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BY ENGINEERS FOR ENGINEERS

September 20, 2012
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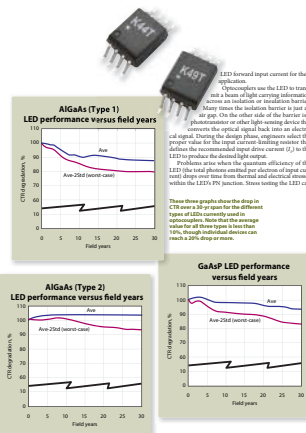
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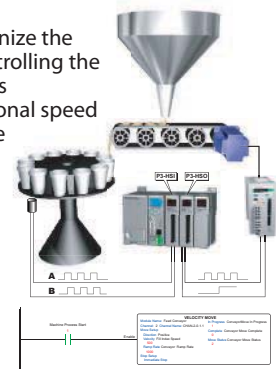
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RECON micro unmanned aerial vehicle from **BCB International**. The VTOL quadrotor weighs less than 200 gm, has a 2.5-km range, flight duration of 25 min, and is packed with a full suite of sensors. Ivan Reedman from **Torquing Robotics** tells us about an even smaller prototype as well as the firm's Spartan C4i helmet-mounted neural

interface control system. See it at www.engineeringtv.com/video/SQ-4-RECON-Micro-UAV-AUVSI-Unma;Only-Engineering-TV-Videos.

Express motors site

Pittman Motors and **Haydon Kerk Motion Solutions** have launched a new Web site that lets visitors evaluate and order a range of precision motion components for 24-hr shipment. Products include stepper-motor linear actuators; precision leadscrew and antibacklash nut assemblies; dc brush, brushless, and gearmotors; and gearboxes, brakes, and linear rails. The site includes downloadable performance data, outline drawings, detailed spec sheets, and CAD models. Visit www.PittmanExpress.com or www.HaydonKerkExpress.com for more information.

New robots site

Epson Robots has launched a new Web site at www.epsonrobots.com. The Toolbox section helps users make informed decisions on SCARA and six-axis robots as

well as linear modules, controllers, and other options. It includes 3D-CAD files, application videos, white papers, case studies, product brochures, photos, and manuals. The site also offers in-depth application support, training materials, and FAQs for easy troubleshooting.

Conveyors catalog

Information on all major conveyor platforms can be found in **Dorner's** new 320-page Full Specifications catalog. It covers sanitary, precision, and many other types for assembly, manufacturing, and packaging. Content includes conveyor comparison and selection charts, specs and performance data, and schematics, as well as details on motor controls, gearmotors, support stands, accessories, belting options, and a belt-selection guide. Request or download a copy at www.dornerconveyors.com.

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If **Steve Jobs** had run the **Mars Rover** project

The late Steve Jobs of Apple was known for berating subordinates harshly and telling them they never did anything right. A recent *Wired Magazine* related a story about Jobs and an Apple subscription service called MobileMe, which went badly off the rails during development. According to *Wired*, Jobs screamed at MobileMe employees from a stage in an Apple auditorium in the wake of the debacle, chewing them out for their performance, and finished up by firing the team leader on the spot.

So it is interesting to speculate how Jobs might have run NASA's Mars landing program, particularly because, despite the recent success of the Mars Rover, the program has had its share of setbacks. In the late 1990s, the Mars Climate Orbiter, Polar Lander, and Deep Space 2 missions all wound up as piles of rubble on the Martian surface because of technical screw-ups. After the Mars Climate Orbiter was lost over the Red Planet in 1999, NASA investigated and found problems with a software routine managing thrusters that compensated for angular momentum. It had been programmed in pounds-second instead of Newtons-second. The trajectory-modeling software that used the information consequently made a big miscalculation. The craft ended up 170 km closer to the planet than expected at the critical point of atmosphere insertion and couldn't recover.

The Mars Polar Lander and two Deep Space 2 probes also were lost in 1999 as they entered the Martian atmosphere. Investigators traced the probable cause of the Polar Lander problem to premature shutdown of the descent engines when transient signals triggered a touchdown sensor. The failure-analysis team was never able to nail down the exact cause of the Deep Space 2 loss. But they did discover a lack of system-level testing that, they felt, probably contributed to the failure. For example, the probes were never impact tested when they were electrically powered, nor was the flight battery impact-tested as a unit. All in all, NASA engineers had overrelied on simulations rather than on physical testing in an effort to keep costs down and to stay on schedule.

Had someone with a Steve Jobs management style been running the Mars program in the 1990s, it's not clear who would have been left standing to learn from mistakes. That's one of the consequences when you fire whoever led the team that blew it. Remaining team members won't want to stick around to find out what happens the next time something hits the fan.

The probable outcome: A new set of people who also can't do anything right. They'll likely create more piles of rubble on Mars via mistakes old hands could have warned them about. But all the old hands have scattered to the winds.

There is, in fact, a point in NASA's history that illustrates what can happen when there is no one around who remembers previous lessons learned: Chroniclers of the 1960s-era moon-shot program say there were serious problems with early Apollo hardware because Apollo engineers took a "not invented here" attitude toward achievements in the earlier Gemini program. Historians blame this kind of culture at least partially for the launch-pad fire that killed three astronauts in 1967.

— Leland Teschler, Editor

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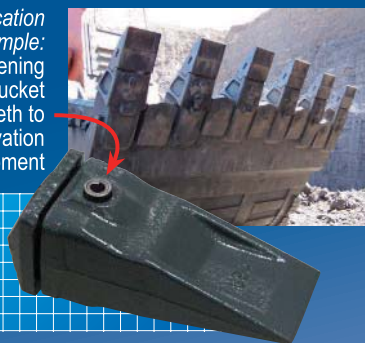
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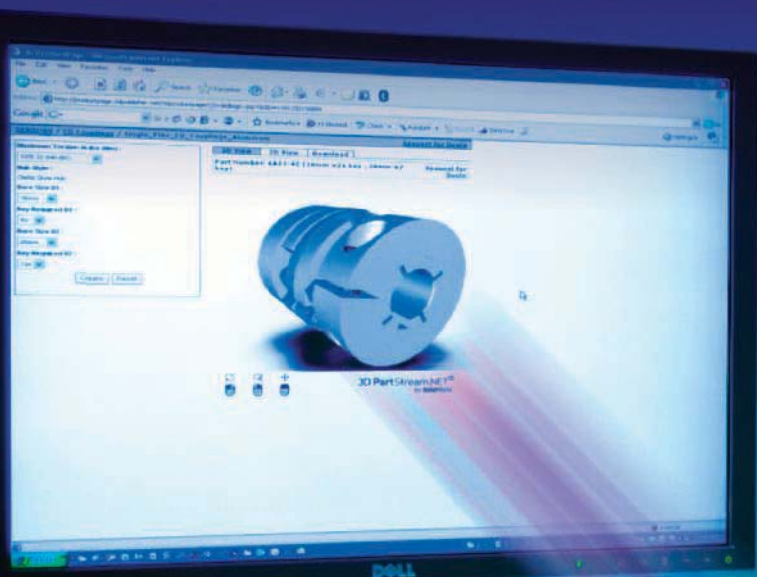
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Chinese and Indian engineers

I believe the information you presented in your commentary ("The Myth of Chinese and Indian Engineers," July 19) accurately reflects what is going on in the U.S., as well as other countries, in terms of engineers and engineering education.

I am so tired of the political spin on data and jobs. It seems nearly impossible to get "real" information these days unless, like you say in your article, one personally does the legwork and makes hours of phone calls. I have been an engineer for 30 years and I am an engineering manager these days. I have never had a problem finding good engineers as long as we pay them well.

I also agree that China and India, as well as most other countries, have thousands more technical, environmental, political and social issues to resolve than we do here in the USA. Indeed, lots of engineering work needs to be done in those places.

I am also disenchanted in the watering down of the title of engineer. It was mentioned in the commentary and I see it daily here in the States. Many folks claim to have the title of engineer but have had no formal training in engineering, problem solving, mathematics, materials science, or electronics and physics, for example. It is a disgrace to the profession that so many folks call themselves engineers without the formal training or certifications.

Jim Adams

In my experience, H1B visa programs give the U.S. better engineers, on average, than most of our homegrown graduate engineers. Do these immigrants/visitors work harder and for lower salaries? Of course, that has been the trend for first-generation Americans since the 17th century. Do they affect the salaries that you and I earn? You bet they do. They also increase the country's productivity, make us more competitive internationally, and decrease the likelihood that our own jobs will be outsourced. My advice is to be challenged by your H1B coworkers.

Engineers: Apples-to-apples comparisons

Most readers are confident that their engineering education puts them miles ahead of their Indian and Chinese counterparts. But one says H1B engineers are better than U.S. engineers and that they make the country a better place to live.



Learn from their work ethic and cultural diversity and move on.

Larry Roberts

There's more than meets the eye here. The push to outsource engineering talent in exchange for lower costs is the bottom line. At my company, there is an edict that 30%+ of the engineering budget (many millions of dollars) must be performed offshore. The excuses range from "there's a shortage of engineers in the U.S." (a lie) to "we must give technical work to other countries (China, India, and Russia) or risk being cut off from bidding on projects in those countries" (another lie).

At the company I work at, we have seen that the engineers in the offshore countries we do business with can't do the work as accurately or efficiently as we can, and this happens over and over again. In addition to what we pay them, we spend 50% more than if we did it in-house here in the States. When we complain about what is happening, we're told to do whatever it takes to make the overseas engineers successful, even if it means handing over proprietary designs. Disgraceful.

Paul Zigsby

Let me get this straight. Foreign countries have the best workers and the best engineers, but America has the best managers. Yeah, right. My question: When do we outsource management?

Bernie Pragle

I travel internationally and although there are some good engineers in other countries, most overseas engineers are little more than paper

tigers. Everyone seems to get a Master's and a Ph.D., but those degrees don't mean much. When one attempts to work with those engineers, it quickly becomes obvious that a degreed engineer in the U.S. and a degreed engineer from another country are rarely the same thing.

Dave Vyde

Finding a few good engineers

I agree with your editorial ("A Better Way to Find Stand-out Engineers," July 19) that resilience is an important factor when hiring engineers. I've always felt that earning an engineering degree in four years rather than five or more, and getting decent grades on top of that, demonstrates the resiliency needed to become a good engineer.

Robert Matz

A bigger problem with hiring engineers these days is that many large companies only accept resumes submitted electronically to an HR department. Then the HR person just tries to match key words in the job description to those in the resume. Sure, some candidates end up getting an interview, but how many stand-out candidates get overlooked because the resume and job description didn't use the same wording?

Carl Tillis

There is a shortage of engineers in this country and the reasons are obvious: low wages, long working hours, and poor working conditions. To suggest that simply "encouraging" those to go into a given profession as a solution is laughable ("An Educated

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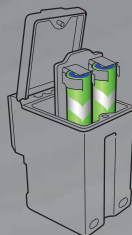
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Workforce is Key to Reshoring," July 19). There has to be an incentive for a person to pursue a particular career path, and a big part of that is earnings. It's nearly impossible to "love your work" if you choose a career path in engineering in the U. S., irrespective of one's salary. Corporate America already views this profession as overpaid. Just look at the amount of money spent lobbying to expand H1B programs. Wall Street and the MBAs have destroyed this country, there is not much that can be done to restore it. The only exception I can see to this would be to employ more engineers in managerial positions. I doubt this will ever happen. Just look at the CEO of Intel. He doesn't have an engineering degree.

Joe Bonasses

Ethanol scam

I am generally disgusted with the whole alternative-fuel debate, pri-

marily because it is driven entirely by politics of various flavors, rarely by real science. A huge subset of the discussion relates to transportation fuels, primarily because that is the biggest issue that people see and feel directly, and that's what a recent article addressed ("Should the U. S. Switch to Natural Gas for Transportation?" Aug. 9).

But the article ignored the politics behind the motor-fuel debate. For example, we burn about one-third of our corn crop after fermenting it into ethanol. The benefits and costs of doing this might be dubious and debatable to some, but not to the millions of South Americans that go to bed hungry every night because their main food source has doubled in price.

There's a company with a process that converts natural gas into ethanol for \$1.50/gallon. Unfortunately, EPA micromanagement prohibits the use of ethanol in fuels that are not derived from fermentation. This man-

LETTERS TO THE EDITOR

Please include your name, address, and daytime phone number. Letters may be edited for brevity and to focus on essential points.

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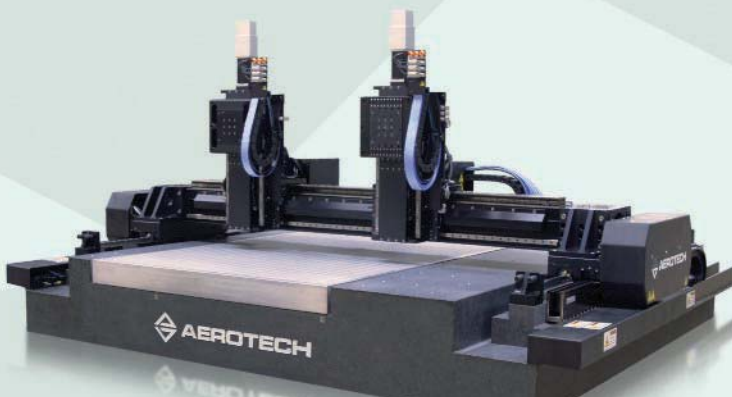
E-mail, Editorial: mdeditor@penton.com

date obviously has nothing to do with the environment, nothing to do with reducing our dependence on foreign oil, and everything to do with the farm lobby and their newfound friends who own ethanol plants.

This summer's drought will depress crop yields, driving prices up unless there's a reduction in demand. We can be sure the EPA will not relax their foolish mandate, even under these almost dire circumstances. It is too bad we can't try free-market capitalism for a change. Instead we are stuck with a micromanaging dictatorship from Washington.

Kevin C. Baxter

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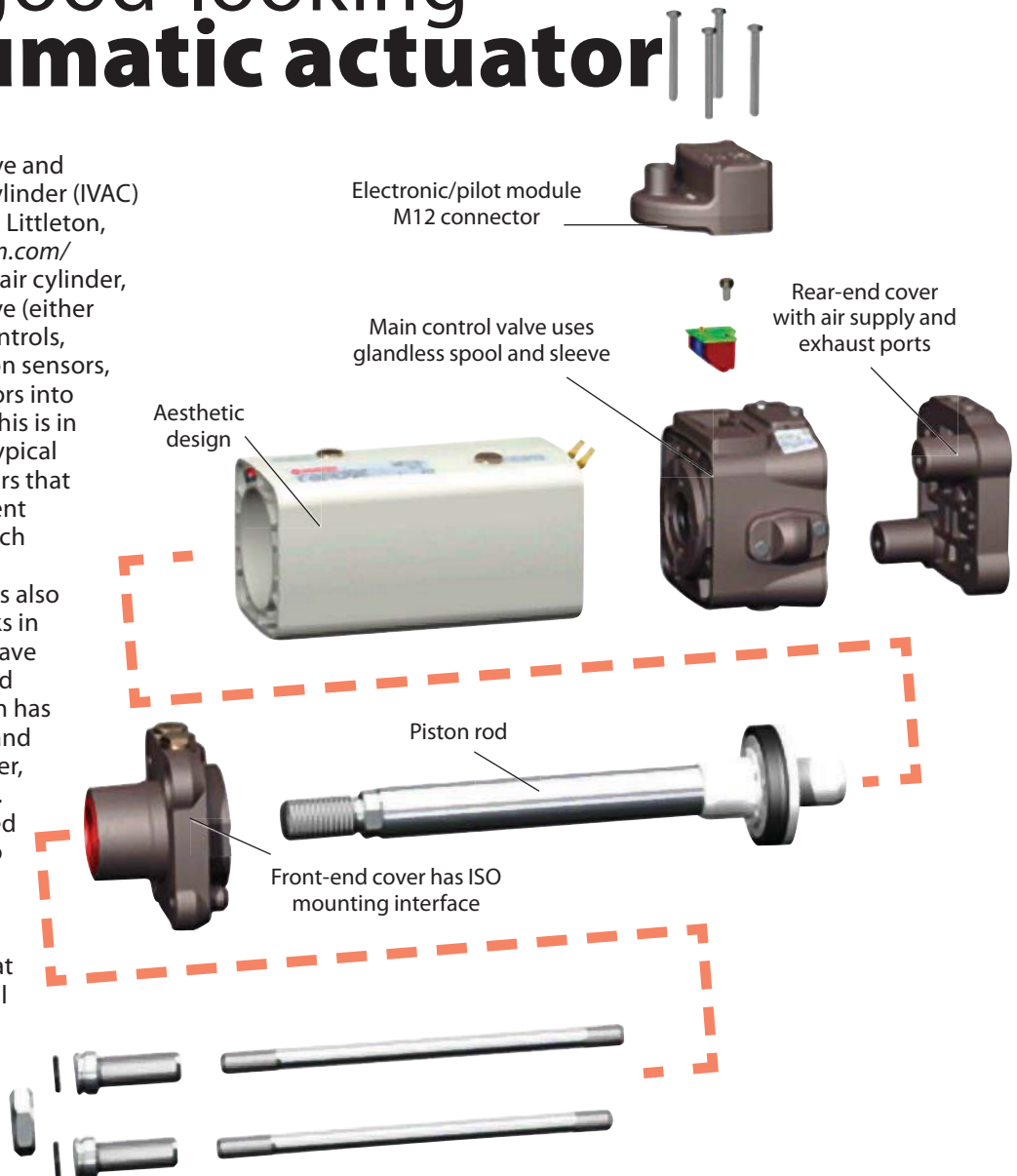
The integrated valve and actuator-control cylinder (IVAC) from **Norgren Inc.**, Littleton, Colo. (www.norgren.com/ivac), combines an air cylinder, the pneumatic valve (either 5/2 or 5/3), flow controls, cushioning, position sensors, and speed regulators into a single package. This is in sharp contrast to typical pneumatic actuators that use up to 13 different components for each actuator function.

The actuator was also designed with looks in mind. Customers have already commented that installing them has given their plants and equipment a cleaner, more modern look. And the streamlined housing is easier to clean compared to the standard array of cylinder, valves, and connectors that make up traditional setups. For food applications that see frequent wash downs with harsh detergents, a cleanline version of the IVAC puts all the switches and the valve inside the housing. The cleanline version carries an IP67 rating.

To keep installation and maintenance simple, the actuator has only one pneumatic and one electrical connection. So there is no need for valve islands, tubing, or other accessories. The lack of tubing minimizes "dead" volume and reduces air consumption by up to 50%. Reducing the amount of compressed air used also cuts down on

energy costs.

The actuator is sized to fit in the same footprint as standard actuators (ISO 15552), making retrofitting easy. Maximum air pressure of the IVAC is 118 psi. Bore sizes range from 32 to 100, and the maximum force exerted by the actuator goes from 148 to 1,436 lb. Strokes go from 25 to 1,000 mm.



