MICRO SOLUTIONS
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SEPT/OCT 2017

GOING TO EXTREMES

CONSERVING ENERGY IN SMART, CONNECTED DEVICES

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COVER STORY

NEW PRODUCTS

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DESIGN CORNER

Who Are You Going to Call?

We know that developing embedded designs can be challenging. Whether you are relatively new to the process or a seasoned professional, there will be times when you need some sort of technical support using our products, software and development tools. Who are you going to call when you can't find an answer to your question in our documentation, forums or other online support resources?

To guide you through the process of getting in touch with a member of our Technical Support team, we have created an online ticket system that is managed through our myMicrochip portal. If you are a new customer, you will first need to create an account. Once your account is activated, you can then submit a request for technical support. Go to our **Technical Support** website and use the "My Support" link in the upper right corner to create your myMicrochip account and submit a support ticket.

After you have completed and submitted your support ticket, you will be assigned a case number and a phone access number. This information will typically be sent within a day to the email address you provide in your support ticket. It's very important that you use an active email address and check it for this incoming email from our support team. If you do not have access to your email, your Case Issue contains this information under the "System Information" section. Look for the "Customer Call-in Info" area. You will also find a list of contact phone numbers by country under the "My Support" link. Find your country and then use the phone number indicated to place your call. If our support team is busy, you can leave a message and someone will call you back at the telephone number you provide.

If you have any questions about our support system, you'll find a number of helpful articles on the Technical Support site. Of course we hope your design process goes smoothly, but we are ready to help if you need us.

As always, we would be happy to get your feedback on MicroSolutions. Feel free to email us at MSFeedback@microchip.com.

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GOING TO EXTREMES

High-Performance PIC32MX Family of Microcontrollers Now Features eXtreme Low Power Technology

Low-Cost PIC32MX1/2 XLP Devices Deliver Increased Performance at Lower Operating, Sleep and Deep Sleep Currents

Energy conservation is a major concern to developers of today's connected applications. Wearable technology, wireless sensor networks and other smart connected devices need to consume as little power as possible and, in extreme cases, need to be able to run from a single battery for 20 years or longer. To enable these types of applications, Microchip offers a range of microcontrollers (MCUs) with **eXtreme Low Power** (XLP) technology. These devices offer the industry's lowest currents for Run and Sleep, where extreme low-power applications spend 90–99 percent of their time.

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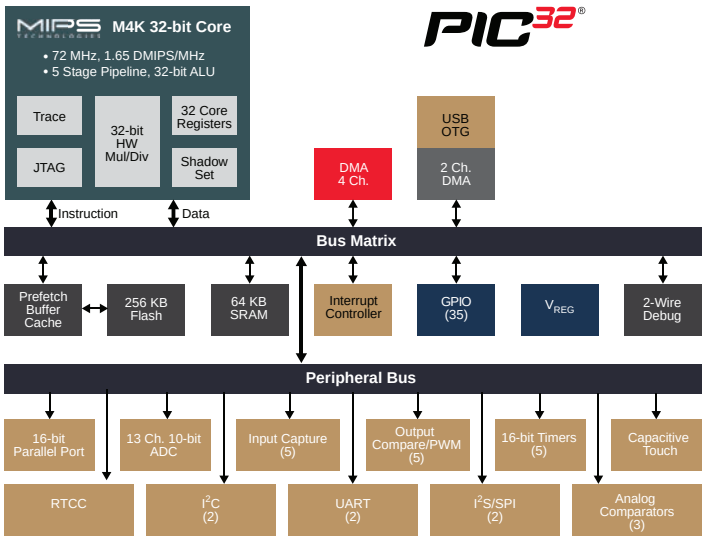
If you have been successfully using our 32-bit PIC32MX family, you can now take advantage of XLP technology for your wearable and other low-power connected designs. The new **PIC32MX1/2 XLP** family offers you an easy migration path, with little code rework needed to achieve higher performance at much lower power. These MCUs deliver increased functionality as well as longer battery life in portable applications.

XLP technology enables Sleep and Deep Sleep shutdown states on the PIC32MX1/2 XLP MCUs, with Deep Sleep currents as low as 673 nA. As a result, these new MCUs offer over 40 percent higher performance than devices in the existing PIC32MX1/2 portfolio, while reducing average run currents by 50 percent.

The low-cost family also offers a range of memory configurations with 128/256 KB Flash and 32/64 KB of RAM in packages ranging from 28 to 44 pins. They also include a diverse set of peripherals including I²S for digital audio, 116 DMIPS performance for executing audio and advanced control applications, a 10-bit 1 Msps 13-channel ADC, mTouch® capacitive touch-sensing and serial communications peripherals. The PIC32MX2 series also supports USB-device, host and OTG functionality.



Block Diagram for PIC32MX Family with XLP Technology

Development Support

You can jump start your low-power application development with the **PIC32MX XLP Starter Kit** (DM320105). This fully integrated platform features a high-performance, 72 MHz PIC32MX254F256 MCU with 256 KB Flash, 64 KB of RAM and Full Speed USB functionality. The PIC32MX XLP development board also includes an integrated programmer/debugger and is fully supported by **MPLAB® X Integrated Development Environment** (IDE). The starter kit also supports Bluetooth® Low Energy connectivity, and it comes with a 9-axis accelerometer, light sensor and barometric sensor to enable the development of a variety of Internet of Things (IoT) and other low-power applications. The on-board mikroBUS™ expansion socket allows you to easily add a variety of click boards™ from MicroElektronika to expand the functionality of your design, while the Microchip X32 header will help accelerate your prototype development.

PIC32MX XLP Starter Kit (DM320105)

The PIC32MX1/MX2 XLP MCUs are also supported by the **MPLAB Harmony Software Development Framework**, which simplifies development cycles by integrating the license, resale and support of Microchip and third-party middleware, drivers, libraries and RTOSs. Our readily available software packages such as Bluetooth audio development suites, audio equalizer filter libraries, decoders (including AAC, MP3, SBC), sample rate conversion libraries and USB stacks will significantly reduce your development time in creating digital audio, consumer, industrial and general-purpose embedded control applications.

If you are ready to take your connected design to the extreme, the PIC32MX1/2 XLP MCUs can be ordered today from **microchipDIRECT** or from **Microchip's worldwide distribution network**.

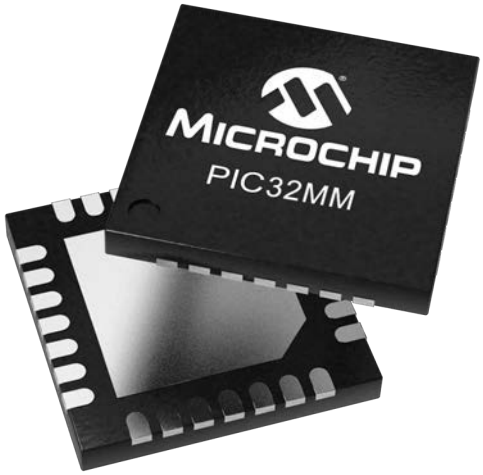
Want More Information?

Visit the website at:

www.microchip.com/PIC32MX-XLP-3861

Boost Your Design

Microchip Extends eXtreme Low Power PIC32MM Microcontroller Family



PIC32MM "GPM" Devices Are Available with USB Support, Core Independent Peripherals and Memory Scalable to 256 KB in Compact Packages

Does your design need a little boost? The **PIC32MM** family of microcontrollers (MCUs) bridges the gap between our popular 16-bit PIC24F MCUs and the low-cost 32-bit PIC32MX family to offer you our lowest-power and most cost-effective family of 32-bit PIC® MCUs. They are a compelling solution for your applications with budget, power and size constraints.

As the latest additions to this portfolio of MCUs, the PIC32MM "GPM" family of eXtreme Low Power (XLP) devices features large memory in small packages, providing ample battery life for space-constrained applications. Offering several connectivity options, Core Independent Peripherals (CIPs) and feature-rich development boards, these PIC32MM "GPM" MCUs are well suited for digital audio applications, gaming/entertainment devices, Internet of Things (IoT) sensor nodes and portable medical devices.

The PIC32MM "GPM" family of eXtreme Low Power devices features large memory in small packages.

The XLP PIC32MM "GPM" family will minimize the power consumption, board space and development time for your application. Their power-saving options—that include sleep modes with current consumption as low as 650 nA with Random Access Memory (RAM) retention—greatly extend battery life in portable applications. These PIC MCUs are available with up to 256 KB of Error Correction Code (ECC) Flash and 32 KB of RAM, providing ample space for application code and communication stacks. They are available in a variety of pin count options ranging from 28 to 64 pins in compact packages as small as 4 × 4 mm with 28 pins, 5 × 5 mm with 36 pins and 6 × 6 mm with 48 pins to optimize your overall design footprint.

Their power-saving options greatly extend battery life in portable applications.

Integrated CIPs such as Direct Memory Access (DMA), Configurable Logic Cells (CLC) and a 12-bit Analog-to-Digital Converter (ADC) allow the system to accomplish tasks in hardware while freeing up the central processing unit (CPU) to do other tasks or to go to sleep. Leveraging these hardware-based CIPs improves execution efficiency while maintaining system flexibility and lowering overall power consumption. The PIC32MM "GPM" MCUs also include a crystal-less USB device/host/On-the-Go (OTG) and I²S functionality, which are crucial for designing USB audio applications and communication gateways. Their accurate on-chip USB oscillator eliminates the need for an external

(continued on page 7)

crystal or oscillator, reducing the overall system BOM cost and board real estate associated with USB applications.

Development Support

The PIC32MM "GPM" MCUs are supported by the **MPLAB® Code Configurator** (MCC) tool. MCC makes it easy to configure the USB stack, pin assignments and peripherals, significantly accelerating development time. They are also supported by the **MPLAB X Integrated Development Environment** (IDE) ecosystem and **MPLAB XC32 Compiler**.

The new **PIC32MM USB Curiosity Development Board** (DM320107) is a low-cost development platform that comes fully integrated with a programmer/debugger. The board also features two MikroElektronika mikroBUS™ interfaces that enable support for more than 300 click boards™, a USB Micro B connector and two X32 interfaces that enable access to the **PIC32 Audio Codec Daughter Card** (AC320100). The **PIC32MM0256GPM064 General Purpose Plug-in Module** (MA320023) plugs into the **Explorer 16/32 Development Board** (DM240001-2) for easy evaluation of the PIC32MM "GPM" MCUs and to jump start your application development.

