Designing for Low-Power, High-Performance Industrial Applications

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Portable applications in the industrial market segment require low power, reliability and high performance. Example industrial applications include barcode readers, shipment data loggers, highway tracking, noise-cancelling headphones, small motor control, and battery chargers. Anything that requires batteries, zero pollution or mobility has similar design requirements.

So, what can designers do to meet these challenges? New generations of microcontrollers that are robust, feature rich and cost effective are available. This article will review the latest microcontroller features and some design considerations to help designers meet these demands in industrial applications.

Keeping the microcontroller in the lowest-power state for the longest-possible amount of time is the primary goal for maximizing battery life. High operating speeds and short wake-up times translate into lower average power consumption, as shown in Figure 1. The quicker the microcontroller can finish its work in the high-power state, the longer it can stay in a low-power state.

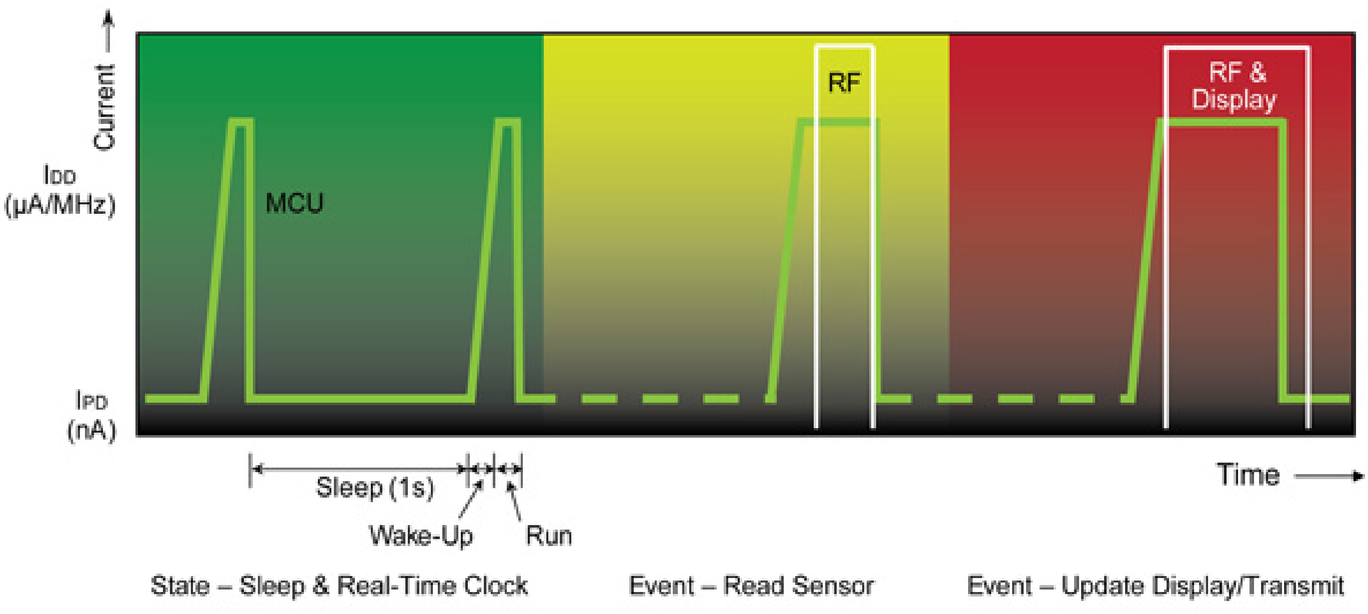

Figure 1. MCU current consumption versus time.

However, reducing power consumption is only half of the answer to achieving long battery life. Getting the most out of your battery is the other half. To do this, it’s valuable to have a microcontroller that supports low-voltage operation. Figure 2 shows the usable life span for an alkaline and a lithium coin-cell battery operating in a typical data logger, courtesy of Energizer. This application spends most of its time in a low-power state, occasionally waking up to process information. The recommended shelf life of alkaline AAAA batteries is five years. You can see that alkaline and lithium batteries benefit from a lower operating voltage. In this example, this translates into an extra six months of battery life, over an equivalent 2-V microcontroller.

