european business press

www.electronics-eetimes.com

September 2015

# EE Times europe

*For the creators of technology*

## 3D CURSOR TACKLES AUGMENTED REALITY

Special Focus: Energy Harvesting

CEO interview: Ambiq's Mike Noonen

# THE WORLD'S LARGEST SELECTION OF ELECTRONIC COMPONENTS AVAILABLE FOR IMMEDIATE SHIPMENT!™


**OPEN ACCOUNTS AVAILABLE**
FOR QUALIFYING CUSTOMERS

**FREE SHIPPING ON ORDERS OVER €65***

**LOCAL SALES & TECHNICAL SUPPORT**


**Free Online Tool**
Access the BOM Manager now!
DIGIKEY.COM/BOMMANAGER

Digi-Key® ELECTRONICS

FIND CONTACT AND ORDERING INFORMATION FOR YOUR REGION AT
**DIGIKEY.COM/EUROPE**

1,000,000+ PRODUCTS IN STOCK | 650+ INDUSTRY-LEADING SUPPLIERS | 3.9 MILLION PARTS ONLINE

*A shipping charge of €18.00 (£12.00) will be billed on all orders of less than €65.00 (£50.00). All orders are shipped via UPS for delivery within 1-3 days (dependent on final destination). No handling fees. All prices are in euro and British pound sterling. If excessive weight or unique circumstances require deviation from this charge, customers will be contacted prior to shipping order. Digi-Key is an authorized distributor for all supplier partners. New product added daily. 

# WHICH SINGER WORE A MEAT DRESS?

# RIGHT, AND WHICH MICROBIOLOGIST MAKES CLOTHES OUT OF MILK YARN?

HEROES OF INNOVATION

**#WHYISIT**

Why is it that most of us know the woman who caused quite a stir when she pioneered a dress made out of meat, but nobody knows the woman who transforms fermented milk into yarn? Isn't it time we recognized the people who invent the things that make our lives better? People like Anke Domaske, whose biopolymers, made from fermented milk, represent a natural alternative to traditional plastics, and could be used to make textiles and electronics more sustainable.

**Let's celebrate the heroes of innovation.**

arrow.com/whyisit

ARROW

# WHO SAID "HASTA LA VISTA, BABY"?

# AND WHO SAID, "ANYONE CAN PROGRAM A ROBOT"?

HEROES OF INNOVATION

**#WHYISIT**

Why is it that most of us know a fictional robot with a thick Austrian accent, but we don't know the German engineer who makes real robots more intelligent? Isn't it time that we recognized the people, whose inventions improve the world? People like Dr. Rainer Jäkel, who teaches industrial robots new workflows by physically demonstrating them.

**Let's celebrate the heroes of innovation.**

arrow.com/whyisit

ARROW

# CONTENTS



## OPINION


4 Is 3D XPoint based on phase-change memory?

50 Let consumers figure out a use case for EEG


## NEWS & TECHNOLOGY


6 Ex-Google engineers promise ultra-low cost Android PC

8 Sensors, liquid crystals make "omnifocal" glasses
Perfect vision – all the time – is the claim from startup Deep Optics Ltd.

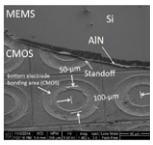
10 Fraunhofer rolls security platform for cars

12 CEO interview: Ambiq sees broader options for low voltage
Mike Noonen from Ambiq Micro, discusses the focus and opportunities for his company designing circuits that can operate below the threshold voltage its transistors.

14 Automotive electronics complexity at tipping point

14 'Test city' opens for autonomous cars

16 3D fingerprint scanner beats Apple's
Password security is already becoming a thing of the past with biometrics taking their place.




17 CoolCube circuit stacking moves to FinFET process

17 3D printing for photonics: a British initiative

18 Is NextInput next winner in Apple products?

18 Notebook displays shrink, Chromebook's 11-inch a winner, says IHS

20 Drones' agenda: new spectrum
As the term UAV (unmanned aerial vehicle) suggests, drones are supposed to fly autonomously. And there's the rub.


## DESIGN & PRODUCTS

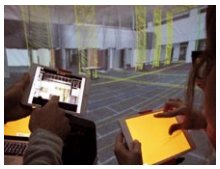
SPECIAL FOCUSES:
- HAPTICS & USER INTERFACES


22 Haptic prosthesis gives back natural feel for missing limb
Austrian researcher develops a sensor-laden artificial limb able to let the wearer feel the surface he or she is walking on.

24 Motion engine beats gestures

26 Augmented theatre: a 100% French feat
During this summer's Avignon festival, French cultural startup Theatre in Paris provided foreign theatre goers see-through and customizable surtitles.

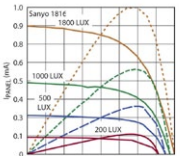
26 A 3D cursor for a 3D world
With the advent of smartphones and smartwatches, how users interact with computers or smart devices in an inherently 3D world begs rethinking.



27 Startup revives smartphones' joysticks: rear-mount


- ENERGY HARVESTING


30 An adaptive power management solution for energy harvesting




34 TNatcore takes silver out of photovoltaics

34 Paper-thin solar charger fits inside a notebook

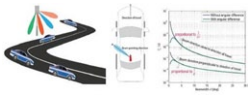
35 'Aqueous solar flow' battery lasts longer

36 Thin film solar cells may rival silicon


- MICROWAVE & RF CIRCUITS


38 IoT network concerns
The Internet of Things lacks a wide area network with broad coverage and low cost, according to a panel of expert working to bridge the gap to fuel IoT deployments.

40 Millimeter waves hitch a ride



41 Changes to radio rules

42 5G the Free WiFi Killer
5G may be not much more than a moniker for what comes after 4G, but Intel clarified its vision recently at a keynote during the Intel Developer Forum 2015.

43 'Funtenna' hack turns IoT devices into radios


## READER OFFER


46 This month, Altera is giving away three of its second-generation Nios II Embedded Evaluation Kit (NEEK), worth $359 each, for EETimes Europe's readers to win.

49 DISTRIBUTION CORNER

# Is 3D XPoint based on phase-change memory?

By Peter Clarke

What would be the simplest way to explain the technology behind 3D XPoint non-volatile memory; a scaled version of phase-change memory?

Intel and Micron chose not to reveal the materials they are using or the switching mechanism at play in their 3D XPoint non-volatile memory launched earlier this summer. But there is some circumstantial evidence for it being phase-change memory technology implemented in a 2Xnm or 1Xnm manufacturing process. The scaling, novel mixes of chalcogenide glass and other developments may have provided the claimed performance improvements.

The 2Xnm feature size can be derived from calculations based on a typical die size, the assumption of a 4F2 memory cell, and the given information of two planes of 64 billion memory cells in the 128Gbit 3D Xpoint memory. A die area of 1 square centimetre yields a feature size of 19nm or less. A larger die would push the upper limit up to the 27nm region.

The secrecy has given rise to much speculation about the underlying 3D XPoint technology. Rob Crooke, general manager of the non-volatile memory group at Intel, and Mark Durcan, CEO of Micron, described it as a fundamental breakthrough. They also said it was "bulk switching" suggesting a non-filamentary behaviour.

Intel did say that 3D XPoint should not be described as a ReRAM but the nomenclature definition of what is or is not a resistive RAM is not formal. Intel also said the 3D XPoint memory cell operates via changes in resistance of the bulk material, which makes it a resistive RAM by the broadest definition, but includes the possibility of it being a phase-change memory.

Also I am not sure I would describe phase-change memory as a bulk phenomenon as it results from a thermal pulse that proceeds from an electric current through the material. But it could be argued that in a sufficiently small cross-point a significant amount of the active material undergoes the phase change.

And then there are similarities between 3D XPoint and physical layout diagrams of previous presentations on PCMS a stacked arrangement of phase-change memory and a selector diode.

Searches of databases of patents and patent applications yielded at least 20 patents assigned to Intel or Micron in recent years that either reference phase-change, PCM or PCMS directly or if they are written more generally about non-volatile memory, reference PCM/PCMS as a specific embodiment.

On top of this there are many similar patent applications not yet granted.

And it is harder to find mentions of other non-volatile memory types in those same searches. The frequency with which PCMS comes up seems to support the view that phase-change is the likely mechanism behind 3D XPoint memory but is not conclusive.

The executives in the press conference described 3D XPoint as fundamentally new technology and yet a single-layer PCMS memory was shown more than five years ago in October 2009 prior to the presentation of PCMS at IEDM in December 2009.

I guess it depends on your definition of new.

"What properties would a memory cell have if made of multiple interleaved chalcogenide and metal-oxide layers?"

Durcan was asked in the press conference to compare 3D-XPoint with phase-change memory and say why 3D-XPoint would be more successful. He said: "Relative to phase-change, which has been in the marketplace before and Micron has some experience with, this is a very different architecture in terms of where it sits in memory hierarchy because of the dramatic improvements in speed and volatility and performance."

This appears to support the idea that 3D XPoint is not PCM but improves upon it.

Phase-change memory has a long and difficult history and perhaps Intel and Micron choose to define 3D XPoint to be something different to PCM?

Micron had previously tried to sell 90nm and 45nm phase-change memories before removing them from its website and said in January 2014 that it was reviewing whether it would continue with phase-change memory technology.

On its website in recent days those PCM datasheets are present again and Micron states: "Micron continues innovating with PCM. After two generations of PCM process technologies, we are developing a follow-on process to achieve lower cost per bit, lower power, and higher performance. PCM is one of several emerging memory technologies that Micron is investing in."

A 2Xnm or 1Xnm phase-change memory process allowing construction of the two-layer 128Gbit 3D XPoint memory is consistent with that statement. But, as Micron says, there are other emerging memory technologies. There could also be technology hybrids. What properties would a memory cell have if made of multiple interleaved chalcogenide and metal-oxide layers?

# Unlocking The Insights That Inspire Your Next "Eureka!" Moment—Sooner

Benoit Neel
Vice President and General Manager
Keysight Technologies, Inc.

For more than 75 years we have been helping you unlock measurement insights, first as the electronic-measurement businesses of Hewlett-Packard and Agilent Technologies, and now, as Keysight Technologies.

From Day 1, there have been two sides to the story. One is the work we do, creating leading-edge instrumentation and software. The other is the work you do: designing, developing, debugging, troubleshooting, manufacturing, testing, installing and maintaining components, devices and systems.

Those seemingly unrelated activities are actually connected by something profound: the "Eureka!" that comes with a moment of insight. When those happen for us, the results are innovations that help you reach new breakthroughs.

## Enabling the right idea at the right time

This is our legacy. Keysight is a company built on a history of firsts, dating back to the days when Bill Hewlett and Dave Packard worked in the garage at 367 Addison Avenue in Palo Alto, California. Our firsts began with U.S. patent number 2,268,872 for a "variable-frequency oscillation generator." Appropriately, the heart of Bill's design was a light bulb, which is often used to symbolize a new idea.

Our future depends on your success, and our vision is simple: by helping engineers find the right idea at the right time, we enable them to bring next-generation technologies to their customers—faster.

Keysight's leading-edge measurement tools and sophisticated, future-friendly software cover all phases of the 5G development cycle.

## Offering expertise you can leverage

This is happening in aerospace and defense applications where increasingly realistic signal simulations are accelerating the development of advanced systems that protect those who go in harm's way. It's happening in research labs where our tools help turn scientific discovery into the discovery of new sciences.

It's taking place with 400G Ethernet and the enabling PAM-4 technology, where our end-to-end solution ranges from simulation of new designs to characterization of hardware inputs, outputs and connectors. And in wireless communications we're providing leading-edge measurement tools and sophisticated, future-friendly software that cover all phases of the 5G development cycle.

Within these application areas, there are often more standards than a single engineer can keep up with. That's why so many of our people are involved in standards bodies around the world. We're helping shape those standards while creating the tools needed to meet the toughest performance goals.

Through our global presence, we also have measurement experts near you: our application engineers have the skills and experience to help you unite the hardware and software solutions that meet your unique requirements.

## Helping inspire your next breakthrough

To help Keysight customers continue to open new doors, we're concentrating our effort and experience on what comes next in test and measurement. Our unique combination of hardware, software and people will help enable your next "Eureka!" moment, whether you're working on mobile devices, cloud computing, semiconductors, renewable energy, or the latest glimmer in your imagination. Keysight is here to help you see what others can't, and then make it reality—sooner.

www.keysight.com

KEYSIGHT TECHNOLOGIES

# Ex-Google engineers promise ultra-low cost Android PC

By Julien Happich


Run all your favourite Android apps like on a smartphone, yet benefit from all the productivity tools commonly found on today's PCs by plugging a palm-sized $49 box to your favourite display, mouse and keyboard: that's the pledge of three ex-Google engineers on their Remix Mini kickstarter campaign.

The trio founded the Jide Techno-logy Co., Ltd software and hardware startup last year in Beijing, China, with roots back to the Silicon Valley where the three founders, Jeremy Chau, David Ko and Ben Luk have lead or worked on key Google projects such as AdWords, Google Maps, or Google Search.

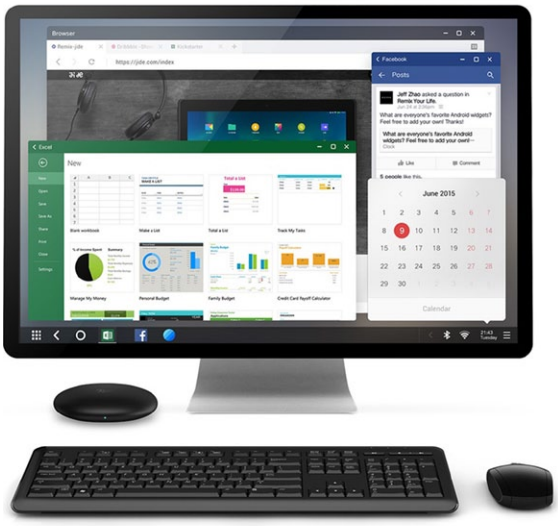
Within a few weeks of campaign, the new company had raised well over a million dollars in excess of it humble USD 50,000 goal from 18,763 backers for their Remix Mini.

Built around a 1.2GHz quad-core Cortex-A53 processor, the ellipse-shaped 124mm long and 88mm wide Android PC, only 26mm thick, runs on Remix OS, a custom engineered version of Android Lollipop developed by Jide Technology.

The small box packs Ethernet, WiFi, Bluetooth, and USB connectivity options and will run under 10 watts, drawing an order of magnitude less power than what most desktop computers would consume today by leveraging existing power efficiencies found in mobile CPU architectures.

Two versions will be offered, one with 1 Gbyte of RAM and 8 Gbyte storage, which could be used as a home media center, to stream and download movies; and a beefed up 2 Gbyte RAM with 16GB storage version to be used as a productivity tool.

Thanks to the Remix OS, users have access to the entire Android app ecosystem (over 1.5 million apps) while taking full advantage of intuitive PC features such as a start menu, a taskbar, multiple window multi-tasking, mouse and keyboard support.




So, Jide Technology claims to offer a PC-like experience at a very low cost and open to all Android apps, but couldn't this have been done more cheaply by simply using an HDMI interface and some sort of hypervisor app on a smartphone to bring on-board that PC-feel? We asked the company.

"The purpose of Remix OS and Remix-based products is to do more than bring a PC-feel to smartphones. The idea is that there are certain functionalities and features that are better fit for larger screen devices. As such, Remix OS incorporates such features into a mobile operating system" wrote us Jeff Zhao, international marketing manager at Jide Technology Co., Ltd.

"We don't see Remix Mini as a replacement for one's smartphone. However, if you have an old desktop PC or tower PC at home, Remix Mini is a great replacement for that PC. Remix Mini was created on three founding principles: affordability, functionality, and adoptability.

Affordability is self-explanatory. Functionality-wise, we want to give our users a chance to experience the Android app ecosystem in a PC form factor alongside key productivity features such as a start menu, taskbar, multi-window support, full keyboard/mouse support, etc.

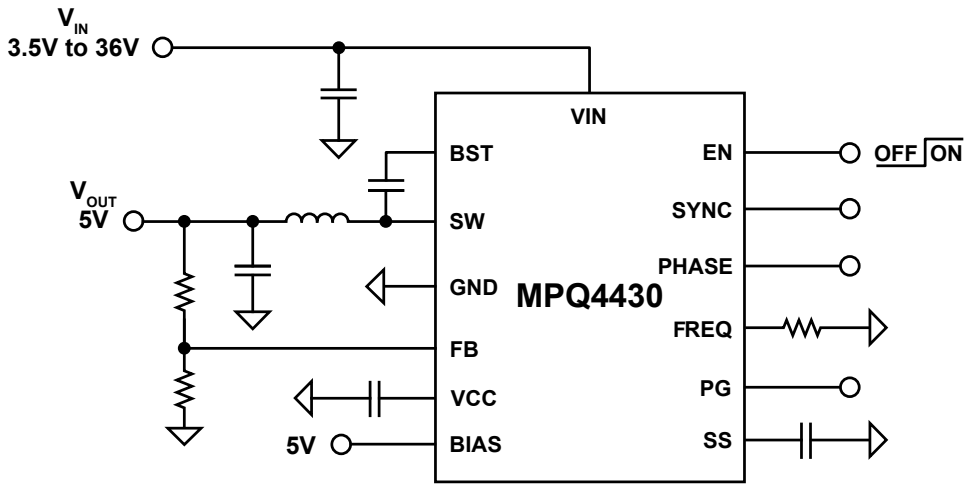
Lastly, adoptability is also a key point in that a majority of the world uses Android smartphones and devices. For many people have experienced an Android but not a PC computer, the transition from those devices to Remix

For ease of use, a capacitive touch power button on top of the Remix Mini will boot everything in working condition within seconds, like on a tablet but extended with your traditional PC peripherals (any large screen you please among other things).

Simple, Easy Solutions

# Low Iq? *Longer Life!*

## "MPQ4430" – Perfect Solution for Automotive E-Call Systems!




## 36V, 3.5A, Low Iq, Synchronous Step-Down Converter

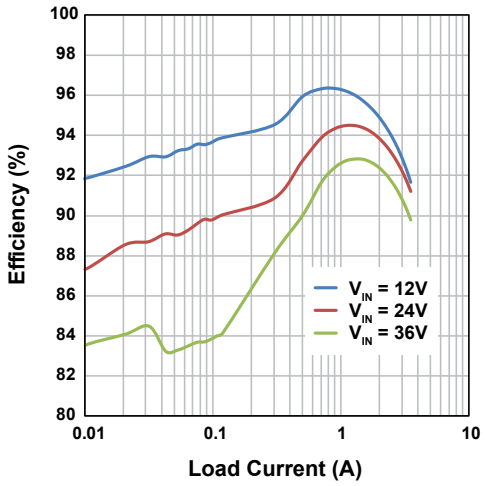
### Key Features

- Very High Efficiency at Low Current – 3.5A Peak Current to Support Strong TX Burst
- 350kHz to 2.5MHz Programmable Switching Frequency
- 10µA No Load Operating Input Current
- Low Dropout Mode to Support Start-Pulse
- Low EMI
- AECQ-100 Grade-1

### Applications

- Automotive Systems
- Industrial Power Systems

**Efficiency vs. Load Current**




**Please email "mpq4430info@monolithicpower.com" for more information.**

www.monolithicpower.com



Follow us on:

Mini will be significantly easier than with a Windows PC or Mac", Zhao continued.

"We've unlocked all of the keyboard and mouse shortcuts and functionalities that you're used to on a traditional PC.

The beauty is in the simplicity of Android combined with the multitude of familiar PC functions that allow you to create content in addition to consuming it".

Would the Android-based Remix OS be open source? Nope is the answer, nor will the hardware be open source, the company will keep the design proprietary for now. But beyond a certain level of success, Zhao admits the company could well consider licensing a hardware platform to OEMs and create revenue from dedicated software applications.

But for the Remix Mini to gain traction, would the company release an SDK?

"Internally, we are considering doing that, but our focus is on developing our software in house first. As soon as we have more users, we will begin opening up SDKs to build a large tablet app ecosystem" told us Zhao, adding "we are currently focused on R&D for our 2nd generation tablet and optimizing the hardware for Remix Mini".

Because prior to launching the Remix Mini, Jide Technology had already launched with success another hardware form factor to make the most of its Remix OS, the Remix 11.6" ultra-tablet.

So what more could Remix Mini offer compared to the Remix ultra-tablet, and what were the lessons learned?

"Making hardware is really hard and we tip our hats off to all the hardware engineers of the world. We felt that in order to further our belief in Android as a productivity device, we wanted to explore additional form factors by which Remix OS can really show off its concept" concluded Zhao.

# Sensors, liquid crystals make "omnifocal" glasses

By Peter Clarke

Perfect vision – all the time – is the claim from startup Deep Optics Ltd. (Petah Tiqva) for its eyeglasses that include sensors and liquid crystal materials to adjust to the wearer's near- and long-distance viewing.

Two optical sensors in the frames continually analyze the eyes' pupillary distance, which changes when the wearer is focusing on objects at different distances.

This information is then sent to an on-board processor that calculates the distance the wearer is trying to focus on and determines the optical compensation needed to produce sharp vision at that distance.

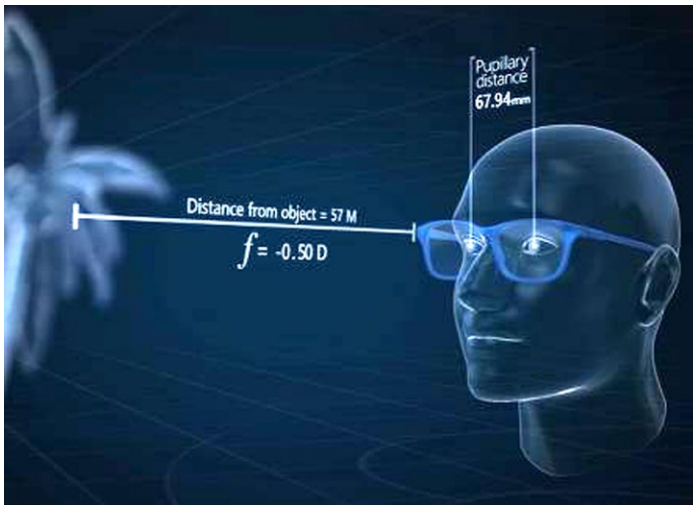
The processor then instructs the lenses, which are a sandwich construction including liquid crystal material in the middle layer, to produce the appropriate degree of refraction. This is done by altering the voltage applied across the liquid crystal and thereby changing its refractive index.

The result, claims Deep Optics in their Youtube video, is perfect eyesight. The video is a cartoon only suggesting that the real-world mock up may not be quite there yet. Deep Optics Ltd. was founded in 2011 by Yoav Yadin who serves the company as CTO, and Yariv Haddad, who serves as CEO.

The Omnifocal eyeglasses could be at least two years from coming to market since Deep Optics Ltd. (Petah Tiqva), the startup behind the development is currently raising a first round of funding to enable it to produce a first physical prototype.

"The glasses will need personal fitting. Like current multifocal glasses, a customer would need a prescription for far vision correction and for the 'addition' part for maximal close-distance correction. The glasses would then be customized to this prescription," said Yariv Hadded, CEO of Deep Optics, in an email correspondence with EE Times Europe. "It would be possible to update the prescription from time to time. I still can't say who and how the prescription updates would be carried out – there are several options," he added.


Concept of Deep Optics' Omnifocal eyeglasses.




Pupillary distance measured by sensor is a means of determining where a person is focusing.
Source: Deep Optics Ltd.

Built-in wirelessly rechargeable batteries that would power the glasses with a battery life of at least a few days is the development target. "We're designing the glasses to consume very little power, and the look will not be bulky, as we're talking about vision correction glasses, which must be light and fashionable."

The eye tracker system uses infrared LEDs to illuminate the eyes so that the sensors can read the distance between the inside edges of the left and right eye pupils. This inter-pupillary distance is used to determine at what distance the viewer is trying to focus and to drive the liquid crystal to alter its refractive index and achieve focus at that distance.

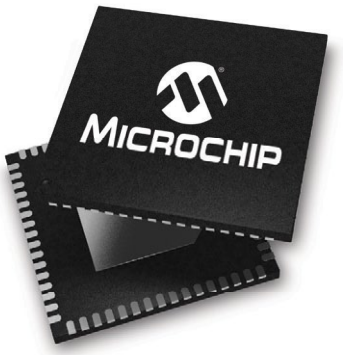
"We received an investment from a local 'angel' when the company was established. We're now completing a seed A round to complete a working model. When this is up and running, we'll raise another round to complete the product," Hadded said.

# Intelligent Design

## Starts with Intelligent Analog PIC® MCUs

INTELLIGENT
ANALOG

Analog design is difficult and consumes precious development time. Microchip's intelligent PIC® MCUs integrate analog functions such as high performance Analog-to-Digital Converters, Digital-to-Analog Converters and op amps providing simple-to-use interfaces that ease analog design. A single-chip solution enables reduced system noise and provides higher throughput, while dramatically reducing design time and cost.




### Applications

- Environmental quality sensors
- Portable medical equipment
- Industrial equipment
- Power conversion
- Efficient motor control
- Lighting
- Power measurement and monitoring
- Energy harvesting equipment
- Solar inverters

ARROW

MICROCHIP

**www.microchip.com/get/euintelligentanalog**

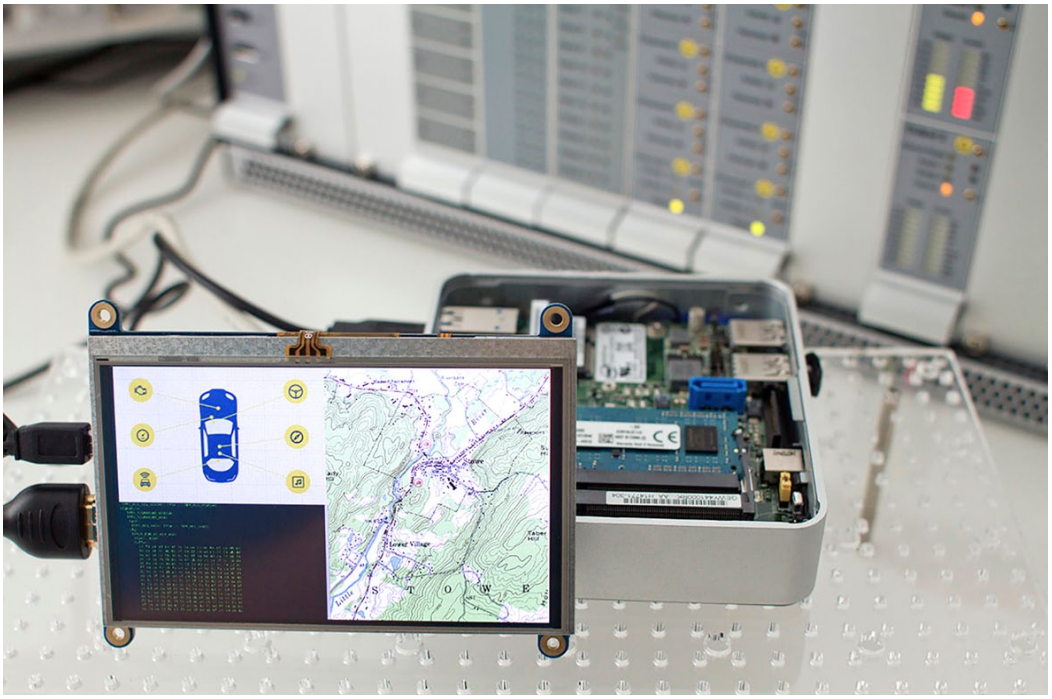
# Fraunhofer rolls security platform for cars

By Christoph Hammerschmidt

Electronic control units in cars, in particular head units, have recently been the target of cyber-attacks. Researchers from Fraunhofer Institute for Secure Information Technology have devised a platform enabling the development of secure head units based on open hardware and software standards.

Electronic control units in today's vehicles are connected to engine control, steering, even the behaviour of the brakes. In an average vehicle several dozens of these small computers are performing their tasks; some top car models have more than 100 such units. Information technology nowadays is one of the strongest drivers of innovation in the car, says Christoph Krauß, researcher at the Fraunhofer Institute for Secure Information Technology (Fraunhofer SIT) in Darmstadt, Germany.

The institute is focusing on the safety and security of embedded IT systems in vehicles. "Nowadays, the car which used to be a closed system, is the target of attacks through the multiple IT interfaces that are increasingly implemented", Krauß says. The list of current examples of attacks is quite long. Hackers spied out private user data, used car dealers manipulate the odometer readings, car thieves outwit the immobiliser and open car doors and even rogue car owners activate functions they have not paid for. Very recently, a hacker duo took control of vital vehicle functions like brakes and steering; another one hacked into GM's OnStar communications system. Along with the progress of hackers' ability to bring cars under their control grows the necessity to increase the security level for the in-car IT.



Of course, cryptographic solutions are available, says Krauß. However, very often they are not flexible enough. Along with his team, Krauß has built a solution that makes use of hardware security modules (HSMs) to ensure security at device level. In doing so, they utilised the Trusted Platform Module, a widely recognised open standard, in its latest version TPM 2.0. It has been developed by the Trusted Computing Group, an organisation bundling the standardising efforts of almost all important IT players. Our solution is a software platform that helps developers to create secure control units based on TPM 2.0, explains project manager Andreas Fuchs.

With this platform all the necessary building blocks of automotive control units, hardware as well as software, can be simulated and subsequently implemented. Thus, car manufacturers and tier ones obtain important information already during the development that helps them try out different application scenarios. To look into real HSMs once they are developed is not possible for security reasons, Fuchs said.

The TPM-based solutions devised with the Fraunhofer platform can be integrated directly into the ECUs or connected upstream of them, depending on what needs to be protected. The hardware of the solution takes the function of a trust anchor in that it is a secure storage for the cryptographic keys and at the same time an application environment for all security relevant operations. It detects attacks and releases the keys only if the device is in a trusted state. If, for example, the parking assistant has been manipulated, the engine control unit inhibits starting the motor to prevent undesired access to steering through this parking assistant, explains Krauss.

The software in this system is required to communicate with the hardware and embed the security functions provided along with the platform into the main tasks of the ECU. Based on this framework, the researchers developed an HSM demonstrator for a head unit, the building block in automotive electronics that runs the infotainment system. It protects the car-related data as well as the owner's private data against unauthorized reading.

Today, TPM modules are installed in almost any desktop or laptop computer, says Fuchs. For instance, they secure the BitLocker disk encryption from Microsoft that is integrated into Windows. Our development environment is a contribution to establish the TPM standard in cars. This makes it easier for car manufacturers to implement these standards as well as applications based on them.

The platform is not only relevant for car designers but likewise for other application areas such as industrial controls or the Internet of Things. The Fraunhofer institute is about to license the technology to two industry sectors, while automotive deployment is already close to series production.

# Dreamteam for success.

**Signal generation and analysis for demanding requirements**
When working at the cutting edge of technology, you shouldn't waste your time with inferior tools. Rely on measuring instruments evolved in the spirit of innovation and based on industry-leading expertise. Instruments like the R&S®SMW200A vector signal generator and the R&S®FSW signal and spectrum analyzer. Each is at the crest of today's possibilities. As a team, they open up new horizons.

See for yourself at www.rohde-schwarz.com/ad/highend


ROHDE&SCHWARZ

# CEO interview: Ambiq sees broader options for low voltage

By Peter Clarke

Mike Noonen, recently appointed interim CEO at microcontroller startup Ambiq Micro, discusses the focus and opportunities for this pioneering company designing circuits that can operate below the threshold voltage of the constituent transistors.

