April 2018

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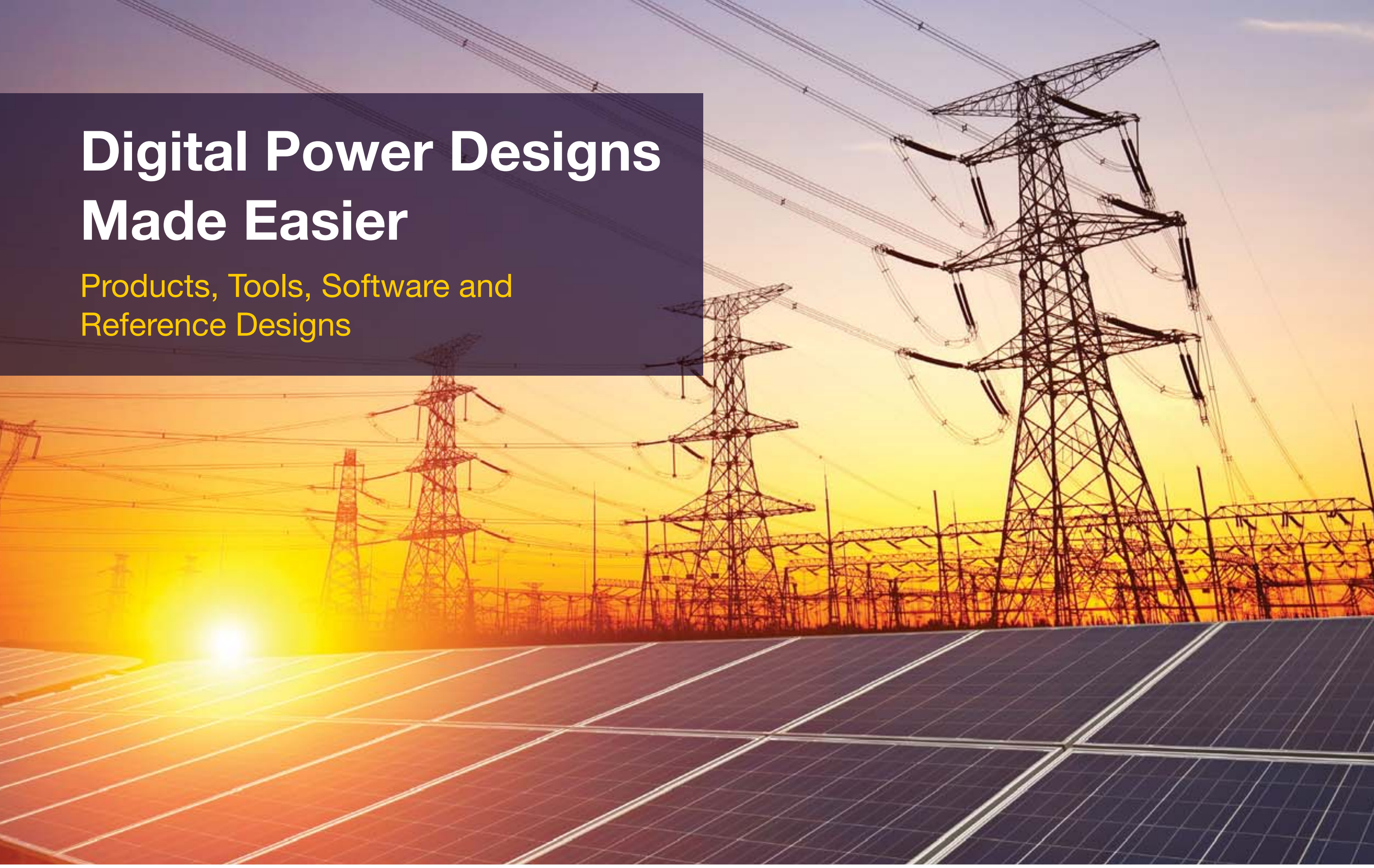

