Antenna Company announced the availability of high performance antenna technologies for Wi-Fi, GPS and Cellular networks.
See page > 7

Clippard has announced a series of direct actuating valves that offer a fast response time for accurate dosing of minute volumes.
See page > 23

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SEPTEMBER 2016

71ST YEAR, ISSUE 6

Advantage Business Media

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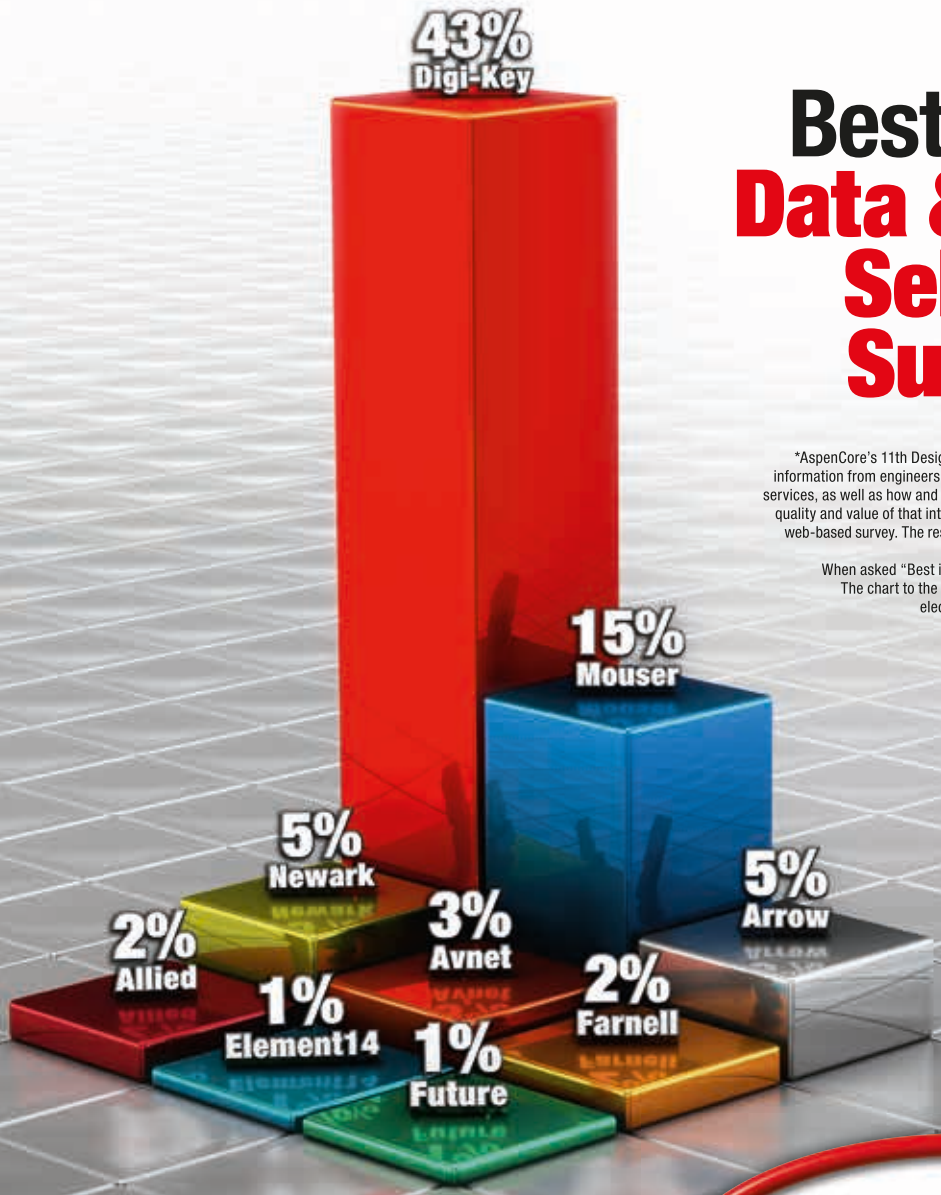

Best in Class: Data & Product Selection Support?*

*AspenCore's 11th Design Engineer and Supplier Interface Study gathered information from engineers regarding their need for product information and other services, as well as how and when they interface with suppliers and how they see the quality and value of that interface. 1,750 U.S. engineers participated in this year's web-based survey. The results represent those surveys completed by April 2016.

When asked "Best in Class for Data & Product Selection Support?" The chart to the left shows the results among the industry's electronic component distributors.

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Periodicals Mail postage paid at Rockaway, NJ 07866 and at additional mailing offices. **POSTMASTER**: Send address changes/cancellations to Product Design & Development, P.O. Box 3574, Northbrook, IL 60065-3574, 847-559-7560, Fax: 847-291-4816, email: abpdd@omeda.com. Publications Mail Agreement No. 41336030. Return undeliverable Canadian addresses to: Imex/Pitney Bowes, P.O. Box 1632, Windsor Ontario N9A 7C9.

Subscriptions are free to qualified individuals. Non-qualified subscription rates per year are: USA $126, Canada, Mexico & Foreign $180, single copy USA $17.50, single copy Canada, Mexico & Foreign $25, prepaid in USA funds drawn on a USA branch bank.

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At Issue

Lee Goldberg, Editor

Join Me at Maker Faire

If you're going to be anywhere near Queens, NY, on October 1, please consider joining me for a tour of one of my favorite tech happenings of the year – the NY Maker Faire. For those of you not familiar with the event, it's a home-grown festival that invites hobbyists and pros alike to celebrate technology, the arts and DIY culture. Besides being a great place to catch a first glimpse of some of the most innovative products and technologies emerging from the Maker Economy, it's one of the few events I've been to where the attendees are as fascinating as the exhibits.

The Maker Faire is much more than an event, it's part of a movement that's re-democratizing technology and innovation. Open Source hardware and software have made it possible for people to translate their ideas into reality more easily than ever before. Meanwhile the Internet has made remote collaboration possible, enabling people with common interests to pool their knowledge, talents, and resources, regardless of where they live. Crowd-funding is helping these technologies go mainstream by giving some of these would-be entrepreneurs to access capital needed to get their ventures off the ground. This alternative path has helped launch everything from kitchen tools to nano-satellites towards commercial success. I've also watched the same forces help many non-profit projects, ranging from open-source hydroponic systems to low-cost adaptive wheelchairs, realize their goals.

I'll be shooting a video blog for the PD&D website and would enjoy having a few loyal readers join me as we check out some of the coolest exhibits at the Fair. We'll spend much of the day seeking out new developments in 3D printing, open-source computing, and environmentally-friendly technologies, but our itinerary will also include visits to less practical exhibits, such as steam-powered robots, a rock band that uses a 10-foot Tesla coil as its lead instrument and the ever-popular power tool drag races. Naturally, we'll also drop by the booths hosted by Atmel, Microchip Technologies, Texas Instruments, and the other semiconductor manufacturers whose chips power the Arduino boards and other open-source computing platforms found in many of the projects being shown at the Faire.

It should be a great day and I hope that you'll join me. We'll be meeting at the traffic circle just beyond the main exhibit hall around 10 am. If you are interested, write me at lee.goldberg@advantagemedia.com for details.

Dennis Aiken

Jeffrey Moore

Cyclecide Rodeo

PRODUCT DESIGN & DEVELOPMENT
71st Year, Issue 6

General Manager | TODD BAKER
todd.baker@advantagemedia.com

Editor | LEE GOLDBERG
lee.goldberg@advantagemedia.com

Managing Editor | SHERI KASPRZAK
sherie.kasprzak@advantagemedia.com

SALES & EDITORIAL OFFICE
199 E. Badger Road, Suite 101,
Madison, WI 53713
Phone: 973.920.7784; Fax: 973.607.5605

Regional VP Sales - East
GLEN SUNDIN
Phone: 973-920-7038
glen.sundin@advantagemedia.com

Advantage Business Media

CORPORATE OFFICE
100 Enterprise Drive, Suite 600, P.O. Box 912
Rockaway, NJ 07866-0912
Phone: 973.920.7000

Chief Executive Officer
JIM LONERGAN

Chief Operating Officer/Chief Financial Officer
THERESA FREEBURG

Chief Content Officer
BETH CAMPBELL

REPRINTS
The YGS Group
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From pddnet.com

Engineering Newswire 198: *First-Ever Smart Golf Shoes Can Cure Your Bad Swing*

bit.ly/pdd16Sept01

Product Design & Development

An official news agency says China has unveiled the world's largest amphibious aircraft that Beijing plans to use for marine missions and fighting forest fires.

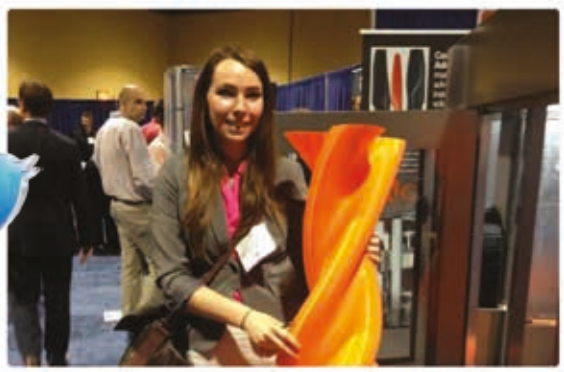
China Rolls Out World's Largest Amphibious Aircraft

PDDNET.COM

bit.ly/pdd16Sept02

Kaylie Duffy @kayliearnduffy

Dear @PDandD readers, it is time for me to say goodbye. Farewell, and keep innovating! pddnet.com/blog/2016/08/s...



bit.ly/pdd16Sept03

Fictiv @fictiv · Aug 2

Our prototype engineer @RichieTranMan wrote an article on batteries in wearables for @PDandD pddnet.com/article/2016/0...

bit.ly/pdd16Sept04

F-35 Reaches Operational Capability

The F-35s at Hill Air Force Base in Utah have been declared ready for combat duty as of Tuesday, August 2nd.

bit.ly/pdd16Sept05 Image credit: U.S. Air Force

Product Design & Development

Tesla's new company roadmap includes building a Semi truck and pickup truck, integrating even further than they already have with SolarCity, and encouraging the wide-scale use of autonomous cars.

Tesla's 'Master Plan Part 2' Includes Semi Trucks, Pickups & Lots of Autonomy

PDDNET.COM

bit.ly/pdd16Sept06

FirstLook

Next-Gen PLC Offers Fast Processing Speeds, Large Memory, Up to 126 Analog I/O

IDEC Corporation (Sunnyvale, CA) has announced its FC6A MicroSmart, a powerful PLC with up to 520 I/O. The MicroSmart PLC provides the power of a PAC (programmable automation controller) in a low-cost controller with a small form factor, making it an ideal fit for demanding applications including oil & gas, chemical, solar, marine, packaging, food & beverage, material handling, utility vehicles, and OEM machinery. Features for all models include:

- Basic instructions can be executed in 0.042 microseconds,
- Program memory is 640 kB.
- There are 1,024 timers, and six of the 512 counters are high-speed at rates up to 100kHz.
- All models have a built-in RJ45 Ethernet port, and an RJ45 RS232C/RS485 serial port. Each model also includes an integral 0-10 Vdc analog input.
- The Ethernet port supports the Modbus TCP protocol, and the serial port supports the Modbus RTU protocol.

