-to-apples comparison, which makes it critical for engineers to use plastic designs for plastic parts. Trying to make a plastic material fit a metal design would be like trying to fit a square peg into a round hole.

Plastics, in other words, may offer different key elements for different industries. And they cannot be used instead of metal without careful consideration from the engineering staff. Yet one common theme remains true since 1967, the year *The Graduate* was released: "There is a great future in plastics." md

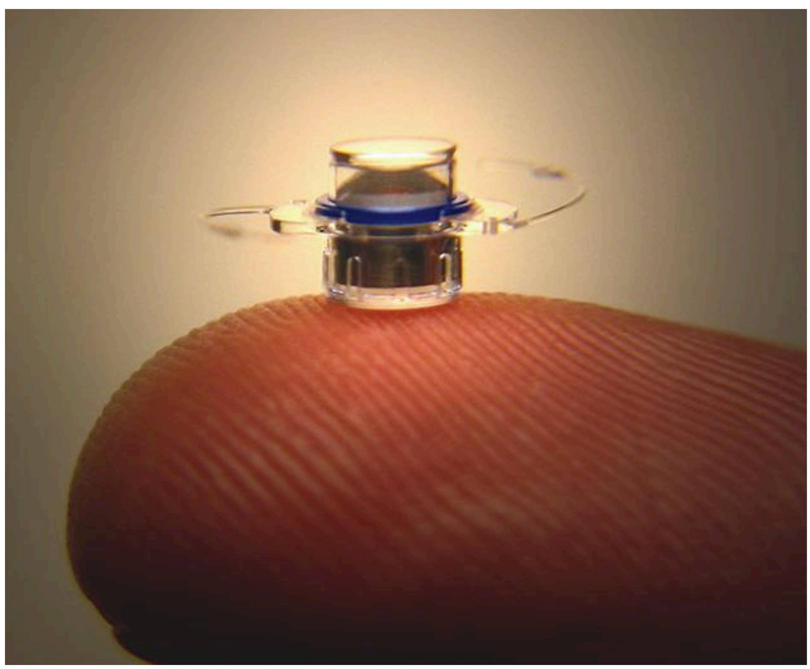


STEPHEN MRAZ | Technical Editor

Implanted Telescope Helps Patients Overcome Macular Degeneration

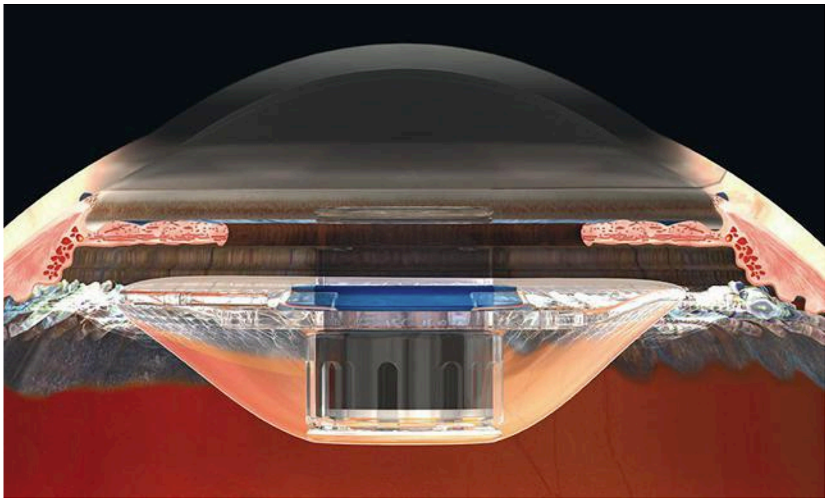
Implanting some magnifying optics into patients' eyes lets them salvage what's left of their vision.

Age-related macular degeneration (AMD) is the leading cause of vision loss and affects 10 million Americans, more than those suffering from cataracts glaucoma combined. That number could grow to over 20 million by 2020 as the U.S. aged population grows. Worldwide, the number afflicted in 2020 could be as high as 196 million.



The implantable telescope from VisionCare improves the central vision of patients suffering from advanced macular degeneration. It gets implanted in one eye so that it can detect central vision (where the person is looking); the other eye then picks up the task of peripheral vision.

There currently is no cure and doctors could do little more than prepare patients for the inevitable loss of vision in one or both eyes. Now, however, patients have an option, thanks to researchers at VisionCare (*visioncareinc.net*) who have developed an implantable telescope that can preserve a patient's vision.



When implanted, the telescope is behind the undamaged cornea. The restrictor, the blue components, prevents too much light from entering around the edges of the telescope and washing out the image.

THE THREAT: Age-Related Macular Degeneration

AGE-RELATED MACULAR DEGENERATION (AMD) is an incurable eye disease that damages the macula, the small area near the center of the retina that contains a high concentration of light receptors (rods and cones). The macula is responsible for sharp, central vision and lets people see objects they are looking directly at.

AMD is a slow-working disease and those with it might not notice any symptoms for years. Over time, however, the person's center of vison in the affected eye(s) becomes increasingly blurry. The blurred spots grow and blind spots can develop in the eye's field of vision over time. Eventually, central vision is lost altogether, rendering the person legally blind. They still might be able to see objects in their peripheral vision, but they can no longer read, see faces, drive safely, or do close work.

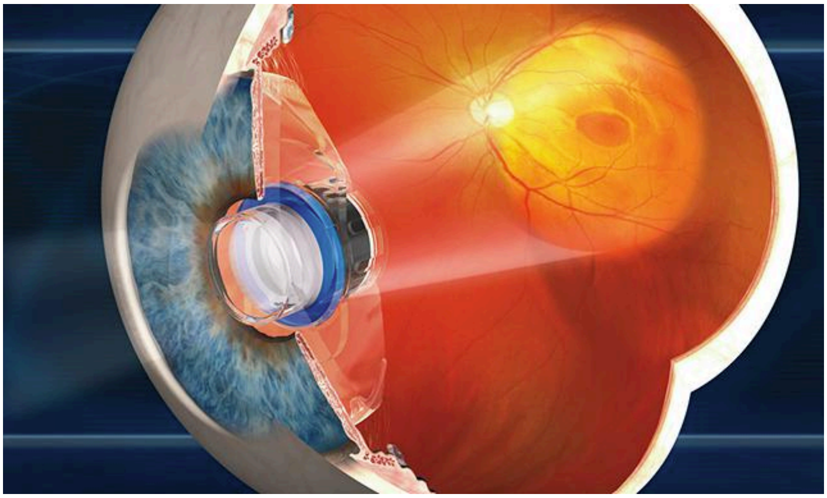
There are two types pf AMD, dry and wet. The dry version, which accounts for 90% of all AMD cases, results from the slow breakdown of light-sensitive cells in the retina and the supporting tissue beneath the macula. The other type, wet AMD, accounts for 10% of AMD patients, and is also known as late-stage AMD. In this stage, abnormal blood vessels grow underneath the macula. The vessels often leak fluids and blood, leading to swelling and damage to the macula. The damage is severe and happens quickly, unlike the slower pace of dry AMD. But not everyone who gets dry AMD develops wet AMD.