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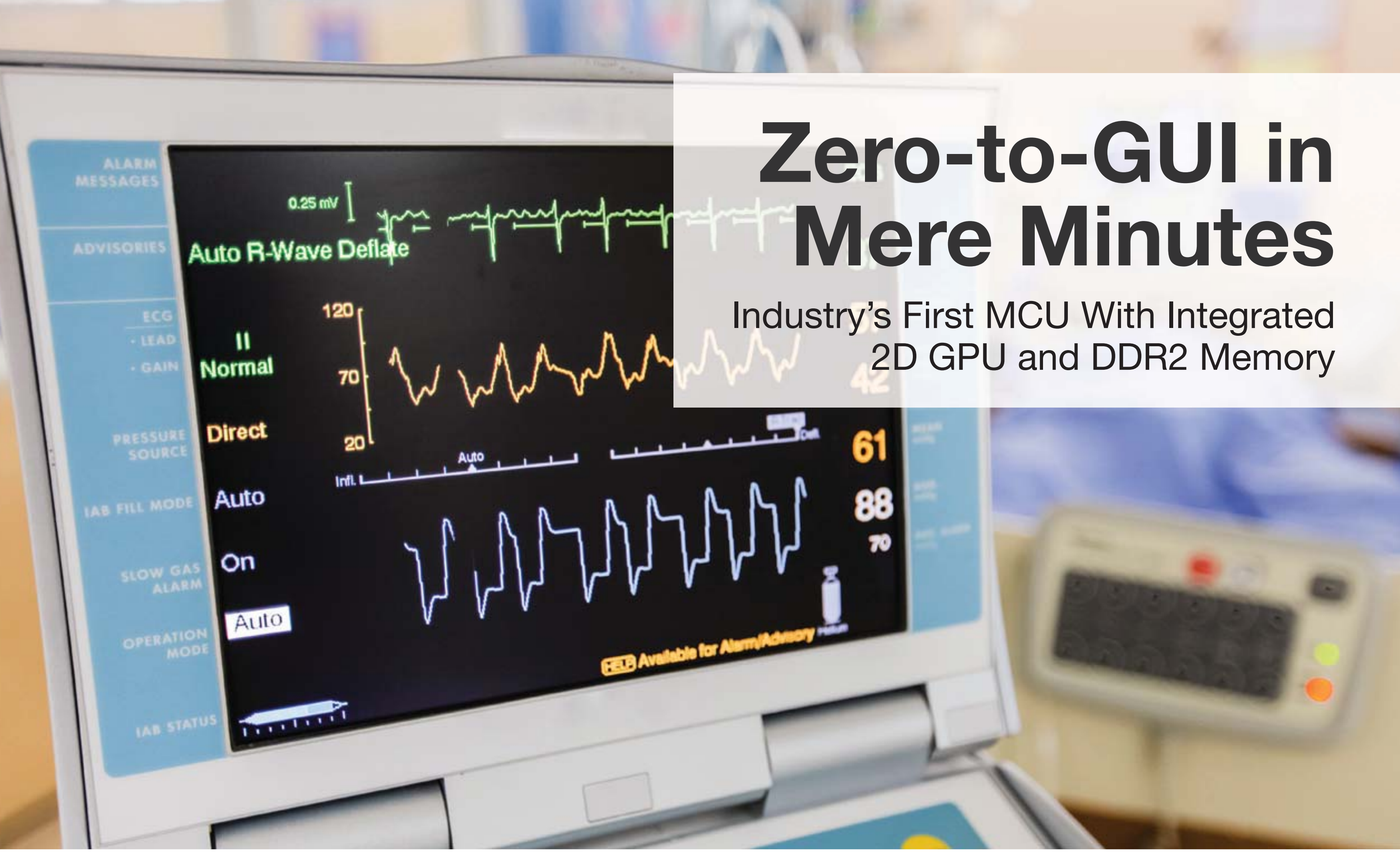

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IoT: Choosing 8-bit vs. 32-bit MCUs

It's generally known that 8-bit MCUs have an overall advantage over 32-bit MCUs in physical size, power efficiency, and cost. But do 8-bit MCUs have what it takes for IoT?

By Lynnette Reese, Editor-in-Chief, Embedded Systems Engineering

Do 8-bit microcontrollers fit in the Internet of Things? In 2015, 8-bit microcontrollers (MCUs) still held more than 35% market share of global microcontrollers, according to Allied Market Research.[1] On Mouser.com (an electronics distributor with a large selection), there are nearly triple the number of 8-bit MCUs to choose from compared to 32-bit MCUs. Clearly, 8-bit is not dying. There remains a very large selection of 8-bit MCUs offered by NXP, Microchip, Silicon Labs, Analog Devices, Renesas, Texas Instruments, Cypress Semiconductor, and several others. The 8-bit MCU has had a 30-year head start over 32-bit MCUs and is entrenched in existing embedded systems where control, not processing power, is the primary focus. While 16-bit MCUs remain in the picture, the extremes in specifications, features, and benefits are best observed in a comparison of 8- and 32-bit MCUs.

A little over a decade ago, 32-bit MCUs began their ascent to dominance as prices decreased while performance increased. These traits, combined with decreasing power consumption, have made the 32-bit MCU irresistible, enabling us to put 32-bit MCUs in everything from watches to refrigerators. The Internet of Things (IoT) is a deluge of smart, data-collecting, decision-making devices that contribute to an informed world; a world where we can more accurately predict anything that can be precisely trended. The IoT promises to improve productivity with more accurately aimed decision-making in several markets, including Automotive, Agriculture, Industrial, Healthcare,

