EP&T

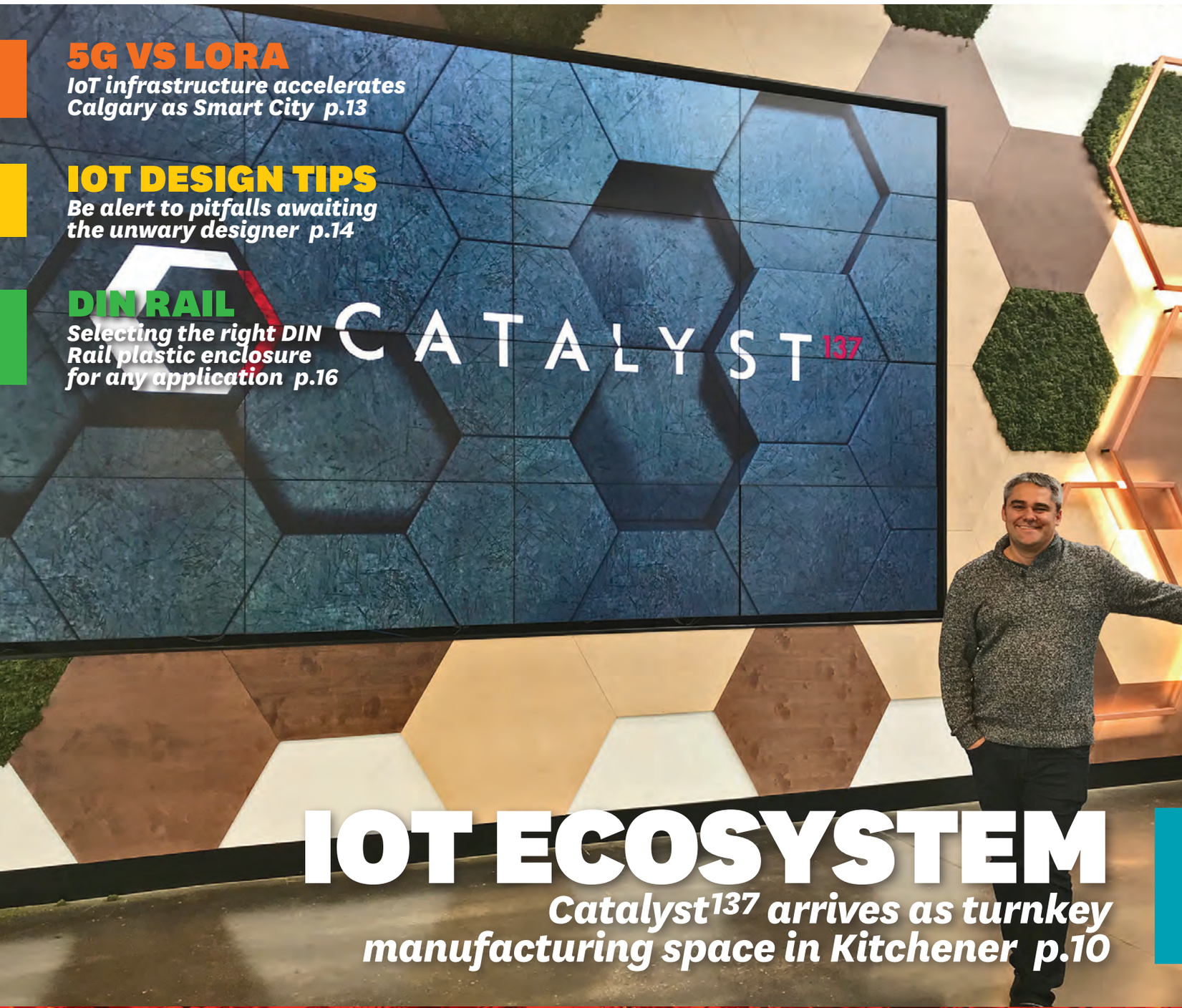
ELECTRONIC PRODUCTS & TECHNOLOGY

40 YEARS

CANADA'S INFORMATION LEADER FOR ELECTRONIC ENGINEERS AND DESIGNERS

EPT.CA

MAY 2019



5G VS LORA

IoT infrastructure accelerates Calgary as Smart City *p.13*

IOT DESIGN TIPS

Be alert to pitfalls awaiting the unwary designer *p.14*

DIN RAIL

Selecting the right DIN Rail plastic enclosure for any application *p.16*

IOT ECOSYSTEM

Catalyst[137] arrives as turnkey manufacturing space in Kitchener *p.10*

YOUR PREFERRED COMPONENT PART SEARCH?

SURVEY SAYS...

FREE SHIPPING ON ORDERS OVER $100 CAD OR $100 USD

SAME-DAY SHIPPING 8:00 PM

Source: Electronics sourcing
ESNA Reader Survey 2018
MMG Publishing LLP

1.800.344.4539

DIGIKEY.CA

Digi-Key® ELECTRONICS

*A shipping charge of $8.00 CAD will be billed on all orders of less than $100.00 CAD. A shipping charge of $20.00 USD will be billed on all orders of less than $100.00 USD. All orders are shipped via UPS, Federal Express, or DHL for delivery within 1-3 days (dependent on final destination). No handling fees. All prices are in Canadian dollar or United States dollar. Digi-Key is an authorized distributor for all supplier partners. New products added daily. Digi-Key and Digi-Key Electronics are registered trademarks of Digi-Key Electronics in the U.S. and other countries.

ECIA MEMBER
Supporting The Authorized Channel

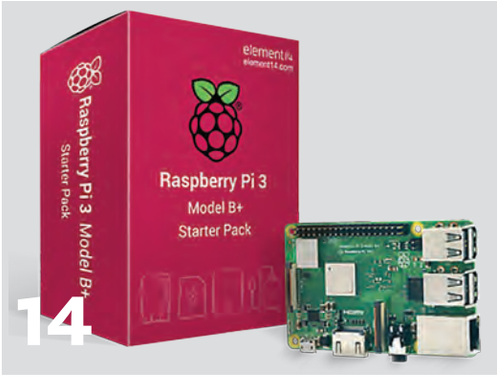
10

13

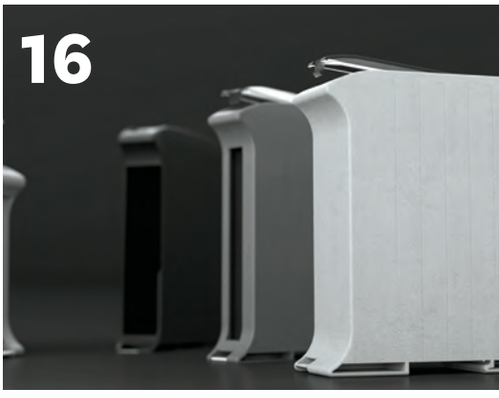
INSIDE

EP&T

MAY 2019



14



16

Columns

In every issue

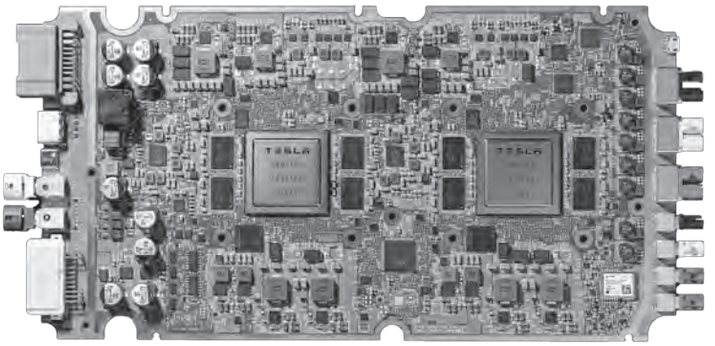
COVER STORY

Cover photo: EP&T
Photos (this page, from top): Catalyst137; Semtech; Newark; TCH Sales Inc.