People with early AMD in only one eye have a 5% chance of developing late-stage AMD within 10 years. These with early AMD in both eyes run a 14% chance of developing late-stage AMD in at least one year after 10 years.

There is another form of macular degeneration called Stargardt disease. It is found in younger patients and is caused by a recessive gene.

THE TELESCOPE

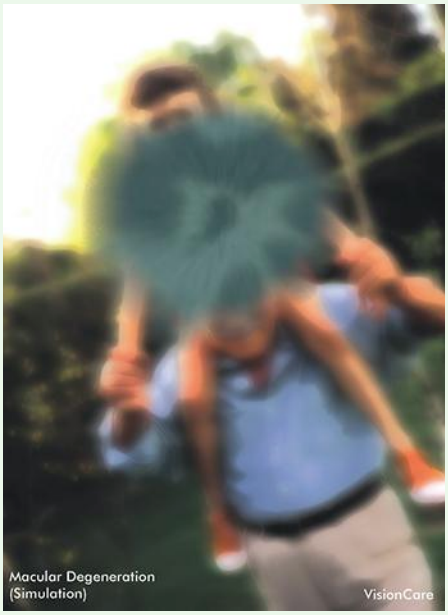
The implantable telescope consists of two lenses within a glass tube. It is about the size of a pencil eraser (3.6-mm in diameter and 4.4 mm) and uses bi-convex and bi-concave convergent and divergent micro-lenses coupled with air lenses,



The implanted telescope sends visual information to areas outside the damaged macula (the dark red spot).

There is no cure for AMD, although high-dose vitamins and minerals and a healthy diet have been known to slow its progression. It's also recommend that those with AMD stop smoking. (Smoking doubles the chances a person will contract AMD.)

Other risk factors for contracting AMD include genetics; AMD does run in families, but researchers have identified 20 genes that affect the risk of developing AMD, and many more are suspected. That's why there are currently no genetic tests that reliably predict if someone will come down with it. AMD is also more common in Caucasians than among African-Americans, Asians, or Hispanics. But the largest risk factor is age: the older you get, the more likely you are to be afflicted by AMD. ■



This image simulates what a person with AMD sees: the central portion of the image is totally unusable, but the peripheral vision is still available but blurry.

according to VisionCare. Details on the micro-optics are proprietary, but the outcome is that the implant acts like a fixed telephoto lens that works with the cornea to project images onto the retina that are enlarged by a factor of 2.7. The iris is also left in place, but the implant is longer than

SPECIAL GLASSES COMBAT COLOR BLINDNESS

RESEARCHERS AT ENCHROMA (*enchroma.com*) have developed glasses that are said to enhance the colors visible to color-blind individuals without compromising color accuracy. This is a boon for the color blind as there is no cure for the largely genetic disease that afflicts 1 in 12 men and 1 in 200 women worldwide. The glasses are designed for people with red-green color vision deficiency (CVD), the most common form of color blindness. It affects 80% of those with color blindness, or an estimated 300 million people.

To explain how the glasses work, a little information is needed on color vision. Each retina contains roughly 6 million cone cells, and they are divided into those that perceive red, green, and blue light. Output from all the cones undergoes a bit of neural signal pre-processing in the retina, creating three data streams that get sent to the brain's visual cortex via the optic nerve. The first stream or channel determines brightness, which is the sum of the signals from the three types of cones (R+G+B). The second determines an image's blue-yellowness by subtracting the red and green inputs from the blue (B-(G+R)). And the third determines the image's green-redness by subtracting the green from the red inputs (R-G).

People with red-green CVD suffer from one of four conditions (see R-G CVD Table). The most common, deutan and protan, involve a color shift, which is caused by an overly large overlap between wavelengths picked up by red and green cones. These overlaps create confusion For R-G CVD, blues are unaffected, while purples are because the green-redness channel cannot resolve the correct amount of red in purple. This makes purples look blue. The same problem affects contrasting red and green colors. The viewer has difficulty resolving either color and both appear brownish.

The EnChroma glasses use multi-notch filters to selectively block signals to the red and green cones. By filtering out signals

CVD Type	Blue cones	
Deutan	Normal	
Protan	Normal	
Deutaranope	Normal	
Protanope	Normal	

it is deep, so the end of the telescope protrudes through the inactive iris. Although the macula of the retina is partially destroyed and useless, the magnified image overlaps the diseased section to stimulate undamaged rods and cones to partially return central vision to the patient.

On the left is a snapshot of Venice adjusted to resemble what a color-blind individual would see. On the right, the same snapshot is shown through an EnChroma lens. The lens brings out the reds and greens, making the image much more vibrant.

Glasses from EnChroma help people with red-green color blindness see colors more accurately. They have no electronics or moving parts and retail for $270 to $470.

to the cones at wavelengths where there is too much overlap—wavelengths in the greenish-yellow to yellow region—the summation of cone signals generates more correct values. So the glasses try to re-stablish the correct balance between the red, green, and blue cones. This, in turn, triggers the dormant neural mechanisms and uses perceived differences between colors, but the glasses do not return 100% of a person's color vision.

What the lenses are made of and how they are made is proprietary. ■

	Green cones	Red Cones
	Red-shifted	Normal
	Normal	Green-shifted
	Missing	Normal
	Normal	Missing

The device is implanted behind the iris in one eye during an outpatient surgical operation that also involves removing the eye's natural lens. There are no moving parts or electronics in the implant.

The implant also has a polymethylmethacrylate (PMMA) carrier and a blue PMMA restrictor. The sealed optical components snap-fits into the carrier, which includes shaped projections that hold the implant in place. These are similar to those found on intraocular lenses implanted in patients who have had cataract-removal surgery in which part of their natural lens is removed. The projections, called "haptics" by VisionCare, are snugged into the capsular bag, a smooth transparent membrane that surrounds the natural lens. Over time, the membrane grows up and around the haptics, securing the implant in place. But patients are still warned to avoid situations in which their head or eyes are exposed to trauma so they don't damage or dislodge the implant. They are also told to refrain from rubbing their eyes too forcefully.

The blue-tinted restrictor, a washer-shaped component, surrounds the implant and reduces the amount of light that can enter the eye from the periphery so it does not wash out images coming in through the implant.

The optics are designed and built to have an optimal focusing distance of about 11.5 ft., assuming an average-sized eyeball. Patients are prescribed glasses if distance or near-viewing corrections are needed. There are no moving parts or electronics in the implant.

The device is implanted behind the iris in one eye during an outpatient surgical operation that also involves removing the eye's natural lens. The implant is sterilized by the manufacturer using ethylene oxide (EtO). This gas infiltrates packaging and kills germs. EtO is often used on medical devices and components that need to be sterilized but cannot withstand conventional high-temperature steam sterilization. After sterilization, the implant is packaged and then not opened until inside the clean operating room.

POST-OP RESULTS

After the operation, which usually lasts one to one-and-a-half hours, patients are given eye exercises and go through some training to get the most out of the implant. For example, they practice tracking objects with the new implant, as well as watching TV and reading. The exercises, which can last six to 12 weeks, also help reprogram the optical cortex of the brain and how it processes inputs from the eyes. This is needed because the patients are now using their eyes in a completely new way. In fact, vision gradually improves and it can take a few months before all the benefits are realized.