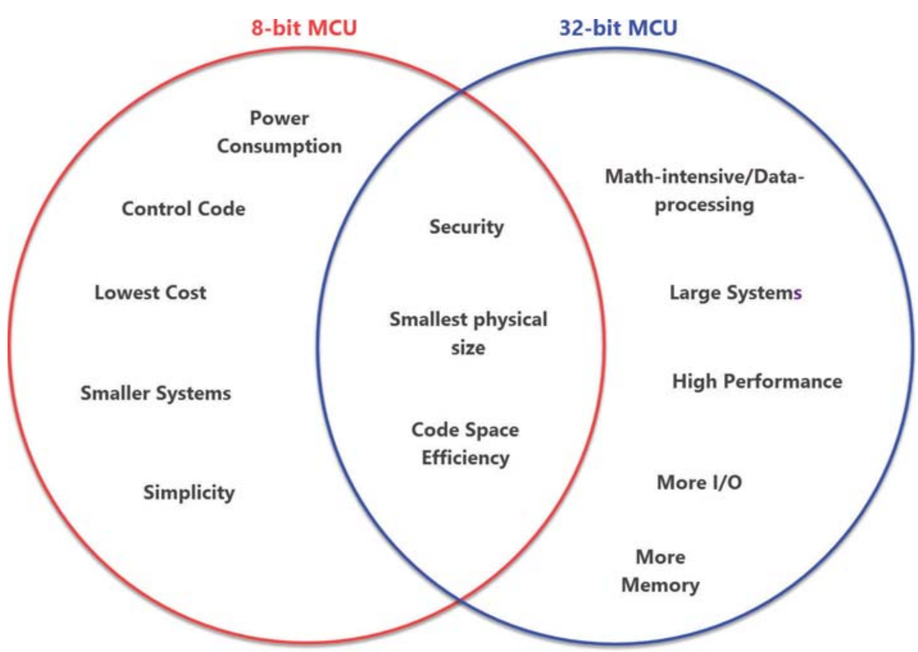

Figure 1: Venn diagram of the 8-bit MCU vs. 32-bit MCU benefits from a general perspective, as direct comparisons of all features combined are relative to tradeoffs. In general, the 8-bit MCU has been lower cost and smaller in size than the 32-bit MCU, but 32-bit MCUs are close to competing on cost and both have at least one "specimen" of a similarly minute physical size. In overall power consumption, the slower 8-bit MCUs will always trump the faster 32-bit MCUs as long as manufacturers stay on their game.

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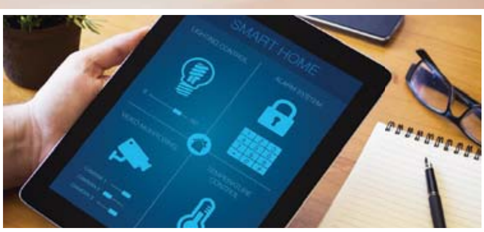

Are you new to 16-bit PIC microcontrollers or starting a new design? Step into the world of unlimited possibilities through an easy-to-start ecosystem including the PIC24F Curiosity Board, MPLAB Xpress Cloud-based IDE and MPLAB Code Configurator (MCC) to simplify your designs. This trio of tools can jump-start your design by facilitating creation of your prototype design.

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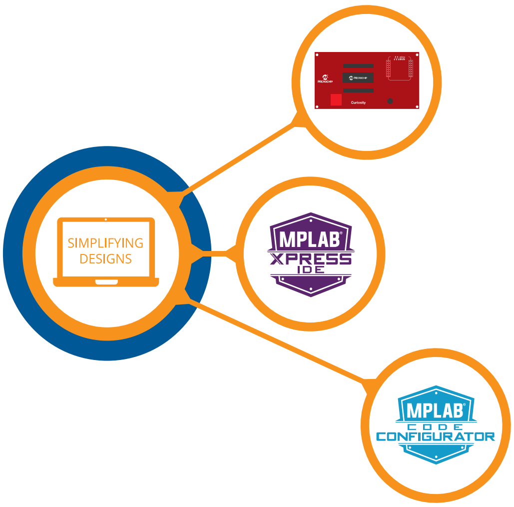
3. **MPLAB Code Configurator:** Intuitive code development tool for PIC24 MCUs and dsPIC33 DSCs



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and Consumer devices. Supply chains will also reap rewards in the form of nimbler logistics, shorter time-to-market, reduced costs, increased employee (and personal) productivity, and more satisfying customer experiences.

IOT AND THE 8-BIT MCU

To qualify as IoT, the most basic of devices need only include a secure processor, a cloud, and some means of communicating data over the internet. However, the low cost, low power consumption, and small physical size of the 8-bit MCU are still compelling in applications that predominantly require simple control code over processing power. A device that reads a few sensors and controls a process will suffice with an 8-bit MCU, even as an IoT application. (IoT is broadly defined, after all.) More sophisticated requirements that require high-performance, more memory and a larger number of I/O often require a 32-bit MCU or even a 64-bit processor. Some IoT devices have enough processing power to make local decisions, termed "edge computing," which avoids sending massive amounts of raw data to the cloud.

MAKING THE CHOICE BETWEEN 8-BIT AND 32-BIT

It's generally known that 8-bit MCUs have an overall advantage over 32-bit MCUs in physical size, power efficiency, and cost. The project itself, or system requirements, will dictate what is necessary, but in a gray area concerning trade-offs between 8- and 32-bits, then either MCU is likely suitable. If you have the time to investigate your use cases, the MCU that could make life easier might show in the details. In that case, there are several areas to look at in determining what's best for your system.

IN BLACK AND WHITE

First, examine your system requirements in several areas. In some cases, it's clear that an 8-bit MCU will suffice, especially if the final program can fit into less than 8 KB of memory, and budget dictates under 50 cents per unit. An 8-bit MCU will likely suffice if your system, along with code and data size, is small, and cost, physical size, and power consumption are large factors. An 8-bit MCU can be as small as Microchip's (Atmel) ATtiny20-UUR at a package size of just 1.5 mm x 1.4 mm. Pushing up to 12MIPS at 12MHz, the ATtiny20 is IoT-ready with ultra-low power consumption at 200µA in active mode, 25µA in idle, and 0.1µA in power-down mode.[2] In comparison, the 32-bit NXP Kinetis KL03 is not far off; at a small 1.6 mm x 2.0 mm in a WLCSP-20 package, the 48 MHz ARM® Cortex-M0+™ has "run power consumption as low as 50 µA/MHz."[3] Both have I2C and SPI. Amazingly, each is priced similarly. The non-monetary price for 32-bit performance works out to a physics problem: pushing more bits at 4x the speed consumes much more power. If battery life is a concern and you are in the gray area, you might find 8-bit MCUs irresistible.

Systems with a need for more I/O, larger programs (> 64KB of code), or larger data memory (> 256 KB) will gravitate beyond what 8-bit MCUs can provide. (Choices in 8-bit MCUs begin to thin out at a data memory size over 256 KB.) High-performance processing with math-intensive computations or a requirement for fast data manipulation belongs to 32-bit and higher.