Elon Musk steps on gas in race to build electric car

Tesla's FSD Computer accelerates EV development as designers compete to define emerging car space

For more than a decade, Tesla engineers have been obsessed with making the world's most efficient electric vehicles. The polemic electric car maker is confident that it is on track towards that goal with its recent release of the FSD (full self-driving) computer, a new custom chip designed to enable full self-driving capabilities.



The chip is now designed into all new Model 3, X and S vehicles, as announced by CEO Elon Musk during the company's Autonomy Day this past April. As a result, Tesla vehicles already travel farther on a single charge than any other production EV on the market. Tesla has accomplished this without increasing the cars' battery size, proving its expertise in system-level design can make its cars dramatically more efficient.

Tesla shared a vast amount of details about its FSD dual SoC 14nm computer, indicating that the 12 ARM core chip has a modest GPU, a custom neural network compute part, while the SoC packs 250 million gates, 6 billion transistors at 260 mm^2. Work is also already underway on a next-generation chip, according to Musk, who claims Tesla is now about halfway through its design.

Adding to the intrigue, the FSD replaces Tesla's Autopilot 2.5 computer, powered by NVIDIA chips. Customers will now be able to pay the car maker to pull out existing Nvidia-based computers from older vehicles and retrofit new computers with Tesla's own chip.

Pete Bannon, the veteran chip architect leading Tesla's project, claims that the FSD computer can handle data at almost seven times the rate of Nvidia's technology – (144 trillion operations per second, compared with 21 trillion for Nvidia). Bannon says the FSD represents the brain in Tesla vehicles, processing input from eight cameras, 12 ultrasonic sensors, a front-facing radar, plus GPS and mapping data.

One other ear-pricking admission made by Musk at the Tesla media event was his pronouncement regarding future use of Lidar sensors in vehicles.

"LiDAR is a fool's errand, and anyone who relies on LiDAR is doomed," he said starkly. Musk went on to explain that he's not wholly anti-LiDAR, just when it comes to cars. He called other LiDAR devices on cars, "expensive sensors that are unnecessary."

Only time will tell which pursuant of autonomous car technology eventually drives away with majority market share? **EP&T**

Model 3 autonomous Tesla with no steering wheel; (above) Full Self-Driving Computer (FSD).

STEPHEN LAW
Editor
slaw@ept.ca

Connect with EP&T magazine

@EPTmagazine facebook.com/EPTmag/ /ept-magazine info@ept.ca ept.ca

EP&T
ELECTRONIC PRODUCTS & TECHNOLOGY

Canada's information leader for electronic engineers and designers

MAY 2019
Volume 41, Number 3

EDITOR Stephen Law
slaw@ept.ca · (416) 510-5208

WEST COAST CORRESPONDENT
Sohail Kamal
sohail@nextgear.ca

PUBLISHER Scott Atkinson
satkinson@ept.ca · (416) 510-5207

ACCOUNT MANAGER Joanna Malivoire
jmalivoire@ept.ca · direct 866-868-7089

MEDIA DESIGNER Andrea M. Smith
asmith@annexbusinessmedia.com

CIRCULATION MANAGER Anita Madden
amadden@annexbusinessmedia.com
Tel: 416-442-5600 ext. 3596

ACCOUNT COORDINATOR Tracey Hanson
thanson@annexbusinessmedia.com

VICE PRESIDENT – EXECUTIVE PUBLISHER
Tim Dimopoulos
tdimopoulos@annexbusinessmedia.com

COO Scott Jamieson
sjamieson@annexbusinessmedia.com

PRESIDENT & CEO Mike Fredericks

EP&T is published eight times per year by

ANNEX BUSINESS MEDIA
111 Gordon Baker Road
Suite 400
Toronto, ON M2H 3R1
Tel (416) 442-5600
Fax (416) 510-5134
www.annexweb.com

SUBSCRIPTION RATES
Canada – $58.50 one year;
$94.00 two years
USA – $103.00 per year
International – US$141.00 per year
Single copy – Canada $15

CIRCULATION
blao@annexbusinessmedia.com
Tel: 416-442-5600 ext. 3552
Fax: 416-510-6875 or 416-442-2191

ISSN 0708-4366 (print)
ISSN 1923-3701 (digital)

PUB. MAIL AGREEMENT NO. 40065710
Return undeliverable Canadian addresses to: EP&T Circulation Department, 111 Gordon Baker Rd. Suite 400, Toronto, ON M2H 3R1

PRINTED IN CANADA

Funded by the Government of Canada | Canada

electro sonic

Presents Hammond Manufacturing

There's a Hammond Manufacturing Enclosure for Every Application!

- **INDUSTRIAL ENCLOSURES**
- **SMALL ENCLOSURES**
- **DIECAST ALUMINUM**
- **EMI/RFI PLASTIC**
- **& THE LIST CONTINUES!**

STOCKED AND DISTRIBUTED BY ELECTRO SONIC

HAMMOND MANUFACTURING®

E-SONIC.COM | 1-800-56-SONIC

ecia AUTHORIZED

Newark
AN AVNET COMPANY

1.800.463.9275
newark.ca

Discover Over a Million **Engineering Products** from Suppliers You Know and Trust

- 900+ new products each week
- Custom services such as kitting, panel meters, enclosures, and many more!
- Market-leading online community of over 600,000 engineers

3M
AlphaWire
Amphenol
AVX
BELDEN
BOURNS
DURATOOL
EATON
FLUKE
HAMMOND MANUFACTURING
HARTING
Honeywell
KEITHLEY A Tektronix Company
Electronic Components KEMET CHARGED.
KEYSIGHT TECHNOLOGIES
Life Is On Schneider Electric
maxim integrated
METCAL
micro:bit
MICROCHIP
molex
multicomp
NXP
OMRON
Panasonic
Raspberry Pi
ROHDE & SCHWARZ
SOLA HD
TDK·Lambda
TE connectivity
Tektronix
TENMA
VISHAY
Weller
XILINX

NEWSWATCH

IOT

FEDDEV ONTARIO SUPPORTS SAFETY TECHNOLOGY

In an increasingly digital and connected world, the Government of Canada is supporting start-ups, such as SmartCone Technologies Inc., that are using innovation to develop products to protect the safety of Canadians.

FedDev Ontario recently contributed $187,500 to the Ottawa-area firm in order to accelerate the market entry of TheSmartCone—a portable surveillance and Internet of Things device, containing multiple sensors with embedded software, housed inside any object, such as a traffic cone or utility box.

The high-tech detection and early warning system of TheSmartCone uses flashing lights, audio and visual messages, posted to traffic signs to alert the public. This warning system increases public safety by sharing pertinent on-the-ground information in many situations including controlling bicycle lane traffic, managing vehicle fleets, monitoring traffic incident scenes, asset tracking, crowd control, site security surveillance and more.