RS# 401

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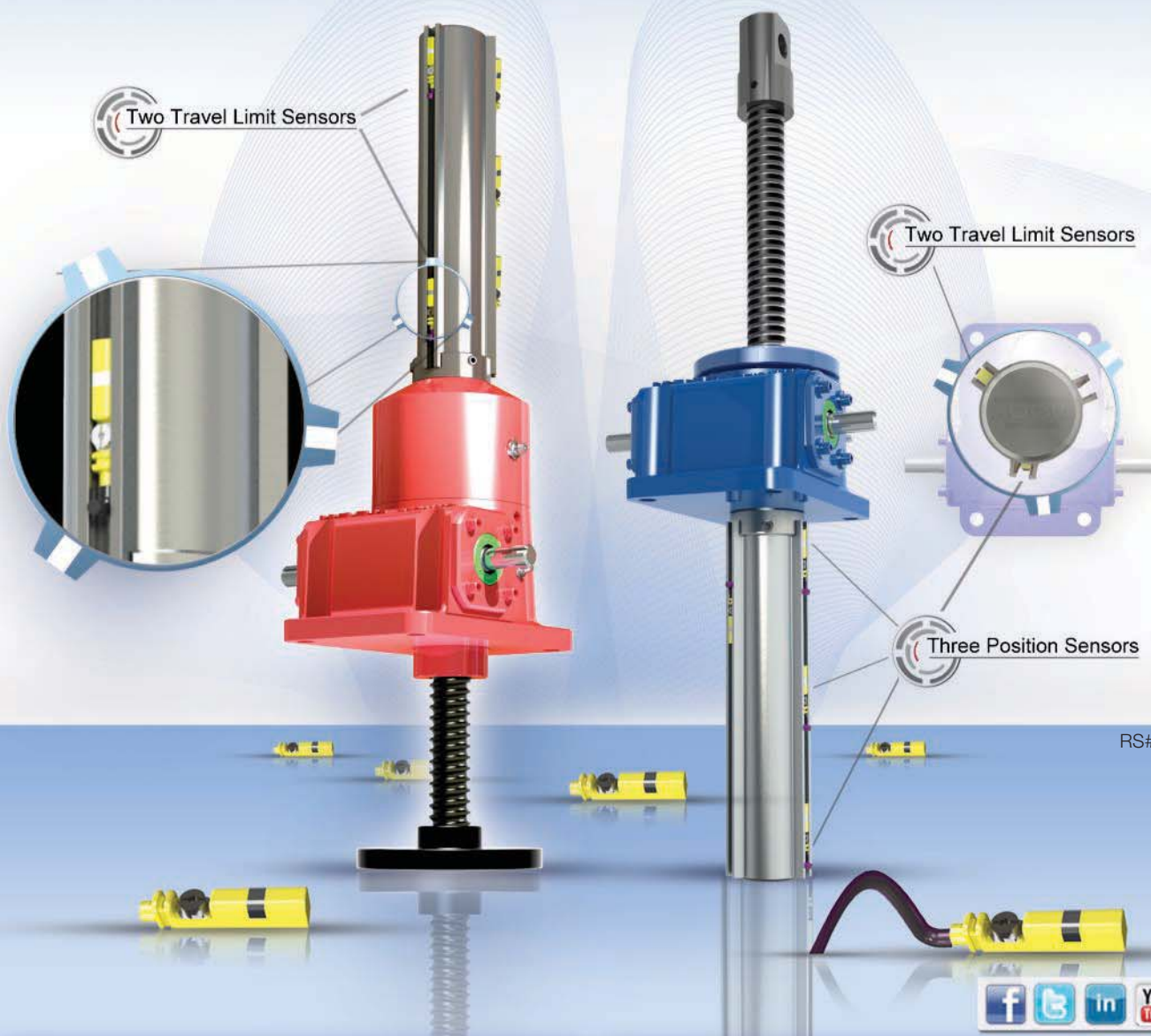
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RS# 115

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- Zero sensor maintenance



Nut-and-bolt fastener resists vibrations and fatigue

The new Huck 360 nut and bolt from **Alcoa Fastening Systems**, Waco, Tex. (afsindustrial.com/huck360/), resists vibrations and doesn't loosen regardless of the vibrations or environment. It can also be installed quickly using standard tooling.

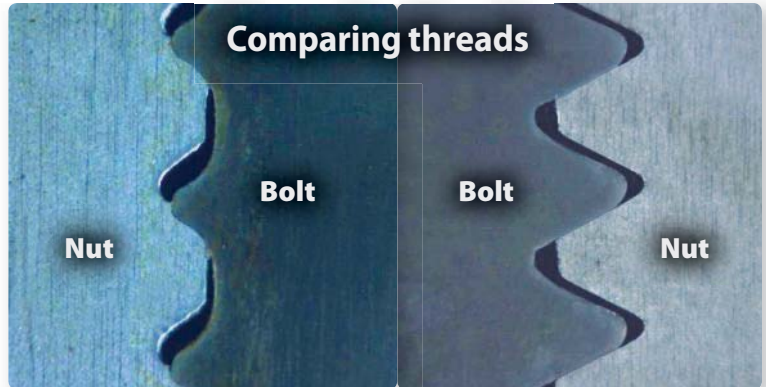
Key to the fastener's vibration resistance are nut threads that are softer and thicker than the bolt threads. So when the nut is tightened on the bolt, the bolt threads become embedded in the nut threads, eliminating any gaps between the nut and pressure flank and crest of the bolt thread. This prevents movement of the nut, which can lead to loosening, and lets the fastener absorb high spike loads.

The bolt threads are also not as deep as standard threads, resulting in 18% more cross-sectional area than conventional bolts. And the radius of the bolt thread's root is up to three times larger than those on most other bolts. These two factors give the Huck 360 up to five times the fatigue strength of conventional bolts.

The nut is designed to quickly spin onto the bolt without tools, although a standard wrench is needed to apply the fastening torque. In studies, the bolts install in one-third the time needed for conventional locknuts. The fastener can be removed with conventional tools.

The nut is dyed red for easy identification.

The bolts come in Imperial ($\frac{3}{8}$ to $1\frac{3}{8}$ -in.) and metric (12 to 36-mm) diameters, and have tensile strengths that meet or exceed Grade 8 and Class 10.9 requirements.

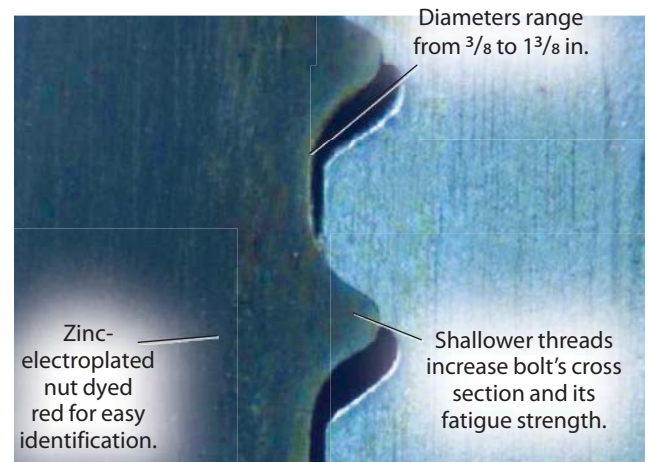


HUCK 360

CONVENTIONAL LOCKNUT

Nut held in place.

Nut can move relative to bolt



Diameters range from $\frac{3}{8}$ to $1\frac{3}{8}$ in.

Zinc-electroplated nut dyed red for easy identification.

Shallower threads increase bolt's cross section and its fatigue strength.

RS# 402



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Composites let van shed half a ton

Use of composites let engineers redesign a walk-in commercial van and eliminate nearly 1,000 lb, which means the van will meet upcoming greenhouse-gas emission requirements for vocational vehicles. The van, developed by **Utilimaster**, Bristol, Ind., a wholly owned subsidiary of **Spartan Motors Inc.**, Charlotte, Mich., is called the Reach and was a joint project between Utilimaster and **Isuzu**.

The lightweight composites, coupled with Isuzu's 4JJ1-TC clean diesel engine and an aerodynamically streamlined body, boosts fuel efficiency by more than 35%. This level of fuel efficiency translates into an 11-ton reduction of CO₂ emissions per vehicle each year. Spartan figures larger Reach fleets will realize fuel savings of up to \$3,000 per vehicle annually. **MD**

Resources:

Spartan Motors Inc.,
www.spartanmotors.com/Content.aspx?id=81

RS# 406

The hood and one-piece molded roof panel are made of a resin-transfer-molded, fiberglass reinforced plastic.



One-piece composite sidewall panels are made of polyethylene inner and outer skins around a reinforcing honeycomb core. The floor is a one-piece composite structure with polyester skins on the top and bottom, and a urethane foam core.

The front wheel wells, step-well liners, and rear side bumpers are made of recycled rubber, TPO, and TPR.



Structural parts are molded from glass-filled polyethylene sheet-molding compound.



The front fenders, front-bumper cover, and lower and rear body panels are reaction-injection molded from urethane.



Instrument-panel parts are molded from urethane material. Parts for the center-console instrument panel are molded-in-color from thermoplastic olefin (TPO).

Upgraded ac motors make **fiber spinning** more efficient

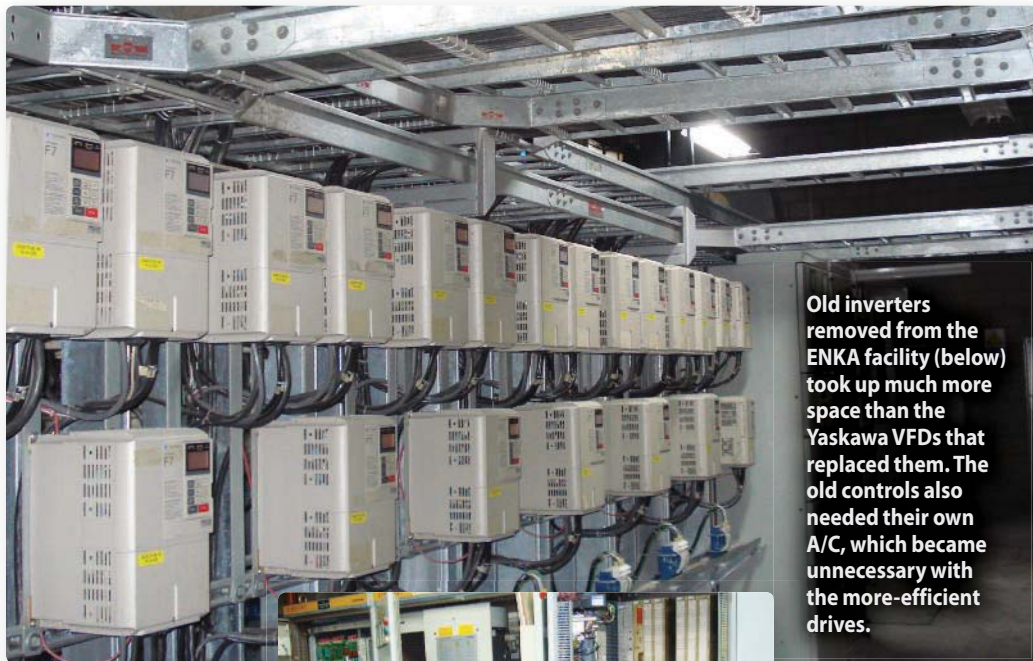
Synthetic-fiber producer **ENKA de Colombia SA**, Medellín, Colombia, replaced dc and ac motors with advanced ac versions coupled to efficient variable-frequency drives on a fiber spinning line. The strategy saves the company more than \$883,000 annually in electricity and downtime.

The spinning line extrudes nylon and polyester filaments from melted resins. Before the upgrade, motor and drive efficiency was about 50%. Part of the production line used an uninterruptible power supply (UPS) meant for protection from power outages, but the UPS ran at 80 to 93% efficiency at best.

One outcome of the inefficiencies was that the old equipment produced enough heat to demand its own a/c system. Elevated temperatures led to more breakdowns and repairs.

The new variable-frequency drives, Yaskawa F7 and G7 ac VFDs, have a nominal 98% efficiency. They create so little heat that ENKA was able to remove nine a/c units formerly needed to cool its factory. The new ac motors are also smaller than the dc motors they replaced. Old electrical equipment and a/c required for the spinning line took up almost 3,500 ft². The new a/c-less electrical installation occupies only 1,163 ft². And the updated UPS relies heavily on battery banks and works at near 100% efficiency.

Yaskawa VFDs were installed in a com-



Old inverters removed from the ENKA facility (below) took up much more space than the Yaskawa VFDs that replaced them. The old controls also needed their own A/C, which became unnecessary with the more-efficient drives.

Resources:

Yaskawa America Inc.,
Waukegan, Ill., www.yaskawa.com

RS# 407



mon-bus configuration, so a drive that is slowing its load can provide power to drives that need it. This reduces the power drawn from the mains.

In addition, the new VFDs let certain machines turn out up to 18 different filament types simultaneously with little modification.

The combination of energy saved from using more-efficient equipment, eliminating a/c, and introducing regenerative braking works out to \$806,131 in annual kilowatt-hour savings. ENKA also figures it saves about \$77,000 annually on technician time because of the new gear. All in all, payback time for the new installation was less than a year. **MD**



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RS# 118

REPORTER'S NOTEBOOK

Constant-airflow vent keeps **satellite-comm system** running

Protective vents keep a personal handheld satellite communication device working by filtering out contaminants like dust, dirt, and water.

The Cerberus global-communication system from **BriarTek Inc.**, Alexandria, Va., lets outdoor enthusiasts stay in contact with family and friends back home — even when traveling through the most rugged and isolated areas of the world. Cerberus records a traveler's location as frequently as every 5 min and sends real-time updates via satellite to a monitoring station.

Unlike emergency position-indicating radio beacons and personal-locating beacons, Cerberus lets travelers send check-in messages any time to update those at home. In addition, the device alerts travelers of approaching severe weather or geo-political events happening in the area.

The hiker or mountain climber carries the CerberLink satellite-messaging device, which has been engineered to withstand the harsh conditions some outdoor enthusiasts enjoy. It operates in temperatures from -20 to 55°C (-4 to 131°F) and meets IP67 standards for keeping out water. This level of water protection means the enclosure needs tight seals and O-ring gaskets. While these gaskets provide excellent protection, variations in air pressure caused by changing temperature or altitude can potentially create a vacuum inside the device, leading to premature seal failure.

To make sure there is no pressure difference between the inside and outside of the housing, BriarTek added a protective vent made by **W.L. Gore & Associates Inc.**, Newark, Del. The constant-airflow vent equalizes internal and external pressures, eliminating any chance of a vacuum forming. At the same time, the vent prevents water, dust, dirt, and other contaminants from getting into the housing and damaging the electronics. **MD**

Resources:

BriarTek Inc.,
www.briartek.com

RS# 408

W.L. Gore & Associates Inc.,
www.gore.com

RS# 409



The constant airflow of a Gore protective vent equalizes the air pressure inside and outside of the CerberLink handheld satellite-communication link, eliminating any possible vacuum in the housing and reducing the risk of premature seal failure.

Solar power lets UAV fly for 14 hours

The Silent Falcon, a UAV from **UAS Technologies**, Albuquerque, has thin-film solar panels mounted on top of its wings. The panels provide power for the sensors as well as the 1.3-hp electric motor which spins the propeller.

Resources:
UAS Technologies,
silentfalconuas.com



The Silent Falcon from UAS Technologies can fly for up to 14 hr using power from solar cells mounted on the top of the wings.



The gimbaled imager on the belly of the Silent Falcon can pan 360°, tilt from 150° to -90°, and contains optical and IR cameras.

Lithium polymer batteries provide additional power for the sensors, which sit in a gimbaled housing on the belly of the aircraft. The inertially stabilized sensors include high-definition optical and infrared imagers, and a laser pointer. The sensor pod also handles video processing, letting the UAV track and identify targets, and stream images to ground stations.

The composite UAV can fly up to 20,000 ft at 12 to 60 knots. Users, such as the military and safety forces, will have the option of mounting one of three wings on the Falcon's fuselage. The smallest (6-ft wingspan) lets the plane fly for up to 6 hr. The 9-ft wings

can keep it aloft for 10 hr. And the largest wings (15-ft wingspan), will extend flight time to 14 hr. The larger wings carry more solar panels, which give the plane more flight time. For comparison, the Falcon batteries limit missions to 6 hr at night. Users can hand-launch the 27-lb plane or employ an optional rocket attachment. It lands on a skid or deploys a parachute that brings it safely to ground.

The Silent Falcon is scheduled to go into commercial production in early 2013. **MD**

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RS# 120

More competition for **carrier-based UAVs**

Lockheed Martin joins three other companies vying to supply the **U. S. Navy** with carrier-based drones that can carry out reconnaissance, fire missiles, and drop bombs. Lockheed's UAV, the Sea Ghost, is said to be a tailless, jet-powered flying wing — a scaled-down B-2 bomber. The Sea Ghost also resembles Lockheed's RQ-170 Sentinel. Lockheed's teaser photo of the new UAV reveals few details, but aviation observers assume it will incorporate stealth technology, including coatings developed for Lockheed's X-35 Joint Strike Fighter.

The other UAVs designed to win the Navy contract include **Boeing's** Phantom Ray, **General Atomic's** Sea Avenger, and **Northrop Grumman's** X-47B. **MD**

Resources

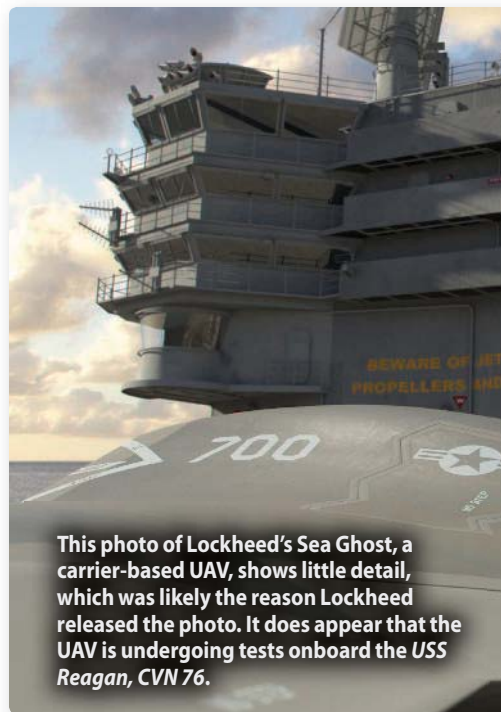
Boeing, boeing.com

General Atomic, ga.com

Lockheed Martin,
lockheedmartin.com

Northrop Grumman,
northropgrumman.com

The Sea Avenger from Northrop Grumman features optical and infrared cameras, an internal weapons bay that helps keep the UAV stealthy, and folding wings, which are commonly used on carrier aircraft so that they take up less space when parked on



This photo of Lockheed's Sea Ghost, a carrier-based UAV, shows little detail, which was likely the reason Lockheed released the photo. It does appear that the UAV is undergoing tests onboard the **USS Reagan, CVN 76**.



Boeing's Phantom Ray UAV has a 50-ft wingspan and measures 36 feet, front to back. It is a tailless flying wing modeled closely after Boeing's B-2 bomber.



the flight or hangar decks. Unlike its predecessors, General Atomic's MQ-1 Predator and MQ-9 Reaper, the Sea Avenger will have a beefed up airframe and landing gear that should withstand carrier landings.



The X-47B, Northrop Grumman's entry in the competition to supply UAVs to the Navy, is scheduled to demonstrate the ability to land and take-off from a carrier autonomously sometime next year. Folding wings let it reduce its width or wingspan from 62 to 31 ft so it takes up less space when parked on an aircraft carrier's flight deck.



Lockheed is also developing a hand-signal recognition scheme that will let crewmen on a carrier control low-flying UAVs using hand gestures.

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RS# 121

A robotic hand on a budget

Robotic hands, especially those that try to mimic the dexterity and flexibility of human hands, can cost \$250,000 apiece. That's too expensive for engineers at **Sandia Laboratory** who are trying to build a device able to disarm improvised-explosive devices (IEDs). This led the design team to develop a more-economical robotic hand, now known as the Sandia Hand.

The hand is modular with different types of fingers that can be quickly attached or removed from the hand frame. The frame also accepts tools such as flashlights, screwdrivers, or cameras instead of fingers. And if the hand accidentally rams into a wall or other object, the fingers simply fall off rather than get crushed. In fact, the remaining fingers on a Sandia hand can pick up a dislocated finger and pop it back into its socket.

The hand and fingers are covered with a tough outer skin of plastic over a gel-like layer that lets the hand more easily pick up and manipulate delicate objects. Operators control the hand using an instrumented glove, which makes the task more intuitive.

Ordinary robotic hands can cost \$10,000 for each independently activated degree of freedom (dof). The Sandia Hand, which was developed with help from **Darpa**, can have up to 12 dof at \$800 each, even in low volumes.

"At this price point, the Sandia hand has the potential to be a disruptive technology," says Sandia senior manager Philip Heerman. "Computers, calculators, and cell phones became part of everyday life once the price became affordable. This hand has the same potential, especially because high-volume production will further reduce cost." **MD**



Resources:
Sandia National
Laboratory, sandia.gov

Photo by Randy Montoya

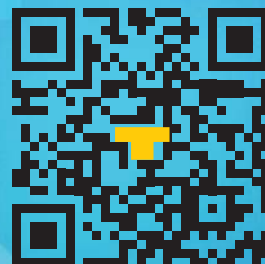
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10 YEARS AGO — 2002

Move those chips: An IBM integrated-circuit-processing line recently got a facelift. A complete new automated handling system designed and built by **Tinsley Design and Fabricating**, Moscow, Pa., now sits in the company's New York facility. The project included transfer stations, accumulating zones, a storage and retrieval module, pick-and-place stations, a scissor lift and turntable, and a variety of robotic,



pneumatic, and electronic controls.

The stationary retrieval design replaces a previous rotary system, eliminating rotational-load problems on bearings, bushings, and related components.

30 YEARS AGO — 1982

Cruise ballistic missile tested: Engine inlet testing has been completed on scale models of the **Boeing**-built cruise ballistic missile, reports the **Air Force**. In the 4-ft transonic wind tunnel at the **Arnold Engineering Development Center**, the jet-engine air-inlet performance was evaluated and found satisfactory under simulated takeoff and cruise conditions.

A typical mission includes a vertical launch from a silo, followed by wing and tail-surface deployment, engine start, and subsonic cruise at an altitude range of 25,000 to 30,000 ft. At the end of the cruise phase, the warhead separates from the cruise missile, ignites its own engine, and flies independently to the target.



