How to Pick the Best 8- or 32-Bit Microcontroller for Your Next Design

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Not so long ago, embedded systems were expensive and complex, limiting their use to such highly sophisticated applications as rocket control systems. Now it seems low-cost embedded microcontrollers (MCUs) are everywhere—from health monitors you wear on your wrist to drones you control with your smartphone. In addition to rapidly increasing number of consumer electronics products, industrial applications such as vehicle control systems and new smart connected devices like smart electricity meters depend on embedded software and MCUs.

In fact, although over 6 billion new microprocessors are used each year, only about 100 million devices (less than 2 percent) of that total are used in general-purpose computers. The rest show up in our kitchens (bread machines, food processors, and microwave ovens), living rooms (televisions, stereos, and remote controls), and workplaces (fax machines, pagers, laser printers, cash registers, and credit card readers). At least one study suggests this huge and growing embedded systems market will reach USD 194.27 billion by 2018.

In addition to low cost, the low power consumption and higher efficiency of today's MCUs also contribute to growth in the embedded system market. These capabilities not only enable application engineers to create new types of battery-powered applications but also make it possible to add new functionality—such as capacitive touch interfaces or wireless connectivity—to their products.

Early in the evolution of the embedded systems industry, Atmel® recognized that MCUs would become ubiquitous. As a result the company devoted extensive R&D to improving its embedded processing technologies. This head start helped to make Atmel one of the leading microcontroller makers in the world. Atmel has made a strong commitment to furthering the expansion and adoption of new Internet of Things devices, and has jumped to an early leadership position in the IoT market. This focus led to a number of enhancements to both the Atmel AVR® and Atmel | SMART ARM®-based MCU architectures.

From the simplest application like a garage door control to a robust and secure onboard automotive system, the broad Atmel portfolio of MCUs provides numerous options for any application, whether it's 8- or 32-bit. These MCUs deliver industry-leading performance and power efficiency.

The devices are not only engineered to work together but are also seamlessly connected through an ecosystem of Atmel and third-party technologies. Atmel Studio, a free integrated development environment (IDE) that works seamlessly across all Atmel 8- and 32-bit architectures, rounds out this portfolio. For example, designers can easily add wireless connectivity to current designs or plan for it in future iterations of their designs. Or, they can leverage built-in or external CryptoAuthentication™ technologies to ensure designs will meet the increasing needs for security.

In addition to free tools like Atmel Studio, Atmel has a broad ecosystem of commercial partners offering professionally supported development and debug tools, RTOS and middleware solutions, and design services. Access to this wide range of commercial development tools, with their dedicated support channels and guaranteed response times, can significantly reduce time-to-market.

8-bit Innovation

Where applications are not compute intensive, 8-bit MCUs deliver high-performance and power-efficient processing, which explains why they continue to enjoy widespread design wins in virtually all market sectors. According to IC Insights, 8-bit MCUs will account for a 28% share of units shipped by 2017.

Atmel AVR technology is one of the leading 8-bit architectures in the industry. Optimized to reduce time-to-market, it is based on the industry's most code-efficient architecture for C and assembly programming. No other 8-bit MCU delivers more computing performance with better power efficiency. In fact, AVR devices perform close to 1 MIPS per MHz.

The AVR architecture has also become synonymous with ease-of-use, making AVR devices the most attractive choice for students and enthusiasts to learn about computer architectures and embedded programming. The AVR processor core was one of the first MCUs to use on-chip Flash for program memory storage. Plus, the AVR architecture allows in-system reprogramming. Since the introduction of the AVR core in 1997, its ease-of-use has made it the preferred processing engine in a wide variety of applications. It is also used in myriad embedded projects at universities and Maker projects around the world. The choice of using AVR in the well-known Arduino open-source development platform further testifies to the success and ease-of-use of this architecture. And the number of successful crowd-funded projects that were initiated from an Atmel AVR device are growing daily.

In addition to the general-purpose MCUs, Atmel offers a wide range of application-specific AVR-based devices suitable for lighting, smart battery, industrial and automotive applications. A huge and fast-growing application area is wireless. In fact, RF is rapidly becoming a standard peripheral in Atmel MCUs of all sizes and bandwidths.

Among the many reasons to choose Atmel AVR devices is that they are not only the easiest to use but also the lowest-power MCUs. With their code-efficient design and single-cycle execution, they also provide better processing than comparable 8-bit products. It is important to note that the code set in the AVR architecture was optimized for C-code vs. assembly language from the beginning. This is partly because the AVR design was invented after the advent of C as the de facto standard language for embedded development. In fact, the original AVR creators worked closely with compiler writers at IAR Systems—the industry-leading Swedish maker of C and C++ compilers, debuggers—to ensure that the instruction set provided for more efficient compilation of high-level languages. This collaboration was instrumental in the optimization of the instructions for C, and gives users the ability to write the instructions in two locations, which enables single-cycle execution of fetch (both the exe and the data, execute and write back).

Atmel continues to improve the AVR portfolio with ongoing innovation and refinements. For example, the industry-leading low power of AVR devices stems not just from the efficient architecture design but also from features such as the unique Atmel event system, which allows peripherals to communicate directly with each other without involving the CPU or bus resources.