In post-op patients, the eye with the implant provided their brain with visual details of what they are looking directly at while the other eye provides peripheral vision. AMD does not affect peripheral vision, a low-resolution form of vision humans rely on for detecting objects near or nearing them and those moving in their field of vision. So instead of using two parts of the same eye, the patients (and their brains) need to switch between eyes to get the same information.

The implant has been shown to improve a person's ability to identify what they are looking at, to "look" someone in the eye during conversation, and to see facial expressions. The implant can't completely restore a person's natural vision. However, in clinical tests, 50% of the people with the implant could read two to three lines lower on the standard eye chart, and 90% reported improved vision. Patients might also still require a magnifying glass to see fine details or small print.

The implant is practically unnoticeable to others because it is totally inside the eye and behind the iris, the colored portion of the eye.

The implant, which costs about $15,000, is approved by the FDA for patients 65 and older, and is covered by Medicare. It is designed to last the life of the patient. ■

The implant, which costs about $15,000, is approved by the FDA for patients 65 and older, and is covered by Medicare. It is designed to last the life of the patient.

CARLOS M. GONZALEZ | Technical Writer
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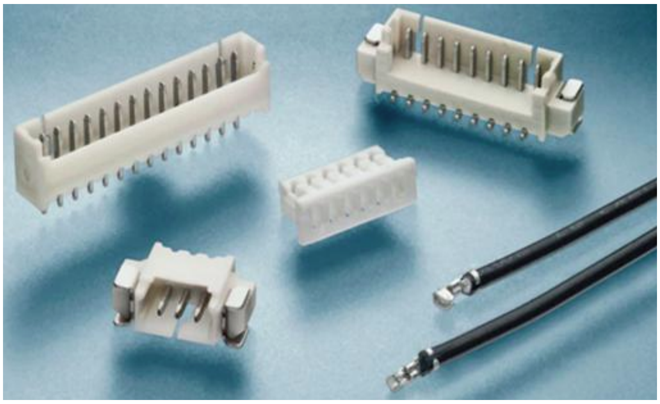
Interconnect Innovations Meet Demands of Shrinking Designs

Some of the latest product trends reveal new methods of mating interconnects in power and mobile applications.

In today's modern applications, interconnects are receiving more attention than ever as designs become smaller and more mobile. Simply put, interconnects are the travel paths of an integrated circuit, connecting elements of the circuit together and to other exterior components, such as batteries or electric switches. Metal layers of interconnects vary in numbers and sizes, depending on the complexity of the device. They can mate with other products via soldering or non-soldering joints. the cause can be traced to improper bearing lubrication.

We will review two types of interconnects: high-performance interconnects (HPIs) and battery interconnects. HPIs are used to send information through circuit boards. Battery interconnects transmit power to and from the circuit.



The high-performance interconnects from TE Connectivity can transmit low power and signals to devices, which allows them to operate certain features like a motor or light display.
(Courtesy of TE Connectivity)

HIGH-PERFORMANCE INTERCONNECTS

HPIs route signals or low power through a device. When using more than one printed circuit board (PCB), HPIs

iJA Series

35A Non-isolated SMT Point of Load with PMBus™

- Only 0.45 in² Board Space
- 8 to 14V Input
- 0.6 - 3.3V Output
- Digital Adaptive Control
- Configurable Sequence and Fault Management

http://us.tdk-lambda.com/lp/products/ijb-series.htm

iJB Series

60A Non-isolated SMT Point of Load with PMBus™

- Only 1.0 in² Board Space
- 8 to 14V Input
- 0.6 - 2V Output
- Digital Adaptive Control
- Configurable Sequence and Fault Management

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iQG Series

300-504W Isolated 1/4 Brick Converters

- Quarter Brick Footprint
- 48V Nominal Input
- 9.6 and 12V Output
- Up to 95% Operating Efficiency
- High True Usable Power

http://us.tdk-lambda.com/lp/products/iqg-series.htm

iAH Series

40A Non-isolated SMT Point of Load

- Only 0.69 in² Board Space
- 3.5 - 17V Input
- 0.7 - 5.5 Output
- No External Tuning Components Needed
- DOSA Compatible Footprint

http://us.tdk-lambda.com/lp/products/dosa2-series.htm

iBH Series

20A Non-isolated SMT Point of Load

- Only 0.36 in² Board Space
- 3.5 - 14V Input
- 0.7 - 5.5 Output
- No External Tuning Components Needed
- DOSA Compatible Footprint

http://us.tdk-lambda.com/lp/products/dosa2-series.htm

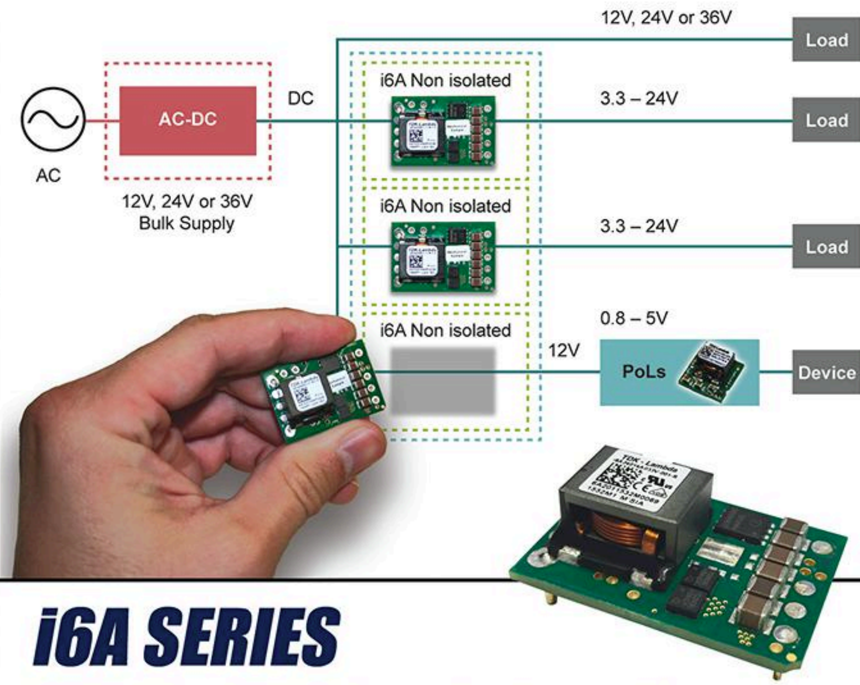
iCH Series

12A Non-isolated SMT Point of Load

- Only 0.23 in² Board Space
- 4.5 - 14V Input
- 0.7 - 8.5 Output
- No External Tuning Components Needed
- DOSA Compatible Footprint

http://us.tdk-lambda.com/lp/products/dosa2-series.htm

Create your own!



i6A SERIES

250W, 3.3 to 24V 14A Output Non-Isolated Converters

The i6A is ideal for creating additional high power output voltages from a single output AC-DC supply. Rated at 250W, this 14A step-down converter can be adjusted across a 3.3V to 24V output, accepting a wide 9 to 40Vdc input.