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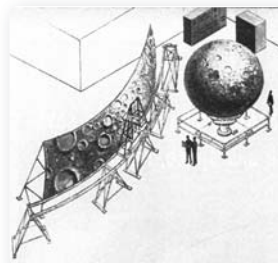
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50 YEARS AGO — 1962

It's only a Plexiglas moon, but it and a moon segment of the same material will be used, with a camera system, to train astronauts for lunar landings. The Lunar Orbit and Landing Approach Simulator, being built by **Radio Corp. of America** for installation at **NASA's Langley Research Center**, Hampton, Va., consists of two intricately detailed moon models (a 20-ft-diameter globe and a 90-ft-diameter segment) which will be photographed by a camera moving on a track, to produce the illusion of landing. Using closed-circuit television, the astronaut will be able to control his attitude while in orbit and his approach and let-down with a real-time system. **MD**



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Tiny thruster for small satellites

Inexpensive, Rubik's cube-sized satellites are finding roles in aerospace — there are currently two dozen of them orbiting Earth. But the so-called CubeSats need small thrusters to prevent them spinning passively in orbit and burning up as they reenter

the atmosphere. Researcher and MIT professor Paulo Lozano has a possible solution: microthrusters consisting of several layers of porous metal, with the bottom layer containing a

Resources:
Massachusetts Institute of Technology, mit.edu

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The microthrusters developed by an MIT researcher measure about a cubic inch. They could be used to give maneuverability and control to CubeSats.

reservoir of free-floating ions in a liquid. The top layer has 500 evenly spaced raised tips. The entire device is gold plated. Applying a voltage and creating an electric field between the reservoir and tips which sends beams of ions streaming from the tips. Researchers could adjust the thrust generated by two thruster in parallel from 0 to about 0.01 lb (50 μ N) by applying 250 mA and varying voltage from 900 to 1,100 V.

Attaching several such microthrusters to a CubeSat would extend its useful life by giving it a means of staying high enough above Earth to remain in orbit. The microthrusters' light weight and small size would incur a minimal penalty in extra fuel for lifting CubeSats into orbit. The small thrusters could also take CubeSats out of orbit by pushing them down into the atmosphere. This would eliminate CubeSats as collision hazards to other satellites and spacecraft. **MD**



RS# 126

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Solar plane's 1,500-mile flight sets a record



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Solar Impulse, a solar-powered plane designed and built at the **Ecole Polytechnique Fédérale de Lausanne**, a Swiss University, recently flew from Switzerland to Morocco, a 48-hr journey. The flight included a stopover in Madrid to change pilots and was scheduled to coincide with the start of construction of a 2,000-MW solar project in Morocco.

The aircraft has a wing-span of 208 ft, about the same as that of an Airbus A340.

The tops of the wing and horizontal stabilizer carry 11,628 photovoltaic cells which cover 2,200 ft². The solar cells generate enough electricity to power the plane's four 10-hp brushless motors and charge a bank of lithium-polymer batteries. Each motor turns a 11.5-ft two-bladed propeller at about 400 rpm. The batteries provide power for night-time flying.

The plane weighs only 3,500 lb, including crew, and the batteries account for a quarter of the total weight. To keep the aircraft light, the cabin, wings, and nacelles are made of engineered polymers from **Bayer MaterialScience**, Pittsburgh.

The aircraft has a 22-mph take-off speed, cruises at 43 mph, and can fly as high as 39,000 ft. To keep the batteries functioning at that height, where temperatures can be -40°F, thermal insulation conserves heat the batteries radiate.

The Swiss team is now working on a follow-on aircraft that will attempt to circumnavigate the Earth on solar power. Unfortunately, the 236-ft composite spar that stretches the entire wingspan cracked during construction, pushing back the planned flight from 2014 to at least 2015. **MD**

Resources
Bayer MaterialScience,
materialscience.bayer.com

RS# 410

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Which engineering schools offer the best value?



Kenneth Korane
Managing Editor

With kids back in the classroom, no doubt many high-school seniors are researching colleges, filling out applications, and writing essays while their parents sweat over financial-aid forms. But it's well worth the effort, right?

It's a universal axiom that the best investment one can make is a college education. The average person with a bachelor's degree earned about 65% more than a high-school graduate with no college in 2011, according to the U. S.

Bureau of Labor Statistics. And the unemployment rate last year was 4.9% for those with four-year college degrees, versus 9.4% for high-school grads and 14.1% for those without a diploma.

Yet an all too common story today involves the student who racks up a sizable debt earning a liberal-arts degree and then can't find a job. At least an engineering degree looks like a safer bet. According to the 2012 *College Salary Report* compiled by Seattle research firm **PayScale**, the 15 best undergraduate degrees for starting median pay were all in engineering, computer and physical sciences, and math — topped by petroleum engineers at \$97,900/year. (See www.payscale.com/college-education-value.)

Nonetheless, all engineering schools aren't created equal. So where's the best value? PayScale tries to answer that by calculating an education's return on

investment. The return is based on the median income of a degree holder over that of a high-school graduate. The investment is the cost of attending college, weighted for the number of years it takes the average student to graduate.

PayScale says **Harvey Mudd College** offers the best value with an annual ROI of 11.2%. Factor in financial aid, which most students receive, and the figure climbs to 13.1%. In dollars, that's a \$1,545,000 return over a 30 year period.

Others in PayScale's top five are **Cal Tech**, **MIT**, **Stanford**, and **Princeton**. Note these are all private schools. Harvey Mudd's tuition, room and board, books, and fees are \$59,713 for the coming year, and the others are in the same ballpark. Many might find that a bit pricey, even with some aid thrown in.

PayScale's highest ranked public school is the **Colorado School of Mines** with in-state costs around \$25,000 and ROI of 13.3%. CSM has the added benefit of a picturesque campus in the foothills of the Rockies that's within walking distance of the **Coors** brewery. But if you don't want to study mining or petroleum engineering, it may not be the right choice.

Public universities including **Georgia Tech** and the Big Ten's **Illinois-Urbana-Champaign**, **University of Michigan**, and **Purdue** rank high on the U. S. *News* list of top undergraduate engineering programs. All have costs in the \$20,000 to \$25,000 range. Relatively speaking, that's pretty good value for in-state residents.

But the best?

With a tuition of zero, in pure monetary terms the best value for an engineering education lies with the military-service academies — **West Point** and the **Naval** and **Air Force Academies**. Of course, spring break in Afghanistan may not appeal to everyone. **MD**



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Manufacturers of on and off-road vehicles are turning to hydraulic fan drives to help meet increasingly tougher emissions requirements.

Belt-driven fans have been the most common method of cooling vehicle engines for more than 100 years because they are simple and reliable. After being aligned by the engine manufacturer, belt drives give years of trouble-free service. However, as emission standards become more demanding, vehicle designers need innovative ways to cool engines.

First, they must develop more-efficient cooling systems because reducing the power required for cooling also

reduces the engine's fuel consumption and makes more power available to do work. Second, diesel-engine temperature affects both fuel consumption and emissions. So maintaining engine temperature within a narrow range has become a priority.

Benefits of belts

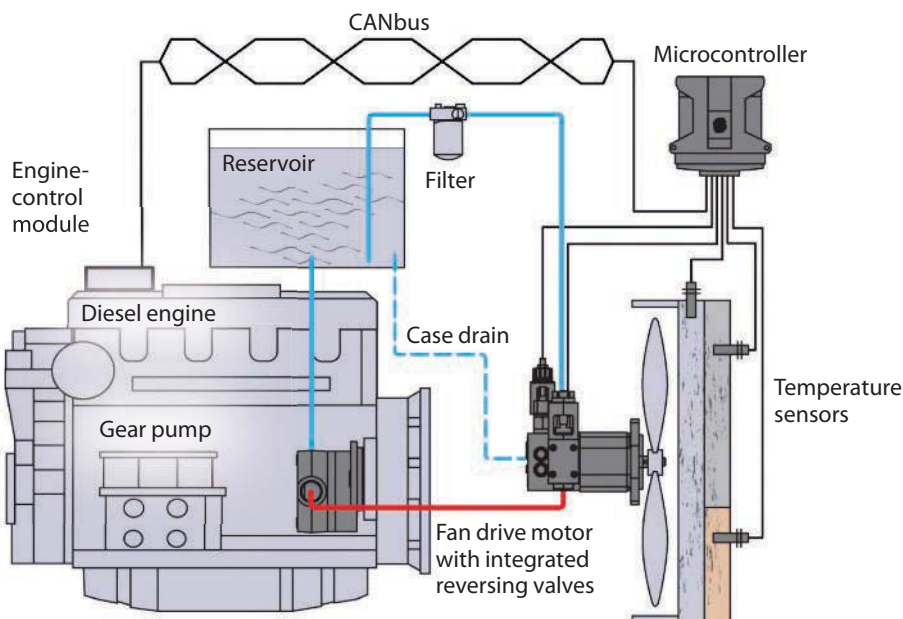
Belt drives are durable and, from an initial cost standpoint, the most economical means of power transmis-

HYDRAULIC DRIVES, CLEANER AIR

Replacing belt-driven fans with hydraulic fan drives makes off-road vehicles cleaner running and more fuel efficient.



Hydraulic fan drive



A basic hydraulic fan drive uses a gear pump to supply high-pressure fluid to a hydraulic gearmotor which, in turn, drives the fan. The ECU monitors coolant temperature and communicates with the engine controls to operate the drive at peak efficiency.

sion. The simplest drives have one or more belts and a set of sheaves (pulleys). Once installed in a vehicle, belts will withstand thousands of hours of operation (or tens of thousands of miles) and the sheaves usually last the life of the engine.

Belt drives are also efficient. At their peak, they transmit more than 90% of the power from the driving shaft to the driven. However, the belt drive itself doesn't provide cooling — the fan does. And a rotating fan uses a substantial amount of power whether the engine is idling or running at full speed.

The problem is, belt-driven fans pull air through the radiator all the time, regardless of how much or how little cooling the engine needs. This is because belt drives operate at a fixed speed ratio to the engine speed. Whenever the engine is running, so is the fan. And the faster the engine runs, the faster the fan.

This is not the most-effective means of cooling because the belt drive consumes engine power whether cooling is needed or not. An engine running at full speed may not necessarily be operating at full load. Likewise, an engine under full load at moderate speed may overheat if the fan is also running at moderate speed. The faster the fan spins, the more air it pulls through the radiator and the more engine power — and fuel — it consumes.

With so much attention placed on efficiency and emissions, except for the least-demanding applications, cooling requirements for today's engines are beyond the capa-

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Key points:

- Belt-driven fans pull air through the radiator all the time, regardless of cooling requirements.
- Hydraulic fan drives determine fan speed based on cooling demands, not engine speed.
- Hydraulic drives consume less power and maintain engine temperature for the best fuel economy and lowest emissions.

Resources:

Turolla OpenCircuitGear, www.turollaocg.com

bilities of belt drives. That's why car manufacturers have switched from belt-driven to motor-driven fan drives. Efficient cooling is even more important for off and on-highway equipment because it requires more power for adequate cooling. And as mentioned above, increasingly stringent emissions standards require tighter control of engine temperature.

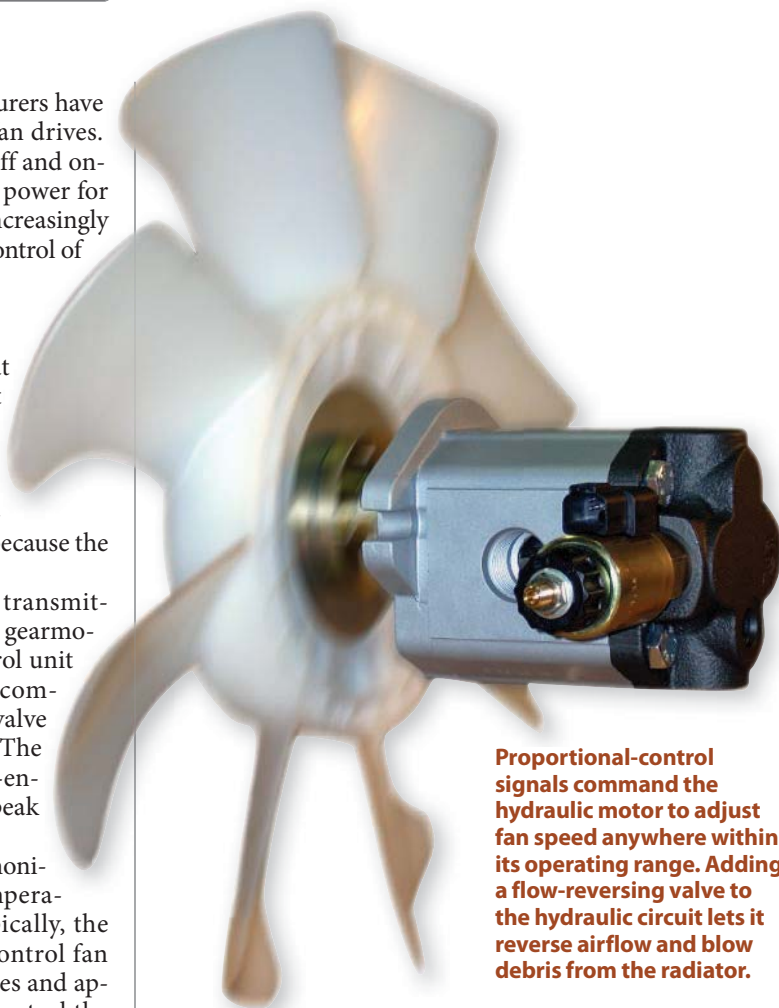
A more-effective alternative

Hydraulic fan drives are more effective at engine cooling because cooling demand, not engine speed, determines fan speed. The hydraulic system drives the fan at the precise speed required to provide only the amount of airflow needed. This means the fan is not wasting energy rotating faster than necessary, just because the engine is running at high speed.

A basic drive has a hydraulic gear pump transmitting power (flow and pressure) to a hydraulic gearmotor, which drives the fan. An electronic-control unit (ECU) monitors operating conditions and commands an electrohydraulic pressure-control valve that regulates power to the hydraulic motor. The ECU typically communicates with electronic-engine controls to ensure the vehicle operates at peak efficiency.

The ECU can receive inputs from sensors monitoring ambient air temperature, coolant temperature, fan speed, and other parameters. (Typically, the ECU only monitors water temperature to control fan speed.) Software developed for specific vehicles and applications lets the ECU generate signals to control the electrohydraulic valve. This proportional valve adjusts hydraulic pressure across the motor based on a proportional command signal, controlling fan speed anywhere within its operating range. Higher pressure equates to higher available torque to turn the fan faster.

A hydraulic drive does not waste power turning the fan when cooling is not needed, so the engine burns less fuel and releases fewer emissions. For example, when a vehicle's engine first starts, the fan is typically not needed. This lets the engine reach operating temperature faster



Proportional-control signals command the hydraulic motor to adjust fan speed anywhere within its operating range. Adding a flow-reversing valve to the hydraulic circuit lets it reverse airflow and blow debris from the radiator.

than if the fan was pulling cold air through the radiator, which is normally the case with belt-driven fans.

On the other hand, when the engine requires peak cooling and maximum fan speed (typically only about 1% of the time), the ECU commands the control valve to supply maximum pressure. Hydraulic-motor torque is proportional to the fluid pressure across it, so regulating hydraulic pressure accurately controls fan speed.



Hydraulic fan drives consume less power than belt drives, improving vehicle fuel economy.

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And because the ECU adjusts fan speed based on coolant temperature and other key parameters, the end result is more-precise control of engine temperature than is possible with a belt drive.

This is especially important with diesel engines because operating temperature has a twofold effect on engine performance. First, a diesel engine's power-to-fuel-consumption ratio peaks within a relatively narrow range of temperatures. Second, emissions released per pound of fuel used are lowest within another narrow range of temperatures. These two operating regions

Saving fuel while improving productivity

Because hydraulic fan drives consume less power than belt-driven versions and control engine-operating temperature for the best fuel economy, they can pay for themselves in fuel savings. How quickly, of course, depends on the application. But the return on investment is often measured in months, not years.

For example, in a recent test comparing belt and hydraulic fan drives under near-identical conditions, the latter generated substantial fuel saving and actually improved vehicle productivity.

Tests were conducted using a **Terex** 50-ton Payhauler mine truck equipped with a **Cummins** 1710 (725 hp @ 1,800 rpm) diesel engine at a quarry. Tests used the same driver, over the same route, and on consecutive days with nearly the same conditions. The only difference: the truck operated with a conventional belt-drive fan on the first day and, after an overnight retrofit, with a hydraulic fan drive on the second day.

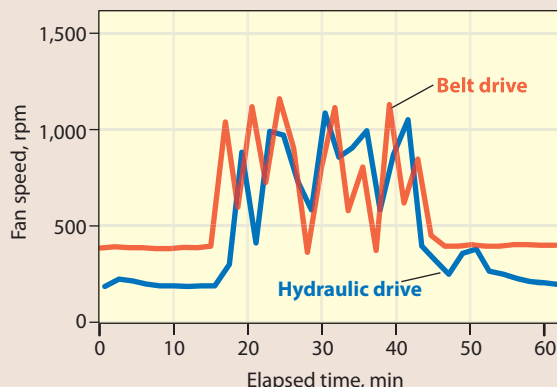
An in-line flow sensor captured fuel consumption data for both setups. Test results are shown in the nearby table. The hydraulic fan drive not only reduced fuel consumption by 14.5%, but it also improved cycle time by nearly 8%. These improvements are based on the hydraulic fan drive reducing fuel consumption from 167.4 to 143.1 gallons and increasing the number of dumps from 72 to 78 in 15 hr.

The graph plots fan speed during one typical run. Fan speed with a conventional belt drive is consistently higher, and the speed fluctuates because the engine constantly accelerates and decelerates as the driver travels his route. The speed peaks at 1,000 rpm or higher five times during the run.

And note that the belt drive's speed-reduction ratio means the fan rotates at only about 45% of the engine's crankshaft speed. Even at this reduced speed, the belt-driven fan still runs faster than the hydraulic fan during most of the work cycle and when the engine is idling. Turning the belt-driven fan at speeds higher than necessary wastes fuel, even at idle.

Fuel savings equate to 1.62 gallons/hr. With a two-shift work schedule at 80 hr/week, 50 weeks/yr, this represents a potential savings of 6,480 gallons of fuel/yr. Even with a conservative price of \$3.00/gallon, this potentially cuts annual

Fan drive speed comparison



Comparing the belt drive to the hydraulic fan drive on comparable runs shows the belt-drive fan runs faster and consumes more power, during work cycles and when the engine is idling.

Test data

	HYDRAULIC FAN DRIVE	BELT-DRIVEN FAN
Hours of operation each day	9 and 6	9 and 6
Total engine run time, hr	14.7	14.7
Number of work cycles	78	72
Fuel consumed, gallons	143.1	167.4
Fuel consumption rate, gallons/hr	9.54	11.16
Fuel used per work cycle, gallons	1.83	2.31

Two-day tests show a hydraulic fan drive cuts fuel consumption by 14%.

fuel cost by nearly \$20,000/vehicle. Total installation cost to retrofit the hydraulic fan drive is less than \$6,000/vehicle, offering a return on investment in about four months.

The hydraulic unit consistently maintained coolant temperature between 180 and 185°F, regardless of operating conditions. Lower fuel consumption and tight control of engine operating temperature also reduces NOx and other emissions.

In addition, tests showed the hydraulic drive increases productivity. After the hydraulic fan drive was installed, the operator indicated that the vehicle had more power at initial acceleration under full load. That's because with the hydraulic fan drive, average fan speed is lower than with a conventional cooling system — both when the engines is idling and when the vehicle is moving. Because lower fan speed requires lower torque, the hydraulic fan drive consumes less power from the engine, so more power is available to do work. This increase in power accounts for the shorter work cycles.

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overlap within an even tighter band, so keeping the engine within this narrow temperature range provides the best fuel economy and lowest emissions.

Additional benefits

Hydraulic fan drives can offer advantages beyond fuel savings and reduced emissions. Adding a flow-reversing valve to the hydraulic circuit lets the hydraulic motor turn in the opposite direction and reverse airflow. Pushing air out through the front of the radiator purges dirt and debris that reduces cooling efficiency as much as 50%. This is especially useful for vehicles operating in dirty environments because it reduces the need for screens, which add cost and size to the radiator and can restrict airflow. The reversing feature can also blow water out of the radiator to prevent freeze damage in cold climates. All of this eliminates the need for someone to periodically clean the radiator. The operator can reverse the fan with a switch, or the ECU can be programmed to reverse it at regular intervals.

Another advantage is design flexibility. Because the hydraulic fan motor connects to a pair of hoses rather than a belt attached to the engine, the radiator and fan can mount anywhere on the vehicle. Installing the radiator and fan outside the engine compartment makes space available for other components — such as emissions-reduction hardware required to meet Tier IV and Stage IV regulations.

Plus, the engine compartment may not be the best place for a radiator because ambient air drawn in by the fan may be hot and dirty. Putting the fan in another location may let it draw in cooler and cleaner air. This flexibility also lends itself to distributed designs, with coolers strategically sized and located throughout the vehicle for better performance and efficiency.