The PIC32MM "GPM" devices are available in 64 KB, 128 KB and 256 KB Flash variants with 28-, 36-, 48- and 64-pin packaging options. You can order them from **microchipDIRECT** or from **Microchip's worldwide distribution network**.

Want More Information?

Visit the website at:

www.microchip.com/PIC32MM

Secure Connectivity

Two New SAM Microcontroller Families Offer Power Performance and Enhanced Security Features

SAM D5x and SAME5x MCUs Also Provide Extensive Connectivity Interface Options

As embedded systems become increasingly more complex, designers need faster microcontrollers (MCUs) with better connectivity options and flexible peripheral support. They are looking for cost-effective solutions that deliver powerful performance, comprehensive interface options and robust, hardware-based security.

As the latest additions to Microchip's portfolio of 32-bit SAM MCUs, the new **SAM D5x** and **SAM E5x** devices are well suited to meet these emerging design requirements. They combine the performance of an ARM® Cortex®-M4 processor with a Floating Point Unit (FPU) to offload the Central Processing Unit (CPU), increasing system efficiency and enabling process-intensive applications on a low-power platform. Running at up to 120 MHz, the SAM D5x/E5x MCUs feature up to 1 MB of dual-panel Flash with Error Correction Code (ECC), easily enabling live updates with no interruption to the running system.

The SAM D5x and SAME5x devices are well-suited to meet emerging design requirements, enabling process-intensive applications on a low-power platform.

Additionally, these families are available with up to 256 KB of SRAM with ECC, which is vital to mission-critical applications such as medical devices or server systems.

> Both the SAM D5x and SAM E5x families contain comprehensive cryptographic hardware and software support.

These new MCUs have multiple interfaces that provide design flexibility for even the most demanding connectivity needs. Both families of devices include a Quad Serial Peripheral Interface (QSPI) with an Execute in Place (XIP) feature. This allows the system to use high-performance serial Flash memories—which are both small and inexpensive compared to traditional pin parallel Flash—for external memory needs. The SAM D5x/E5x devices also feature a Secure Digital Host Controller (SDHC) for data logging, a Peripheral Touch Controller (PTC) for capacitive touch capabilities and best-in-class active power performance (65 uA/MHz) for applications requiring power efficiency. The SAM E5 family also includes two CAN-FD ports and a 10/100 Mbps Ethernet Media Access Controller (MAC) with IEEE 1588 support, making it well-suited for industrial automation, connected home and other Internet of Things (IoT) applications.

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The SAM D5x and SAM E5x families contain comprehensive cryptographic hardware and software support, enabling you to incorporate security measures at your design's inception. Their hardware-based security features include a Public Key Cryptographic Controller (PUKCC) supporting Elliptic Curve Cryptography (ECC) and RSA schemes, as well as an Advanced Encryption Standard (AES) cipher and Secure Hash Algorithms (SHA).

If you are looking for a cost-effective solution for your next 32-bit application, the SAM D5x and SAM E5x MCUs provide an excellent migration path to deliver powerful performance, comprehensive interface options and built-in security to your design.

Development Support

The **SAM E54 Xplained Pro Evaluation Kit** (ATSAME54-XPRO) incorporates an on-board debugger and additional peripherals to jump start and simplify your application development.

All SAM D5x/E5x MCUs are supported by the **Atmel Studio 7 Integrated Development Environment** (IDE) as well as **Atmel START**, a free online tool to configure peripherals and software that accelerates development.

Available in a variety of pin counts and package options, the SAM D5x and SAM E5x device families can be ordered from **microchipDIRECT** and also from **Microchip's worldwide distribution network**.

Want More Information?

Visit the website at:

www.microchip.com/design-centers/32-bit

Chain of Communication

New MOST® Technology Intelligent Network Interface Controller Enables Daisy-Chain Communications in Automotive Applications

OS81119 Reduces Automotive Wiring Requirements and Component Count for Lower System Cost

Media Oriented Systems Transport (MOST) technology is the choice of many automobile manufacturers and tier one suppliers for in-vehicle networking. It specifically targets infotainment and telematics applications such as smart antennas, head units, amplifiers, digital clusters, rear seat entertainment, Advanced Driver-Assistance Systems (ADAS), driver/passenger information systems, public transportation infotainment, and information systems. Continuous innovation in this technology is enabling even more cost-effective solutions for the automotive market.

A new MOST150 Intelligent Network Interface Controller (INIC), the **OS81119**, now enables the implementation of MOST networks in a daisy-chain configuration on coaxial physical layer with the support of full-duplex communication, in addition to a ring topology. In a full-duplex daisy-chained network, a single cable segment is sufficient to connect two adjacent devices in the network, reducing the number of cables and connectors required for the back channel on each network connection. It also eliminates the need for a return wire to connect the last node of the network to the first. This reduction in wiring and component count lowers overall system costs and can result in potential weight savings that can impact Corporate Average Fuel Economy (CAFE) goals and other fuel efficiency regulations.

The OS81119 INIC simplifies the network architecture of in-vehicle infotainment systems by allowing you to use integrated coaxial physical layer (cPHY), optical physical layer (oPHY), daisy-chain topologies or creative hybrid combinations. If you are currently using MOST150 systems, you can also rapidly migrate to new topologies or daisy-chain additional nodes with little hardware and software redesign required.

In addition to the integrated cPHY, the OS81119 also includes a USB 2.0 high-speed user interface. This integration further reduces system component count, driving down overall costs. Using the USB standard and corresponding standardized MOST Linux® Driver can speed your time to market, and using the open-source Linux operating system and driver for the OS81119 will help reduce costs. You can also minimize the risk of application issues by using the standard Application Programming Interfaces (APIs).

Development Support

The OS81119, which is offered in a QFN88 package, is supported by **MOST NetServices V3.2.x**, MOST Linux Driver and Microchip's new **Unified Centralized Network Stack** (UNICENS). Additional hardware and software tools from **K2L** also support the development of OS81119-based automotive connectivity applications. They include the OS81119 USB Application Board, MOST150 Slim Board Family, OptoLyzer® MOCCA compact 150c and 150o, INIC Explorer and MediaLB® Bus Analyzer.

To purchase the OS81119, contact your local **Microchip sales representative or distributor**.

Want More Information?

Visit the website at:

www.microchip.com/OS81119

Meeting the Grade

ATA65xx Is Industry's First CAN Flexible Data-Rate and CAN Partial Networking Transceiver Family Including Automotive Grade 0 Qualified Parts

Provides High-Temperature Variants for the Harsh Automotive Environment

Originally created for automotive applications, the high-speed and reliable Controller Area Network (CAN) serial bus protocol delivers robust communication capabilities to a range of embedded designs. Microchip offers one of the strongest and most complete CAN transceiver portfolios in the industry. This portfolio includes transceivers that ensure reliable communication and offer a high degree of noise immunity within the harsh automotive environment, while significantly reducing system costs.

The ATA65xx family of **CAN transceivers**, which includes a set of automotive Grade 0 qualified devices, supports the recently established CAN Flexible Data-Rate (FD) protocol to support data rates up to 5 Mbps and the new CAN Partial Networking (PN) standard for improving the energy efficiency of vehicles. The **ATA6562**, **ATA6563**, **ATA6564**, **ATA6565**, **ATA6566** and **ATA6570** are fully compliant with the 11898-2/5, ISO 11898-2:2016 and the SAE J2962-2 standards and support an ambient temperature rating of -40° to 150°C. The ATA6570 also supports ISO 11898-6 CAN PN and includes a window watchdog.

The ATA65xx family includes a set of Grade 0 qualified devices supporting the CAN FD protocol.

All devices in the ATA65xx family are approved by major car manufacturers for use without the external Common Mode Choke (CMC) that is required for most CAN transceivers. They also include wake-up capability via the CAN bus with a dual wake-up pattern according to ISO 11898-2:2016. A modern vehicle contains more than 70 Electronic Control Units (ECUs) with a CAN interface. This feature avoids unwanted power-up sequences, leading to significant energy savings and reduced emissions.

Development Support

You can prototype and test your CAN designs based on the ATA65xx family with the ATA656x-EK development kit and the ATAB6570A development kit. MikroElektronika also offers the **ATA6563 click**.

Devices in the ATA65xx family are available in DFN packages with wettable flanks, ready for automatic optical solder-joint inspection. The ATA6562/63/64/66 is available in an SO8 package or DFN8 package. The ATA6565 is available in a DFN14 package, and the ATA6570 is available in an SO14 package. To purchase any of these products, contact any **Microchip sales representative or authorized worldwide distributor**.

Want More Information?

Visit the website at:

www.microchip.com/CAN

Lighten Up

Next-Generation CL88020 Sequential Linear LED Driver is Designed for Offline Lighting

Create More Reliable and Cost-Effective LED Lighting Applications

The transition from traditional lighting to LEDs is here and is moving along at a fast pace. As designers are continually seeking better electronic solutions to implement their lighting designs, Microchip's rich and diverse portfolio of LED drivers can help you develop a wide range of LED-based illumination applications.

As an extension to our popular CL88xx family, the **CL88020** is a next-generation sequential linear LED driver for offline lighting applications. It is designed to drive a long string of low-cost LEDs directly from the 120 VAC line input. This new LED driver enables you to create reliable, cost-effective and compact LED lighting applications by delivering a high power factor without the need for switch-mode power conversion, which is typically required for LED lighting design.

The CL88020 was designed to minimize the driver circuit component count, resulting in a very small and efficient design.

The CL88020 is a next-generation sequential linear LED driver for offline lighting applications.

The simple design allows for a single-layered Printed Circuit Board (PCB) layout. Unlike the conventional AC/DC switch-mode power supply, the basic driver circuit consists of the CL88020 IC, two small ceramic capacitors and a bridge rectifier only. High-voltage capacitors, transformer or inductors, Electromagnetic Interference (EMI) filters or Power Factor Correction (PFC) circuitry are not required. This allows for a smaller solution size and a lower overall Bill of Material (BOM) cost as compared to traditional LED solutions.

This approach of driving LEDs directly from the AC mains addresses many design concerns. The CL88020 LED driver enables you to design simpler, smaller and more robust high-performance LED lighting systems than previously possible.