In January 2015 Ambiq Micro Inc. (Austin, Texas) introduced the Apollo family of Cortex-M4F-based microcontrollers. These MCUs can operate at voltages below 0.5V and the company claims that this can provide a 10-fold improvement in MCU power consumption compared with competitors' MCUs. This is mainly based on the fact that power consumption scales with the square of voltage, although the achievable clock frequency for digital circuits also reduces with the voltage.

Mike Noonen, interim CEO at Ambiq Micro Inc.

However, Ambiq's sub-threshold technology is not limited to MCUs. MCUs are almost always mixed-signal circuits and Ambiq already sells a range of real-time clock (RTC) circuits based on its technology. Noonen's ambitions for the company are broad.

Noonen is a widely experienced semiconductor executive and also serves on the board of directors of Kilopass Technology Inc. (San Jose, Calif.) a pioneer of NVM antifuse technology, is chairman and co-founder of Silicon Catalyst, a semiconductor-oriented startup incubator based in Silicon Valley and also sits on the boards of directors of Adapteva and a stealthy startup called Quora Semiconductor.

*EE Times Europe* started by asking if the move by leading foundry Taiwan Semiconductor Manufacturing Co. Ltd. (TSMC) to introduce ultra-low power versions of its manufacturing processes at 55, 40, 28 and 16nm nodes was a welcome development and something that Ambiq could use.

TSMC is offering ULP processes that operate below 1V at 55, 40 and 28nm while the 16FFC FinFET process at voltages down to 0.55V. These processes have all been described as offering near-threshold voltage operation. As a fabless pioneer of sub-threshold circuit operation spun out of the University of Michigan in 2010, Ambiq has had to perform its own process characterization for its low voltage use of foundry processes.

"What TSMC has done is moving things in the right direction although, near-threshold is quite a way above the [voltage] world where Ambiq lives. But it is a good thing for Ambiq. The platforms make our lower voltage development work easier," said Noonen.

Emphasizing the advantage that Ambiq's SPOT (Sub-threshold Power Optimized Technology) brings Noonen added that the Apollo series is currently based on a 90nm CMOS process from TSMC. "What we have at 90nm is better than what other companies have at 55nm," he states.

## FDSOI?

Noonen said he is not ready to disclose the next manufacturing node Ambiq will use but said that the Ambiq technology is applicable to multiple process technologies including fully-depleted silicon-on-insulator (FDSOI) processes. Back in 2013, when Noonen was executive vice president of marketing and sales at Globalfoundries Inc. he was an advocate of that company's adoption of FDSOI.

For now FDSOI processes are only being offered at 28nm by STMicroelectronics and Samsung and at 22nm by Globalfoundries and without a declared non-volatile memory option. This is not beyond Ambiq's requirements if it starts targeting SoCs.

And despite the technical claims for SPOT and the Apollo microcontroller range, MCU buying decisions are often based on the maturity of development environments and relationships with major vendors. Some of the leaders in microcontroller sales include: NXP, Freescale, Texas Instruments, STMicroelectronics, Microchip and Atmel. Has this been a problem for Ambiq?

Noonen responded: "Our first major customer will launch in the fourth quarter. As to competition, what you say may be true in the traditional embedded space where there can be long development cycles. So the best way forward is to target a market that doesn't have so many legacy issues. Wearables is that market for us because it's a new market and hypersensitive to battery life."

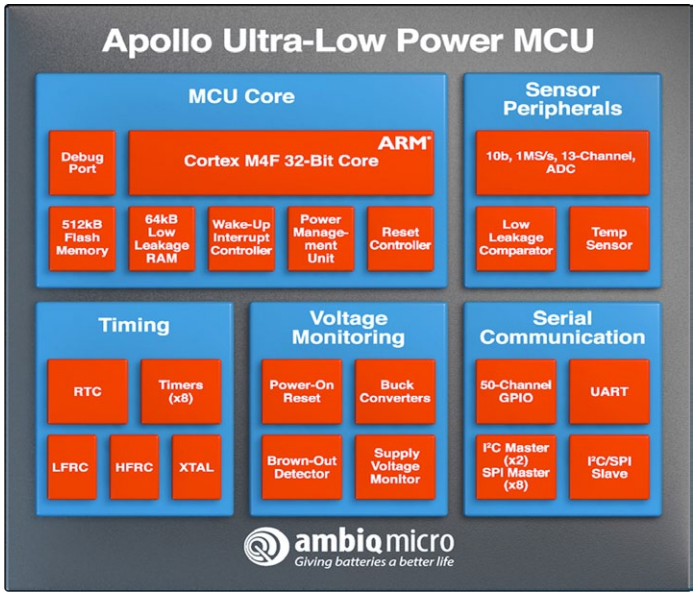
## Not limited to the MCU

With regard to the third-party ecosystem to support the ARM-based Apollo microcontrollers Noonen said that the ARM Keil tool chain and IAR Systems provide support as well as internal GCC compiler and debuggers.

In many wearable systems the MCU is only part of the solution, being deployed alongside sensors, sensor hubs, power management ICs and wireless transceivers. As such saving power in the MCU is only a portion of the overall requirement and some equipment is based on highly integrated system-on-chip (SoC) designs. Does Ambiq intend to move into any of these other areas?

"Our capability for power saving is not limited to the MCU," said Noonen. At present one of the things that Ambiq provides to developers is head-room to run more sophisticated sensor algorithms which produce superior results to the competition at reduced power consumption he added. "We can provide help to sensor and connectivity partners and we do have a holistic energy focus," said Noonen referencing work being undertaken with Dialog Semiconductor on reference boards.

It may sound like Noonen is trying not to appear threatening to current semiconductor partners but nonetheless, the op-




portunity remains for Ambiq to start adding wireless and other circuits to its product offerings using SPOT. ARM is now offering a Bluetooth connectivity package of IP under the name Cordio. Noonen declined to say whether Ambiq has licensed the Cordio technology from ARM.

Another area of relevance to all low power systems is embedded non-volatile memory, often seen as a key to fast shut-down and wake up operations to allow power saving. However, while embedded flash memory has been deployed at CMOS logic nodes, due to problems with scaling, rival technologies may displace it for embedded memory at 28nm and below.

Is this something that Ambiq ponders or do they just work with whatever embedded memory a chosen foundry can provide?

"There is a renewed opportunity in memory in general. And for the Internet of Things having non-volatile memory is vital. There's flash, one-time-programmable antifuse and many other choices," said Noonen reminding us that he is also on the board of Kilopass Technology Inc. (San Jose, Calif.) a licensor of NVM antifuse technology. "Having a broader understanding of memory certainly helps," adds Noonen.

## Ambiq and PsiKick

We also asked Noonen about the chances of Ambiq working with, or acquiring another company that has specialized in sub-threshold voltage operation, PsiKick Inc. (Charlottesville, Virginia).

That company launched a couple of years after Ambiq and has focused on developing wireless sensor network SoCs. With operations down to 0.25V it claims it can provide a 100 to 1,000-fold improvement in power consumption in a single chip compared with multi-component solutions.

Noonen points out affinities between Ambiq and PsiKick without indicating any closer ties. "PsiKick came out of the University of Michigan, like Ambiq did. We think the fundamental philosophy of sub-threshold can be applied in multiple directions. Previously this sort of technology was only used for hearing aids and Swatch watches. There's plenty of room for multiple companies to work in energy optimization."

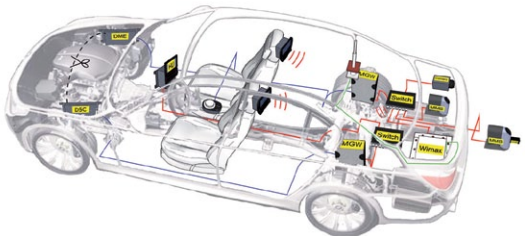
In December 2014, Ambiq raised a $15 million round of venture capital led by Kleiner Perkins Caufield & Byers and has no immediate need of additional capital, Noonen said. "Now the job is to get lots of design wins." Ambiq has already sold out a first issue of evaluation kits having shipped several hundred but expects to have them available again within a matter of days.

# Automotive electronics complexity at tipping point, study warns

By Christoph Hammerschmidt

Features and functions are added at rapid pace to new cars. Typically, the E/E engineers add a dedicated electronic control unit (ECU) for every new function. This approach is hitting its limits, because it increases the complexity. Consultancy Roland Berger sounds the alarm.

Adding a new ECU for new features is no longer sustainable, the study says. Dedicated processors, memories and other electronic components for new features increases cost and architecture complexity, says Thomas Wendt, Senior Partner in Roland Berger's North American Automotive Practice. The solution he suggests is module consolidation. This approach would leverage modern technologies to add speed and flexibility to vehicle electronic architectures, while saving cost. The consultancy estimates at average $175 per vehicle for cockpit electronics.



"All major automotive trends today, from improved cockpit electronics to new ADAS features, are largely enabled by advanced electronics systems," says Wendt. "OEMs will not be able to keep up with consumer's expectations, both in terms of quality and price, if they continue to add ECUs every time they want to add a new feature. A 'blank sheet' approach to electronic architecture design is needed."

Module consolidation is a technical solution leveraging modern, multicore processing technologies to operate multiple ECUs which all traditionally had their own processors. In a multicore solution, these ECUs retain dedicated processing space, usually in the form of their own core in the processor. However, a number of redundant components are eliminated, including housings, power supplies, wire mounts and harnesses, as well as the processors themselves, all saving cost. Additionally, ECUs communicate within the processor itself instead of communicating over a network such as the CAN bus; increasing speed and reducing complexity. The study quantifies the cost advantages of module consolidation from the perspective of an OEM. Taking a sample set of cockpit electronics, Roland Berger conducted a total cost of ownership (TCO) analysis, comparing the cost of independent ECUs to the cost of a consolidation solution running on a multicore processor with the same feature and function set. The result was a TCO advantage of $175 per vehicle, including direct piece price savings which are just the "tip of the iceberg." The savings identified also include indirect, yet quantifiable, advantages of consolidation such as weight savings.

Despite the clear advantages of module consolidation, OEMs have been slow to adopt the solution. This is largely due to safety and security concerns related to running multiple control functions on the same processor. While there is some merit to this concern, advanced suppliers have already developed a solution to this issue, known as "hardware virtualization."

Due to a clear need and availability of a solution it is now time for the automotive community to re-think legacy E/E architectures and adopt consolidated module solutions. The first movers have an opportunity to capture a tremendous amount of value, both through savings and the ability to offer a superior product to end consumers. These findings are in line with a discussion started some time ago in the European automotive industry. In particular carmaker BMW is advocating a strategy of consolidation and has presented its concept in numerous engineering meetings and congresses. BMW favours a concept of "Domain Controllers" which assume multiple tasks associated to the respective domain, i.e. chassis, body, powertrain or infotainment.

In the meantime, the idea of virtualization has also reached the automotive industry. The Genivi infotainment operating system will soon enable virtual machines in cars; and automotive supplier Continental has officially introduced a product concept based on virtualization.

# 'Test city' opens for autonomous cars

By Rich Pell

The University of Michigan (Ann Arbor, MI) has officially opened a simulated city that will be used for developing and testing driverless and connected vehicles.


Located on the university's campus, the $10 million, 32-acre outdoor environment - called Mcity - features life-sized building facades, various surfaced roads, intersections, signs, and even simulated pedestrians. The environment is designed to allow automakers and others in the industry a controlled environment in which to test connected and automated vehicle technologies.

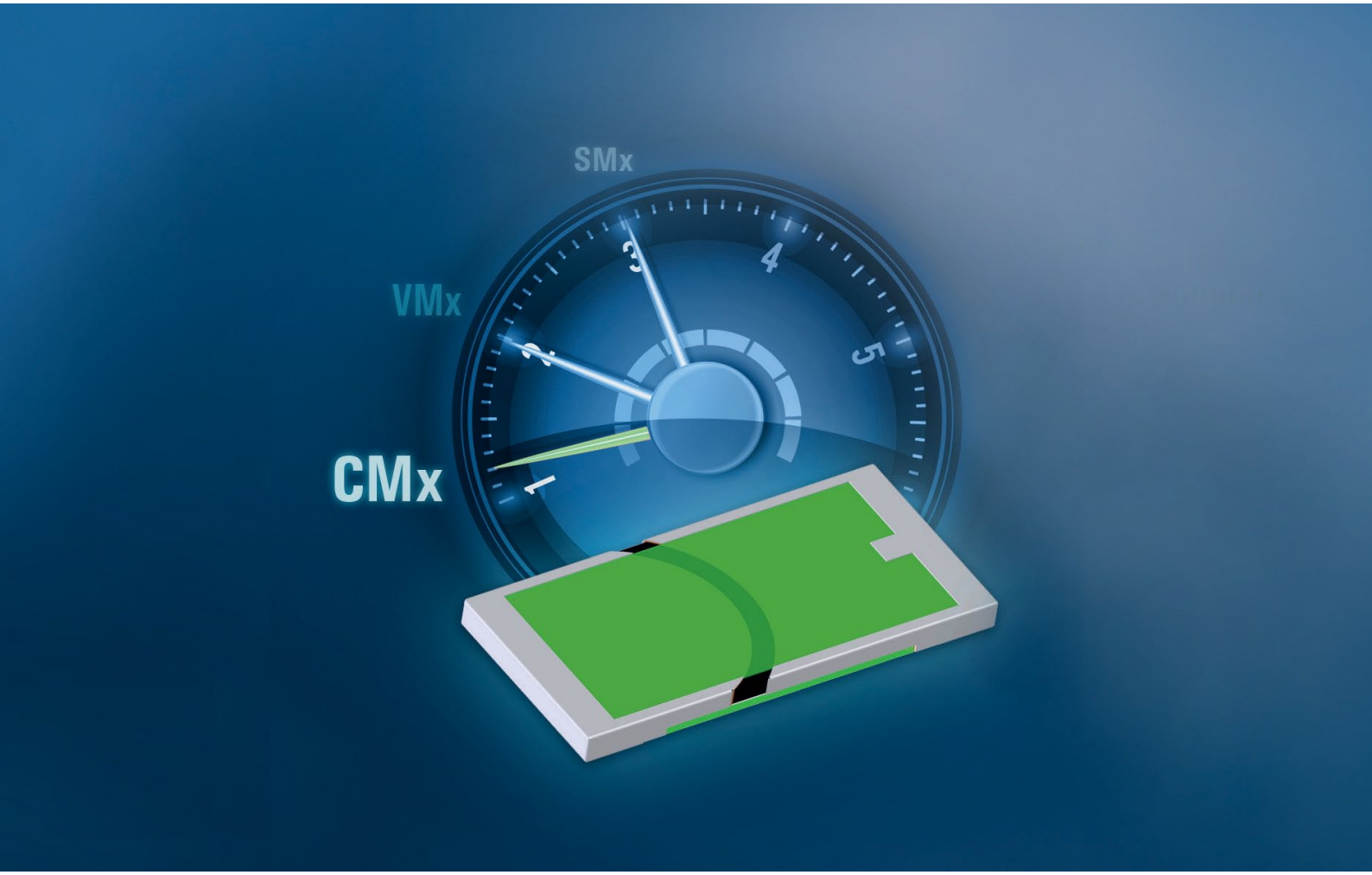
In an attempt to reflect real-world conditions as much as possible, Mcity even includes details such as faded lane markings and partially obscured signs. In addition to testing the physical navigational capabilities of connected vehicles, the environment includes capabilities for testing car-to-car and car-to-infrastructure communications.

First announced in May of last year, Mcity was designed and developed by the University of Michigan's Mobility Transformation Center in partnership with the Michigan Department of Transportation. General Motors, Ford, Bosch, Honda, Nissan and Toyota are among companies that also helped back the project.

"There are many challenges ahead as automated vehicles are increasingly deployed on real roadways," says Peter Sweatman, director of the U-M Mobility Transformation Center.

"Mcity is a safe, controlled, and realistic environment where we are going to figure out how the incredible potential of connected and automated vehicles can be realized quickly, efficiently and safely."

# NOW ALSO LEADING THE LOW RANGE!




LOW OHMIC PRECISION AND POWER RESISTORS

## LOWER REQUIREMENTS, SAME QUALITY, SAME ADVANTAGE.

Our new CMx series is specially designed for lower performance requirements, meaning that we now lead the competitive environment in both high and low performance ranges for the first time.

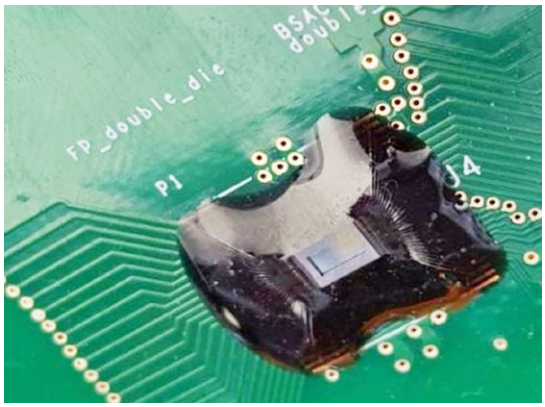
It features, for example, an outstanding power value of 2 watts at a contact point temperature of 100°C.

ISABELLENHÜTTE
Innovation by Tradition

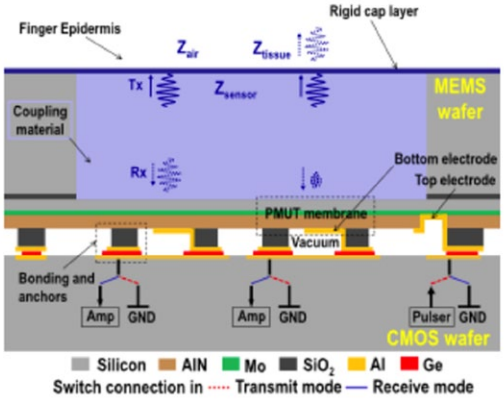
Isabellenhütte Heusler GmbH & Co. KG
Eibacher Weg 3 – 5 · 35683 Dillenburg · Phone +49 (0) 2771 934-0 · Fax +49 (0) 2771 23030
sales.components@isabellenhuette.de · www.isabellenhuette.de

# 3D fingerprint scanner beats Apple's

By R. Colin Johnson




An ultrasonic fingerprint sensor on a board here measures a three-dimensional (3D) volumetric image of the finger's surface and the tissues beneath--making it near impossible to defeat. (Source: University of California).




The various layers, vias and other structures that make the 3D microelectromechanical system (MEMS) fingerprint detector to its underlying CMOS ASIC. (Source: University of California).

Password security is already becoming a thing of the past with biometrics taking their place. For instance, fingerprint identification is being built-in to every new Apple mobile device, thus forcing the rest of the herd to follow.

Even retinal scanners are becoming common in corporate settings, when in the past their expense was only justified by high-security areas like the White House, the Central Intelligence Agency (CIA) and the National Security Agency (NSA).

Now, however, academic researchers sick-and-tired of memorizing long passwords and bolstered by the fact that even Captcha is no longer secure, have invented a 3-D fingerprint scanner that is not only immune to false-negatives due to oil or moisture on the skin, but even looks beneath the surface of the skin, to create an ultra-secure identification system that could make passwords a thing of the past.

"In terms of robustness, the ultrasound sensor is less prone to errors due to dry/wet/oily fingers since it can image the dermis (beneath the surface) rather than just the epidermis," Professor David Horsley (University of California Davis) told EE Times. He is also co-director of the Berkeley Sensor and Actuator Center, along with co-director professor Bernhard Boser at the University of California at Berkeley. "Secondly, conducting fingerprint recognition from 3D features makes these images harder to spoof, since you need to create a 3D model of the finger to reproduce them."

Today a determined hacker can lift your fingerprints from any glass you touch, using the same methods that the police do to identify criminals, making it relatively easy to reproduce that image of a 2D fingerprint and spoof a device protected that way. Not so with a 3D fingerprint that looks beneath the skin with ultrasonic microelectromechanical system (MEMS) sensor.

"With a 3D fingerprint, the subsurface features are private," Horsley told us.

To prove the concept, Horsley's research team collaborated with Invensense Inc. (San Jose, California), using Invensense to fabricate the device using its Invensense shuttle service which gives MEMS developers access to its patented MEMS-on-CMOS Nasiri fabrication toolkit.

"Invensense provided the fabrication service. We used a modified version of their NF Shuttle which is a multi-project wafer (MPW) service," Horsley told us. "They also provided funding to our students through a collaboration membership at our research center, the Berkeley Sensor and Actuator Center (BSAC)."

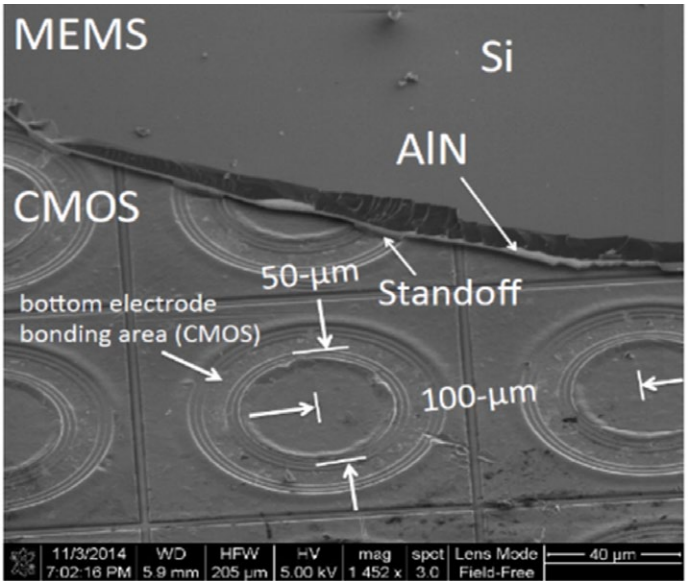
The project built on the Berkeley Sensor and Actuator Center's previous success with piezoelectric micromachined ultrasonic transducers (PMUTs) from which it spun out the commercial company Chirp Microsystems Inc. (Berkeley, California).

Using its MEMS-based PMUTs to analyze the returning ultrasonic echoes, the Berkeley Sensor and Actuator Center was able to fabricate the 3D fingerprint scanner prototypes on an Invensense wafer whose Nasiri process bonds the MEMS wafer to the ASIC wafer to seal the former from contamination.

Currently the project is still in the research stage, but a second prototype that improves the performance of the first generation device is taking the project closer to commercialization.

"We're testing a 2nd generation chip that is closer to the commercial requirements. I expect we'll have a new announcement this fall," Horsley told us.

Horsley also thinks the technology has medical applications in imaging for personal health monitoring. And since the PMUTs are so well matched, they could also be used in arrays.




A scanning electron microscope (SEM) image show the integration of the MEMS layers with the underlying CMOS electronics. (Source: University of California).

# CoolCube circuit stacking moves to FinFET process

By Peter Clarke

The CEA-Leti research laboratory at Grenoble France, has reported that its CoolCube 3D interconnect technology is suitable for use with FinFET manufacturing processes as well as with fully-depleted silicon-on-insulator manufacturing processes.

The research institute has demonstrated the feasibility of CoolCube used to stack FinFET layers on its 300mm production line. This is particularly relevant to Qualcomm which has previously announced that it would be using a monolithic 3D (M3D) approach to stacking circuits instead of through-silicon vias (TSVs).

CEA-Leti's previous work on CoolCube had been based only on FDSOI. CoolCube is Leti's sequential integration technology that stacks of active layers of transistors. It is enabled by halving the thermal budget for manufacturing transistors in second and higher layers while minimizing a sacrifice in performance. It also allows about 10,000 times higher density of interconnect than is possible with TSVs.

For CoolCube the next layer is produced on a second wafer and then transferred as a thin silicon wafer film peeled off from a wafer blank after planarization. Because the transferred film is so thin and optically transparent, well under a micron (compared to around 50 microns thin for thinned wafers), the new layer of transistors that are processed on top can be aligned to the bottom transistors with lithographic precision.

The process is good for stacked ICs as well as for the combination of heterogeneous process layers and the co-integration of sensors, MEMS with CMOS.

"In heterogeneous integration, we expect CoolCube to be an actual enabler of smart-sensor arrays by allowing a close integration of sensors, detection electronics and digital signal processing," said Maud Vinet, Letis advanced CMOS laboratory manager. "In the digital area, we expect this 3D technique to allow a gain of 50 percent in area and 30 percent in speed compared to the same technology generation in classic 2D gains comparable to those expected in the next generation," she also said.

The researchers already reckon that the co-integration of two layers of 14nm technology could create a denser FPGA than a 2D design in 10nm process technology. However that would require a fine-grained redistribution of the design so that memory would be substantially contained in one layer and logic substantially in another.

That requires supporting EDA software tools. "We are working with Mentor Graphics and a couple of other EDA firms on that," said Vinet.

The next steps will include: 1) Getting EDA firms to deliver tools to support 3D design with CoolCube; 2) Scaling up production from small test circuits to commercial scale circuits; and 3) Working on customer design, said Vinet. "The target is to intersect the 10nm process node late in 2017, early in 2018" she added.

# 3D printing for photonics: a British initiative

By Julien Happich

Researchers at the University of Southampton are set to investigate the use of 3D printing, or additive manufacturing techniques for the fabrication of optical fibres, or at least the complex preforms that they are drawn from.

Current techniques used to produce optical fibre preforms, the piece of glass from which an optical fibre is drawn, give a consistent structure along the length of the preform but make it difficult to control the shape and composition of the fibre in 3D.

This is the limitation that Professor Jayanta Sahu, together with his colleagues from the University of Southampton's Zepler Institute and co-investigator Dr Shoufeng Yang from the Faculty of Engineering and Environment, hope to go past.

While today's micro-structured fibres are made by manually stacking several smaller glass capillaries or canes together to form the preform, the new techniques investigated would rely on the laser sintering of very fine glass powders, layer-by-layer.

While discussing this new initiative with EETimes Europe, Professor Sahu admitted he was starting pretty much from scratch.

"First, we'll have to figure out the finesse of the glass powders and the power level of the lasers used to melt or coalesce the particles during the sintering process in order to achieve optical-grade quality preforms" he said.

"Once we'll have determined the optimum particle size and sintering process, we'll want to tailor the dopant concentrations during sintering by mixing different doped glass powders to be dispensed by the 3D printer's nozzles".

But what Sahu finds the most exciting, is the level of precision that could be reached in the full 3D of a preform (instead of today's only radially assembled preforms with the same longitudinal structure).

**Silica fibre drawing tower in the Zepler Institute cleanroom complex.**

"First, you could build larger preforms, in excess of 100mm so all the features would scale down to a greater extent when the fibre would be drawn" Sahu explained, "but you could also envisage new built-in optical or photonic functions along the length of the preform"

In the long run, the idea would be to build a 3D-printable CAD library of dopant profiles and photonic blocks that designers could use to make special-purpose optical fibres or even photonic chips.

The researcher is well aware that numerous challenges lay ahead, including the high melting temperature of the glass (over 2000°C in case of silica), the need for precise dopant control and refractive index profiles for accurate waveguide geometries.

# Is NextInput next winner in Apple products?

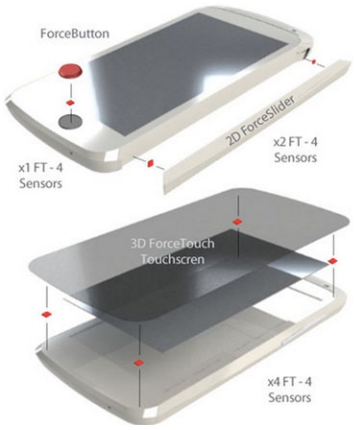
By Peter Clarke

NextInput Inc., a startup founded in 2012, could be the latest MEMS sensor company to be catapulted to fame and fortune by design wins with that doyen of consumer electronics, Apple.

NextInput has started shipping its "ForceTouch" sensor and Apple's iPhone 6s or will it be iPhone 7 is expected to debut in September with a feature called Force Touch. Add to that the fact that the company has just imported a CEO from Apple supplier InvenSense and circumstantial evidence starts to favor NextInput.

InvenSense was one of the design slot winners in the Apple iPhone 6 last September.

Could this be a case of Apple asking the startup to install an experienced executive as CEO to make sure they can handle a sudden ramp to 10s of millions of units? According to the Wall Street Journal Apple is asking for its contract manufacturers and suppliers to make 85 million and 90 million units of two new iPhone models with 4.7-inch and 5.5-inch displays by Dec. 31, 2015. NextInput was founded as a spin-off from Georgia Institute of Technology to commercialize a pressure-sensitive sensor technology. The company says that multiple sensors can be placed under a display surface or track pad and offer a lower-cost solution that also consumes less power when compared with capacitive touch.




Mobile equipment makers always welcome lower power. Next Input's ForceTouch can also sense multipoint touch, the location and amount of force from each touch point down to sub-millimeter spatial resolution, and sub-millinewton force resolution.

NextInput said it has just begun sampling its FT4010F ForceTouch sensor with software and algorithms to enable 1D, 2D and 3D touch control. The good news is that NextInput can be looking at selling between four and six sensor per piece of equipment.

However, it may not be such a rapid ramp for NextInput as the company could already be shipping into the Apple Watch and certain versions of the MacBook, where the pressure sensitive technology allows software to differentiate between a light tap and a deep press and respond accordingly.

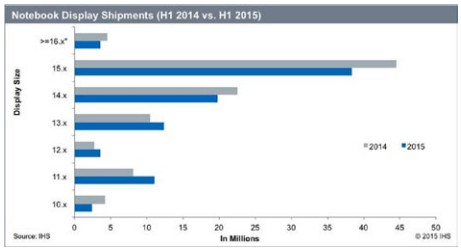
Interestingly InvenSense has exemplar art work for all three use cases: the laptop computer, the smartphone and the smartwatch.

Cambridge Touch Technologies Ltd. is a startup aiming at the same design slots but as that company was founded in 2014 it feels like it would be a little too young to have proven its technology to the satisfaction of a consumer giant such as Apple.

# Notebook displays shrink, Chromebook's 11-inch a winner, says IHS

By Julien Happich

Global consumers have lately become less interested in acquiring conventional notebooks with 15-inch displays, and they are instead shifting their spending to smaller product segments according to market research firm IHS.




In its Notebook and Tablet Display Supply Chain Tracker, the company reveals that in the first half of 2015, panel shipments in the 15-inch range (i.e., 15.0 inches to 15.9 inches) dropped 14 percent year over year, from 44.5 million to 38.4 million units. At the same time, driven by the popularity of Chromebook, notebook display shipments in the 11-inch range enjoyed over 35% growth from 8 million units to 11 million units.

"Thanks to affordable prices, and a completed ecosystem with a host of hardware and app choices and a user-friendly cloud environment, Chromebook has expanded its customer base from small and medium-sized businesses and the education market to general users," comments Jason Hsu, supply chain senior analyst for IHS Technology. "The Chromebook sales region has also expanded from the United States to emerging countries, where more local brands are launching Chromebook product offerings. There are also more products set to debut in the 12-inch range, thanks to the success of the Microsoft Surface Pro 3 and rumours of Apple's upcoming 12.9-inch tablets."

While total notebook panel shipments to Lenovo and Hewlett-Packard fell 27 percent month over month from 6.4 million units in May to 4.7 million units in June, overall set production increased by 13 percent from 5.4 million units to 6.1 million units. These two leading notebook PC brands have recently taken steps to regulate panel inventory, in order to guard against excess product pre-stocking.

"The currency depreciation in Euro zone and emerging counties earlier this year jeopardized consumer confidence and slowed the purchase of consumer electronics, including notebooks," Hsu said.