Hydraulic fan drives can also increase power to the engine for short periods. When the machine needs quicker acceleration or more muscle for work, the ECU has the valves shift the pump and motor to a neutral position, so the fan drive consumes no power.

This may let equipment designers use a smaller engine. This is important because increasingly strict regulations have led to new engine designs which demand more power for emissions control, instead of for work or propulsion. Consequently, larger engines often are needed. However, a power boost from the fan drive may sufficiently offset power requirements to avoid using a larger engine.

Moreover, hydraulic fan drives can be integrated with other vehicle systems. For example, excess capacity from the fan pump can provide hydraulic power to assist auxiliary functions. And by incorporating the fan drive into a vehicle's braking system, the hydraulic fan circuit can help decelerate the drivetrain by using the fan motor to dissipate excess power. This relieves some of the load on the brakes, helping extend brake life.

Hydraulic fan drives also help OEMs meet more-stringent noise legislation, because the fan in proportional drives is tested at only 70% of maximum speed, compared

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Hydraulic units offer more design flexibility, because the fan and radiator can mount anywhere on a vehicle.

with full speed for belt drives. Noise is not proportional to fan speed, so noise reduction exceeds 30%.

Finally, the ECU constantly monitors operating conditions and instantly alerts the operator to any malfunctions. In fact, the controller calculates and can display power draw of the fan drive at any time, helping maximize performance and efficiency.

Selecting fan drives

Given that hydraulic fan drives hold several advantages over belt drives, engineers might be tempted to assemble one from off-the-shelf components. This isn't necessarily the best approach.

Cooling experts generally recommend selecting and sizing fan-drive components to match specific applications. A mining truck has different cooling requirements from an excavator, which has different requirements from a harvester. So it's advisable to choose suppliers well versed in hydraulic fan drives to ensure a system best suits the equipment and application. A capable fan-drive manufacturer should have:

- Engineers and technicians experienced in hydraulics, electronic control, cooling systems, and Tier and Euro emissions standards.
- Pumps, motors, valves, and controls designed and manufactured specifically for hydraulic fan drives.
- Engineering tools that help experts design fan drives that deliver the highest performance and efficiency for the quickest return on investment.

Hydraulic fan drives may not be a viable alternative in every case. OEMs simply looking for the lowest initial cost will still find belt drives the power transmission method of choice. But in most cases, hydraulic fan drives offer vehicle manufacturers and users higher productivity, better fuel economy, and lower emissions — as well as significant savings over the life of a vehicle. **MD**

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The combination of closed-loop control and clever management of winding currents let ordinary stepper motors perform like servos.



A German bag-making machine substituted Nanotec closed-loop stepper systems for servos in feeding out and cutting bag material. The stepper systems are more compact than the servos they replace and still regulate torque and position throughout the motion profile.

The stepper motor is a well-known way of translating electrical energy into precise mechanical motion. Each electric impulse sent to the motor moves the shaft one increment corresponding to a defined angle of rotation. For example, sending 100 impulses to a 1.8° stepper motor would turn it exactly 180°.

One of the attractions of stepper motors is that they generally can operate open loop, with no position feedback for correcting shaft-position errors, because the pulse count defines their shaft position. This scheme can work if a stepper motor is never overloaded or if it never operates near its resonance frequency. But there are problems in many real-world applications that are associated with these two conditions.

To assure the stepper motor never overloads and loses track of its shaft position, many engineers overspecify the motor. So they may end up using a larger and more-expensive model than would be necessary to handle normal conditions.

Moreover, stepper-motor resonances frequently occupy the same band needed to handle application needs, so they may be difficult to avoid in practice. At lower frequencies the resonance behavior is more pronounced; a small increase in load or a torque peak makes the motor lose steps or fall out of step and even come to a standstill.

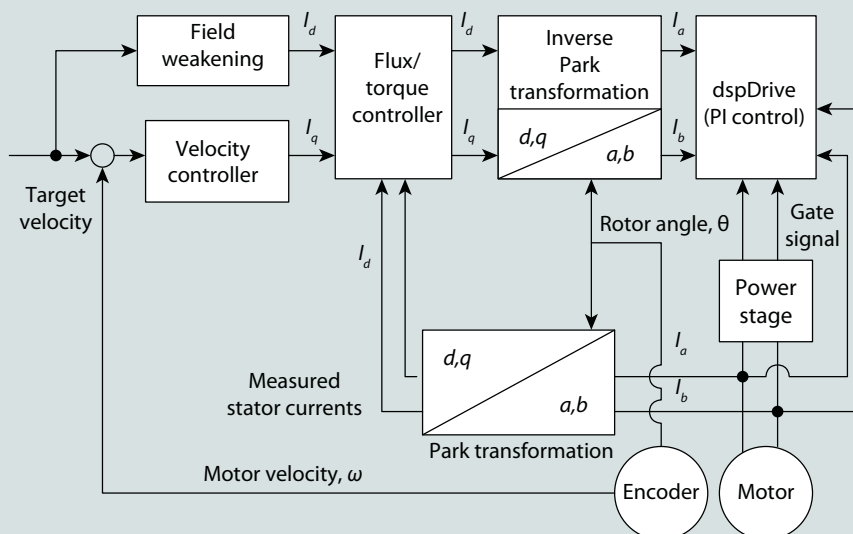
One technique for mitigating resonances is to divide step commands into smaller microsteps, but this entails use of filtering and more complicated controls.

Another way of handling temporary overloads and loss of shaft position is to add a position encoder to the motor shaft in a manner analogous to that used with servomotors. The encoder reads the actual position of the shaft and sends this information back to a controller which compares it to the commanded position. The controller uses the resulting error signal to manage pulses in a manner that either accelerates or decelerates the motor shaft to position it at the right spot.

Unfortunately, this position feedback scheme has no effect on issues associated with oversizing the motor and resonances. But there is a way to formulate a closed-loop stepping-motor system that eliminates difficulties around resonances and allows less-conservative motor sizing.

The technique combines position feedback with a special way of controlling the current in the stepper-motor windings. It is analogous to the vector control of ac-induction motors. It orthogonally aligns currents of the field and armature (or torque component) currents such that, when torque is controlled, the field flux linkage is not affected, thus enabling dynamic torque response. However, this

FOC of a two-phase hybrid stepper



A dspDrive system basically implements vector control of a stepper motor. (For sake of clarity, the position loop is not shown.) It is analogous to vector-control schemes for induction motors but needs no Clark transformation ordinarily used to project the three-phase currents into two vectors. I_d is the flux-generating part of the current vector, while I_q is the torque-generating portion. The velocity controller changes the torque-generating current vector. The flux-generating current vector is only influenced by field weakening. The system always tries to maintain a 90° angle between the stator and rotor magnetic fields and, thus, tries to keep I_d at zero. The I_d component only comes into play in the event of field weakening when the speed is over the constant torque range of the motor.

scheme needs no Clark transformation ordinarily used to project three-phase currents into two vectors because ordinary stepper motors have only two phases.

In the accompanying diagram, I_d is the flux generating part of the current vector, I_q is the torque generating part. A velocity controller changes the torque-generating current vector. The flux-generating vector is only influenced by field weakening. (Because the controller tries to have the optimum 90° angle between the stator and rotor magnetic field, it always tries to keep I_d at zero. Only if we are using field weakening, implying the speed is above the constant-torque range of the motor, do we need the I_d component.)

A point to note is that the motor-drive waveform in this case is sinusoidal rather than steps or microsteps. One advantage of this technique is that motors powered this

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Key points:

- Clever management of motor current in a closed-loop stepper system can eliminate problems around resonance points and reduce motor noise.
- Judiciously managed stepper motors can easily compete with servomotors in the lower rpm range.

Resources:

Nanotec Electronic U. S. Inc., <http://www.nanotec.com>



For more on stepper motors, scan this code or go to: <http://machinedesign.com/article/dynamics-of-hybrid-stepper-motors-0217>

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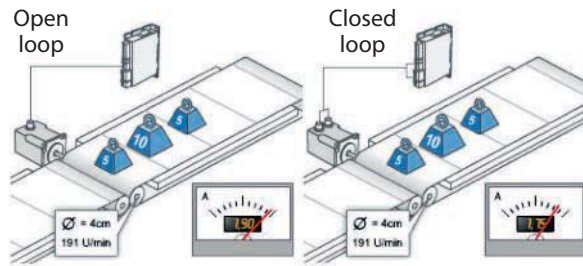
way have no problem with temporary load peaks. Their field-oriented current regulation lets them adjust in real time, a feature ordinarily available only through use of servomotors which are more expensive.

Dissecting closed-loop feedback

Readers are probably aware there have long been stepper-motor controls claiming to use closed-loop schemes with position encoders. Such systems merely check the step position and add or subtract steps to compensate. They cannot correct step angle errors on the fly.

In contrast, sinusoidal commutation coupled with field-oriented control can indeed compensate for step-angle and load-angle errors within a full step. Vector control of the magnetic field ensures that the stator magnetic field is always perpendicular to the rotor magnetic field and the field intensity corresponds precisely to the required torque. This

Current draw, open versus closed loop



In an open-loop system, the stepper motor is sized such that it can move the maximum expected load, usually with a safety factor of 20%. When the load drops suddenly, the open-loop motor cannot react. Use of a closed-loop system lets a smaller stepper motor handle a sudden load increase without wasting energy. As depicted in the diagram, steady-state current draw can be less. Efficient power regulation lets the motor generate less heat and stay cool. In a closed loop, the motor receives only as much energy as needed for the external load; there is no torque reserve nor an associated excitation at resonance, so there is practically no resonance behavior.

maximizes torque, optimizes energy efficiency and dynamics, and minimizes torque fluctuations while letting the motor operate more quietly than with ordinary open-loop control.

Closed-loop stepper motors offer dynamics similar to those of servomotors up to about 2,000 rpm. At higher speeds, however, servomotors continue to dominate. The ideal range for stepper motors is below 1,500 rpm where they boast much higher torque than servomotors. They can retain good dynamics even at higher speeds.

These qualities prove beneficial where there's a need to cover small distances or make small movements during an extremely short reaction time. Applications where sine-wave-commutated, closed-loop stepper motors can replace servomotors include wafer positioning in

Tips for selecting a stepper motor

To choose the right stepper motor, start with the torque the motor must deliver and the rotational speed at which this torque must be available. Consider an example where required torque $M_d = 10 \text{ Nm}$ at speed $n = 200 \text{ rpm}$. Then motor power $P =$

$$M_d \times n \times \pi / 30 = 209 \text{ W}$$

or, less exact but simple:

$$P = M_d \times n \times 0.1 = 200 \text{ W}$$

This approximation lets you practically read the power directly from the characteristic curve. The speed-torque curve for the stepper motor depicts the dynamic torque relative to the rotational speed or step frequency. The dynamic characteristic of a stepper motor also depends on factors such as the type of power driver and the amount of supply current.

If the power data for a motor are known, then the equation for computation of the required torque is:

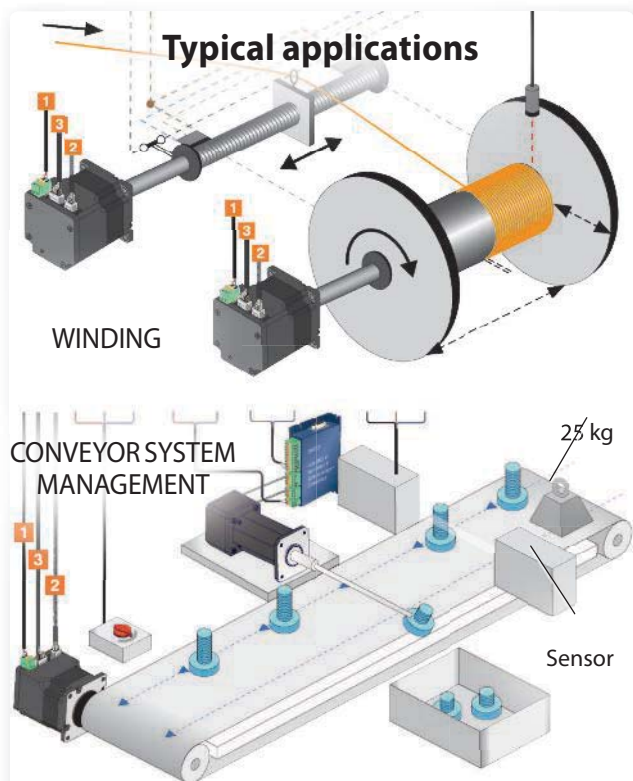
$$M_d = P / (n \times 0.1)$$

Again, rotational speed is in rpm, torque is in nanometers. Alternatively,

$$M_d = P \times z / 6.28 \times f$$

where $z = \text{steps/rotation}$ and $f = \text{frequency, Hz}$

The power of a stepper motor rises until it hits its breakpoint speed and remains relatively constant at higher speeds because the torque falls roughly linearly with rising speed.



Typical applications where closed-loop stepper systems come in handy include winding and conveying systems where the belt load can suddenly change.

die-bonding machines, welding-wire feeds, and nozzle control for regulating the throughput of pumps. Additionally, such stepper motors often need no gearbox, which makes them interesting for domains where drive components must be small.

Finally, it should be noted that stepper motors with field-oriented control receive only as much current as they need. They run cooler and deliver the same performance as an ordinary stepper while dissipating less electric power. The advantage becomes clear when considering belt-driven applications which normally use induction motors coupled with flange-mounted gearboxes. It is not uncommon for induction motors in these situations to be replaced by closed-loop steppers weighing one-third as much and which occupy about one-third the space. **MD**

Stepper-motor basics

A stepper motor consists of a magnetic rotor and multiple offset stator windings. Current through these windings generates a magnetic field. Reversing the direction of current flow changes the polarity of the magnetic field. When windings get energized in a defined sequence, the result is a rotating stator field that the toothed permanent magnet of the rotor follows. The electrical impulses thus determine the speed of the rotating magnetic field and the rotor translates these impulses into mechanical rotation with a defined step angle.

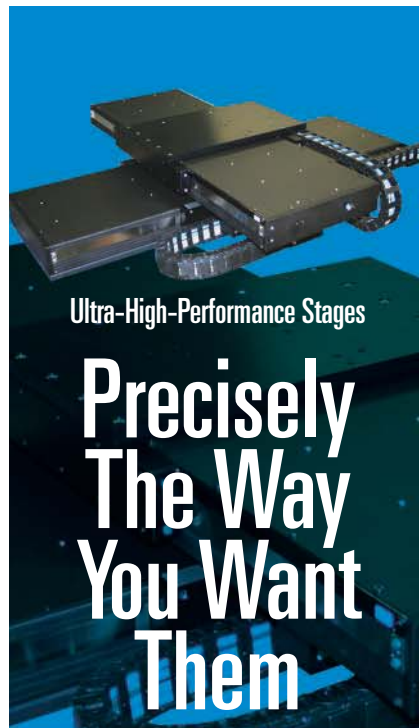
Stepper motors are widely used when the job demands a low-priced drive for positioning tasks accompanied with highly precise speed control. There are three specific variants: permanent magnet, variable reluctance, and hybrid motors. The permanent-magnet stepper motor operates on the reaction between a permanent-magnet rotor and an electromagnetic field. The rotor has a permanent magnet mounted at each end. Both the stator and rotor have teeth. The teeth on the rotor surface and the stator pole faces are offset so there will be only a limited number of rotor teeth aligning themselves with an energized stator pole. The number of teeth on the rotor and stator determine the step angle movement that will arise each time the polarity of the winding reverses. The greater the number of teeth, the smaller the step angle.

The variable-reluctance stepper motor differs from the PM stepper in that it has no permanent-magnet rotor and no residual torque to hold the rotor at one position when turned off. When the stator coils energize, the rotor teeth will align with the energized stator poles. This type of motor operates on the principle of minimizing the reluctance along the path of the applied magnetic field. By alternating the windings that are energized in the stator, the stator field changes, and the rotor moves to a new position. The stator of a variable-reluctance stepper motor has a magnetic core constructed with a stack of steel laminations. The rotor is made of unmagnetized soft steel with teeth and slots.

The hybrid step motor consists of two pieces of soft iron, as well as an axially magnetized, round permanent-magnet rotor. The term hybrid comes from the fact that the motor operates under the combined principles of the PM and variable-reluctance stepper motors. The stator core structure of a hybrid motor is essentially the same as its VR counterpart. The main difference is that in the VR motor, only one of the two coils of one phase is wound on one pole, while a typical hybrid motor will have coils of two different phases wound on one the same pole. Each pole of a hybrid motor is covered with uniformly spaced teeth made of soft steel. The teeth on the two sections of each pole misalign with each other by a half-tooth pitch. Torque is created in the hybrid motor by the interaction of the magnetic field of the permanent magnet and the magnetic field produced by the stator.

Hybrid combines the benefits of reluctance and permanent-magnet motors. They offer high-step resolution, high-repetition accuracy, and excellent holding torque and nominal torque into high speed ranges.

A correctly sized stepper motor is a reliable drive element. There is no hunting around the motor axis when the motor remains at its null position, a frequent problem with servomotors.



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Performance of a lifetime

A simple and straightforward application analysis can keep optocouplers working at their peak.

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Key points:

- Light output of an LED drops with intrinsic aging.
- Heat and high forward currents destroy the crystalline structure of LED junctions.
- The current-transfer-ratio of most LEDs degrades no more than 10% over a normal lifespan.

Resources:

Avago Technologies, www.avagotech.com

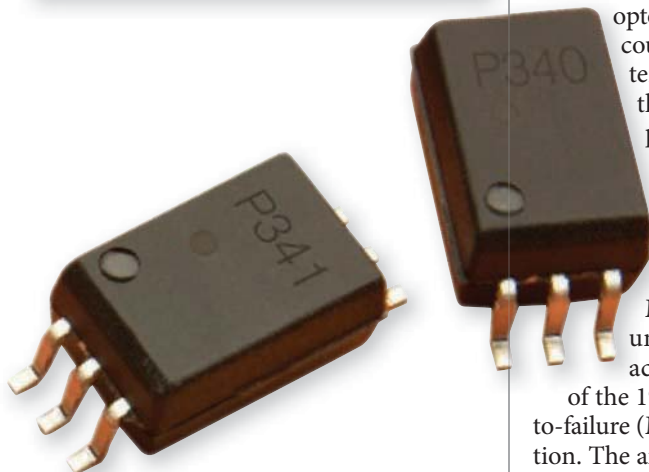
Optocouplers primarily transmit information or data between two circuits that have different electrical potentials. To transmit this data without error, the optocoupler needs two essential specifications: high-voltage isolation and good electrical-noise rejection.

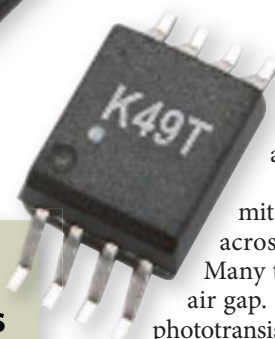
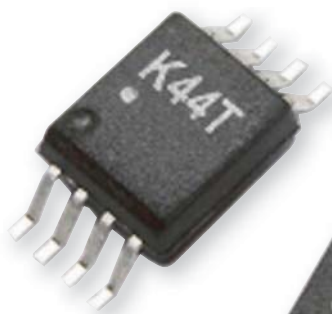
In addition, these devices are expected to provide many years of reliable operation. These demands all but dictate optocouplers employ high-reliability LEDs to fulfill mission-critical needs.

LEDs are considered a mature technology. The first practical LED was developed 50 years ago, though evidence suggests that it was discovered even earlier. LED vendors have continually enhanced the manufacturing process to improve and refine LED performance. High-reliability optocouplers let vendors offer products for industrial, renewable energy, automotive, and even ultra-high mission-critical applications for aerospace and the military.

Despite the many harsh applications that employ optocouplers, concerns still linger regarding optocoupler operating life. Much of this concern centers on the output of light from the LED within the optocoupler. As the LED ages, its light output power drops from intrinsic aging. That light output loss could potentially degrade optocoupler performance.

To ease those concerns, optocoupler manufacturers project the amount of LED degradation based on the Black Model. The Black Model uses LED reliability stress data obtained under accelerated conditions. It is a generally accepted empirical model developed at the end of the 1960s by J.R. Black to estimate the mean-time-to-failure (MTTF) of a wire associated with electromigration. The analysis gives designers greater confidence and design flexibility so they can specify the most appropriate



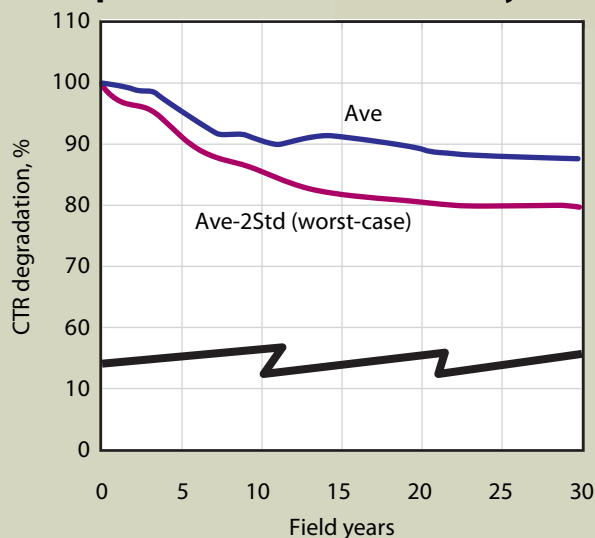


LED forward input current for their application.