Packaged in the industry standard 1/16th brick footprint, with an ultra high efficiency of 98%, the i6A can operate in even the most demanding thermal environments.

Contact TDK-Lambda for an evaluation board or check our website for distribution inventory

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- Only 1.2 in² Board Space
- 9 to 40V Input
- 3.3 to 24V Output
- Up to 98% Efficiency
- Minimal External Components Required

For more information on how **TDK-Lambda** can help you power your unique applications, visit our web site at
www.us.tdk-lambda.com/lp/
or call 1-800-LAMBDA-4

TDK

become an option to connect them. When deciding which interconnect to use, it is helpful to keep several design guidelines in mind. First, choose the correct gauge wire (AWG). The higher the AWG measurement number, the smaller the discrete wire. For example, a 32 AWG is smaller than a 22 AWG and will have less current-carrying capacity. HPIs can transfer signals that turn on low-powered devices like a fan, switch, display, or light.

Another key guideline is to know your operating conditions. This includes current, voltage, temperature, size of the PCB, height limitations, material restrictions, etc.

The HPIs developed by TE Connectivity come in a variety of settings. The vertical and horizontal interconnects have a centerline of 1.0 to 2.5 mm with max rated current amps from 1 to 3. Max rated voltage ranges from 50 to 250 offered in ac, dc, or ac/dc. Operating temperature ranges from –40 to 105°C. They are offered in either a through-hole (DIP) or surface-mount-termination configuration.

According to TE, its HPIs provide design flexibility and cost-effective wire-to-board installation to ensure proper compatibility of both the header and the housing; prevent stubbing contacts, and enable interchangeability with industry-standard designs. They will find homes in consumer, industrial, medical, and automotive applications.

Soldering is one of the primary ways to install interconnects, oftentimes using lead. However, the reflow-process-compatible (RPC) interconnect solutions from Molex offer a lead-free solder process. With reflow soldering, solder paste is temporarily attached to the contact pads and subjected to heat, permanently connecting the joint.

Molex KK RPC products, which can withstand the lead-free process (temperatures up to 260°C), help maximize installation efficiency—applications can be designed to use the KK RPC with regular surface-mount components. Together they go through only one reflow process rather than sending them through an additional wave-soldering process after the surface-mount reflow process.

Specifically, KK 254 RPC interconnects are available in configurations up to 5.0 A, 250 V per circuit, and in 2.54-mm-pitch packages. The KK 396 RPC is well-suited for low- to mid-power, wire-to-board, and board-to-board applications. Operating temperature for brass versions is –40 to 80°C; for phosphor bronze, it ranges from –40 to 105°C. Contact resistance is 10 milliohms maximum, while insulation

The KK 254 Right Angle (right) and the Vertical interconnects from Molex provide a lead-free solder process that speeds up the installation process. *(Courtesy of Molex LLC)* resistance is 1,000 megohms minimum.

Other connectors offer mating pieces that require no soldering at all. For example, interconnects from Autosplice are press-fit terminals and connectors.

Converting board connections to a lead-free process has been difficult. They have been particularly challenging for heavy copper PCBs, such as power interconnects. While manufacturers have made progress converting surface-mount-termination processes to lead-free, secondary soldering operations have always been problematic in achieving a high productivity and volume assembly rate. This problem is apparent in markets like the automotive industry, where large molded connectors are frequently used for power and control signals.

Autosplice's Compliant technology allows for high-speed machine insertion of an individual interconnect, or multiple interconnects, with no need of soldering. The Compliant technology uses a special design for the insertion section of each pin, providing a robust and gas-tight interface with the plated through hole. The insertion section of the pin is larger than the diameter and deforms as it is being inserted, creating a strong friction-fit.

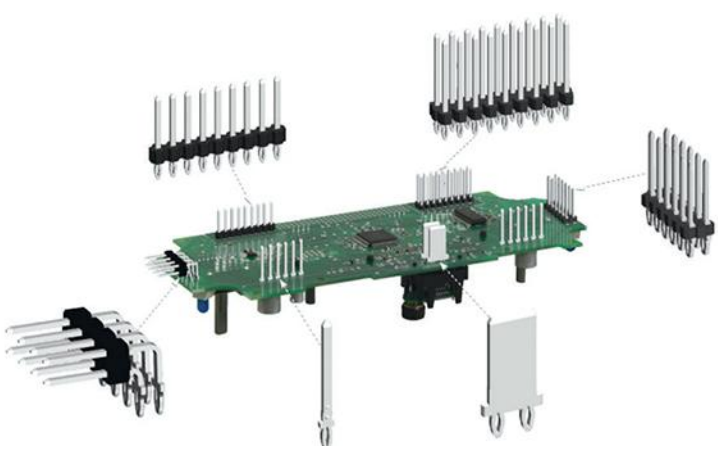
Besides a non-solder joint, the Compliant terminals come in handy for those power interconnects on heavy copper PCBs. The ability to insert the contacts directly onto the PCB without soldering can eliminate the need for separate molded connectors. This helps accommodate fine-pitch space constraints and reduces overall size and weight.

The Autosplice Compliant/Press-Fit interconnects and contacts are plated with tin or tin-lead over nickel. The forces required to insert the connectors is a maximum of 60 N for a 0.64-mm connector and 132 N for a 0.81-mm connector. Retention force is 47 N and 88 N for 0.64- and 0.81-mm connectors, respectively. The series has a current rating range from 7.5 to 25 A. They can operate in environments ranging from –40 to 125°C, and handle vibration and mechanical shocks of 1.8 G on a random axis. The interconnects can function for 40 cycles from –40 to 125°C at a relative humidity of 95%.

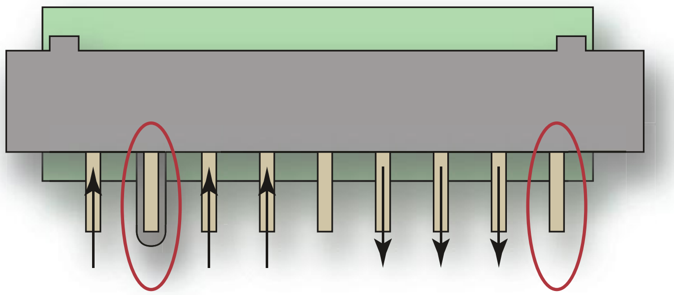
BATTERY INTERCONNECTS

As mobile equipment continues to shrink in size, available space for battery packs disappears as well. As a result, design requirements demand that they carry a balanced current, provide higher amps, and support faster charging times.