The SmartCone portable surveillance & IoT unit contains multiple sensorswith embedded software.

PHOTONICS

POET TECH OPENS PHOTONICS DESIGN CENTRE IN OTTAWA

Optoelectronic developer POET Technologies Inc., San Jose CA, has entered into an agreement with Ottawa-based MillView Photonics Inc., to establish a collaborative design center in Canada'a capital.

MillView was established two years ago by Dr. Trevor J. Hall, Professor in the School of Electrical Engineering & Computer Science and founding director of the Centre for Research in Photonics at the University of Ottawa.

The agreement between the two companies brings together in one lab the MillView team, including Dr. Hall, additional staff from MillView, and three PhD-level photonics engineers from POET.

"MillView is similarly situated to bring in the specific talent needed to address and solve a broad range of engineering challenges in photonics," says Dr. Hall, a graduate of Cambridge University.

POET Tech's CEO, Dr. Suresh Venkatesan, added: "We have assembled a team in one place dedicated to one goal – the design and development of waveguides and filters for our Optical Interposer platform. In addition, this places POET squarely in both a region and university where photonics design and development are vibrant and pervasive."

Tech startup Guard-Ex co-founders invented an impairment screening device.

ENTREPRENEURS

LAURIER STARTUP FOCUSES ON ROAD-SAFETY TECHNOLOGY

Waterloo-based Guard-Ex, an impairment screening device startup company founded by participants in the Schlegel Centre for Entrepreneurship and Social Innovation's LaunchPad incubator at Wilfrid Laurier University, have raised a $1-million CAD seed round.

The four founders, Laurier students Harmeet Chauhan and Rahul Malhotra, Laurier business graduate Baltej Sandhu and University of Waterloo student Dastiger Khan, launched Guard-Ex in 2017 to address the need for an accurate and unbiased roadside impairment screening device for law enforcement.

As opposed to traditional impairment screening methods, Guard-Ex takes an innovative approach by using physiological indicators such as eye movement and body temperature, rather than measuring chemicals from saliva or breath. Guard-Ex has developed a universal impairment screening device with the help of machine learning to screen for real-time impairment. Guard-Ex automates the manual process that is conducted by law enforcement officers today.

Sole investor, Bob Schlegel, is a CPA and 1972 graduate of the economics program at Laurier's Lazaridis School of Business and Economics. Schlegel is founder & CEO of Schlegel Capital and Pavestone Company's Bedrock Logistics in Dallas, TX. He provided the initial funding for the centre in 1998.

"These guys are unlike anyone else. They are filling a market need that is critical to the safety and welfare of Canadians. They are smart and driven and I know they'll do well," said Schlegel. The Guard-Ex founders are looking to complete their prototyping and commercialization process within the next year.

CONTRACT MANUFACTURING

MICROART INJECTS MORE CAPITAL INVESTMENT

Microart Services, an electronics manufacturing services (EMS) provider with factories in Markham ON and Buffalo NY continues to upgrade with additional capital equipment.

Thus far in 2019, the firm has purchased two additional high-speed pick-and-place machines, one flexible pick-and-place, two screen printers, a 3D X-ray, an X-ray component counter, plus a factory floor smart cart for SMT component storage.

PCB PRODUCTION

BITTELE OPENS NEW PCB FACILITY IN MARKHAM

Bittele Electronics Inc. will launch a new Canadian assembly facility in Markham ON this June.

The building will be fitted with brand-new, state-of-the-art equipment including fully automated assembly lines inside the 14,000-sq-ft facility feature fully automated pcb loading, solder paste printing, component placement, reflow and inspection. EP&T

Photos:SmartCone Technologies; Guard-Ex

HARBOUR AIR spreads its wings with world's first electric seaplane

Photo: Credit Harbour Air

Venturing out with two planes to service the forestry industry more than three decades ago, Harbour Air has emerged to become one of the largest all-seaplane airlines in the world and a vital piece of B.C.'s transportation infrastructure. With more than 450 staff and transporting more than 500,000 passengers each year, the Nanaimo-based airline recently partnered with an engineering firm, magniX, in an effort to pioneer the world's first all-electric airline.

West Coast Report sat down with Harbour Air Seaplane's founder and CEO, Greg McDougall, to learn what has aided their success so far, why they want to become an all-electric airline, and why they are so keen to tackle big obstacles in aviation.

"I grew up in Santa Barbara, California, but came up to B.C. every year to spend the summers at our family cabin on the coast, which could only be accessed by float plane. I always knew I wanted to be a pilot and when I graduated in 1974 returned to Canada to begin flying," says McDougall.

When he began his career, the culture of seaplane flying carried a wild west mentality. He recognized there was an incredible opportunity for these aircraft as a reliable way to get around the coast, however, it was imperative to elevate the safety, perception, and profession of seaplanes to that of commercial airlines. This is where they have earned their success, as McDougall explains: "Our steadfast focus on safety, innovation and service was the breakthrough of our operation and certainly its ongoing success."

The task of plane electrification is a challenging one. Harbour Air has been committed to sustainability by becoming the first fully carbon-neutral airline in North America in 2007, through the purchase of carbon offsets. They are now pushing the boundaries of aviation by becoming the first commercial airline powered by electric propulsion.

"The decision and vision to go electric, and specifically to operate the world's first all-electric commercial flight, has been a goal of ours for a number of years. We are excited to bring commercial electric aviation to the Pacific Northwest, turning our seaplanes into ePlanes," says McDougall.

The aviation industry is hung up on a traditional way of operating and is handcuffed by its dependence on jet fuel. On the other hand, Harbour Air, owing to their short-haul routes, aircraft size, and progressive agenda is in a unique position to morph into an electric airline. Their average flight time is 30-minutes, which makes electric propulsion a viable option. The pilot e-plane will come into service later this year.

"The first step currently being developed is the (electric) conversion of one of our DHC-2 de Havilland Beaver aircraft, a six-passenger commercial seaplan. Harbour Air and magniX expect to conduct first flight tests of the all-electric aircraft in late 2019", explains McDougall. "From there the aircraft and components will go through certification and approval. Once approved we'll look to expand the conversion across the entire fleet." **EP&T**

Sohail Kamal *is EP&T's West Coast correspondent. sohail@nextgear.ca*

Simplify Product Design with NEMA Sockets

ONE Cutout!

Interpower® offers four NEMA snap-in sockets (5-15, 5-20, 6-15, and 6-20) with one common panel cutout. This allows for designing products with various voltages and amperage ratings. Choose quick disconnect or solder tab options.

Current Ratings for These Sockets Include:

- NEMA 5-15—15A/125VAC
- NEMA 5-20—20A/125VAC
- NEMA 6-15—15A/250VAC
- NEMA 6-20—20A/250VAC

Screw-mount sockets are also available.

Let Us Help You Simplify Your Product Design For Various NEMA Sockets

- Made in Iowa
- No minimum order or dollar requirements
- 1-week U.S. manufacturing lead-time on non-stock Interpower products
- Same day shipments on in-stock products
- Blanket or scheduled orders available
- Value-added options available
- Free technical support

Contact Customer Service for More Information

interpower®

Order Online! **www.interpower.com**

Business Hours: 7 a.m.–6 p.m. Central Time

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

CATALYST 137 IoT design epicentre

Kitchener-based turn-key ecosystem on its way to becoming the world's largest IoT manufacturing space, spurred by its 'pay it forward' mentality

BY STEPHEN LAW, EDITOR

If your design world revolves around the Internet of Things (IoT), you should be aware of Catalyst, because there's some really cool stuff happening there.