Optocouplers use the LED to transmit a beam of light carrying information across an isolation or insulation barrier. Many times the isolation barrier is just an air gap. On the other side of the barrier is a phototransistor or other light-sensing device that converts the optical signal back into an electrical signal. During the design phase, engineers select the proper value for the input current-limiting resistor that defines the recommended input drive current (I_F) to the LED to produce the desired light output.

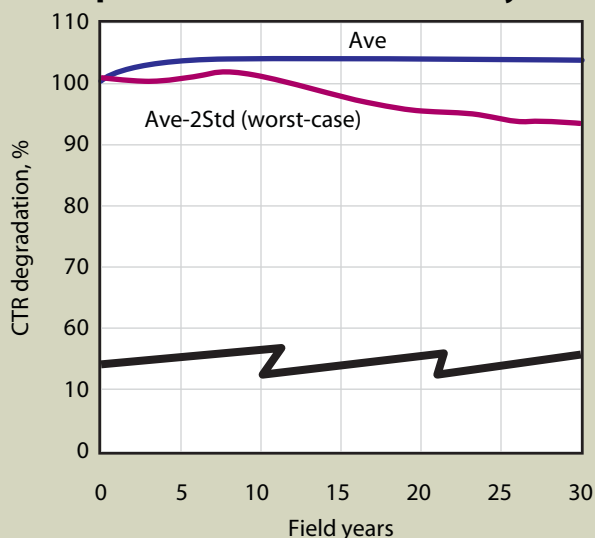
Problems arise when the quantum efficiency of the LED (the total photons emitted per electron of input current) drops over time from thermal and electrical stresses within the LED's PN junction. Stress testing the LED can

AlGaAs (Type 1) LED performance versus field years

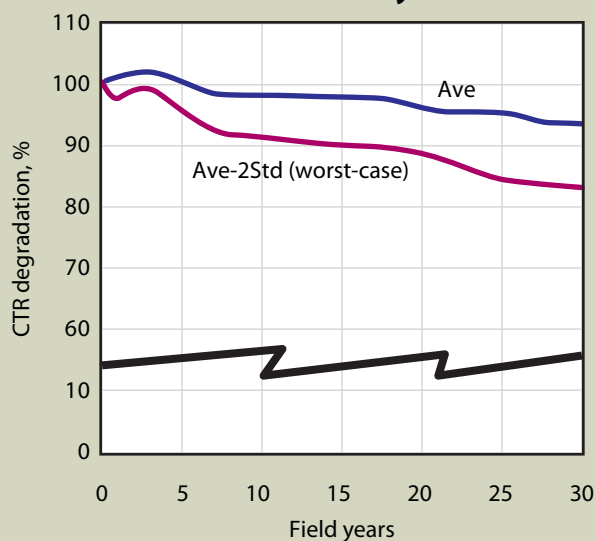


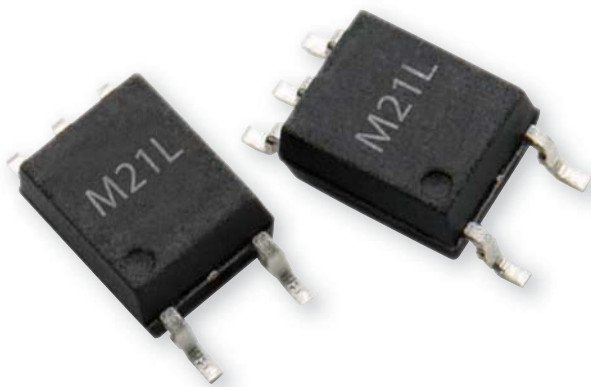
These three graphs show the drop in CTR over a 30-yr span for the different types of LEDs currently used in optocouplers. Note that the average value for all three types is less than 10%, though individual devices can reach a 20% drop or more.

AlGaAs (Type 2) LED performance versus field years



GaAsP LED performance versus field years





help determine reliability for periods of continuous operation up to 10,000 hr. Unfortunately optocoupler vendors don't always provide stress test data in the device datasheets.

Furthermore, the conditions under which each vendor conducts their stress-test may differ making it difficult to directly compare test results. For example, the I_F used to test the LED can be set at any value ranging from a few milliamps to 20 mA or more. Higher currents place more stress on the junction and could lead to widely varying reliability figures.

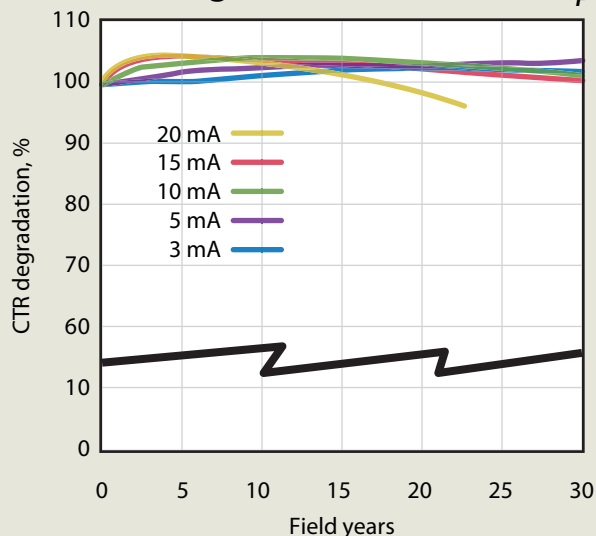
One of the stress tests performed by **Avago Technologies**, San Jose, is the high-temperature operating life (HTOL) test. This test takes place with the LED operating at a temperature of 125°C and a continuous I_F of 20 mA. The test monitors the current transfer ratio (CTR) that compares the ratio of the output collector current (I_C) to the forward LED input current (I_F) that generates the light. The amount of light hitting the photodiode determines collector current, so the drop in CTR over time plots the drop in light output as the LED degrades.

$$\text{Current transfer ratio, CTR} = \frac{I_C}{I_F} \cdot 100\%$$

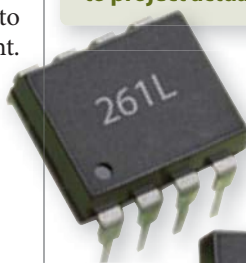
Even though the I_F stays constant, the light output from the LED drops over time because of heat stress in the LED crystalline structure. Thus, the photosensitive device I_C and CTR will drop with time. At predetermined points in the stress test, such as at 168, 500, and 1,000 hr, I_C is measured and the CTR calculated. Performance plots then show the change in CTR against the number of hours that the stress test ran.

LEDs used in optocouplers are fabricated from either aluminum-gallium-arsenide (AlGaAs) Type 1 and 2 or gallium-arsenide-phosphide (GaAsP). Each vendor optimizes its optocouplers to leverage the LED

AlGaAs (Type 2) LED degradation at different I_F



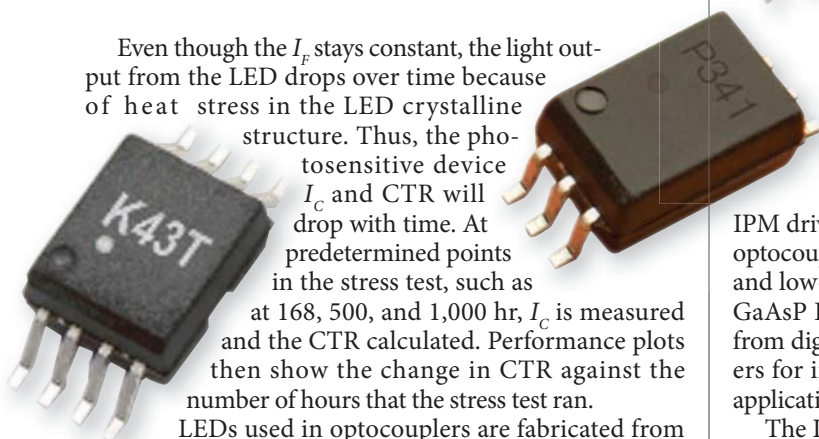
This graph shows the LED light degradation caused by the effects of different forward currents (I_F). Note projections from the stress test show that at 125°C and 20 mA of I_F , reliable optocoupler operation will last only 22.6 years. More stress data points will be needed to project actual operation beyond that point.



technology that best suits the application. Additionally, optocoupler vendors have developed a wide variety of devices that have various types of interfaces to suit many different applications.

At Avago, for example, Type 1 AlGaAs LEDs are mainly used in optocoupler product families that include digital optocouplers, isolation amplifiers, gate drivers, and IPM drivers. Type 2 AlGaAs LEDs mainly go into Avago's optocoupler families that handle high-speed digital signals and low-power 10-Mbps digital optocouplers. Lastly, the GaAsP LEDs find use in a broad range of optocouplers, from digital optocouplers, analog optocouplers, gate drivers for intelligent power management, and many other applications.

The LEDs are manufactured using different processes. One type might use a diffusion-type process while another type would use epitaxial growth. LEDs are also subject to different doping concentrations. This lets the LED de-





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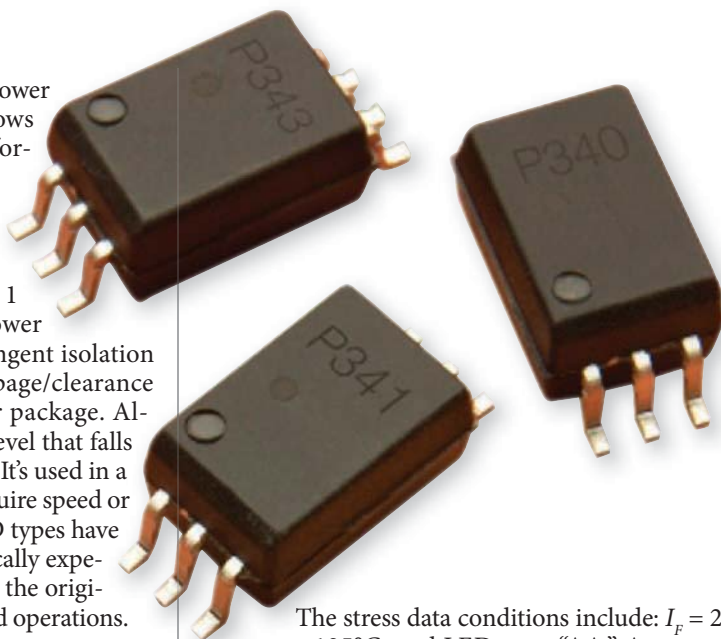
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signer customize the light output power of the LED at different current flows to address speed and power performance needs of the optocoupler.

Among the three different LED types, GaAsP-based LEDs are the most mature but have the lowest light output power. AlGaAs Type 1 offers the highest light output power that lets them serve in more-stringent isolation applications that need high creepage/clearance distances inside the optocoupler package. AlGaAs Type 2 has a performance level that falls between the other two LED types. It's used in a wide range of applications that require speed or power performance. All three LED types have similar degradation qualities, typically experiencing less than a 10% loss from the original CTR value after 30 years of field operations.



Acceleration factor

Obviously, it's not practical to test an LED for its full 50,000 hr-plus expected lifespan. An acceleration factor (AF) based on the Black Model can be used to correlate actual HTOL stress test data points to the expected lifetime based on the actual operating conditions. But like the stress test data, not all of the values needed to calculate the AF are on the data sheets. In many instances, the only way to obtain the necessary information is to contact the vendor.

$$AF = \left(\frac{J_{acc}}{J_{norm}} \right)^N \exp \left(\frac{E_a}{K} \left\{ \frac{1}{T_{norm}} - \frac{1}{T_{acc}} \right\} \right)$$

where AF = acceleration factor; J_{acc} = accelerated current density (HTOL stress-input current); J_{norm} = nominal operation-current density (application operating input current at 100% duty cycle); E_a = activation energy of 0.43 eV; K = Boltzmann's constant of 8.62×10^{-5} eV/K; T_{norm} = nominal operating temperature (application ambient operating temperature); T_{acc} = accelerated operating temperature (HTOL stress temperature); and N = model parameter of 2.

For the same CTR degradation performance, the field lifetime of the LED can be projected according to the following equation:

$$T_F = AF \times T_S$$

where T_F = field time of the LED in hours, AF = acceleration factor, and T_S = stress time of the LED in hours.

Data from the stress test of an Avago optocoupler will illustrate the use of the AF as a multiplier.

The stress data conditions include: $I_F = 20$ mA, temperature = 125°C , and LED-type "AA." At a stress test length of 1,000 hr, the CTR degradation is measured as 99.2%. If that optocoupler is used with actual application conditions of $I_F = 5$ mA, assuming a 100% duty-cycle operation, and an ambient temperature of 60°C , the AF is calculated as:

$$AF = \left(\frac{20 \text{ mA}}{5 \text{ mA}} \right)^2 \exp \left(\frac{0.43}{8.62 \times 10^{-5}} \left\{ \frac{1}{273+60} - \frac{1}{273+125} \right\} \right) \approx 184.7$$

The projected field lifetime for the LED becomes $AF \times T_S$, or $184.7 \times 1,000 = 184,767$ hr (or 21 years). With the AF value calculated, all data points of stress hours can map to the expected field lifetime of the LED.

Typically, at the end of 30 field years of operation, the CTR of most LED types degrades no more than 10%. Depending on the system-design-to-expected-lifespan usage, the degradation calculations give designers more flexibility in choosing the I_F value. They can, thus, optimize their system designs to get the best combination of reliable operating lifetime and power consumption.

In general, there are three basic factors to consider in maximizing the LED operating lifetime: Operate the LED at a lower I_F , at a lower duty cycle, and at an ambient temperature of less than 125°C .

Automotive use

Automotive-grade optocouplers must address all emerging automotive isolation applications, particularly in applications that demand reliable long term operation at ambient temperatures as high as 125°C . Tests show that the LEDs used in these applications must possess a CTR drop of no more than 20% at 125°C to meet automotive requirements. Commercially available consumer-grade and general-purpose industrial infrared LEDs typically experience a CTR drop of up to 60% at 125°C . As this is beyond the recommended temperature range for commercially available LEDs, it highlights the importance that only LEDs specially designed for high-temperature operation should go into automotive-grade optocouplers. **MD**



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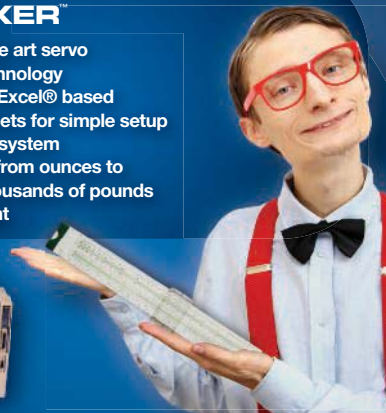
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Foil-based heaters can have a heating element of etched foil as thin as 0.003 in. arranged in a pattern with adjacent traces no more than 0.003 in. apart. This makes for uniform heating.

Understanding ETCHED-FOIL HEATERS

Foil heaters give designers flexibility in thermal management.

Etched-foil heaters have become the engineer's choice for advanced thermal management and applications that require heaters but lack space. These heaters are made from metal foil patterned and etched to create a precise conductive element on its surface. The element's rectangular cross section exposes more of the element's heating surface and puts more of it in contact with the object being heated, than the alternative, wound-wire heaters.

Advantages of foil heaters

Compared to flexible wound-wire heaters, foil heaters need wider elements to achieve the same resistance and wattage, but the elements can be spaced much closer together. This tight spacing, with traces as close to each other as 0.004 in., translates into even heat distribution, a key reason engineers use foil heaters. Additionally, because the element pattern is created using photolithography, elements can't contact adjacent elements and short out

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All Flex Flexible Circuits,
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Comparing flexible heaters: foil versus wire

There are two common types of flexible heaters: the older wound-wire devices and foil-based devices. Both use metals with different resistivity and heating characteristics.

Wire heaters use a single or several strands of wire to transfer heat to a tangent point or arc area of its circular heating element. In contrast, the flat surface of foil heaters provide more uniform heating, thanks to significantly more surface area devoted to heat transfer.

Foil-based heaters can be made small and concentrate heat just where it is needed.

internally. The photoimaging process also ensures all foil heaters coming off the production line are identical.

Another important feature of foil heaters is that they can be extremely thin. For example, materials such as polyimide (**DuPont's** Kapton) can be used to make heaters as thin as 0.005 in., with the foil heating element as thin as 0.0005 in. Being thin lets foil heaters fit in tight spaces, and their flexibility lets them wrap around tight corners and complex shapes.

Foil heaters also let designers add devices to the heaters such as thermistors, fuses, and other electrical components. They can be soldered directly to the heater using traditional soldering methods. The result can be a heater with built-in control logic.

Common substrates

Two of the most commonly used materials for making flexible heaters are polyimide and silicone rubber. The materials serve as both carriers for the foil and as dielectric layers covering the top of the heating element.

Polyimide heaters are typically less than 0.007-in. thick (without the mounting adhesive). This lets them wrap tightly around curved and irregular surfaces and provide short thermal response times. The low profile also lets designers mount heaters in tight spaces, which can be helpful

if the heater is added late in the design process. The designer might be able to add the heater without changing the packaging or component layout.

Although polyimide is the material of choice when thinness is a necessity, the adhesive commonly used on polyimide heaters cannot withstand temperatures over 292°F (200°C). Polyimide heaters can only withstand continuous temperatures of 300°F (150°C). But they have quick response times and deliver the desired heat quickly.

Silicone rubber, on the other hand, is durable and withstands continuous temperatures as high as 455°F (235°C). Silicone rubber heaters are typically 0.030-in. thick (without a backing adhesive). This limits its bend radius to approximately 1.5 in. The thicker silicone is also less compliant, so it may not bond well to curved surfaces.

Silicone rubber also adds more thermal insulation compared to polyimide. So a silicone-rubber heater may be slower to reach temperature and a higher wattage heater may be needed.

Making foil heaters

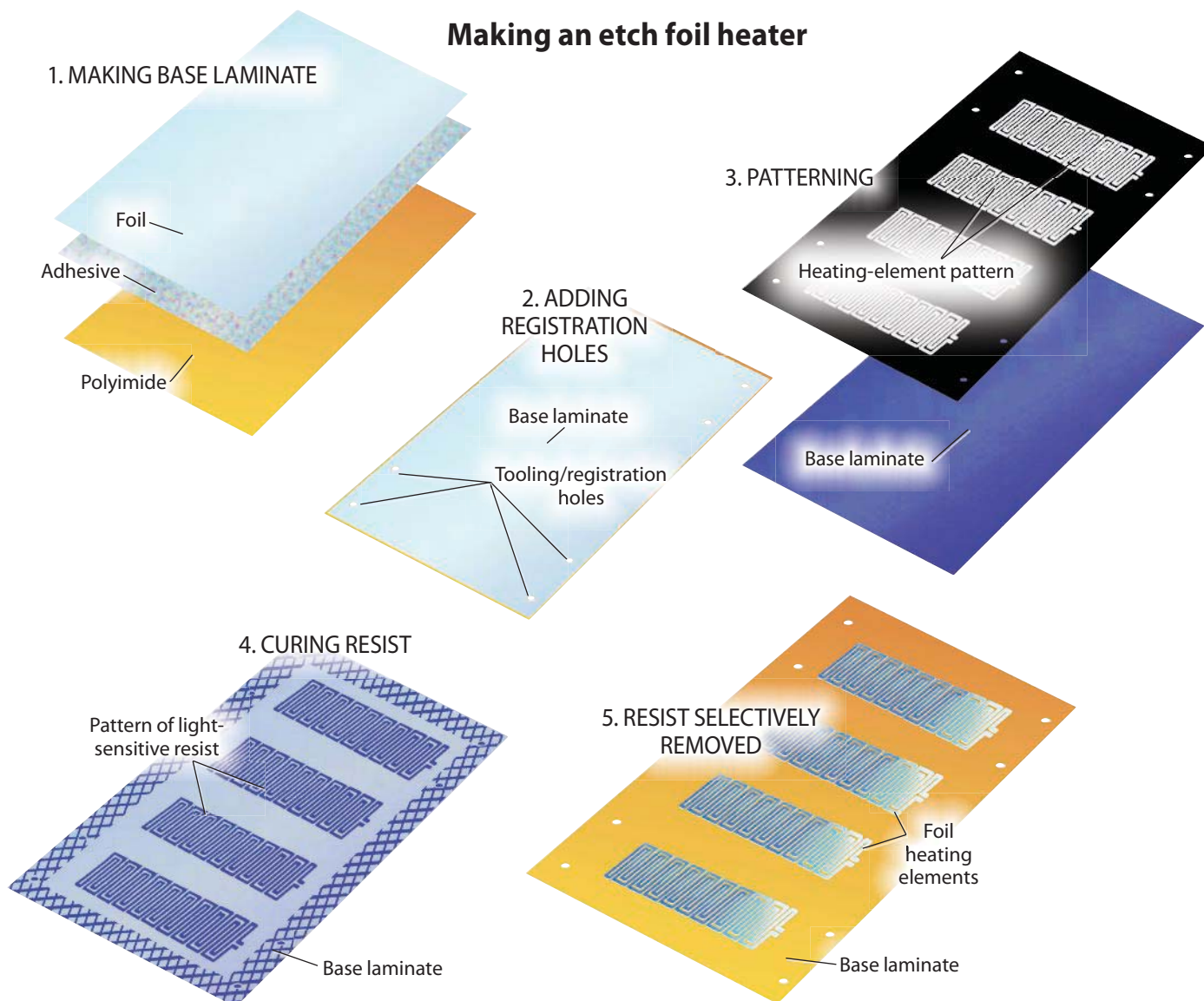
The processes used to manufacture foil heaters are much like those used in the paper/foil-conversion industry with one key exception: Polyimide films are unstable and its dimensions can change in response to changes in heat or humidity. And different lots of the same film can have different thicknesses or inconsistent material stability in the X and Y axes. This injects variability that must be taken into account during fabrication.