Development Support

To help you get started with designing and testing your own LED load applications, the **CL88020 LED Driver Evaluation Board** (ADM00766) is a complete solution powered directly from the 120 VAC line and consisting of an LED Driver Source Board and an **LED Load Board** (ADM00767) that features 10 LEDs grouped in four taps.

The CL88020T-E/SE is available in a SOIC-8 package and can be ordered from **microchipDIRECT** or from **Microchip's worldwide distribution network**.

Want More Information?

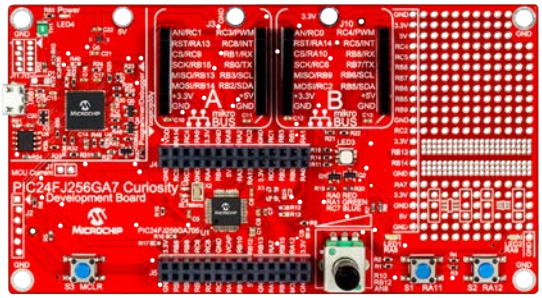
Visit the website at:

www.microchip.com/CL88020

Curiosity for the IoT

Turn Your Internet of Things Design Idea into a Reality with Newest Curiosity Development Board

Harness the Potential of an eXtreme Low Power 16-bit PIC® Microcontroller



As the latest expansion to the Curiosity platform, the new **PIC24FJ256GA7 Curiosity Development Board** (DM240016) lets you rapidly prototype and harness the potential of the low-cost, eXtreme Low Power (XLP), 16-bit **PIC24FJ256GA705** family of microcontrollers (MCUs). The PIC24FJ256GA7 Curiosity Development Board is a cost-effective, fully integrated 16-bit development platform targeted at first-time users, makers and designers seeking a feature-rich rapid prototyping board. You can now step into a world of unlimited possibilities for your next project and make your embedded design a reality, even if you are new to using PIC MCUs.

The PIC24FJ256GA7 Curiosity Development Board enables easy and faster adoption of the PIC24FJ256GA705 family of MCUs. Featuring up to 256 KB of ECC Flash memory and 16 KB of RAM, the PIC24FJ256GA705 family is well suited for low-power, general-purpose applications that require longer battery life, large memories and a small footprint. Offering a Retention Sleep current down to 190 nA, these MCUs can extend the battery life for portable devices, wearables and Internet of Things (IoT) nodes. Their Sleep and Idle modes can selectively shut down peripherals and/or the core to significantly reduce power consumption and enable fast wake up.

The layout of the PIC24FJ256GA7 Curiosity Development Board and its array of external connectors offer you unparalleled access to the MCU's Core Independent Peripherals (CIPs) that include a Configurable Logic Cell (CLC), Multiple Capture/Compare/PWM (MCCP) and Direct Memory Access (DMA) controller. These CIPs enable you to integrate various system functions onto a single MCU, simplifying your design and keeping system power consumption and BOM cost low.

The PIC24FJ256GA7 Curiosity Development Board is crafted for cloud-based development. It offers seamless integration with Microchip's software tool chain, including the cloud-based **MPLAB® Xpress Integrated Development Environment** (IDE), **MPLAB XC16 Complier** and **MPLAB Code Configurator** (MCC) for easy set up and prototyping.

Priced at just $25, the PIC24FJ256GA7 Curiosity Development Board is an economical platform for launching many creative design ideas. Out of the box, the development board offers several options for user interface, including physical switches, RGB LEDs, user LEDs and an analog potentiometer. The board also includes an integrated programmer/debugger and requires no additional hardware to get started. You can quickly begin working with your first example project by using the RGB color mixing application that comes preprogrammed on the PIC24FJ256GA7 Curiosity Development Board. This demonstrates how the potentiometer can be used to adjust the intensity of each color channel independently and how the push buttons can be used to select the channel to be adjusted.

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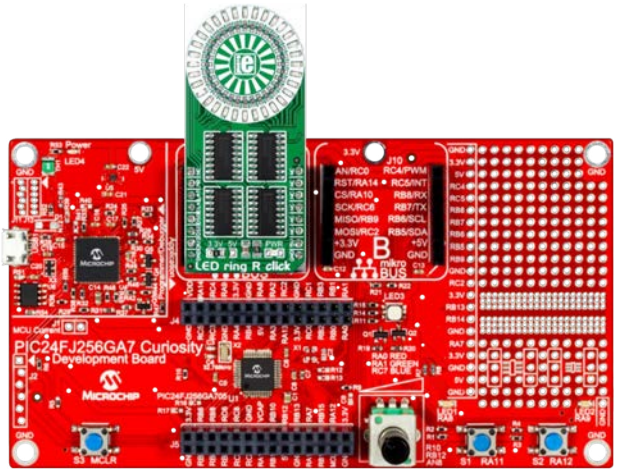
Two on-board MikroElektronika mikroBUS™ interfaces make it easy to add sensors, connectivity and other functionality using hundreds of **MikroElektronika click boards™**. If you are interested in developing IoT applications, one connector can be used as a sensor interface and the other can be used to add Wi-Fi®, Bluetooth® or LoRa® wireless connectivity. These add-on boards give you many options for customizing your design. To help you bring your ideas to life even faster, **quick-start software libraries** for a number of MikroElektronika click boards have been added into the MCC plug-in. New click boards are being added to the library on a regular basis.



The PIC24FJ256GA7 Curiosity Development Board with the LED ring R click

The Ring LED Demo is an example of many design possibilities that you can create using the PIC24FJ256GA7 Curiosity Development Board and your choice of click board. This demo uses the **LED ring R click** and simulates an arcade game where you are required to stop a revolving light with push of a button between two reference points. The on-board potentiometer allows you to control the speed of the moving LED to adjust the difficulty.

If you need more ideas to get started with building your design, you can download helpful **demo code** and the **PIC24FJ256GA7 Curiosity Board Quick Start Guide** is also available. We also encourage you to join the **Microchip forums** and become part of the Curiosity community. Sharing and acquiring new ideas is part of the fun.

In addition to the PIC24FJ256GA7 Curiosity Development Board, Microchip offers a range of **Curiosity Development Boards** that will help you harness the power of 8-, 16- and 32-bit PIC MCUs. Some of these boards offer Wi-Fi, Bluetooth and USB connectivity. To address the security requirements of IoT designs, some families of 16-bit and 32-bit PIC MCUs supported by Curiosity Development Boards come equipped with an integrated hardware cryptographic engine for data encryption/decryption and authentication.

If this board has sparked your curiosity, visit the **PIC24FJ256GA7 Curiosity Development Board** web page and start working on your innovative embedded designs today.

UPCOMING TRADESHOWS

Catch up with Microchip at our upcoming shows:

ARM TechCON 2017
Booth #721
Oct. 24–26, 2017
Santa Clara, CA

2017 IEEE-SA Ethernet & IP @ Automotive Technology Day
Booth #2
Oct. 31–Nov. 2, 2017
San Jose, CA

Get Launched!

Do you have a new idea, breakthrough technology or are you working on an innovative prototype?

Microchip can help you get your idea launched from your workshop into the marketplace!

- *Support*: we have you covered, from business to operational resources you may need
- *Mentoring*: design and manufacturing expertise
- *Network*: introduction to people and companies that can help you
- *Product portfolio*: IoT, hardware, software and design tools

Coming soon to a location near you.
Go to www.microchip.com/getlaunched for more information.

Make It Smart

Boost Your Development of Intelligent Power Supply Applications with Reference Designs Featuring dsPIC® Digital Signal Controllers

An intelligent power supply doesn't need to be complex or expensive. Microchip offers a broad range of "power-supply enabled/specific" microcontrollers and supporting power devices. While traditional power supply designs use analog ICs with fixed functionality to provide regulated power, an intelligent power supply integrates a dsPIC Digital Signal Controller (DSC) or PIC® microcontroller (MCU) to enable a fully programmable and flexible solution. Using digital control to implement power conversion functions in your design offers many benefits. Digital power devices with intelligent peripherals enable you to design intelligent power supplies with higher efficiency and optimum performance at lower cost.

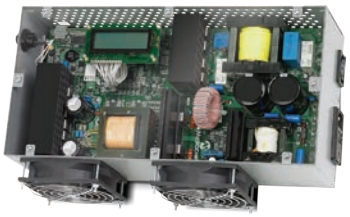
dsPIC DSCs and PIC MCUs enable a fully programmable and flexible solution.

To assist you with bringing your application to market more quickly, we offer a number of reference designs, development boards and software tools specifically targeting intelligent power applications. Here are some featured Intelligent Power reference designs that use Microchip dsPIC DSCs to enable full digital control of power conversion, as well as all system management functions in a variety of applications.

Platinum-Rated 720W AC/DC Reference Design

Demonstrating the flexibility of dsPIC DSCs in SMPS applications, this reference design has a peak efficiency of 94.1% and achieves the ENERGY STAR® CSCI Platinum Level. It features a 2-phase interleaved power factor correction boost converter followed by a 2-phase interleaved two-switch forward converter with synchronous rectification. **More information.**

Digital Pure Sine Wave Uninterruptible Power Supply (UPS) Reference Design



Implemented using a single dsPIC33F "GS" digital-power DSC, this reference design demonstrates how digital power techniques can be applied to UPS applications to reduce audible and electrical noise via a purer sine-wave output. It also shows how these techniques enable easy modification through software, the use of smaller magnetics, the creation of higher-efficiency and compact designs, and a low bill-of-materials cost. **More information.**

(continued on page 16)

SMPS AC/DC Reference Design

Evaluate the power and features of dsPIC DSCs in high-wattage AC/DC conversion applications. This reference design unit works with the universal input voltage range and produces multiple DC outputs. It is based on a modular structure featuring three major power stages. The input stage is a Power Factor Circuit (PFC) boost converter, the intermediate stage is a Phase-Shift Zero Voltage Transition (ZVT) converter, which includes a ZVT full-bridge converter and a synchronous rectifier, and the third stage, the point of load, is a single-phase and a multi-phase buck converter. This reference design uses one dsPIC33 DSC for the PFC boost converter and ZVT full-bridge converter and a second dsPIC33 DSC for the single-phase and multi-phase buck converters. **More information.**

Quarter Brick DC/DC Converter Reference Design

This reference design provides an easy method to evaluate the power and features of dsPIC DSCs used in high-density quarter brick DC-DC converters for Intermediate Bus Architectures (IBAs). A single dsPIC33F "GS" DSC enables you to create products using advanced switching techniques—such as the Phase Shift Full-Bridge (PSFB) topology—that lower switching losses and enable efficiencies as high as 94%. The reference design also supports the Full-Bridge topology through minor hardware modifications. **More information.**

Digital Power Interleaved PFC Reference Design

This reference design provides an easy method to evaluate the power and features of dsPIC DSCs for IPFC applications. It features a universal input voltage range and produces a single high-voltage DC output up to 350W with low Total Harmonic Distortion (THD) of the input current. **More information.**

Grid-Connected Solar Microinverter Reference Design

This reference design demonstrates the flexibility and power of dsPIC DSCs used in grid-connected solar microinverter systems. It has a maximum output power of 215 Watts and ensures maximum power point tracking for PV panel voltages between 20V to 45V DC. High efficiency was achieved by implementing a novel interleaved active-clamp flyback topology with Zero Voltage Switching (ZVS). **More information.**

If you would like to see a demonstration of any of these Intelligent Power Supply reference designs, please contact your local **Microchip Sales Office**.