Don't forget to look at the simplicity factor. The simplicity of 8-bit MCUs has created a following; 8-bits is a lot easier to work with than 32-bits on several levels. Following the software and hardware on an integrated level at 8-bits is simpler than at 32-bits. Development tools can be a decision-maker in that free tools may not be available for a particular MCU. The cost of paid tools can be anywhere from a few hundred to a few thousand dollars per seat. Free, open source tools are worth checking out. The level of community and forum support for your MCU of choice may also have weight, depending on how much personal support you believe the manufacturer will provide. Documentation matters, as well, in terms of the frustration factor. If documentation is sparse, look for extremely active and supportive forums, otherwise, that should be a mark against an MCU in competition for your business.

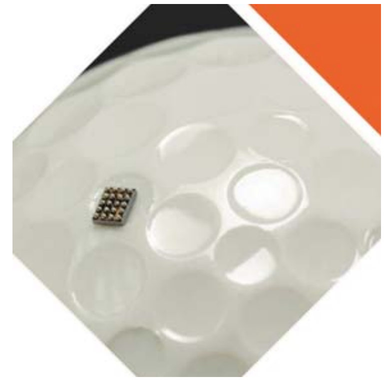

Figure 2: The NXP Kinetis KL03 20-pin ARM® Cortex®-M0 powered MCU, at 1.6 mm x 2.0 mm, is suitable for ingestible healthcare sensing. The KL03 (MKL03Z32xxx4) supports 32 KB Flash, 2 KB SRAM, 8 KB boot ROM, and up to 22 GPIO.

SECURITY

After you have considered the above and you are still on the fence between 8-bit and 32-bit, determine what kind of security is needed. Security begins at the silicon. External security chips, if installed at all, are vulnerable at the connection point. What security options will you have for your IoT device? Ideally, it should be integrated into the silicon, such as ARM's TrustZone®, which can simultaneously run a secure operating system (OS) and a normal OS on the same core. TrustZone is designed for protection over a wide span of assets. The 8-bit MCU may provide some cryptographic support in software or external devices, but external security hardware increases costs and security implemented in software creates the burden of extra overhead.

THE LARGER THE SYSTEM...

Last, you can look at the finer details of processing, perhaps comparing latency if real-time is on your requirements list. Superiority in low-latency does not necessarily belong to 32-bit MCUs, however. The details depend on the use case. Issues like delays in an interrupt service routine of a larger system can become insignificant as execution time increases, as witnessed by Josh Norem of Silicon Labs, who did a comparison of an ARM core with an 8051. Norem states, "In keeping with the established theme, the larger the system gets, the less the 8051 advantage matters."[4] Norem's fairly detailed comparison between a 32-bit ARM Cortex and an 8051 led Norem to find that in many cases, the detailed differences between the 8-bit 8051 and the 32-bit ARM-core MCU related back to overall system size: larger systems trend towards requiring 32-bit MCUs.

Before casting away the humble 8-bit MCU, however, make note that makers of 8-bit MCUs have not been twiddling their thumbs; over the past 30 years, many advances have been made to 8-bit MCUs. Today's 8-bit MCUs sport advances in security, wireless connectivity, ultra-low power consumption, integrated features like analog-to-digital converters, modules, Analog Front Ends (AFEs), and other advanced features.

Microchip's 8-bit PIC18F65K40 MCUs include Core Independent Peripherals (CIP), which bypass the processor to deal directly with other peripherals. According to Microchip, "Core Independent Peripherals are designed to handle their tasks with no code or supervision from the CPU to maintain operation. As a result, they simplify the implementation of complex control systems and give designers the flexibility to innovate."[5]

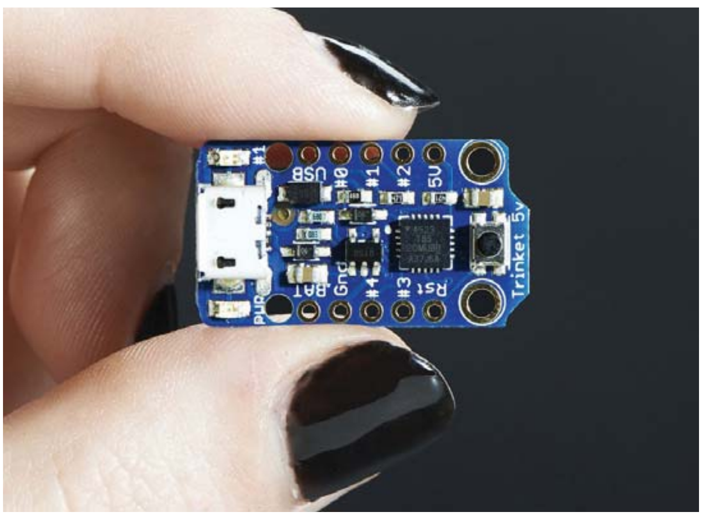

Figure 3: Adafruit's Trinket board comes mounted with a Microchip ATtiny85 MCU, 8KB of flash, and 5 I/O pins, including analog inputs and PWM 'analog' outputs. At a tiny 1.2" x 0.6" x 0.2" (31mm x 15.5mm x 5mm), it works with free Arduino IDE tools. (Source: adafruit.com)

ADDITIONAL CONSIDERATIONS

The 8-bit MCU moves fewer data at a time than the 32-bit MCU. Will you be moving a lot of data around? Does your natural data set size match the MCU data width, or will you be converting every line of 32-bit data for 8-bit consumption? Be aware that the 8-bit system is simpler to work with overall. Development tools play a part, but in general good tools are available for MCUs in both categories. The more complex 32-bit MCUs can handle more variations on peripherals, but with more features comes more complexity. Fewer moving parts are best for beginners, especially if you want to really get deep into how it all works together. Keeping your distance from the hardware with neat, well-behaved layers of abstraction is not always an option, however, so make complexity a deciding factor, all other things being equal.