Here are the steps in making etched-foil heaters:

Creating the base laminate. The first step is to select and laminate the foil to the base substrate (polyimide in this example). This is often done with a thermosetting adhesive compatible with the two materials. The resulting bond must withstand subsequent fabrication processes, such as chemical etching, as well as any stresses the final



Making an etch foil heater



application will put on it. For some applications, the bond needs to meet other requirements such as reduced out-gassing, UL flame retardancy, and mechanical flexing.

Bonding the foil to the substrate is typically done at elevated pressure and temperature for an extended period of time. The goal is flat and nonstressed laminates with high bond and peel strengths.

Drilling registration holes. Tooling holes drilled into the base laminate serve as registration method for aligning the heater's layers aligned during fabrication.

Imaging. This step puts the pattern of the conductive element on the base laminate. A photoimageable resist is applied to the foil/polyimide panel. A mask layer is then placed over the resist. This mask is usually created using CAD software. The mask specifies the dimensions and shape of the heater element, which should give it the proper resistance and output.

The resist layer is then exposed to UV light, curing

it so it can be used as a chemical-etch resist. This resist protects the heater element while uncured resist gets removed, exposing the foil for etching and its removal.

Etching. The panel goes through a series of chemical etching, stripping, and cleaning cycles to remove foil unprotected by the resist while leaving the heating element bonded to the polyimide. The process is also controlled so that the heater element has the desired thickness and width. Etching creates elements that are within 10% of the proper resistance. This variance is less with wider elements.

Chemicals used in this step depend on the foil being etched. Alkaline-based chemical are used for copper alloys, while other chemicals are used for stainless steel and foils with iron.

The heater's resistance is tested and the device validated at this step in the fabrication sequence.

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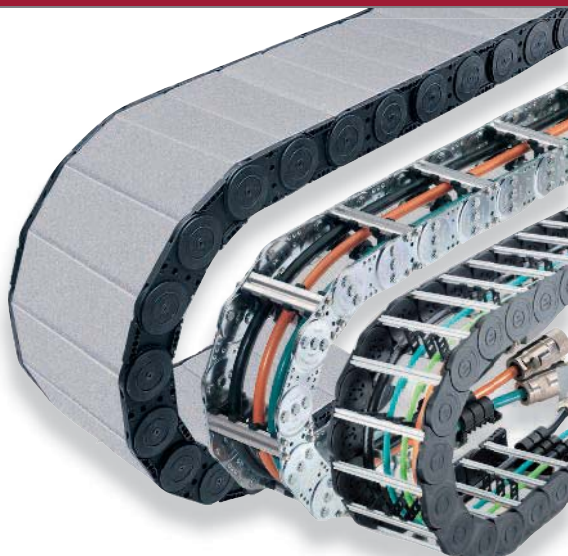
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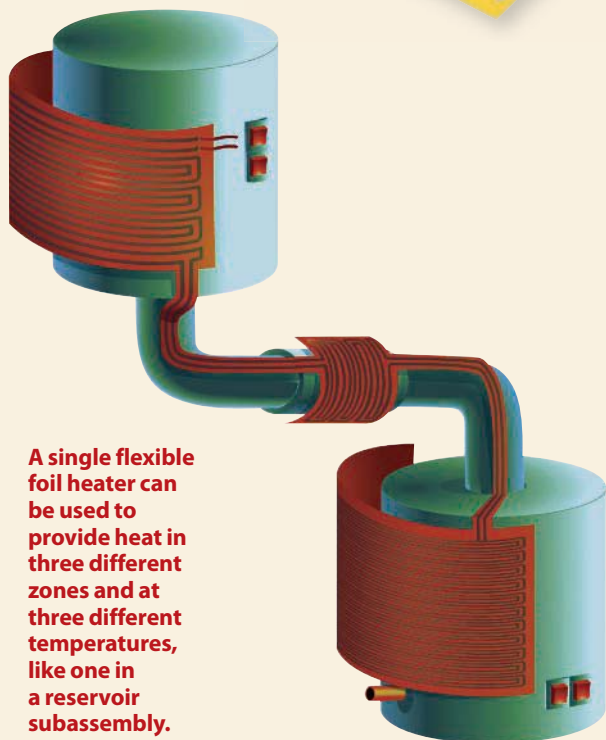
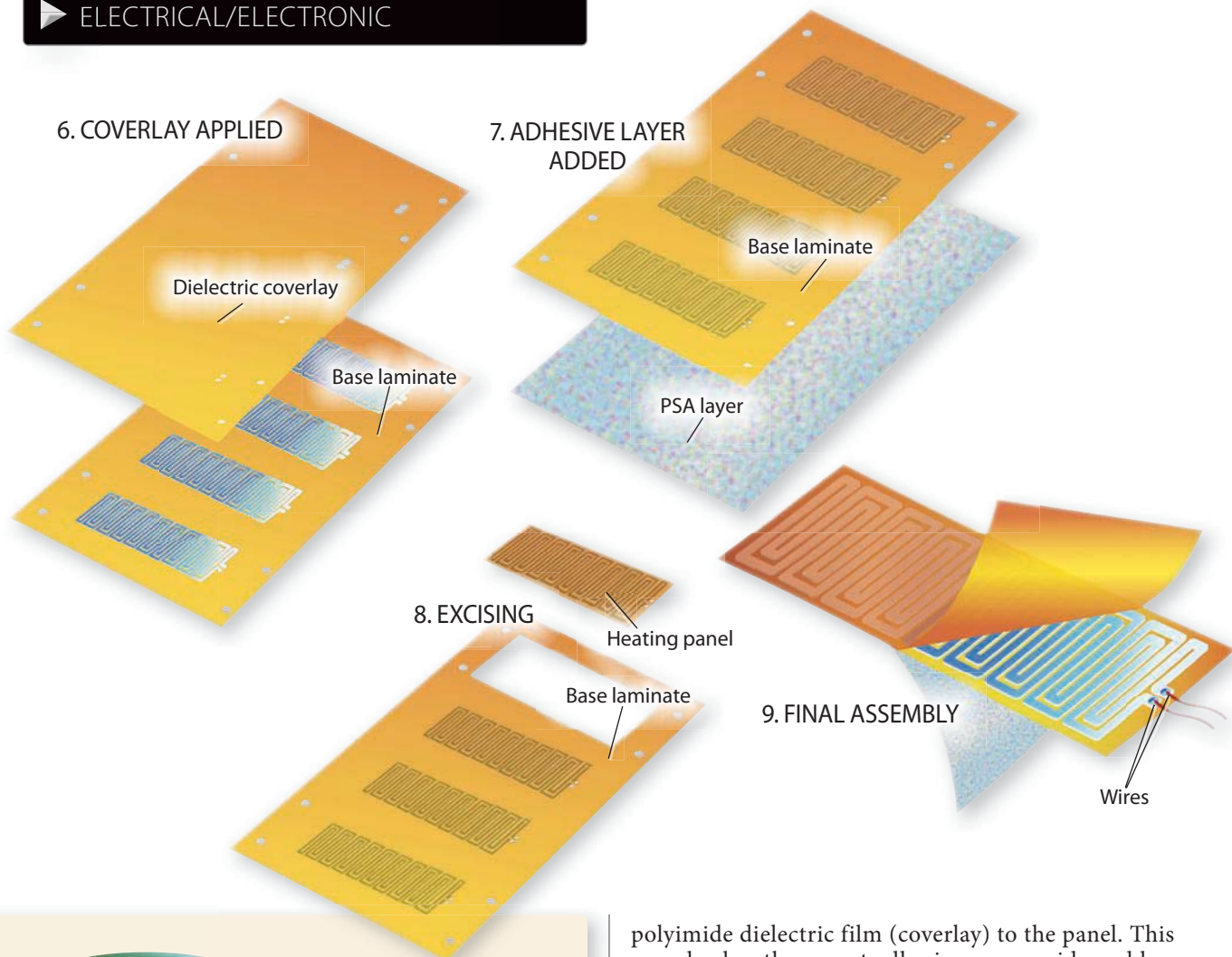
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A single flexible foil heater can be used to provide heat in three different zones and at three different temperatures, like one in a reservoir subassembly.

polyimide dielectric film (coverlay) to the panel. This coverlay has thermoset adhesive on one side and has pre-drilled tooling alignment holes and access points. These access points provide wire attachment points, sensor attachment locations, or component mounting positions.

The dielectric layer is aligned with the base panel and pressed onto it so that it conforms without creating voids or air bubbles.

Optional: backside adhesive. To simplify the task of attaching the heater to a heat sink or housing, some customers want a pressure-sensitive adhesive (PSA) placed on the back of the heater.

The most common PSAs are 0.002-in. thick and shipped with release liners customers remove prior to installation. The PSA's bond strength reaches its final and greatest level about 72 hr after it is pressed into place.

Excising. The final step is to remove the finished part from the panel, a task commonly done with steel-rule dies. These dies can maintain dimensional tolerances within ± 0.01 in.

After the heater is removed from the panel, wires, custom marking, and other components can be added.

Flexible heaters are an affordable and effective way to protect devices against freezing, and to control viscosity, condensation, and processes. The thin profile and precise output helps engineers meet a variety of design challenges. **MD**

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RS# 150

The Basics of DEEP-DRAWN STAMPINGS

A process that makes more shapes than you might think.

A deep-drawn stamping can be more than a metal trash can. Metal blanks can be deep drawn to form complicated shapes of varying sizes.

Unlike the machining process, stations of the stamping press can incorporate secondary operations such as piercing, notching, coining, embossing, beading, and grooving. And the stamping process uses sheets of raw material instead of blocks of metal which can help reduce upfront costs.

However, the stamping process requires extensive metallurgical and process knowledge. For a 101 on deep-drawn stampings, here is a list of basic terminology and some examples of unexpected deep-drawn shapes. **MD**



The process of machining a block of metal to make multiple thin parts such as these can be less economical than the deep-drawn stamping process which can make specially shaped and textured parts out of various types of metal.



CRIMPED

The creation of this piece requires several steps in a single press. A tube is drawn and then its closed end is cut. Both open ends are then trimmed to remove scrap. The piece is crimped by two specially shaped mandrels. A wire electrode is later inserted through one end of the crimp, where it is welded in position. The application will expose this part to high temperatures and corrosive environments so the piece is manufactured in a niobium alloy.

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Key points:

- Deep-draw stamping can be an economical alternative to machining large blocks of metal.
- Secondary operations such as piercing and grooving can be an integral, automated operation with deep drawing.
- Deep-draw stamping works for parts with variations in diameters and large, hollow areas.

Resources:

Evans Technology, www.evanstechnology.com



KEYED FLANGE

The pierce pattern in this stainless-steel cup is not centered. The cup also has a nonround flange to help keep the part in position in relation to corresponding parts. Because the key on the flange must be in perfect orientation to the pattern of piercings, the press was modified to index rotation during part transfer.



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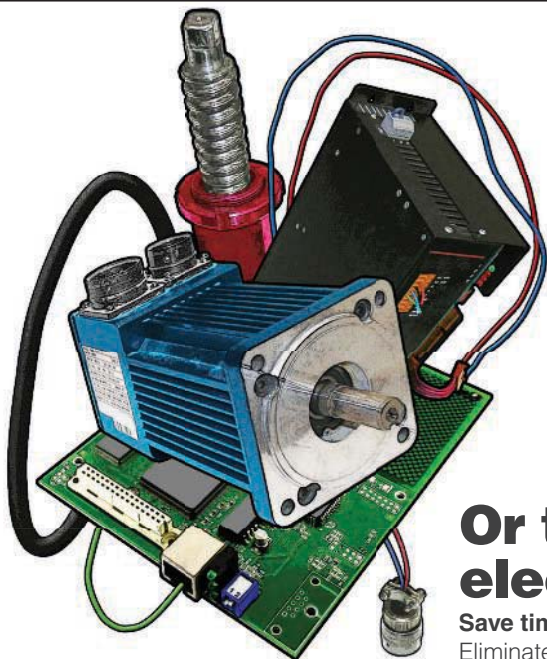


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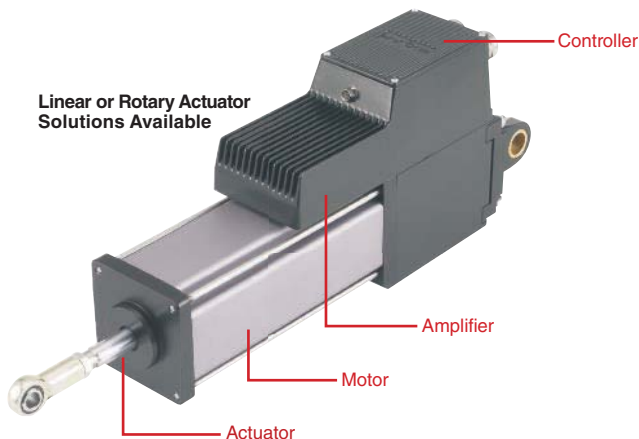
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GROOVED

Parts deep drawn in a single press can be quickly roll formed to add grooves or threads. The bases of incandescent light bulbs, for example, are deep drawn then roll threaded.



ROLLED HEAD

Rolled heads are commonly used for eyelets, rivets, and grommets. They create a smooth flange and a strong contact area away from the fastener hole. Surprisingly, the die for a rolled head piece is flat, not rounded, but the punch is shaped to form and trim the piece in one stroke.



MULTISIDE PIERCED

Dozens of holes can be simultaneously punched in a single deep-draw stamping press, producing parts that can filter, strain, or depressurize.



END CUT

Flangeless straight tubes are the simplest and most common deep-drawn stampings. The tubes are used in products ranging from ballpoint pens to satellite antennae.



CONTROLLED ORIFICE

By calculating the exact size of the small-diameter orifice and the pressure on the fluid or gas that will pass through, a precise flow rate can be achieved and maintained.



STEPPED DIAMETER

A part with a stepped diameter often replaces a two-piece machined assembly. These tin-plated commercial bronze parts were previously screw machined from solid stock.



RECTANGULAR

Prismatic-drawn parts protect sensitive circuits from magnetic currents, radio waves, and static electricity. They frequently house small electric and electronic assemblies.



EMBOSSED

Stampings can have raised or sunken embossments to identify parts and brands. Conical, round, flat, and cylindrical surfaces can be embossed.



BEADED

Inside or outside, beads act as stops, divisions, or connections between different sections of a stamping. Sometimes they are formed by forcing tube ends together, some times by secondary processes like roll forming.



SIDE PIERCED

The side-piercing operation can be automated, integral to the deep-drawing process.

COMBINATION DRAWN/FLAT

A roll of strip is first deep drawn, forming tubes on flat flanges. These flanges are pierced, then trimmed off the strip in a specified shape. The piercing can serve many functions such as anchoring injection-molded plastic.



SIDE CUT

Side cuts can be notched in a combination flat/flat/drawn technique. Or, parts can be trimmed from strip, then side cut in a subsequent process.



FUNNEL

Like stepped-diameter and flat/drawn combination stampings, this funnel replaces multiple machined parts. When this part was screw machined, the variation in diameters and the large, hollow area had created unwanted waste.



SHAPED CUP

Shaped cups are difficult to draw because of the wide clearance between the strip and die at the beginning of the strike. Air pressure is used to control the stock and minimize wrinkles. Shaped cups are frequently used for pressure vessels and diaphragms.

Consider assemblies

instead of one-piece machined parts

It's common knowledge that parts can be combined to create assemblies, but how many designers consider building an assembly to create a part? This approach may often yield a better, more-consistent product because it eliminates stress reactions that often result from machining a part where material removed from one side of the part is not equally offset from the other side.

In the days when manual machining was the norm, designers understood that creating a part which required a lot of unnecessary material removal meant he or she would be hearing from the poor machinist who had to make it. They, thus, limited such designs to situations where there were no other options.

However, today's easy-to-use CAM programs have given many designers the impression that it's best, and oftentimes easiest, to machine a part from a single block of material. Therefore, the cost of material removal is often overlooked in favor of creating easy-to-design parts. Such designs, however, may often result in unsatisfactory and expensive end products.

For example, consider the plastic part with four legs. It was originally designed to



The plastic part (top) shows what the designer intended — a machined frame that was straight, parallel, and with legs perpendicular to the top surface. But what the designer got instead was a warped part (bottom).

be machined out of a single block of material, with nearly 85% of the material removed from one side. The resultant part warped in two directions and the product yield was around 50%.

To address this problem, our shop redesigned the part to be made from five pieces and assembled them. We made the frame from a single rectangular piece of thin material, requiring little machining on the faces, and turned the legs from bar stock. The legs were then threaded into the frame. This approach upped the product yield to 100%, and slashed machining cost.

The same theory of creating assemblies for milled components can also apply to many turned parts. In one case, a bar-feed indexer originally called for machining two journals down to a 2-in. diameter on each end from a solid 6-in.-diameter billet of 4140 weighing 93 lb. The part included several impossible to reach areas that required additional milling operations. After our shop consulted with the engineer, it became evident that a weldment would be acceptable. In this case, our shop made the new indexer

design from two parts, performed the milling operations before welding, and finish-turned the final assembly. This approach saved more than 60 lb of material and many machining hours.

The moral of the story? When designing a part, don't be afraid to ask your machine shop for suggestions. Most shops are willing to help. Understandably, not all parts can be redesigned as assemblies. But those that can may make for a more consistent and less expensive part. **MD**



The frame was machined from several parts. The resulting assembly fell 100% within the tolerance range.

Authored by:

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Tooling Research Inc., www.tooling-research.com **RS# 621**

Edited by **Leslie Gordon**, leslie.gordon@penton.com, Twitter @LeslieGordon

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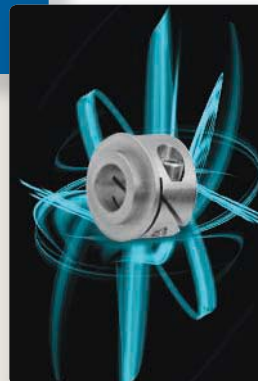
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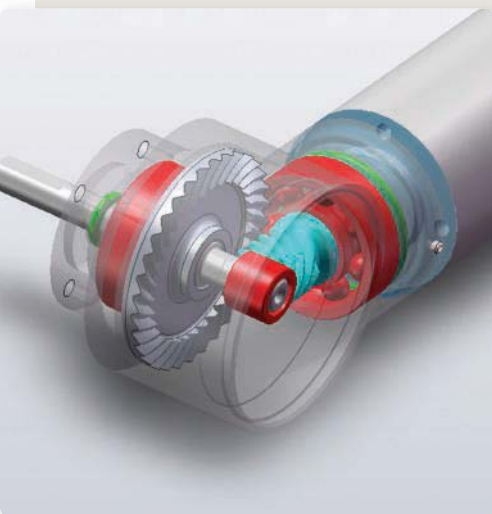
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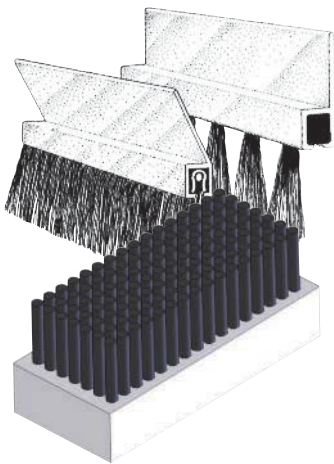
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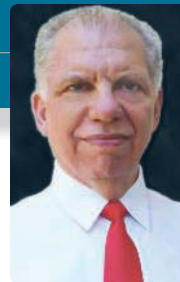


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ORR ON ENGINEERING



Don't just "build a better mousetrap"

The recommendation by Ralph Waldo Emerson to "build a better mousetrap, and the world will beat a path to your door" continues to be followed by many inventors — to their ultimate chagrin.