Why Would I Specify?

- These capabilities are combined with extensive data and bit memory, double the capacity of a typical micro PLC.
- The MicroSmart PLC is programmed with IDEC's WindLDR PC-based software, which includes no cost updates for the life of the product.
- IoT capability is provided by custom web pages which can be configured for remote monitoring and control.

http://FC6A.idec.com/

Rechargeable Coin Cell Batteries Offer Highest Capacity & Reliability

Illinois Capacitor (Evanston, IL) has introduced the RJD Series of rechargeable lithium ion coin-cell batteries. They offer significantly higher capacity thanks to a new encapsulation technology which significantly increases storage capacity. The new process also makes the batteries even more reliable than previous designs.

- RJD Coin Cells are available in eight different capacity levels.
- Each is rated at: 3.7VDC (4.2VDC to 3.0VDC). Operating temperature range is -20°C to +60°C.
- Applications include smart watches, fitness bands and other IoT applications, as well as automotive dash cams, key fobs, memory backup, and security devices.
- OEM pricing starts at $3.50 each.

Why Would I Specify?

- RJD Series batteries up to 20% higher capacity than an equivalent conventional lithium rechargeable coin cell battery.
- UL-Listed RJD cells are more resistant to overheating than conventional coin-cell batteries
- Their patented technology virtually eliminates risk of internal shorts.

www.Power-IoT.com

Industry's First Rad-Tolerant 36V Instrumentation Amplifier with Integrated Differential ADC Driver

Intersil Corporation (Milpitas, CA), has introduced the industry's first radiation tolerant 36V instrumentation amplifier (in-amp) featuring an integrated differential analog-to-digital converter (ADC) driver. The ISL70617SEH differential input, rail-to-rail output in-amp delivers the industry's highest signal processing performance for low-level sensor telemetry data critical to communication satellites.

The ISL70617SEH's features include:

- Low input offset of 30µV, and low input bias current of 0.2nA
- 120dB CMRR & PSRR (typical)
- Wide power supply range :8V (±4V) to 36V (±18V)
- Closed loop -3dB bandwidth 0.3MHz (AV = 1k) to 5.5MHz (A = 0.1)
- Extended operating temperature range of -55°C to +125°C
- Electrically screened to DLA SMD# 5962-15246
- Acceptance tested to a higher dose level of 75krad(Si), wafer-by-wafer
- Industry's lowest dose rate (0.01rad(Si)/s) radiation tolerance of 75krad(Si)

Why Would I Specify?

- The ISL70617SEH enables higher CMRR and PSRR than the competition, at all gain settings.
- Designers can easily program the in-amp's gain from 0.1 to 10,000 using two external resistors.
- Provide single event latch-up (SEL) and single event burnout (SEB) robustness of 60MeV in heavy ion environments.
- Its single event transient (SET) performance of <10usec eliminates the need for extra filtering.

www.intersil.com/products/isl70617seh

Miniature Voice Coil Actuators

H2W Technologies (Santa Clarita, CA) has built its smallest moving magnet voice coil actuator (NCM01-04-001-2IB) and moving coil voice coil actuator (NCC01-04-001-1X) to date.

The NCM01-04-001-2IB moving magnet voice coil actuator features:

- An outside diameter of 0.40 in [10 mm] and a length of 0.735 in [18.8 mm].
- A stroke of 0.10 in [2.5 mm]
- Generates a continuous force of 0.10 lbs [0.45 N] and a peak force of 0.30 lbs [1.35 N].
- Weight: 0.20 ounces [5.7 grams].

The NCC01-04-001-1X moving coil voice coil actuator features:

- An outside diameter of 0.44 in [11.1 mm] and a length of 0.36 in [9 mm].
- A stroke of 0.13 in [3.2 mm]
- Generates a continuous force of 0.06 lbs [0.27 N] and a peak force of 0.18 lbs [0.8 N].
- Weight: 0.20 ounces [5.7 grams].

Why Would I Specify?

- The actuators' compact designs allow them to be used in a number of handheld applications.

www.h2wtech.com

Improved Length Gauge Offers Higher Accuracy for In-Process Measurement

Heidenhain (Schaumburg, IL) has introduced its new and improved +/- 1um accurate ACANTO 1217 and 1218 Length Gauges. The ACANTO can be implemented in a multitude of gauging applications, from automotive manufacturing, medical device, in-process measurements, as well as fixtured gauging stations. Important specs of the ACANTO length gauge include:

- Accuracy: +/- 1um
- Stroke Length: 12 mm
- Interface: EnDat 2.2 (Datum memory, Error monitoring, Gauge Auto-Recognition)

Why Would I Specify?

- Along with built-in error monitoring, the ACANTO remembers the last datum used, eliminating the need to re-master due to the gauge itself.
- The ACANTO also auto-connects and reports data to any control that has implemented EnDat.
- With an IP rating of IP64 or IP 67, the ACANTO can be used on the shop-floor in automated systems or in clean environments.

www.heidenhain.us

From the Cover

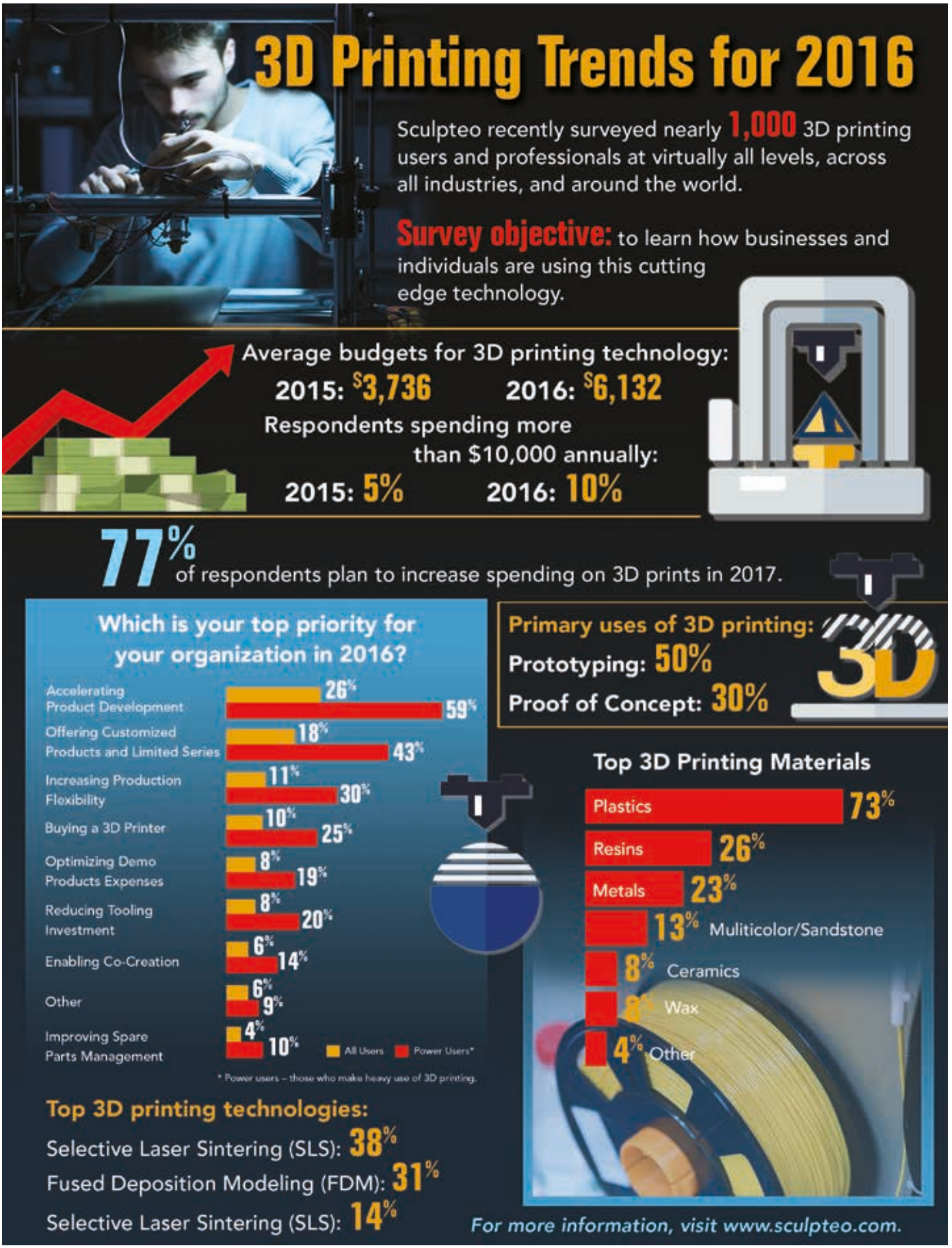
Antennas Boost Performance of Wi-Fi, GPS and Cellular Networks

Antenna Company (Pleasanton, CA) announced the availability of new high performance antenna technologies and systems for a wide variety of applications which include both indoor and outdoor Wi-Fi, connected home, mobile computing, telematics and IoT applications. Their patented SuperShape technology improves gain, efficiency, isolation, and coverage versus conventional embedded antenna designs on the market.

Why Would I Specify?

- Independent benchmark tests have shown SuperShape antennas can increase range and throughput by 50 to 100% in both line of sight and non-line of sight test conditions.
- These new antenna designs can be 40% smaller than competing designs. In fact, the laptop antennas are small enough to fit into the hinge connecting the base to the display.
- Optimized reference designs are available for 802.11ac MIMO or Multi-User MIMO system configurations ranging from 2×2 up to 8×8, delivering gigabit wireless performance.

www.antennacompany.com


3D Printing Trends for 2016
Sculpteo recently surveyed nearly 1,000 3D printing users and professionals at virtually all levels, across all industries, and around the world.
Survey objective: to learn how businesses and individuals are using this cutting edge technology.
Average budgets for 3D printing technology:
2015: $3,736
2016: $6,132
Respondents spending more than $10,000 annually:
2015: 5%
2016: 10%
77% of respondents plan to increase spending on 3D prints in 2017.
Which is your top priority for your organization in 2016?
Accelerating Product Development 26% 59%
Offering Customized Products and Limited Series 18% 43%
Increasing Production Flexibility 11% 30%
Buying a 3D Printer 10% 25%
Optimizing Demo Products Expenses 8% 19%
Reducing Tooling Investment 8% 20%
Enabling Co-Creation 6% 14%
Other 6% 9%
Improving Spare Parts Management 4% 10%
All Users
Power Users*
* Power users – those who make heavy use of 3D printing.
Primary uses of 3D printing:
Prototyping: 50%
Proof of Concept: 30%
Top 3D Printing Materials
Plastics 73%
Resins 26%
Metals 23%
13% Muliticolor/Sandstone
8% Ceramics
8% Wax
4% Other
Top 3D printing technologies:
Selective Laser Sintering (SLS): 38%
Fused Deposition Modeling (FDM): 31%
Selective Laser Sintering (SLS): 14%
For more information, visit www.sculpteo.com.