Battery interconnects are available in coplanar, parallel, or perpendicular configurations. It is important to note the lengths of the pins and sockets to ensure they do not exceed their mating counterpart on a PCB. The voltage



The Compliant technology developed by Autosplice allows for friction-fit mating of interconnects, eliminating the soldering process. *(Courtesy of Autosplice)*



In this eight-position connector, three pins are reserved to flow power out of the system to the battery while three other pins flow power from the battery pack into the system. The large pin circled on the right is reserved for grounding. The center pin is designated for signal requirements, and the circled pin on the left is a keying feature for mating components. *(Courtesy of TE Connectivity)*

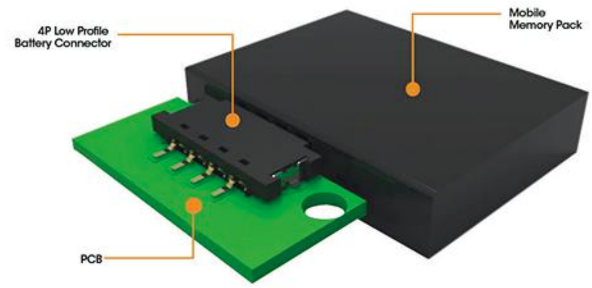
key is indicated on the PCB.

For coplanar configurations, the PCBs are on the same plane when both plug and receptacle are mated. When mated on a parallel configuration, the PCBs do not intersect. On perpendicular configurations, PCBs meet at a right angle when the plug and receptacle are mated.

The following terminology helps define the power design requirements for battery interconnects:

- ***Current-carrying capacity:*** The maximum current an insulated conductor is capable of carrying without exceeding the safety of the interconnect (i.e., insulation or jacket temperature).
- ***T-Rise:*** The change in temperature in a terminal from a no-load condition to a full-current load.
- ***De-rating:*** Specified reduction in output power required for operation during high temperature levels. This feature is necessary when loading multiple contacts between a system and battery pack.
- ***Keying feature:*** Mechanical arrangement that allows connectors of the same size and type to mate.
- ***Grounding pin:*** Typically the longest pin used as a conductor to provide a return path for the current from a device to ground.

To calculate the carrying capacities of a battery-pack interconnect, one cannot multiply the maximum current



The TE Connectivity 5A interconnect's low mounting profile helps reduce the space needed for installation.
(*Courtesy of TE Connectivity*)

per pin by the number of contacts. The maximum current typically listed for a battery pack is for a single contact. When many contacts are used to transfer power, it decreases the maximum current-carrying capacity of the individual contacts. Assume one contact can carry 7 A. This is the total current for both power in and out. To calculate the one-way maximum current, the total current is divided by two.

The battery interconnects from TE Connectivity offer high-performing and multi-directional performance—a key feature for devices such as PCs or smartphones. Their operating temperature range is –30 to +85°C. The contacts are comprised of brass or copper with duplex plated tin, gold, or tin or gold lead solder tails and nickel on the mating area. The materials ensure the life longevity of the product and provide high cycle mating/unmating of interconnects. The housings consist of high-temperature UL 94V-0-rated thermoplastic to protect from overheating.

The newest battery connector from TE is the 5A Low Profile battery connector. Its one-piece contact design supports fast charging speeds. The 5-A current rating and 30-V dc rating help support the charging speeds. This is useful for many mobile devices, such as portable keyboards, tablet PCs, mobile phones, and navigation systems. Its dimensions also help reduce the space requirements that are needed for small and mobile devices. The base materials are copper alloy for the contacts with gold over nickel for the contact mating area. Four point positional contacts allow for development of different product configurations. md

KAREN HORTING | Society of Women Engineers

Closing the Gender Gap Through STEM

Young ladies learn about engineering at SWE's annual K-12 event, "Invent it. Build it."

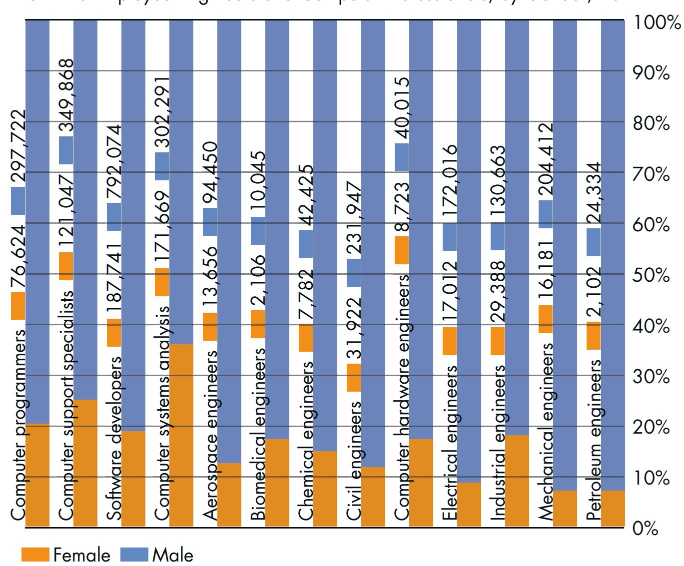
Technology is expanding faster as connectivity offers sensing and control, preventive maintenance, supply-chain optimization, and full remote control of industrial processes.

As the demand for more engineers in the workforce intensifies—the U.S. Department of Labor expects jobs in engineering to grow by 8% between 2012-2022—the need to thoughtfully groom our future engineers becomes stronger than ever. Part of that increase in jobs means putting efforts into closing the present gender gap in STEM, empowering capable future women engineers to discover their talent and find their place within the STEM pipeline.

Women remain widely under-represented in most STEM professions. While women make up over 57% of college graduates, only 14.8% of engineers in the workforce are women.[1] The gender gap in professional STEM fields varies by specialty, but it remains relatively wide across the board. For example, only (approximately) 7% of mechanical engineers, 12% of civil engineers, 15% of chemical engineers, and 13% of aerospace engineers are women.[2]

However, progress has been made toward equalizing the gender imbalance between men and women in STEM fields. Over the last 10 years, interest in majoring in engineering, math, statistics, and computer science has increased among both males and females. We are seeing the most progress in computer-engineering disciplines, with women making up approximately 36% of computer systems analysts, and 26% of computer support specialists.[3] However, overall, males are far more interested in pursuing a degree in STEM fields, with almost 27% of male

Full-Time Employed Engineers and Computer Professionals, by Gender, 2014



The graph above shows the number of engineers employed in 2014 based on gender. *(Source: U.S. Census Bureau. 2014 American Community Survey 1-year Estimates)* freshmen indicating an intention to major in engineering, math, statistics, or computer science compared to only 8% of female freshmen in 2014.[4]

BREAKING THE BARRIERS AS A YOUNG GIRL INTERESTED IN STEM

One of the ways to close the gender gap is to take efforts all the way down to the K-12 level. It has been demonstrated that the K-12 stage in life is significantly important for career motivation. K-12 is the timespan where girls first get exposed and take an interest in STEM. However, despite performing at similar levels as their male counterparts, girls' confidence and interest in engineering and math experiences a decline during middle school.

The decline can be attributed to a variety of events. Often, girls have a lack of exposure to STEM-related activities outside of school. These types of activities include computer programming, gaming, engineering (building) things, etc. Boys are naturally exposed to these things, while girls are usually more exposed more to things like dolls, cooking playsets, and dress up. Unconscious bias plays into this—parents and influencers do not necessarily know that their children are being exposed so differently and sometimes it just happens naturally.

Engineer Sylvia Acevedo talks to girls at "Invent it. Build it" about being a woman engineer.