"Moreover, in April, Microsoft leaked the announcement of its new Windows 10 operating system. Despite Microsoft's claims that a free upgrade to the new operating system would be available to Windows 8 users, many consumers still deferred purchases, which increased the brands' set inventory. Notebook manufacturers could decide to lower set production in the third quarter, after the end market becomes sluggish in May and June." With notebook panel prices remaining very low, profitability has become an issue, and many panel makers are facing pressure to maintain fab loading and gain market share. "Panel cost structure has become crucial in the struggle to stay competitive," Hsu said. "Continuous panel over-supply not only hurts profitability, but could also confuse the real panel market demand in the fourth quarter of 2015 and the first quarter of 2016. It's time for panel makers to revise their production numbers, and curb capacity utilization, to keep pace with actual market demand."

# Critical Recording in Any Arena

## When You Can't Afford to Miss a Beat!


Introducing Pentek's expanded line of Talon® COTS, rugged, portable and lab-based recorders. Built to capture wideband SIGINT, radar and communication signals right out-of-the-box:

- Analog RF/IF, 10 GbE, LVDS, sFPDP solutions
- Real-time sustained recording to 4 GB/sec
- Recording and playback operation
- Analog signal bandwidths to 1.6 GHz
- Shock and vibration resistant Solid State Drives
- GPS time and position stamping
- Hot-swappable storage to Windows® NTFS RAIDs
- Remote operation & multi-system synchronization
- SystemFlow® API & GUI with Signal Analyzer
- Complete documentation & lifetime support

Pentek's rugged turn-key recorders are built and tested for fast, reliable and secure operation in your environment.

Call 201-818-5900 or go to www.pentek.com/go/eettalon for your FREE *High-Speed Recording Systems Handbook* and *Talon Recording Systems Catalog*.

TALON


PENTEK
*Setting the Standard for Digital Signal Processing*

Pentek, Inc., One Park Way, Upper Saddle River, NJ 07458 • Phone: 201.818.5900 • Fax: 201.818.5904 • e-mail:info@pentek.com • www.pentek.com

# Drones' agenda: new spectrum

By Junko Yoshida

As the term UAV (unmanned aerial vehicle) suggests, drones are supposed to fly autonomously. And there's the rub.

Unresolved questions for regulators and drone manufacturers are: a) how drones, while flying, can maintain a reliable communication link with the ground for "command and control," and b) if so, what communication spectrum is available.

Panelists on the recent EE Times' Radio Show on drone talk debated what lies ahead for commercial drones.

As currently proposed rules for commercial drones are written (proposed in Feb. by FAA), drones are banned from flying at night and operating beyond line-of-sight. More important, under proposed rules, "drones can't fly over personnel unrelated to a [drone] project," noted lobbyist Michael Drobac, executive director of the Small UAV Coalition, during the radio show. In essence, "you are for the most part prohibiting the use of drones for commercial purposes all together," stressed Drobac.

The irony of the proposed drone regulation is that it permits "no robotization."

Michael Drobac

"It's as if we are putting some sort of manned overlay over what's supposed to be an unmanned system," Drobac summed up.

The chief concern that emerged during the drone debate is the communication link between drone and pilot. The key question is whether drones need a dedicated communication spectrum, or if Wi-Fi and cellular communication links suffice.

## 5GHz for dedicated drone communication

The drone industry will be getting two bands they can use for dedicated communication. The World Radio Conference, which takes place every four years, has already approved — in 2012 — "a spectrum around 5GHz" for command and control of UAVs, explained Jim Williams, ex-FAA chief. This is a vacant band originally set aside for "microwave landing systems."

It's designed as an all-weather, precision landing system for aircraft. This spectrum has since been made obsolete by the wide availability of GPS, he said. Hence, it's unused.

Jim Williams

There is also "a small chunk of L-band around 1GHz" – originally set aside for aircraft to see ships at sea, now approved for dedicated drone communication, he added.

During the radio show, Williams acknowledged that a handful drones today are permitted to fly in the United States beyond line of sight and over people. But one of the requirements is that they have "reliable communication between a pilot and an aircraft."

Those drones with permission to fly beyond line of sight, for example, depend on relatively unregulated public frequencies used by Wi-Fi and mobile phones. Williams noted, "But those [frequencies] are set up in such a way that is not tremendously reliable, since when a lot of people are using it, your range drops." In some incidents, drones flew away when signals got jammed, he added.

Although drones are getting smarter and are dealing with [such potential problems], Williams insisted, "Reliable communication is a key for the [drone] industry." For that, the world is moving toward allowing drones to use a dedicated spectrum – within 5GHz – for their communications.

Asked about the reliability of Wi-Fi and cellular networks as communication links, Yannick Levy, vice president, corporate business development at Parrot, said, "As a drone maker, I'd like to say that both Wi-Fi and cellular networks are good networks, developed by professionals. They have redundancy in place." But he acknowledged that The French Civil Aviation Authority (Direction générale de l'aviation civile, DGAC) doesn't allow commercial drones to use cellular networks, either. "They want a special network dedicated to drone flight."

Yannick Levy

What about Delair-Tech, the French drone company known as the first civilian UAV in the world approved by an official government agency to fly beyond visual line-of-sight? Delair-Tech's drones use 3G for communication.

Levy said Delair-Tech is one of the French drone companies allowed to fly beyond visual line of sight, with their drones having a cellular modem on-board. "Their intent is trying to demonstrate that it works."

## Who will manage the spectrum?

Although the FCC recently changed the U.S. table of allocation – issuing rules about what can and can't be done to various portions of spectrum, drones can't yet begin to transmit signals on those bands.

According to Williams, "channelization schemes" need to be worked out, which are essentially rules about how much power you can transmit, what centre frequency you have to use and what out-of-band power you can tolerate, etc. The Radio Technical Commission for Aeronautics (RTCA) is working to establish such rules. They're due next summer. The regulatory process

will start after that's done, said Williams. The big question, however, is spectrum management. "Who's going to… assign those channels to users," the ex-FAA chief noted. "There really isn't enough [spectrum] to pass out to all users and take all comers."

An industry consortium or a government process must be put in place, and that's when "a non-traditional approach" may be needed, observed Williams. "The traditional approach would take 10 years to get through this, and this is where the industry push is necessary so that they can start taking advantage of the spectrum."

## Compete with Wi-Fi?

As much as a dedicated drone communication spectrum makes sense, the 5GHz spectrum currently can't be accessed by Wi-Fi chips.

According to Williams, new drone spectrum wouldn't compete with Wi-Fi, because this is an "unused, clean band." But Parrot's Levy pointed noted that this isn't exactly good news for drone makers like Parrot who thrive on standards components used in smartphones to keep the cost down. If the FAA assigns drones to the newly dedicated spectrum, drones can no longer use widely available, cheap Wi-Fi chips. Ergo, more expensive drones, he said.

During the online chat on the EE Times Radio Show, the ex-FAA drone chief reiterated why the existing cellular infrastructure is hardly ideal for drone communication.

He noted, "There are many problems with using existing cellular infrastructure for controlling drones. The antennas are pointed at the ground not the sky, the technology is not set up for high speeds, some of the spectrum used is prohibited from being transmitted from an airborne transmitter, and the lack of link reliability is also a problem."

Qualcomm's director of engineering Chad Sweet, countered: "Jim, it turns out, due to free space properties, even with the antennas pointed at the ground the problem is seeing too many towers and not too few."

Obviously, the lack of cell signal availability worries drone users. Qualcomm's Sweet said, "As the craft goes higher in rural areas, the coverage gets better." However, he added, "Existing networks would likely only be a stop-gap. A dedicated network would be needed longer term."

Chad Sweet

There are alternative communication methods, but they aren't great. "A satellite transceiver is too heavy for small UAVs," Sweet said. He opined that cellular networks might be designed for all sorts of coverage scenarios. "Australia is a great example. They have sites that go for up to 100 miles."

Sweet concluded. "Cellular technology has been optimized for efficient multiple access over the last 30 years. It also has a nice property of being light weight. Regardless of spectrum chosen, leveraging cellular technology will help quickly deploy UAV to ground communications."

# Haptic prosthesis gives back natural feel for missing limb

By Julien Happich

In close collaboration with the University Clinic for Reconstructive Plastic and Aesthetic Surgery in Innsbruck / Austria, Professor Hubert Egger from the department of medical engineering of the FH Upper Austria (University of Applied Sciences) developed a sensor-laden artificial limb able to let the wearer feel the surface he or she is walking on.

The prosthesis uses six pressure sensors mounted within its foot sole and sends the pressure signals back to the wearer via vibrating elements embedded within the prosthesis shaft, as haptic feedback directly applied to the wearer's stump skin.


This only works after the surface of the stump has been surgically reinnervated, that is, once the residual severed nerves which ought to control the missing limb have been brought back to the stump's skin surface to reinnervate the surface muscles and provide a sensory interface relevant to the missing limb.

From there on, a sensory map of the lost limb can be established on the skin and used both ways, to control a prosthesis using surface electromyography (EMG) and to receive sensory stimuli from the prosthesis (here in the form of small actuators).

For the foot prosthesis he developed, Egger worked with patient Wolfgang Rangger from Austrian self-help group "living with amputation" (www.leben-mit-amputation.at) who had to have his leg amputated below knee after a stroke and subsequent thrombosis in 2007. Rangger had suffered severe phantom pain after his leg-amputation, and as a first clinical solution, Rangger underwent surgical operation for a so-called "targeted sensory reinnervation" as suggested by work from Todd Kuiken, MD, PHD from the Rehabilitation Institute of Chicago in the late 1990, explained Egger.

Since the patient now received real sensory data from his limb, rather than his brain being left guessing, he no longer felt phantom pain. The stimulators used in the 6-channel vibratory stimulator socket prototype are magnetic resonators. They contain a coil with a ferric-anchor. By powering the coil with rectangular current of 80mA and 160Hz the anchor gets in resonance and produces vibration applied on the surface of the reinnervated skin.

"Targeted sensory reinnervation is a method where residual (no more used) sensory nerve endings in the stump of an amputee are redirected towards a small skin area (reinnervation area or target area) where nerve endings grow towards skin receptors", clarified Egger.

"As soon as the reinnervation process is completed (nerve growth is about 1mm per day), skin receptors supply the redirected nerve endings with sensation from the targeted skin. Eight months after surgery, if Wolfgang Rangger is touched on the reinnervation area, i.e. medial shank, he feels the lateral margin of the foot and the heel" says Egger.

6-channel sensor sole (prototype)

6-channel feedback socket (prototype)


"The reinnervation area acts as a kind of "interface" to the prosthesis. The patient of our case study, Wolfgang Rangger, can "feel" heel strike and roll off motion of the prosthesis at six spots as fed back by the sole's sensors. The patient can "feel" conditions of the ground like slopes, kerbside and obstacles up to about 5cm", continued Egger.

In theory, according to further research published by Kuiken, if the prosthesis was equipped with other types of sensors (such as temperature) tied to equivalent forms

of haptic feedback (maybe Peltier elements), the amputee could also feel temperature projected to his/her missing limb.

Prior to this feat, Egger headed the research project "mind controlled prosthesis arm" at prosthetics manufacturer Otto Bock in cooperation with American research partners, the prosthesis later got the FDA approval (USA) in 2014.

Although in this particular research, only the feedback channel was implemented (thus the patient cannot control the foot prosthesis by his mind like in other studies), theoretically, a two-way-connection, i.e., a motor-path (targeted muscle reinnervation) and a sensory-path (targeted sensory reinnervation) from the human body to the prosthesis is possible, explained Egger.

Now, could future prostheses require a dedicated integrated circuit to figure out the best signal mapping, from the nerve terminations to the prosthesis and vice-versa? Or should the patient figure out how to make use of all the signals he generates (even through a form of sensory substitution) if the actual nerve terminations were not properly corresponding to the intended prosthesis sensing points? We asked Egger.

"As sensory nerves are redirected to a small skin area (during sensory reinnervation), the different types of tactile sensory nerve fibers grow to their corresponding tactile skin receptors for vibration, temperature, force, or pain" detailed the researcher.

"Then motor nerves can be redirected to residual muscles of the stump. EMG-Signals of the residual muscles (connected with the redirected residual motor nerves) produce EMG-Signals corresponding to the phantom limb movement, which only take place in the patient's mind (thus mind controlled). EMG-signals can be picked up from the surface of the skin by sensitive differential amplifier (with a typical gain of 70 dB - 100 dB).

But reinnervation surgery cannot be exactly planned. That means it is not possible to exactly predict which way the different types of nerve fibers use to get to their residual muscles and skin receptors, respectively. At the end the result for each reinnervation surgery is individual. But this is not a big problem from a technical point of view".

"For the control signals, pattern recognition methods (Support Vector Machines) are implemented to recognise the different movements of the phantom limb (thought movements, EMG-patterns). During an initial training procedure taking only a few minutes, the patient performs phantom movements (in his mind) according to the moves shown on a video. The corresponding EMG-patterns are picked up from the reinnervation area and stored into the prostesis' embedded memory. After that training procedure, phantom movements can be recognised and artificial joints are thus controlled simultaneously, following the phantom limb's movement".

"As for the feedback-signals, they are first applied by an array of actuators according to a test routine (actuators are switched on/off sequentially). During this initial test routine the patient has to decide which actuators he can feel best and then select them. This procedure takes a few minutes too, but once completed, the prosthesis is ready for use" concluded Egger.

# Motion engine beats gestures

By Julien Happich

As the Austin-based startup Quantum Interface (Qi) unveiled its first predictive navigation software and technology, *EEtimes Europe* caught up with the company's founder and CTO Jonathan Josephson to know more about the underlying technology.

End of May, the company started to offer an Android smartwatch launcher called QiLaunch Ware, for a private beta testing. The motion-based interface is blazing fast and allows users to navigate through any app in a continuous motion, totally eliminating the "point and click" scenarios that we have been accustomed to with touch screens.

Key to the Qi interface is the motion engine developed by Josephson, way before touch screens and smartphones became commonplace, let alone all the apps they power.

"We have global patents and IP dating back to 2002 and we've been working on that since before then", Josephson said, admitting that when he first thought of using natural motion instead of coded gestures to interact with interfaces, his idea was to control light switches across a room, for easy light selection and dimming.

"It struck me how we could use simple geometry and the principles of motion and time to control objects, control programs and data, seamlessly".

The motion engine software is sensor agnostic, it is architected to take any sensor data (capacitive finger touch, IR or time of flight, eye tracking or name it) and do the maths to convert the user's hand or finger direction, angle, speed, and even acceleration into dynamic control attributes.

"For us, it doesn't matter which sensors you use, we convert user motion into dynamic attributes that can reach threshold events to trigger selection, all in real time. Compare this to gesture-based interfaces where you have to finish the action (gesture) before the processor can go to a look up table and decide what to do with it", explains Josephson.

In fact, as soon as the user moves in a direction, the predictive algorithm starts unfolding menus and pre-selecting the icons that the user is likely to be looking for, and even better, these icons come to the user, all that at a proportional speed that reflects the user's agility.

The benefits are many fold. First the user interface is much more intuitive, you no longer have to imitate a cursor across a screen and move to reach a fixed icon on its XY coordinates, start moving in the icon's direction and you'll trigger a new layout of options. Then the Qi interface is much faster than your traditional "scroll and click" app interface where all the options of a given menu appear once you have selected it, which translates into a better user experience but also in power savings.

"We have made a side by side test with traditional touch-screen interfaces, trying to access different menus. The Qi interface averaged out at around 5% of CPU power, versus 20 to 30% for other solutions. That's also because the menu develops on-demand, and only the options that matter show up on your screen", said Josephson.

The company has been demonstrating its technology to OEMs and is building a software development kit to include seven modules for different types of use-cases, and some automotive OEMs in particular are very interested to integrate the technology into their head-up displays.

When you drive, it can be very distracting to scroll through many options from a menu, but using eye tracking and QI's motion engine, only a glance in the approximate direction is enough to trigger the right response. In that case the company analyses the motion of the eyes instead of requiring the user to focus his/her sight on particular coordinates.

"We've done a demo where we combined eye tracking to perform menu pre-selection, say if you glance quickly at your dashboard towards the radio area, with a thumb pad mounted on the steering wheel to verify and give attribute control (music selection, volume). Within seconds of watching the demo, most companies go "Wow! This changes everything"".


Also on the company's roadmap is the integration of its motion engine at chip level.

"Now, our solution seats at the top layer, it pulls the sensor data already filtered through the base OS and it works after the OS to interact with the API, but ideally we would want to go down to silicon and access the sensors' raw data", explained Josephson, arguing this would further reduce user-interface power consumption.

"We've been approached by a couple of silicon manufacturers but we are probably two years out before silicon integration". Such IP would certainly make sense for touch-screen controllers, but in the coming months, embedded integration is the most likely.

"Virtual reality and gaming are bigger markets and we are also building demos for Oculus, using eye tracking, and possibly taking body motion into the equation" concluded Josephson.

# Redefining RF and Microwave Instrumentation

## with open software and modular hardware


Achieve speed, accuracy and flexibility in your RF and microwave test applications by combining NI open software and modular hardware. Unlike rigid traditional instruments that quickly become obsolete by advancing technology, the system design software of LabVIEW, coupled with PXI hardware, puts the latest advances in PC buses, processors and FPGAs at your fingertips.

### WIRELESS TECHNOLOGIES

NI supports a broad range of wireless standards, including:

| | |
|---|---|
| LTE | GSM/EDGE |
| 802.11a/b/g/n/ac | CDMA2000/EV-DO |
| WCDMA/HSPA/HSPA+ | Bluetooth |

**>> Learn more at ni.com/redefine**

*Follow us on* *Search* **National Instruments** *or* **LabVIEW**

**Austria** 43 662 457990 0 ▪ **Belgium** 32 (0) 2 757 0020 ▪ **Czech Republic, Slovakia** 420 224 235 774 ▪ **Denmark** 45 45 76 26 00
**Finland** 358 (0) 9 725 72511 ▪ **France** 33 (0) 8 20 20 0414 ▪ **Germany** 49 89 7413130 ▪ **Hungary** 36 23 448 900 ▪ **Ireland** 353 (0) 1867 4374
**Israel** 972 3 6393737 ▪ **Italy** 39 02 41309277 **Netherlands** 31 (0) 348 433 466 ▪ **Norway** 47 (0) 66 90 76 60 ▪ **Poland** 48 22 328 90 10
**Portugal** 351 210 311 210 ▪ **Russia** 7 495 783 6851 ▪ **Slovenia, Croatia, Bosnia and Herzegovina, Serbia, Montenegro, Macedonia** 386 3 425 42 00
**Spain** 34 (91) 640 0085 ▪ **Sweden** 46 (0) 8 587 895 00 ▪ **Switzerland** 41 56 2005151 ▪ **UK** 44 (0) 1635 517300

NATIONAL INSTRUMENTS™

# Augmented theatre: a 100% French feat

By Julien Happich

During this summer's Avignon Festival, French cultural startup Theatre in Paris leveraged another French startup's augmented reality eyewear, the ORA connected glasses from Optinvent, to provide foreign theatre goers see-through and customizable surtitles.

As a world's first live demonstration, the surtitles were provided in English and Chinese for 'King Lear' and English and French for 'Return to Berratham' at the Avignon Festival. EETimes Europe caught up with Carl De Poncins, co-founder and president of Theatre in Paris to learn more about this new field of augmented reality (AR).

Created in 2014, the company offers surtitling services including translation and projection setups, but also booking and reception services to literally accompany non-French speakers to their seats, in the capital's theatres. These services help theatre companies share their live performances across multiple languages for a more international reach.

While surtitles are not new, typically projected above the stage, they are usually limited to one language and still require theatre or opera goers to glance at them, away from the main scene. The novelty here is that augmented reality glasses are used to offer individual surtitles to spectators, even outside theatres.

"We've developed a surtitling Android platform that includes a kit of ten AR glasses and a control tablet with our dedicated app", explains De Poncins. "The see-through surtitles projected in front of the eyes can be configured for each individual glasses, for letter size, brightness, colour and location within the spectator's field of view. Although typically, the theatre hostess would set the glasses for first time users, a touch pad control on the glasses let them scroll through simple configuration menus, very much like those they would find on a smartphone", he continued.

But surtitles are only one application, told us De Poncins. "With the control tablet, stage managers could augment a scene with visual effects, such as adding rain, lighting or even entirely new decors within street performances".

On its roadmap, the company plans to build a library of visual effects and bespoke content creations for stage managers to make the most of augmented reality.

As for the actual hardware, Theatre in Paris chose Optinvent's ORA connected glasses because they were the only ones up to the job, according to De Poncins.

"We know of another experimental theatre company in New-York which explored the use of AR for their live performances using Google Glass, but their field of vision was too narrow and too restrictive for the text density of theatrical performances", told us De Poncins. "The Optinvent glasses give us three times as much field of view, and it is centred so you can choose where to place your text or visual effects, without forcing spectators to glance up every second for their surtitles".

At just under 700 euros, the Bluetooth and WiFi connected glasses deliver a full colour 4:3 see-through display with 33 pixels of resolution per degree, across a 24° field of View (this translates in a diagonal of 84" at 5m). Another claim from Optinvent is that it's patented Clear-Vu technology is light weight and shatter proof since all its key optical components are based on molded plastic.

Movies theatres represent another potential market for Theatre in Paris' AR-enabled surtitling services, as the surtitles could be provided either in place of today's subtitles for foreign movies, or even for local language movies, for hearing impaired movie goers.

"We've showcased our technology to some movie distributors and they were quite interested", admitted De Poncins, but as for 3D spectacles in cinemas, it is a matter of customer accessibility and entertainment experience added value versus added costs for the cinema operators.

# A 3D cursor for a 3D world

By Jean-Pierre Joosting

With the advent of smartphones and smartwatches, how users interact with computers or smart devices in an inherently 3D world begs rethinking. This brings us to question whether the 2D cursor should be replaced with a better concept, the 3D cursor. To this end, researchers at the University of Montreal have developed techniques that enable computer cursors to interact in 3D in single or multi-user, local or remote collaboration scenarios.

The system, unveiled at the SIGGRAPH 2015 Conference in Los Angeles, is not so much about turning Word into an IMAX experience as offering designers an opportunity to navigate through and modify their creations manipulating 3D objects with 3D interactions.

"Our new technology challenges the notion of what a cursor is and does," explained lead researcher Professor Tomás Dorta, of the university's School of Design. "The cursor becomes a drawing and controlling plane. The techniques we're unveiling today involves using a tablet to control the cursor, but as it does not necessarily rely on external tracking of the user's move-

# 32-bit Microcontrollers


MICROCHIP

## PIC32 Microcontroller Families


www.microchip.com/get/32-biteu

# Performance-Leading PIC32 Microcontrollers

***Building on the heritage of Microchip Technology's world-leading 8- and 16-bit PIC® microcontrollers, the PIC32 family delivers 32-bit performance and more memory to solve increasingly complex embedded system design challenges.***

## Broad Portfolio

*From simple USB device connectivity to RTOS-driven graphical user interface applications with advanced audio processing, there is a PIC32 device to meet your design challenges.*

- PIC32MZ Series: Up to 200 MHz/330 DMIPS, MIPS® microAptiv™ or M-Class core with DSP instructions
- PIC32MX Series: Up to 120 MHz/150 DMIPS, MIPS M4K core
- Floating Point Unit (FPU) for fast single- and double-precision math
- Memory Management Unit (MMU) for optimum embedded OS execution
- Fast interrupts and context switch
- Dual-panel Flash with live update
- 16 KB to 2 MB Flash
- 4 KB to 512 KB RAM for data and program execution
- Temperature range: –40 to 85°C; –40 to 105°C; 0 to 70°C; *–40 to 125°C (planned)*
- Low pin count devices with Peripheral Pin Select (PPS) for pin remapping of most digital I/O

## Industry-Leading Compatibility

*Create scalable products in a consistent environment.*

- Common MPLAB® X development tools
- Pin- and peripheral-compatible with 16-bit PIC MCUs
- Common software stacks across MCUs
- Common tools environment for over 1,100 PIC MCUs

## Fast, Easy Development

*Shorten your project design cycle.*

- Free MPLAB X Integrated Development Environment supporting all Microchip MCUs
- Free MPLAB XC32/XC32++ Compiler
- MPLAB Harmony Software Framework to get you started with communications, graphics, Bluetooth®, file system, audio and signal processing
- Work in a familiar environment with a broad third party ecosystem of IDEs, RTOS and debuggers
- Development kits starting at $34.95 with free C compiler

## More Design Options

*Simplify your system design through integration.*

- Extensive analog and digital peripherals including 10/100 Ethernet MAC, I²C™, I²S, 10/12-bit ADCs with up to 48 analog channels, serial communications, SQI, EBI and Hi-Speed USB
- Up to 26 DMA channels
- 8/16-bit parallel master port supporting graphic interface and additional memory
- Capacitive touch for improved human interfaces with capacitive buttons or slider control

## PIC32 Software Solutions Support

**Get the latest updates at www.microchip.com/harmony.**

| | |
|---|---|
| **USB** | USB Host, Device, On-the-Go with Class Drivers |
| **HMI** | Microchip Graphics Library<br>MPLAB® Harmony Graphics Composer (HGC)<br>mTouch® Capacitive Touch Library<br>Touch System Service Library |
| **CAN** | CAN Driver and PLIB support for PIC32 |
| **Audio and Speech** | Audio Library for PIC32MX: Speex, ADPCM and WAV; MP3; AAC Decode and WMA Decode<br>USB Audio 2.0 Device Class; Sample Rate Conversion (SRC) Library;<br>PIC32 Bluetooth Audio Software Suites; Audio Equalizer Filter Library |
| **Connectivity** | Microchip TCP/IP with SSL and BSD; IrDA® Stack; Bluetooth® SPP Stack for PIC32;<br>Wi-Fi® Software Library; IEEE 802.15.4 and Sub-GHz MiWi™ Development Environment |
| **Encryption** | Cryptographic Library |
| **Basic Libraries** | File System Library; Floating Point Math Library; Peripheral Library; EEPROM Emulation;<br>IEC 60730 Class B Software; Fixed Point Math Library; Fixed Point DSP Library |
| **Boot Loader** | Serial Port Boot Loader<br>USB Host Boot Loader<br>Ethernet Boot Loader |

MPLAB Harmony Software Framework compatible.
Additional software libraries listed in the table above are planned to be included in MPLAB Harmony.

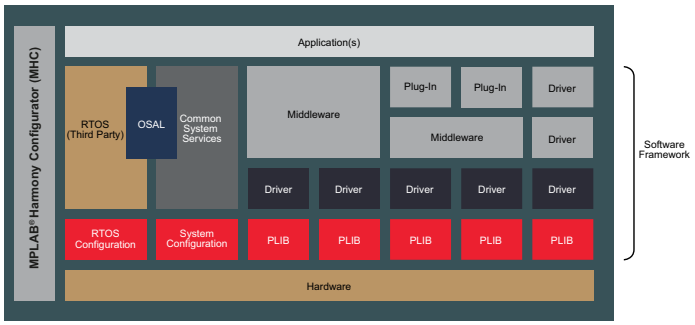
# MPLAB® Harmony for PIC32

## Introduction

MPLAB Harmony is a flexible, abstracted, fully integrated firmware development environment for PIC32 microcontrollers. It enables robust framework development of interoperable RTOS-friendly libraries with quick and extensive Microchip support for third party software integration. MPLAB Harmony includes a set of peripheral libraries, drivers and system services that are readily accessible for application development. The code development format allows for maximum re-use and reduces time-to-market. It features the MPLAB Harmony Configurator (MHC) plug-in that provides a graphical way to select and configure all MPLAB Harmony components, including middleware, system services and peripherals with ease.