Kurtis McBride, the driving force and steward behind the project has a vision of the Kitchener Ontario-based innovation hub becoming one of the world's leading development centres for IoT designs. Located at 137 Glasgow St, the 475,000-square-foot former car tire factory has been converted into a hub of burgeoning, high-tech hardware companies.

Representing a one-stop-shop for anyone involved in IoT design, Catalyst clusters together everything hardware designers need to get to market quickly in the IoT sphere, whether it's help with prototyping, certification, IT, industrial design and branding, even component sourcing.

"This place is designed for entrepreneurs by entrepreneurs," says McBride, who aside from being co-founder & 'chief hype guy' for Catalyst, resides as CEO of Miovision, also a tenant within the facility.

Catalyst137 is the result of a converted car tire factory located in downtown Kitchener ON.

The Catalyst137 campus is described as a 'brand vessel' that houses all of the uniquely different individual firms and services under one roof.

"Catalyst is a sum of its own parts, so each of us (tenants) have a vested interest in strengthening it, which often means lending our own brands to strengthen the Catalyst brand."

Catalyst is described by McBride as a brand vessel – housing all of the uniquely different individual brands under one roof.

Tenants represent all segments of electronics design cycle

The facility itself is best described as a mall comprised with tenants, each representing a portion or segment of the electronics design cycle. McBride identifies two classes of tenants within Catalyst, including amenity and service providers, along with the user-class occupant.

The facility sits on property that is equivalent to 24-acres in size, whereas the building consumes about half of that – the other half allocated to parking spaces. The work environment here for the more than 2,000 employees of approximately 30 different firms is convivial – it is collaborative

Photo: Credit Catalyst137

Photo: Credit Catalyst137; EP&T

– or, as McBride puts it "operates within a very pay it forward culture."

Under the amenity umbrella resides such players as contract manufacturer Sigmapoint; product design and engineering firm SnapPea Design; Clausehound brings start-up-focused legal resources; Blakes is one of Canada's top business law firms; Swift Labs Inc., provides wireless & IoT product development and testing services; electronic component distributor Mouser Electronics. Firms such as Strive and Madhatter perform digital marketing and demand generation. EDC, BDC and NRC form a government and capital support network.

"The Catalyst brand is more than a physical building filled with tenants who sign leases – that is not what this is all about," says McBride. "It is about bringing people together to help each other to build companies and create wealth for the country."

Sitting at just over 80% capacity (at time of writing), the community of start-up peers boasts a variety of players. Leading the way as anchor tenant is McBride's own firm, Miovision, which creates smart city intelligent solutions for in-house and outsourced traffic data collection and advanced traffic signal operations.

Kurtis McBride, co-founder & 'chief hype guy' for Catalyst137 says the facility operates under a pay it forward culture.

Other user-side residents include an IoT innovation lab for Toyota; Electric vehicle technology company FleetCarma; Fleet telematics by Geotab; blockchain cryptocurrency firm Kik.

"Sustainability was very important to us, we wanted to make sure that we have a model that wasn't going to fall apart if the existing political support on tech changes. We want it to be a sustainable model," McBride says. "All of the tenants must be viable commercial entities with business models. The idea there is you can deliver all of these different services, but there is no need for the government to prop it up with support. It supports itself."

Sourced best-in-class players for each IoT bucket

While vetting prospective tenants, McBride says he looked at the landscape as an emerging designer and thought about what types of services are necessary to launch a concept. Once it was determined – he went out to source best-in-class players "in each bucket." It was important to determine that they service the IoT ecosystem, as well as being capable of paying their rent. McBride did turn away a number of entities that sought to join, as it was determined to be too much of a stretch.

"If you are a company that focuses on creativity and technology to drive a business model – that is a match with our perspective," he says.

Also part of the model was to ensure that Catalyst allocated a small percentage of its available space to small three to 10-person start-up companies.

"It will serve as a late-stage incubator for firms that are growing and taking next stage steps, but are unsure of just how much space they will ultimately require," he adds.

McBride points to the Kitchener/Waterloo Region as the obvious birthplace to such a concept. The decline and contraction of BlackBerry as Canada's crown jewel of electronics leadership, spread the seeds of tech knowledge around the community, spawning hundreds of new tech firms as a result.

> ***"We have a density of talent here – not just engineering talent, but all the supporting talent that goes around it"***

"We have a density of talent here, not just engineering talent, but all the supporting talent that goes around it," says McBride. "It is probably pretty unique, not just in Canada, but anywhere in the world. Some of that talent left town – but, a lot of it is still here. I like to think Catalyst delivers opportunity by providing a physical density and a brand vessel to communicate that capability."

Collaborative, supportive working environment

Lending support to the collaborative working environment, the facility's common areas include a gym, café and a brew pub, while a 6,000-square-foot special event space at the front of the building is offered up for free to all Catalyst tenants. McBride stresses the importance of clustering together capabilities, talent, capital and culturally aligned companies - then stepping back and letting 'it' happen.

"You don't know what is really going to happen within these walls, but things do happen and will happen," he says.

"We all compete for talent, capital and to a lesser degree customers. We tend

to look past all of that and tend to focus on the idea that 'a rising tide lifts all boats'," he adds.

"As for our journey in the next five years? Who knows what will come out of this place, but my sense is if you cluster all of these things in one place – Catalyst becomes a destination for other firms looking in."

McBride serves example of a recent visit by Volkswagen, which stopped in for a tour of the facility - simply because they heard about it.

"They asked to take a look around and who knows, maybe they'll hang a shingle on our property one day. And, by doing so, maybe that creates business development opportunities for a little start-up that doesn't exist here yet," McBride adds.

More than a physical building, McBride says Catalyst137 is about bringing people together to help each other – to build companies and create wealth for the country.

"We want this place to become a globally renowned destination that companies come to in order to get to market fast and get exposure. Under this roof, there will be opportunity for large global brands to come here and take up 500-square-feet of office space and to proclaim their interest in participating," enthuses McBride.

To its advantage, Catalyst is situated roughly 3km from the University of Waterloo, considered as the 'MIT of Canada' and consistently ranked amid the top technical universities countrywide. Albeit mostly circumstantial according to McBride, the close proximity to graduating engineers does inject some synergistic energy.

"The feeling amongst many (UofW) graduates is that they often find a ready-made ecosystem that accepts them right here in Waterloo," he says. "When you map out all of these different assets – it is a great place to come and build your business."

McBride believes the KW region's abundance of capabilities in engineering, design and product management

> ***"With this culture, there is a higher velocity of collective community learning, which actually creates successs"***

helps draw talent in globally. He says this synergy of braintrust provides a 'concentration of thought' that the Federal and Provincial Governments can draw upon to run better innovation policy.

"How do we turn Canada into an innovation economy – much like Germany, USA, Japan and Korea – because those were not accidents – those were intentional," he notes. "I think with this culture, there is a higher velocity of collective community learning, which actually then creates success – which begets success," McBride continues.