Anti-Static Air Gun

EXAIR (Cincinnati, OH) has announced its Ion Air Gun, which removes static electricity, contaminants, and dust from parts prior to labeling, assembly, packaging, painting, or finishing. The product has undergone independent laboratory tests to certify it meets the safety, health, and environmental standards of the USA, European Union, and Canada that are required to attain the CE and UL marks. Features include:

- RoHS compliance.
- A metal armored high voltage cable to protect against abrasion and cuts.
- A replaceable emitter point, integrated ground connection, and electromagnetic shielding.
- The ability to neutralize static electricity and cleans at distances up to 15 ft. (4.6 m).
- A high velocity air jet.
- An electrically energized emitter at the discharge end.
- An optional regulator, which allows infinite adjustment of the air volume and velocity.

www.exair.com

Self-Clinching Pins

PennEngineering (Danboro, PA) has announced that its Type MPP microPEM self-clinching pins provide solutions for demanding micro positioning and alignment applications in compact electronic assemblies. The pins clinch permanently where designed into stainless or other metal sheets as thin as 0.5 mm (.020”). Features include:

- A chamfered pin end.
- The ability to be installed automatically.
- Diameters as small as 1 mm (.040”).
- Lengths as short as 2 mm (.080”).
- Precipitation-hardened stainless steel.

www.pemnet.com

Artificial Intelligence Invades Consumer Electronics

By Lee Goldberg, Megan Crouse, and Alianna Maren, Ph.D.

While even experts can't all agree on a precise definition for "artificial intelligence" (AI), the technology behind it continues to become more powerful, less expensive, and easier to implement. As a result, we're seeing AI capabilities beginning to appear in many types of consumer electronic products. In this article, we'll look at some of the ways designers are coaxing their designs across the fuzzy chasm between "smart" and "intelligent," along with a few notable examples of AI-enabled products.

Defining AI

The origins of modern AI theory date back to the early 1940's when Alan Turing and Alonzo Church postulated that digital computers might be capable of simulating any process of formal reasoning. Their pioneering work was in good part the inspiration for the group of researchers who gathered at Dartmouth University in the summer of 1956 to define and solve a set of basic problems (a.k.a. goals) which continue to define modern AI research. These include *reasoning, knowledge representation, planning, learning, natural language processing, perception, and social intelligence.*

Solving these problems has required the development of new concepts and tools to navigate the new problem space. This has given rise to symbolic reasoning, expert systems, neural networks, and fuzzy logic; fields that made possible the first practical applications of AI in the 1980's.

AI Challenges

At that time, however, expert systems suffered from serious deficiencies. In attempting to codify how human experts identified key distinctions (ranging from diagnosing medical symptoms to space shuttle communications), they had become too rigid. Human experts think in terms of patterns and weighted combinations of factors, more than in terms of rules.

Another big challenge that had emerged by the early 1990's was that many of the crucial problems required dealing with lots of little pieces of low-level data, rather than a few chunks of largely symbolic data. For example, image understanding (a field related to AI), requires processing huge volumes of pixel-level data, using various algorithms to extract the lines and regions in an image. The AI-based challenge is to connect these lines and regions to known and identifiable objects, such as people, landmarks, and activities or interactions.

Deep Learning Allows AI to Move Ahead

In order to overcome these limitations, those early AI systems had to develop the ability to deal with more ambiguous data sets and to perform some level of self-learning. These challenges made it difficult to field practical AI systems, until the recent advances made possible by the development of *deep learning*. Jesse Clayton, product manager, Autonomous Machines at NVIDIA, explains "Deep learning is a neural-network based approach to machine learning. What makes it fundamentally different than previous

The Moorebot voice-interactive robot assistant with a warm, funny digital personality. Its AI capabilities allow it to interpret and respond to human speech, as well as infer activity and emotion from the images its camera captures. Photo: Courtesy of Moorebot.

approaches is that it makes it practical to train systems using very large datasets. Training on large datasets results in better accuracy for tasks like image recognition, natural language processing, medical diagnosis, game playing, and many others."

Deep learning technologies have enabled a key breakthrough in AI technology - the synthesis of multiple ways of describing something. When applied to image processing, this means first identifying the line and region segments, and then connecting "like-with-like," using algorithms that are loosely based on the workings of the brain's visual cortex. Once provisional shapes are assembled, algorithms call upon higher-level symbolic knowledge to suggest possible shape interpretations. Matching the shapes against possible interpretations ultimately yields an interpreted image. This capability is essential, for example, to Google's self-driving car, as well as to robots that can move around houses and factory floors.

Thanks to these developments, by the late 1990s, AI was being commonly used for many applications such as data mining, financial analysis, logistics management, and medical diagnosis. At the time, it was expected that AI would eventually be applied to nearly any application which involved "big data".

AI Gets Personal

What we did not expect was what is occurring now – that AI is becoming both hidden and pervasive, popping up in unexpected places like our smartphones and fitness devices. This emergence of consumer-level, functionally-useful, and adaptive AIs has been made possible by the confluence of several key factors; (1) substantial evolutions in core AI algorithms, (2) powerful new insights in machine learning theory, (3) advances in low-cost, high-throughput processing chips, and (4) the prevalence of cloud-based computing resources.

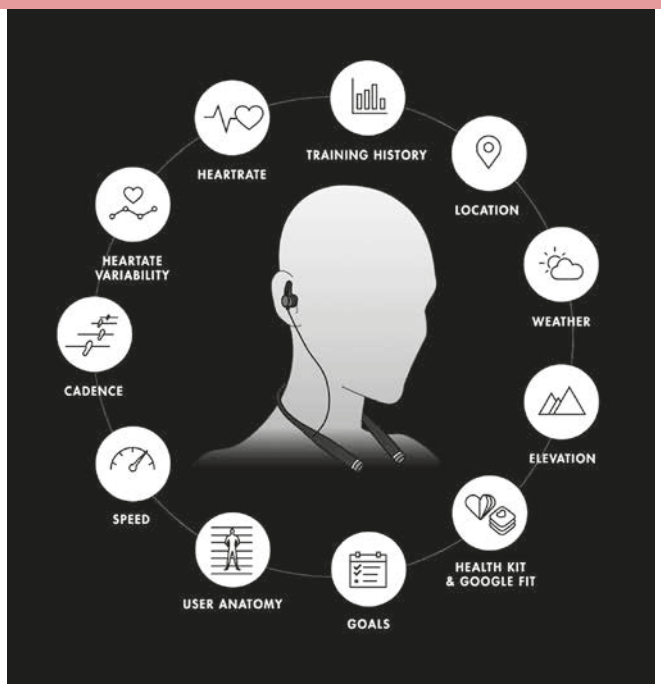
Cloud-based computing, in particular, made many of the first consumer AI applications practical and affordable by eliminating the need for the host device to have a processor powerful enough to support all the compute-intensive AI functions itself. Smart Phones, for example, can now understand your natural way of speaking and react intelligently, thanks to digital assistants like Siri or Google Assistant, both of which are powered by deep learning algorithms running in the cloud.

Another more recent application of cloud-based AI is the Moorebot, a robot assistant that's designed to be cute as well as helpful. The affable one-eyed device can perform customer service and shop inventory in a business setting, read emails, or give reminders and play videos at home. Moorebot reaches into the cloud for voice recognition services and information that requires an internet connection, such as weather and news. However, despite the fact that Moorebot is based on AI technologies such as facial and voice recognition, the company's CEO Jun Ye said that the makers intentionally avoided using the term "artificial intelligence" in marketing material. "We think some regular consumers start to hate artificial intelligence," Ye said.

New Hardware Essential to Embedded AI

The June Intelligent Oven. Photo courtesy of June Life Inc.

Although many AI-enhanced consumer devices have much of their processing down on the cloud, it is not always the best solution - especially for real-time, or safety-critical applications. Self-driving cars, for example, need to have their deep learning functionality residing onboard in order to function safely even when network connections may be unreliable, or there's lots of



LifeBeam's VI intelligent fitness monitor. Image courtesy of LifeBeam

latency in the connection.

In these applications, specialized multi-core processors known as graphics processing units (GPUs) have been essential to efficiently supporting locally-hosted deep learning. NVIDIA's Clayton describes GPUs as "highly parallelized architectures that can run those algorithms fast, making it possible to train very large data sets in hours or days, instead of weeks or months." For example, NVIDIA's Jetson TX1 is a module designed specifically for deep learning for embedded systems. It incorporates a powerful GPU, and only uses 10W, and it's smaller than a credit card. The Jetson TX1, with its multi-GPU designed specifically for embedded applications, has been a key enabler for new devices.

One of the recently-released consumer devices powered by NVIDIA's Jetson TX1 chip is the Horus wearable assistant for the blind. It uses a small head-mounted camera to gather imagery and then translates what it is seeing to an audio description. For instance, it can enable a blind mother to read a written book to her child.

The TX1 chip also powers the June Intelligent Oven, which uses computer vision and deep learning to help you optimally prepare your food. It has a variety of sensors and it's been trained to determine exactly the right level of doneness for all sorts of recipes. It can even tell what kind of food you're putting in just by looking at it.

Partitioning between the Device and the Cloud

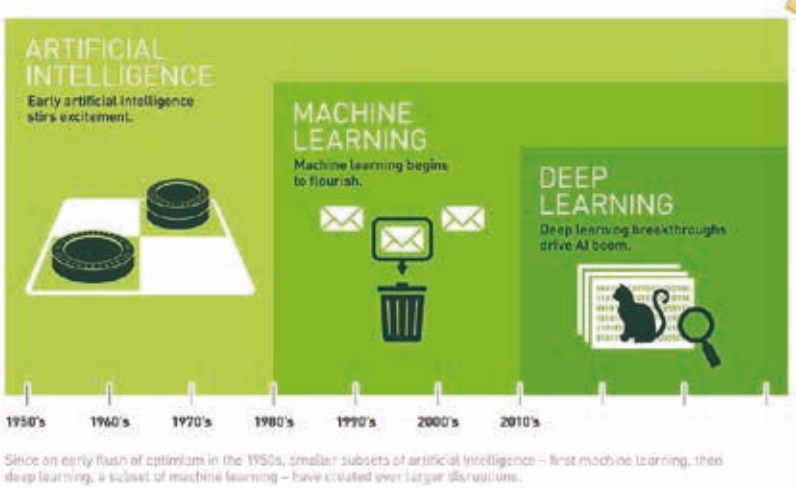
Although the Horus assistant and the June Oven keep their intelligence entirely locally-resident, it's not a cost-effective approach for many types of products where price is a primary design driver. As a result, most of the next generation of consumer-facing AI systems will likely partition various percentages of their large-scale algorithms and deep learning processes between on-board and cloud-based platforms, while keeping user-specific and identifying information device-local.