MPLAB HARMONY Integrated Software Framework

### MPLAB Harmony Block Diagram




## Benefits

- Faster time-to-market
- Improved code interoperability
- Simplified support
- MPLAB Harmony Configurator (MHC) for enhanced user experience
- Improved 32-bit scalability
- Enhanced third party software integration

### PIC32 Software Development Tools Available with MPLAB Harmony

| Applications | Operating System Abstract Layer (OSAL) | Middleware/ Software Libraries | Device Drivers | Development Software | Third Party Software |
|---|---|---|---|---|---|
| ■ Graphics applications<br>■ TCP/IP applications and utilities<br>■ USB applications | ■ OSAL interface with "basic" and "none" implementation<br>■ ThreadX<br>■ embOS<br>■ FreeRTOS<br>■ OpenRTOS<br>■ Micrium µC/OS-II<br>■ Micrium µC/OS-III | ■ Graphics<br>■ TCP/IP<br>■ USB<br>■ Cryptographic libraries<br>■ File systems<br>■ System services<br>■ Bluetooth®<br>■ DSP/Math | ■ ADC<br>■ Ethernet media access controller<br>■ Ethernet PHY interface<br>■ Controllerless graphics<br>■ Epson LCD controller<br>■ Non-volatile memory<br>■ SPI, UART, high-speed USB<br>■ Timer, parallel master port | ■ MPLAB® X IDE<br>■ MPLAB XC32++<br>■ MPLAB Harmony Configurator (MHC) Plug-In<br>■ MPLAB Harmony Graphics Composer (HGC)<br>■ Board Support Packages (BSP) | ■ DHCP<br>■ DNS<br>■ Networking<br>■ Security<br>■ Cloud services |

Additional software components planned

### Application Layer

- Implements desired overall behavior
- Abstracted hardware access
- Allows for easy port across PIC32 parts

### Common System Services

- Provides common functionality to avoid duplication and conflicts
- Eliminates complex interactions and interdependencies between modules
- OSAL provides OS compatibility and interface
- Manages shared resources
- Supports low-level configuration and board support package

### Peripheral Libraries (PLIB) Layer

- Provide functional interface for Microchip PIC32 scalability
- Implements part-specific features

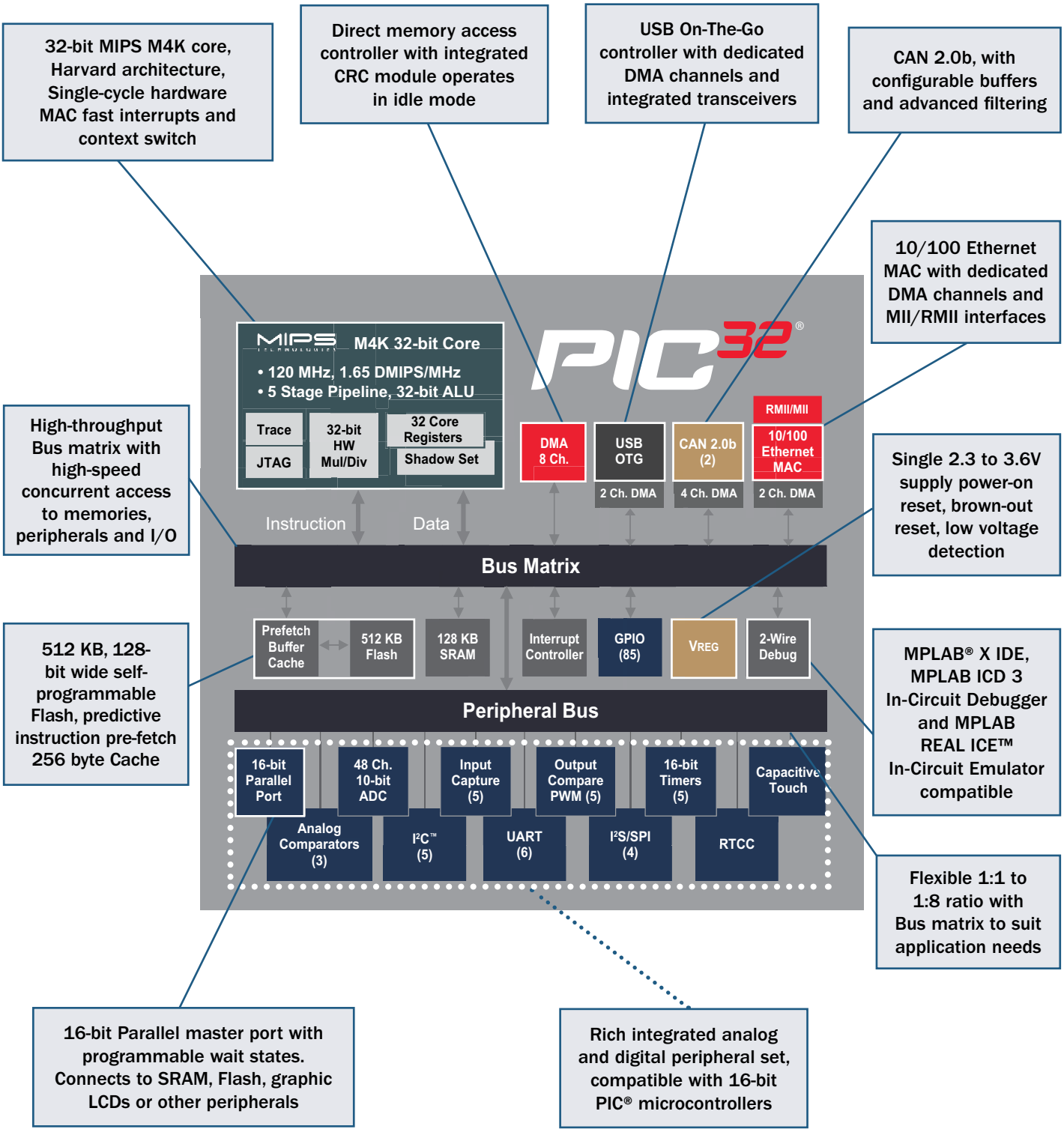
### Middleware Layer

- Implements complex libraries and protocols (USB, TCP/IP, file systems, graphics)
- Provides a highly abstracted application program interface
- Libraries are thread-safe and RTOS-ready
- Built on drivers, PLIBS, system services
- Supports third party library integration

### Device Driver Layer

- Provides highly abstracted interface to peripheral
- Controls access to the peripheral
- Manages multiple hardware instances and software clients with select drivers
- Manages peripheral state and multiple peripheral instances
- Accesses hardware via PLIB
- Supports blocking or non-blocking code

# Inside the MIPS® M4K Core PIC32 MCU




**Note:** Not all features are available on all PIC32 devices. Please see product family table for more information.

# Inside the MIPS32® microAptiv™ Core PIC32 MCU

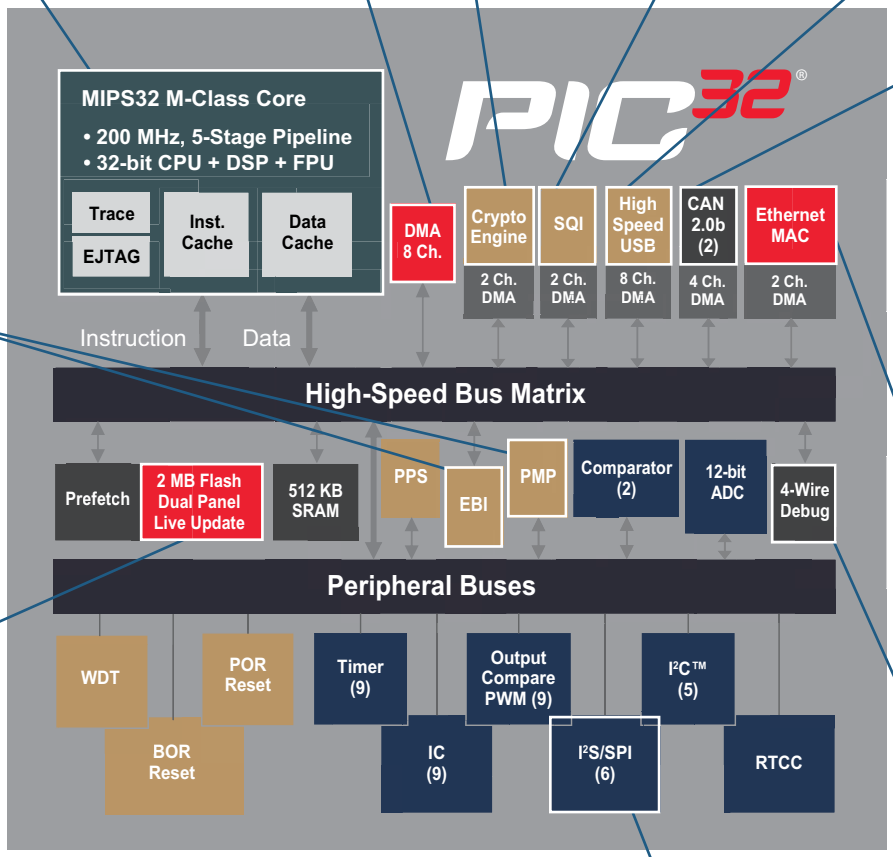
High-performance, real-time embedded MCU core with DSP and FPU. Offers up to 35% code size reduction operating at near-full rate.

Direct memory access controller with integrated CRC module operates in idle mode

Reduces software overhead and actions such as encryption, decryption and authentication are executed more quickly

A synchronous serial interface that provides access to serial Flash memories and other serial devices

Hi-Speed USB Device/Host/OTG controller with dedicated DMA channels and integrated transceivers




CAN 2.0b, with configurable buffers and advanced filtering

PMP/EBI provides a high-speed and convenient interface to external parallel memory devices, camera sensors and LCDs

10/100 Ethernet MAC with dedicated DMA channels and MII/RMII interfaces

High-endurance, flexible and secure Flash with dual Flash banks for live update

MPLAB X IDE, MPLAB ICD 3 In-Circuit Debugger and MPLAB REAL ICE In-Circuit Emulator compatible

Convenient standard CODEC interface for high-quality audio

**Note:** Not all features are available on all PIC32 devices. Please see product family table for more information.

# Developing with the PIC32 Microcontroller

***Microchip is the only silicon vendor with a full 8-, 16- and 32-bit microcontroller portfolio supported by a unified development environment. The MPLAB® X IDE is free and easy to use.***


## PIC32 Starter Kits

Getting started is easy with any of the fully integrated PIC32 Starter Kits. They feature simple installation, a getting started tutorial and a PIC32 starter board which easily connects to your PC via USB. The starter kits include:

- MPLAB X IDE and MPLAB XC32 C Compiler†
- PIC32 starter board with integrated programmer and debugger
- Code examples, documentation, tutorials and sample projects; optional I/O expansion board allows signal breakouts and connections for PICtail™ Plus daughter cards

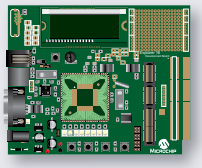
†Free version has **no code size limit** and full optimizations. After 60 days some optimizations are disabled.

## PIC32 Development Tools

**Choose a Platform: *Explorer 16 Platform* OR *Starter Kit Platform***

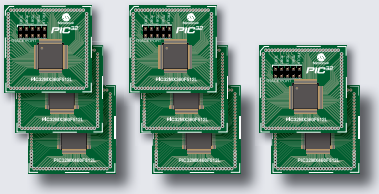
### Explorer 16 Platform

Explorer 16 Development Board (DM240001)



+

PIC32 Plug-in Modules (MA320001/2/3/11/12/14/15/18) (MA320002-2)

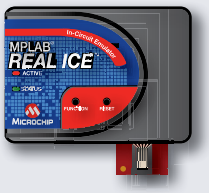


**AND**

MPLAB® ICD 3 In-Circuit Debugger (DV164035)


**OR**

MPLAB REAL ICE In-Circuit Emulation System (DV244005)




### SPECIAL OFFER ON SELECTED DEVELOPMENT TOOLS

**25% OFF**

PIC32MX1/2/5 Starter Kit (DM320100)

PIC32 Bluetooth Starter Kit (DM320018)

PIC32 Audio Codec Daughter Board (AC320100)

Note: "Plug-in board for PIC32 Bluetooth Starter Kit".

CAN Bus Analyzer (APGDT002)


**USE THE COUPON CODE (*MX57MHZ8*) at www.microchipdirect.com TODAY!***

***This Offer applies to purchases made before 31st December 2015**

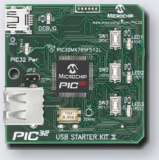
# Developing with the PIC32 Microcontroller

## Starter Kit Platform

PIC32MX1/2/5 Starter Kit (DM320100)

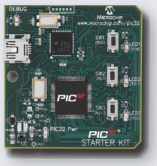
Microstick II (DM330013-2)

PIC32 USB Starter Kit II (DM320003-2)



PIC32 USB Starter Kit III (DM320003-3)

PIC32 Starter Kit (DM320001)



Wi-Fi® G Demo Board (DV102412)

PIC32 Bluetooth Starter Kit (DM320018)

PIC32 Ethernet Starter Kit II (DM320004-2)

PIC32MZ Embedded Connectivity Starter Kit (DM320006)

PIC32MZ Embedded Connectivity Starter Kit with Crypto Engine (DM320006-C)

PIC32MZ with FPU Embedded Connectivity Starter Kit (DM320007)

PIC32MZ with FPU and Crpyto Engine Embedded Connectivity Starter Kit (DM320007-C)

### OPTIONAL

PIC32 Audio Codec Daughter Board (AC320100)

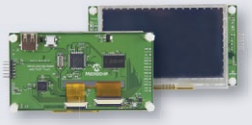
Multimedia Expansion Board (DM320005)

Multimedia Expansion Board II (DM320005-2)

PIC32 Plug-in Modules for Bluetooth Audio Development Kit (MA320013/16/17/19)*

PIC32 Audio DAC Daughter Board (AC320032-2)

PIC32 GUI Development Board with Projected Capacitive Touch (DM320015)



PIC32 I/O Expansion Board (DM320002)

PIC32 Bluetooth® Audio Development Kit (DV320032)

*Does not work with the Explorer 16 Development Board*

# Developing with the PIC32 Microcontroller

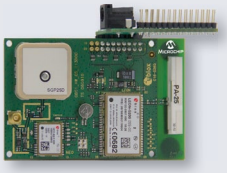
## PICtail™ Boards Common to Both Development Platforms

Graphics Daughter Board with 3.2" Display Kit (AC164127-3)

CAN/LIN PICtail Plus Daughter Board (AC164130-2)

Low-Cost Controllerless (LCC) Graphics PICtail Plus Board (AC164144)

M2M PICtail Daughter Board (AC320011)



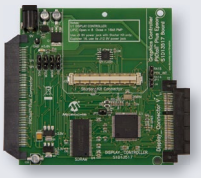
PIC32 VGA Camera Sensor (VCS) PICtail Plus Board (AC164150)

MRF24WB0MA Wi-Fi Daughter Board (AC164136-4)

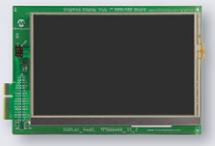
MRF24J40MA PICtail Plus 2.4 GHz RF Card (AC164134)

PIC32MX CTMU Evaluation Board (AC323027)

Graphics Controller PICtail Plus Epson S1D13517 Board (AC164127-7)



Graphics Display Truly 7" 800 × 480 (WVGA) PICtail Plus Board (AC164127-9)



**... and many more!**

## Third Party Application Software and Hardware Support

- Ashling Microsystems
- AVIX-RT
- chipKIT.net
- CMX Systems
- Digilent Inc.
- E.E. Tools
- EasyCode
- EasyGUI
- eflightworks
- ELNEC
- Express Logic
- FreeRTOS
- Fubarino
- Green Hills Software Inc.
- HCC-Embedded
- Interniche Technologies Inc.
- Lauterbach
- Macraigor Systems
- Micriμm
- Micro/sys Inc.
- OLIMEX Ltd.
- OpenRTOS
- Pumpkin
- PubNub
- RoweBots Research Inc.
- Schmalzhaus
- SEGGER
- Serious Integrated
- Softlog
- SparkFun Electronics
- TechToys Company
- Virtual Fab
- wolfSSL

MPLAB Harmony Software Framework compatible.
For up-to-date information about our 32-bit portfolio, related development tools and technical support, visit: www.microchip.com/PIC32.

# PIC32 Microcontroller Product Families

## PIC32MX Devices

| Device | Flash KB + Boot Flash (KB) | SRAM (KB) | Pin Count | Speed (MHz) | I²S/SPI | I²C™ | UARTs | DMA Channels General/Dedicated | PPS | USB (Full/Hi-Speed) | 10/100 Ethernet | CAN 2.0b | IC/OC/PWM | 10-bit ADC 1 Msps | Analog Comparator | Timers 16b/32b | RTCC | Parallel Master Port | JTAG Program, Debug, Boundary Scan | Temp. Range (°C) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PIC32MX110F016B | 16 + 3 | 4 | 28 | 40 | 2/2 | 2 | 2 | 4/0 | Y | N | N | N | 5/5/5 | 10 | 3 | 5/2 | Y | Y | Y | –40 to +105 |
| PIC32MX110F016C | 16 + 3 | 4 | 36 | | | | | | | | | | | 12 | | | | | | |
| PIC32MX110F016D | 16 + 3 | 4 | 44 | | | | | | | | | | | 13 | | | | | | |
| PIC32MX120F032B | 32 + 3 | 8 | 28 | 40/50 | | | | | | | | | | 10 | | | | | | |
| PIC32MX120F032C | 32 + 3 | 8 | 36 | | | | | | | | | | | 12 | | | | | | |
| PIC32MX120F032D | 32 + 3 | 8 | 44 | | | | | | | | | | | 13 | | | | | | |
| PIC32MX120F064H | 64 + 3 | 8 | 64 | | 3 | | 4 | | | | | | | 28 | | | | | | |
| PIC32MX130F064B | 64 + 3 | 16 | 28 | 40 | 2/2 | 2 | 2 | 4/0 | Y | N | N | N | 5/5/5 | 10 | 3 | 5/2 | Y | Y | Y | –40 to +105 |
| PIC32MX130F064C | 64 + 3 | 16 | 36 | | | | | | | | | | | 12 | | | | | | |
| PIC32MX130F064D | 64 + 3 | 16 | 44 | | | | | | | | | | | 13 | | | | | | |
| PIC32MX130F128H | 128 + 3 | 16 | 64 | 40/50 | 3 | | 4 | | | | | | | 28 | | | | | | |
| PIC32MX130F128L | 128 + 3 | 16 | 100 | | 4 | | 5 | | | | | | | 48 | | | | | | |
| PIC32MX130F256B | 256 + 3 | 16 | 28 | | 2 | | 2 | | | | | | | 10 | | | | | | |
| PIC32MX130F256D | 256 + 3 | 16 | 44 | | 2 | | | | | | | | | 13 | | | | | | |
| PIC32MX150F128B | 128 + 3 | 32 | 28 | | 2/2 | | | | | | | | | 10 | | | | | | |
| PIC32MX150F128C | 128 + 3 | 32 | 36 | | | | | | | | | | | 12 | | | | | | |
| PIC32MX150F128D | 128 + 3 | 32 | 44 | | | | | | | | | | | 13 | | | | | | |
| PIC32MX150F256H | 256 + 3 | 32 | 64 | | 3 | | 4 | | | | | | | 28 | | | | | | |
| PIC32MX150F256L | 256 + 3 | 32 | 100 | | 4 | | 5 | | | | | | | 48 | | | | | | |
| PIC32MX170F256B | 256 + 3 | 64 | 28 | | 2/2 | | 2 | | | | | | | 10 | | | | | | |
| PIC32MX170F256D | 256 + 3 | 64 | 44 | | | | | | | | | | | 13 | | | | | | |
| PIC32MX170F512H | 512 + 3 | 64 | 64 | | 3 | | 4 | | | | | | | 28 | | | | | | |
| PIC32MX170F512L | 512 + 3 | 64 | 100 | | 4 | | 5 | | | | | | | 48 | | | | | | |
| PIC32MX210F016B | 16 + 3 | 4 | 28 | 40 | 2/2 | 2 | 2 | 4/2 | Y | FS | N | N | 5/5/5 | 9 | 3 | 5/2 | Y | Y | Y | –40 to +105 |
| PIC32MX210F016C | 16 + 3 | 4 | 36 | | | | | | | | | | | 12 | | | | | | |
| PIC32MX210F016D | 16 + 3 | 4 | 44 | | | | | | | | | | | 13 | | | | | | |
| PIC32MX220F032B | 32 + 3 | 8 | 28 | 40/50 | | | | | | | | | | 9 | | | | | | |
| PIC32MX220F032C | 32 + 3 | 8 | 36 | | | | | | | | | | | 12 | | | | | | |
| PIC32MX220F032D | 32 + 3 | 8 | 44 | | | | | | | | | | | 13 | | | | | | |
| PIC32MX230F064B | 64 + 3 | 16 | 28 | 40 | 2/2 | 2 | 2 | 4/2 | Y | FS | N | N | 5/5/5 | 9 | 3 | 5/2 | Y | Y | Y | –40 to +105 |
| PIC32MX230F064C | 64 + 3 | 16 | 36 | | | | | | | | | | | 12 | | | | | | |
| PIC32MX230F064D | 64 + 3 | 16 | 44 | | | | | | | | | | | 13 | | | | | | |
| PIC32MX230F128H | 128 + 3 | 16 | 64 | 40/50 | 3 | | 4 | | | | | | | 28 | | | | | | |
| PIC32MX230F128L | 128 + 3 | 16 | 100 | | 4 | | 5 | | | | | | | 48 | | | | | | |
| PIC32MX230F256B | 256 + 3 | 16 | 28 | | 2 | | 2 | | | | | | | 9 | | | | | | |
| PIC32MX230F256D | 256 + 3 | 16 | 44 | | 2 | | | | | | | | | 13 | | | | | | |
| PIC32MX250F128B | 128 + 3 | 32 | 28 | | 2/2 | | | | | | | | | 9 | | | | | | |
| PIC32MX250F128C | 128 + 3 | 32 | 36 | | | | | | | | | | | 12 | | | | | | |
| PIC32MX250F128D | 128 + 3 | 32 | 44 | | | | | | | | | | | 13 | | | | | | |
| PIC32MX250F256H | 256 + 3 | 32 | 64 | | 3 | | 4 | | | | | | | 28 | | | | | | |
| PIC32MX250F256L | 256 + 3 | 32 | 100 | | 4 | | 5 | | | | | | | 48 | | | | | | |
| PIC32MX270F256B | 256 + 3 | 64 | 28 | | 2/2 | | 2 | | | | | | | 9 | | | | | | |
| PIC32MX270F256D | 256 + 3 | 64 | 44 | | | | | | | | | | | 13 | | | | | | |
| PIC32MX270F512H | 512 + 3 | 64 | 64 | | 3 | | 4 | | | | | | | 28 | | | | | | |
| PIC32MX270F512L | 512 + 3 | 64 | 100 | | 4 | | 5 | | | | | | | 48 | | | | | | |

**Note:** AEC-Q100 qualified for grade 2 and 3. Check individual product pages on www.microchip.com for details.

# PIC32 Microcontroller Product Families

## PIC32MX Devices (Continued)

| Device | Flash KB + Boot Flash (KB) | SRAM (KB) | Pin Count | Speed (MHz) | I²S/SPI | I²C™ | UARTs | DMA Channels General/Dedicated | PPS | USB (Full/Hi-Speed) | 10/100 Ethernet | CAN 2.0b | IC/OC/PWM | 10-bit ADC 1 Msps | Analog Comparator | Timers 16b/32b | RTCC | Parallel Master Port | JTAG Program, Debug, Boundary Scan | Temp. Range (°C) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PIC32MX320F032H | 32 + 12 | 8 | 64 | 40 | 2/2 | 2 | 2 | 0/0 | N | N | N | N | 5/5/5 | 16 ch | 2 | 5/2 | Y | Y | Y | –40 to +105 |
| PIC32MX320F064H | 64 + 12 | 16 | 64 | 40 | | | | | | | | | | | | | | | | |
| PIC32MX320F064H | | | | 80 | | | | | | | | | | | | | | | | |
| PIC32MX320F128H | 128 + 12 | 16 | 64 | 80 | | | | | | | | | | | | | | | | |
| PIC32MX320F128L | | | 100 | | | | | | | | | | | | | | | | | |
| PIC32MX330F064H | 64 + 12 | 16 | 64 | 100 | | | 4 | 4/0 | Y | | | | | 28 ch | | | | | | |
| PIC32MX330F064L | | | 100 | | | | 5 | | | | | | | | | | | | | |
| PIC32MX340F128H | 128 + 12 | 32 | 64 | 80 | 2/2 | 2 | 2 | 4/0 | N | N | N | N | 5/5/5 | 16 ch | 2 | 5/2 | Y | Y | Y | –40 to +105 |
| PIC32MX340F128L | | | 100 | | | | | | | | | | | | | | | | | |
| PIC32MX340F256H | 256 + 12 | 32 | 64 | 80 | | | | | | | | | | | | | | | | |
| PIC32MX360F256L | | | 100 | | | | | | | | | | | | | | | | | |
| PIC32MX340F512H | 512 + 12 | 32 | 64 | 80 | | | | | | | | | | | | | | | | |
| PIC32MX360F512L | | | 100 | | | | | | | | | | | | | | | | | |
| PIC32MX350F128H | 128 + 12 | 32 | 64 | 100 | 2/2 | 2 | 4 | 4/0 | Y | N | N | N | 5/5/5 | 28 ch | 2 | 5/2 | Y | Y | Y | –40 to +105 |
| PIC32MX350F128L | | | 100/ 124 | | | | 5 | | | | | | | | | | | | | |
| PIC32MX350F526H | 256 + 12 | 64 | 64 | | | | 4 | | | | | | | | | | | | | |
| PIC32MX350F526L | | | 100/ 124 | | | | 5 | | | | | | | | | | | | | |
| PIC32MX370F512H | 512 + 12 | 128 | 64 | | | | 4 | | | | | | | | | | | | | |
| PIC32MX370F512L | | | 100/ 124 | | | | 5 | | | | | | | | | | | | | |
| PIC32MX420F032H | 32 + 12 | 8 | 64 | 40 | 0/1 | 2 | 2 | 0/2 | N | FS | N | N | 5/5/5 | 16 ch | 2 | 5/2 | Y | Y | Y | –40 to +105 |
| PIC32MX430F064H | 64 + 12 | 16 | 64 | 100 | 2/2 | | 4 | 4/2 | Y | | | | | 28 ch | | | | | | |
| PIC32MX430F064L | | | 100 | | 2/2 | | 5 | | | | | | | | | | | | | |
| PIC32MX440F128H | 128 + 12 | 32 | 64 | 80 | 0/1 | | 2 | 4/2 | N | | | | | 16 ch | | | | | | |
| PIC32MX440F128L | | | 100 | | 0/2 | | | | | | | | | | | | | | | |
| PIC32MX440F256H | 256 + 12 | 32 | 64 | 80 | 0/1 | | | | | | | | | | | | | | | |
| PIC32MX460F256L | | | 100 | | 0/2 | | | | | | | | | | | | | | | |
| PIC32MX440F512H | 512 + 12 | 32 | 64 | 80 | 0/1 | | | | | | | | | | | | | | | |
| PIC32MX460F512L | | | 100 | | 0/2 | | | | | | | | | | | | | | | |
| PIC32MX450F128H | 128 + 12 | 32 | 64 | 100 | 2/2 | | 4 | 4/2 | Y | | | | | 28 ch | | | | | | |
| PIC32MX450F128L | | | 100/ 124 | | | | 5 | | | | | | | | | | | | | |
| PIC32MX450F256H | 256 + 12 | 64 | 64 | 100/ 120 | | | 4 | | | | | | | | | | | | | |
| PIC32MX450F256L | | | 100/ 124 | | | | 5 | | | | | | | | | | | | | |
| PIC32MX470F512H | 512 + 12 | 128 | 64 | | | | 4 | | | | | | | | | | | | | |
| PIC32MX470F512L | | | 100/ 124 | | | | 5 | | | | | | | | | | | | | |

**Note:** AEC-Q100 qualified for grade 2 and 3. Check individual product pages on www.microchip.com for details.

# PIC32 Microcontroller Product Families

## PIC32MX Devices (Continued)

| Device | Flash KB + Boot Flash (KB) | SRAM (KB) | Pin Count | Speed (MHz) | I²S/SPI | I²C™ | UARTs | DMA Channels General/Dedicated | PPS | USB (Full/Hi-Speed) | 10/100 Ethernet | CAN 2.0b | IC/OC/PWM | 10-bit ADC 1 Msps | Analog Comparator | Timers 16b/32b | RTCC | Parallel Master Port | JTAG Program, Debug, Boundary Scan | Temp. Range (°C) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PIC32MX530F128H | 128+3 | 16 | 64 | 40/50 | 3 | 2 | 4 | 4/4 | Y | FS | N | Y | 5/5/5 | 28 | 3 | 5/2 | Y | Y | Y | –40 to +105 |
| PIC32MX530F128L | 128+3 | 16 | 100 | | 4 | | 5 | | | | | | | 48 | | | | | | |
| PIC32MX570F512H | 512+3 | 64 | 64 | | 3 | | 4 | | | | | | | 28 | | | | | | |
| PIC32MX570F512L | 512+3 | 64 | 100 | | 4 | | 5 | | | | | | | 48 | | | | | | |
| PIC32MX570F512H | 512+3 | 64 | 64 | | 3 | | 4 | | | | | | | 28 | | | | | | |
| PIC32MX570F512L | 512+3 | 64 | 100 | | 4 | | 5 | | | | | | | 48 | | | | | | |
| PIC32MX534F064H | 64 + 12 | 16 | 64 | 80 | 0/3 | 4 | 6 | 4/4 | N | FS | N | 1 | 5/5/5 | 16 ch | 2 | 5/2 | Y | Y | Y | –40 to +105 |
| PIC32MX534F064L | | | 100 | | 0/4 | 5 | | | | | | | | | | | | | | |
| PIC32MX564F064H | | 32 | 64 | 80 | 0/3 | 4 | | | | | | | | | | | | | | |
| PIC32MX564F064L | | | 100 | | 0/4 | 5 | | | | | | | | | | | | | | |
| PIC32MX564F128H | 128 + 12 | 32 | 64 | 80 | 0/3 | 4 | | | | | | | | | | | | | | |
| PIC32MX564F128L | | | 100 | | 0/4 | 5 | | | | | | | | | | | | | | |
| PIC32MX575F256H | 256 + 12 | 64 | 64 | 80 | 0/3 | 4 | | 8/4 | | | | | | | | | | | | |
| PIC32MX575F256L | | | 100 | | 0/4 | 5 | | | | | | | | | | | | | | |
| PIC32MX575F512H | 512 + 12 | 64 | 64 | 80 | 0/3 | 4 | | | | | | | | | | | | | | |
| PIC32MX575F512L | | | 100 | | 0/4 | 5 | | | | | | | | | | | | | | |
| PIC32MX664F064H | 64 + 12 | 32 | 64 | 80 | 0/3 | 4 | 6 | 4/4 | N | FS | Y | N | 5/5/5 | 16 ch | 2 | 5/2 | Y | Y | Y | –40 to +105 |
| PIC32MX664F064L | | | 100 | | 0/4 | 5 | | | | | | | | | | | | | | |
| PIC32MX664F128H | 128 + 12 | 32 | 64 | 80 | 0/3 | 4 | | | | | | | | | | | | | | |
| PIC32MX664F128L | | | 100 | | 0/4 | 5 | | | | | | | | | | | | | | |
| PIC32MX675F256H | 256 + 12 | 64 | 64 | 80 | 0/3 | 4 | | 8/4 | | | | | | | | | | | | |
| PIC32MX675F256L | | | 100 | | 0/4 | 5 | | | | | | | | | | | | | | |
| PIC32MX675F512H | 512 + 12 | 64 | 64 | 80 | 0/3 | 4 | | | | | | | | | | | | | | |
| PIC32MX675F512L | | | 100 | | 0/4 | 5 | | | | | | | | | | | | | | |
| PIC32MX695F512H | | 128 | 64 | 80 | 0/3 | 4 | | | | | | | | | | | | | | |
| PIC32MX695F512L | | | 100 | | 0/4 | 5 | | | | | | | | | | | | | | |
| PIC32MX764F128H | 128 + 12 | 32 | 64 | 80 | 0/3 | 4 | 6 | 4/6 | N | FS | Y | 1 | 5/5/5 | 16 ch | 2 | 5/2 | Y | Y | Y | –40 to +105 |
| PIC32MX764F128L | | | 100 | | 0/4 | 5 | | | | | | | | | | | | | | |
| PIC32MX775F256H | 256 + 12 | 64 | 64 | 80 | 0/3 | 4 | | 8/8 | | | | 2 | | | | | | | | |
| PIC32MX775F256L | | | 100 | | 0/4 | 5 | | | | | | | | | | | | | | |
| PIC32MX775F512H | 512 + 12 | 64 | 64 | 80 | 0/3 | 4 | | | | | | | | | | | | | | |
| PIC32MX775F512L | | | 100 | | 0/4 | 5 | | | | | | | | | | | | | | |
| PIC32MX795F512H | | 128 | 64 | 80 | 0/3 | 4 | | | | | | | | | | | | | | |
| PIC32MX795F512L | | | 100 | | 0/4 | 5 | | | | | | | | | | | | | | |