It's a good thing that the 8-bit MCU market doesn't show signs of slowing down, as many maker-level (DIY) projects are very accessible to tinkering with just about everything at 8-bits (see Figure 3). The 32-bit MCU is probably a better choice for a certain class of IoT devices that process data before sending it to the cloud. The market is fluid, and 8-bit wins often for IoT devices that must sip power as a top priority, but nothing says that one 32-bit device cannot process the raw data from several 8-bit IoT devices locally before pushing it up to the cloud as an edge device.

In short, know your system requirements well, including the budgeted cost, the power budget in several MCU states, and how long the MCU might reside in each state. Have an idea of any physical size limitations, the level of security desired, and where the MCU will be spending most of its time: on control code/general processing or computational/math intensive processing? Security has become a concern in recent years as internet connectivity has opened the door to hacking, adding an additional burden in overhead for all MCUs. As for 8-bit MCUs powering IoT devices, it's likely we will see more 8-bit MCUs as "accidental IoT" as some systems get implemented with remote communication via the internet for convenience.

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Lynnette Reese is Editor-in-Chief, Embedded Intel Solutions and Embedded Systems Engineering, and has been working in various roles as an electrical engineer for over two decades. She is interested in open source software and hardware, the maker movement, and in increasing the number of women working in STEM so she has a greater chance of talking about something other than football at the water cooler.

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Adding Intelligence to Fixed Function ICs: Q&A with TI

A low-cost entry point approach to simple sensing applications

By Anne Fisher, Managing Editor

Dave Smith, Texas Instruments

Editor's Note: The announcement that Texas Instruments (TI) now offers its ultra-low-power MSP430™ microcontrollers (MCUs) at around 25 cents in high volume made for a good occasion to speak with Dave Smith. Smith is the Product Marketing Manager for TI's MSP430 FRAM-based microcontrollers and argued that there are Big Reasons for Small MCUs in an earlier article. Now, Smith explains that reasons for designer interest in the MSP430 line go beyond just the low-price entry point. Edited excerpts from our conversation follow:

EECatalog: What comprises the MSP430 Value Line Sensing MCU family?

Dave Smith, TI: This is a collection of application reports complete with code libraries aimed at adding a little bit of intelligence to fixed function ICs—that is, some of the common things found on a PCB: comparators; real-time clocks; EEPROMs; supply voltage supervisors; reset controllers—some of the simple functions that many PCBs have.

EECatalog: What goes into the decision to use a microcontroller rather than an off-the-shelf product?

Smith, TI: When thinking about the decision to use a microcontroller as compared to an off-the-shelf product you're often looking at a situation where there is not an exact fit for one of the off-the-shelf products. In those cases, using a microcontroller can enable an engineer to tailor the functionality, whether a simple timing parameter or a particular sequence of wake up events, for example, to their application needs. However, we are not trying to go head-to-head with an off-the-shelf whatever-type IC, but rather adding to that.

EECatalog: Could you offer an example?

Smith, TI: Yes. Things like a real-time clock or a system wake up controller is where we are targeting some of these applications or these functional blocks. So, while I can buy an off-the-shelf real-time clock, what I can't buy is something that really fits in with the system needs that I have. In this case we are using the FRAM nonvolatile memory along with the real-time clock and allowing them to use that as a combination of real-time clock and EEPROM.

Another example is a programmable system wake up controller. Yes, I can buy an external chip that is going to trigger a wake up every 100 milliseconds, two hundred milliseconds, whatever is hard-wired into that part. With the MSP430 based solution we can adjust the sleep interval and wake up schedule by simply sending a command over the UART, this added flexibility can help to extend system battery life.

Or say I have an RF chip, Bluetooth, Wi-Fi or whatever, but I want it in a battery-powered system, some home security product or network product. I may not want that to be active all the time because I want the battery to last more than six months, 12 months. With this type of device, I can program it so that it only wakes up that RF chip when something relevant happens—that could be monitoring an ADC for example.

In the low-power MSP430 we can monitor an ADC or use the window comparator to significantly drive down the power consumption of that overall system. Many of those functions could be incorporated into the main logic processor, but it is often very inefficient to do that. So, it may be a part that may have low-power modes and may be able to go into some of the shut-down modes but may be limited or use even more power when it is in those modes, than the MSP would.