The better-mousetrap theory is that superior devices or methods, regardless of application, will attract customers. The product will hardly need marketing. People will simply hear about it and rush to buy it.

However, the theory is wrong. Most consumers buy stuff — mousetraps, CAD software, cars, appliances, and so on — in response to immediate needs. An old appliance breaks and repair is too time consuming or expensive. A new client uses CAD package B, but you only have software A. The airline loses your tent at the start of your hunting vacation. Fill in your own tale of need.

Don't get me wrong. Most engineers scan *Consumer Reports*, canvass friends, and spend hours reading blogs and review sites before buying a new car, camper, or cell phone. However, most purchases happen as the result of an immediate need, not careful analysis of all the alternatives.

The lesson for inventors? Learn why your target market buys things. Don't pour your life savings into designing and manufacturing the best, most-efficient waffle iron.

Here's a real example: I met someone recently who is raising funds to build the first laundry-folding robot. This seemed like a good idea. Folding laundry is a time-consuming task loved by few. So what's not to like about a machine that neatly folds and stacks clothes and linens hot out of the dryer?

Unfortunately, the robot is nothing but a "better mousetrap." Users can't just dump laundry into it. They must first separate towels, sheets, socks, shirts, pants, and undergarments. The bottom line is users have to do so much work to get laundry ready for the robot that they could have folded it all in the same amount of time. Worse yet, the inventor hopes to get the price below \$1,500 before going to market, but he's not sure this is possible.

But what about the iPod, you might ask? When it hit the market in 2001, there were already other music players available — they were just much clunkier and harder to use. The iPod was slick and cool. Despite its \$400 price tag, and the fact that it was initially not Windows compatible, **Apple** had correctly determined that a lot of people wanted to carry 1,000 songs in their pocket. Fast forward to 2012: More than 300 million iPods have been sold. And that does not include the 240 million iPhones that have full iPod functionality.

The iPod was not a better mousetrap. It was completely new. Even though there were music players on the market, the iPod did not try to compete with them. It addressed a desire Apple perceived in the market, one strong enough to get customers to part with lots of cash. And by creating *iTunes*, Apple leveraged the invention into a real game-changer — one that nobody has been successful in competing with yet.

So, inventors, think about your idea — the one you've been tinkering with or planning to prototype. Is it just a better mousetrap, like the laundry-folding robot? Or is it in the same category as an iPod? And if it seems too much like the former, what can you do to make it more like the latter?

The upshot is, if you have an idea for an invention, make sure it addresses an actual need people or companies have. Otherwise, it might join the more than 4,000 mousetrap patents granted by the **United States Patent and Trademark Office** that were commercial failures.

— Joel Orr, Copywriter
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Edited by **Leslie Gordon**, leslie.gordon@penton.com, Twitter @LeslieGordon

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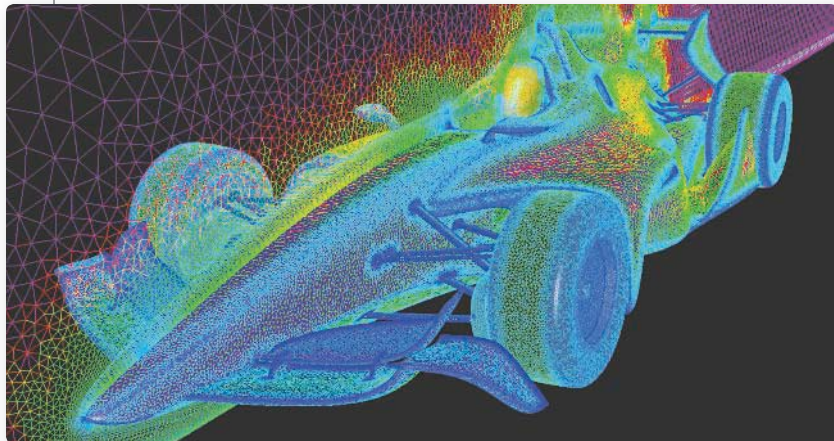
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Illinois: 800-944-0333

Georgia: 888-354-9470

CFD software sports an advanced hybrid mesher

CFD meshing software, Pointwise Version 17, includes an advanced version of the T-Rex hybrid meshing technique for viscous flows as well as native readers for CAD files. According to the developer, the T-Rex technique (anisotropic tetrahedral extrusion) is a highly automated method for generating a hybrid mesh suitable for resolving boundary layers, wakes, and other



features of a viscous flowfield. T-Rex extrudes layers of high-quality tetrahedra, avoids collisions with layers extruding from adjacent geometry, and optionally combines the layered tets into prisms. The technique ensures consistency of the volume mesh with the adjacent surface meshes, something which previously had to be managed manually. The new release can read geometry data from CAD formats including ACIS, Catia V4, Catia V5, NX, Parasolid, Pro/Engineer, SolidWorks, and STEP. Importing directly from a native format bypasses the requirement to produce an IGES file and avoids the possible errors introduced by translating to an intermediate format. The readers, bundled into Pointwise, operate without a license of the CAD software.

Pointwise Inc., 213 South Jennings Ave., Fort Worth, TX 76104, (817) 377-2807, www.pointwise.com

RS# 426

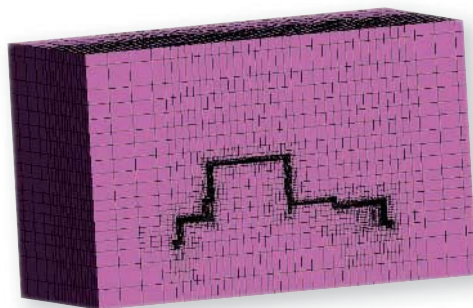
Tablet for field technicians



The rugged T510K tablet for field technicians has a 10-in. resistive touchscreen, with a 23-key interface, Bluetooth, 3G/4G integrated module, camera, 2D scanner, and RFID. The computer comes with Windows XP or 7 Pro and the Intel Atom processor. The tablet has "grip-and-go" handles and desktop and vehicle cradles. Optional features include an RS-232 connection, GPS, and Smart Card Reader.

Glacier Computer, 46 Bridge St., New Milford, CT 06776, (860) 355-7552, www.glaciercomputer.com

RS# 428



Electrical modeling add-in to SolidWorks

SolidWorks Electrical, an add-in to SolidWorks, lets users create 2D schematics and 3D electrical models. The software synchronizes project design data with real-time, bidirectional updates. Automated management tools streamline the design of complex PLC connections.

Fisher/Unitech, 1150 Stephenson Highway, Troy, MI 48083, (800) 816-8314, www.funtech.com

RS #427

Software simulates injection molding

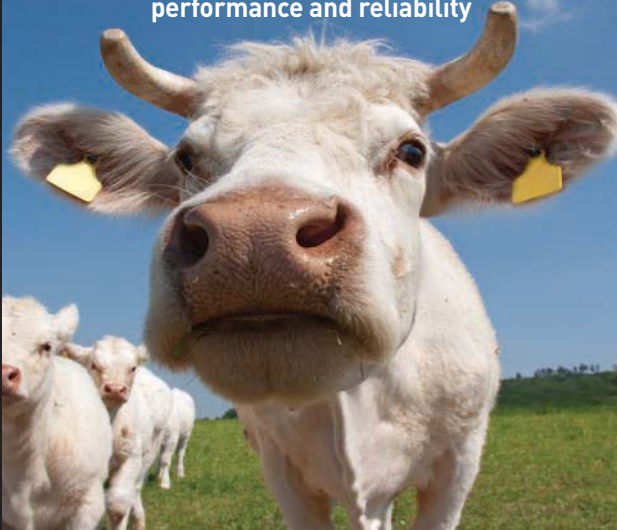
Sigmasoft Version 5.0 simulates injection-molding processes using finite-volume numerical methods to analyze the complete mold, including the cavity, tempering channels, heating elements, and inserts. Users can quickly generate a mesh, without having to manually optimize it.

Sigma, Aachen, Germany, www.3dsigma.com

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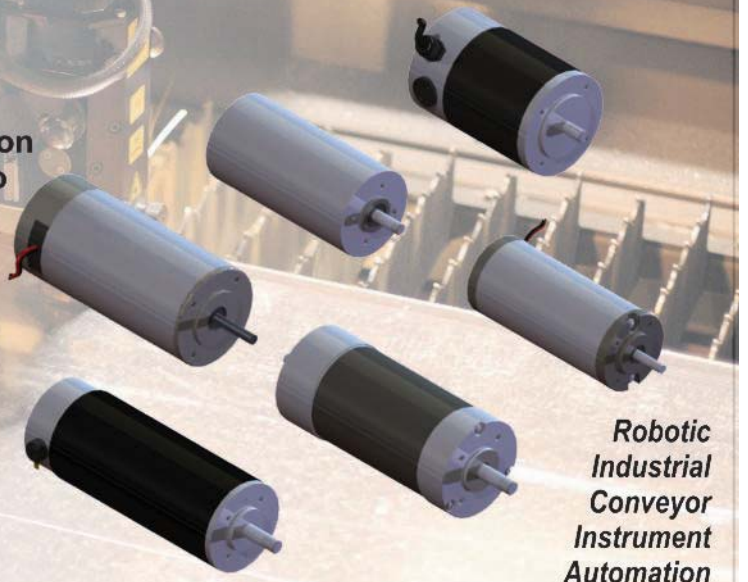
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RS# 167

Two-component silicone

MasterSil 153 is an addition-cured system that requires no air for complete cross-linking. It can be cured over wide surface areas as well. The easy-handling, two-component silicone features a one-to-one mix ratio by weight and its paste consistency



allows for precise application. The silicone has a low exotherm and long working life of 5 to 7 hr at room temperature. It is a self-priming system, which enhances its bonding abilities to a wide variety of similar and dissimilar substrates, including most metals, plastics, glass, ceramic and cured silicone rubber. The translucent silicone is serviceable over a temperature range of -65 to over 400°F.

MasterSil 153's flexibility lets it withstand severe thermal cycling as well as vibration and mechanical shock. Its softer durometer of 20 to 35 Shore A hardness improves its reparability.

Additional properties and features include excellent electrical insulation capabilities, water resistance, and low shrinkage upon cure.

When stored in its original containers, MasterSil 153 has a shelf life of 6 months. It comes in ½ pint, pint, quart, gallon, and 5-gallon container kits.

Master Bond Inc., 154 Hobart St., Hackensack, NJ 07601, (201) 343-8983, www.masterbond.com

RS# 446

Alloys for electronics

Terraloy BP 70010 and 70011 polylactic acid (PLA) compounds let manufacturers of electronic housings and components use substantial amounts of bio-based content in their products without sacrificing mechanical and thermal properties provided by engineering thermoplastics (ETPs).

Based on alloys of PLA and ETPs, Terraloy provides similar or greater strength, stiffness, and heat-distortion temperature in comparison with standard polycarbonate, ABS, and PC/ABS blends while including 40 and 36% levels of bio-based content, respectively.

Potential applications for the new compounds include injection-molded housings, handles, covers, and other components of electronic devices, medical equipment, and consumer products.

Teknor Apex Co., Bioplastics Div., 505 Central Ave., Pawtucket, RI 02861, (800) 556-3864, www.teknorapex.com



RS# 447

Impact-modified PLA compounds

The company's line of polylactic acid (PLA) bioplastic compounds has been expanded to include impact-modified grades suitable for select semidurable and durable applications. The compounds offer

enhanced impact strength and higher heat-deflection temperatures than are possible with unmodified PLA resin.

Available in both injection and extrusion grades, the new materials also include impact modified, nucleated, and mineral-reinforced compounds. Varying



levels of impact modification are available. The compounds are available in both opaque and translucent versions and can also incorporate FDA-compliant ingredients.

RTP Company, 580 East Front St., Box 5439, Winona, MN 55987, (800) 433-4787, www.rtpcompany.com

RS# 448

Resins for thermoset systems

Noryl SA90 and SA9000 resins can be used as additives for epoxy and nonepoxy thermoset systems, as well as by makers of prepregs and copper-coated laminates, electrical adhesives, composites and coatings to significantly boost the performance and sustainability of their existing thermoset products.

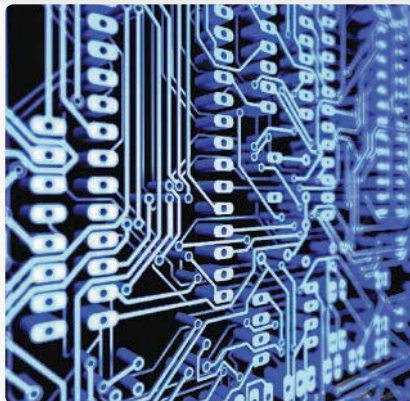
Noryl SA90 resin, designed as an additive for epoxy and cyanate ester-based thermosets, provides lower dielectric constant and loss factor for better high-frequency performance (1 to 10 GHz) in epoxy-based PCBs. It is soluble (at loadings of up to 50%) in methyl ethyl ketone (MEK) at room temperature, thus avoiding the use of extreme solvents commonly needed for traditional polyphenylene ether (PPE) resins that pose difficulties in safe handling in the electrical laminate market.

Noryl SA9000 resin provides lower dielectric constant and loss for improved high-frequency performance (up to 20 GHz) in nonepoxy based thermoset systems. This lets manufacturers provide nonhalogenated flame retardants in free radical cure (vinyl or triallylisocyanurate (TAIC)) PCBs.

Both resins provide lower moisture uptake for more-stable dielectrics and higher glass transition (Tg) temperatures.

SABIC Innovative Plastics, 1 Plastics Ave., Pittsfield, MA 01201, (413) 448-7110, www.sabic-ip.com

RS# 449



Silicone thermal interface

EPM1-2493 is a low-viscosity, low-modulus silicone elastomer with a nominal thermal conductivity of 1 W/mk. The material offers bond lines as thin as 5 microns and can be used to adhere materials with differing coefficients of thermal expansion for significant stress reduction during thermal cycling. The low-volatility elastomer can reduce or even prevent contamination of electronic components used in applications exposed to high heat, such as solder reflow at 260°C. The elastomer adheres well to aluminum. Its adhesive strength can be improved using a primer, achieving average lap shear values of 120 psi (0.8 MPa).



EPM1-2493 does not have a paste-like consistency like other thermally conductive silicones; it is a pourable, conformal liquid for potting/filling recessed areas and applying to intricate geometries in electronic applications. It can also adhere to integrated circuit substrates, base plates, or heat sinks, or where grooves or other configurations require a limited flow material.

EPM1-2493 is supplied in a 1:1 mix ratio and can be loaded into syringes and dispensed as a one-part material for automated dispensing. The elastomer cures at lower temperatures but can be heat-accelerated for faster cure time.

NuSil Technology LLC, 1050 Cindy Lane, Carpinteria, CA 93013, (805) 684-8780, www.nusil.com/products/engineering/electronics/index.aspx

RS# 451

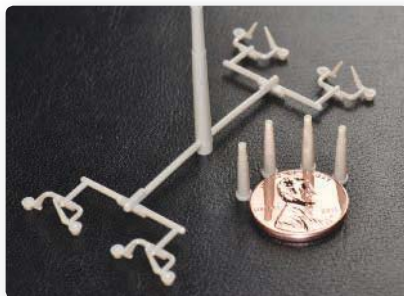
Polymers for intricate components

Victrex 90-Series high flow PEEK polymers, for thin-walled, intricate components, offer higher mechanical properties with improvements in modulus, toughness, and coefficient of thermal expansion. Available in unfilled and in carbon and glass-filled grades, the polymers facilitate the replacement of metals, thermosets, and ceramics. They reduce weight by up to 80% and improve reliability through their thermal and mechanical properties.

The polymers outperform materials like liquid-crystal polymers, polyphenylenesulfides, and ceramics due to their enhanced mechanical properties and toughness.

Victrex USA Inc., 300 Conshohocken State Rd., Suite 120, West Conshohocken, PA 19428, (800) 842-8739, www.victrex.com

RS# 450



Locking handle kit

The CB-Hand locking handle kit adds lock-in and lock-out features to drawers or trays mounted on heavy-duty slides. The one-handed locking operation is easily activated with a centrally located pushbutton. Two options are available: a standard front-mounted

kit with lock-in only, and a rear-mounted conversion kit that adds the lock-out feature.

The kit, made with lightweight and corrosion-resistant components, is suitable for applications such as drawers and trays in utility and emergency vehicles. The lock-in feature secures



pullouts for transit, while the lock-out ensures safe access to contents. The kit accommodates drawers up to 60-in. wide.

Cut-to-length stainless steel rods lets installers add the locking handle to a variety of drawer widths.

Accuride International Inc., 12311 Shoemaker Ave., Santa Fe Springs, CA 90670, (562) 903-0200, www accuride.com **RS# 465**

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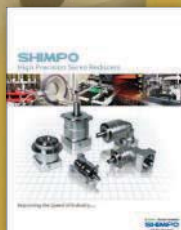
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The SA1E family offers seven different optical functions: through-beam, polarized retroreflective, polarized retroreflective for transparent objects, diffuse reflective, small-beam reflective, convergent, and background suppression.

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SmartMotor upgrade

Improvements based on recommendations from machine builders have been made to the NEMA-23 frame SM23165D and SM23165DT SmartMotors.



The -CDS option SmartMotor gives users the option of using CAN communications through the D-Sub connector on top of the motor instead of through the five-pin connector on the back of the motor. A small change to the circuitry decreased the space the motor requires.

The SmartMotor is a programmable motion controller with a servomotor, drive, amplifier, and encoder all in one. Each SmartMotor can be a slave or master to any other SmartMotor, with the ability to link over 100 SmartMotors over one CANbus.

Moog Animatics, a div. of Moog Inc., 3200 Patrick Henry Dr., Santa Clara, CA 95054, (408) 748-8721, www.moog.com

RS# 468

Ultrasonic sensor

The UK1 Series ultrasonic sensor line now includes 18-mm round plastic dc models. The devices are IP67 rated with a 15 to 30-Vdc operating range and are fitted with a M12 quick-disconnect. The Series offers six different output types:

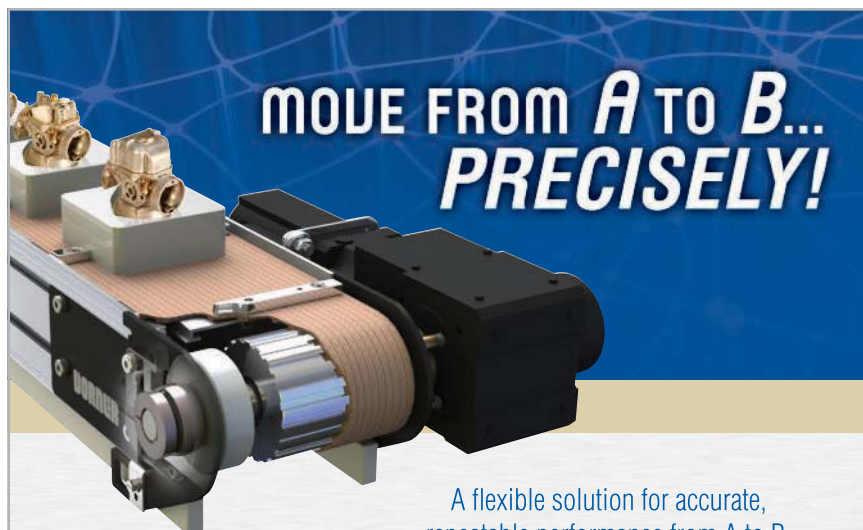
single *pnp*, dual *pnp*, 4 to 20 mA only, 0 to 10 V only, *pnp* and 0 to 10 V, and *pnp* and 4 to 20 mA. Four different sensing ranges are available: 50 to 400, 100 to 900, 150 to 1,600, and 200 to 2,200 mm. The sensors have LED status indicators and a pushbutton



teach feature for configuration of normally open and normally closed states for dc-output models and for adjusting sensitivity on analog models.

AutomationDirect, 35015 Hutchinson Rd., Cumming, GA 30040, (770) 889-2858, www.automationdirect.com/ultrasonic-sensors

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A variety of brackets are available for mounting, including right-angle with curved slot; swivel with tilt and pan movement; and flat and right angle with articulation slots. With an IP69K-rated housing, the indicators operate at -40 to 50°C, even in harsh wash-down environments.

Banner Engineering Corp., 9714 Tenth Ave. N, Minneapolis, MN 55441, (888) 373-6767, www.bannerengineering.com

RS# 470



Voltage sensors

The ACPL-C87B/C87A/C870 voltage sensors are optical isolation amplifiers for voltage sensing. A 2-V input range and 1 GΩ input impedance makes them suitable for electronic power-converter applications. A resistive voltage divider scales the dc-link link voltage to suit the sensor's input range. A differential output voltage proportional to the input voltage is created on the other side of the optical isolation barrier.