The unconscious bias plays inside and outside of school, all the way up to the collegiate and professional level. Many people do not see STEM opportunities as a viable opportunity for girls. Therefore, girls who express an interest in STEM early on often lack encouragement to pursue these fields, while their male counterparts receive full support from teachers, parents, and other influencers.

Finally, many girls, minorities, and even boys may experience a general a lack of resources in school and their community. Many public school districts are cutting programs, and often times, STEM-related programs are the first to go. Moreover, many communities do not even offer these programs in the first place. Federal support of STEM education is moving the needle, but we still have a way to go.

THE IMPORTANCE OF INFLUENCE AND MENTORSHIP

Parents, guardians, and teachers—all adult influencers—usually take on an important mentorship role when it comes to STEM influence, engineers by trade or not. Adult influencers do not have to be engineers or technologists to make an impact. In fact, the top influences on choosing to pursue science and engineering have been found to be your parents and your K-12 teachers.

Parents, teachers, and guardians will play the most important role in helping young girls overcome the unconscious bias and lack of support for girls in STEM. If there is potential, it is up to these influencers to turn it into something successful. Most women engineers you talk to will say they became an engineer because a parent or teacher saw something in them, told them what an engineer does, and encouraged them to eventually become one.

Outside influencers are just as important, though. Women engineers have an opportunity to play a big role in encouraging our young, future engineers. You cannot be what you cannot see, making women engineers so important in driving change.

WOMEN IN MODERN ENGINEERING

Women in engineering are still facing adversity in the workplace. Many STEM industries remain generally male-dominated and, therefore, isolating to women occupying positions at these organizations. Many Society of Women Engineers (SWE) members can tell stories about receiving surprised looks from their male colleagues when they step out into the field, or take control of a meeting in the office.

The adversity can be attributed to unconscious bias—many do not even realize they are doing it. Some simply do not view engineering as a sustainable career option for a woman. That view trickles down to the K-12 level, so we must dispel these myths, prove ourselves, and influence our younger female counterparts.

Showing young girls what an engineer looks like is one of the most significant impacts a woman engineer can make. Talking to young girls and showing them that women are just as capable as men will change the misguided perception of an actual engineer.

One of the ways that our SWE members accomplish this goal is by participating in outreach activities in their local areas. For example, you can talk to the science teachers at your local schools to organize informal presentations so that students can learn more about what you do as an engineer. You can arm them with resources to learn more about engineering; therefore, when you step outside the classroom, it will extend your influence.

Getting in front of students will give you the opportunity to tell them about groups like National Center for Women & Information Technology's "Aspirations in Computing" (https://www.ncwit.org/programs-campaigns/aspirations-computing), a high school program you can join online, connecting you with role models and other peers. The program connects girls with young women already studying computer science and doing things like creating their own apps.

Girls Who Code (*https://girlswhocode.com*) is another great program where young girls interested in computer science can get information, support, and hands-on experience. Being part of networks like this is very powerful, and from here, girls can discover more activities happening locally that will foster their interest in STEM.

Organizations like SWE are helpful, too. Our members will talk to young girls about the resources we offer, including SWENext, a program for girls under 18 that provides resources to help them on their path to pursuing engineering—scholarship opportunities, engineering camps and competitions, webinars featuring engineers from different disciplines talking about a day in their life, mentors, and other resources for families and educators that can help promote a career in engineering to young girls.

Another way to influence young girls in your area is hosting events and showing girls what engineering is all about. You can host these in conjunction with schools, local camps, or your company. Visit Design Squad's website (http://pbskids.org/designsquad/) to find simple activities you can do with girls to show them the fascinating world of engineering.

Many professional women engineers attribute where they are today to role models and mentors—sometimes parents, sometimes teachers, and many times other women engineers. Showing young girls what a women engineer looks like will give young girls the confidence to go out and be that engineer themselves. md

KAREN HORTING is the Executive Director & CEO for the Society of Women Engineers (SWE), overseeing the non-profit organization's global initiatives in support of women in engineering and technology.

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5. Seth, Deeksha, "Building on the experience of enthused women engineers to enhance gender diversity in engineering," presented at the Society of Women Engineers Region E Conference, Philadelphia, Pa., 2015.

Products

1.5-kW Power Supplies Targets Intermediate Bus Architectures

THE PFE1500-12-054XA AC-DC power supply converts AC-mains power into a 12-Vdc, 1500-W main output for powering intermediate bus architectures (IBA) in servers, routers, and networks. System communications follow I2C/PMBus protocol to fully monitor the input and output voltage, current, power, and inside temperature of the supply. Fan-cooled, it can be integrated with matching airflow paths, and adjusts the fan speed automatically depending on the power demand and temperature. Status information is provided with front-panel LEDs.

BEL POWER SOLUTIONS, (866) 513-2839, *www.belpowersolutions.com*

Sensitive Grippers Offer Variable Force Ratings

GRAMFORCE PNEUMATIC grippers operate at pressures ranging from 0.02 to 0.7 MPa and offer holding forces as slight as 0.25 N (0.056 pounds) and as high as 8.6 N (1.9 pounds). Internally driven by two 5.6-mm bore, ultra-low friction pneumatic actuators, their synchronous and counterbalanced parallel design maintains steady gripping force in any mounting orientation. For installation, carriage blocks can be mounted on an IKO-precision stainless-steel rail, which also enables easy mounting of holding jaws. They require no lubrication and work in ambient temperatures ranging from -20°C to 80°C. With a useful life of 5 million cycles, they weigh a mere 206 grams and measure less than 50-mm high, 79-mm in length, and 26-mm wide.

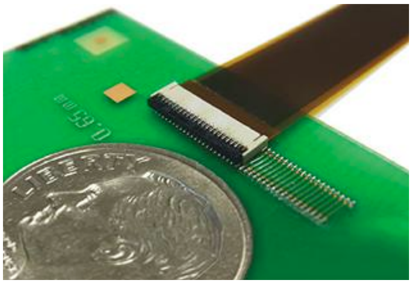
AIRPOT CORP., (203) 846-2021, *www.airpot.com/grippers*

Contactless Linear-Position Sensors are Low-Maintenance

WITH NO moving parts and virtually contactless components, LR-27 linear variable-inductance transducers (LVITs) are claimed to outperform other contactless linear-position sensing technologies including linear variable differential transformers (LVDTs) and magnetorestrictive sensors. The LR series of LVITs includes four ranges from 50 to 200 mm (2 to 8 in.) They have a near-unity stroke-to-length ratio. They are offered in radial cable-exit versions with swivel rod-eye ends, as well as in axial-termination versions with either an M-12 connector or a 1-m cable. They operate from a variety of DC voltages and offer four analog-output choices. They target factory-automation applications, and heavy-duty commercial and industrial applications including solar-cell positioners, wind-turbine prop pitch and brakes, chute or gate positioners on off-road or agri-vehicles, position-feedback systems for robotic arms, and packaging equipment.
ALLIANCE SENSORS GROUP, (856) 727-0250, *www.alliancesensors.com*