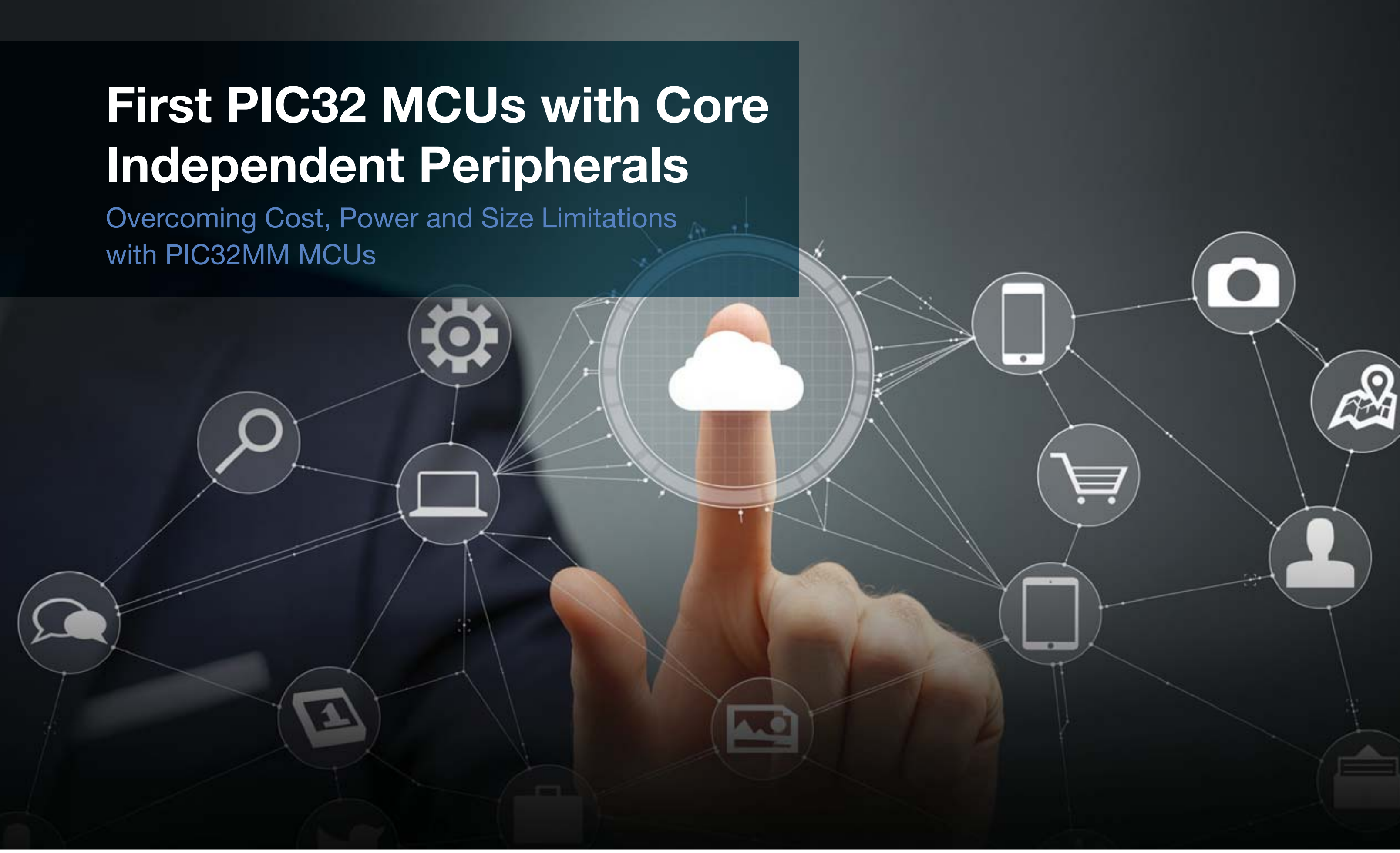
EECatalog: So designers can hew a bit closer to their application's demands than they might be able to with an off-the-shelf IC?

Smith, TI: Yes, we see a lot of customers that are trying to develop energy harvesting or maybe scavenging applications where the ability to do very low power stores, or nonvolatile stores, or operate for longer with a very limited power supply. Whether that's a rechargeable battery that is charged by solar panels or just a conventional battery, lasting longer between service intervals will help to reduce maintenance costs and overall system ownership costs.

A couple of other examples: On the PWM one of the example code snippets creates a dual 8-bit DAC, so in a standalone situation this

First PIC32 MCUs with Core Independent Peripherals

Overcoming Cost, Power and Size Limitations with PIC32MM MCUs



As the first PIC32 microcontrollers to offer Core Independent Peripherals, the PIC32MM family delivers cost-effective, low-power embedded control for IoT, consumer, industrial and sensorless BLDC applications.

The Core Independent Peripherals, such as Configurable Logic Cells (CLCs) and Multiple Output Capture Compare PWMs (MCCPs), offload tasks from the CPU to deliver lower power consumption and lower design complexity. Additional power savings, enabled by low-power sleep modes, plus small, 4 × 4 mm package options support longer battery life in space-constrained applications.

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could be a simple sounder. Maybe it gets a push button or some other trigger from an ADC or a comparator and then it plays a tone or a series of tones to indicate that something has happened. Everything from a simple doorbell to a simple timer.

Or it could be incorporated into a larger system, where you are going to send some communication data, some serial data, to trigger that signal. So that's a little dual DAC. It could be as simple as controlling color blending on an RGB LED.

Figure 1: Smith notes the applicability of microcontrollers that allow the customization of system-level functions to markets such as Smart Home. (Courtesy TI)

One of the areas that we have really seen this being taken up by our customers is where they are looking to do very low power nonvolatile writes. With an energy-harvesting solution or with a small coin cell battery, if you need to write data in a conventional flash or EEPROM memory the mA's of current required will quickly deplete the available stored energy. Conventional EEPROM and Flash technologies include a charge pump within the device that is required to boost the supply voltage to a higher voltage. It takes timing to do that and, more critically, it takes a significant amount of energy to do that.

If you want to store something in a system whether sensor data or whatever data it is—and want to store it frequently—that can quickly deplete the battery. The FRAM technology we're using with the MSP430 Value Line is very, very low power. We don't have the charge pump involved, which also makes it faster.