"The idea with this building is we want to create venues for the kind of collision that happens organically out in the community. We want to kind of take that organic osmosis culture that we already have and provide venues to amplify and accelerate it." **EP&T**

Photo: Credit Catalyst137

5G *vs* LoRa: Inside the city of Calgary

BY ALISTAIR FULTON

The United Nations estimates that 68% of the world's population will live in an urban setting by 2050. As more residents move to city locations, government officials continue to adopt new smart solutions to better manage services improve quality of life and reduce operating expenses in a sustainable way. Smart city solutions can be leveraged in a number of ways to improve parking, the flow of traffic, street lighting, maintenance, waste management and pollution.

LoRa Technology and low power wide area networks (LPWAN) based on the LoRaWAN™ protocol have emerged as a top option for cities as they look to deploy a smart infrastructure. This technology provides a smart sensing and control infrastructure to collect and analyze data from thousands of connected devices in a streamlined manner, in order to make intelligent decisions about the services they need to offer.

Why LoRa?

There's lots of discussions about 5G, but it's still hard to predict when this disruptive technology will become a reality. LoRa Technology is available today all around the globe with more than 600 known use cases and 87-million devices deployed.

LoRa Technology enables data communication over a long range while using very little power. When connected to a non-cellular LoRaWAN network, LoRa accommodates a vast range of IoT applications by transmitting packets with important information. LoRaWAN fills the technology gap of cellular and Wi-Fi/BLE based networks that require either high bandwidth or high power, or have a limited range or inability to penetrate deep indoor environments. In effect, LoRa Technology is flexible for rural or indoor use cases across smart cities, homes and buildings.

LoRaWAN operates in unlicensed radio spectrum, which means that any city can use the radio frequencies without having to pay copius amounts of fees for transmission rights. LoRa Technology is also highly secure and offers an efficient, flexible and economical connectivity solution ideal for IoT applications whether indoor or outdoor and installed in public, private or hybrid networks. Simple sensor data can fuel analytics platforms, such as those for artificial intelligence and machine learning. These require data diversity which is made possible by low-cost LoRa-enabled sensors.

Enhancing the quality of life

In 2016, the City of Calgary became one of the most innovative cities in Canada. For 20 years, Calgary worked to build a strong infrastructure with internal city business units, civic partners, educational institutions and the broader industry. Calgary was the first city in North America to deploy LoRaWAN-based networks. Its smart city approach helped the city become more sustainable by bringing openness to data sharing and technology, as well as building trust and transparency with municipal government and citizens.

The City of Calgary worked with government officials to source funding in order to bring its vision of a City Network of Things Platform (CNoT) to life. Through extensive research Calgary proved its commitment to innovation and to providing business units, industry partners and citizens a secure and resilient IoT infrastructure. LoRaWAN is able to provide security functionality, ease of implementation and comprehensive network coverage to Calgary's one million residents.

With help from various technology vendors such as Semtech, the City of Calgary was able to deploy more than 300 miles of dark fiber for a high speed reliable data network with 10 radio towers and Wi-Fi access points installed at traffic intersections. Continued efforts to secure additional funding for the City's underlying fiber backbone and new IoT network laid the groundwork for increased connectivity to provide coverage and data transfer capabilities for public safety organizations, water and waste management and transit organizations. These actions allowed Calgary to avoid monthly service expenses incurred from third party mobile carrier tower leases and optimized asset tracking for its 3,300+ vehicles around the city.

68%

of the world's population will live in an urban setting by 2050

LoRa in real life?

The range of smart city applications for Calgary is vast. Some examples are:

- The Urban Alliance is able to measure noise levels to address issues and improve the quality of life for residents. With help from the University of Calgary, the Urban Alliance is able to use LoRa-based sensors to characterize noise and create a use case on Calgary's LoRaWAN based network.
- The Shanganappi Golf Course uses LoRa technology to track the pace of play, improving operational efficiencies to ensure the overall experience is enjoyable for customers. Location sensors embedded within the golf carts share real-time information to course marshals to avoid anomalies in pace of play. Once detected, these oddities can be swiftly addressed making for a seamless golfing experience.
- Calgary's Devonian Gardens uses LoRa-based devices to measure soil conditions for urban canopy maintenance and water valve status remotely, which saves time, conserves resources and provides more accurate and timely data. By utilizing LoRa-based devices to gain an understanding of fundamental characteristics such as air, water, light and humidity, Calgary can provide more efficient predictive care to these plants.

LoRaWAN and LoRa Technology has been a great catalyst for Calgary to foster innovation and accelerate IoT development in the city. EP&T

Alistair Fulton is vice-president and general manager, wireless & sensing product group at Semtech.

10 Tips for improving IoT design success

From wearable tech and home automation gadgets to intelligent industrial sensors, there are a number of design pitfalls awaiting the unwary design engineer

BY CLIFF ORTMEYER

Developing a new IoT-ready device leads to challenges for even the most experienced design engineers. The successful integration of an IoT edge device calls for good design and manufacturing, adequate deployment, timely battery replacement if applicable, and an ability to accept and incorporate software/firmware updates as required.

Here are 10 ways to avoid potential pitfalls:

1. Robust project planning

According to a recent Cisco study, one third of all completed IoT projects are considered a failure, with 60% of IoT initiatives stalling at the Proof of Concept (PoC) stage. Businesses can reduce the potential for failure by ensuring their IoT project is well planned, scoped, and the proof of concept tested prior to rollout. Project managers need to examine the breadth of the project to understand the competencies required – ensuring the team has the right skills, or partnerships where required.

2. Utilizing modular solutions

Some challenges can be reduced by building in modular solutions, simplifying the development process. Raspberry Pi has an ecosystem of products that allow designers to focus on their core expertise while delivering their end product quickly.

3. Considering compliance upfront

IoT edge installations can contain varied device types as well as router or gateway platforms that manage communications among all the devices and the wider IoT infrastructure. Project designers should choose a platform that supports an extensive mix of protocols for data ingestion, such as OPC-UA, BACNET and MODBUS, as well as more current ones like ZeroMQ, Zigbee, BLE and Thread.

4. Choosing the right power capability

Most IoT products depend on having exactly the right level of processing power. Recent developments in edge technology, including AI at the edge, provide design engineers with options around where that processing power sits – either at the cloud, gateway or edge itself. Insufficient capability at any point will render them unable to handle their target application. However, if the processor is too powerful, it can also cause problems related to pcb real estate, cooling, power use and cost.

5. Identifying the right memory option

There are many memory options for design engineers: traditional external flash memory, embedded flash memory, multichip package memory and multi-media cards. Making the right choice depends on your project's priorities.

COST The more expensive the memory selection, the more expensive the final device.

SIZE The amount of space required for memory processing and the more silicon wafer space required, the more costs go up.

POWER CONSUMPTION Most IoT devices either run on small batteries or rely on energy harvesting for recharging. Design engineers should choose an option that uses the least power and lowest voltage.

STARTUP TIME Memory must support a quick startup to ensure good device performance. Implementing a code-in-place option, which allows the device to execute code directly without needing to copy operating code from a separate EEPROM chip, reduces the time required to boot up, as well as the cost of the chip with less need for RAM with substantial on-chip storage.

6. Getting the most out of your firmware

IoT devices are controlled by coding implemented in firmware. Design engineers should make the following considerations when designing their firmware:

- ***Ensure a stable firmware architecture*** that is scalable and

well documented.