Perfect Timing

Meeting Advanced Automotive Design Challenges with MEMS-Based Timing Devices

Automotive evolution is proceeding at a blistering pace. The largely mechanical enhancements of the first half-century, such as automatic transmissions, power steering, windshield wipers and cruise control, are taken for granted by today's drivers. A completely new set of innovations is now being enabled by silicon computing power, the wireless communication infrastructure and the connectivity of the Internet.

This convergence of telecommunications and information processing, called vehicle telematics, is directed primarily at providing features that improve driving safety and convenience. These evolving capabilities are greatly enhanced by connectivity to the communications infrastructure. Some of the key design initiatives include:

Safety

Advanced Driver Assistance Systems (ADAS) alert the driver to potentially hazardous situations and, in some cases, control the vehicle automatically. They employ radar and surround-view cameras, along with intelligent image processing, to detect nearby objects and road features, assess their location and determine the speed of movement. For example, an ADAS can provide tactile feedback to the driver through the steering wheel if the car is veering from its lane. Similarly, an ADAS can apply the brakes automatically if it detects that the car in front is too close.

Other safety aspects are provided by connectivity. These might include making e-calls in case of an emergency and providing navigation services to identify road hazards in real time.

Convenience

In-Vehicle Infotainment (IVI) provides in-car content services such as entertainment, GPS navigation, smartphone and phone application integration with the car's touchscreen and hands-free voice recognition functions.

Other Services

Vehicle management services allow a user to track their vehicle if it is stolen, for example, and also provide vehicle maintenance recommendations and update functionality by software download.

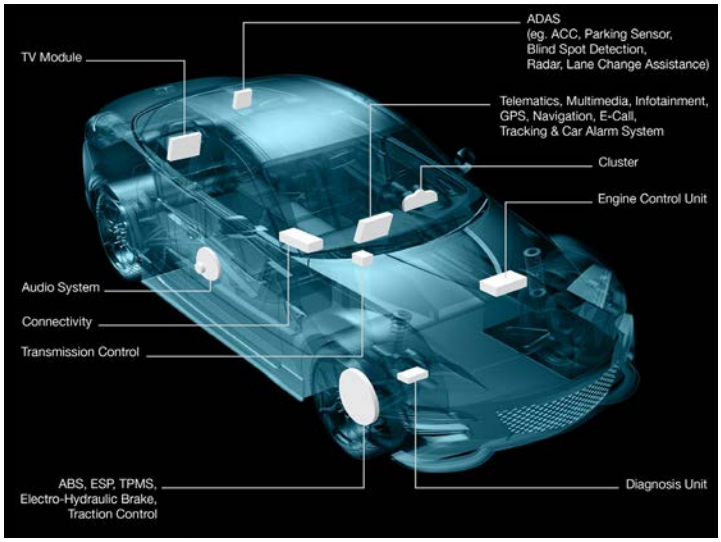


Figure 1: Electronic sub-systems in a modern car

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Automotive manufacturers have three main challenges in implementing this smart, connected technology.

1. The new technology has to be reliable—the safety and security of passengers and pedestrians depend upon it.
2. It must operate under temperature extremes. Depending upon its placement within the vehicle and the influence of weather and driving conditions, electronic circuitry within a vehicle can experience temperatures ranging from –40°C to +150°C. While traditional industrial electronic components are rated from –40°C to +85°C, automotive applications demand 105°C (Grade 2) and 125°C (Grade 1) reliability outside the vehicle engine compartment, with 150°C (Grade 0) or higher for engine and transmission applications.
3. Size and weight are primary concerns since in-vehicle electronic systems are numerous and complex.

For many of these emerging applications, Microchip's oscillators and clocks that are based on MicroElectroMechanical Systems (MEMS) technology are ideal solutions to meet the advancements and challenges the automotive industry is facing.

MEMS Oscillator and Clock Technology

Quartz resonators have provided the frequency-determining elements in oscillators and clocks for many decades, and they work well in many applications. However, MEMS technology has enabled the replacement of quartz crystals with tiny MEMS resonators. The benefits of MEMS-based oscillators include high reliability (including AEC-Q100 certification), shock resistance, stable frequency output over extended operating temperatures, small size and low power consumption. Below is an overview of how these benefits are achieved.

High Reliability from Ultra-Clean MEMS Silicon Packaging

Quartz crystals are millimeter-sized slivers of pure quartz (silicon dioxide), silvered on each side, connected by conductive epoxy to contacts and housed in a hermetic package (either ceramic or metal) filled with dry nitrogen. Each resonator is ground to the desired frequency before assembly.

MEMS resonators are created from pure silicon wafers and produced in a semiconductor foundry using the same lithographic processes as silicon die. The resonator consists of a tiny polysilicon beam (30 µm × 50 µm) suspended by silicon supports above a polysilicon ground plane (Figure 2). The beam flexes when it is attracted to the ground plane by electrostatic—as opposed to piezoelectric—forces (Figure 3).

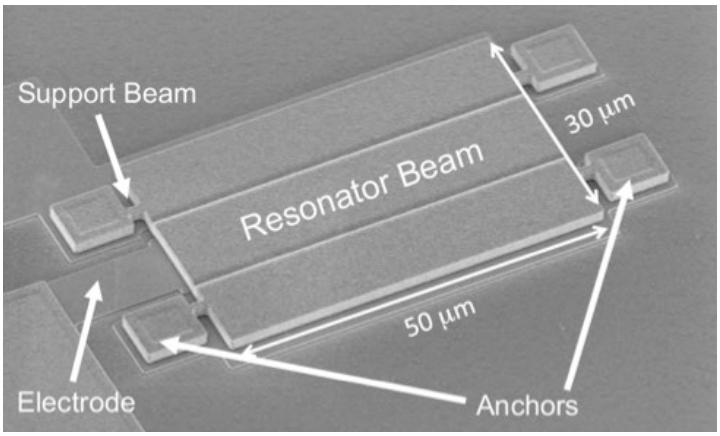

Figure 2: A SEM photomicrograph of a MEMS resonator before packaging

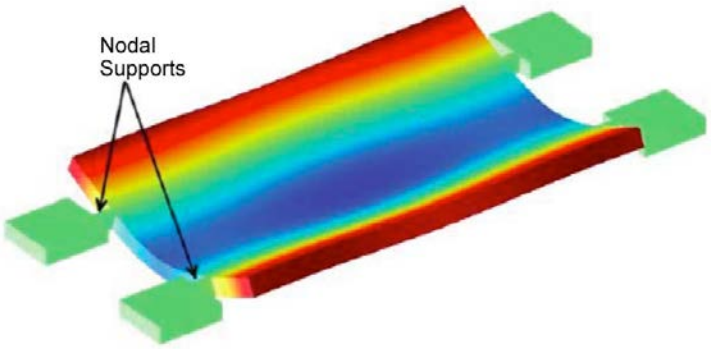

Figure 3: The flexing of a resonator under electric excitation

Approximately 100,000 resonators can be produced on each silicon device wafer using conventional silicon lithography plus some MEMS-specific etch steps needed to create the 3D structure. A "cap wafer" is also produced and etched with depressions that correspond to each of the resonator structures on the device wafer. These two wafers are accurately aligned, pressed together in a vacuum and annealed in a high-temperature furnace. The fusion bond between the two wafers is extremely strong (Figure 4). The bonded wafers are then singulated to create MEMS dice, with the resonator encased in a hermetic cavity that is formed by the depressions of the cap wafer (Figure 5).

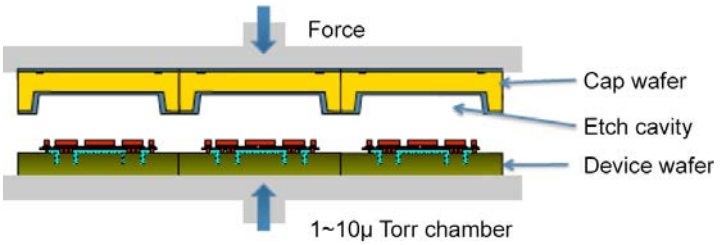

Figure 4: The bonding process of multiple resonators on a wafer

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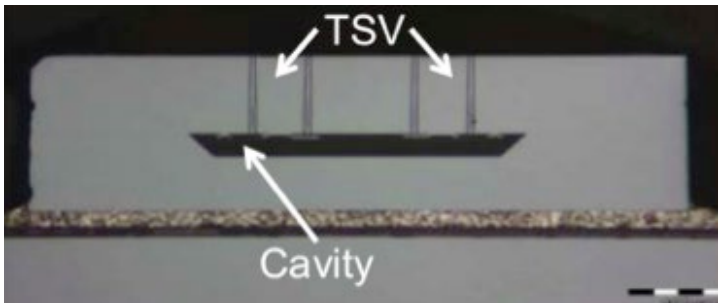

Figure 5: The resonator die with the MEMS structure inside a hermetic cavity. Through Silicon Vias (TSVs) enable resonator connections to be brought to the outside of the die.

The vacuum and heat process drives out any contaminants, resulting in an ultra-clean cavity that is directly responsible for the high reliability of the MEMS resonator. Connections to the resonator in the cavity are brought to the outside of the die by using Through Silicon Via (TSV) technology, which preserves the cavity hermeticity. In contrast, the ceramic or metal package that contains a quartz crystal and an ASIC oscillator die is larger and cannot achieve this level of cleanliness. Also, outgassing from the mounting epoxies causes some frequency drift.