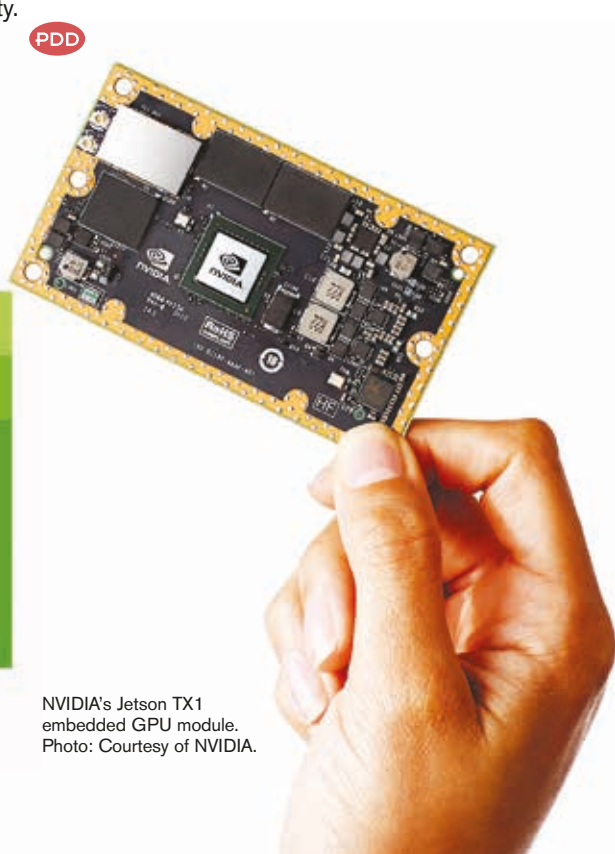
This approach is essential not only for personal assistant and household management and utility devices, but also for the emerging realm of intelligent wearable devices. One such device is the Vi, an AI-based personal trainer developed by LifeBeam which can respond to voice prompts and offer "coaching" advice based on its analysis of the user's performance and vital signs.

A Lifebeam's intelligence resides partially on the headset device itself and partially on the connected phone app. A company representative divides VI's artificial intelligence according to two different aspects. One is a set of rules based on pre-defined data inputs, through which the user's behavior is filtered. The second is a more adaptable data collection and pattern recognition capability, and this is the part that actually learns. Eventually, after it gets to know the user's behavior, it can suggest activities and audio or come to conclusions based on that behavior.

Regardless of how next-generation intelligent consumer devices will partition their processing between local and cloud-based platforms, the one aspect of the future is clear: intelligent devices will become more ubiquitous and will find roles in many aspects of our lives, both individually and at as a society.

PDD





NVIDIA's Jetson TX1 embedded GPU module. Photo: Courtesy of NVIDIA.

Series of 650 W Power Supplies

Murata Power Solutions (Mansfield, MA) has announced the D1U54P-W-650-12-HBxC series of 650 W power supplies. Packaged in an industry standard 1U format measuring 54.5 x 40 mm (2.15 x 1.57"), it has a length of 228.6 mm (9") compared to the 12" length of other power supplies in this family. Features include:

- A power density of 21.4 W/in³.
- A single 12 VDC primary supply.
- A standby 12 VDC/2 A output.
- A capability of N+1 redundancy.
- An active current sharing (ORing FET), permitting connection up to a maximum of eight in parallel.
- An I2C compliant PMBus interface and front panel LED status indicators.
- Overvoltage, overcurrent, and overtemperature protection.
- Forced air cooling.

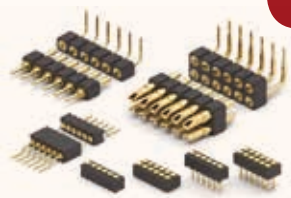
www.murata-ps.com

Network-Attachable USB Charge & Sync Device

Saelig (Fairport, NY) has introduced the Cambrionix EtherSync – a network-attachable USB charge and sync device that allows multiple USB devices to connect with an Ethernet network, simplifying remote software and firmware updates. EtherSync is available with multiple USB ports which can be used with all types of USB-based peripheral devices, tablets, and smartphones. Features include:

- The ability for each USB port to simultaneously provide correct charging currents of up to 2.1 A.
- USB 2.0 high-speed (480 Mbps) syncing of multiple device types – irrespective of manufacturer.
- The ability to enable a host computer to remotely access USB ports to charge and sync USB devices in different locations from one central controller.
- Either a fully-enclosed EtherSync unit or a component board with 8 USB ports.

www.saelig.com



Spring-Loaded Target Connectors

Mill-Max (Oyster Bay, NY) is expanding its selection of target connectors in both its .100" and .050" grid families. Target connectors are used in place of SMT pads on a PCB as the mating surface for spring-loaded pins. The new series include right angle with concave mating face (.100" grid), through-hole and surface mount with concave face (.050" grid), and horizontal surface mount and right angle (.050" grid) with both flat and concave face options available. Features include:

- Precision-machined and gold-plated pins.
- Connector insulators molded from high temperature plastic suitable for most soldering processes.
- RoHS compliance.

www.mill-max.com

Figure 1. Design concept: LEV ESS.

Materials and Packaging Solutions to Drive Electromobility

By Ignacio G. Osio, Ph.D.
Key Growth Programs Manager, Covestro LLC

Electromobility is emerging as a global alternative to transportation based on the internal combustion engine. Battery technology is largely responsible for the recent success of electric vehicles (EVs) from bicycles to passenger cars and buses. A sustained drop in lithium-ion battery costs and performance improvements are also fueling innovation in electromobility. At the same time, these changes are pushing the limits of design, and designers are looking for ways to maximize the value of lithium-ion energy storage systems (ESS).

An area of growing focus is the materials and packaging solutions for ESS used in electromobility. Even though packaging represents a small fraction of the cost of any ESS, it is an essential component that enables functionality, safe operation and the ability to capture value over the product lifecycle. The use of durable flame-retardant polycarbonates for packaging components and the adoption of modular designs capture value, allow multiple applications, and facilitate second life use.

Modularity and the battery life cycle

ESS are moving toward modularity as part of the natural development cycle of EV and stationary ESS. Battery modules with standard interfaces may be used as building blocks to satisfy the power and energy requirements of different types of EVs.

Currently, ESS for electric passenger vehicles tend to be over-engineered and may be able to retain 70 percent of their capacity at the end of their vehicular life. Applications for repurposing former EV ESS modules include renewable energy storage, power-peak shaving, energy buffers for rapid EV charging, and emergency back-up systems.

Repurposing modules improve the economics of EVs, facilitate upgrades, and create new sources of revenue along the value chain. Modularity will not only enable a new class of electric products and applications; it will also reduce refurbishing costs, enable new business models, and facilitate safe end-of-life disposal and recycling.

Safety and compliance

Packaging plays a critical role in helping to ensure the safe and reliable operation of ESS. Various global and national standard development organizations are working together to create standards, codes, and regulations that enable safe use of ESS.

Compliance helps to ensure that the ESS satisfies

minimum safety requirements. Testing assesses the performance of cells, modules, and packs. Testing conditions include battery abuse, transportation, handling, storage, recycling, crash, intrusion of components in the occupant compartment, and electric shock. New standards for secondary battery use and recycling are also in development.

Although ESS packaging does not directly determine cell performance in terms of energy and power, properly designed frames and enclosures help to ensure efficient use of space, protection against damage, and adequate thermal management. All these factors ultimately affect power and energy density, safety, and lifespan.

Material and design solutions

Designing battery enclosures, frames or trays depends on many factors. Cell format and available packaging space are among the top concerns. However, safety, compliance, performance, and affordability are also major drivers. As EVs improve, more advanced designs will not only account for the immediate needs of a particular EV, but also allow for modularity, interoperability, second life uses and recycling.

Figure 1 shows a typical design of an ESS for a light EV, such as an e-bike, pedelec, or scooter. These typically include an integrated electronic battery management system and external connectors for in-situ charging or swapping. Internally, the enclosure provides support and precise cell-placement with sub-millimeter features requiring precision injection molding. Externally, the enclosure provides mechanical interfacing, and protection against impact, dust, and intrusion. In addition, this enclosure should be aesthetically pleasing, ergonomic, and provide brand identification. To comply with UL 2271, Batteries for Use In Light Electric Vehicle (LEV) Applications, the enclosure should have a UL 94 flame class rating of V-2.

For such cell holders or enclosures, polycarbonate materials designed for battery housing are typically specified. Materials like these typically have a long track record in lithium-ion

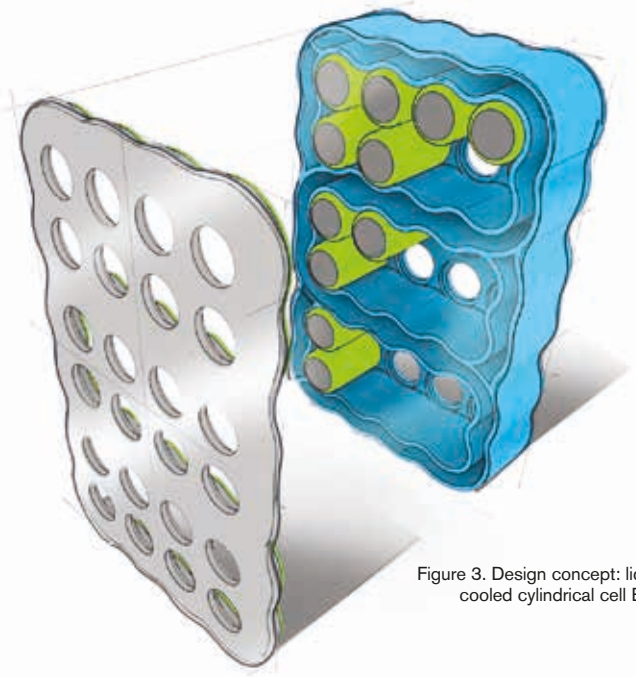


Figure 3. Design concept: liquid-cooled cylindrical cell ESS.

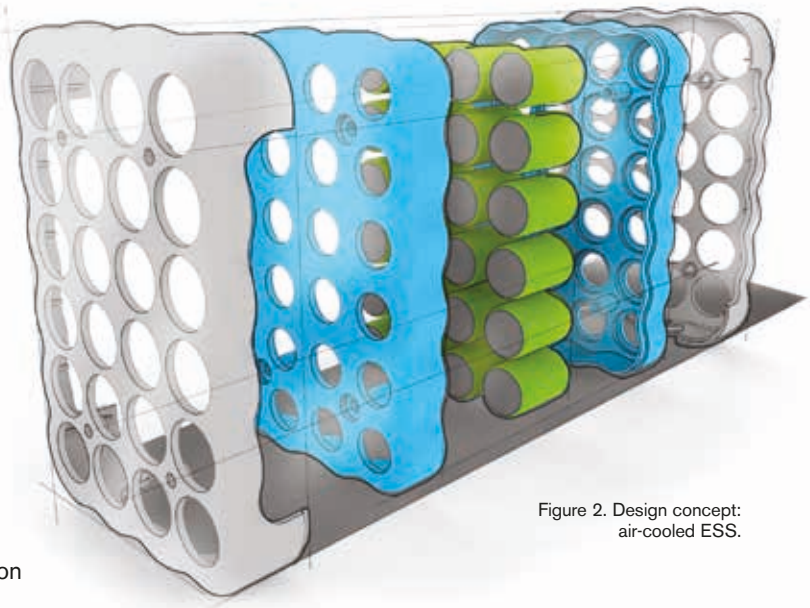


Figure 2. Design concept: air-cooled ESS.

battery packs with proven performance in IT, consumer electronics, and medical devices.