- ***Design for constrained systems*** such as low-power MCUs with limited memory, no memory management and no direct interfaces.
- ***Build in stability*** and error recovery including application watchdog timers, error correction and auto-recovery from system faults.
- ***Paying attention to inputs & outputs*** including sensor data gathering, digital signal processing, local compression, and storage of data.
- ***Minimizing power consumption*** by writing firmware that allows devices to enter sleep mode and consume the bare minimum energy required.
- ***Optimizing bandwidth*** for cellular communication from your device to the cloud.
- ***Revise firmware*** continuously with OTA updates to improve stability and functionality. Add value without changing hardware.

7. Effective software management

In the IoT ecosystem, first to market is a huge competitive driver, which can mean that security, quality and dependability can be sacrificed for speed to release. There are four important software development practices:

REVIEW Proper code review and repetitive testing should be a priority with a call for strict software quality measures.

ASSESSMENT Continuous deployment in the connected world is common with updates often getting pushed multiple times a day. With the quality assurance burden on the software that interacts with IoT devices is greater than ever, if the software isn't continuously monitored and the code evaluated, failure is almost guaranteed.

RESPONSIBILITY Management must take responsibility for quality assurance. Any OEM that doesn't have a set of analytics to track its software risk is negligent.

ADVOCACY A cultural shift to include education needs to occur. Developers must champion the need for standards.

8. Proper power management

Excessive power demand will drain an IoT device's battery too quickly and can cause overheating. Minimizing a SoC's power demand as much as possible is key for IoT edge device designers, especially if the device is battery-operated or relies on energy harvesting. This can be done by reducing voltage, frequency or capacitance.

Design engineers could also consider reducing switching activity, sacrificing transistor density for higher frequencies, layering heat-conduction zones within the CPU framework, recycling at least some of the energy stored in the capacitors, or optimizing machine code by implementing compiler optimizations that schedule clusters of instructions using common components.

9. Prioritizing security

Security issues include protection of critical assets, safe crypto implementations, secure remote firmware updates, firmware IP protection & secure debugging.

10. Reducing Electrostatic discharge (ESD)

Certain components are sensitive to static electricity and can be damaged by ESD. The pcb can be damaged as the discharge, caused by physical contact with a person charged with static, passes through the conductive pattern to a static sensitive component. **EP&T**

Cliff Ortmeyer is the global head of technology product marketing and solutions development, Newark

Detailing the selection process of a DIN rail plastic enclosure

Picking the right enclosure for any application can be a little challenging when it's your first time **BY JOHN MEIKLE**

DIN rail plastic enclosures are used to house multiple types of populated printed circuit boards (pcb) that serve various types of applications. One of the most popular are the single board computers (i.e. Raspberry Pi, Arduino and Beaglebone).

These enclosures are based on DIN (Deutsches Institut für Normung) specifications and were introduced primarily by European manufacturers. These embedded enclosures are available from several different manufacturers around the globe today. They come in an array of sizes, orientations, colours and styles. It really is the next evolution from the more mature pcb supports or carriers.

Typical vertical sizes (how the pcb sits in enclosure) begin at 7.5mm – and move right up to 45mm, while the horizontal sizes start with 1M (18mm width) right up to the 12M (213mm). Most vendors offer different features and accessories. Some of these features have pre-loaded terminal blocks, led holes, vents, removable covers and sides, clear plastic face plates and different profiles for multiple board applications.

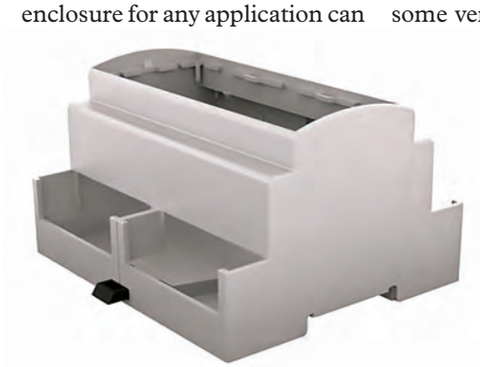
Picking the right DIN Rail enclosure for any application can be a little challenging when it's the first time working with these units. To assist with the process, most enclosure makers have good information available on their websites. Some even have a configurator that walks you through the design or selection steps.

The printed circuit board has to be designed with the enclosure in mind.

The pcb has to be designed with the enclosure in mind and it's important to look at this upfront, as it's a critical stage during the design process.

In most cases you need to leave a clean edge or leading edge on the board, so it can be snapped into place or sandwiched into place as you assemble the enclosure.

As part of the selection process, it would be wise to use the manufacturer's websites to help with this - as discucssed above. Here's what you will find on some vendor sites - and it tends to be only with the horizontal, multi-board enclosures. Most sites walk you through the selection process, indicating various profiles and sizes. In most cases, you will be asked to select the type of face plate or top cover (solid, clear, rounded, flip up and so on). Now you will need to choose accessories, such as screwcaps, jumpers and connectors. Some will even offer a step where you can select value-added features like CNC work, or some form of printing.



Most enclosure suppliers have info available on their websites to help the design process.

Many of these features are also offered from select manufacturers on the vertical type enclosures. Some makers provide a BOM and estimated quote once you've finished the selection process – including all the accessories and value-adds.

Key points when choosing your enclosure

Be sure to check the plastic specification and approval rating. At times, this is not readily available on some websites, but it is an important step. You will find that some vendors use plastic rated for 65°C, while others use a higher grade plastic that comes with an improved rating of 90°C. Wall thickness also comes into play when using different plastics.

One last point: not all DIN rail enclosures are made by the vendor you selected. If you are looking to include any modifications, or added-value, it may be wise to choose an original manufacturer (OEM supplier). You will have a much wider selection of vendors to choose from if you only want an empty shell and no features.

Why use these type of products? Here's some key points:

- Low cost entry to market, low capital startup.
- Easily scalable to higher volumes, starting with short run CNC production to semi-custom molded solution.
- Interchangeable common covers for product variations.
- Launching point for the design cycle with pre-design pcb form factor.
- CNC production can be used for certification and testing because it is the actual product (not a rapid prototype).
- Standard mounting to DIN rail.

Always be sure to check the plastic specification and approval ratings.

In the end, you should be happy with the product you've selected for your application – and now you are ready to go. **EP&T**

John Meikle is the director of electronics, TCH Sales Inc., Toronto, exclusive franchised distributor of Italtronics enclosures in North America.

Photo: Credit TCH Sales Inc, Italtronics

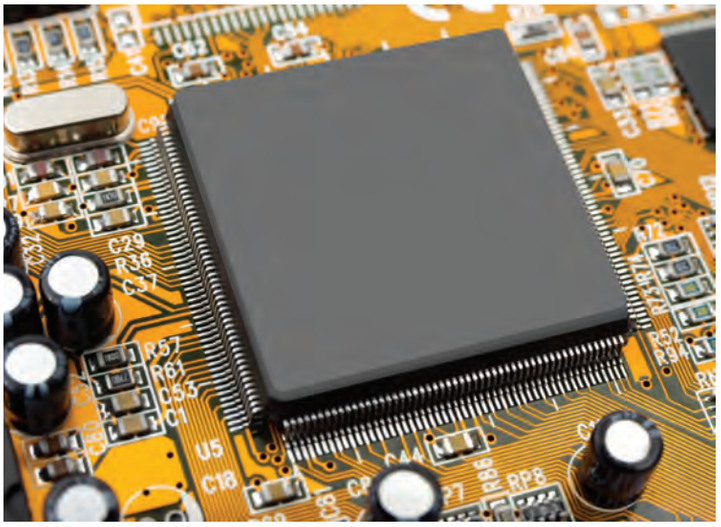
PROTOCASE

Custom Electronic Enclosures, Sheet Metal Parts & CNC Machining for Engineering, Research & Innovation

Made in 2-3 Days **No Minimum Order**

We're Ready to Build Your Design.