Signal Conditioner Accepts Wide Range of Inputs

THE APD 8000 signal conditioner accepts thermocouple, RTD, thermistor, dc, or potentiometer inputs, and converting it to optically isolated DC-voltage or current output. It can be set up or calibrated via onboard switches and pushbuttons, eliminating the need for a computer or special programmer. In addition, its microprocessor-based linearization and low-noise 18-bit analog output are offered with ±0.1% accuracy. A variable-brightness LED indicates the input-signal level and an output-test function is included in the design.
ABSOLUTE PROCESS INSTRUMENTS INC., (800) 942-0315, *wwww.api-usa.com*



Dual-Sided Connectors Target Wearable Electronics

THE FH58 SERIES of flexible printed circuit (FPC) connector supports USB 3.0, embedded DisplayPort ver1.3, and MIPI D-PHY ver1.1 standards. A "back-flip" style actuator with dual-sided electrical contacts offers space savings, excellent impedance characteristics, and high-speed transmission, along with high retention forces in medical, consumer, point-of-sale, and portable electronics. Flexible and weighing only 0.046 g, the FPC connector is also useful for wearable electronics. It has a 0.2-mm pitch, 3.1-mm mounted depth, and a height of 0.9 mm.

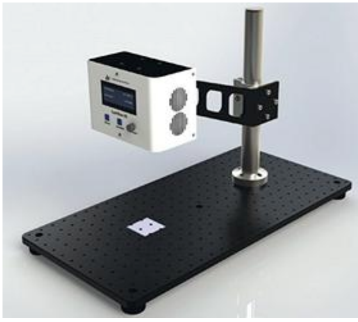
HIROSE, (805) 522-7958, *www.hirose.com*

Motorized Axial Fans Feature Speed-Controllable PSC Motor

AMI MOTORIZED AXIAL FANS are available with open-blade, ring, or panel designs. Featuring a single-phase permanent split capacitor (PSC) motor, they are speed controllable and offer IP44 motor protection, Class F insulation, and UL and CE approval. They operate in ambient temperatures ranging from -40 to 158°F and are designed so that the motor an impeller are located directly in the airstream for optimal cooling. Matching capacitors are available. Model sizes range from 170 to 300 mm, and air displacement capacities range from 300 to 1,700 cubic feet per minute. They target applications with limited space including fume hoods, clean-room modules, electronic-cabinet cooling, and air filtration.

CONTINENTAL FAN, (800) 779-4021 *www.continentalfan.com*

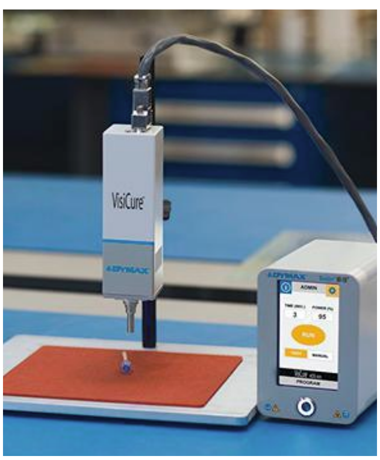
LED Solar Simulator Reaches Full Irradiance Upon Activation



THE LUMISUN-50 high power, multi-wavelength LED solar simulator features high energy efficiency, a compact design, and controllability in comparison to traditional xenon or metal-halide arc lamps. It meets IEC 60904-9 Class AAA solar-simulator requirements. It offers continuous, flashed, or pulsed modes, and its total irradiance ranges from 0.1 to 1.1 sun units. It instantly reaches its irradiance setting when turned on, rather than needing time to warm up. Targeting terrestrial photovoltaic testing and PV research, it features a low-maintenance and mercury-free chip-on-board (COB) LED die array. It has an air-cooled housing and covers a 50 x 50-mm field of illumination at a working distance of 200 mm. Angular-beam rotation is possible with positioning guided by a converging pair of red-dot laser pointers.

INNOVATIONS IN OPTICS, INC. (IOI), (781) 933-4477, *www.innovationsinoptics.com*

LED Spot Curer Ensures Consistency at Long Working Distances



THE BLUEWAVE MX-150 LED spot-curing system can be integrated into an automated system, or used as a benchtop unit. LED emitters are available in 365, 385, or 405-nm wavelengths, and offer consistent curing intensities, even when mounted far from the controller on robotic arms. Equipped with a controller and touchscreen interface, the unit can also be activated by a foot pedal or through a PLC interface.

DYMAX, (860) 482-1010, *www.dymax.com*

Linear Stages Can Be Stacked for Two-Axis Operation

LINEAR STAGES from the PCL50 Series offer micron-level repeatability and accuracy for travel lengths up to 400 mm. Their design integrates a 5-mm (or 10-mm upon request) ballscrew drive with long-lasting recirculating ball linear bearings. They target applications in assembly, inspection, and material handling, and can be used individually or directly stacked for XY configurations. They support mounting on PLG110 linear stages and PDR110 rotary stages, and can be directly stacked on the PCL65 series. Standard features include forward- and reverse-limit sensors, a standard NEMA23-motor mount, and a protective hard cover.

PRIMATICS, (541) 791-9678, *www.primatics.com*

Chokes Offer Protection, Energy Savings in Rail Apps

THESE IP66-RATED chokes protect against water and dust for mounting onto the exterior of inverters in rail-vehicle and oil-rig applications. This placement eliminates the need for cooling systems on the inside of the inverters to save energy in the overall system. Since the chokes are externally mounted, they avoid the high temperatures of the inside of the inverters, which can reach 70 or 80°C in railway applications. The chokes' coating protects against ambient temperatures as high as 40°C. Resistant to intense sunlight, seawater, rain, and chemical gases, they come with special mounting fixtures for external mounting and wires can pass through the interior through a sealed opening. In addition, inductive components including single-conductor chokes, individual chokes, and choke modules or filters are offered.

SINTERMETALLE PROMETHEUS GMBH & CO KG (SMP), (414) 380-9730, *www.smp.de*

Dust-Monitoring System Identifies Nano-Range Air Impurities

THE AIRWATCH dust-monitoring system employs an integrated ventilator and internal laser system to detect dust and other impurities in the air, ranging from 100 nanometers to 16 microns. This range includes fine-dust categories PM2.5 for alveolar common dust (A dust) and PM10 for all inhalable dust (E dust) as defined by the World Health Organization. A traffic-light style LED display shows low, medium, and high dust concentrations; concrete values can be viewed via smartphone or tablet, and the system will automatically classify the captured particles. AirWatch can be mounted on the ceiling, wall, or a versatile pedestal.

KEMPER AMERICA INC., (770) 416-7070, *www.kemper.eu/en*

Conveyor Safety Switches Enable Instant Emergency Stop

THE GLHD SERIES of safety-rope switches can be mounted onto machines and sections of conveyors that cannot be protected by guards. These stainless steel heavy-duty switches protect conveyor lengths up to 250 m. Unlike traditional mushroom-head emergency stop buttons, these switches can initiate the emergency command from any point along the installed rope, and provide robust emergency stop and rope-pull protection for exposed conveyors or machines. They conform to ISO13850 and EN60947-5-5 standards for indoor and outdoor use. With a washdown NEMA 6 (IP67) rating, they can be used in conveyors for the chemical, water, electronics, automotive, and warehousing/shipping industries.