Shock Resistance

Each MEMS die is bonded on top of a CMOS oscillator die and connected using industry-standard wire bonding (Figure 6). The whole assembly is packaged using standard plastic injection molding (Figure 7) to create the final product. Unlike quartz, no final hermetic package assembly is required.

Figure 6: The resonator die bonded above a CMOS oscillator ASIC

Figure 7: The packaged integrated oscillator

Since the MEMS resonator has very small mass—by orders of magnitude when compared to quartz blanks—the resonator alone can theoretically withstand one million g. In practice the package is the limiting factor, making a MEMS device able to withstand many tens of thousands of g, whereas quartz devices are only able to withstand 50–100g.

Stable Frequency Output

The MEMS resonator has a strong, but predictable, temperature characteristic. The CMOS oscillator design incorporates a highly accurate temperature sensor which, together with a fractional-N phase lock loop, provides an automatic correction to the frequency. The MEMS resonator can operate above 200°C. Today's MEMS oscillator designs provide very stable frequency to at least 125°C, as shown in Figure 8.

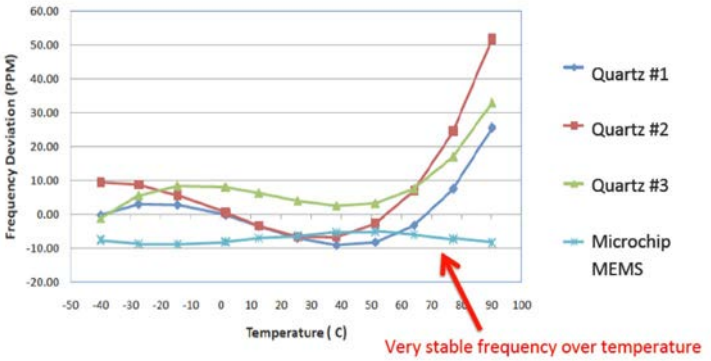

Figure 8: Comparison of frequency stability of quartz and MEMs oscillators

Small Size

The resonator die is only 400 microns square, and rapidly falling CMOS technology nodes have enabled CMOS oscillator dice sizes of less than 1 mm^2. The newly introduced DSC6000 is available in packages as small as 1.6 × 1.2 mm.

Using MEMS-Based Oscillators and Clocks for Automotive Applications

Here are some ways Microchip's MEMS can be used in emerging automotive applications.

Advanced Driver Assistance Systems (ADAS)

ADAS long-range radar is designed to identify the speed, azimuth and elevation of multiple cars, pedestrians and other objects in a complex urban traffic scenario. Simply put, radar systems transmit microwave beams into the environment, and nearby objects signal their presence by reflecting energy back to the receiver.

Figure 9 illustrates an ADAS long-range radar implementation. RF TX and RF RX refer to the radio frequency transmitter and receiver, each with its own antenna system. The time difference between the transmitted and received signals and the Doppler

(continued on page 20)

frequency shift of the latter are used to determine both the range and relative speed of the object. This measurement is simplified by frequency modulation of the transmitted signal, called chirp, which is created by the Digital Signal Processor (DSP) block and translated to an analog modulation by the baseband block. The received reflections are also converted to baseband and then digitized for use as range and speed data in the DSP. Steerable beam technology allows the azimuth to be obtained. The Power Management IC (PMIC) ensures that all functions receive clean DC power from the car battery.

Overall control of the system is provided by the microcontroller (MCU). Data from the system, and potentially from vehicle actions, is transmitted by the Controller Area Network (CAN) bus to the engine and vehicle controller. This is then communicated to the driver and the car's systems.

A MEMS-based clock, the **DSC2311**, provides two separate CMOS outputs at 20 MHz to the MCU and DSP. It is shock resistant and reliable, provides a very stable frequency from –40°C to +125°C and saves space by achieving two separate buffered outputs from a single 2.5 × 2.0 mm package.

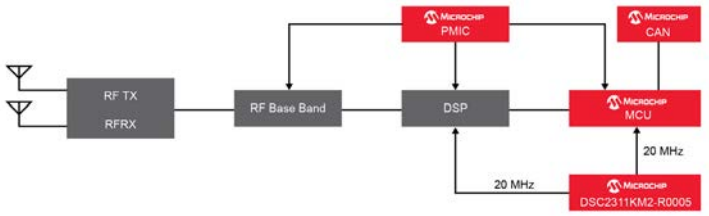

Figure 9: ADAS Long-Range Radar Block Diagram

In-Vehicle Infotainment

Infotainment systems provide driving information and entertainment services. Figure 10 shows a specialized automotive application processor interfacing to a touch panel display. A radio (including GPS, satellite and terrestrial services) and CD/DVD drives provide music, video and navigation via the audio system and display. A Bluetooth® and/or Wi-Fi® module provides a connection to smartphones and a camera provides surround-view pictures to enable the driver to safely reverse or maneuver the vehicle.

An MCU provides overall control of the system, communicating via the vehicle's network (usually a CAN bus) to car functions such as temperature control, door locks or tire pressure monitoring. A **DSC400** clock provides a very low jitter 100 MHz HCSL clock reference for the end system's PCIe communication with Flash memory. It also supplies a 12.288 MHz reference for digital audio. A separate **DSC6100** oscillator provides a 12 MHz source for the MCU function inside the application processor.

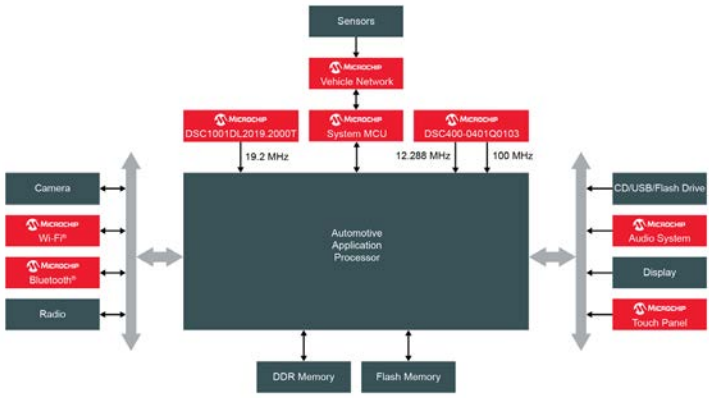

Figure 10: In-Vehicle Infotainment Head Unit Block Diagram

Connectivity

Connected smart cars that feature GPS, multimedia, advanced engine control and driver assistance need networking protocols that offer much higher bandwidth than CAN supports. To meet the requirements for in-vehicle connectivity, Microchip offers transceivers that support Media Oriented Systems Transport (MOST®) technology with data transfer speeds up to 150 Mbps, USB 3.1 Gen 2 (up to 10 Gbps) and 100Base-T1 Ethernet (up to 100 Mbps).

Microchip's Integrated Network Interface Controllers (INICs) for MOST networks operate with a distributed network clock. A back-up clock is also required, and the use of a tiny 1.6 × 1.2 mm DSC6100 at 18.432 MHz and 24.576 MHz for this purpose is under evaluation.

The high data rates of USB 3.1 and 100Base-T1 Ethernet need clocks with reduced jitter (phase noise). A noisy clock will introduce bit errors in the data streams. Figure 11 includes the block diagram of an Ethernet/USB reference design. A DSC2311 running at 25 MHz has approximately 400 fs (rms) of integrated jitter over the 100 kHz–20 MHz offset bandwidth, with performance well above the minimum standard.

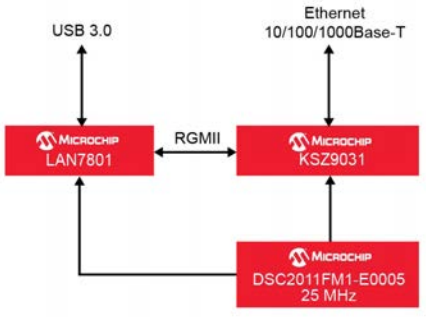

Figure 11: In-Vehicle Networking Block Diagram

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A Perfect Match for the Next Generation of Cars

Silicon MEMS-based timing devices are a perfect match for the smart, connected cars of tomorrow, offering high reliability that includes AEC-Q100 certification, wide operating temperatures of –55°C to 125°C, superb shock and vibration resistance, high accuracy (±10ppm) and small sizes.

Microchip offers the industry's most complete MEMS-based timing solutions. These include both single output oscillators that are drop-in replacements for traditional quartz oscillators, and multiple output clock generators that provide highly reliable and accurate reference clocks without the need for an external reference crystal.

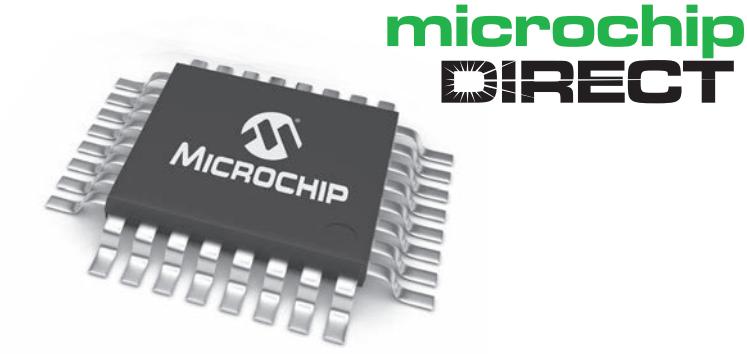
Visit our **MEMS Timing** web page to learn more about our products and design resources.

Removing Roadblocks

microchipDIRECT Now Offers Production Programming for AVR® and SAM Microcontrollers

For many years, buyers of AVR microcontrollers (MCUs) often encountered issues with having small-to-mid volumes of their devices preprogrammed. Due to the limitations of the previous systems, the Minimum Ship Quantity (MSQ) was quite large, especially for devices with smaller Flash sizes. This was because the MSQ had a dollar value; therefore, lower-cost devices required a higher minimum unit volume. Another challenge was getting the preprogrammed devices quickly. In the past, it could easily take up to two months for customers to receive their preprogrammed units for validation. As a result of these roadblocks, many AVR MCU buyers chose to use programming houses or other third parties to have their devices programmed.