It's also very high erase/write endurance, with 1015 cycles as compared to the typical 100K or 1M cycles of EEPROM or Flash.

EECatalog: What are you seeing in the ecosystem of folks coming up with interesting sensors?

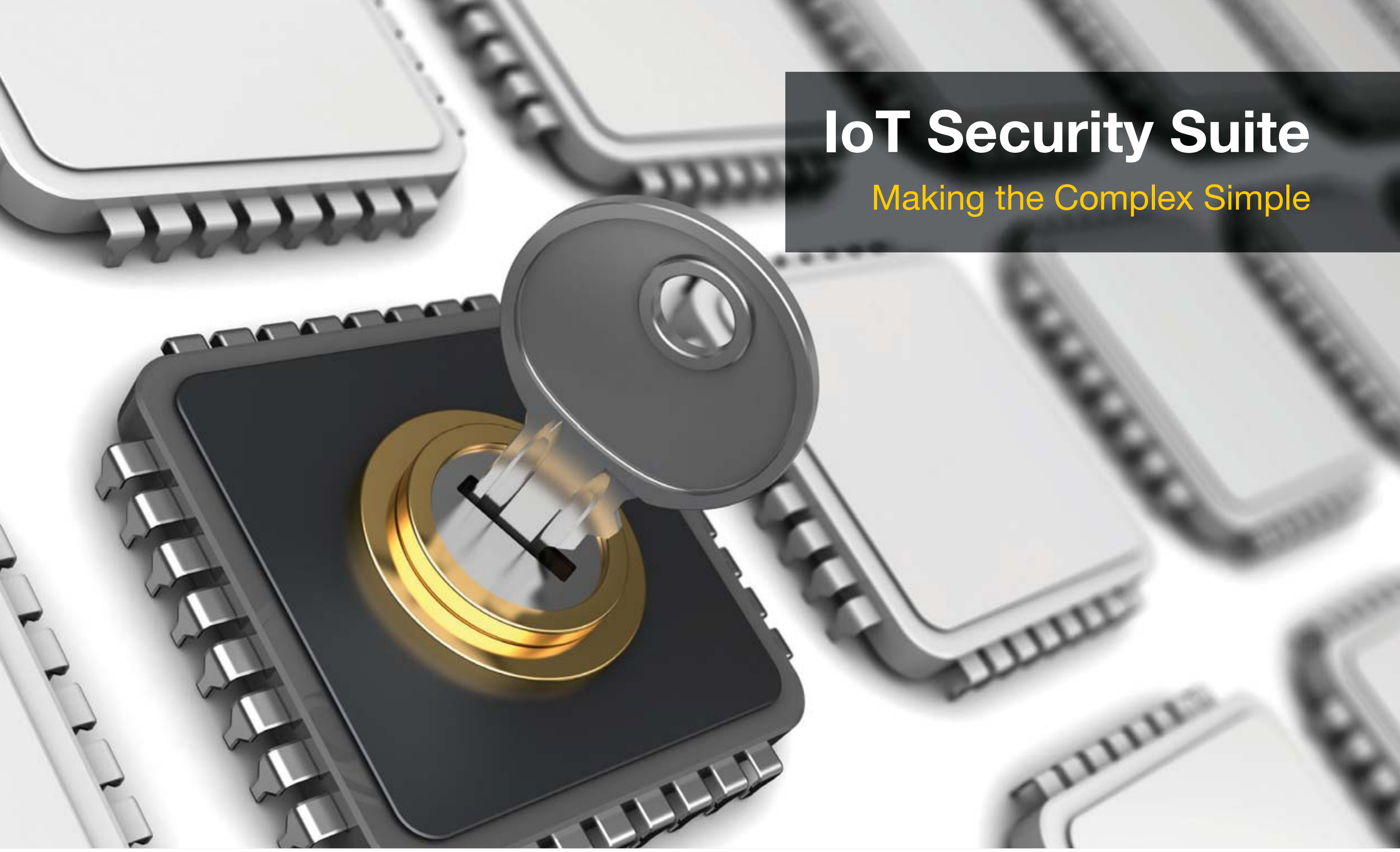
Smith, TI: We see a lot of activity in and around the connected home. Yes, there is a lot of activity going on in office and factory automation as well, but the home automation that is going on at the moment and is driven by cloud services and the big names rolling out the personal assistants stands out.

The automation being built into homes is going into places that I don't think even a couple of years ago we would have expected to see that level of intelligence, whether through some of the simple applications we have been talking about here, or things that use capacitive touch to program thermostats or to operate a voice assistant just to trigger something. I think where we are going to see explosive growth is in the home automation, small appliance, and personal assistant areas, and these parts can definitely play roles in that because many of these are battery-powered. Longer battery life makes battery changes less frequent and helps the environment.

EECatalog: Are there some additional things our readers should know before we wrap up?

Smith, TI: These half-a-kilobyte to 1-kilobyte in FRAM devices also have half a kilobyte in SRAM, and this is one of the characteristics which sets them apart from competitive devices. Usually if you have a small program memory, you will have a very small data memory. With the competitions' 512-byte program memory, you might get 64 or 128 bytes of data memory.

In our parts, if you get 512 bytes of program memory, you actually get 512 bytes of data memory as well, so that makes it a little more programmer friendly; it allows you to do more with the device.