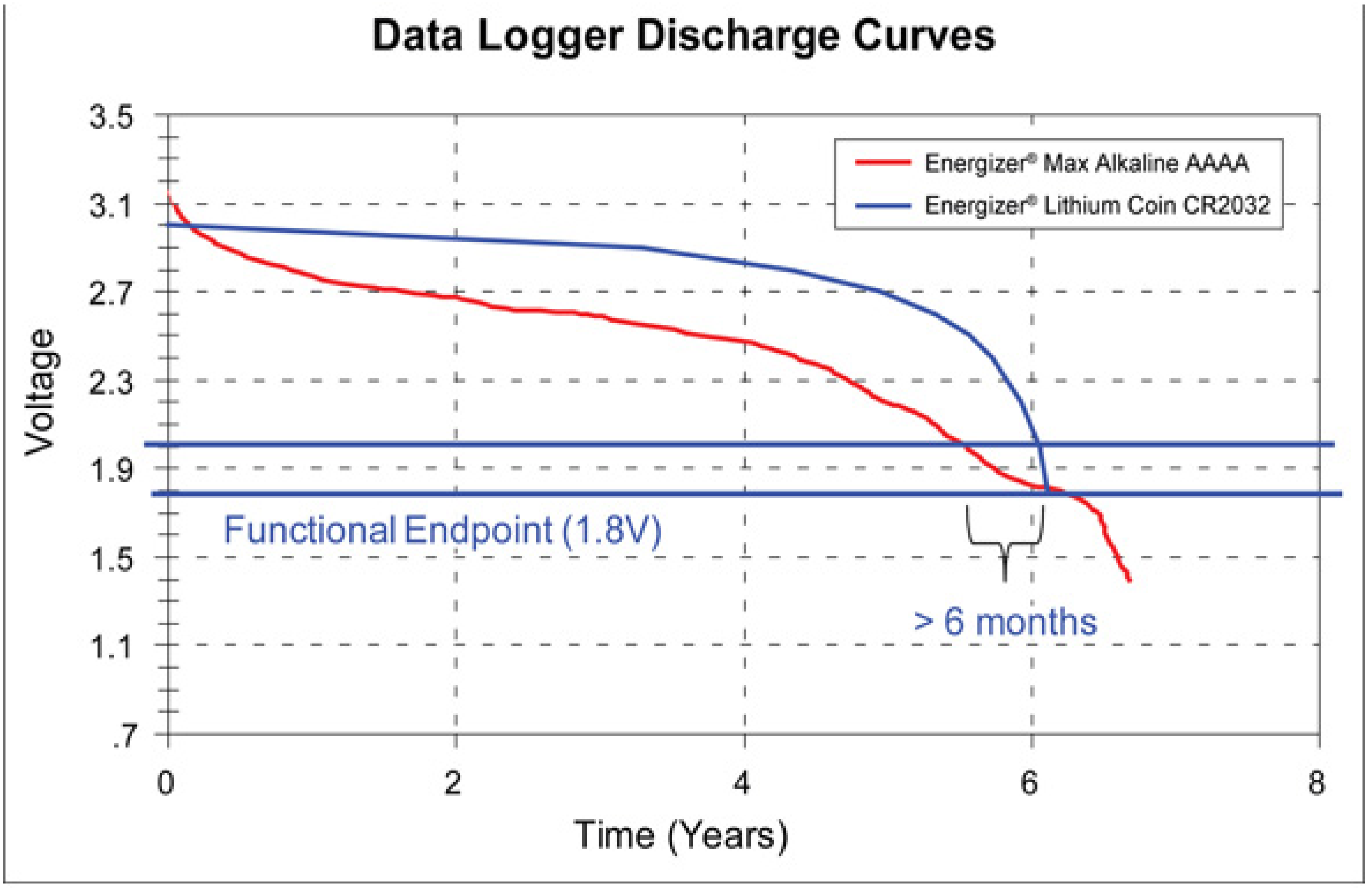

***Figure 2. Data logger battery-performance example. * Source: Energizer at Eveready Battery Company, Inc. Reprinted with permission.**

An additional consideration for designing high-performance and robust industrial applications is the microcontroller's oscillator features, the importance of which is often underestimated. Oscillator features impact many areas, including performance, system cost, manufacturability and reliability.

Newer microcontrollers operate at higher speeds and are capable of running at full speed without an external clock source. A wide variety of internally generated clock frequencies are also available. This permits the software to switch to a lower frequency as the voltage drops to stay within operating specifications or increase speed when a power source is attached.

Another common challenge in manufacturing is reliable crystal start-up. Some common causes of this are variable component quality, flux residue and layout oversights. Many of these problems can be avoided by choosing a high-quality crystal, and implementing layout and testing techniques, such as negative resistance testing, which are available from crystal and microcontroller manufacturers. Configurable crystal biasing, especially for low-frequency circuits, can also help. This permits the bias to be increased, to ensure reliable startups across a variety of conditions, or decreased to reduce power consumption. A little extra effort will help your manufacturing team avoid these types of headaches.

An excellent feature to improve reliability is the Fail-Safe Clock Monitor. It continuously monitors for system clock transitions. As soon as a few transitions are missed, it automatically switches the clock source to the internal oscillator and interrupts the CPU. This permits the microcontroller to maintain critical functions and perform an orderly shutdown.

While low-voltage microcontrollers can be carefully designed into highly reliable applications, sometimes 5-V operation is required. It can simplify board layouts, increase noise immunity and improve support for legacy designs. However, as geometries have shrunk, the availability of new 5-V microcontrollers has dwindled. Chip manufacturers realize there is still significant demand for these devices, and have developed new, high-voltage operation techniques found new ways to operate at higher voltages using smaller, less-expensive geometries. This is good news for designers who seek the benefits of 5-V operation.

To further improve noise immunity, various input buffers are being used by the port and peripheral pins. Different functions may have different input-buffer types, even though they are multiplexed on the same pin. Schmitt trigger inputs offer wider input thresholds than their TTL counterparts and increase the system’s noise tolerance.