The path to getting programmed devices has now been cleared. microchipDIRECT has recently launched production programming support for AVR and SAM MCUs. Support for additional devices will be added weekly to the microchipDIRECT Programming Center. The setup is identical to the one that has been in place for many years for programming Microchip's MCUs and memory devices. It provides quick, secure and inexpensive production programming through our online interface. In a few minutes, you can get a quote, upload your code and marking specifications, order your validation samples and have them shipped in a couple of days. There is no minimum order quantity. An additional benefit of microchipDIRECT's programming service is that you upload all your code directly to our secure server. This means that you never have to share your code with a third party, potentially exposing your proprietary solution.



Get started today by going to our **AVR/SAM Microcontroller Programming page** on microchipDIRECT. There you will find helpful links to guide you through the process of setting up your programming order and uploading your code. If you have not done so already, you will also need to create an account. You can also watch the Programming Tutorial for some helpful tips and look up pricing for your specific device using the Programming Cost Lookup tool. If you still need assistance, click on the "Questions? Contact Us" link to get in touch with microchipDIRECT's support team.

We hope you find this new road to having your AVR and SAM MCUs preprogrammed easy to travel.

Coloring the Montreal Skyline

Photo Credit: The Jacques Cartier and Champlain Bridges Incorporated

LED Manufacturer Lumenpulse Selects Microchip Devices for its Contribution to Jacques-Cartier Bridge Intelligent Lighting Design

Founded in 1642 as Ville-Marie, Montreal is Canada's second largest city and is internationally acclaimed for its distinctive culture. It developed over the years from a small mission settlement to a major metropolis that now encompasses the entire island of Montreal as well as surrounding neighboring shores. The St. Lawrence River has played a significant role in Montreal's development throughout its history. As one of a number of iconic architectural landmarks gracing Montreal's skyline, the Jacques-Cartier Bridge crosses the St. Lawrence to connect Montreal to Ile Ste-Helene and Montreal's South Shore communities.

Given its significance to Montreal's history and heritage, the Jacques Cartier Bridge was recently one of the structures that were chosen to be illuminated to help celebrate Montreal's 375th and Canada's 150th anniversaries. The new, interactive lighting design, called "Living Connections," came to life on May 17th, 2017. It has been designed to use intelligent programming to adapt the colors of the lights to match the changing seasons. Residents and visitors to the city can even use a Twitter hashtag to indirectly control the intensity, speed and density of the light throughout the day. This amazing project was the result of the creative collaboration of several design, multimedia and lighting studios. You can read more about it on **The Jacques Cartier and Champlain Bridges Incorporated** website.

Lumenpulse™, a Montreal-based LED lighting solutions provider, helped illuminate the bridge with its LED fixtures and control boxes. The design used approximately 95 high-performance Lumenfacade luminaires to light the bridge pillars, while approximately 480 durable, high-output Lumenbeam XLarge luminaires, carefully concealed from view within the structure, bathe the interior structure with a uniform wash of color.

Their "intelligent" LED fixtures take advantage of the high-speed PWM peripheral in the **dsPIC33** DSCs and also use the **MCP1801T** LDO for voltage regulation. They can be controlled and monitored using the industry-standard DMX and RDM protocols. Their system network control boxes incorporate **PIC32MX** MCUs and our **LAN9354** Ethernet switch ICs. The firmware was developed using **MPLAB® Harmony**. These boxes enable the distribution of high-performance, Ethernet-based lighting protocols, such as Art-Net and StreamingACN, and convert them into the DMX/RDM protocols required by the LED fixtures.

"We are very proud to have helped illuminate these iconic symbols that grace Montreal's skyline," said Francois-Xavier Souvay, Chairman, President and CEO of the Lumenpulse Group. "As proud Montrealers, we felt a great responsibility to make sure we provided an effective, sensible lighting solution that revealed Montreal's splendor, bringing forth a new beacon of inspiration to Montreal's sky for years to come."

Looking Ahead

Compressing the IoT Product Innovation Cycle through Technological Abstraction

Contributed by Breadware

Project yourself ahead to the year 2025, when Tony Stark-level technology is old news. What interfaces do you think will exist to connect human users to the advanced technologies that power their daily life? Will it be a keyboard? A mouse? Not likely. The technological interface of the future is projected to be highly connected, virtualized and tactile. In this article we will taking a peek behind the curtain to delve into the abstraction technologies that will make futuristic interfaces possible while glimpsing some early traces of them in today's Internet of Things (IoT) development disciplines.

The IoT has ushered in new challenges for product development. Since an IoT device encompasses several layers of technology—silicon, embedded systems, mechanical design, networking, cloud computing and storage, user interface/user experience design and mobile app support—the design cycle for these devices spans several historically disparate modes of product development.

Technological abstraction is the process of removing the underlying complexities from a development process to reduce it to a set of essential characteristics. Abstraction is a necessary pillar of technology development because it simultaneously provides both robustness and flexibility to the designer and the resulting system. The challenge in building an IoT product isn't the inherent complexity of the product itself; it is the blending of the different modes of product development. The industry and the tools are too new and change too often to provide a standard of clean, modular separation between layers.

This rapidly evolving paradigm and the corresponding industry excitement around the IoT have caused the demand for these new technologies to grow faster than the industry's development tools are capable of supporting.

Figure 1: The Internet of Things technology stack network

(continued on page 25)

The IoT stack is loosely modeled as the network depicted in Figure 1. The stack is intentionally depicted as scattered to reflect the newness and lack of strong interconnections between layers of IoT development processes.

Technological abstraction will specialize and strengthen each layer of this stack to provide multiple benefits:

- Translation of expert specialties into a more creative domain
- Collapsing complex packages into modules provides design access to a much wider development audience outside of the engineering realm
- Creating a modular, intuitive base within all layers allows for extreme specialization and optimization of the individual layers
- Savings in time and resources of lean prototyping methodologies provide stepping stones for dramatic and rapid evolution of IoT technology

To provide some concrete historical evidence to these claims, we can look back at the evolution of computing, particularly to the herculean efforts that went into building the world's first computers before there were well-developed abstraction layers available in computing technology. The current state of the IoT appears similar to that of the CSIR Mk1 back in the early 1950s, shown in Figure 2. As one the first five computers in the world, this huge machine ran its first test program in 1949. Its claim to fame at that time was that it could run 1000 times faster than mechanical machines. The evolution from the CSIR Mk1 to the latest iPhone® was only possible through abstraction. The complexity of the computing machine was described in the software stack and progress was made by allowing individuals (and industries) to specialize in particular areas of the stack.

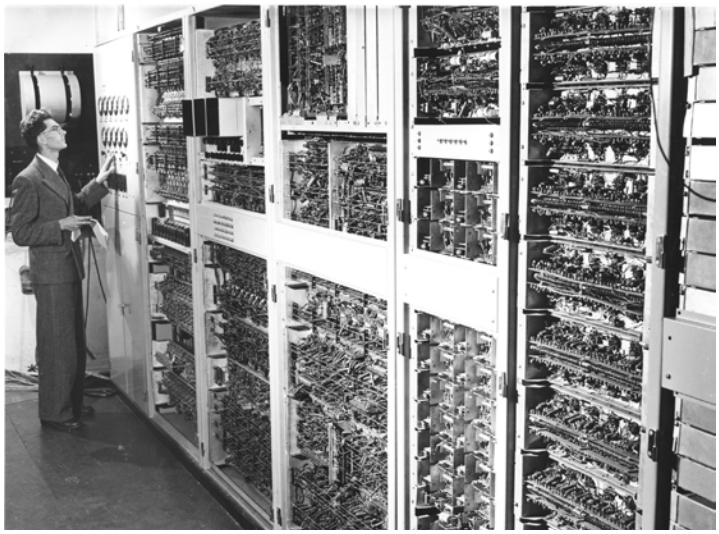


Figure 2: The CSIR Mk1 (Photo credit: CSIRO)

The Breadware Mission

Breadware has begun working with Microchip to provide solutions for creating and ordering custom electronics for prototyping or for production units. Breadware's design suite allows for custom electronics to be developed efficiently, affordably and reliably.

For prototyping, the **Breadware B-Line Toolkit** uses modular building blocks to create Minimally Viable Products (MVPs) in the software, hardware, firmware, mobile app and cloud layers of an IoT device. For production builds, **BreadPCB**, Breadware's engineering and production suite, allows for creation of, quoting for and placing orders on custom electronics using Breadware's intuitive design platform. Both the Breadware B-Line and the BreadPCB platform leverage a host of Microchip sensors and microcontrollers in their module libraries to allow for a broad array of solutions.

Breadware B-Line

The Breadware B-Line Toolkit is an IoT development kit that provides all the necessary tools to rapidly build full-pathway IoT prototypes. The B-Line centers on the **B-Line Bread Boards** and their corresponding Breadware Module Library. These Bread Boards provide wireless connectivity (either Bluetooth® Low Energy or Wi-Fi® variants) and host an array of sockets which accept the plug-and-play Breadware modules or external custom hardware. In addition, the Breadware Toolkit provides access to the Breadware Integrated Development Environment (IDE), an easy-to-use centralized software design environment that helps you to write the device firmware, customize a mobile app and build a web dashboard structure.

The Breadware B-Line Toolkit is comprised of four key tools:

B-Line Hardware: Build a near-instant MVP with Breadware's B-Line Development Kits. The Breadware B-Line kits are compatible with Arduino® open-source hardware. The B-Line hardware acts as a modular and user-friendly toolkit to allow you to efficiently begin hardware development in the IoT stack.

Mobile App Builder: Create an application to interface with your device through Breadware's customizable Mobile App Builder. Mobile applications can easily be built to be interactive, allowing the app to trigger device actions and read device sensor data. Using the Breadware BLE API, you can alternatively interface the Breadware B-Line hardware with your own mobile applications.

(continued on page 26)

Web Dashboard Builder: Organize, build, and customize your web app dashboard using the Breadware IDE to allow for real-time data display, data logging and data visualization. Using the Breadware RESTful API, you can alternatively interface the Breadware B-Line hardware with your own web applications.

Breadware IDE: Utilize the multi-layer IoT platform to configure your B-Line hardware, build your mobile application and web applications, write your device's firmware with the code editor and flash your device with the Breadware flasher.

Figure 3: The Breadware B-Line Mega-B Development Kit

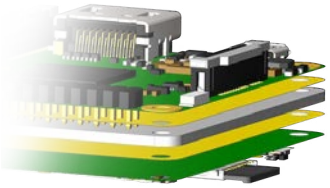
BreadPCB

The BreadPCB Platform is available for customers who require specific PCB form factors, are building at higher volume, or are designing for production manufacturing runs. The BreadPCB Platform is built on the same pillars of modular abstraction and encapsulation as the Breadware B-Line Toolkit, allowing for a seamless migration from the prototype phase to the production phase. The BreadPCB line of customizable electronics is highly flexible while retaining a compact form factor and substantial power optimization. Each BreadPCB solution can each be customized at the hardware level with modules from the extensive Breadware library.