**Note:** AEC-Q100 qualified for grade 2 and 3. Check individual product pages on www.microchip.com for details.

# PIC32 Microcontroller Product Families

## PIC32MZ Devices

| Device | Flash KB + Boot Flash (KB) | SRAM (KB) | Pin Count | Speed (MHz) | I²S/SPI | I²C™ | UARTs | DMA Channels General/Dedicated | PPS | USB (Full/Hi-Speed) | 10/100 Ethernet | CAN 2.0b | IC/OC/PWM | 10-bit ADC | ADC S/H | Analog Comparator | Timers 16b/32b | RTCC | SQI | EBI | Parallel Master Port | JTAG Program, Debug, Boundary Scan | Crypto Engine | Temp. Range (°C) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PIC32MZ2048ECG144 | 2048 + 160 | 512 | 144 | 200 | 6 | 5 | 6 | 8/12 | Y | HS | Y | N | 9/9/9 | 48 ch | 1 | 2 | 9/4 | Y | Y | Y | Y | Y | N | −40 to +85 |
| PIC32MZ2048ECH144 | 2048 + 160 | | | | | | | 8/16 | | | | 2 | | | | | | | | | | | | |
| PIC32MZ2048ECG124 | 2048 + 160 | 512 | 124 | 200 | 6 | 5 | 6 | 8/12 | Y | HS | Y | N | 9/9/9 | 48 ch | 1 | 2 | 9/4 | Y | Y | Y | Y | Y | N | −40 to +85 |
| PIC32MZ2048ECH124 | 2048 + 160 | | | | | | | 8/16 | | | | 2 | | | | | | | | | | | | |
| PIC32MZ2048ECG100 | 2048 + 160 | 512 | 100 | 200 | 6 | 5 | 6 | 8/12 | Y | HS | Y | N | 9/9/9 | 40 ch | 1 | 2 | 9/4 | Y | Y | Y | Y | Y | N | −40 to +85 |
| PIC32MZ2048ECH100 | 2048 + 160 | | | | | | | 8/16 | | | | 2 | | | | | | | | | | | | |
| PIC32MZ2048ECG064 | 2048 + 160 | 512 | 64 | 200 | 4 | 4 | 6 | 8/12 | Y | HS | Y | N | 9/9/9 | 24 ch | 1 | 2 | 9/4 | Y | Y | N | Y | Y | N | −40 to +85 |
| PIC32MZ2048ECH064 | 2048 + 160 | | | | | | | 8/16 | | | | 2 | | | | | | | | | | | | |
| PIC32MZ1024ECG144 | 1024 + 160 | 512 | 144 | 200 | 6 | 5 | 6 | 8/12 | Y | HS | Y | N | 9/9/9 | 48 ch | 1 | 2 | 9/4 | Y | Y | Y | Y | Y | N | −40 to +85 |
| PIC32MZ1024ECH144 | 1024 + 160 | | | | | | | 8/16 | | | | 2 | | | | | | | | | | | | |
| PIC32MZ1024ECG124 | 1024 + 160 | 512 | 124 | 200 | 6 | 5 | 6 | 8/12 | Y | HS | Y | N | 9/9/9 | 48 ch | 1 | 2 | 9/4 | Y | Y | Y | Y | Y | N | −40 to +85 |
| PIC32MZ1024ECH124 | 1024 + 160 | | | | | | | 8/16 | | | | 2 | | | | | | | | | | | | |
| PIC32MZ1024ECG100 | 1024 + 160 | 512 | 100 | 200 | 6 | 5 | 6 | 8/12 | Y | HS | Y | N | 9/9/9 | 40 ch | 1 | 2 | 9/4 | Y | Y | Y | Y | Y | N | −40 to +85 |
| PIC32MZ1024ECH100 | 1024 + 160 | | | | | | | 8/16 | | | | 2 | | | | | | | | | | | | |
| PIC32MZ1024ECG064 | 1024 + 160 | 512 | 64 | 200 | 4 | 4 | 6 | 8/12 | Y | HS | Y | N | 9/9/9 | 24 ch | 1 | 2 | 9/4 | Y | Y | N | Y | Y | N | −40 to +85 |
| PIC32MZ1024ECH064 | 1024 + 160 | | | | | | | 8/16 | | | | 2 | | | | | | | | | | | | |
| PIC32MZ2048ECM144 | 2048 + 160 | 512 | 144 | 200 | 6 | 5 | 6 | 8/18 | Y | HS | Y | 2 | 9/9/9 | 48 ch | 1 | 2 | 9/4 | Y | Y | Y | Y | Y | Y | −40 to +85 |
| PIC32MZ2048ECM124 | 2048 + 160 | | | | | | | | | | | | | | | | | | | | | | | |
| PIC32MZ2048ECM100 | 2048 + 160 | 512 | 100 | 200 | 6 | 5 | 6 | 8/18 | Y | HS | Y | 2 | 9/9/9 | 40 ch | 1 | 2 | 9/4 | Y | Y | Y | Y | Y | Y | −40 to +85 |
| PIC32MZ2048ECM064 | 2048 + 160 | | 64 | | 4 | 4 | | | | | | | | 24 ch | | | | | | N | | | | |
| PIC32MZ1024ECM144 | 1024 + 160 | 512 | 144 | 200 | 6 | 5 | 6 | 8/18 | Y | HS | Y | 2 | 9/9/9 | 48 ch | 1 | 2 | 9/4 | Y | Y | Y | Y | Y | Y | −40 to +85 |
| PIC32MZ1024ECM124 | 1024 + 160 | | 124 | | | | | | | | | | | | | | | | | | | | | |
| PIC32MZ1024ECM100 | 1024 + 160 | 512 | 100 | 200 | 6 | 5 | 6 | 8/18 | Y | HS | Y | 2 | 9/9/9 | 40 ch | 1 | 2 | 9/4 | Y | Y | Y | Y | Y | Y | −40 to +85 |
| PIC32MZ1024ECM064 | 1024 + 160 | | 64 | | 4 | 4 | | | | | | | | 24 ch | | | | | | N | | | | |

# PIC32 Microcontroller Product Families

## PIC32MZ Devices with Floating Point Unit (FPU)

| Device | Flash KB + Boot Flash (KB) | SRAM (KB) | Pin Count | Speed (MHz) | I²S/SPI | I²C™ | UARTs | DMA Channels General/Dedicated | PPS | USB (Full/Hi-Speed) | 10/100 Ethernet | CAN 2.0b | IC/OC/PWM | 10-bit ADC | ADC S/H | Analog Comparator | Timers 16b/32b | RTCC | SQI | EBI | Parallel Master Port | JTAG Program, Debug, Boundary Scan | Crypto Engine | Temp. Range (°C) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PIC32MZ2048EFG144 | 2048 + 160 | 512 | 144 | 200 | 6 | 5 | 6 | 8/12 | Y | HS | Y | – | 9/9/9 | 48 | 6 | 2 | 9/4 | Y | Y | Y | Y | Y | N | –40 to +85 |
| PIC32MZ2048EFH144 | 2048 + 160 | | | | | | | 8/16 | | | | 2 | | | | | | | | | | | | |
| PIC32MZ2048EFG124 | 2048 + 160 | 512 | 124 | 200 | 6 | 5 | 6 | 8/12 | Y | HS | Y | – | 9/9/9 | 48 | 6 | 2 | 9/4 | Y | Y | Y | Y | Y | N | –40 to +85 |
| PIC32MZ2048EFH124 | 2048 + 160 | | | | | | | 8/16 | | | | 2 | | | | | | | | | | | | |
| PIC32MZ2048EFG100 | 2048 + 160 | 512 | 100 | 200 | 6 | 5 | 6 | 8/12 | Y | HS | Y | – | 9/9/9 | 40 | 6 | 2 | 9/4 | Y | Y | Y | Y | Y | N | –40 to +85 |
| PIC32MZ2048EFH100 | 2048 + 160 | | | | | | | 8/16 | | | | 2 | | | | | | | | | | | | |
| PIC32MZ2048EFG064 | 2048 + 160 | 512 | 64 | 200 | 4 | 4 | 6 | 8/12 | Y | HS | Y | – | 9/9/9 | 24 | 6 | 2 | 9/4 | Y | Y | N | Y | Y | N | –40 to +85 |
| PIC32MZ2048EFH064 | 2048 + 160 | | | | | | | 8/16 | | | | 2 | | | | | | | | | | | | |
| PIC32MZ1024EFG144 | 1024 + 160 | 512 | 144 | 200 | 6 | 5 | 6 | 8/12 | Y | HS | Y | – | 9/9/9 | 48 | 6 | 2 | 9/4 | Y | Y | Y | Y | Y | N | –40 to +85 |
| PIC32MZ1024EFH144 | 1024 + 160 | | | | | | | 8/16 | | | | 2 | | | | | | | | | | | | |
| PIC32MZ1024EFG124 | 1024 + 160 | 512 | 124 | 200 | 6 | 5 | 6 | 8/12 | Y | HS | Y | – | 9/9/9 | 48 | 6 | 2 | 9/4 | Y | Y | Y | Y | Y | N | –40 to +85 |
| PIC32MZ1024EFH124 | 1024 + 160 | | | | | | | 8/16 | | | | 2 | | | | | | | | | | | | |
| PIC32MZ1024EFG100 | 1024 + 160 | 512 | 100 | 200 | 6 | 5 | 6 | 8/12 | Y | HS | Y | – | 9/9/9 | 40 | 6 | 2 | 9/4 | Y | Y | Y | Y | Y | N | –40 to +85 |
| PIC32MZ1024EFH100 | 1024 + 160 | | | | | | | 8/16 | | | | 2 | | | | | | | | | | | | |
| PIC32MZ1024EFG064 | 1024 + 160 | 512 | 64 | 200 | 4 | 4 | 6 | 8/12 | Y | HS | Y | – | 9/9/9 | 24 | 6 | 2 | 9/4 | Y | Y | N | Y | Y | N | –40 to +85 |
| PIC32MZ1024EFH064 | 1024 + 160 | | | | | | | 8/16 | | | | 2 | | | | | | | | | | | | |
| PIC32MZ2048EFM144 | 2048 + 160 | 512 | 144 | 200 | 6 | 5 | 6 | 8/18 | Y | HS | Y | 2 | 9/9/9 | 48 | 6 | 2 | 9/4 | Y | Y | Y | Y | Y | Y | –40 to +85 |
| PIC32MZ2048EFM124 | 2048 + 160 | 512 | 124 | 200 | 6 | 5 | 6 | 8/18 | Y | HS | Y | 2 | 9/9/9 | 48 | 6 | 2 | 9/4 | Y | Y | Y | Y | Y | Y | –40 to +85 |
| PIC32MZ2048EFM100 | 2048 + 160 | 512 | 100 | 200 | 6 | 5 | 6 | 8/18 | Y | HS | Y | 2 | 9/9/9 | 40 | 6 | 2 | 9/4 | Y | Y | Y | Y | Y | Y | –40 to +85 |
| PIC32MZ2048EFM064 | 2048 + 160 | 512 | 64 | 200 | 4 | 4 | 6 | 8/18 | Y | HS | Y | 2 | 9/9/9 | 24 | 6 | 2 | 9/4 | Y | Y | Y | Y | Y | Y | –40 to +85 |
| PIC32MZ1024EFM144 | 1024 + 160 | 512 | 144 | 200 | 6 | 5 | 6 | 8/18 | Y | HS | Y | 2 | 9/9/9 | 48 | 6 | 2 | 9/4 | Y | Y | Y | Y | Y | Y | –40 to +85 |
| PIC32MZ1024EFM124 | 1024 + 160 | 512 | 124 | 200 | 6 | 5 | 6 | 8/18 | Y | HS | Y | 2 | 9/9/9 | 48 | 6 | 2 | 9/4 | Y | Y | Y | Y | Y | Y | –40 to +85 |
| PIC32MZ1024EFM100 | 1024 + 160 | 512 | 100 | 200 | 6 | 5 | 6 | 8/18 | Y | HS | Y | 2 | 9/9/9 | 40 | 6 | 2 | 9/4 | Y | Y | Y | Y | Y | Y | –40 to +85 |
| PIC32MZ1024EFM064 | 1024 + 160 | 512 | 64 | 200 | 4 | 4 | 6 | 8/18 | Y | HS | Y | 2 | 9/9/9 | 24 | 6 | 2 | 9/4 | Y | Y | Y | Y | Y | Y | –40 to +85 |

**Note:** AEC-Q100 qualified for grade 1, 2 and 3. Check individual product pages on www.microchip.com for details.
Please contact your Microchip representative for availability.

# PIC32 Microcontroller Product Families

## PIC32MZ Devices with Floating Point Unit (FPU) (Continued)

| Device | Flash KB + Boot Flash (KB) | SRAM (KB) | Pin Count | Speed (MHz) | I²S/SPI | I²C™ | UARTs | DMA Channels General/Dedicated | PPS | USB (Full/Hi-Speed) | 10/100 Ethernet | CAN 2.0b | IC/OC/PWM | 10-bit ADC | ADC S/H | Analog Comparator | Timers 16b/32b | RTCC | SQI | EBI | Parallel Master Port | JTAG Program, Debug, Boundary Scan | Crypto Engine | Temp. Range (°C) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PIC32MZ1024EFE144 | 1024 + 160 | 256 | 144 | 200 | 6 | 5 | 6 | 8/12 | Y | HS | Y | – | 9/9/9 | 48 | 6 | 2 | 9/4 | Y | Y | Y | Y | Y | N | −40 to +85 |
| PIC32MZ1024EFF144 | 1024 + 160 | | | | | | | 8/16 | | | | 2 | | | | | | | | | | | | |
| PIC32MZ1024EFE124 | 1024 + 160 | 256 | 124 | 200 | 6 | 5 | 6 | 8/12 | Y | HS | Y | – | 9/9/9 | 48 | 6 | 2 | 9/4 | Y | Y | Y | Y | Y | N | −40 to +85 |
| PIC32MZ1024EFF124 | 1024 + 160 | | | | | | | 8/16 | | | | 2 | | | | | | | | | | | | |
| PIC32MZ1024EFE100 | 1024 + 160 | 256 | 100 | 200 | 6 | 5 | 6 | 8/12 | Y | HS | Y | – | 9/9/9 | 40 | 6 | 2 | 9/4 | Y | Y | Y | Y | Y | N | −40 to +85 |
| PIC32MZ1024EFF100 | 1024 + 160 | | | | | | | 8/16 | | | | 2 | | | | | | | | | | | | |
| PIC32MZ1024EFE064 | 1024 + 160 | 256 | 64 | 200 | 4 | 4 | 6 | 8/12 | Y | HS | Y | – | 9/9/9 | 24 | 6 | 2 | 9/4 | Y | Y | N | Y | Y | N | −40 to +85 |
| PIC32MZ1024EFF064 | 1024 + 160 | | | | | | | 8/16 | | | | 2 | | | | | | | | | | | | |
| PIC32MZ1024EFK144 | 1024 + 160 | 256 | 144 | 200 | 6 | 5 | 6 | 8/18 | Y | HS | Y | 2 | 9/9/9 | 48 | 6 | 2 | 9/4 | Y | Y | Y | Y | Y | Y | −40 to +85 |
| PIC32MZ1024EFK124 | 1024 + 160 | 256 | 124 | 200 | 6 | 5 | 6 | 8/18 | Y | HS | Y | 2 | 9/9/9 | 48 | 6 | 2 | 9/4 | Y | Y | Y | Y | Y | Y | −40 to +85 |
| PIC32MZ1024EFK100 | 1024 + 160 | 256 | 100 | 200 | 6 | 5 | 6 | 8/18 | Y | HS | Y | 2 | 9/9/9 | 40 | 6 | 2 | 9/4 | Y | Y | Y | Y | Y | Y | −40 to +85 |
| PIC32MZ1024EFK064 | 1024 + 160 | 256 | 64 | 200 | 4 | 4 | 6 | 8/18 | Y | HS | Y | 2 | 9/9/9 | 24 | 6 | 2 | 9/4 | Y | Y | N | Y | Y | Y | −40 to +85 |
| PIC32MZ0512EFE144 | 512 + 160 | 128 | 144 | 200 | 6 | 5 | 6 | 8/12 | Y | HS | Y | – | 9/9/9 | 48 | 6 | 2 | 9/4 | Y | Y | Y | Y | Y | N | −40 to +85 |
| PIC32MZ0512EFF144 | 512 + 160 | | | | | | | 8/16 | | | | 2 | | | | | | | | | | | | |
| PIC32MZ0512EFE124 | 512 + 160 | 128 | 124 | 200 | 6 | 5 | 6 | 8/12 | Y | HS | Y | – | 9/9/9 | 48 | 6 | 2 | 9/4 | Y | Y | Y | Y | Y | N | −40 to +85 |
| PIC32MZ0512EFF124 | 512 + 160 | | | | | | | 8/16 | | | | 2 | | | | | | | | | | | | |
| PIC32MZ0512EFE100 | 512 + 160 | 128 | 100 | 200 | 6 | 5 | 6 | 8/12 | Y | HS | Y | – | 9/9/9 | 40 | 6 | 2 | 9/4 | Y | Y | Y | Y | Y | N | −40 to +85 |
| PIC32MZ0512EFF100 | 512 + 160 | | | | | | | 8/16 | | | | 2 | | | | | | | | | | | | |
| PIC32MZ0512EFE064 | 512 + 160 | 128 | 64 | 200 | 4 | 4 | 6 | 8/12 | Y | HS | Y | – | 9/9/9 | 24 | 6 | 2 | 9/4 | Y | Y | N | Y | Y | N | −40 to +85 |
| PIC32MZ0512EFF064 | 512 + 160 | | | | | | | 8/16 | | | | 2 | | | | | | | | | | | | |
| PIC32MZ0512EFK144 | 512 + 160 | 128 | 144 | 200 | 6 | 5 | 6 | 8/18 | Y | HS | Y | 2 | 9/9/9 | 48 | 6 | 2 | 9/4 | Y | Y | Y | Y | Y | Y | −40 to +85 |
| PIC32MZ0512EFK124 | 512 + 160 | 128 | 124 | 200 | 6 | 5 | 6 | 8/18 | Y | HS | Y | 2 | 9/9/9 | 48 | 6 | 2 | 9/4 | Y | Y | Y | Y | Y | Y | −40 to +85 |
| PIC32MZ0512EFK100 | 512 + 160 | 128 | 100 | 200 | 6 | 5 | 6 | 8/18 | Y | HS | Y | 2 | 9/9/9 | 40 | 6 | 2 | 9/4 | Y | Y | Y | Y | Y | Y | −40 to +85 |
| PIC32MZ0512EFK064 | 512 + 160 | 128 | 64 | 200 | 4 | 4 | 6 | 8/18 | Y | HS | Y | 2 | 9/9/9 | 24 | 6 | 2 | 9/4 | Y | Y | N | Y | Y | Y | −40 to +85 |

**Note:** AEC-Q100 qualified for grade 1, 2 and 3. Check individual product pages on www.microchip.com for details.
Please contact your Microchip representative for availability.

# Package Options

28-pin QFN
6 × 6 mm (ML)

28-pin SSOP
10.2 × 7.8 mm (SS)

28-pin SOIC
17.9 × 10.3 mm (SO)

28-pin SPDIP
36 × 7.5 mm (SP)

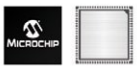
36-pin VTLA
5 × 5 mm (TL)

44-pin VTLA
6 × 6 mm (TL)

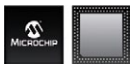
44-pin TQFP
10 × 10 mm (PT)

44-pin QFN
8 × 8 mm (ML)

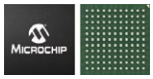
64-lead TQFP
10 × 10 mm (PT)



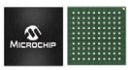
64-lead QFN
9 × 9 mm (MR)



124-lead VTLA (TL)
9 × 9 mm



121-ball BGA
10 × 10 mm (BG)



100-ball TFBGA*
7 × 7 × 1.2 mm

100-lead TQFP
12 × 12 mm (PT)

100-lead TQFP
14 × 14 mm (PF)

144-lead TQFP (PH)
16 × 16 × 1 mm

144-lead LQFP (PL)
20 × 20 × 1.4 mm

*For availability please contact your local Microchip Sales Office.

## Support

Microchip is committed to supporting its customers in developing products faster and more efficiently. We maintain a worldwide network of field applications engineers and technical support ready to provide product and system assistance. In addition, the following service areas are available at www.microchip.com:

- **Support** link provides a way to get questions answered fast: http://support.microchip.com
- **Sample** link offers evaluation samples of any Microchip device: http://sample.microchip.com
- **Forum** link provides access to knowledge base and peer help: http://forum.microchip.com
- **Buy** link provides locations of Microchip Sales Channel Partners: www.microchip.com/sales

## Training

If additional training interests you, then Microchip can help. We continue to expand our technical training options, offering a growing list of courses and in-depth curriculum locally, as well as significant online resources – whenever you want to use them.

- Technical Training Centers and Other Resources: www.microchip.com/training
- MASTERs Conferences: www.microchip.com/masters
- Worldwide Seminars: www.microchip.com/seminars
- eLearning: www.microchip.com/webseminars

## Sales Office Listing

### AMERICAS

**Atlanta**
Tel: 678-957-9614
**Austin**
Tel: 512-257-3370
**Boston**
Tel: 774-760-0087
**Chandler**
Tel: 480-792-7200
**Chicago**
Tel: 630-285-0071
**Cleveland**
Tel: 216-447-0464
**Dallas**
Tel: 972-818-7423
**Detroit**
Tel: 248-538-2250
**Houston**
Tel: 281-894-5983
**Indianapolis**
Tel: 317-773-8323
**Los Angeles**
Tel: 949-462-9523
**New York**
Tel: 631-435-6000
**San Jose**
Tel: 408-735-9110
**Toronto**
Tel: 905-673-0699

### EUROPE

**Austria - Wels**
Tel: 43-7242-2244-39
**Denmark - Copenhagen**
Tel: 45-4450-2828
**France - Paris**
Tel: 33-1-69-53-63-20
**Germany - Dusseldorf**
Tel: 49-2129-3766400
**Germany - Munich**
Tel: 49-89-627-144-0
**Germany - Pforzheim**
Tel: 49-7231-424750
**Italy - Milan**
Tel: 39-0331-742611
**Italy - Venice**
Tel: 39-049-7625286
**Netherlands - Drunen**
Tel: 31-416-690399
**Poland - Warsaw**
Tel: 48-22-3325737
**Spain - Madrid**
Tel: 34-91-708-08-90
**Sweden - Stockholm**
Tel: 46-8-5090-4654
**UK - Wokingham**
Tel: 44-118-921-5800

### ASIA/PACIFIC

**Australia - Sydney**
Tel: 61-2-9868-6733
**China - Beijing**
Tel: 86-10-8569-7000
**China - Chengdu**
Tel: 86-28-8665-5511
**China - Chongqing**
Tel: 86-23-8980-9588
**China - Dongguan**
Tel: 86-769-8702-9880
**China - Hangzhou**
Tel: 86-571-87928115
**China - Hong Kong SAR**
Tel: 852-2943-5100
**China - Nanjing**
Tel: 86-25-8473-2460
**China - Qingdao**
Tel: 86-532-8502-7355
**China - Shanghai**
Tel: 86-21-5407-5533
**China - Shenyang**
Tel: 86-24-2334-2829
**China - Shenzhen**
Tel: 86-755-8864-2200
**China - Wuhan**
Tel: 86-27-5980-5300
**China - Xiamen**
Tel: 86-592-2388138
**China - Xian**
Tel: 86-29-8833-7252
**China - Zhuhai**
Tel: 86-756-3210040

### ASIA/PACIFIC

**India - Bangalore**
Tel: 91-80-3090-4444
**India - New Delhi**
Tel: 91-11-4160-8631
**India - Pune**
Tel: 91-20-3019-1500
**Japan - Osaka**
Tel: 81-6-6152-7160
**Japan - Tokyo**
Tel: 81-3-6880-3770
**Korea - Daegu**
Tel: 82-53-744-4301
**Korea - Seoul**
Tel: 82-2-554-7200
**Malaysia - Kuala Lumpur**
Tel: 60-3-6201-9857
**Malaysia - Penang**
Tel: 60-4-227-8870
**Philippines - Manila**
Tel: 63-2-634-9065
**Singapore**
Tel: 65-6334-8870
**Taiwan - Hsin Chu**
Tel: 886-3-5778-366
**Taiwan - Kaohsiung**
Tel: 886-7-213-7830
**Taiwan - Taipei**
Tel: 886-2-2508-8600
**Thailand - Bangkok**
Tel: 66-2-694-1351

01/27/15

microchip DIRECT
www.microchipdirect.com

MICROCHIP

**Microcontrollers • Digital Signal Controllers • Analog • Memory • Wireless**

**www.microchip.com**



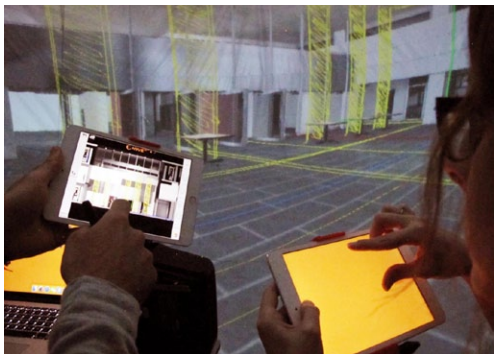
Microchip Technology Inc.
2355 W. Chandler Blvd.
Chandler, AZ 85224-6199

ments, eventually other devices could be used, such as smart phones or watches."

What does control plane mean?

"We use a Butterfly-net analogy to explain how the cursor selects objects in space, the users simply sweep the 3D cursors through," Dorta said. "For the manipulations of objects, the users can use gestures and movements such as pinching and orientation."

The cursor is in fact being demonstrated within the researchers' Hyve-3D design system, a full scale immersive 3D environment that enables users to create drawings on hand-held tablets, which can then be manipulated on the tablets to create a 3D design within the space. As the designers are immersed in their work, for example designing a living room, they can test different furniture options according to the scale and even work on the interior detailing.



**Researchers at the University of Montreal have developed techniques that enable computer cursors to interact in 3-D in single or multiuser, local or remote collaboration scenarios. Image courtesy of Hybridlab, Université de Montréal.**

The immersive images are the result of an optical illusion created by a high-resolution projector, a specially designed 5m-diameter spherically concave fabric screen and a dome mirror projecting the image onto the screen. Specialized techniques render the 3D scene onto a spherical projection in real-time

Univalor, the university's technology commercialization unit, is supporting the market launch of the Hyve-3D system and the 3D cursor, via the startup Hybridlab Inc. Several patents are pending.

"Beyond its utility for sketching, we believe the 3D cursor has applications in a wide range of fields, such as architectural design, medical imaging and of course computer games. This isn't a gimmicky rebirth of the cursor, it's about rethinking how humans interact with computers as part of the creative process," Dorta said.

# Startup revives smartphones' joysticks: rear-mount

By Julien Happich

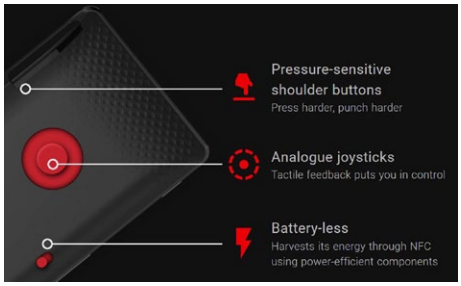
Tiny rubber joysticks had their time embedded in the keyboards of laptops and smartphones from a few years ago, but they could never compete with the versatility of today's touch-screens. Today, London-based start-up Supenta is reviving the idea of built-in joysticks with the Flitchio smartphone case.

The snap-on device adds two shoulder buttons and two ultrathin and pressure-sensitive joysticks at the back of a smartphone shell, promising a much intuitive user interface for mobile gaming or drone control. The actual joysticks rely on Peratech's Quantum Tunnelling Composite pressure-sensitive sensors, enabling users to punch, accelerate or spin harder or faster depending on the pressure they apply. The battery-less case is powered through the phone's NFC reader (harvesting enough energy to power the sensors).

Supenta was incorporated two and a half years ago, it has already won three EU/UK awards and received funding from Innovate UK to build up an engineering team and develop its first prototypes. Its Kickstarter campaign to bring Flitchio to market was short-lived, indeed, the company quickly attracted private investors and decided to cancel the crowd-funding process in favour of a faster ramp-up, hoping to reach the consumer market by February next year.

"Initially, we were planning to offer Flitchio cases for the Samsung Galaxy S6 and S6 Edge, but we had many requests to support more phones, so in February, we'll come up with cases to support at least four flagship smartphones, then we'll add more if need be", told us Dr. Amir Shadmand, CEO and Co-Founder of Supenta during a phone interview.

**Flitchio smartphone case with built-in game controller**




But in the longer term, Shadmand may consider licensing his patent-pending joystick solution to smartphone OEMS, since the technology is thin enough to be integrated directly into the phones' plastic shells.

The add-on joysticks and buttons could find other uses, such as for selfies, menu scrolling, smart TV remotes using your smartphone or even as a novel way to secure and unlock your phone with customized pressure-sensitive patterns.

These add-on buttons impinge no delays on the action, claims Shadmand, they are as fast as today's touch-screen controls, but they operate with more precision and they don't block the view on the display, probably the best-selling argument considering smartphones' limited screen real-estate.

"We are negotiating with a company making miniature drones, they want Flitchio as their controller", told us Shadmand. "Their current remote controller is double the size of the drone itself, and the problem with smartphone-based touch-screen control is that when you are streaming video, you don't see what's happening if your fingers block half the view".

Supenta will soon release a software development kit, so many more applications could emerge. Early 2016, Flitchio is expected to retail for GBP 39 including VAT.

## First 6-inch 4K AMOLED panel targets VR devices

EverDisplay Optronics (EDO) has launched what is claimed to be the world's first 6-inch 4K AMOLED display. Although 4K TV is already commonplace among the consumer market, replicating the same resolution onto a 6-inch panel has demanded a hike up to 734 PPI and represents a hundred-fold scale challenge in terms of both design and process. The advent of the 6-inch 4K AMOLED panel, which has a resolution of 3840 x 2160, opens up wider possibilities for newer applications, such as virtual reality (VR). Whether smartphone display demands super high resolution remains to be seen, but a host of new applications would definitely use much more pixel packed displays. More than perfect color, AMOLED displays offer low latency, real darkness with superb contrast ratio and minimal hazardous high-energy blue ray. All those features are ideal to support VR devices. EDO has been quickly catching up on the industry, first with HD resolution from March 2014 to FHD, then WQHD (2.5K) and UHD (4K) today, all done in less than 18 months. With its 6-inch 4K display, EDO has projected itself to the forefront of first tier in the industry.

**EverDisplay Optronics**
www.everdisplay.com

## SVGA TFT LCDs rated for 11 years, 24/7 in harsh applications

MSC Technologies offers two SVGA (800 x 600 pixels) TFT LC displays from NLT for harsh industrial applications. The LCDs integrate long-life LED backlights that provide 100,000 hours of operation, a new breakthrough for NLT products. This corresponds to a continuous operating time of eleven years for 24/7. The long-life backlight reduces significantly the maintenance times and costs of the visualization system. Thanks to their extended temperature range of -30°C to +80 °C, the robust displays are also ideal for outdoors. Typical fields of application are factory automation, analytical instrumentation as well as high-performance test and measuring equipment. The NL8060AC21-21D and NL8060AC26-52D TFT LCDs available in diagonal sizes of 8.4-inch (21.34 cm) and 10.4-inch (26.42 cm) deploy ColorXcell technology developed by NLT that ensures true color reproduction combined with low power consumption. The typical power consumption is specified as 3.4 W (4.7 W for the larger display). Furthermore, the displays provide the technical data required typically for industrial applications: A luminance of 400 cd/m² (typ.) and a contrast ratio of 800:1 (NL8060AC21-21D) or 900:1 (NL8060AC26-52D). The color palette covers 16.77 million colors. Viewing angle is 160 degrees (horizontal and vertical) and the display surface is coated with an anti-glare film. The NL8060AC21-21D measures 200x152x8.2mm, the NL8060AC26-52D is 243x185.1x10.5mm.

**MSC Technologies**
www.msc-technologies.eu

## Touch panel adds complete HMI to Raspberry Pi

4D Systems ( Sydney, Australia) and distributor element14 have introduced the 4DPi-24-HAT, a touch panel that enables the display to function with the Raspberry Pi without the need of a mouse or an alternate HMI device. 4DPi-24-HAT is a 2.4-inch, 320x240 pixel fully HAT standard compliant primary display with resistive touch that plugs directly on top of a Raspberry Pi. It displays the primary output of the Raspberry Pi, which is normally sent to the HDMI or Composite output. The integrated Resistive Touch panel enables the display to function with the Raspberry Pi without the need for a mouse or an alternative HMI device. The 4DPi-24-HAT is designed to work with the Raspbian Operating System and is powered directly off the Raspberry Pi's 40-way header requiring no external power supply and allows touch-based interaction with the Raspbian Operating System. The display has a typical framerate of 25 frames per second, which can be increased with kernel compression. The display's backlight can be turned on or off using an on-board jumper or dimmed using PWM controls. The on-board EEPROM allows for quick identification of the 4DPi-24-HAT by the Raspberry Pi. The 4DPi-24-HAT is compatible with Raspberry Pi A+, B+ and Raspberry Pi 2 and is fully HAT Standard compliant.