Industry Ecosystem Fosters Best-of-Breed 32-bit MCUs

As consumer products and industrial applications become increasingly complex and incorporate more advanced features like touch interfaces and wireless connectivity, needs for performance and scalability are growing. In a simple application like a water-level sensor, for instance, an 8-bit MCU might offer the ideal mix of cost-effectiveness and performance. However, when you move to many water-level sensors linked via a cloud-based application, the design's needs would become more complex. Connecting to the

Internet would require enough horsepower to run a TCIP stack. TCIP is a complicated protocol and requires RAM buffering, which suggests the need for larger Flash memory and RAM as well as security to encrypt the data traffic to and from the network. Or, for example, many designs are calling for capacitive touch interfaces, which require more processing power.

Situations like this warrant a move to a 32-bit processor architecture like the ARM Cortex® processor family. Sometimes designers want to move to 32-bit early, before running out of power in an 8-bit architecture, simply to future-proof their product because with some manufacturers the 8-bit code cannot be reused when the design moves to 32 bits.

Combining industry-leading performance and power efficiency, Atmel | SMART ARM-based MCUs build on decades of innovation and industry firsts—including the first on-chip Flash memory. They offer 8-bit ease of use in a 32-bit MCU, and range from entry-level devices to highly integrated Flash-based products with extensive connectivity, enhanced interfaces, and ironclad security. These advanced Atmel ARM-based MCUs are designed to optimize system control and user interface management.

Where designs call for higher processing power, these chips deliver more than 10x the performance of 8-bit MCUs. And yet these 32-bit chips offer remarkable low power operation. In fact, the ultra-low-power Atmel | SMART SAM L21 is the lowest power consuming 32-bit ARM-based MCU in the world.

What does this low power mean in today's applications? In a wearable with basic touch or for sensors in the Internet of Things, for example, devices can run more than a decade on a single battery. The SAM L21 uses less than a third of the power consumption of competitive solutions and can run in active mode down to 35uA/MHz and retain 32kB of Flash while running a real-time clock at 940nA. It uniquely achieves this ultra-low power consumption in active mode without having to limit Flash or SRAM size, making it ideal for IoT, fitness bands, smart metering, human interface devices, and other battery-powered applications where large embedded memories are needed. To offload the CPU computation intensive tasks like capacitive touch sensing have also been distributed to smarter standalone peripherals. To further simplify program flow and reduce power consumption, these peripherals are interconnected with event and sleepwalking systems to enable operation without CPU intervention.

Like the Atmel AVR architecture, the ARM architecture is based on a reduced instruction set computing (RISC) architecture that requires significantly fewer transistors than legacy architectures such as MIPS. It offers a number of advantages such as smaller program size and faster software development time.

Additionally, Atmel has enhanced its ARM-based products with a number of unique innovations such as a SERCOM module that lets designers basically mix and match up to five USARTs. This feature not only reduces BOM costs but also offers more layout flexibility.

Atmel | SMART ARM-based MCUs are scalable, compatible, energy efficient, and easy to use. For Atmel customers, another key advantage is better software reusability, which not only makes it easy to move up

and down the Atmel | SMART families but dramatically eases the migration from 8-bit Atmel AVR MCUs to 32-bit devices in the Atmel | SMART family like the SAM D21 Cortex-M0+- based microcontroller.

The dynamic technology environment surrounding ARM cores offers another major advantage. The use of ARM architecture processors in smartphones and tablet computers such as the iPad, Android, and Windows RT translates to competition that drives rapid innovation, as well as a very robust set of user groups and world-class technology partners supporting these systems.

Atmel | SMART MCUs are also supported by a world-class ecosystem with an extensive list of partners and comprehensive tools and software, including the free Atmel Studio. This means designers don't have to rely on one third-party provider.

The portfolio offers different models based on customer needs—from entry-level devices (like the SAM D10) to more full-featured MCUs (like the SAM D21). Plus, these devices all use the same tool-chain, architecture and code, making it easy to move up or down the family chain and reuse code.

Finally, these devices come in multiple package options, including the world's smallest wafer level chip scale package (WLCSP). Also, a .454 mm ball pitch offers significant height advantage for mobile devices and wearables. In addition, a unique cap-less package design maximizes the number of I/O pins because the IDO regulator and reset pins can be reset to function as I/O pins.

Conclusion

Atmel offers a complete portfolio of MCUs that combine ease-of-use, low power, and a high level of integration. These 8- and 32-bit devices deliver a rich blend of proven technology and groundbreaking innovation, making them ideal for a new generation of smart and secure connected products. The wide range of MCUs available in this portfolio is also one of many reasons that more than 300,000 designers worldwide use Atmel devices for their designs. They can find just the right mix of power, efficiency and cost. Meanwhile, the large, code-compatible Atmel families allow designers to easily and cost-effectively reuse knowledge when improving products, extending product lines, or expanding into new markets. And with a free IDE that works with both 8- or 32-bit devices—not to mention low-cost debuggers and kits—they set a new benchmark for ease of use and reduce time-to-market.

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