Plug-in hybrid EVs and EVs feature a much larger ESS. They are comprised of modules housed in large metal or composite enclosures that centralize the battery management and thermal management systems. Internal modules are still composed of trays or frames that hold cells in place providing dimensional stability and safe access to cooling media as needed. Depending on the original equipment manufacturer (OEM) preference, the cell format could be cylindrical (Figures 2 and 3), prismatic (Figure 5), or pouch (Figure 4). These concepts may also be applicable to 48V mild hybrids.

For cylindrical cells, the use of injection molded thermoplastics trays is necessary. This solution provides the proper positioning and cooling given the cell geometry. Because cylindrical cells act as pressure vessels, designers are not concerned with swelling during charge and discharge cycles. However, delivering cooling media to critical areas becomes a challenge.

Figure 3 shows one such concept made entirely of plastics. This concept eliminates the need to use separate conductive metal conduits, positioning cooling channels directly on the holding frame. The result is integrated functionality with a reduced number of components, using less space at a lower cost. The sealing between the frame with cooling channels and the lid may be achieved by overmolding a self-adhesive liquid silicone.

Thermal simulations and tests conducted by materials experts show that it is possible to achieve cooling performance targets despite the lower conductivity of thermoplastics - by choosing high-flow materials that allow thin walls to be molded. It may be necessary to utilize a thermal interface material to ensure direct contact between the cell and frame walls.

Similar solutions can also be achieved with pouch cells, as shown in Figure 4. In this concept, the cooling channels are molded into the thermoplastic and an aluminum sheet is bonded with a self-adhesive silicone. In this design, the complexity of the cooling channel is built into the injection molded part without any extra cost.

Due to their geometry, pouch cells are easy to fit into tight spaces, but packaging designs must also account for swelling

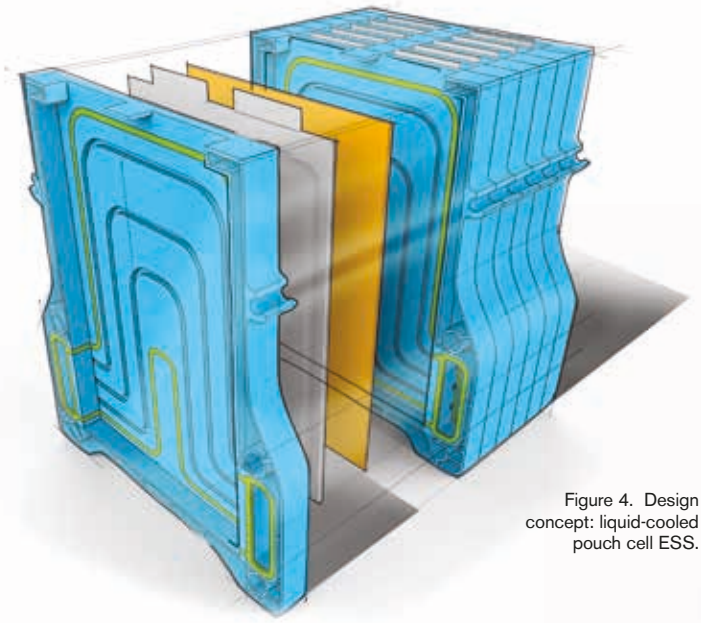


Figure 4. Design concept: liquid-cooled pouch cell ESS.

during charge and discharge cycles. Frames must satisfy the need for precision molding with permanent water-glycol resistance. A flame-retardant polycarbonate with excellent adhesion to self-adhesive silicone and good chemical and impact resistance is typically specified for this type of design.

Figure 5 shows a concept for an air-cooled prismatic cell package for use in heavy-duty EVs requiring long-term vibration tests, such as e-buses and trucks. For such designs, a flame-retardant polycarbonate + acrylonitrile butadiene styrene (PC+ABS) blend is an ideal solution.

For lithium-ion cell packaging, the use of flame-retardant polycarbonates has shown to provide an additional level of safety against fire spread initiated by a short-circuit or an external ignition source. PDD

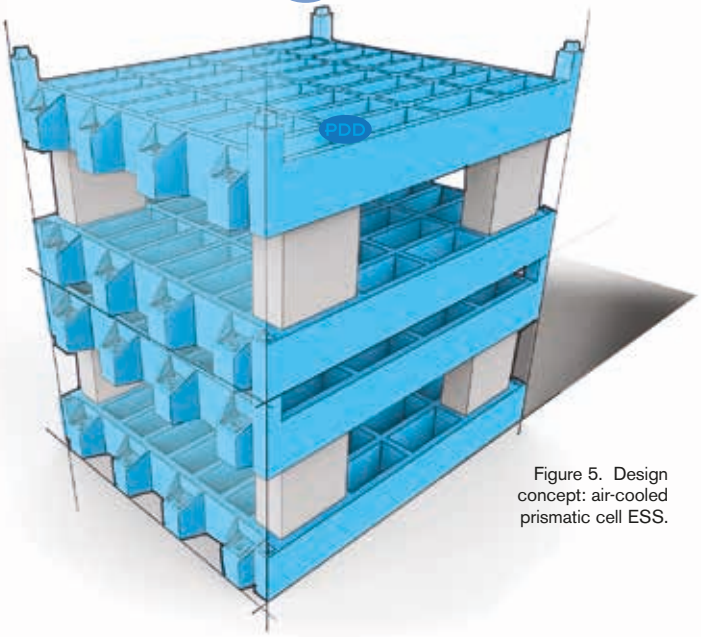


Figure 5. Design concept: air-cooled prismatic cell ESS.

NewProducts

Family Transportable Radar Transmitter Upgrade Kits

Diversified Technologies (Bedford, MA) has announced a series of AN-TPS-70 family transportable radar transmitter upgrade kits that replace all outdated components with solid-state components. DTI PowerMod AN-TPS-70 Family Radar Transmitter Upgrade Kits deliver a complete solid-state modulator to replace the thyratron, trigger amplifier, regulator, pulse forming networks (PFN), pulse transformer, SF6 tank, and oil tank used in the AN-TPS-43, 70, and 75 family of air surveillance radar. Features include:

- Enhanced pulse agility from 0 to 8 µs.
- > 50,000 hours of life expectancy.
- PLC control with circuit board high-speed fault detection.
- Built- in self-diagnostics and a touch-screen interface.
- Control board access from outside of the transmitter cabinet.

www.divtecs.com

1,000 W DC-DC Bus Converter

GE's Critical Power business (Plano, TX) has launched its Barracuda-series QBVE094A0S10R7 1,000 W DC-DC bus converters, providing the highest power density and lowest cost-per-rated-watt in a quarter-brick solution available on the market today. The modules offer 20 percent more power than standard 800 W solutions. Features include:

- An operating input voltage range of 45 to 56 V DC.

The ability to provide up to 1,000 W output power at output voltages of 10.7 V.

- The ability to deliver 1,800 W output power with two modules or 2,700 W power with three units when used in parallel configurations.
- The ability to support 10.7 V intermediate bus applications where multiple low voltages are subsequently generated using point-of-load modules.
- Over-current, -voltage, and –temperature protection.
- An operating temperature range from -20° to 85°C.

www.geindustrial.com

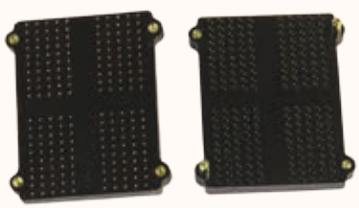
Multi-Phase 55 V Synchronous Boost Controllers

Intersil (Milpitas, CA) has introduced two 55 V two-phase synchronous boost controllers with integrated high-side and low-side MOSFET drivers. The ISL78227 and ISL78229 simplify the design of high power automotive applications. Operating from a 12 V battery supply, these devices boost the output voltage to 24, 36, or 48 V for premium 200 to 800 W trunk audio amplifiers, start-stop systems, and headlamp LED strings. Features include:

- The ability to provide input/output voltage from 5 to 55 V, and withstand transients up to 60 V.
- The ability to use peak current mode control for fast line response with adjustable slope compensation.
- Configurability for single phase, 2-phase, and 4-phase operation.
- An adjustable switching frequency from 50 kHz to 1.1 MHz, and external synchronization.
- Two layers of over-current protection.
- Negative current protection.
- Average current limiting.
- Soft-on capability, which provides a smooth transition from soft-start to full operation in CCM.
- Adaptive and programmable dead-time control.
- Selectable diode emulation and phase dropping.
- AEC-Q100 qualification for operation from -40° to +125°C.

www.intersil.com

High Performance BGA Socket Adapter



Ironwood Electronics (Eagan, MN) has announced that its SFS-BGA200B-52 high performance socket allows a 0.65 mm pitch, 11 x 14.5 mm body, 12 x 22 array 200 ball BGA package to be placed in socket and operated without compromising performance in high speed applications. The Giga-snaP BGA socket adapter pair consists of SFS-BGA200B-52, patented female BGA sockets with BeCu pins assembled into a substrate that matches the male pin adapter. Features include:

- RoHS compliance.
- Soldering to a PCB using standard soldering methods without warping.
- Construction of the BGA socket and adaptor with high temperature polyimide and FR-4 body.
- A physical length from the top connection point on the male adapter to the solder ball on the female socket of 3 mm.
- Transmission of high frequency signals up to 20 GHz with -1 dB insertion loss.
- An operating temperature range from -55° to +160°C.
- A current rating of 3 A per pin.

www.ironwoodelectronics.com

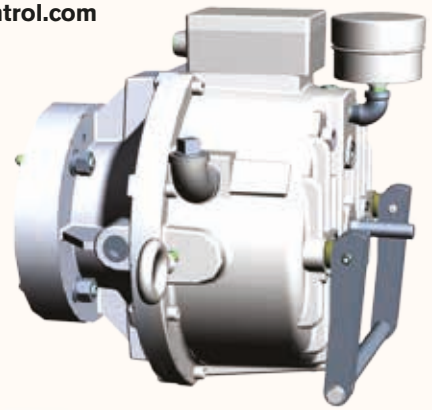
New Products

Hazardous Duty Brakes

Force Control Industries (Fairfield, OH) has announced that its MagnaShear hazardous duty brakes, which employ oil shear technology to provide longer service life with virtually no maintenance or adjustment, now meet Class I and Class II Div 2. Features include:

- Spring set torque ratings from 3 to 900 foot-pounds.
- "Quick mount" features for mounting to drive motors in NEMA frame sizes 56 to 405.
- Seal integrity for harsh and washdown environments.
- Oil shear technology, which transmits torque between lubricated surfaces.
- A fluid recirculation system dissipates heat.

www.forcecontrol.com



Integrated Stepper Motors with Profinet Industrial Ethernet

JVL (Birkerød, Denmark) has added Profinet Industrial Ethernet capabilities to their NEMA 34 Series of integrated steppers with programmable controllers. The motors are available in four torque ratings of 3, 6, 9, and 12 Nm, and they include all necessary electronics within the IP67 rated motor housing. Features include:

- Expanded Ethernet protocols, which connect to Ethernet bus systems such as: EtherCAT, Ethernet I/P, Powelink, ModbusTCP, Sercos III, and Profinet.
- Availability with Bluetooth, ZigBee, WLAN, PLC, RS485, and CANbus.
- Availability with a separate SMC85 controller.
- 409,600 steps per revolution.
- An integrated PLC, which features eight I/Os, RS-422 and RS485 connections for encoders, and point-to-point or multi axes operations to 254 axes.