Contact Us Today! **1.866.849.3911 | protocase.com**



THIN FILM DELIVERS THERMAL CONDUCTIVITY OF 2.2W/M•K

FUJIPOLY AMERICA

Sarcon 45-YR-a is a V-0 rated, 0.45mm thick advanced silicone material that eliminates near-microscopic air gaps that exist between a heat source, such as a high-performance semiconductor and a nearby heatsink. The high-performance thin-film delivers a thermal conductivity of 2.2 W/m•K with a thermal resistance of .33°C•in2/W. Product is recommended for applications with operational temperatures that range from -40°C to +150°C.

www.fujipoly.com

ALUMINIUM ENCLOSURES PROTECT SENSITIVE DESIGNS

BOPLA

Bocube ALU aluminium enclosures are IP69 tested and enhance protection against harsh environmental conditions, as well as against high pressure water jets. Meeting protection classes IP66 (strong water jets) and IP67 (submersion in 1 metre of water for 30 minutes), product series consists of eight sizes. All enclosure components, including the hinges, are made of metal and joined captive to the enclosure. The sturdy units provide mounting space for rectangular pcbs, while delivering a recessed front surface for extra protection.

www.bopla.de

WATERTIGHT ENCLOSURES COME WITH NEMA 6 RATING

EQUIPTO ELECTRONICS

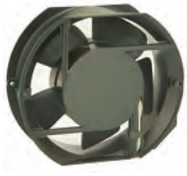
N6 shielded, high-end NEMA cabinets are designed and constructed to protect valuable electronics deployed in harsh environments. Units deliver beyond the basic NEMA rating and handle strenuous shock and vibration conditions. Product comes with 14 gauge steel frame body construction and can be custom painted, using a durable epoxy paint. The fully EMI/RFI shielded units are built to protect critical electronics in any weather condition.

www.equiptoelec.com

ELECTRONICALLY COMMUTATED (EC) FANS OPERATE IN RUGGED DESIGNS

ORION FANS

EC IP68-ATEX electronically Commutated (EC) fan series includes spark proof IP68-ATEX rated versions for applications involving explosive atmospheres or flammable gases. Devices eliminate the possibility of an explosion or fire and are available in a range of sizes - including 60mm, 120mm and 172mm. Most models are available with a universal voltage range. By maintaining the same interface between the fan and equipment, EC fans can be used as drop-in replacements for equivalent-sized ac fans.



www.orionfans.com

ROOF-MOUNTED COOLING UNITS BOOST ENERGY EFFICIENCY

RITTAL

Blue e+ roof-mounted cooling units are suitable for enclosures from a size of 800 x 600 mm (W x D) upwards and provide a cooling output of 1.3kW. This means that cold air can also flow from above and around the devices installed inside the enclosure, such as frequency converters. Alternatively, cooling can also be provided in combination with the new VX25 large enclosure system as a complete integration solution.

www.rittal.ca

POLYCARBONATE ENCLOSURES PASS UL TESTING

POLYCASE

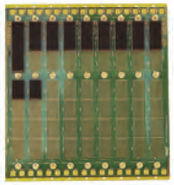
HD Series of polycarbonate NEMA enclosures have obtained an official UL 508A Listing to Types 1, 2, 3, 3R, 3RX, 3S, 3SX, 3X, 4, 4X, 5, 6, 6P, 12, and 13. Products can be molded in either gray or black polycarbonate plastic and are available in three sizes, ranging from 4.63" x 4.63" up to 6.63" x 4.68". Additional features include molded on surface-mounting flanges, brass inserts in the screw towers, pcb standoffs on both the base and cover plus an extra deep cover that is fastened from the base.

www.polycase.com

6U OPENVPX BACKPLANES COME IN NEW CONFIGURATIONS

PIXUS TECHNOLOGIES

OpenVPX backplanes for 6U applications come in new configurations including a 9-slot, 6-slot power and ground, 5-slot, and a 1-slot development backplane. The 5-slot unit has a BKP6-CEN05-11.2.5 profile and it features PCIe Gen3 speed performance. Firm now offers power and ground only backplanes for development applications. This allows signals to pass through to the rear transition modules (RTMs) for easy prototyping and de-bugging.



www.pixustechnologies.com

AIR-TO-AIR HEAT EXCHANGER COOLS ENCLOSURE, KEEPS DUST OUT

PFANNENBERG USA

PKS Series Air-to-Air Heat Exchangers use firm's Kinetic System next generation cooling technology that out-performs conventional heat exchangers. Units are lightweight and easy to install, while products deliver a cooler ambient environment when closed-loop cooling is required, sealing against gas, humidity and dust. Products are suitable for indoor, outdoor, remote and washdown applications that require a closed loop system to protect electronics.

www.pfannenbergusa.com/thermal-management/air-to-air-heat-exchangers

TEAS OPTIMIZE THERMAL PERFORMANCE

LAIRD THERMAL SYSTEMS

AA-250 Outdoor Cooler Series of thermoelectric assemblies (TEAs) are designed for use in outdoor environments. Units are compact and deliver efficient air-to-air cooling and heating of vital electronics in outdoor environments. Products deliver a lower total cost of ownership by maintaining the appropriate temperature range using minimal energy due to its high coefficient of performance (COP).

www.lairdthermal.com

*Visit **ept.ca** for the latest new products, news and industry events.*

HAMMOND MANUFACTURING®

Hundreds
of industries served

19" Rack Cabinets

Thousands
of models IN STOCK

Unlimited Applications

Relay Racks

19" Accessories

www.hammondmfg.com

WIRE PROCESSING EQUIPMENT HANDLES MICRO-COAXIAL CABLES

SCHLEUNIGER

CoaxCenter 6000 fully automatic machine for processing micro-coaxial cables delivers high precision, enabling unit to process down to 42AWG micro-coax and with the length precision to process conformable coax. Machine's QCam 360 automatically monitors stripping quality, eliminating the need for time-consuming manual post-production quality monitoring processes. Machine's output is 3Xs higher than with manual and semi-automatic equipment and requires less personnel to operate.

www.schleuniger.com/wpte

OSCILLOSCOPES COME WITH 15.4" DISPLAY, DEEP TOOLBOX

TELEDYNE LECROY

WaveRunner 9000 Series mixed-signal oscilloscopes come with a large, 15.4" display, bandwidths from 500MHz to 4GHz and sample rates up to 40GS/s. Unit provides a deep toolbox and a complete collection of serial data debug and validation solutions, making it suitable for embedded systems, automotive and EMC/EMI test applications. Units provide powerful, flexible serial triggering with an intuitive color-coded decode overlay. Additionally, measure/graph and eye-diagram test (TDME) packages complement the TD packages by enabling extraction of decoded data and subsequent waveform data plots, performing bus timing measurements and creating eye diagrams for testing against standard or custom masks.