The value of using the BreadPCB Platform is efficient, affordable, and reliable product development. The abstraction engine allows PCBs to be designed at the modular level and directly ordered through the Breadware platform without requiring traditional low-level schematic design, PCB layout or bill of materials preparation. BreadPCB also offers a highly competitive manufacturing price and rapid product delivery, as well as options to receive precertification (such as FCC, CE, etc.) for the custom electronics.

The BreadPCB Platform includes the following features:

- Easy-to-use interface to customize the shape and functionality of your PCB
- Free quote for manufacturing that includes a detailed product brief for your custom hardware
- Exact pricing and lead times for the manufacturing, testing and delivery of your PCB
- 3D CAD available for download
- Customizable manufacturing detail: colors, tolerances, lead times, testing options



Layer	Thickness
Solder Mask	0.01 mm
Top Layer (1 ounce)	0.035 mm
Core	1.5 mm
Bottom Layer (1 ounce)	0.035 mm
Solder Mask	0.01 mm

Figure 4: View of the BreadPCB design interface depicting customized manufacturing details of a modularly designed PCB

The Breadware Story

Breadware was founded by engineers and designers who were frustrated by the costs, time frames and roadblocks associated with developing connected IoT products. The company has helped numerous businesses develop and launch their IoT concepts with the intuitive model of hardware and software design and development. The Breadware technology applies a high-level software abstraction technology to Internet-connected hardware to make electronics development affordable, flexible and accessible. Visit **www.breadware.com** to learn more about their products and services.

Arduino®/Genuino MKR1000 Meets Python®

Creating Secure Battery-Powered Projects for the Internet of Things

Contributed by Zerynth

Computing power, connectivity and security are some of the essentials for successfully developing projects for the Internet of Things (IoT). Created to meet these requirements and more, the **Arduino/Genunio MKR1000** is a powerful board that is based on Microchip's **ATSAMW25** module. This low-power module combines a 32-bit **SAM D21** microcontroller (MCU) for the processing, an **ATWINC1500** Wi-Fi® core to enable connectivity and an **ATECC508** CryptoAuthentication device to provide secure communication.

Zerynth®, a Microchip Authorized Design Partner, offers a complete set of high-quality embedded development tools for mobile and cloud integration based on the Python programming language. The Zerynth Stack is modular set of development tools that enables you to use Python or hybrid C/Python programming to develop IoT solutions based on 32-bit MCUs. It currently supports several Microchip MCUs, including SAM 3X8 and SAM D21 devices, with support for PIC32 devices coming soon. The Zerynth Stack consists of:

- Zerynth Virtual Machine, a multi-threaded real-time OS
- Zerynth Studio, a free and open-source, browser-based IDE plus toolchain that includes a compiler, debugger, an editor and other resources
- Zerynth Advanced Device Manager (ADM) that is compatible with many cloud providers
- Zerynth App, a general-purpose interface for all network- or Bluetooth®-powered Zerynth objects.

These solutions support a number of Microchip-based boards—including the MKR1000—to make it easy to get started with developing battery-powered IoT projects.

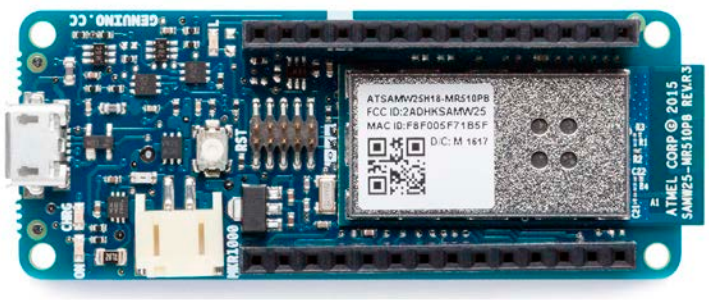


Figure 1: The Arduino®/Genunio MKR1000

Setting up Your Arduino MKR1000 and Python Project

To get started with developing your IoT application, download and install **Zerynth Studio**. When this is complete, launch it and create a **Zerynth user account**. You then need to connect and virtualize the MRK1000 using a USB port on your computer. If you are using Microsoft Windows® as your operating system, you will need to download and install the drivers from the **MKR1000 page** on the Arduino website. If you are using OS X® or Linux® operating systems, Zerynth Studio will automatically

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recognize the board. You should see the MKR1000 listed in the **Device Management Widget** (Figure 2).

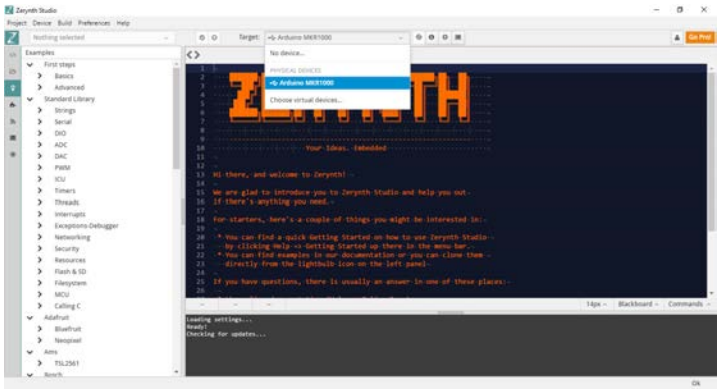

Figure 2: The MKR1000 detected and shown in the Device Management Widget

To register and virtualize the MKR1000, double click on the "RST" button to put the board in virtualization mode. Then select "Arduino MKR1000 Virtualizable" on the Device Management Widget and register the device by clicking the "Z" button on the "Target" toolbar (Figure 3).

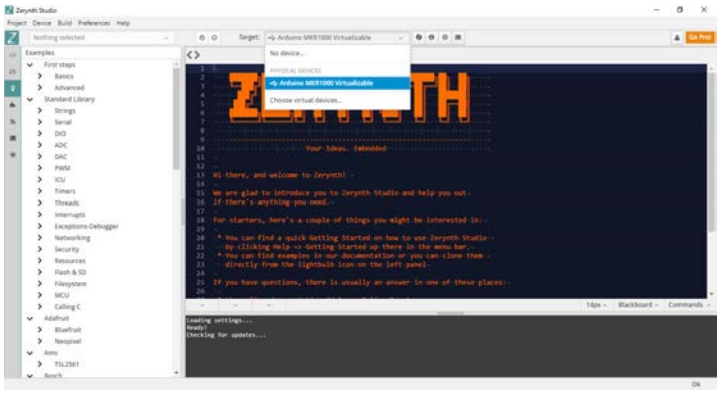

Figure 3: The MKR1000 is now virtualizable

Put the board in virtualization mode again by double clicking the "RST" button and create a Zerynth Virtual Machine for the device by clicking the "Z" button for the second time. You can then virtualize the device by clicking the "Z" button for the third time. If you need additional information, read our **"Connect, Register and Virtualize Your Device" tutorial**. You can now start programming your MKR1000 in Python.

Cloning the "Blink" Example

Zerynth Studio includes a number of **examples** of Python scripts that you can clone with just a few clicks. Let's start with the "Blink" example. You can find it in the **Examples Browser** or you can search for "Blink" using the **Quick Search** feature. The simple Python script in the "main.py" file is shown in Figure 4.

```
Python
# loop forever
while True:
    digitalWrite(LED0, HIGH)  # turn the LED ON by setting the voltage HIGH
    sleep(1000)               # wait for a second
    digitalWrite(LED0, LOW)   # turn the LED OFF by setting the voltage LOW
    sleep(1000)               # wait for a second
```

Figure 4: Python® script for "Blink" example

View the pin map for the MKR1000 by clicking the third button on the "Target" toolbar. As you can see (Figure 5), the on-board LED is connected to pin D6. However, Zerynth abstracts the board layout allowing you to customize the name of the LED. In this "Blink" example, LED0 is used.

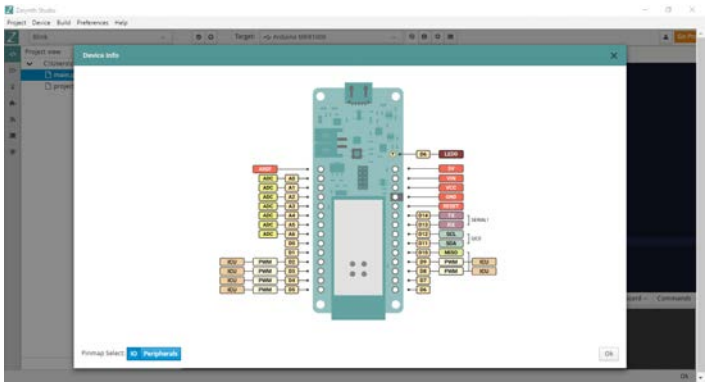

Figure 5: The Zerynth pin map of the MKR1000

Once you have cloned the example, upload the code to your board and reset the device by pressing the "RST" button when asked. The Python script will then turn the LED on the MRK1000 on and off.

Enabling IoT Security

One of the significant features of the MKR1000 board is its ability to access a Wi-Fi network via the ATWINC1500 module. Zerynth makes it easy to implement SSL/TLS security in your application using just a few clicks. Import the **lib.microchip.winc1500 library** in the Zerynth script. (Root certificates must be also be uploaded on the chip too; follow the instructions that can be found on the **Firmware and Certificates Updater** page on the Arduino website.) Then clone the "Secure HTTP" example the same way you cloned the "Blink" example.