**4D Systems**
www.4dsystems.com.au

## Automotive HMI design suite shapes digital instrument clusters

Integration of Green Hills Software's Integrity real-time operating system with Luxoft's Populus Suite HMI design tool chain enables its use many MCU platforms that are frequently employed in automotive digital instrument clusters Together with the use of Green Hills Software's Multi integrated development tool chain, this combination allows Populus to run on a wide range of automotive grade microcontrollers (MCUs), enabling the creation of robust digital instrument clusters with a low memory footprint. Luxoft's Populus is designed for operation using a low memory footprint. By addressing the specific features of the MCU, a highly optimised Populus runtime engine enables the combination of a high performance HMI with very low memory consumption for both the engine stored in the flash memory as well as the RAM memory needed during the runtime. Luxoft's Populus Suite enables the rapid HMI development for customisable, 2D or 3D, fully digital instrument clusters, head-up displays (HUD), in-vehicle infotainment systems and entry level to mid-tier Head Units. Security is achieved by the use of hardware memory protection to isolate and protect embedded applications. Secure partitions guarantee each task the resources it needs to run correctly and fully protect the operating system and user tasks from errant and malicious code, including denial-of-service attacks, worms, and Trojan horses.


**Green Hills Software**
www.ghs.com

# THINK™

## CATALOG M65


- Easy to use, 152-page Catalog
- Details more than 5,000 quality products
- Featuring hundreds of new products
- Illustrated with engineering drawings, specifications and product photographs
- Imperial and Metric dimensions
- *Call or visit our website to request your free catalog

**European Headquarters:** www.keyelco.com • (718) 956-8900 • (800) 221-5510

*For FREE Catalog Contact Keystone Today!

| DATE | DESCRIPTION | REV. |
|---|---|---|
| | | |

# An adaptive power management solution for energy harvesting

By Bruce Haug

Energy surrounds us everywhere and is available in the form of temperature, light, galvanic and even electromechanical energy. However, the energy from these sources is often found in such minute quantities that it cannot continuously supply adequate power for any viable purpose.
In fact, until recently, it has not been possible to capture sufficient energy to perform any useful function, with the exception of solar and geothermal. Energy Harvesting is the process of capturing minute amounts of energy from one or more of these naturally occurring energy sources, then accumulating or storing them for later use. Energy harvesting devices can efficiently and effectively capture, accumulate, store, condition and manage ambient energy and condition them in a form that can be used to perform useful functions.

Recent technical advancements have increased the efficiency of devices in capturing trace amounts of energy from the environment, transforming it into electrical energy. In addition, advancements in converter technology have not only increased power conversion efficiency but have also reduced their internal power consumption requirements. These developments have sparked interest from the engineering community to develop even more applications that utilize energy harvesting.

Energy harvesting from an ambient source, where a remote application is deployed, and where a natural energy source is essentially inexhaustible, is an increasingly attractive alternative to wired power or batteries. These essentially free energy sources, when utilized properly, can be maintenance-free and are usually available throughout the working lifetime of many applications.

Alternatively, energy harvesting can be used as a secondary energy source to supplement a primary power source such as a battery to greatly extend the life of the battery, reducing maintenance costs.

## Energy harvesting applications

Many real life applications using energy harvesting as the main power source are now in use. Wireless sensor networks (WSNs), for example, often benefit from energy harvesting power sources. When a wireless node is deployed at a remote site where wired power or a battery is either unreliable or unavailable, energy harvesting can supply the power needed to operate it. In other situations, multiple energy sources can be used to enhance the overall efficiency and reliability of a given system.

Some of the most common energy harvesting sources include mechanical energy from sources such as vibration, mechanical stress and strain; thermal energy from waste energy by-product from furnaces, heaters, motors and friction sources; light energy captured from sunlight or room lighting via photo diodes, or solar cells; electromagnetic energy from inductors, coils and transformers; natural ambient energy from the environment such as wind, water flow, ocean currents, galvanic and solar; human body through a combination of mechanical and thermal energy generated or through actions such as kinetic movement; and other energy from chemical and biological sources.

It is important to note that all these energy sources are virtually unlimited and essentially free, if they can be captured at, or near, the system's point of deployment.

A typical energy harvesting system requires an energy source such as vibration, heat or light plus some key electronic components. These include an energy conversion device (transducer) such as a piezoelectric element or solar panel that can translate the ambient energy source into electrical form; an energy harvesting conversion IC that captures, stores and manages power; sensors, microcontrollers and a transceiver to read, record and transmit the data as part of the WSN; optional supplementary energy storage device such as thin-film or primary cell battery or super capacitor.

It is very important that the power conversion device have a high efficiency and a low quiescent current so as to allow most of the harvested energy to be used for powering the sensor network or control and monitoring device. Furthermore, it is essential to understand how much average power is available from the harvestable energy source and how much energy is required to power the device being powered (its duty cycle of operation).

## Energy harvesting IC solutions

Fortunately Linear Technology has several energy harvesting devices for processing, storage and utilization of harvestable energy. The LTC3106 is one such device that is a highly integrated, ultralow voltage buck-boost DC/DC converter with automatic PowerPath management optimized for multiple input sources and low power systems. If the primary power source is unavailable, the LTC3106 seamlessly switches to the backup power source and is compatible with either rechargeable or primary cell batteries and can trickle charge a backup battery whenever there is surplus energy available.

If a light source is used, an optional maximum power point control ensures power transfer is optimized between power source and load. At no load, the LTC3106 draws only 1.6µA

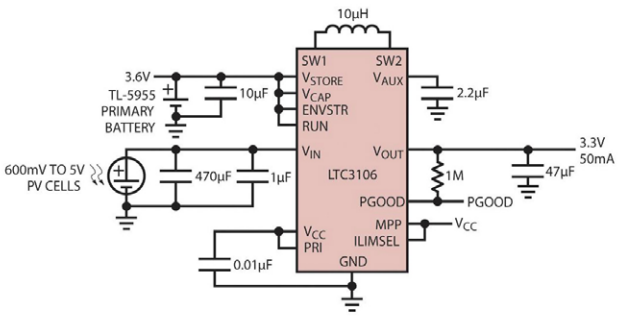



**Fig. 1: The LTC3106 uses either a solar panel or primary battery to provide continuous power to a downstream load.**

**Bruce Haug** is Senior Product Marketing Engineer for Power Products at Linear Technology Corporation – www.linear.com

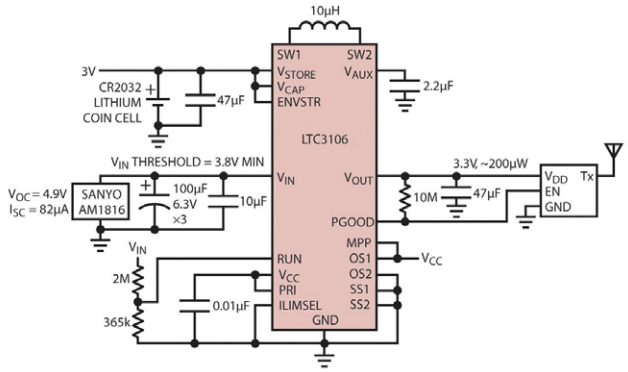



**Fig. 2: LTC3106 configured as a solar harvester with primary battery backup powering a wireless network node.**

while creating an output voltage up to 5V from either input source. Figure 1 shows a typical schematic.

The LTC3106 employs a PowerPath™ control architecture to allow the use of a single inductor to generate a user-selectable fixed regulated output voltage through seamless transition between either of the two power inputs. If input power is available ($V_{IN}$) the buck-boost regulator will operate from $V_{IN}$, provi-ding up to 300mA to the load. Should the $V_{IN}$ source become unavailable, the regulator will select $V_{STORE}$/$V_{CAP}$ as its input delivering up to 50mA to the load. If a rechargeable battery is used as the backup source, a low current recharge power path is also provided allowing use of excess input energy to charge the backup source if the output voltage is in regulation.

User selectable upper and lower charge/discharge thresholds are available to handle multiple battery chemistries and to protect the battery from overcharge/deep discharge. Charging can be externally disabled using the PRI when a primary battery is used as the backup source.

The main input voltage, $V_{IN}$, can be configured to operate over a voltage range from 850mV to 5.1V without a back-up source and from 330mV to 5.1V with a back-up source, like a primary battery. This range accommodates multiple power source types including high impedance sources such as a small solar panel. To ensure maximum power extraction, the LTC3106

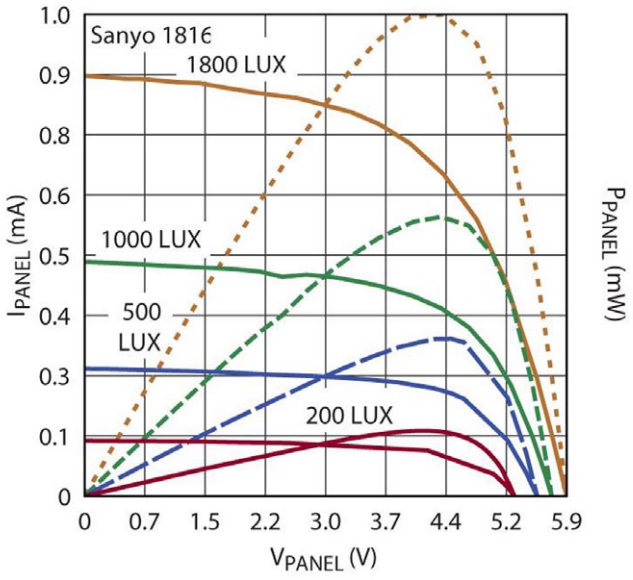



**Fig. 3: Measured I-V and P-V curves under variable light conditions for AM-1816.**

| LOCATION | ILLUM. (Lux) |
|---|---|
| Meeting Room | 200 |
| Corridor | 200 |
| Office Desk | 400 to 700 |
| Lab | 500 to 1000 |
| Outdoors (Overcast) | 1000 to 2000 |
| Outdoors (Clear) | >2000 |

Table 1: Typical light conditions.

integrates an accurate RUN pin and an optional maximum power point function. Both can be used to control regulator turn on at the maximum power point of an input source. For higher power input sources the accurate RUN pin function is ideal to program predictable regulator turn on at a specific input voltage.

In the event that the input harvestable energy voltage is lost, a primary or secondary battery may be connected from $V_{STORE}$ to GND to power the system. In the case of a rechargeable battery, current will be sourced from this pin to trickle charge the battery, up to the maximum selected voltage.

The LTC3106 will start up from either input voltage source but gives priority to $V_{IN}$. The AUX output is initially charged with the synchronous rectifiers disabled. Once $V_{AUX}$ has reached its terminal voltage the output voltage is then also charged asynchronously until $V_{OUT}$ reaches approximately 1.2V. The converter then leaves the asynchronous mode in favor of a more efficient synchronous start-up mode until $V_{OUT}$ is in regulation and the part enters normal operation. It is normal for the output voltage to rise as $V_{AUX}$ is charging. The main output voltage is user programmed to one of four pre-set regulated voltages of 1.8V, 2.2V, 3.3V or 5V.

## A real-life design example

In a traditional battery powered-only wireless network node, the main control unit (MCU) is connected directly to the battery. Several factors contribute to reduced battery capacity in these applications. Typically these wireless systems poll the node at a very low frequency with long low power inactive periods with occasional high current bursts when communicating with the node. The peak current during the pulsed load can be much greater than the nominal drain current given by the battery manufacturer, reducing capacity beyond that specified at the typical static drain current. Further, the usable input voltages for most MCUs (2V min typ) limit the usable battery capacity.

The application circuit in Figure 2 shows the LTC3106 interfaced with the AM-1816 solar cell with an overall dimension of 9.8cm X 5.7cm (size of business card) and is supplemented with a CR2032 primary battery configured to deliver power to a pulsed load output. Though an energy harvesting system can eliminate the need for batteries, it can also serve to supplement and increase battery life. When sufficient ambient energy is available, the battery is unloaded and is only used when the ambient source is inadequate to service the load. This not only extends battery life but improves reliability by extending battery life and also reducing service cost.

The main input voltage of the LTC3106 ($V_{IN}$) is designed to accommodate high impedance solar cells over a wide voltage range. Solar cells are classified according to their output power level, material employed (crystal silicon, amorphous silicon, compound semiconductor) and application space (indoor or outdoor lighting). Sanyo Electric's Amorton product line (a subsidiary of Panasonic) offers a variety of solar cells for various light conditions (see Table 1 for typical light conditions) and power levels as well the ability to customize cells for specific application size and shapes. Additional companies that manufacture small solar cells suitable for use with the LTC3106 include PowerFilm, G24 Power and Alta Devices.

The I-V and P-V curves for the AM-1816 panel are shown in Figure 3. The maximum power from the cell (PMAX) changes with light level but the voltage at PMAX changes only slightly. The $V_{IN}$ threshold voltage in this application example is set to equal the voltage at PMAX using the resistive divider on the RUN pin. The input voltage rising UVLO threshold $V_{IN(OV)}$ set point was chosen to be 4.2V. With internal hysteresis, the $V_{IN(UV)}$ is then 3.8V, so the average VIN voltage of ~4V is at the maximum power point from the manufacturer I-V and P-V data on the AM-1816 solar cell.

| INTERVAL | MCU FUNCTION | PEAK CURRENT $I_n$ (mA) | INTERVAL $T_n$ (ms) | CHARGE $I_nT_n$ (µC) | REGION DUTY CYCLE (%) | INTERVAL OUTPUT POWER (mW) | AVERAGE OUTPUT POWER (µW) | LTC3106 POWER LOSS (FROM CURVES) (mW) | LTC3106 AVERAGE POWER LOSS (µW) |
|---|---|---|---|---|---|---|---|---|---|
| Region 1 | Wake | 0.3 | 1 | 0.3 | 0.1 | 1.0 | 1 | 0.2 | 0.2 |
| Region 2 | Pre-Processing | 8 | 0.6 | 4.8 | 0.1 | 26.4 | 16 | 3 | 1.8 |
| Region 3 | Rx/Tx | 20 | 1 | 20 | 0.1 | 66.0 | 66 | 5 | 5.0 |
| Region 4 | Processing | 8 | 0.5 | 4 | 0.0 | 26.4 | 13 | 3 | 1.5 |
| Region 5 | Rx/Tx | 20 | 1 | 20 | 0.1 | 66.0 | 66 | 5 | 5.0 |
| Region 6 | Sleep/Idle | 0.001 | 1000 | 1 | 99.5 | 0.003 | 3 | 0.02 | 19.9 |
| | | Total Period: 1004ms | | | | Total Avg Power: 165µW | | Total Avg. Power Loss: 37µW | |

Table 2: Application load profile power budget for figure 2.

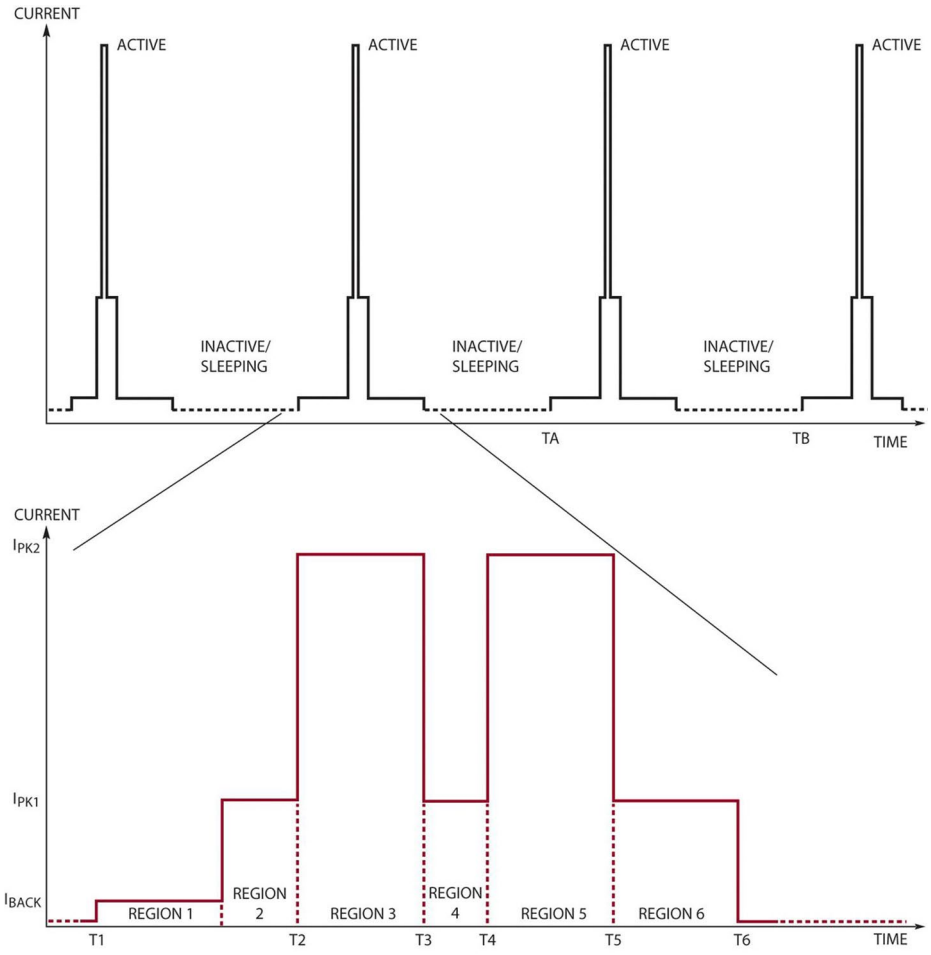



**Fig. 4: Application load profile for the schematic in Figure 2.**

For this application the load is a low power RF device and its load profile is shown in Figure 4. The regions of operation, output and power losses are tabulated and the peak levels are defined for each as shown in Table 2.

The total average LTC3106 operating power loss for the load profile is 37µW. The resister divider load adds an additional 5µW of input power loss for a total input power requirement of 207µW. The calculated average efficiency, including the resistive divider is η = 165µW/207µW which is 80%. The available power from the AM-1816 at 200lux is about 400µW. With a converter efficiency of about 80%, the 400µW powers the total 207µW average load with some margin, drawing no power from the battery.

If the light conditions become less favorable, the available input power may drop below that needed to maintain the output voltage. The LTC3106 will then operate in "hiccup" mode turning on as $V_{IN}$ increases above 4.2V and turning off if $V_{IN}$ drops below 3.8V. With $V_{IN}$ off, power is then taken from $V_{STORE}$ (primary battery) until $V_{IN}$ recovers and increases above the 4.2V threshold. If the light conditions become more favorable, $V_{IN}$ will rise to the open-circuit voltage of the harvested source and once again provide all of the load power.

## Conclusion

Even though some energy harvesting sources only provide low levels of useable power, as shown in the design example in this article with a solar cell the size of a business card, they are usually enough to power most wireless sensors. The LTC3106 buck-boost DC/DC converter is optimized for multiple input sources commonly found in low power systems, and provides the necessary feature set for a broad range energy harvesting applications. As a result, the designers of energy harvesting systems, such as WSNs now have useful and appropriate power conversion ICs to greatly simplify the design task.

# Natcore takes silver out of photovoltaics

By Julien Happich

Research company Natcore Technology claims its scientists have produced a low-cost all-back-contact silicon heterojunction photovoltaic structure in which silver has been completely eliminated, being replaced by aluminium.

The findings at the firm's Rochester R&D Center are key to lower the cost of mass-produced silicon photovoltaic cells and could be licensed to large producers looking at cutting over 10% off their raw materials costs.

Traditionally, and so for the last 60 years, silver has been the conductor of choice to manufacture the electrodes in solar cells, for its high-conductivity metal despite its high price. Indeed, with the average solar panel using about 14 grams of silver, the metal can represent over 48% of the metallization cost of a solar cell, or about 11% of the total raw material cost of a solar module.

At today's prices, silver costs about $0.491 per gram. The same quantity of aluminum costs $0.0016, about 0.3% of the cost of silver. The cost saving realized by switching from silver to aluminum are important, even considering that it would be necessary to use twice as much aluminum as silver in order to have an equal amount of conductivity from cell to cell. The raw material cost of aluminum would still be just 0.6% of the direct material cost of using silver in the cell.

Although Dr. David Levy, Director of Research & Technology at Natcore's Rochester (NY) R&D Center didn't want to share more details about the exact pattern geometries and processes yielding a full silver replacement at no conductivity loss, he expects that in the case of black silicon and aluminium, the company will get revenues not only from licenses and royalties but also from materials sales.

Patents are pending for proprietary laser technology to apply the back contacts to the rear of the cell as well as for other critical aspects of the low-temperature process.

"Licensing our aluminum patterning process is one of our goals. Three companies (two in the U.S., one in Australia) have expressed interest. These are all companies that are planning to get into solar energy. They want to build cell fabs, module fabs, and/or power plants", Levy wrote *EETimes Europe* in an email.

So what have been the challenges to use aluminium instead of silver so far?

"Part of the historical challenge has been the avoidance of a corrosive 'galvanic couple' and fatigue life of aluminum. The Natcore solution has overcome these hurdles. Three other main issues impede the use of aluminum in the types of cells that we are demonstrating. Its lower conductivity than silver means that thicker layers are required, which can pose problems for certain manufacturing techniques.

Aluminum layers can also be prone to oxidation and thus poor electrical properties. Finally, it is difficult to apply aluminum at atmospheric conditions with near bulk conductivity, especially with methods that do not require high temperature and inert atmosphere sintering.

High temperature steps would be incompatible with many of the devices we are demonstrating. Our technology addresses these issues. While we cannot go into details of the structure due to its proprietary nature, expect details to emerge in the next few months as we produce advanced demonstrations and secure the necessary patent protection".

Today, roughly 47 metric tonnes of silver are currently required to generate 1 GW of solar power. That demand translated into roughly 1900 metric tonnes of silver in 2014, or about 6% of the total demand for the metal. Before Natcore's achievement, that demand was projected to rise to 15% of the total market in 2018, but the company is hoping it will have an impact on this market forecast.

# Paper-thin solar charger fits inside a notebook

By Rich Pell

A paper thin and ultra-lightweight solar charger from solar design startup Yolk (Seoul) has already raised over $750,000 of its $50,000 goal in its crowdfunding campaign. Designed to be as thin and aesthetically pleasing as possible, the charger, called Solar Paper, is claimed to be "the world's thinnest and lightest solar charger." It is thin enough that it can be placed inside a notebook or planner, yet the basic 5-W version is powerful enough to charge a smartphone in 2.5 hours on a sunny day according to the company.


Modular in design, Solar Paper can be expanded to handle larger devices by adding new magnetic panels in place. As part of their campaign, the company is offering 5-, 7.5- and 10-W chargers, with two, three or four panels, respectively.

The charger works with almost any device that charges via USB and measures 9x19x1.1cm when folded, and weighs 120 grams. It also includes an LCD current meter that displays the amount of current between the charger and device at any time. The first shipments are expected to start in September.

# ‘Aqueous solar flow’ battery lasts longer

By Paul Buckley

Researchers at The Ohio State University are claiming a new milestone for the world’s first solar air battery by reporting a 20 percent energy saving compared with traditional lithium-iodine batteries.

In the Journal of the American Chemical Society, the Ohio State University researchers report that their patent-pending design, which combines a solar cell and a battery into a single device, is capable of producing 20 percent of its energy from sunlight, which is captured by a novel solar panel on top of the battery, explained Yiying Wu, professor of chemistry and biochemistry at Ohio State.

In tests, the researchers compared the solar flow battery’s performance to that of a typical lithium-iodine battery. The researchers charged and discharged the batteries 25 times. Each time, both batteries discharged around 3.3 volts.

The difference was that the solar flow battery could produce the same output with less charging. The typical battery had to be charged to 3.6 volts to discharge 3.3 volts. The solar flow battery was charged to only 2.9 volts, because the solar panel made up the difference. That is an energy savings of nearly 20 percent.

The device’s solar panel is now a solid sheet, rather than a mesh as in the previous design which was created in 2104. Another key difference comes from the use of a water-based electrolyte inside the battery. Because water circulates inside it, the new design belongs to an emerging class of batteries called aqueous flow batteries.

“The truly important innovation here is that we’ve successfully demonstrated aqueous flow inside our solar battery,” said Yiying Wu, professor of chemistry and biochemistry at Ohio State University.

The device claims to be the first aqueous flow battery with solar capability. Or, as Wu and his team have dubbed it, the first ‘aqueous solar flow battery’.

“It’s also totally compatible with current battery technology, very easy to integrate with existing technology, environmentally friendly and easy to maintain,” added Wu.

“This solar flow battery design can potentially be applied for grid-scale solar energy conversion and storage, as well as producing ‘electrolyte fuels’ that might be used to power future electric vehicles,” said Mingzhe Yu, lead author of the paper and a doctoral student at Ohio State.

Previously, Yu designed the solar panel out of titanium mesh, so that air could pass through to the battery. But the new aqueous flow battery does not need air to function, so the solar panel is now a solid sheet.

The solar panel is called a dye-sensitized solar cell, because the researchers use a red dye to tune the wavelength of light it captures and converts to electrons. Those electrons then supplement the voltage stored in the lithium-anode portion of the solar battery.

Something has to carry electrons from the solar cell into the battery, however, and that is where the electrolyte comes in. A liquid electrolyte is typically part salt, part solvent; previously, the researchers used the salt lithium perchlorate mixed with the organic solvent dimethyl sulfoxide. Now they are using lithium iodide as the salt, and water as the solvent. (Water is an inorganic solvent, and an eco-friendly one. And lithium iodide offers a high-energy storage capacity at low cost.)

“We hope to motivate the research community to further develop this technology into a practical renewable energy solution,” added Wu.

The team’s ultimate goal is to boost the solar cell’s contribution to the battery past its current 20 percent - maybe even to 100 percent.

“That’s our next step,” Wu said, “to really achieve a fully solar-chargeable battery.”

# Thin film solar cells may rival silicon

By R. Colin Johnson

A consortium of eleven European partners in eight countries claims to have an efficient alternative to silicon that achieves 25% efficiency with its Sharc25 (super-high efficiency CIGS thin-film solar cells) program to produce single-junction thin-film solar cells that rival silicon at 25 percent efficiency for a fraction of the cost of the cheap low-efficiency Chinese varieties.

Today run-of-the-mill single-crystal silicon solar cells—the most used variety—average about 25 percent efficiency, although advanced designs have been reported to have efficiencies approaching the theoretical limit of 33 percent. The cheap thin-film variety favoured by Chinese manufacturers and other low-cost solar cell suppliers use achieve significantly lower efficiencies, although last month Japan's National Institute of Advanced Industrial Science and Technology (AIST), the Photovoltaic Power Generation Technology Research Association (PVTEC), Sharp, Panasonic, and Mitsubishi reported a triple-junction thin-film solar cell built in a joint venture that achieved in excess of 13 percent efficiency.

**Empa doctoral candidates Patrick Reinhard and Benjamin Bessig check out the latest run of thin-film solar cells aiming for 25 percent efficiency. (Source: Eidgenössische Materialprüfungs- und Forschungsanstalt (Empa))**

The Sharc25 project, coordinated by the Centre for Solar Energy and Hydrogen Research Baden-Wurttemberg (ZSW, Stuttgart, Germany) was funded to the tune of $6.9 million by the European Union's Horizon 2020 program in conjunction with the Swiss government's Federal Laboratories for Materials Science and Technology at Eidgenossische Materialprufungs und Forschungsanstalt (Empa, Dubendorf, Switzerland).

"Our solar cells could be used for small devices such as wearables," Ayodhya Tiwari, head of Empa's Thin Film and Photovoltaics laboratory and the scientific coordinator of Sharc25 told *EE Times.* "But our main interest is large scale power generation for applications in buildings and solar farms on a utility scale."

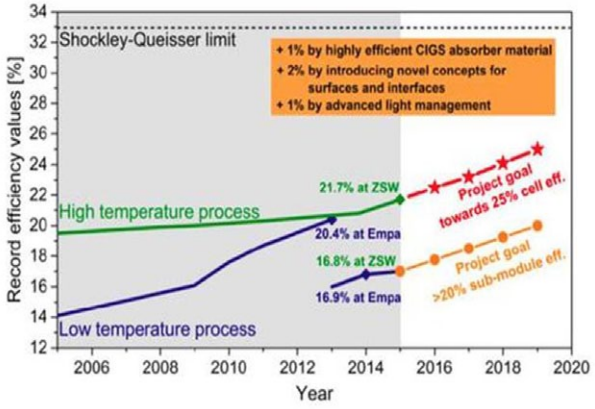
Many other solar cell researchers worldwide have tried to increase the efficiency of thin-film copper indium gallium diselenide (CIGS) solar cells, and indeed have made advances in the last few years—some of which could be called breakthroughs, nevertheless no thin-film solar cell technology today rivals silicon. Empa, on the other hand, believes it has the hubris and the funding to achieve the as yet unachieved goal. Why?

"Because of the breakthrough results achieved during the last two years, and our analyses of the remaining losses in efficiency for which we see possibilities for further improvement. In science you follow logical facts and work on certain assumptions with good conviction based on your experience and knowledge provided by other experts. Innovation and breakthroughs are probable and we work to achieve success by trying our best and hoping for advancements," Tiwari told EE Times.

Their goal is admittedly ambitious, however these E.U. scientists believe they have to collective abilities to surmount the engineering hurdles they have already identified as holding back thin-film CIG-based cells from achieving efficiencies rivalling silicon. Plus they have the funding they need to do it, but their motivation is humanitarian—not for profit—giving their efforts a better chance of success.

"Our next step is to collaborate with our partners on this very ambitious project with a plan on which all the project partners are enthusiastic to bring their expertise to bear. I don't think we, as scientists, are just working for the end game, our ambitions and targets keep on rising, and we set new challenging targets as we go along. So our endeavour is to try our best until easily affordable solar electricity for all around the world is available. We have to work on processes suitable for industrial production and collaborate to transfer know-how into innovative ideas," Tiwari told *EE Times*.

The other project partners, besides Empa and ZSW, include the universities of Luxembourg, Rouen, Parma and Aalto, the Interuniversitair Micro-Elektronica (Imec), the Helmholtz-Zentrum Berlin (HZB) für Materialien und Energie, the International Iberian Nano-technology Laboratory (INL), Flisom AG and Manz CIGS Technology GmbH.




**The 3.5 year program has two goals the most ambitious of which is it rival silicon with 25 percent efficiency for thin-film solar cells. (Source: Eidgenössische Materialprüfungs- und Forschungsanstalt (Empa))**

Empa has already achieved over 20 percent efficiency for CIGS-based thin-film cells on plastic foil, and ZSW has topped Empa at 21.7 percent and the rest of the partners believe they have identified the areas that need improvement to achieve 25 percent--namely improve absorption, more efficient surfaces and interfaces along with optimizing light management.

The consortium's ultimate goal is to best Asia's multi-junction solar cells with a cheaper single-junction thin film cell that reduces the cost of manufacturing solar modules in Europe below that in China, namely to $0.38 per Watt-peak for wearables, households and even grid-sized mass produced installations, according to Tiwari.

# Shock absorber harvests energy from car's suspension

By Rich Pell

Researchers at Virginia Tech's College of Engineering (Blacksburg, VA) have developed a shock absorber system designed to harvest large-scale vibrational energy from a car's suspension.

