Enabling tomorrow's sensing applications with smart analog microcontrollers

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More emphatically than ever, the emergence of the Internet of Things (IoT) has highlighted the critical importance of networked intelligent sensing systems.

Such sensing and measurement applications in turn place a premium on microcontroller (MCU) versatility and scalability, low power consumption, functional integration to reduce system size, and a wide range of connectivity options. The many sensing applications that will comprise the IoT of the future, as well as many standalone applications, will be widely diverse and each will have its own set of functionalities and system resources. Increasingly, designers will turn to highly integrated, yet versatile low-power microcontrollers such as the MSP430FR231x MCU family to simplify system design and accelerate time-to-market.

Introduction

More and more applications are emerging that require end-node intelligent sensing capabilities. These applications cross various industry segments, including building automation, medical health and fitness and personal and portable electronics. For new product development teams, designing each new product or system individually without capitalizing on previous design work will surely tax the engineering resources of any organization.

Now a new generation of microcontrollers can be quickly and efficiently adapted to many different types of sensing and measurement applications, such as those involving the sensing of light, humidity, temperature, power current, carbon monoxide and many other conditions or parameters. The most prominent example of this new type of microcontroller is the MSP430FR231x MCU family, which integrates ferroelectric random access memory (FRAM) technology and incorporates one of the industry's most sensitive transimpedance amplifiers (TIA) for precise current sensing and ultra-low-power consumption.

The MSP430FR231x MCU Family

The very ultra-low-power MSP430FR231x microcontrollers not only feature a host of advanced capabilities like low-power, nonvolatile FRAM memory and, in one case, an integrated low-leakage TIA, but they also include configurable analog technology as well as many different connectivity peripherals that allow developers to quickly deployed these devices in a wide variety of applications. A 16-bit RISC controller operates at up to 16 MHz and includes standby power modes that consume as little as one micro-ampere (µA).

Because of the high level of integration in the MSP430FR231x MCU family, as many as six discrete devices can be eliminated from designs, reducing the physical size of the system's printed circuit board (PCB) by as much as 75 percent, saving significantly on bill of material (BOM) costs and simplifying system design challenges. The MSP430FR231x devices include a high-performance eight-channel 10-bit analog-to-digital converter (ADC), an enhanced comparator, a 32-kHz oscillator, timers, a real-time clock, multiple general purpose input/output channels, and all of this in 16- or 20-pin package as small as 4 mm x 3.5 mm.

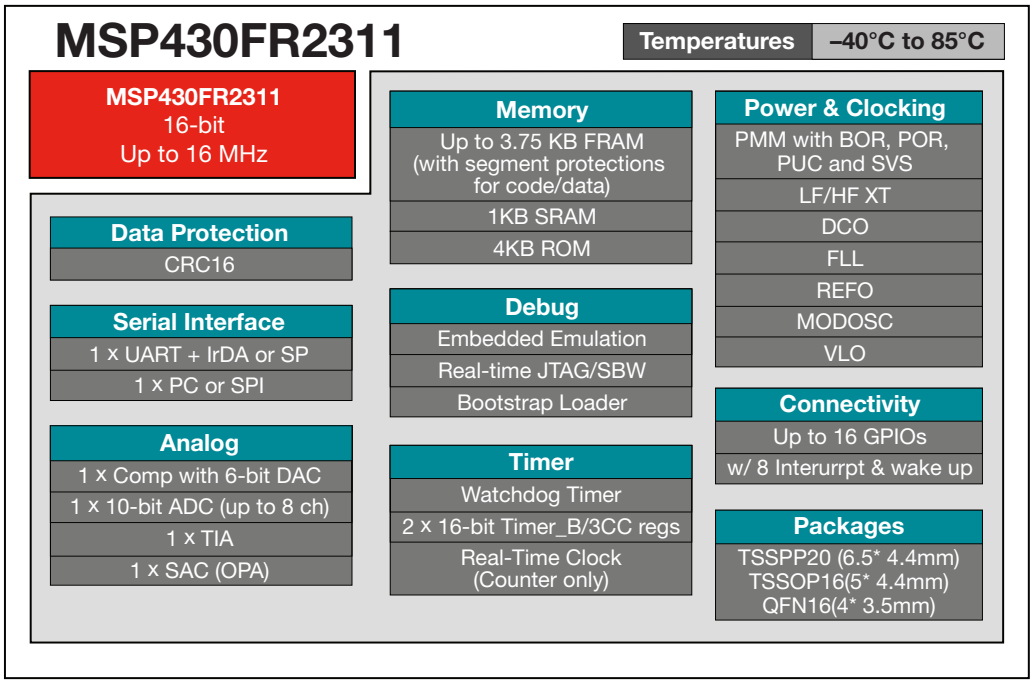

Figure 1. *MSP430FR2311 MCU block diagram*

The integrated low-leakage TIA and FRAM memory give the MSP430FR2311 MCU next-generation capabilities never before integrated into a microcontroller for sensing applications. For example, the integrated TIA can sense current levels 100-times more effectively than other controllers with integrated TIAs; plus, the MSP430FR2311 MCU's TIA extends the battery life of the system because it has the industry's lowest current leakage of only 5 pico-amperes (pA). In addition, FRAM memory is more secure than traditional types of memory and, when compared to Flash memory technology, it is 100 times faster, consumes 250 times less power and it stores 100 times more data.