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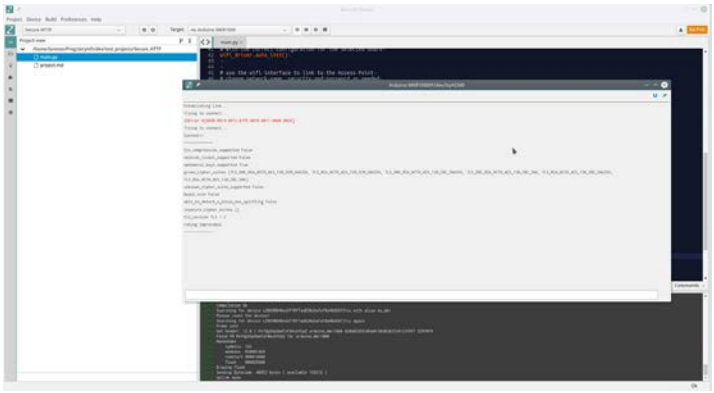

Figure 6: The "Secure HTTP" example in Zerynth Studio

A section of the "Zerynth Secure Sockets" code is shown in Figure 7. Simply change "Network-Name" and "Wifi-Password" to match your actual network configuration, and you're ready to go. It's that easy.

```
# use the wifi interface to link to the Access Point
# change network name, security and password as needed
print("Establishing Link...")
try:
    # FOR THIS EXAMPLE TO WORK, "Network-Name" AND "Wifi-Password" MUST BE SET
    # TO MATCH YOUR ACTUAL NETWORK CONFIGURATION
    wifi.link("Network-Name",wifi.WIFI_WPA2,"Wifi-Password")
except Exception as e:
    print("ooops, something wrong while linking :(", e)
    while True:
        sleep(1000)
```

Figure 7: Section of "Zerynth Secure Sockets" code

This simple script connects to https://www.howsmyssl.com/a/check and displays info about the SSL/TLS connection on the serial monitor, as shown in Figure 8. Refer to the **Secure Socket Layer module** in the standard library to learn how to expand this example.

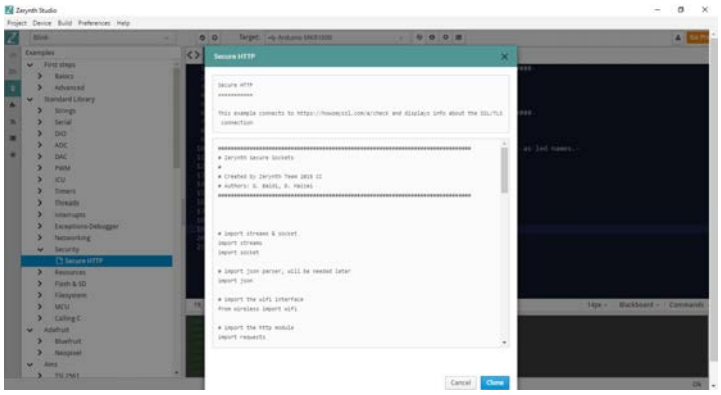

Figure 8: The script displaying information about the SSL/TLS connection on the serial monitor

Enabling Firmware Over-the-Air Updates

Once your MKR1000-based, battery-powered IoT system has been built, you probably won't want to disassemble everything to upgrade the firmware. Recognizing this, Zerynth has included a Firmware Over-the-Air (FOTA) feature within **Zerynth Studio PRO**. Available in competitively priced monthly or yearly subscription plans, Zerynth Studio PRO also offers industrial-grade features that include:

- Selectable RTOS
- Power saving
- Hardware-driven secured firmware burned on the device at industrial volumes

The Zerynth FOTA module enables access to Zerynth VM functionalities for updating firmware and/or Zerynth VM at runtime. It can be safely imported into every program, however, its functions will raise an "UnsupportedError" if the target Zerynth VM is not enabled for FOTA features (available for PRO users only).

The FOTA process can be performed manually by using the low level libraries offered in the Zerynth Standard Library. However, the FOTA process can be significantly simplified by using the **Zerynth Advanced Device Manager** (ADM) and Zerynth Studio (or the Zerynth Toolchain) together. When a device running a FOTA-enabled Zerynth VM connects to the Zerynth ADM, it automatically sends the required FOTA information:

- The type of device
- The VM unique identifier
- The current bytecode and VM slots
- The preferred size of update blocks

Detailed information can be retrieved with a dedicated Zerynth Toolchain command. It is also summarized in the ADM panel in Zerynth Studio (Figure 9).

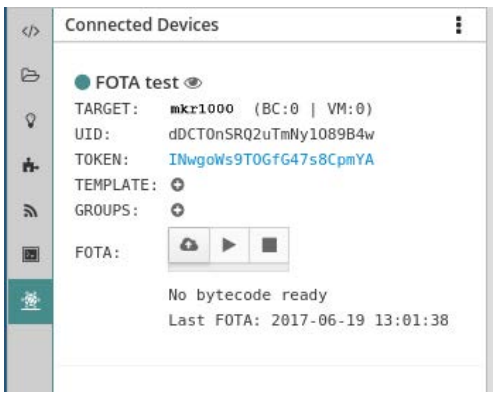

Figure 9: The Zerynth Studio ADM Panel showing the required FOTA information for the device

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To run the FOTA process, the correct firmware to be sent to the device must be prepared first. Firmware preparation can be done within Zerynth Studio by simply pressing the upload button (Figure 10).

Figure 10: The Zerynth Studio ADM Panel showing that the firmware is correctly prepared for the FOTA update

After the new firmware is prepared, press the "play" button to start the FOTA process (Figure 11). The ADM splits the new firmware into small blocks and sends each block to the device that checks and writes them on the device memory. If necessary, the FOTA can be stopped by pressing the "stop" button. Although the FOTA process may be slow, a major advantage of using FOTA-enabled VM is that the process can take place while the rest of the firmware keeps running normally. This significantly reduces the amount of time the device needs to be offline.

Figure 11: The Zerynth Studio ADM Panel showing FOTA update progress

When the FOTA is complete, the message shown in Figure 12 will appear.

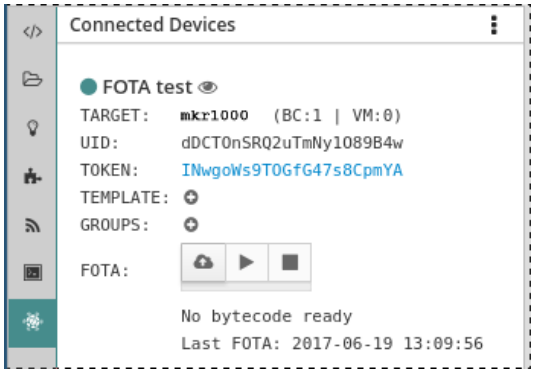

Figure 12: The Zerynth Studio ADM Panel showing the FOTA update is complete

The device will restart, and one of these two outcomes will occur:

- The new firmware will work correctly and will reconnect to the ADM to confirm the success of the FOTA process – from that point on, a device restart will execute the new firmware.
- The new firmware will not work correctly – on device reset, the prior version of the working firmware (and VM) will be executed

If you are ready to get started using Python to develop IoT and other projects using 32-bit MCUs, visit **www.zerynth.com** to learn more about Zerynth, see additional tutorials and discover helpful resources that will inspire you.

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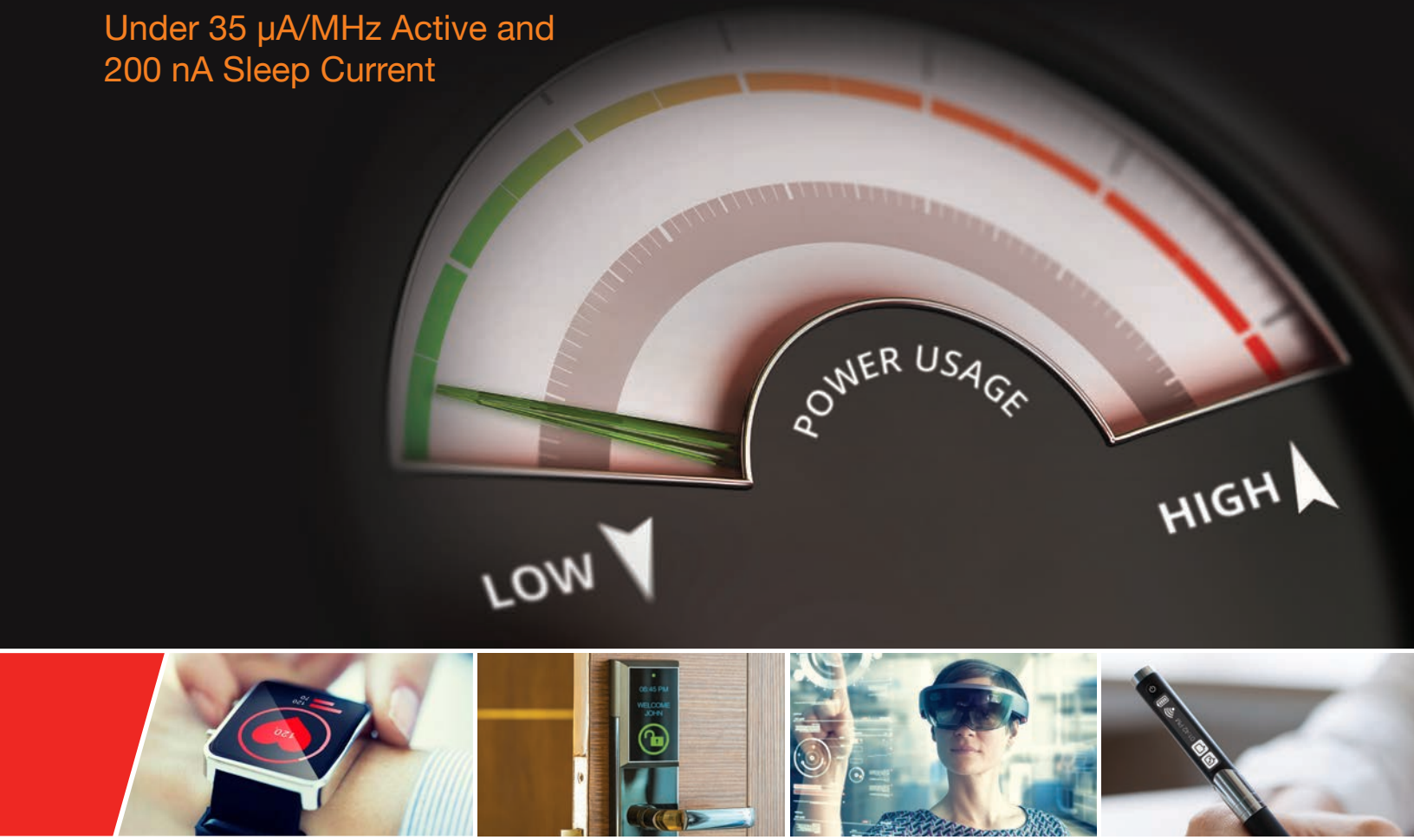

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