Using a combination of gears allowing motion in both directions, the energy-harvesting shock absorber works by converting the vertical vibrations of a moving car's suspension into a rotational motion that turns a generator. The generated electricity is then delivered directly to the car's battery or electronic devices, reducing demands on the alternator.

According to Lei Zuo, associate director of the Virginia Tech Center for Energy-Harvesting Materials and Systems, a car's shock absorbers should be able to provide between 100 and 400W on normal roads (and even more on bumper roads). Tests of the energy harvesting shock absorber on campus roads, he says, have shown that the system can capture about 60% of the available energy. The test model was constructed by students using off-the-shelf components.

According to the researcher, an efficiency of 85% should be achievable if this system is built using precision components and manufacturing. The next phase of development will focus on cost and performance. Zuo is looking into a MPU-controlled system using self-powered semi-active control, where suspension settings would adjust automatically to vehicle and road conditions for optimum comfort and energy harvesting.

## Startup offers energy harvest management IC

Startup company E-peas Semiconductors (Liege, Belgium) has announced its first chip in energy management IC for use with photovoltaic and thermoelectric energy harvesting. The AEM1x940 is an energy management IC that extracts DC power from photovoltaic cells or thermoelectric generators to supply electronic systems in order to extend their battery life and ultimately get rid of the primary storage element.

It uses a low power boost converter that can operate with input voltages in the range of 100mV up to 2.5V. With a special "cold-start" circuit it can start operating with empty storage elements at an input voltage as low as 380mV and an input power as low as 3µW, according to the e-peas website.

The device includes two LDO regulators for 1.8V output at up to 10mA load and a variable LDO at 2.5V to 4V with up to 30mA load current. Overcharging and over-discharging protection are provided and the design is described as being RF transmission friendly.

# IoT network concerns

By Rick Merritt

The Internet of Things lacks a wide area network with broad coverage and low cost, according to a panel of experts working to bridge the gap to fuel IoT deployments.

Today's long range machine-to-machine networks generally use wired or cellular links that are widely available but too expensive to be profitable, said Syed Hosain, chief technologist at Aeris Communications Inc., an M2M carrier. In the next couple years, none of a handful of emerging technologies likely will have the coverage needed to spark widespread use, he said in a panel at the recent ESC SV event.

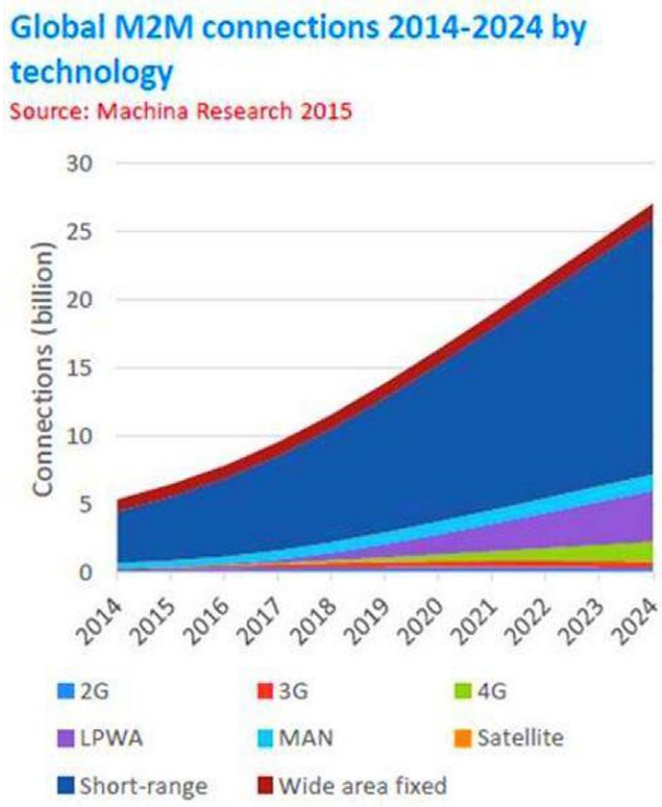
People deploying IoT networks don't want to have to think about whether a network is available in their area, said Hosain whose first customers were alarm and trucking companies offering services across the U.S.

"I postulate that for the next ten years cellular is the only viable option for that kind of coverage," Hosain said. "I'm not sure where we will get the dollars to deploy [these new IoT networks]," he added.

The LoRa Alliance led by Semtech has the best shot at being the first to have broad coverage, in part because it has backing from more than 90 companies including Cisco, IBM, Microchip and SK Telecom, Hosain predicted. One U.S. carrier is said to be close to signing a deal to deploy the 900 MHz LoRa net in one of its U.S. regional markets for applications such as smart buildings, agriculture and asset tracking.

Sigfox (Toulouse, France) is widely thought to have an edge because it already has national networks in a handful of European countries and snagged more than $90 million last year to deploy a U.S. network. In February, Sigfox said it plans to 1,300 base stations in ten U.S. cities by the end of the year - including Houston, LA, New York, Portland San Francisco and Seattle - and as many as 4,000 base stations covering a total of 30 cities by the end of 2016.

Hosain praised Sigfox for its simple API and network architecture, but said having coverage limited to 30 cities over the next year and a half was subpar. He also expressed concern SigFox may not be able to meet an FCC requirement to limit 900 MHz networks to 400 millisecond transmissions when deployed in urban environments. The FCC requirement is the reason Sigfox limits nodes to transmitting 140 12-byte messages and receiving four 8-bytes a day, Hosain said.




**Low power wide area (LPWA) networks will make up just 14% of all M2M links by 2024.**

In addition, he took issue with the Sigfox business model of charging a fixed cost per node, estimated at about 1-10 euros a year. A Sigfox representative was invited to the panel but was unable to attend and did not answer questions sent via email.

Data plans of any sort are beyond the budget for many IoT applications, said Paul Peck, a representative of the 900 MHz NWave technology which is the basis for the Weightless-N specification. Most apps "just need to say a trash can is full or not, or let you know that the ground is moist or dry," he said.

Peck said the NWave network supports a 3-10 km range, depending on environment conditions, 20 byte payloads, with "virtually unlimited" daily updates, up to 7 years of autonomy on 3.6V lithium-chloride batteries and bi-directionality coming in a 3Q 2015 update, all at a $4,500 cost per base station, not including installation.

By 2024, the emerging class of low power nets such as LoRa, Sigfox and NWave may carry nearly half the wide area IoT traffic, according to estimates by market watchers at Machina Research. However they will still only represent 14% of all IoT nets, the vast majority of which will be confined to short range links in the home or office typically using Bluetooth, Wi-Fi and Zigbee, it said.

## Wi-Fi in the equation

Cellular and Wi-Fi proponents are not standing still when it comes to IoT, but they are not moving very quickly either. The specification for a so-called Cat-M version of LTE optimized for IoT networks will not be ready until sometime in the first half of next year. It could take more than a year for networks to enable it.

The good news is Cat-M could enable building a power amplifier in CMOS for more integrated baseband chips, said Eran Eshed, co-founder and vice president of marketing and business development at Altair Semiconductor during a round table at this year's Silicon Valley Embedded System Conference (ESC SV). The integrated chips could enable engineers to build $5 LTE modules, a Holy Grail for cellular M2M pricing, he said.

Chip designers such as Altair and Sequans are banking on a market for such low power, lost cost LTE devices. At least one other cellular option is in the works, a variant of 2G or 3G networks known as cellular IoT. It has backing from giants such as Huawei and Qualcomm, but is still in an early stage of development, Eshed reported.

In the meantime, companies such as Altair are sampling

**Rick Merritt** is Silicon Valley Bureau Chief at EE Times - www.eetimes.com

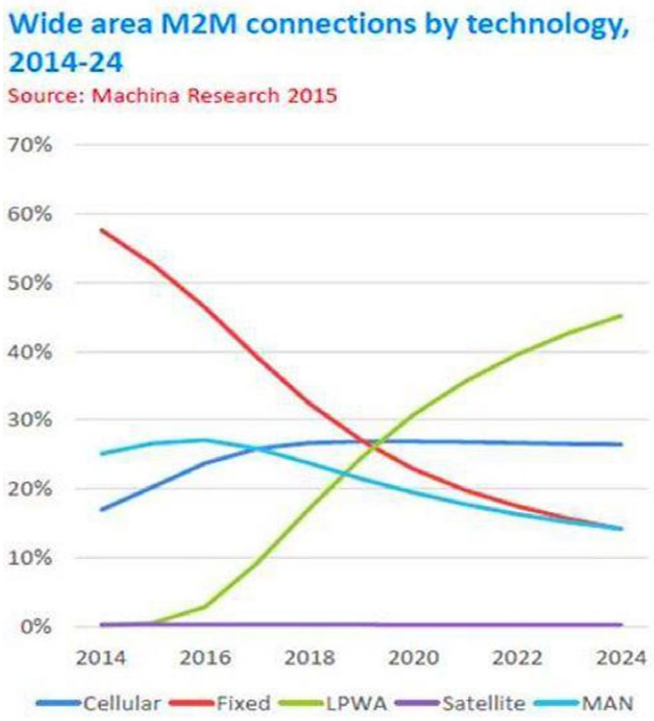
prototype Cat-1 LTE cards.

They consume 23 dBm power to deliver up to 10 Mbits/second data rates compared to the future Cat-M which will hit 20 dBm at rates as low as 200 Kbits/s.

A handful of chip designers are sampling Cat-1 products now, including Qualcomm, said Hosain of Aeris. However the modules using the chips are not yet in production, he said. Today's users don't want to wait another year for an interim Cat-0 or the ultimate Cat-M products – let alone another five years for an IoT optimized 5G network, he added.

Despite the wait, Machina Research predicts as many as 2.2 billion cellular M2M connections will be running in 2024, up from 256 million at end of 2014. LTE will command the majority of those links (54%), followed by 3G at 21%, it said.

A 900 MHz version of Wi-Fi for IoT is even further behind.




**LPWA networks will replace many of today's expensive wired and cellular links.**

Chips supporting the 802.11ah standard are not expected until 2017 and a certification program for the products won't be ready until 2018, said Rolf De Vegt, a senior director of technical standards at Qualcomm Atheros.

The good news is the 11.ah spec supports a range of up to 1 km, data rates from 150 Kbits/s to 4 Mbits/s using a single stream and a MHz channel, data rates up to about 78 Mbits/s for wider channels and up to four streams. Its transmit power is as low as 30-60 milliwatts and the new spec could support thousands of nodes and enhancements for outdoor coverage.

One of the great advantages of .11ah is that like all Wi-Fi systems it is royalty free and does not require a network operator, said De Vegt.

"It's perfect for something like tracking a fleet of bicycles in a city," he said. "Farmers can put up a network themselves linking sensors in a field by putting an access point up on a pole," he concluded.

# Millimeter waves hitch a ride

By Jessica Lipsky

Researchers at the University of Texas at Austin are studying how millimeter wave (mmW) wireless signals could be used in cars. They believe mmW bands will provide the high data rates and accuracy needed in communication between connected cars, while also improving the resolution of radar operations.

Frequencies between 10 GHz and 30 GHz have been used in cellular research by NYU Wireless, whose director is a former UT Austin professor. While NYU Wireless studied mmW propagation in New York City, the UTA Wireless Networking and Communications team lead by professor Robert Heath Jr. is trying to predict mmW performance.

Heath said UTA faculty and students have taken the insights from NYU Wireless and developed mathematical performance models for mmW and massive MIMO (multiple-input multiple-output), a technique for using a large number of antennas seen as key to future cellular base stations.

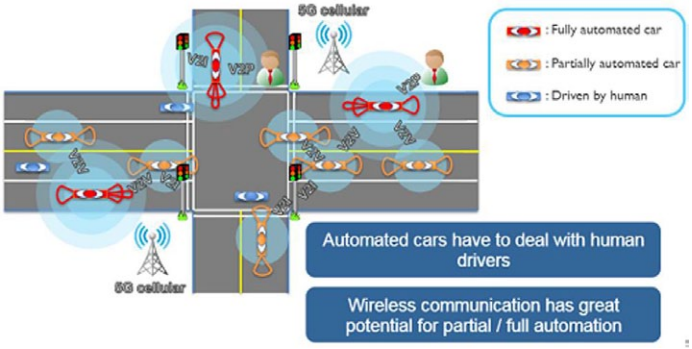
"Millimeter waves work well when densely deployed in areas that don't have much blockage", Heath told *EE Times*. Massive MIMO on a low frequency could overlay a whole city, then small areas could be lit up with mmW for additional cellular coverage.

Heath expanded upon this idea for use in connected or automated vehicles.

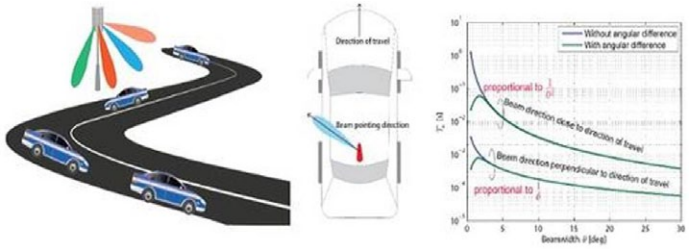
UTA leveraged the mmW consumer WLAN standard 802.11ad to develop a vehicular communication-radar waveform for long range automotive radar (LRR) and vehicle-to-vehicle communication (V2V) at 60 GHz. Automotive radar operates at 77 GHz, making the bands close together enough to do radar on mmW.

"Communication is lagging tremendously behind everything [in connected cars]. We have radars on cars, cameras, interest in IR, and yet communications is through the DSRC [dedicated short-range communications] standard or cellular. The problem is all sensors generate a huge amount of raw data. I think car companies are going to want to get access to sensor data on other vehicles….I think there's going to be interest in streaming high volume low latency data from cars".

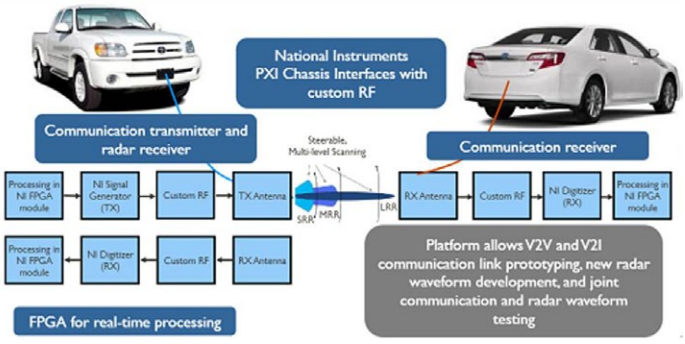
Heath's team of 15 researchers have modelled how mmW could serve as the framework for V2V and vehicle-to-infrastructure (V2I) communications for congestion or collision reduction. The model shows both the effects of beam width and pointing error (the ease with which a narrow beam is pointed at an incorrect location) to show how signals vary over time. The team found that directional antennas with an approximately 3 degree width support stable channels when well pointed.




**Partially automated car UT vision for the future of transportation. Source: University of Texas, Austin.**




**Millimeter waves could be beamed from atop a light pole (above), though building communications into infrastructure poses its own challenges. Source: University of Texas, Austin.**




**mmW communication and radar prototype. Source: University of Texas, Austin.**

Heath will present the model at IEEE's vehicular conference this fall. He hopes the mathematical models will help inform engineers how many antennas to use at a given time.

To further improve communications, Heath's group teamed up with UT Austin's Center for Transportation Research to develop a mmW and radar communication prototype that does V2V and V2I. The prototype will use a National Instruments PXI chassis interface with custom RF, and aims to leverage the close location of radar and 60 GHz frequencies to cut down on hardware cost.

UTA's Wireless Networking and Communications Group is also working on ways to use 802.11 OFDM waveforms on a single forward directional antenna at 5.9 GHz for collision detection.

"The problem with radar is there are a lot of ways to fake the signal, something that causes a processing engine to take evasive action. It has many potential insecurities," Heath said. "We're looking at a couple of ways to augment radar with communications."

---

**Jessica Lipsky** is Associate Editor of EE Times - www.eetimes.com

Mimicking radar, the OFDM wave communicates with a car in front through two antennas while simultaneously listening to that car's echo. Heath said this communication method could make many message types possible and, with some signal processing, could allow for better accuracy than what other bandwidths would dictate.

Most new cars likely will have radar as a standard feature in two years, Heath predicted - and if those cars also have an embedded communications chip, information from the vehicle can be cross-validated with existing hardware.

Heath's team is working on a vehicle security prototype that uses 802.11p at 5.8 GHz to communicate alongside a 77 GHz radar and a custom wave form generator from National Instruments "to show that communication helps you avoid the spoofing problem, and improve radar security."

Research into the overlap between radar and communications is sponsored by the Texas Department of Transportation with the goal of using joint sensor data through machine learning and sensor fusion. Heath's team hopes to collaborate further on radar security projects and prototyping.

# Changes to radio rules

## By Jean-Louis Evans

The Radio and Telecommunications Terminal Equipment Directive (R&TTE) was introduced in April 2000, but the European Commission became concerned about the low level of compliance for some categories of radio equipment. This, coupled with the growth of mobile devices and wireless applications, led the Commission to publish the new Radio Equipment Directive (RED) 2014/53/EU in the Official Journal of the European Union on 22 May 2014.

As the RED will be applicable from 13 June 2016, Member States now have a transition period of less than nine months to transpose the new RED into their national laws. However, manufacturers will have an additional year to comply, as equipment compliant with the current R&TTE Directive before 13 June 2016 may continue to be placed on the market until 13 June 2017.

Within Article 43 of the RED, a "making available on the market" and "putting into service" provision means that products which comply with the R&TTE Directive before 13 June 2016, and which are placed on the market before 13 June 2017, may be sold and brought into service later.

### Where the RED applies

Products which fit within the following definition are subject to the RED:

"Radio equipment – an electrical or electronic product which intentionally emits or receives radio waves for the purpose of radio communication and/or radio determination, or an electrical or electronic product which must be completed with an accessory (such as an antenna) so as to intentionally emit and/or receive radio waves for the purpose of radio communication and/or radio determination."

All radio receivers, including broadcast radio and TV receivers, fall within this definition.

Radio communication means 'communication by means of radio waves', while radio determination means the determination of the position, velocity and/or other characteristics of an object, or the obtaining of information relating to those parameters, by means of the propagation properties of radio waves.

**Jean-Louis Evans** is Managing Director at TÜV SÜD Product Service, a global product testing and certification organisation, and at its sister company, TÜV SÜD BABT, the world's leading radio and telecommunications certification body - www.tuv-sud.co.uk

The RED excludes equipment that is "radio equipment exclusively used for activities concerning public security, defence, State security, including the economic wellbeing of the State in the case of activities pertaining to State security matters, and the activities of the State in the area of criminal law".

Marine equipment that falls within the scope of Council Directive 96/98/EC is also excluded. This includes equipment on board a new European ship, even if it was constructed outside of the EU, as well as replacement equipment or additional equipment installed on an existing European ship. Airborne products, parts and appliances falling within the scope of Article 3 of Regulation (EC) No 216/2008, and custom-built evaluation kits designed for professionals to be used solely at R&D facilities are also excluded.

Another exclusion is radio equipment used by radio amateurs, which falls within the meaning of Article 1, definition 56, of the International Telecommunications Union Radio regulations'. Such equipment must not be available on the market which means:

- Radio kits for assembly and use by radio amateurs
- Radio equipment modified by and for the use of amateurs
- Equipment constructed by individual radio amateurs for experimental and scientific purposes related to amateur radio.

### Increasing compliance levels

The core goals of the RED are to strengthen the level of compliance, as well as clarifying and simplifying the Directive.

The RED's new requirements are therefore intended to clearly spell out the responsibilities and obligations for every economic operator involved in the supply chain (manufacturer, importer, distributor, authorised representative). This means that all items of equipment that fall within its scope, placed on the European market for the first time, must follow a RED conformity assessment procedure.

The good news is that the general principles for product compliance in the RED are very similar to the R&TTE Directive. This is because compliance is within a set of essential requirements. Harmonised standards also provide a presumption of conformity with the essential requirements.

The RED also requires the use of a Notified Body where no radio or relevant Article 3.3 Harmonised Standard exists.

Read the full article online at www.electronics-eetimes.com

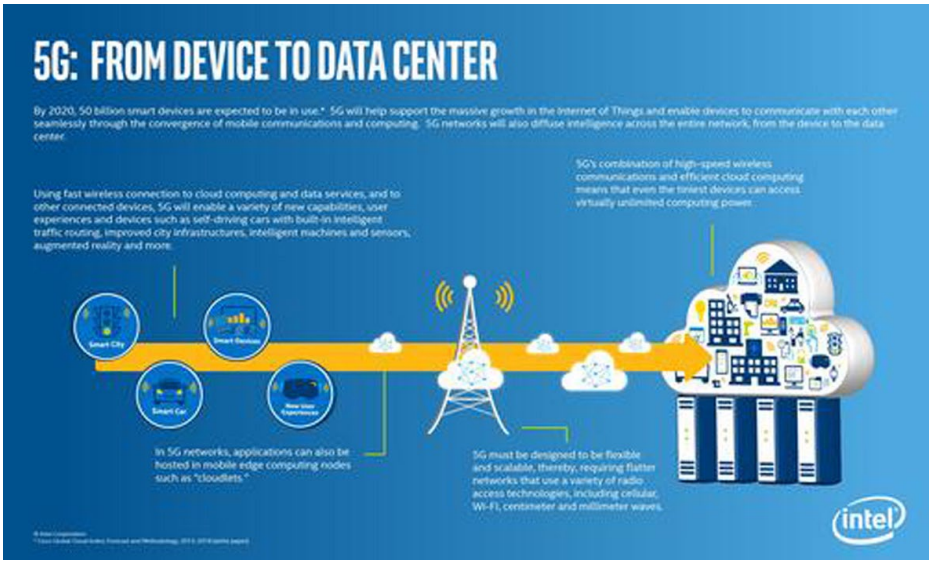
# 5G the Free WiFi Killer

By R. Colin Johnson

5G may be not much more than a moniker for what comes after 4G, but Intel clarified its vision recently at a keynote during the Intel Developer Forum 2015. “Seamless” is the goal and it comes at a price.

The top-line is that Intel hopes to apply all its expertise in computing, networking and wireless communications to make a seamless 5G solution that incorporates distributed intelligence at all levels--from the smartphone to the router to the base-station aggregator to cloudlets, clouds and our fastest supercomputers.

The bottom line is that cellular, WiFi, centimeter- and millimeter wavelength bands must be seamlessly integrated from the user’s point-of-view, according to Aicha Evans, vice president of platform engineering group and general manager of the communications and devices group at Intel.




**The goal of 5G is to give even meager mobile devices access to the virtually unlimited power available in the cloud. (Source: Intel)**

“5G is not about faster, but about integrating all types of connectivity,” Evans told her keynote attendees at IDF. “The building blocks of 5G are already here today.”

To the carriers this integration will come at a price, since 5G-for-all presents the opportunity to kill free WiFi and instead charge users for every data packet they send or receive, no matter which of the integrated communications technologies is used. At Evans’ keynote she gathered together carriers, service providers and strategists to outline what it is that they expect from 5G, including Alex Choi, chief technical officer (CTO) of SK Telecom (Asia), Bin Shen, Verizon’s vice president of strategy (U.S.) and Paul McNamara, vice president of Ericsson’s corporate strategy group (Europe).

However, before the panel painted the world-changing picture of extraordinary speeds and ultra-low latency - at a price - Intel’s Sandra Rivera, vice president of the data center group and general manager of the Internet of Things (IoT) described the benefits of 5G to the users.

“Intelligence will begin with at the base station,” Rivera asserted to the crowd at IDF. “Creating more immersive experiences.”

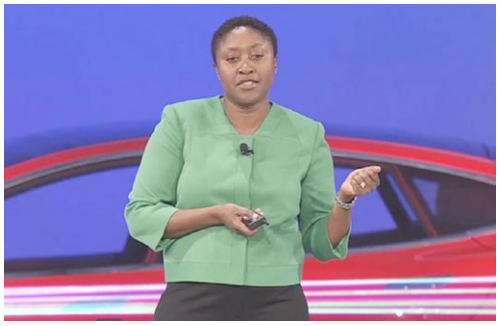
Rivera described a society where 50 billion devices--even including people with communications implants--will have sub-millisecond access to service-aware networks whose intelligence will begin by being built-into the base-station. These smart base-stations will never get overloaded by transparently handing off excess to nearby resources. For the user, that will mean no more dropped calls--ever--and not more sluggish videos--ever. It will also mean a whole new layer of intelligent applications based on service-aware networks that prioritize requests and automatically annex the resources to fulfil them in realtime.

“Software defined networking” and “network virtualization,” according to Rivera “will be able to seamlessly take advantage of other local resources that have the bandwidth to prevent dropped calls and sluggish videos.”

Rivera also made clear that Intel believes it is uniquely positioned to provide the computing power, networking expertise and the wireless communications capabilities to integrate service-aware intelligence across the entire network, from device to the data center using its Network Builders Fast Track program, which will help developers connect everyone in the world by 2020 (using copper, fiber, RF, balloon- and drone-base-stations).

The panel made it clear that their major metric was speed--which they predicted would be 100-to-1000 times faster with sub-millisecond latency, enabling the kind of realtime interactivity--such as virtual worlds--which today only exist in science fiction books like William Gibson’s Neuromancer which virtually defined the concept of cyberspace as a world on a level-playing-field with nature.

Of course, IoT will be driving 5G--from the end of traffic collisions and driverless cars, to smart cities, to smart agro-business, to worldwide access to education, literacy, health and longevity. In the end, however, all these miracles will come at a price, starting with the end of free WiFi and ending with a worldwide regulatory framework under which



**Aicha Evans, vice president of platform engineering group and general manager of the communications and devices group at Intel explains her vision of 5G. (Source: Intel)**

---

**R. Colin Johnson** is Advanced Technology Editor at EE Times

Sandra Rivera, vice president of the data center group and general manager of the Internet of Things (IoT) described the benefits of 5G to the users. (Source: Intel)

everybody's life will be made safer and better--at a price yet to be determined.

Along the way, Intel hopes to help accelerate adoption, standardization and intelligent solutions for equipment and device manufacturers, network operators, service providers and academic institutions. Intel is already working alongside the engineering visionaries making 5G happen, including Nokia's AirFrame Data Center, NTT DoCoMo's advanced field trials, SK Telecom's collaborative development of 5G modems using multiple radio access technologies and its Anchor-Booster Cell effort to combine LTE and WiGig. Intel is also a member of a number of research projects including the 5G Public Private Partnership (5GPPP), the Flex5GWare project and Horizon2020.

## 'Funtenna' hack turns IoT devices into radios

By Rich Pell

Security researchers have revealed a technique that could allow hackers to steal data from IoT devices by essentially turning them into radios and then listening to the signals they broadcast via a receiver and antenna.

The software-based hack - called "Funtenna" - causes an infected computing device to broadcast data via a radio backchannel (or even audio frequencies) to attackers who can monitor it without using standard wireless communication protocols like Wi-Fi and Bluetooth. Using just seven lines of code, the researchers, from security startup Red Balloon Security (New York, NY), were able to turn an otherwise unmodified laser printer into a radio transmitter by rapidly switching the power state of the printer's I/O ports.


The resulting modulated radio signal was broadcast via the wiring and components associated with the printer's I/O circuitry and connections. The GPIO connections, which had relatively short wires, resulted in a radio transmission of a few meters while the printer's UART output, which had a 10-foot cable, generated a signal that could be received outside of the building.

According to the researchers, who presented their "Funtenna" proof of concept at last week's Black Hat conference, the same type of attack could be used on almost any IoT device, or devices with onboard computing like network routers. The only real defense against such attacks, they say, needs to be host based and built into embedded devices.

"A network [intrusion detection system] is no substitute for host-based defense," says Ang Cui, chief scientist at Red Balloon Security. "You could monitor every known spectrum, but it would be very expensive and may not work. The best way is to have host-based defense baked into every embedded device."

## Compact, multiband transceiver for industrial telemetry and remote control

LPRS has announced the availability of the STD-601 400 MHz transceiver module from Circuit Design for telemetry, remote control and industrial applications. The advanced design has

many innovative features including four frequency ranges conforming to various ISM bands available in the single device. Featuring high performance narrowband, blocking and sensitivity, the module is suited for rugged, noisy industrial environments where good channel selectivity is required. Other standard features include a range of selectable RF power levels (maximum 50 mW RF power) and data rates and user data input is transparent allowing the use of proprietary protocol. The STD-601 module is surface mountable, requiring minimal PCB area and is just 5 mm high making it suitable for design into portable equipment. Key specifications of the STD-601 400 MHz include 429, 434, 447 and 458 MHz customer selectable frequency bands, selectable RF power outputs of 50, 25, 20, 10, 5 and 1 mW, selectable RF bit rates of 1200, 2400, 4800, 9600, 19200 bps, and asynchronous data input with transparent interface. Further features include power consumption of 35 mA typical (TX 10 mW, 3 V), communication range of 600 m (LOS) at 10mW, compact size 20×32×5mm SMD.

**LPRS**
www.lprs.co.uk

## Implantable RF module is only 5.5x4.5x1.5mm

Measuring only 5.5x4.5x1.5mm, Microsemi's ZL70323 RF module is the smallest radio module the company has ever produced. Optimized for implantable medical devices such

as pacemakers, cardiac defibrillators and neurostimulators, the ZL70323 implements all RF-related functions needed to deploy the implant node in a Medical Implantable Communications Service (MICS) RF telemetry system. The integrated antenna tuning circuit allows the module to be used with a wide range of implantable antennas (nominal antenna impedance is 100+j150 ohms). The module includes the ZL70103-based MICS-band RF transceiver with integrated matching network, surface acoustic wave (SAW) filter for suppression of unwanted blockers, and antenna tuning; a 2.45GHz wake-up receiver matching network; an integrated 24MHz reference frequency crystal; and decoupling capacitors and series termination resistors. The device operates in the 402–405 MHz MICS band. Multiple low power wake-up options are supported including using an ULP 2.45 GHz industrial, scientific and medical (ISM) band wake-up receive option. The ZL70103 consumes less than 6mA when transmitting or receiving and consumes only 290nA when in a periodic sleep/sniff mode (1 second sniff interval).

**Microsemi**
www.microsemi.com

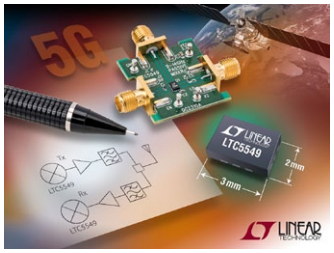
## 380-micron-thick package puts Bluetooth in credit-card formats

Cypress has added to its Bluetooth Low Energy (BLE) portfolio for banking, industrial and lighting applications; its BLE offerings; PSoC 4 BLE and PRoC BLE, are now available in ultra-thin chip scale package and with extended industrial temperature range. The PSoC 4 BLE Programmable System-on-Chip and PRoC BLE Programmable Radio-on-Chip solutions each now have an option for a micro-ball Chip Scale Package (CSP) package optimised to bring Bluetooth Smart connectivity to secure credit card applications. The package is only 0.38-mm thick, enabling the Bluetooth-certified solutions to replace chip-on-board devices. Cypress also offers products with an extended industrial temperature range option with operation from -40ºC to +105ºC. This ensures consistent product performance throughout this temperature range for industrial, automotive and lighting applications that must operate in extreme climates. Both the micro-ball CSP package and extended industrial temperature options will be available for the 128 kB and 256 kB flash versions of the PSoC 4 BLE and PRoC BLE solutions. The new offerings are pin-to-pin compatible with Cypress's original Bluetooth Low Energy solutions, simplifying upgrades. PRoC BLE is a Bluetooth Smart microcontroller with Cypress's CapSense capacitive touch-sensing functionality, while PSoC 4 BLE offers expanded design versatility by adding intelligent analogue and programmable digital blocks.

