Continuously Energy Consumption Measure Approach Using a DMA Double-Buffering Technique

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Research

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Abstract

Measuring the consumption of electronic devices is a difficult and sensitive task. Data Acquisition (DAQ) systems are often used to determine such consumption. In theory, measuring energy consumption is straightforward, just by acquiring current and voltage signals we can determine the consumption. However, a number of issues arise when a new analysis is required. The main problem is that sampling frequencies have to be high enough to detect variations in the assessed signals over time. In that regard, some popular DAQ systems are based on RISC ARM processors for microcontrollers combined with Analog-Digital Converters (ADC) to meet the frequency acquisition requirements. The efficient use of the Direct Memory Access (DMA) modules combined with pipelined processing in the microcontroller allows to improve the sample rate overcoming the processing time and the internal communication protocol limitations. This paper presents a novel approach for high frequency energy measurement composed of a DMA rate improvement (data acquisition logic), a data processing logic and a low-cost hardware. The contribution of the paper is the combination of a double buffered signal acquisition mechanism and an algorithm that computes the device's energy consumption using parallel data processing. The combination of these elements enables a high-frequency (continuous) energy consumption measurement of an electronic device, improving the accuracy and reducing the cost of existing systems. We have validated our approach by measuring the energy consumed by basic circuits and Wireless Sensors Networks (WSNs) motes. The results indicate that the energy measurement error is less than 5%, and that the proposed method is suitable to measure WSN motes even during sleep cycles, enabling a better characterization of their consumption profile.

Full Text

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Figures

Figure 1

Hardware components of the proposed approach for energy measurement.

Figure 2

Pipeline processing data acquisition logic and data processing implemented for a double buffer in the SRAM.

Figure 3

SCTimer state machine. It has only one state with two autoreload downward timers and two events associated to each timer. The timer 1 is twice as fast as the timer 0. The priority of the !timer 0 event is higher than the priority of the !timer 1 event. Each event is activated when its associated timer value is 0. If the !timer 0 event is activated, the SCT trigger set action is activated. If the !timer 1 event is activated, the SCT trigger clean action is activated.

Figure 4

Energy consumption measure of a ZigBee mote using the LOKA algorithm [35] and without it.

Figure 5

Energy consumption measure of a TelosB mote using the Jiang et al. method (SPOT) with a 2 Hz duty-cycling algorithm [18].