High port drive strength is another important design consideration. This goes beyond directly driving LEDs. High port drive strength prevents unwanted coupling near notoriously noisy circuits, such as switching regulators and high-speed PWM signals. There is a potential tradeoff for increased radiated noise. A small RC filter on the port pin will help offset these effects while maintaining high drive strength benefits.

Internal data EEPROM appears to have gone the way of floppy disk drives and 8-track players. This is the natural result of manufacturers going to smaller process geometries, which makes this integration costly. There are software solutions to emulate data EEPROM using Flash memory—however, some applications require independent data storage. Recent microcontroller offerings provide high-endurance data EEPROM and yet remain cost effective. They are rated as high as 100K erase/write cycles. Be mindful of the minimum voltage range for write operations — it is sometimes higher than the minimum operating voltage of the microcontroller, which can limit the effective operating range.

As shown in Figure 3, a flow meter is a good example for the topics covered in this article. The microcontroller’s integrated Charge Time Measurement Unit (CTMU) reads the meter’s flow, temperature and capacitive touchpad. Battery voltage is monitored using a 12-bit differential Analog-to-Digital Converter (ADC) and voltage reference. The Ultra Low-Power Wake-up module initiates periodic wake ups. As illustrated by this example, choosing the right microcontroller will provide a robust, low-power solution with plenty of power under the hood.

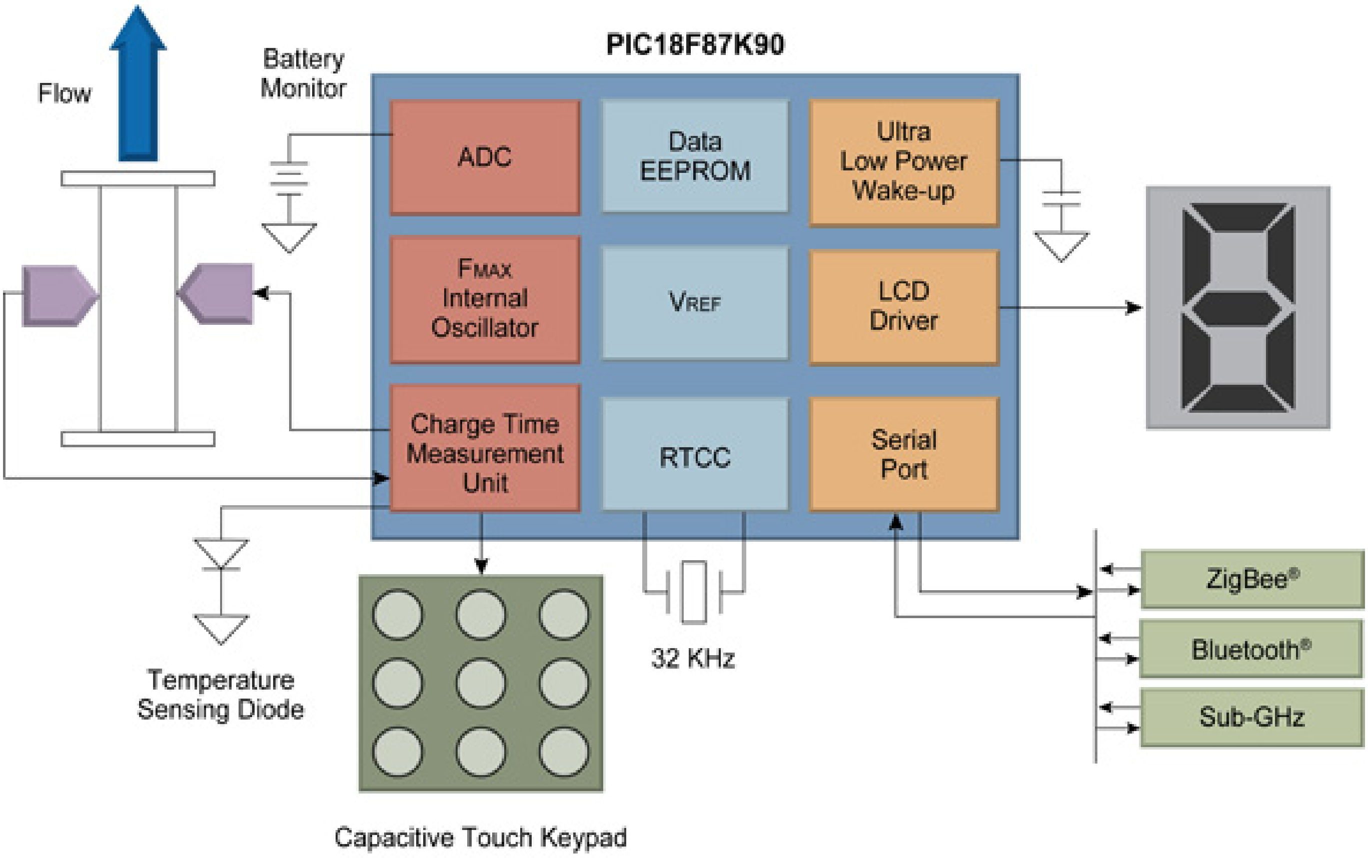

Figure 3. Flow-meter example.

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