www.jvl.dk

Microstepping Motor Drive

Testra Corporation (Tempe, AZ) has announced its RoadRunner SoftStep R213S microstepping motor drive. The intelligent on board processor treats the input steps as small vector moves and smoothly chains them together with 250 or 256 micro-steps per regular motor step with controlled accelerations. Features include:

- Dual chopper stabilized current comparators.
- Auto-calibration.
- Gecko drive compatibility.
- The ability to micro-step finely in either 250 or 256 increments per step for DS (double step) settings, 1 (full step), 2 (half step), 4, 8, 16, 32, 64, 128, and 256.
- A measurement of 2.5 x 2.5 x 0.825".
- An input power of 20 to 80 VDC.
- A current drive from 1 to 7 A.
- Resistor programmable current, opto-isolated inputs, step, direction, disable input (not isolated), and step frequency to 5 Mhz.

www.testra.com

Electric Cylinders

PHD (Fort Wayne, IN) has announced the PHD Plus Series ECP Electric IP69K Cylinder. Series ECP Electric IP69K Cylinders are designed for food processing and packaging equipment utilized in high pressure/high temperature washdown and clean-in-place (CIP) environments. Features include:

- Availability in either ball screw or lead screw (polymer nut) versions.
- A range of high thrust or high speed capabilities.
- Your Motor, Your Way, a configurable online system that allows the user to power the unit with the motor and controls of their choice.
- The ability to mount motors in an inline or foldback configuration.
- Three available models in three sizes.
- USDA certification for two models.

www.phdinc.com

Oversized Mechanical Parts

Stafford Manufacturing (Wilmington, MA) has announced a full line of mechanical components for large cranes, conveyors, and equipment in the bulk processing, pulp and paper, and other heavy industries. Stafford Oversized Parts have larger bores and are wider than conventional parts, incorporate larger clamp screws, and can be modified with threaded bores and special bore contours, keyways, and tapped holes as required. Features include:

- Steel, stainless steel, special alloys, and aluminum.
- 1-pc and 2-pc styles, sizes up to 14" I.D., and varying O.D's with widths to 10".
- Flange mounts with bores up to 6" and flanges to 14" O.D.
- Rigid couplings with bores up to 6".

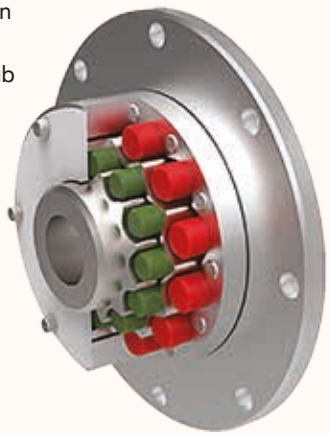
www.staffordmfg.com

Engine Coupling Offers Stiffness Adjustments

Ringfeder Power Transmission (Westwood, NJ) has developed an engine coupling that optimizes torsional stiffness and misalignment tolerance across a range of torque. The TSCHAN TNR coupling is intended primarily for mobile and stationary diesel-driven powertrains. Features include:

- An aluminum housing and steel hub separated by one or two rows of mechanically-linked, cylindrical elastomer inserts.
- 20% less weight than traditional rubber motor shaft couplings.
- A torque range from 160 to 68,000 Nm and speeds up to from 6,000 rpm.

www.ringfeder.com

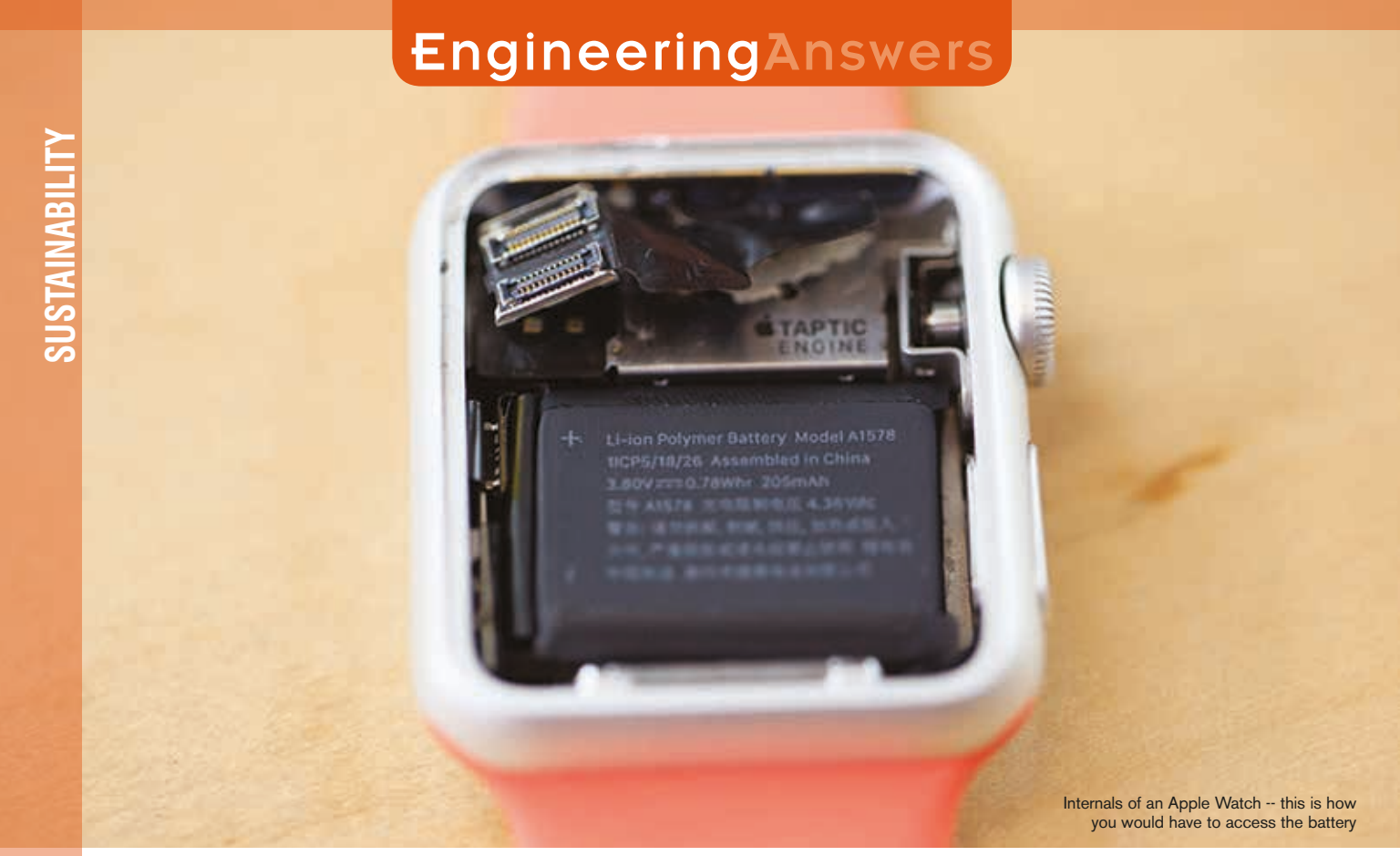


Mounting Components

Stafford Manufacturing (Wilmington, MA) has announced a full standard line of mounting components featuring various options for attaching something to a shaft, pipe, and tube. Stafford Mounting Components feature a variety of shaft collar designs and mounting options including face, flange, flat, and stackable as well as different fastening alternatives. Features include:

- Sizes ranging from 6 mm to 10" I.D., depending upon the configuration.
- Steel, stainless steel, and aluminum, and special design modifications to customer specification.
- The Accu-Clamp feature for applications that require extreme squareness and flatness.

www.staffordmfg.com



Internals of an Apple Watch -- this is how you would have to access the battery

DESIGNING BEYOND THE CONSUMER: 3 STRATEGIES FOR PROMOTING SUSTAINABILITY IN CONSUMER ELECTRONICS

By Sunny Sahota, Hardware Prototyping Engineer, Fictiv

We're living in a time where technology is advancing faster than ever before, and as a byproduct, the relevant life of our electronics grows shorter and shorter. This technologic revolution was sparked by Intel Corporation's founder, Gordon Moore, in 1975 when he predicted that the number of transistors in an integrated circuit board will double approximately every two years.

What Moore didn't predict was that in the last fifteen years alone, the amount of e-waste produced here in the states would nearly double as we toss outdated products to upgrade to the latest model. From a buyer standpoint, I get to geek out on the latest and greatest technology, but as an engineer, I have a responsibility to understand and teach how products can be designed to promote sustainability.

EPA studies show a rapidly increasing amount of e-waste, but facilities are still only able to recycle about 40% of consumer electronics. In fact, The Global E-Waste Monitor 2014 Report estimates that the e-waste discarded in 2014 contained substantial amounts of potentially reusable resources—some 16,500 kilotons of iron, 1,900 kilotons of copper, and 300 tons of gold, as well as significant amounts of silver, aluminum, and palladium, with a combined estimated value of $52 billion. However, it also contained substantial amounts of health-threatening toxins, such as mercury, cadmium, chromium. That sucks for our planet.

The biggest positive influence on a product's environmental impact will be made by companies that focus on sustainable manufacturing and design practices. So how have companies implemented sustainable design, and what can you do to help?

"A GREENER APPLE"

Apple is known to heavily practice planned obsolescence, by making their products very difficult for the average consumer to repair or update. It's a strategic business plan by Apple to both entice consumers with better technology, while making their older products obsolete. This is also a practice that brought Apple heavy public criticism and ultimately led Steve Jobs to release an open letter in 2007 titled "A Greener Apple", which promised Apple's commitment to sustainability.

By eliminating toxic materials and starting their "take-back" recycling facilities for old Apple products, they are now considered one of the greenest consumer electronic companies, a title that's great for our planet and the Apple brand.

So sustainable design sounds great, but it's expensive, right? Well, not really– in fact, it can actually save a company money. Most companies don't have Apple's scale and can't just start "take-back" recycling programs. Fortunately, sustainable design can be implemented on a much smaller scale, and the impact can still be just as significant, if you focus on the right areas.

1. PEOPLE

Taking a page from Steve Jobs' open letter, change starts with ownership of the problem and creating a focus around sustainable design within your company. Incorporating sustainability as one of the key drivers for your engineering and design teams can create a ripple effect that goes beyond creating an eco-friendly product. For example, sustainability considerations can help focus a project's design requirements, thus facilitating quicker decision-making.