OMEGA ENGINEERING, (203) 359-1660, *www.omega.com*

Inner-Diameter Grinding Pins Feature Carbide-Shanks

The **CMPD-016 AND CMPB-016** micro diamond and borazon grinding pins can be used for extremely small inner-diameter grinding. With diameters starting as small as 0.016-in., they are mounted onto a carbide shank for improved strength and precision. Their working end is coated with diamond or borazon with 500/600 grit. Meanwhile, 325/400 grit is available for models with 0.020 and 0.024-in. diameters.

TITAN TOOL, (716) 873-9907, *www.TitanToolSupply.com*

Length Gauges Offer Serial Interface Monitoring

The ACANTO 1217 and 1218 length gauges feature pairing with the bi-directional serial interface, EnDat 2.2, for diagnostics and error monitoring in real time. With an accuracy of +/- 1 micron and a stroke length of 12 mm, ACANTO gauges can be used for in-process measurements in automotive and medical-device manufacturing, and in fixed gauging stations. Models are offered with IP ratings of IP64 or IP67. The new interface enables storage of past datum for uninterrupted use after powering on and off.

HEIDENHAIN CORP., (847) 519-3296, *www.heidenhain.us*

LITERATURE Express

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Cincinnati, OH
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ALTECH CURRENT LIMITING CIRCUIT BREAKERS

Current limiting circuit breakers minimizes the short circuit current to a relatively small amount in an extremely short time. This minimizes the harmful short circuit potential energy.

Other Features:
DIN Rail Mounted
17.5mm width
Thermal Magnetic
AC: 240V, 480Y/277V AC, 50/60Hz
DC: 125V DC (1 pole); 250V DC (2pole)
10kA Short Circuit
Interrupting Capacity
HACR Type 40°C
Line/Load reversible

Visit ***www.AltechCorp.com*** or call ***908-806-9400***

ALTECH INDUSTRIAL ENCLOSURES

Altech offers a broad selection of non-metallic and aluminum Industrial Enclosures to meet your diverse design requirements.
Sizes range from 1.97 x 2.05 x 1.38 to 35.43 x 11.81 x 5.59 inches.

Materials include polycarbonate, polystyrene, polypropylene, ABS or aluminum.
Polycarbonate and aluminum series have been recently expanded.
Protection up to IP67 (NEMA 4, 4X).
Smooth sidewalls or sidewalls with knockouts.
Enclosures can be mounted directly onto a panel, frame or other mounting surfaces.

EMI / RFI Coating is available.
Competitive cover printing is available.
Hinge Kits.
Customization available.

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ALTECH DC-UPS SOLUTIONS

Altech has a full line of DC-UPS solutions which include the All-In-One DC-UPS for battery based systems and Ultra Capacitor DC-UPS (no battery).

All-In-One DC-UPS:
- Power supply, battery charger, battery care module and backup module in one device
- Three charging modes
- Available in 12VDC, 24VDC and 48VDC
- Adjustable charging current up to 35A
- Easy battery diagnosis and fault identification

Ultra Capacitor DC-UPS:
- Environmentally safe, no toxic chemicals
- Virtually maintenance free
- Operating temperature range -40°C to +65°C
- Available in 12V DC or 24V DC
- Customized systems up to 600A available
- Higher power vs. batteries
- Resists shock and vibration

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ALTECH SOLID STATE RELAYS

Solid State Relays (SSR) are fully electronic, there is no moving parts inside SSR; they have no audible noise, withstand significant vibration without operating problems, have fast response time, but most of all they have higher life-time expectancy.

Used in appropriate operating conditions, SSRs have nearly unlimited life versus 100K cycles for Electro Mechanical Relays (EMR). SSRs don't require any maintenance and prevent manufacturers from unforeseen machines/production stop, which is a great advantage with 24h/24 industrial activity.

Product Offering:
- Single, Two and Three Phases
- Solid State Relays for Motor Control
- Phase Angle Controllers • DC Solid State Relays
- Special Relays / Special Customer Products
- Heatsinks • Accessories

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PRODUCTS/SERVICES

Ad index

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BRADFORD L. GOLDENSE | Contributing Technical Expert

Measuring Product Development Effectiveness

What is "Effectiveness"? It is the degree to which something is successful in producing the desired result. Effectiveness in product development is still elusive. Pharmaceutical companies believe they should get a larger percentage of trial drugs successfully through clinical trials. High-tech and consumer industries believe they should have better than a 90% failure rate. In general, industry average failure rates run around 40% to 50%. Yet, except for a small number of products where management just crosses their fingers, products approved into the pipeline are expected to create revenues. And, half or more of the time they do not.

Contrast this to current manufacturing operations in this day and age. Most plants have been running close to perfection for the past 30 years. They count defects in parts per million; and a good percentage of the work force has Six Sigma Black Belts to assure this remains the case. How different is that from product development!

R&D, product development, product management, marketing, and select groups of other business functions are not yet mature enough to primarily focus on productivity. But, because of the success of this metric in mature business functions, senior management is forcing productivity metrics into every business function.

How much more should a company spend to "save" a product that will otherwise die on the vine due to an overloaded pipeline? That "saved" product more than pays for any additional (unplanned) monies spent because of the multiple. Backing further upstream, how many approved products should a company not have approved so that fewer died on the vine? As well, how much of the time spent on vine-dead products could have been reallocated to the rest of the products in the pipeline to assure their success? Were any of the vine-dead products caused by subpar engineering or designer skill sets? What if the company spent a few extra thousand on training and it resulted in an additional product being saved and launched? Doesn't that few extra thousand more than pay for itself? Any of these scenarios will result in higher pipeline yield and lower failure rates. At 3 to 15x revenue multiples, it would be cheap money spent.

Effectiveness = Output Achieving The Intended Results

These are but a few examples of places where the effectiveness of product development could be significantly improved. There are dozens more. Management will never ever reduce their demand for output. Therefore, because productivity is output divided by input, productivity in product development means reducing the input. Will less input cause product development to become more effective or more mature? Wouldn't spending a bit more unplanned money when needed actually increase output which, in turn, would increase both effectiveness and productivity at the same time given multipliers of 3 to 15x?

BRADFORD L. GOLDENSE is founder and president of Goldense Group, Inc. (GGI) (www.goldensegroupinc.com), a consulting, market research, and education firm focused on business and technology management strategies and practices for product creation, development, and commercialization. He has been an adjunct faculty member of the graduate engineering school at Tufts University's Gordon Institute for 19 years.

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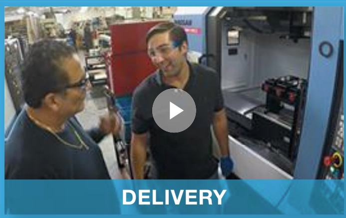

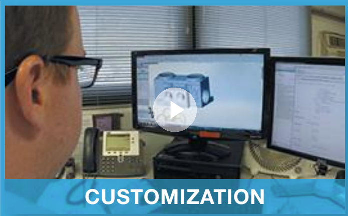

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