The sensors feature advanced Sigma-Delta ($\Sigma\Delta$) modulation technology; unity gain 1 V/V, $\pm 0.5\%$ high-gain accuracy; 0 to 2 V nominal input range; -35-ppm/°C low-gain drift; 21 $\mu\text{V}/^\circ\text{C}$ offset voltage drift; 0.1% nonlinearity maximum; active-high shutdown pin; 100-kHz bandwidth; 3 to 5.5-V supply range for output side; -40 to 105°C operation; 15-kV/ μsec common-mode transient immunity; and an autoinsertable stretched SO-8 package.

Avago Technologies, 350 West Trimble Rd., Building 90, San Jose, CA 95131, (408) 435-7400, www.avagotech.com

RS# 471

Brushed motors

Series 1336 and 1741 CXR brushed motors offer high-power density with dynamic 4 or 8-mNm continuous output torque and a flat gradient of the n/M curve. The two new graphite-commutated motors measure 13 or 17 mm in diameter, are 36 or 41-mm long, and have an operating range of -30 to 100°C. Both variants can be combined with two-channel encoders and a compatible range of precision gearheads.

MICROMO, 14881 Evergreen Ave., Clearwater, FL 33762, (727) 572-0131, www.micromo.com

RS# 472



Machine-mounted EtherCAT box

The EP1908 EtherCAT box features TwinSAFE open-safety technology, which includes an IP67-rated variant for use outside of electrical cabinets and in harsh environments.

The box has eight 24-Vdc inputs



to connect safety sensors via rugged and reliable M12 connectors. The unit also permits the acquisition of safety sensor signals directly on the machine instead of having to mount the I/O inside a control cabinet. Inputs can accept OSSD signals from light curtains and laser scanners. Zero-speed monitoring via encoder or proximity switch in the range of 0 to 500 Hz is also possible.

Beckhoff Automation LLC, 12150 Nicollet Ave. S, Burnsville, MN 55337, (952) 890-0000, www.beckhoffautomation.com

RS# 473

Capillary thermostat

The WK, WK-H, and WP Series of capillary thermostats, complete with mounting hardware, offer accurate temperature control, smooth adjusting, and reliability. These mechanical switches are activated by temperature change in the capillary tube. The sensor is charged with a refrigerant gas, and temperature changes are converted to travel via the bellows/diaphragm, which is actuated by the mechanical-level switch closing on temperature rise. The devices can be used as temperature or defrost control elements with or without constant cut in.

Performance capabilities include operating temperatures of 0 to 40°C (WK Series), -35 to 40°C (WK-H Series), and -30 to 55°C (WP Series). Amperage ca-



pacities vary between models with the WK-H Series featuring the higher amperage of 25 A. All models are available with or without forced off and forced on positions and with SPST or SPDT switching contacts.

Selco Products, 8780 Technology Way, Reno, NV 89521, (800) 257-3526; www.selcoproducts.com

RS# 474

Plug & Drive stepping motors

The Plug & Drive Series stepping motors now have IP65 wash-down ratings. The motors include true torque-control through the entire motion profile, ranging from NEMA 17 to NEMA 34. The Series is fully programmable. The motors eliminate unnecessary wiring between motor, control, and encoder and feature M12 and M16 connectors. The control and encoder are inside the motor frame. Holding torque ranges from 0.5 to 9.3 Nm with maximum speed up to 3,000 rpm.

The Plug & Drive controls include true torque, speed, and position control over the entire motion profile.

Nanotec Electronic U. S. Inc., 98 Sheridan Ave., Medford, MA 02155, (781) 219-3343, www.nanotec.com

RS# 475

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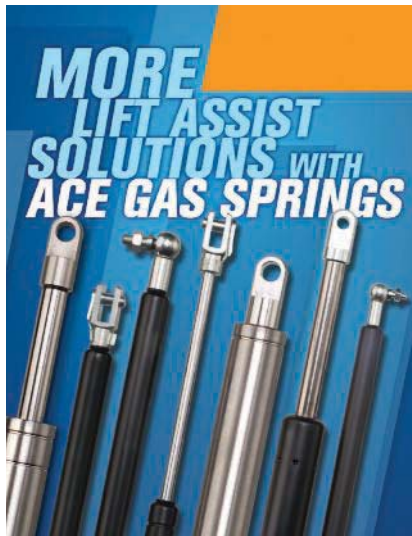
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RS# 175



30 New Models
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New GST Tandem Gas Spring Model

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PRODUCTS

Angular gripper

The PWG-plus angular gripper features a double-oval piston drive; a one-piece, high-strength aluminum housing; and a practically wear-free lever mechanism. Extensive accessories are available, including inductive sensors and magnetic switches.

The angular gripper is equipped with a connecting pattern identical to that of the PGN-plus universal gripper, which lets it work with compensation units, valves, or quick-change jaw systems.

The gripper is available in three sizes for workpiece weights between 0.5 and 7.3 kg, gripping moments between 3.5 and 143 Nm, a stroke per finger of 15°, and a travel tension angle per jaw of at least 3°.

Schunk, 211 Kitty Hawk Dr., Morrisville, NC 27560, (919) 572-2818, www.schunk.com



RS# 476

Stainless-steel cylinders

New 9/16-in. bore stainless-steel cylinders are available in stud or universal mount, double, single or reverse acting, rotating or nonrotating rod, with standard stroke lengths up to 4 in. Standard features include polished ID stainless-steel tubes; precision rolled construction; machined aluminum heads; sintered bronze bushings; ground, polished, and roller burnished 303 stainless rods; full piston breakaway; Buna-N "U"-cup piston seals; and Buna-N "U"-cup rod seals.

Clippard Instrument Laboratory Inc., 7390 Colerain Ave., Cincinnati, OH 45239, (877) 245-6247, www.clippard.com



RS# 477

Milling-machine control

The TNC 640 control lets turning operations be done on a milling machine so operators can transition from milling to turning cycles in the same program. Turning operations can be programmed in plain text, just like milling operations. Comprehensive turning cycles are available for frequently repeated operations, such as roughing, finishing recessing, and thread cutting.

The TNC 640 features a new and completely digital interface platform that reduces cabling during setup. An ergonomic, 19-in. screen — the operating panel with stainless-steel fronts and status displays — provides an optimized user-friendly appearance.

Heidenhain Corp., 333 E. State Pkwy., Schaumburg, IL 60173, (800) 233-0388, www.heidenhain.us



RS# 478

Air cylinders

Three styles of air cylinders are available with all exposed surfaces made of stainless steel. The Pancake is a round cylinder of unibody construction with a smooth outside surface that does not trap wash-down solution or allow bacteria growth. NFPA tie-rod cylinders and the "F" Series "throw-away" styles are for applications requiring complete stainless-steel protection.

Fabco-Air Inc., 3716 N. E. 49th Ave. Gainesville, FL 32609, (352) 373-3578, www.fabco-air.com

RS# 479



Handheld moisture meter

The HSM50 Series handheld moisture meter measures the moisture level of soil or similar materials. Housed in ABS plastic, the microprocessor-based meter displays data quickly and accurately on an LCD screen for landscapers, soil sci-



entists, nursery managers, turf managers, and in other fields where soil moisture needs to be monitored.

Omega Engineering Inc., One Omega Dr., Stamford, CT 06907, (203) 359-1660, www.omega.com/pptst/HSM50.html

RS# 480

Dc micromotors

High-performance slotless brushless-dc motors for medical applications produce little or no EMI, provide long life, and have low audible noise. The slotless design eliminates magnetic



cogging. Stator teeth are completely eliminated by forming and encapsulating the entire stator winding along the inside surface of the back iron, resulting in zero detent torque, low inductance, and fast response rates.

The motors have a maximum speed of 70,000 rpm, a torque rating of 0.3 oz-in (0.002 Nm), and an overall length of 2.00 in. (50.8 mm). The motor has a two-pole permanent-magnet rotor, a three-phase stator, and sensorless commutation.

The motors consist of four pole rotors, three phase stators, and Hall-sensor feedback spaced for 120 electrical degrees.

Standard features include shielded ball bearings, stainless-steel construction, and high-energy neodymium-rotor magnets. Permanent-magnet rotors are balanced for smooth and quiet operation at high speeds.

Pittman, 343 Godshall Dr., Harleysville, PA 19438, (330) 673-3453, www.pittman-motors.com

RS# 481



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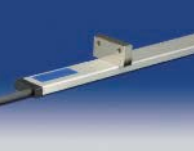
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- Protection class IP67 / IP69K

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PRAS5V



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PTAM27 / PTDM27



RS# 178

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MedicalSilicone CONFERENCE

The fifth edition of the Medical Silicone Conference (MSC) will travel back to Minneapolis, a major hub for medical device manufacturing. Minnesota is set to become an even bigger player in the medical device industry as small and midsize companies proliferate and grow.

The two-day event will feature presentations by leading industry experts on material, processing, and design topics specific to medical device OEMs. Keynote sessions will address medtech issues and trends.

Unlike other polymer or silicone conferences, the Medical Silicone Conference will focus exclusively on utilizing silicone in the medical device industry.

www.medicalsiliconeconference.com

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Pressure-relief valve

The new Hi-Q pressure-relief valve provides both high-relief pressure



and high flow rate. This valve, capable of relief pressures up to 5,400 psid and flow rates over 19 gpm, uses a side inlet flow path to minimize the installation boss size and weight.

The valve comes in a range of cracking pressures from 1,000 to 5,400 psid, and is designed for nominal pressures up to 5,000 psi and peak pressures up to 6,750 psi.

The Lee Co., 2 Pettipaug Rd., Box 424, Westbrook, CT 06498, (860) 399-6281, www.theleeco.com

RS# 482

CNC routers

The HDS Series CNC router is a precision cutting device that uses quality components such as THK rails and bearings. The router features an industrial Osai servocontroller with high-powered ac servomotors and drives for powerful, fast, accurate motion and features a user-friendly interface.

The unit is available in sizes from 4 x 8 ft and up. It also features a 12-hp HSD high-frequency toolchanger spindle with multiposition tool holder rack, multizone vacuum T-slot table combination, and material pop-up location pins.



Techno CNC Router Systems, 2101 Jericho Turnpike, Box 5416, New Hyde Park, NY 11042, (800) 819-3366, www.technocnc.com/cnc-router-systems/hds-series-cnc-router.htm

RS# 483

Logic valves

The LC2A-1X Series actively controllable 2/2 directional cartridge valve comes in seven sizes ranging from 16 to 100. The hydraulic valve can directly mount almost any LFA logic cover in the company's standard program, allowing the creation of any hydraulic function imaginable.

Variable assignment of the pilot oil channels to the active area opens up new levels of freedom. The valve lets users set different functional priorities, including a direct replacement of existing standard logics if a user

wants to add position monitoring or prevent internal leaks. New additional piston models allow for highly dynamic check-valve functions or analog position sensing.

In Sizes 80 and 100, the hydraulic flow parameters were optimized through design modifications. In combination with the shaft seal, hydraulic losses are further reduced, which contributes to better efficiency.

Bosch Rexroth Corp., 2315 City Line Rd., Bethlehem, PA 18017, (610) 694-8266, www.boschrexroth-us.com

RS# 484

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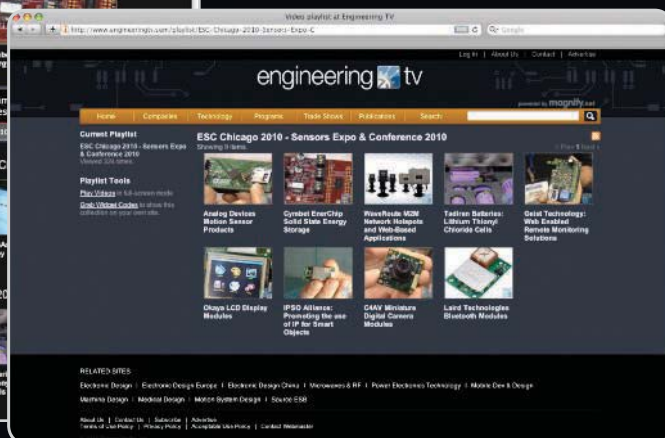
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Battery holders

Battery holders in tape and reel packaging makes it easier to use automated assembly. Tape and reel are also available for through-hole mount CR2032 holders, as well as surface and through-hole mount holders fitting CR1216, CR1225, CR2016, and CR2025 coin cells.

The holders nickel-plated phosphor bronze construction provides good conductivity and strength. Two metal arms secure the battery to the contact patch.

Linx Connectors, 159 Ort Lane, Merlin, OR 97532, (800) 736-6677, www.linxtechnologies.com



RS# 485

Rotary pump and compressor

The oilless Picolino rotary pump and compressor is designed for a variety of applications, including medical, vacuum lifting, laboratory, air sampling, sewage aeration, and printing. The quiet, pulsation-free pump comes in two configurations – the DTE (pressure) with inlet silencer, pressure-relief valve and outlet tube connector, and the VTE (vacuum) with outlet silencer and tube connector.

Features include 3.5 m³/hr to 12.0 m³/hr (2.06 cfm to 7.6 cfm) maximum flow; pressure to 1.0 bar (14.5 psig); and vacuum to 150 mbar abs. (25.1 in.-Hg).

Thomas Div., a Gardner Denver Co., 1419 Illinois Ave., Sheboygan, WI 53081, (920) 457-4891, www.gd-thomas.com/productlist.aspx?id=10490&tp=p



RS# 486

Bearing coating

A new and improved coating, SQ171E, protects bearings and components in applications including material handling, agricultural machinery, chemical and pharmaceutical industries, as well as compressors and pumps. The coating is thinner and provides longer-lasting protection against corrosion than its predecessor.

The coating can be used for standard or special bearings as well as for all-metal parts that are exposed to wet or corrosive environments. Machined surfaces, such as races, can also be coated. The coating provides protection against water, condensation, and slightly alkaline or acidic cleaning agents. For more-effective protection, the coating also comes with a silicate-based sealing layer. Due to the reduced thickness of the coating (from 2 to 4 µm), coated and uncoated parts are completely interchangeable.

NKE Austria GmbH, Im Stadtgut C4, 4407 Steyr, Austria, www.nke.at/en/home



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RS# 257

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RS# 260

New ACE Controls Gas Springs

ACE expands its Gas Spring product line with 28 new models including 20 new Stainless Steel versions and over 280 additional stroke lengths. New Tandem Gas Springs featuring two pressure tubes with different extension forces now available. ACE Gas Springs provide counterbalance motion control for lifting and lowering covers, lids, panels, hoods, hatches and guards. Fixed force and adjustable models with push and pull type designs. Wide variety of end fittings for ease of installation. Exclusive customer application support.



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RS# 252

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Apple Rubber's Seal Design Guide has everything you need for your sealing solutions. With an interactive Technical Summary and multiple formulas available, it's never been easier to find the seals you need. Bookmark the Seal Design Guide for information at your fingertips to determine compression, cross sections, stretch, and more.

Apple Rubber Products

RS# 255

New BEI Sensors Selection Guide Covers Products, Environments and Technology for Motion Control



BEI Sensors' product selection guide explains the fundamentals of various speed and position sensing technologies and how to choose which is best suited to a particular application. BEI's extensive line of rugged products include rotary encoders, rotary and linear potentiometers and rotary Hall effect sensors, all of which are displayed in easy-to-read charts that summarize the most critical specification criteria side-by-side.

www.beisensors.com/guide

RS# 258

Clamps and Tooling Components



This 688-page, illustrated catalog includes toggle clamps, pins, hoist rings, knobs, modular fixturing, supports, jig and fixture bases, drill bushings and power workholding devices. Full specs included. Online version at carrlane.com.

Carr Lane Mfg. Co.
St. Louis, MO
www.carrlane.com

RS# 261

Digital Pressure Gauge



AP60 digital pressure gauge is CR2032 battery powered, offers wide viewing angle and provides an accurate readout. They are rated for pressures up to 1.0MPa (145 psi) with

user-programmable display pressure units for MPa, kgf/cm², bar and psi. Suitable for filtered air and non-combustible and non-corrosive gases; excellent repeatability of $\pm 0.2\%$ F.S. ± 1 digit or better.

Adsens Technology Inc.
City of Industry, CA

RS# 253

New tutorials and podcasts on Learn Web site



"What is a PLC" plus many more topics on industrial control products including new videos and podcasts on AutomationDirect's free self-service learning site. Visit <http://learn.automationdirect.com> to watch these and other tutorials on a range of industry topics.

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RS# 256



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RS# 259

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RS# 262



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CPV Manufacturing
RS# 263



Free design guide to servo-hydraulic motion control

www.deltamotion.com

Popular, practical 64-page guide with 16 topics by Peter Nachtwy:

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- Sizing Cylinders and Valves
- Selecting Accumulators
- Transducers and Resolution
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RS# 265

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RS# 267



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Galil Motion Control
RS# 269

Halogen Free, PUR Control Cable for Long-Distance Cable Tracks

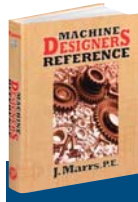
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RS# 273



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CPV Manufacturing Inc., Philadelphia, PA

RS# 264

Brushless DC and Intelligent Servo Motors



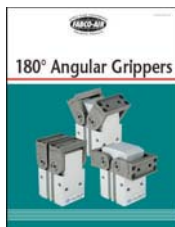
Dunkermotor releases its 2012 Low Voltage Brushless DC and Intelligent Servo Motors catalog.

Expanded catalog includes specifications on custom configurable BLDC motors, controls, gearheads, brakes, encoders and accessories. Available for complimentary download at Dunkermotor website or email request for hard copy.

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RS# 266



180° Pneumatic Gripper

180° Angular Grippers

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Gainesville, Florida

RS# 268



New Spring Brochure

New brochure, "The spring for the 21st century," describes Helical's special expertise in designing and producing single piece, maintenance free, "machined" springs for a broad range of applications. It also features examples of integrated attachments plus data comparing wire-wound and machined springs. Helical machined springs are used in industries such as medical, aerospace, military, nuclear, industrial and electrical/electronics.

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RS# 270



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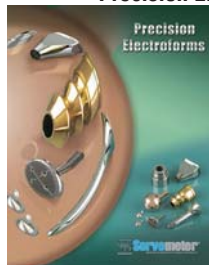
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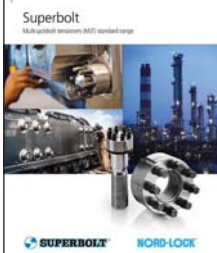
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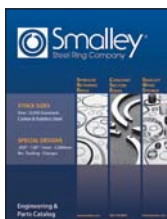
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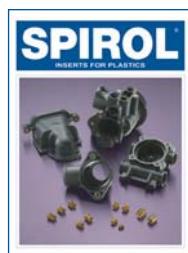


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~~$$20 \log_{10}()$$~~

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13,400 Legos replicate LASR facility

William Adams works in the Navy Center for Applied Research in Artificial Intelligence at the **Naval Research Laboratory**, where he supports research in human-robot interaction, sensing, and autonomy. Adams manages the Center's robot lab, and he keeps the Center's Mobile, Dexterous, Social (MDS) robots - Octavia, Isaac, and Lucas - operating and configured to meet research needs.

Earlier this year, NRL opened its brand-new Laboratory for Autonomous Systems Research. The one-of-a-kind facility sparked an idea in William's mind that led to a Lego model of the facility.

Adams says building it took approximately 120 hr over the course of three months, working a few evenings a week. He made seven trips to three local Lego stores to purchase the bricks needed for the project. Adams estimates that around 13,400 pieces make up the model.

Due to limitations on time and brick (the community's collective term for Lego pieces), Adams wasn't able to do a complete interior of the LASR facility, although



Photos: U. S. Naval Research Laboratory, Jamie Hartman

he did represent most of the spaces. Included in the model are the Reconfigurable Prototyping High Bay, Littoral High Bay, Desert High Bay, Tropical High Bay, Power and Energy Lab, two Human-System Interaction Labs, the Machine Shop, Electrical Shop, and

changing room, all of which have full interiors.

Adams says he was inspired to create the model when Lego released a line of small-scale architectural kits. He had some aging Lego models in his office that needed replacing, so he figured he could also build a model of the LASR building. He thought about larger models he'd seen in displays and decided to build a large-scale version for the opening of the LASR facility. Building to a larger scale allowed for detailed interiors, while keeping it slightly under Lego-figure scale kept it transportable.

When asked if he had built other models of this size and complexity, he said not really. He and his siblings would

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RS# 183

would build castles on the dining room table and lay siege, according to a well thought out set of rules inspired by various board games. Adams and his brother built a model of the National Cathedral that rose with different color strata

as they exhausted their brick supply of each. Several years ago, he built a set of detailed models with the theme of a medieval shipyard, each showing a particular trade or technology. Those models were much smaller and could have fit within

the LASR model's large high bay.

The model is on display in the front area of the LASR facility. It will stay there until either the LASR Director needs the space, or Adams needs the brick for a new model. **MD**

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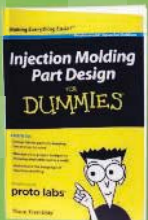
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