Applications

The application areas appropriate to the MSP430FR231x MCU family are quite broad, but three in particular stand out: building automation, medical health and fitness, and personal and portable electronics.

Building Automation

Many building automation systems include smoke detectors. A smoke detector based on a MSP430FR2311 microcontroller would be able to process the entire signal chain in a single device. In addition, the integrated TIA's extreme sensitivity to low levels of current would make any smoke detector sensitive to even the slightest amount of smoke in the air. Of course, the low power leakage of the integrated TIA, overall low power requirements and standby power modes of these microcontrollers would allow a smoke detector to operate for years on a single battery charge.

Figure 2. *Building automation systems require the ability to monitor several sensors at once*

Thermostats in a building automation network could make use of the MSP430FR231x MCU's configurable analog front end and general purpose inputs to support various sorts of sensors, like temperature sensors, humidity sensors and others. Likewise, **occupancy or security sensors** based on the MSP430FR231x MCU could monitor any number of sensor types such as infrared or temperature sensors to determine when someone enters a room or whether a certain space is occupied by a person.

Light or current sensing could also be incorporated into **wireless power switches** in a building automation system. A change in the light level in a room, for example, might cause a power switch to adjust the voltage provided to light fixtures in order to maintain the specified light level. Or monitoring the current provided to a bank of lights could be part of an energy saving system that automatically adjusted light levels in order to reduce the building's energy consumption.

Medical Health and Fitness

Very small size or a single-chip system could be a very desirable attribute in many medical and fitness applications, especially as wearable health and fitness devices increase in popularity. For example, a wristwatch-like **ultra violet (UV) light monitor** based on the MSP430FR231x MCU could inform someone with a sensitive skin condition when his or her UV exposure had reached a predefined threshold. The very small form factor of a MSP430FR231x MCU could also allow it to be integrated directly into a smartwatch where it could provide UV monitoring and other health-related functionalities while enhancing the value of the smartwatch to consumers.

Figure 3. *Medical devices, like digital thermometers, require small single-chip solutions*

A small **thermometer** based on one of the MSP430FR231x devices could easily sense the temperature when the instrument's probe came into contact with skin or bodily tissue. The temperature could be communicated over one of the general purpose I/O channels to a small liquid crystal diode (LCD) display where it could be read. Any number of specialized health monitors like a pregnancy tester or other such devices could also be enabled by an integrated low-power microcontroller.

Personal and Portable Electronics

Because of the increasing prevalence of battery-operated consumer electronic systems as well as the green power movement to reduce power consumption, power sensing or monitoring has become increasingly critical in many consumer electronics..

Of course, in battery-operated systems, low power consumption by the power monitoring subsystem is a prerequisite. For the **battery packs or power banks** in cell phones or smartphones, for example, users must know how much of the battery's charge is left so that a recharge cycle can begin before the battery charge is depleted. The small, low-power MSP430FR2311 MCU with its integrated TIA could detect the current as it is discharged by the battery and keep track of the remaining charge.

Figure 4. *Printers, electric shavers, power banks and more can benefit from the MSP430FR231x MCUs*

Certainly many other types of **battery monitoring** applications could also be enabled by the MSP430FR231x MCU family. For example, several portable **electric shavers** could utilize an MSP430FR231x microcontroller to prolong the life of the battery's charge. The battery monitoring subsystem would optimize the current being drawn from the battery relative to the speed of the shaver's motor. With the addition of pulse width modulation (PWM), the microcontroller might actually control the speed of the motor to extend the life of the battery.

The MSP430FR231x MCUs could also be at the heart of an extensive range of energy saving green power applications. For instance, various types of **printers** could make use of these microcontrollers to monitor power usage and control when the printer should be powered down to a standby power mode in order to reduce power consumption. Pushing a button or an automatic signal from the microcontroller might wake up the printer to a full power mode when it is needed.

Conclusions

Sensing and measurement applications will be essential to the IoT of the future as well as to a wide range of unrelated applications. Sensors, managed and controlled by microcontrollers, will provide the information and data that applications need to respond, operate efficiently and, in general, more effectively serve users who benefit from them. Highly integrated, low power microcontrollers like the MSP430FR231x MCUs with their innovative next-generation features like FRAM memory storage and a low-leakage transimpedance amplifier give system designers the right combination of versatile functionality, small size, low power and adaptable I/O connectivity needed to quickly develop a broad range of successful products.

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