IoT Security Suite

Making the Complex Simple

The IoT Security Suite for the SAMA5D2 MPU enables rapid and easy use of its advanced security features, such as ARM® TrustZone® technology and hardware cryptography, without a long learning curve. The suite covers the security requirements for IoT device manufacturers in a single, easy-to-use package. It supports storing, encrypting, decrypting and exchanging keys between devices and applications, and its easy-to-use APIs save you time.

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Tag-Connect, LLC

Tag-Connect Plug-of-Nails In-Circuit Programming and JTAG Cables

Supported 8-bit Architectures: ARM, PIC, dsPIC, MSP430, Atmel, Generic JTAG, Altera, Xilinx, BDM, ADI, TI DSP & More

Tag-Connect's Plug-of-Nails™ cables provide a simple, reliable means of connecting Debuggers, Programmers and Test Equipment to your PCB's while lowering board costs, reducing board space and facilitating efficient production programming.

Tag-Connect uses specially designed connectors which eliminate the need for a programming header or other mating connector on every PCB. Instead, Tag-Connect uses tried and tested spring-pins to make a secure connection to a special footprint of pads and locating holes in your PCB.

The PCB footprint can take up as little board space as 0.02 square inches (about the board space of an 0805 resistor).

Plug-of-Nails Cables are available with 6, 10 and 14-pins and come in "Legged" and "No-Legs" versions. The Legged versions have feet that snap into your PCB for prolonged debugging or programming operations whereas the No-Legs versions are designed for fast and efficient hand-held operations and are well suited to production programming.

A growing range of adapter boards and cables makes these cables compatible with most families of MCUs, DSP's, FPGAs and other JTAG devices including ARM Cortex, PIC, MSP430, ATMEL, Freescale, Renesas, Altera, Xilinx, ADI, TI DSP's as well as being great for SPI / IIC and test point access.

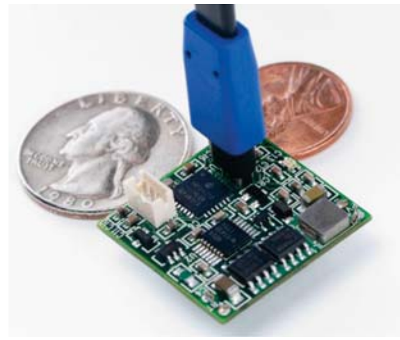
Tag-Connect's TC2030-CTX cable for ARM Cortex has been selected as a Finalist in the EETIMES / EDN 2013 ACE awards.

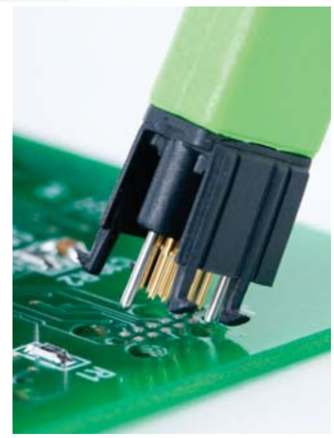
FEATURES & BENEFITS

- Zero Connector Cost per Board!
- Tiny Footprint!
- No mating connector required on your PCB!
- High-Reliability Spring-Pins for a Secure Connection!
- Save Cost & Space on Every Board!

TECHNICAL SPECS

- Available in 6, 10 and 14-pins "Legged" & "No Legs" versions.
- Legged version snaps to PCB for a prolonged secure connection. No-Legs version is hand-held during a quick programming operation.





- TC20x0-IDC cables terminate in standard ribbon connectors compatible with many device programmers. TC2030–MCP cables have RJ12 modular plugs For Microchip IDC3. There is also a USB to TC2030 Serial cable.

AVAILABILITY

Full product range at www.Tag-Connect.com. Also sold at Digikey, Mouser, MicrochipDirect, and others. See website for full details.

APPLICATION AREAS

MCU, DSP, FPGA & CPLD device programming and debug. Test Signal and ATE Access.

Tag-Connect

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Partner Guide

Neutronix Ltd - United Kingdom

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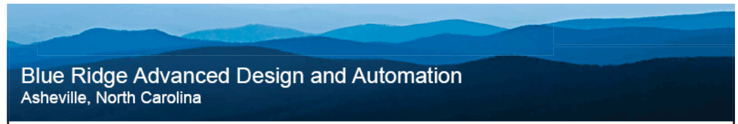

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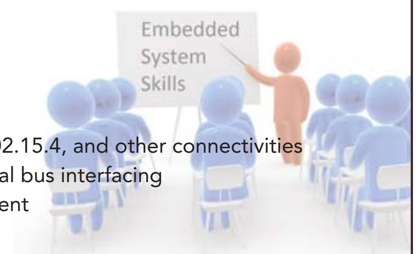

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CAN Connectivity

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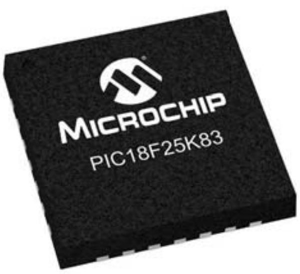

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ATmega4809 MCUs Enable Robust Embedded Control Systems

Microchip's new megaAVR® microcontrollers (MCUs) extend the capability of real-time control systems by combining intelligent hardware peripherals with the low-power performance of the AVR® core. As the first megaAVR device to include Core Independent Peripherals (CIPs), the ATmega4809 can execute tasks in hardware instead of through software. The processing power of the integrated high-speed Analog-to-Digital Converter (ADC) enables faster conversion of analog signals, resulting in faster, more deterministic system responses. These features make the new megaAVR series of an ideal companion MCU in complex microprocessor-based systems, or an excellent standalone processor in command-and-control system designs.

Key Features

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- 6-channel peripheral event system

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