**Cypress**
www.cypress.com

## 2GHz to 14GHz mixer with LO frequency doubler achieves low IIP3

LTC5549 is a double-balanced mixer that can operate either as an upconverter or downconverter, with a wide RF frequency range from 2 GHz to 14 GHz. It has high linearity of 24.4 dBm IIP3 at 9 GHz. LTC5549 enables efficient microwave transmitter and receiver designs with an integrated LO buffer that needs only a 0-dBm drive level, effectively eliminating an external high power LO amplifier circuit. It has an integrated on-chip, switchable frequency doubler for LO signal, providing an option to use lower cost, commonly available low frequency synthesisers. The LTC5549 employs wideband integrated balun transformer optimised to extend RF frequency bandwidth from 2 GHz to 14 GHz while enabling single-ended operation. Its IF port also has wide bandwidth up to 6 GHz. All three ports are 50-Ω matched. The mixer offers high port-to-port isolation, minimising undesireable LO leakage, and easing external filtering requirements. Conversion loss is specified as 8.0 dB. The device's performance matches a range of microwave applications including microwave backhaul, high unlicensed band LTE-Advanced base stations, satellite broadband radios, radar systems, X-band and Ku band transceivers, test equipment and satellite modems. The device is available in a 12-lead, 3 x 2 mm plastic QFN package, rated for operation from –40°C to 105°C case temperature.




**Linear Technology**
www.linear.com

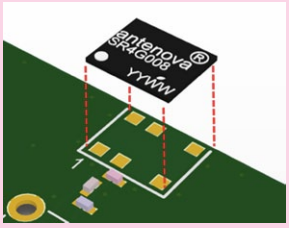
## 34.4MHz to 4.4GHz RF signal generator/power detector

The SynthNV from Saelig is a programmable 34.4MHz to 4.4GHz software-tunable RF signal and sweep generator with a built-in RF power detector. It is controlled and powered from any device running Windows, Linux or Android OS via a USB port. The included onboard RF power detector can be used as a generic RF power meter or combined with the SynthNV's sweep function to create a basic RF network analyzer. When the RF signal generator frequency is set, RF power can be measured in less than 400uS. The SynthNV design also includes nonvolatile memory so it can be programmed to wake up with any frequency, power, sweep, and modulation setting. Controlled by easy-to-use open-source Labview GUI software, the SynthNV can be powered from a USB port or from an external 6 - 9V source. It can run all its features with or without a connected PC, its specifications include a 2.5ppm generator frequency accuracy, 150us generator lock time, 1kHz or smaller generator step size, phase noise of 93dBc/Hz at 1kHz offset and 117dBc/Hz at 100kHz offset with a 1GHz carrier (typical). Modulation capabilities include AM with sinusoid, ramp, sawtooth or programmable arbitrary waveforms, as well as Pulse Modulation with 1us minimum pulse width and resolution. Output power is +19dBm which can be adjusted in 0.5dB amplitude steps. The broadband RF power detector measurement time is only 200us, and it measures from -60dBm to +10dBm with 0.1dB resolution.

**Saelig**
www.saelig.com

## Thin, light GNSS antenna is suitable for drones, wearables

Antenova Ltd. (Hatfield, England), manufacturer of antennas and RF antenna modules for M2M and the Internet of Things, has developed an antenna it calls Sinica for use with the 1559MHz to 1609MHz satellite bands. The Sinica antenna, part number SR$G008, operates with all of the public satellite constellations - GPS, GLONASS, Baidou and Gallileo. It is made from FR4 materials and novel dielectric constant laminate substrates to provide a surface mount antenna in a package measuring 7.0mm by 5.8mm and just 0.4mm thick. It weighs 0.2 grams.




**Antenova Ltd.**
www.antenova-m2m.com

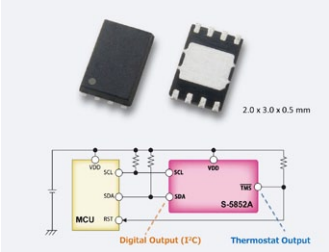
## Waveguide detectors cover the 26.5 to 110GHz range

Pasternack is rolling out a brand new collection of high performance zero biased waveguide detectors that exhibit optimum performance in Ka, Q, U, V, E and W frequency bands. These waveguide detectors are widely deployed in various aerospace, defense and commercial wireless applications used in instrumentation, power detection, power monitoring, direct detection receivers, high frequency communications, radar, SATCOM, point-to-point radio, telecom, data links and R&D. The new range consists of 6 unique models covering a broad frequency range of 26.5 GHz to 110 GHz. The input ports use popular waveguide sizes ranging from WR-28 to WR-10, while the video output ports utilize SMA female connectors. The detector circuits use high performance GaAs Schottky Barrier Beam lead diodes with extremely low junction capacitance. These designs perform with minimal sensitivity variation resulting in a flat frequency response across the entire waveguide band. All the devices ar zero biased, so no external DC bias or mechanical tuning is required. The package designs utilize rugged steel construction and are thermally stable. Integrated waveguide connectors make the outline extremely compact. Performance is guaranteed over 0°C to +50°C. These detectors offer negative output voltage polarity for a variety of applications. Typical voltage sensitivity levels range from -600mV/mW to -3000 mV/mW.

**Pasternack**
www.pasternack.com

## Digital temperature sensor IC delivers accuracy with thermostat function

Seiko Instruments Inc. (SII) has released a digital temperature sensor IC featuring both digital output with I2C interface for continuous temperature monitoring as well as a thermostat function (temperature switch) to signal out of range temperature conditions. Users can set the upper and lower limit values of the temperature range. For the temperature monitoring, typical digital temperature sensor ICs require a microcontroller to read temperature information at all times via a digital interface. The S-5852 Series has the added thermostat function in addition to the digital output, which can send a detection signal via an independent pin in the event of an out of range temperature condition. This dual temperature monitoring control enables simplifying systems and securing temperature control. Typical applications include temperature management of SSD, HDD, tablet PCs, and HEMS. The S-5852A Series offers low voltage operation of 1.7 V, high temperature accuracy of ±0.5°C, and a wide operating temperature range of -40°C to +125°C making this part suitable for both battery operated applications and line powered applications. Two thermostat output modes are available: a dual trip mode (that can set upper and lower limit values of the temperature range) and a single trip mode (that can set the upper limit value of the temperature range). Users can set these values to their required levels.




**Seiko Instruments Inc.**
http://datasheet.sii-ic.com

## UV-A LED flashlight focuses on nondestructive testing

Spectroline has introduced a cordless, rechargeable UV-A (365 nm) LED flashlight that is ideal for nondestructive testing applications such as MPI, FPI and general fluorescent examination. The Optimax 365 inspection lamp utilizes ultra-hi-flux LED technology to produce a nominal steady-state UV-A intensity of 18,000 μW/cm² at a distance of 38 cm. The device's Electronic Intensity Stabilizer assures consistent performance; the beam strength will not weaken between charges. Powered by a rechargeable NiMH battery, the flashlight provides 90 minutes of continuous use between charges. The LED lifetime is 100,000 hours. The Optimax 365 is lightweight and compact, weighing just 11.8 ounces (335 g). The device is ergonomically designed to provide ultimate comfort and freedom of movement during inspections. The flashlight has a corrosion-resistant anodized lamp body, which makes it perfect for use in the field. A push of a button turns the lamp on instantly at full power. The flashlight comes with UV-absorbing spectacles, a rubber lamp protector, a belt holster and smart AC and DC battery chargers, all conveniently packed in a padded carrying case. The AC charger is available in 120 V, 230 V, 240 V or 100 V versions.

**Spectroline**
www.spectroline.com

## Grab Altera's latest MAX 10 FPGA kit

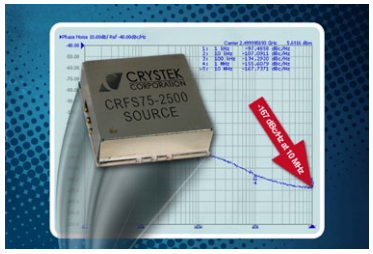

This month, Altera is giving away three of its second-generation Nios II Embedded Evaluation Kit (NEEK), worth $359 each, for EETimes Europe's readers to win. The feature-rich platform provides a fast and simple way for embedded designers to experience the capabilities of a custom embedded processor in a non-volatile FPGA. The MAX 10 NEEK was jointly developed by Altera and its board partner, Terasic. It combines a MAX 10 FPGA-based board with a 7-inch, 5-point multi-touch display. Embedded developers can select from a variety of networking, audio, video and image processing reference designs, and launch example applications with the touch of a finger. The kit includes many amenities that enhance human machine interface (HMI), machine vision, and surveillance operation including an 8 megapixel MIPI CSI-2 camera, HDMI support, humidity & temperature sensor, 3-axis accelerometer, and built-in microphone.Combining a Nios II soft processor and a MAX 10 FPGA with on-die flash provides several advantages over microcontroller-based solutions, including enabling custom hardware configuration, obsolescence proofing, and custom hardware acceleration for real-time processing.


**Altera**
www.altera.com

**Check the reader offer online at www.electronics-eetimes.com**

## 2.5 GHz phase locked clock source

Crystek Microwave has released a 2.5 GHz phase locked clock source with internal reference, the CRFS75-2500. The company designed the module using proprietary circuitry and SAW (surface acoustic wave) resonator technology to provide ultra-low jitter/phase noise performance with true SineWave output. The resulting source features -105 dBc/Hz phase noise at 10 KHz offset and a noise floor of -167 dBc/Hz. The CRFS75-2500 comes in a 19x19mm (0.75x0.75-inch) SMT package. With 5 V input voltage, it generates a true-sinewave with +5 dBm minimum output power. The source has no sub-harmonics; second harmonic is -20 dBc typical. Frequency stability is rated at ±25 ppm. The CRFS75-2500 operates from -20°C to +70°C. Applications include: analog-to-digital (A/D) converters, system clocks for network clock generators/synchronizers; clocks for DDS; test and measurement; avionics; point-to-point radios; and multi-point radios.




**Crystek Microwave**
www.crystek.com

## 4K video CMOS sensors boast fast autofocus

Toshiba Electronics Europe has expanded its range of high performance backside illumination (BSI) CMOS image sensors equipped with Phase Detection Auto-Focus (PDAF). Designed for use in smartphones and tablets the sensors achieve high performance image capture and low power consumption. The range expansion features the 8 megapixel (MP) T4KA3-121, the 16 MP T4KC3-121, the 13 MP T4KB3-121 and the 20 MP T4KA7-121. Originally developed for SLR cameras, PDAF locks in focus at speeds much faster than the auto-focus systems currently used in smartphones and tablets. Image brightness is boosted by up to four times using Toshiba's Bright Mode technology and the sensors also support high dynamic range (HDR) to capture natural images of scenes with a high contrast ratio, ending the problem of over- and underexposed images. The T4KA3-121 achieves output speeds of up to 30fps at full 8MP-resolution - with power consumption figures of just 140mW or lower. Full-HD outputs are supported at frame rates of up to 60fps, and HD outputs are supported at 120fps in normal mode and 240fps in Bright Mode. The T4KB3-121 and T4KC3-121 achieve output speeds of up to 30fps at 4K2K resolutions, Full-HD at frame rates of up to 60fps, and HD outputs at 120fps. The T4KA7-121 achieves output speeds of up to 22ps at full 20MP-resolution 24fps at 18.8MP and 28fps at 16.3MP, with a power consumption of 440mW.


**Toshiba Electronics Europe**
www.toshiba.semicon-storage.com

## Secure solid state drive for embedded applications

Positioned by Microsemi as applicable for situations requiring the highest levels of security and reliability, Microsemi's low power mSATA SSD offers 64 GB single-level cell (SLC) flash capacity in a 50x30mm compact form factor and is 65% smaller than similar 2.5-in. devices. The SSD also features Microsemi's Armor processor, which the company says solves obsolescence issues common in industrial and defence applications by guaranteeing long-term security and performance. In the advanced deep sleep low power mode the SSD is only using 150 mW and can be 'instant on'. The device is Microsemi's newest addition to the advanced TRRUST-Stor family of secure SSDs in a compact MO-300 mSATA form factor. This SSD includes security features such as hardware based AES-256 XTS encryption and advanced key management systems. The Armor III processor also has the capability to sanitise the drive with the NSA 9-12 protocol in less than two minutes. For sensitive applications, a hardware or software signal can trigger an erase of the encryption key in less than 30 msec. A second security layer can be activated to erase the entire storage media in less than 10 seconds, rendering data forensically unrecoverable.

**Microsemi**
www.microsemi.com

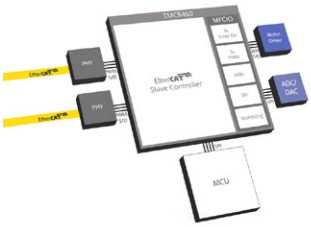
## Box PC with Intel IoT Gateway

Kontron's KBox A-202 PC supports Intel Gateway Solutions for the Internet of Things. Based on the Intel Atom processor E3800, the 56.8x150x95mm low maintenance, fanless and battery-free machine-to-machine platform is designed to serve as an intelligent gateway in data intensive IoT applications. It supports Kontron's embedded application programming interface (KEAPI) and Intel Gateway Solutions for the Internet of Things. The KBox A-202 system comes complete with a wide range of industrial interfaces for integration of new and legacy installations as well as several connectivity options including wireless LTE (4G), GSM (2G/3G) or WiFi support. For local data acquisition, the Box PC offers a range of industrial interfaces such as 2x Gbit Ethernet, 2x USB 2.0, as well as an optional CAN bus and/or Profibus interface, and for legacy installations, two serial interfaces (RS232/485). For wireless connection to the cloud or the local network, the Kontron K-Box A-202 can be equipped with LTE (4G) and GSM (2G/3G) or WiFi. The integrated SSD with up to 64 GB capacity offers rugged as well as fast storage capacity for OS and data. There is an integrated TPM for increased data security.

**Kontron**
www.kontron.com

## Dedicated controller IC offers real-time characteristics for EtherCAT

Trinamic has introduced an IC for EtherCAT networks; the first slave controller IC offering latency-free advanced peripherals; the device is intended to be the first in an Interface Device family The EtherCAT-compliant slave controller IC, TMC8460, incorporates PWM and Step/Dir I/O peripherals that do not require routing through the firmware of an application processor, eliminating latency for applications requiring real-time response. The TMC8460 extends the feature set of the core EtherCAT technology with an array of peripherals and features: an integrated smart peripherals block accessible from an MCU or EtherCAT master and, in addition to a PWM unit and Step/Dir interface, an SPI master and encoder interface that can be directly mapped to the PDO (Process Data Object) by the memory manager. This unique SPI interface enables latency-free read from an ADC or write to a DAC. The IC includes a standalone mode that enables direct mapping of integrated peripherals to bus registers, while in parallel an external MCU can perform higher layer protocol operations. To enable wide interoperability, the TMC8460 communication hardware has been verified as 100% compatible with the existing Beckhoff EtherCAT Slave controller through extensive interoperability testing. The new device meets the -40C to +125C industrial temperature specification.




**Trinamic**
www.trinamic.com

## Control systems optimized for the Industrial Internet of Things

NI has announced embedded systems hardware based on the open, flexible LabVIEW reconfigurable I/O (RIO) architecture. This hardware includes the high-performance CompactRIO

Controller for integrators with rugged, industrial applications, Controller for FlexRIO for designers with high-performance embedded applications and Single-Board RIO Controller for designers who require more flexibility in their embedded applications. These controllers integrate the latest embedded technologies from Intel and Xilinx to deliver unparalleled performance and flexibility, empowering system designers and machine builders to address the most demanding control and monitoring challenges. The controllers are fully supported by LabVIEW software, the LabVIEW FPGA Module and NI Linux Real-Time, now based on Security-Enhanced Linux, which enables advanced security features for Industrial IoT applications.

**NI**

www.ni.com

## Wireless occupancy sensors deliver Smart LED lighting flexibility

Dialight has unveiled a wireless occupancy sensor which is a battery-powered plug-and-play sensor that speeds and simplifies installation to provide maximum lighting control

flexibility and energy savings in industrial applications. Designed to integrate seamlessly with any Dialight smart lighting system, the wireless sensor can be placed virtually anywhere within a facility, without the need to install or move cabling, for nearly unlimited lighting control options. A single sensor can be programmed to control multiple lights and groups of lights, eliminating the need to install a sensor on every light. Using Pyroelectric InfraRed (PIR) technology, each sensor can instantly switch a single light or a group of lights from off to on or from a dimmed state to on when motion is detected for full visibility and brightness only when needed, greatly reducing on-time and power consumption. Multiple sensors can be linked to a single Dialight gateway to manage several (or up to 100) nodes (sensors and lights) from a single wall controller. Programmable dimming and customizable timeout options allow facilities to configure fixture on-time for each sensor at one-minute intervals. Lights can be programmed to remain on for up to 30 minutes once motion is no longer detected and then dim or turn off instantly. Each light and sensor in the network can be securely monitored and configured remotely from anywhere through the Dialight cloud-based gateway portal using a tablet, laptop or smartphone. Featuring 10-year lithium batteries and a self-healing 2.4 GHz IEEE 802.15.4 mesh networking system, the occupancy sensors are available in two lens types. A wide-angle lens detects motion up to 30 feet at a 120-degree angle, while a long-range lens detects motion up to 100 feet away at a narrow 10-degree angle, best suited for wall mounting and aisle coverage.

**Dialight**

www.dialight.com

## Wireless power receiver IC charges mobile devices quickly

Toshiba Electronics Europe has launched a wireless power receiver IC that will enable mobile devices to be charged wirelessly as fast as if they were connected to the charger via a cable. The TC7764WBG supports a maximum power output of 5 W and is compliant with the Qi standard's low power specification V.1.1.2, defined by the Wireless Power Consortium (WPC). Wireless

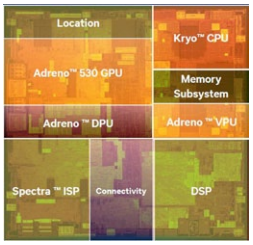

power transfer allows adoption of a fully insulated case free of exposed charging ports, an advantage that is stimulating demand for waterproof and dustproof portable products, such as smartphones and tablets. However, wireless charging has not always been as fast as charging by cable. To overcome this difference, Toshiba has optimised the circuit design of the TC7764WBG so that maximum output power is increased to 5 W and a maximum power conversion efficiency of 95% is achieved (excluding the influence of the power signal receiving coil and tank capacitor). This enables mobile devices to be charged wirelessly as fast as if they were connected to a cable charger. The IC integrates a Qi protocol authentication circuit for power transfers, foreign object detection functions, under-voltage lockout and over-voltage lockout functions for the external power supply bypass option as well as thermal shutdown functions. The IC comes in a 2.4x3.67x0.5mm WCSP28 package.

**Toshiba Electronics Europe**

www.toshiba.semicon-storage.com

## New GPU cores for Qualcomm's Snapdragon processors

Qualcomm Technologies has unveiled its next-generation visual processing technology with new versions of its graphics processing unit (GPU) and image signal processing (ISP) unit, which the company believes will deliver significant advancements in performance, power efficiency and user experience to its Snapdragon processors. The Qualcomm Adreno 5xx GPU architecture is claimed to deliver increased speed and efficiency over the previous generation and supports high-definition mobile graphics while introducing general-purpose compute co-processing for exceptionally low power consumption. The first two GPUs available on the new architecture, the Adreno 530 and Adreno 510, will be available integrated within the forthcoming Snapdragon 820 and Snapdragon 620/618 processors. In addition, Snapdragon 820 will also debut the new 14-bit Qualcomm Spectra image signal processing (ISP) unit, designed to support superior DSLR-quality photography and enhanced computer vision. The Qualcomm Spectra ISP is expected to deliver superior image quality, with more natural skin tones via advanced, 14-bit dual ISPs supporting up to 3 simultaneous cameras and up to 25 megapixels at 30 frames per-second with zero shutter lag. It features a flexible hybrid autofocus framework and multi-sensor fusion algorithms for next generation computational photography.




**Qualcomm Technologies**

www.qualcomm.com

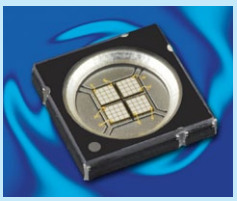
## XBee Wireless Connectivity Kit, from Digi and Digi-Key

This kit is designed to allow developers to gain expertise and insight to applications of wireless connectivity with XBee modules. M2M product designer Digi International, and distributor Digi-Key Electronics (not otherwise connected than by coincidence of names) offer the Digi XBee Wireless Connectivity Kit (XKB2-AT-WWC), for an initial-offer-period price of $59. The platform provides a resource for developers to better understand how XBee RF modules can be used for wireless device connectivity and sensor networking solutions. The kit features two XBee Grove Development Boards – a board for XBee modules that incorporates the universal 4-pin connector used by Grove sensors, two XBee RF modules and micro-USB cables.

**Digi-Key Electronics**
www.digikey.com

## 4-die 365nm LED engine delivers 4W of flux

Solid State Supplies now makes available of a new high-power and high-performance ultra-violet (UV) light emitter from manufacturer LED Engin, aimed at a wide range of industrial applications. The LZ4-04UV00 365nm LuxiGen combines a high performance surface-mount package with the latest generation of high-power LED die. The 2.2x2.2mm light-emitting surface area for a 7.0x7.0mm emitter footprint provides exceptional optical power density, delivering 2.9W radiant flux output at 700mA or more than 4W at 1000mA. The flat glass lens facilitates the use of imaging optics as well as light pipes and other optics enabling extreme narrow beam angles – down to +/–3°.



**Solid State Supplies**
www.sssltd.com

## Netduino 3 for fast prototyping, in distribution

Distributor Mouser Electronics has the Netduino 3 platform, aimed at both quick-to-market commercial hardware solutions, and personal electronics projects, with maximum design flexibility and reduced risk. This newest version of the open-source Netduino platform includes, say its makers, the best of the features that made previous versions popular, with added Wi-Fi connectivity. Netduino 3 is an open-source electronics platform designed around the Microsoft .NET Micro Framework, combining the ease of high-level coding and the raw feature set of the STM32 F4 family of microcontrollers. The 32-bit ST microcontroller on the Netduino 3 has a 168 MHz ARM Cortex-M4 processor with 2 MBytes of dual-bank, read-while-write flash memory and up to 256 kBytes of SRAM, including 64 kBytes of core-coupled memory (CCM).


**Mouser**
www.mouser.com

## Raspberry Pi bundled with Matlab/Simulink

Farnell element14 is listing a package that puts together MATLAB and Simulink Student Suite software with a complete starter kit of Raspberry Pi hardware. The MATLAB and Simulink Student Suite – Raspberry Pi Bundle includes the Raspberry Pi Starter Kit and the MATLAB and Simulink Student Suite from MathWorks, allowing the student or self learner to start a project with model-based block diagrams on the Raspberry Pi 2 using the same tools commercial engineers and scientists use every day. "Learning programming is the number one priority for Raspberry Pi users. Among students Raspberry Pi is our most popular single board computer" said Claire Doyle, Global Head of Raspberry Pi at element14

**Farnell element14**
www.element14.com

## Excelsys adds Divisoft to its distribution network

High efficiency power supply manufacturer Excelsys Technologies has added Divisoft AB to its distribution network. The new partner will distribute Excelsys' solutions to OEM customers in the industrial, medical and government sectors throughout Scandinavia & Northern Europe. Divisoft will particularly focus on our Xgen, UltiMod and Xsolo platforms all of which are all field proven and have a 5 year warranty. These platforms meet the most stringent certification requirements from the Medical, Industrial and Government Sectors including; UL/EN60950 2nd edition, UL/EN60601-1 3rd edition, MIL STD-810G, MIL-STD-461F, SEMI F47.


**Divisoft AB**
www.divisoft.se

## Acal BFi and Stollmann announce distribution agreement

Acal BFi and Stollmann E+V GmbH have entered into an agreement to distribute Bluetooth modules throughout Europe. Acal BFi will incorporate Stollmann's Bluetooth modules into their product portfolio effective immediately. Based in Hamburg, Germany, Stollmann has specialised in the development of Bluetooth and Bluetooth Low Energy modules for years. Thanks to its extremely low energy consumption, the "BlueMod+S" single-mode module is especially well-suited for use in sensors and other battery-operated applications. The pin-compatible "BlueMod+SR" dual-mode module is available for easy Bluetooth pairing with NFC handover and it is compatible with classic Bluetooth. With the development kit for the single-mode module, also available through Acal BFi, customers can develop their own firmware on a previously-certified Bluetooth module.

**Acal BFi**
www.acalbfi.com

EE Times europe

**PUBLISHER**
**André Rousselot**
+32 27400053
andre.rousselot@eetimes.be

**EDITOR-IN-CHIEF**
**Julien Happich**
+33 169819476
julien.happich@eetimes.be

**EDITORS**
**Christoph Hammerschmidt**
+49 8944450209
chammerschmidt@gmx.net
**Peter Clarke**
+44 776 786 55 93
peter.clarke@eetimes.be
**Paul Buckley**
+44 1962866460
paul@activewords.co.uk
**Jean-Pierre Joosting**
+44 7800548133
jean-pierre.joosting@eetimes.be

**CIRCULATION & FINANCE**
**Luc Desimpel**
luc.desimpel@eetimes.be

**ADVERTISING PRODUCTION & REPRINTS**
**Lydia Gijsegom**
lydia.gijsegom@eetimes.be

**ART MANAGER**
**Jean-Paul Speliers**

**ACCOUNTING**
**Ricardo Pinto Ferreira**

**REGIONAL ADVERTISING REPRESENTATIVES**
Contact information at:
http://www.electronics-eetimes.com/en/about/sales-contacts.html

**ELECTRONIC ENGINEERING TIMES EUROPE**
is published 11 times in 2015
by **EUROPEAN BUSINESS PRESS SA**
Chaussée de Louvain 533,
1380 Lasne, Belgium
Tel: +32-2-740 00 50
Fax: +32-2-740 00 59
email: info@eetimes.be.
www.electronics-eetimes.com
VAT Registration: BE 461.357.437.
Company Number: 0461357437
RPM: Nivelles.
Volume 17, Issue 8 EE Times P 304128
It is is free to qualified engineers and managers involved in engineering decisions – see:
http://www.electronics-eetimes.com/subscribe




# Let consumers figure out a use case for EEG

By Julien Happich

That's what you could think of Imec an Holst Centre's recent launch of an electroencephalogram (EEG) headset which the research centres hope will seduce consumers.

Once belonging to the realm of brain research within medicalized environments, electroencephalograms (brain electrical signals) can now be picked up wirelessly at the surface of the head (without surgically implanted electrodes). For a long time, the best wireless signal results had only been achieved through careful skin preparation (with a medical assistant or a nurse care and placing the electrodes manually after a special gel was applied).

Lately, a number of companies have developed dry-electrode EEG headsets, hassle-free to put on, with the promise to control a number of electronic appliances and software only using brainwaves. Presented as a revolutionary Brain Computer Interface and starting at $399, the Emotiv EPOC with its 14 EEG channels is still mostly an instrument for scientific research. California-based Emotiv also markets a lighter and more fashionable version, the Insight. Though apart from mobility-impaired users who could certainly benefit from the remote and handless operations enabled by the device, it has yet to be seen if EEG could become a mainstream enabler tied to smartphone apps or games.

So when imec, the Holst Centre and the Industrial Design Engineering (IDE) faculty of Delft University of Technology promote a consumer-grade wireless EEG headset that can be worn comfortably and yet achieves medical-grade EEG data acquisition at a very low cost, the technological feat is certainly there, but who will be first to lure consumers into wearing it?

With dry polymer and flexible active electrodes, miniaturized and low-power data acquisition, with low-power wireless interfaces to smartphones, the EEG headset ticks a number of boxes as a wireless brain-computer interface, for some professional use cases maybe or in some far flung virtual reality environments.

Consumer applications could include games that monitor relaxation, engagement and concentration, but the wireless headsets could also be used for attention training, sleep training and treatment of Attention Deficit Hyperactivity Disorder (ADHD), say the researchers.

"The mobile app relates the user's emotional state to environmental information such as agenda, location, proximity to others and time of day, in order to provide feedback about the unconscious effects of the environment on the user's emotions, thus creating awareness and actionable new insights", reads the statement from imec.

But will EEG headsets become the necessary gadget for the millions of digitally-intoxicated and isolated smartphone users to check their emotions and mood, in the absence of real people to interact with?

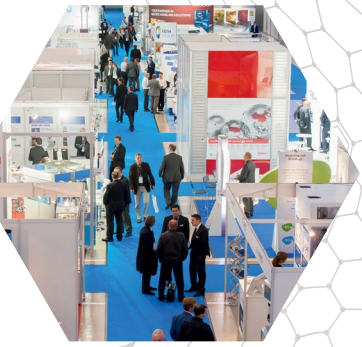
Will anyone truly benefit from such monitoring apps, adding another layer of digitalization to our self, or will this be another accelerator for digital burnouts?

I guess EEG interfaces are an ongoing experiment, and only the future will tell if consumers are willing to embrace this technology and through which marketing tactics

# SEMICON® Europa 2015 | PE 2015

6 – 8 October • Messe Dresden, Germany
www.semiconeuropa.org

without limits.



**SEMICON Europa technology and business programs address the critical issues and challenges facing the microelectronics industry and provide the information, education, and guidance that you need to move your innovations and products to market.**

## EXHIBITION AREAS

- **Semiconductor Manufacturing**
  Equipment for Front-End and Back-End, Materials and Services
- **Allée des Clusters**
- **Applications and Components**
  Industry 4.0, Medtech, Automotive, Imaging, Power Electronics, Plastic Electronics, IoT, Cool Silicon
- **Innovation Village**
- **Science Park**

## PROGRAM TOPICS

- Semiconductor Technology including Fab Management, Automation, Advanced Technology Nodes, Lithography, Metrology, New Materials, MEMS
- Advanced Packaging and Test
- Imaging Conference
- Low Power Conference
- Power Electronics Conference
- Plastic Electronics Conference
- Executive and Market Programs
- Silicon Innovation Forum

**Register now online:**

**Y9XIJ**

***Use promotion code and save 25 Euro!***
***Free access to SEMICON Europa 2015.***

**www.semiconeuropa.org**

Supported by:

Dresden.

STAATSMINISTERIUM FÜR WIRTSCHAFT ARBEIT UND VERKEHR | Freistaat SACHSEN

WIRTSCHAFTSFÖRDERUNG SACHSEN

SILICON SAXONY THE HIGH-TECH NETWORK

semi™


# Infineon solutions for switch mode power supplies

SMPS

## Bringing energy efficiency to the next level

Tighter specifications, increasingly shorter cycle times, higher cost pressure – Infineon meets your challenges head on. With our broad portfolio of high quality semiconductor solutions we provide you state-of-the-art power supplies that fulfill the highest demands in terms of efficiency, power density and reliability.

**Latest product solutions:**

› 600 V CoolMOS™ C7 – HV MOSFETs for highest efficiency and total cost of ownership (TCO) driven applications
› 2EDN EiceDRIVER™ – Optimized gate driver for standard and superjunction MOSFETs as well as GaN

**Learn more about our offering for your system:**
www.infineon.com/smps

Infineon