http://teledynelecroy.com

PLASTIC CONNECTORS ARE COMPATIBLE WITH METAL DEVICES

HARTING

Han-Eco B product series includes plastic housings that are fully compatible with the standard Han B, which means that Han-Eco B plastic connectors can be mated with Han B metal connectors. Devices provide a rear mounting option for prefabricated cabinet harnesses. This feature simplifies the assembly process as

the insert side of the wiring harnesses can be easily snapped into the bulkhead mounted housing from the inside of the switch cabinet – rearward. This simplifies the assembly, saving time and costs.

www.harting.com

PRODUCT SOURCE GUIDE

COMPACT DC-DC CONVERTER SERVES HARSH CONDITIONS

MURATA POWER SOLUTIONS

IRS-Q12 series encapsulated 1/16th brick dc-dc converter is a board-mount power module that incorporates advanced assembly techniques, 2250Vdc isolation with a basic insulation system and an industry leading efficiency. Device's high reliability, safety features and optional packaging configurations provide an improved level of performance in harsh environmental conditions.

www.murata-ps.com

300W CONSTANT POWER LED DRIVER DELIVERS WIDE INPUT

MEAN WELL

ELGC-300 series of 300W, constant power mode LED drivers provide wide ac input range from 100~305Vac. Devices adopt the Global Input / Output cable design, which can be applied worldwide. Units provide 94.5% efficiency, wide working temp range (-40°C~85°C) and dimming functions with 3 in 1 / DALI or Smart timer control to achieve IoT control. Products also extend with a C.C+C.V mode series, ELG-300-24A type.

www.meanwell.com

AD INDEX

40 YEARS

A Look Back

Celebrating four decades of electronics design

Marking its 40th anniversary this year, EP&T will feature this special column throughout 2019, providing readers with a peek at our past, while paying homage to our history.

In this issue, *A Look Back* puts its focus on a Technology Report which appeared in EP&T's September issue in 1979. The article, titled: Magnetic bubbles fill gaps in memory market, details new product announcements made by leading manufacturers that were taking long, hard looks at feasible applications – specifically Magnetic Bubble Memories or MBM. The thought at the time was that these MBMs were finding their place in the hierarchy of memory devices available to circuit designers at that time.

In lay terms for today's designer, bubble memory is a type of non-volatile computer memory that uses a thin film of a magnetic material to hold small magnetized areas, known as bubbles or domains, each storing one bit of data.

The EP&T article indicated that – in some respects, the MBM was creating its own 'niche', not merely replacing devices already having large followings, but carving out new territories. In fact, 40 years ago MBMs were readily available from at least three component vendors.

- Texas Instruments produced two devices, the 92-kbit and 254 kbit models.
- Rockwell International offered the 256-kbit RBM 256.
- Intel Magnetics had just introduced the 128-kbyte (1-megabit) model 7110.

technology report

Magnetic bubbles fill gaps in memory market

With recent new product announcements by leading manufacturers and a number of users taking long, hard looks at feasible applications, magnetic bubble memories (MBM) may finally be finding their place in the heirarchy of memory devices available to today's circuit designers.

In some respects, the MBM is creating its own niche, not merely replacing devices already having large followings, but carving out new territories.

Magnetic bubble memories are now available from at least three manufacturers:

- Texas Instruments produces two devices, the 92-kbit TIB0203 and the 254 kbit TIB0303.
- Rockwell International offers the 256-kbit RBM 256.
- Intel Magnetics has just introduced the 128-kbyte (1-megabit) model 7110.

Gap-filler

Bubble memories can be classified as read/write, serial-access, non-volatile devices. Compared to semiconductor random-access memories (RAM) they have significantly slower access and transfer times because of their inherent serial organization, but provide a higher physical storage density and are inherently non-volatile, retaining data without system power.

Compared to moving magnetic media storage devices, such as floppy and hard discs and drums, the MBM should be more reliable because of a lack of mechanical movements, exhibit faster access and transfer rates, require simpler interfaces and have a higher storage density. They should soon be less costly than comparably sized floppy discs used with small computers, but do have one drawback when compared to floppies: the storage media cannot be changed easily.

Bubble memories are filling an access-time versus price gap that has existed for several years between semiconductor and core memories on one hand, that provide fast access but relatively high cost per bit, and

There are two main technological competitors that also fit in the memory price-performance gap:

- Charge-coupled devices (CCD) store data as discrete charges, an electrical analog to the magnetic MBM. Access time is an order of magnitude lower and transfer rate correspondingly higher. Two devices are commercially available, but only in sampling quantities, as the technology has taken longer than expected to get off the ground.
- Electron beam addressable memories (EBAM) are specialized storage CRT units using MOS technology and storing data as discrete capacitances. Access time is better than with the CCD, but these devices are still only in research phases.

Market position

Magnetic bubble memories are expected to have their greatest market

Texas Instruments 256-kbit bubble memor

and semiconductor RAM is a difficult drawback for these devices to overcome and the relatively high prices, lack of reliability and large size make the MBM preferrable to hard disks.

Bubble memories will replace floppy discs in some applications. However, advances in floppy technology are expected to increase storage density and reliability while decreasing their cost, and will continue to make them attractive for small systems.

Intel 7110 bubble memory chip stores more than 1 million bits on this single chip.

tems.

A move up to larger minicomputer and mainframe systems will begin as storage density increases and cost comes down. In these applications inroads against high-speed fixed-head discs and drums should be made first. Later applications

An article which appeared in EP&T's September 1979 issue illustrated the thought that MBMs were finding their place in the hierarchy of memory devices available to circuit designers at that time.

Whatever happened to bubble memory? Well, it certainly was the rage – promising to replace the hard disk, according to tech columnist, podcaster and blogger John C. Dvorak. Invented by Bell Labs in the 1970s, it was commercialized by Intel and heavily marketed in the early 1980s as the ultimate answer for microcomputer memory storage.

"Not only would it retain its memory after the computer had been turned off, unlike Dynamic Random Access Memory (DRAM) chips, but it wouldn't have any moving parts," Dvorak says in his blog on the subject.

So what happened? First of all, it turned out to be harder to make bubble memory than expected. The fabrication process never proved to be smooth or cheap enough to compete with other technologies. Furthermore, it required a complex controller, not unlike a hard disk controller, to make the system work. Worse, it was power hungry. While it was a static technology when inactive, it required a lot of juice to move those bubbles around. Users also discovered that glitches in the data were a problem. And finally, it was slow, says Dvorak.

All this added up to expense and inconvenience. The memory chips themselves never came close to the price points of DRAM chips, and hard disks continued to drop in price and improve (a practice still happening). Combined, the two managed to pop bubble memory's chances at wide acceptance. **EP&T**

Widest selection of electronic components in stock

Mouser opens new office in Canada

Ph# 800-346-6873
Catalyst137
137 Glasgow Street
Unit 475 A
Kitchener, Ontario N2G 4X8
Canada

ecia MEMBER

Order now at
ca.mouser.com

MOUSER ELECTRONICS

Photo by Nick Stanley / SRM Architects

Authorized Distributor of Semiconductors and Electronic Components

ALLIED
ELECTRONICS & AUTOMATION

POWER:

We stock enough power to brew a 12 oz. cup of coffee for the entire population of New Orleans.

Put that in your mug and drink it.

Get your A&C fill at **alliedelec.com** **1.800.433.5700**