To get a team on board, start by creating an open internal document that shares the sustainable design policies you want to encourage. A typical framework for this document includes:

1. Sustainability commitment statement
2. Company impact and policies
3. Environmental impact
4. Product requirements
   a. Banned substances
      i. List of toxic metals
      ii. List of batteries
      iii. List of plastics
   b. Material recyclability
   c. Product emission standards
5. Sustainable design practices

2. DESIGN

From an engineer's perspective there are several best design practices for creating a sustainable product which are united by the overarching theme tends to be simplicity. A simple product that reduces the number of unique components leads to improved reliability, which in the end means fewer failed parts. Here are a few other tips to consider:

Design for Manufacturing

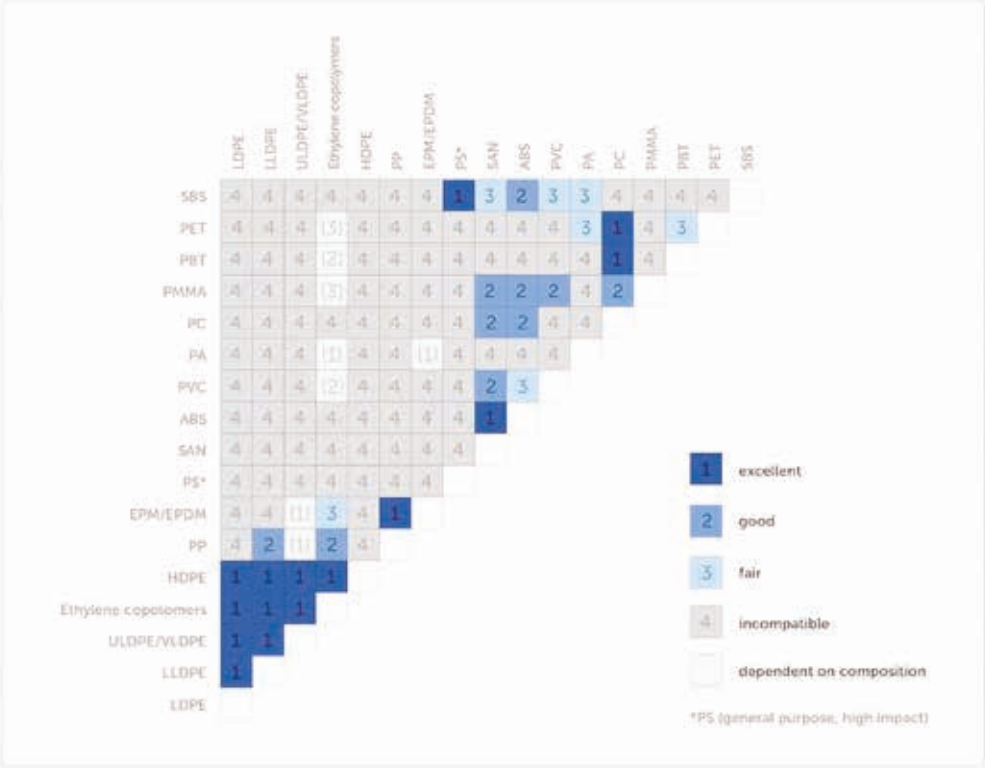
- Avoid thick walls: Save material by using ribbing, supports, or hollow structures.
- Minimize the number of materials: Increase the likelihood of recycling by using fewer different materials, and lower production cost by buying higher volumes of a specific material.
- Understand production processes: Don't use processes with toxic byproducts (e.g., chrome plating)

Design for Disassembly

- Use snap fits: Snap fits replace fasteners (another material) and make disassembly easier, both of which increase the likelihood of recycling.
- Accessible fasteners: If you have to use fasteners, make them easy to access, to promote disassembly and recyclability.
- Avoid power tool disassembly: Requiring power tools (especially specialized ones) to disassemble a product adds difficulty to disassembly. Even adding a small amount of extra labor to the recycling process can have a big impact on the economic payback of the recycling process.
- Design for repair: Allow the product to be easily disassembled and repaired by consumers.
- Avoid Adhesives: Adhesives discourage recycling by making products hard repair/disassemble.

Materials

- Label your materials: Let consumers know which parts are recyclable and which are not. Several standards exist, including the Resin Identification Code (https://en.wikipedia.org/wiki/Resin_identification_code).



Compatibility of different polymer combinations for recycling.
Visual inspired by Envirowise

- Avoid using hazardous/toxic materials: A list can be found at http://ewasteguide.info/hazardous-substances.
- Use compatible materials: If you must use different materials, use two that can be recycled together. For example, PC and ABS can form to make PC/ABS. See the chart below.

Logistics

- Make the product light: Heavier products require more energy to move. More energy means higher carbon monoxide levels, which leads to a higher carbon footprint.
- Keep it small: The less room your product + packaging takes up, the more items you can move on one pallet reducing fuel for shipping.

3. PROCESS

To gain a holistic understanding of the impact your product has on the environment, it is important to also understand the impact your product has at each stage of the its life, from raw material extraction, through prototyping and production, to distribution and finally disposal. This is often referred to as a life-cycle assessment (LCA) or cradle-to-grave analysis.

Luckily, the International Organization for Standardization has created, you guessed it, a standard for how to carry out a Life Cycle Assessment which breaks down the process into four steps:

- *Goal and Scope: What are you trying to learn about your product and achieve from this study?* There are so many areas to focus on when it comes to environmental impact that it's important to narrow it down to high impact items. This phase should define the purpose, what is being studied, the scope of the analysis, any assumptions, and the environmental impact area your team wants to improve.
- *Inventory: What is the flow, from nature to disposal, for all parts associated with the product, within the defined scope?* This step takes into account each energy input that goes into sourcing, producing, and moving a material. Think about the energy required for material extraction, the environmental impact for moving the material before and after production, and byproducts or recyclability of the material after consumer use. Typically this is shown for each part in a flow chart, with energy inputs calculated based on the mass of the material.
- *Impact: Classify and characterize each inventory flow to uncover its quantified environmental impact.* Classification is done simply by assigning an environmental impact to each inventory flow (e.g., global warming, toxicity, ozone depletion, etc.). Then, based on the scope set out in phase one, focus your time on those impacts you initially want to improve.

  To assess the impact, "characterize" means to convert those material masses into measurable units specific to the environmental impact (i.e., global warming can be measured in kgCO2). Since it can be hard to measure the impact of global warming vs. toxicity, an optional step is to weight each environmental impact based on assumed importance and convert to a universal measurement, like millipoints. Weighting values can change drastically from team to team, as their value is often subjective and based upon person or company's values.

  See the visual below for an example on how to convert an inventory flow to a quantified and measurable form.

LIFE CYCLE INVENTORY		LIFE CYCLE IMPACT ASSESSMENT			
Compound	Mass	Classification	Characterization	Weighting	Total (millipoints)
SO_2	11.2 kg	Acidification Potential	AP = 280 kg SO_2 (e)	x 20%	56.2 mp
NOx	48.4 kg				
H_2SO_4	13.6 kg				
HCl	0.05 kg				
NOx	120.6 kg	Eutrophication Potential	EP = 518 kg N (e)	x 30%	155.4 mp
NH_3	14.8 kg				
P	0.002 kg				
PO_4	6.8 kg				
CO_2	1423 kg	Global Warming Potential	GWP = 2012 kg CO_2 (e)	x 50%	1006 mp
CH_4	283 kg				
PFCs	4.5 kg				
HFCs	14 kg				
SF_6	0.06 kg				

Example LCA Impact Assessment. Table courtesy of Solidworks

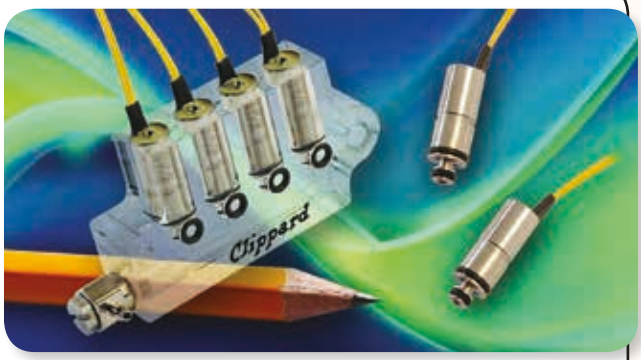
- *Interpretation: Understand and evaluate the finding from each of the above phases.* The Life Cycle Assessment is an evolving process, and the results of one phase can often impact others. Because of this, interpretation is recommended after both the inventory and impact phases. The desired outcome of the interpretation phase is to walk away with a clear understanding of the significant issues, reassurance that the assessment was thorough and consistent, and finally, a list of recommendations for improvements.

A Life Cycle Assessment can take some time to do properly, but when completed, it will influence your internal design policies and help solidify guidelines for how your company thinks about and makes decisions with sustainability in mind. Plus, by doing so, you're literally making the world a better place.

TAKEAWAYS

The explosion of consumer electronics doesn't seem to be slowing down anytime soon, and with that, e-waste is going to continue to build. As with many things in life, it's better to be proactive, rather than reactive. The proactive approach is for companies, engineers, and designers to take ownership of the cradle-to-grave product lifecycle and start building for a sustainable future. It all starts with a framework and building a process. PDD

From the Cover

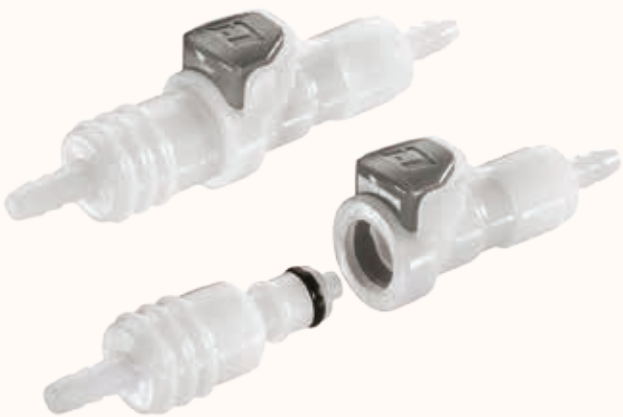


2-Way Normally-Closed Electronic Valves

Clippard (Cincinnati, OH) has announced a series of direct actuating valves that offer a fast response time for accurate dosing of minute volumes with the same long life of the original Clippard EV line of valves, now in a 7 mm cartridge package. Subminiature size and low energy consumption make them suitable for transportable and mobile systems, among others. Features include:

- An expected life of over 1 billion cycles.
- An extremely small dead volume.
- Quiet operation and very low vibration.

www.clippard.com



Small All-Plastic Series Coupling

LinkTech Couplings (Ventura, CA) has announced its 30AC Series small all-plastic series coupling. It offers the same 1/8" flow size as the 20 Series, but is more reliable with less moving parts due to its advanced design with no external springs. Features include:

- An all-plastic thumb-latch design, which makes an audible click when coupled.
- A durable Acetal (POM) thermoplastic, which is resistant to most mild chemicals.
- Cycle testing to 100,000 connections.

www.linktechcouplings.com

PRODUCT DESIGN & DEVELOPMENT® RESOURCE GUIDE

Advanced Ceramic Solutions

Astro Met's unique advanced ceramics provide cost effective solutions to material performance problems in a wide range of demanding applications. "Amalox 68" a 99.8% alumina ceramic and "Amzirox 86" an yttria stabilized zirconia provided superior wear resistance, corrosion resistance, high temperature stability, low thermal expansion, high stiffness to weight ratio, biocompatibility and high dielectric strength.

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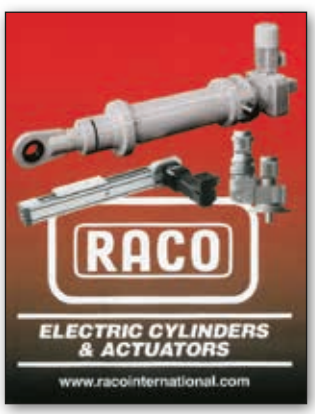
Electric Actuators



Raco Ball & ACME screw Electric Actuators cover a broad range of applications, are environmentally friendly, robust & low maintenance replacements for hydraulic/pneumatic cylinders. The modular systems design allows for Straight/Right-Angle/C-Design variations. Thrust up to 225,000 lbs, speeds up to 30"/sec, strokes up to 20 feet. For fast linear movements up to 400"/sec RACO produces the belt driven LM-Actuator. X-Y-Z arrangement can be easily designed for paint/cutting/sorting/testing/material-handling applications.

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THE BRAINSTORM

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

There's a growing consensus that environmental considerations must be factored into the design, manufacture, and disposal of products and many companies have already taken the first steps towards helping build a sustainable economy. To get a better sense of how far along we are, PD&D asked several leading manufacturers and materials suppliers; "How do you define sustainability with regard to materials, and how will it influence your product development efforts over the next year? And over the next 5 years?"

Dawn Rittenhouse, DuPont Director of Sustainability

DuPont generally defines sustainability according to the Brundtland Commission definition: Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. We apply this definition in a couple of ways. First and foremost, our Core Values of safety and health, environmental stewardship, respect for people, and highest ethical behavior guide our strategy and beliefs and influence many of the policies and positions that we've developed, including our commitment to safety, health and the environment. This not only means developing materials in a responsible way with a robust product stewardship process but also developing renewable or bio-based materials to replace those derived from conventional fossil fuel-based feedstocks.

We also have a set of 2020 Sustainability Goals led by our flagship Sustainable Innovation Goal. Our Innovation Goal commits us to further embed sustainability in our innovation process and challenge all products in our pipeline to contribute to a safer, healthier, more sustainable world, including materials. We plan to track our progress and measure and report the quantifiable safety, health, and sustainability benefits from major growth innovations through 2020. These terms all tie back to sustainability. For example, "safer" can translate to improved food safety and quality, as well as products that help protect people or have reduced toxicological risk. "Healthier" can mean improved nutrition as well as disease prevention and control — for people as well as animals. And "more sustainable" can cover a wide range of benefits, from reduced energy and water use, to lower pollution and waste, to more efficient resource and material use. We will report these benefits as we roll out the goal within the company. We believe these terms are specific enough to allow meaningful measurement, while being broad enough to encompass a wide array of benefits flowing from sustainable policies and action.

Aneta Clark, market development representative, medical packaging, advanced materials-specialty plastics, Eastman

Sustainable materials not only help reduce the use of resources, but, most importantly, contribute to patient safety and positive outcomes. Sustainable products and business practices have, rightfully so, become the norm, and many companies look to implement sustainability early in the development process.

From a material supplier standpoint, sustainability — along with patient safety and product performance — is one of the core drivers of medical design and development for both devices and packaging. Material suppliers are addressing product developers' sustainability needs by providing alternative solutions to products that have been on the market for many years.

Sustainable materials are those that are long-lasting, can be processed efficiently and don't contain questionable ingredients. They can reduce waste by addressing performance failures. These materials can be designed to help with reduced energy usage. They also can lower the safety risk by eliminating materials of concern.

Medical packaging failures are costly and could be catastrophic when time is of the essence. Products made with tough materials that can stand up to sterilization, harsh disinfectants and environmental factors during distribution help ensure that products arrive at health care facilities uncompromised, further contributing to patient safety.

In medical packaging, where using recycled content is limited due to material traceability requirements, sustainability can be realized in different ways — such as through leveraging materials that reduce scrap and

waste. The ability to use existing thermoforming, trimming and sealing equipment can be beneficial for a processor when adding new materials to their portfolio. This allows packaging manufacturers to save costs. Furthermore, when materials allow for optimizing processing conditions — such as lowering the temperature and increasing the processing speed — the outcome often yields higher throughput and allows manufacturers to improve their carbon footprint.

Patient safety is a key driver in creating sustainable healthcare products. Developing new products and redesigning existing solutions with materials that don't contain components such as bisphenol A, styrene or halogens further help contribute to providing sustainable products.

Over the next year, and even five years, using sustainable materials to create long-lasting products that are free of materials of concern will continue to be a strong driver in new product innovation.

Kevin Ireland, Communications Manager, Green Dot

At Green Dot, the four R's of sustainability are reduce, reuse, recycle and return. Green Dot's bioplastics and biocomposites help our customers meet a range of sustainability goals, whether they are seeking to reduce the amount of nonrenewable petroleum-based feedstocks, increase the use of reclaimed biobased feedstocks or recycled plastics, or create products and packaging that can be returned to nature when placed in a composting environment.

We believe that making plastic more sustainable is similar to increasing fuel efficiency in the automotive industry – small changes can have large impacts. Reducing petroleum feedstock in plastics by just 25% can decrease greenhouse gas emissions equivalent to removing 16.5 million passenger cars from the road every year. Our customers are doing just that, reducing the amount of petroleum-feedstocks in their plastics by using starch, natural fibers, agricultural byproducts, and wood fibers to lighten the environmental impact of their products.

We see exciting opportunities to 'upcycle' recycled plastics. In the past, recycled plastics were relegated to low-end applications and disposable goods. We've combined recycled plastic with natural fibers to make biocomposites that are stronger and more durable than recycled plastic alone. Our customers are using these biocomposites to make high quality durable goods designed to last for decades.

In the next five years, we believe that an increasing number of products will use biodegradable plastics. In the past, biodegradable plastics lacked the physical properties. However, new formulations have allowed these plastics to meet or exceed the physical properties of some conventional plastics. Our customers are finding that biodegradable plastics can not only reduce plastic pollution and landfill waste, but also prevent chemicals like phthalates, and BPA, often used in traditional plastics, from entering into our environment. As the infrastructure for plastic composting continues to develop, we believe that more companies will turn to these materials to meet rising consumer demand for more sustainable products.

Luis Tissone, Director of Life Sciences, Trelleborg Sealing Solutions

Over the last decades, population growth and current trends have put a burden on renewable and non-renewable resources. Material sustainability is becoming a central aspect within the Life Sciences industry and it is an increasingly important driver for business growth and new product developments.

Companies are being faced with the challenge of setting up an adequate business platform to enhance innovations that meet the demand for sustainable materials that perform, add value, meet quality requirements, are environmentally friendly, and are not a burden to limited natural resources. For component manufacturers, it is mandatory to continuously work in higher performance sustainable materials that have been engineered to work in demanding environments while allowing new design possibilities and critical product aesthetics.

The preferred materials to be used in the coming years are the ones that can provide abilities to be processed in a sustainable way while controlled and shaped into advanced new products. In an age of constrained resources and stringent regulatory requirements, such materials need to add value and eliminate the risks of unforeseen situations that can affect a company's reputation and bottom line. Everything starts with quality and few things are more disruptive than production line shutdown due to material quality, the importance of inspection and quality assurance across the supply chain will continue to grow when selecting sustainable materials.

Product development will be influenced by the need to find suppliers that can master these challenges and have access to quantity of sustainable raw materials. In the next 5 years, government regulations will continue to place emphasis on material sustainability and force it to play a stronger role in the product life cycle of medical devices from inception to disposal. Global companies that can deliver cost effective products with materials that are regionally sourced and manufactured will have an edge over the competition.

Design for sustainability will progressively become a central aspect of product development putting more emphasis on the selection of environmentally friendly materials, the reduction of waste, and the optimization of devices without compromising on quality or performance.

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Marketplace

The Ups & Downs of Economic Growth

Karl Stephan, Professor of Electrical Engineering, Texas State University

Economic growth is one of those things like your body temperature that you probably don't give much thought to, unless it gets out of whack. The business website Kiplinger's tells me that in 2016, the U.S. gross domestic product (GDP) will probably grow by about 1.8%, a little down from 2015's 2.4%. Why should we engineers care about economic growth, and what difference does it make to us, to our companies, and to the country?

On a personal basis, I have worked for growing organizations, and I have worked for downsizing organizations. Growing is better. For one obvious thing, if you're looking for work, you stand a lot better chance of getting a job with a firm that's hiring than one that's laying off workers. Growth in numbers isn't the same thing as economic growth, but the two tend to go together. In a growing firm, there's a sense of optimism, the pleasure of meeting new people and getting to know the old-timers who remember back when the whole company could fit in a garage, and the excitement of taking part in something that could amount to a lot more than it does right now.

From a corporate point of view, especially for publicly-owned firms, growth is a near-necessity. In French, "roi" means "king," and in the corporate world, ROI – return on investment – tends to rule everything else. Especially in these days of indistinguishable-from-zero interest rates, anyone wanting to grow their money invests in equities that they expect to grow in value. So a company that can't show growth, or at least promise it, can't attract new capital, which is in turn the main way companies can grow. So there is a chicken-and-egg thing here, but the overall picture is, economic growth is the norm for companies in a capitalist economy.

On a national basis, Benjamin Friedman argues in his 2005 book The Moral Consequences of Economic Growth that the same good effects of growth you notice in a growing firm apply also to a nation whose economy is growing. He claims that "[e]conomic growth . . . more often than not fosters greater opportunity, tolerance of diversity, social mobility, commitment to fairness, and dedication to democracy." On that last point, one can think of some counterexamples where high GDP growth has not moved a country notably toward democracy. But even in places like China, a growing economy has improved the lives of millions and allowed them to trade menial farm jobs for work in factories and offices in city environments that while not perfect, are nevertheless a vast improvement over the places they used to live.

Economic growth has its downsides, of course. Growth rarely benefits everyone equally. In capital-intensive industries that use lots of engineers, economies of scale tend to produce only a few big winners and a whole lot of also-ran losers. Think of how the dozens of U.S. automobile manufacturers founded in the early days of motorcars shook out to leave only the Big Three firms by 1930. If you get into a new field and happen to pick the wrong company, you either jump ship to a winner or go down with the loser.

No physical thing can grow indefinitely, and there are those who say economic growth is a false god that will eventually betray us. While

growing individual incomes, growing firms, and growing national economies surely involve the growth or larger-scale making of physical stuff, that is not all that's involved. An economy is a mysterious thing, involving both physical assets and millions of people who make unpredictable decisions about how to better their lives – and "better" means a different thing for every single one of them. So while I have some sympathy for those who are worried that economic growth may one day run out of gas, I think it's fair to say that an engineering-intensive economy needs to grow. How fast a given company, region, or country needs to grow economically is one of those hard questions that can only be answered by experience. But most engineers probably do best in an environment where economic growth is encouraged and viewed as the generally good thing it is.

Have you experienced the downsides of either too much economic growth or not enough? Do you think there's too much emphasis on economic growth, or too many obstacles in the way of achieving it? Send your responses to kdstephan@txstate.edu. PDD

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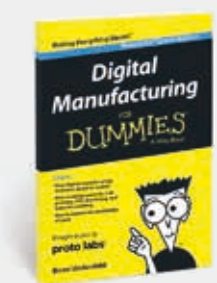

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