

Microcontroller Power Consumption Measurement Based on PSoC

Strahinja P. Janković, *Student Member, IEEE*, Vujo R. Džundarević, *Member, IEEE*

Abstract — Microcontrollers are often used as central processing elements in embedded systems. Because of different sleep and performance modes that microcontrollers support, their power consumption may have high dynamic range, over 100 dB. In this paper, a data acquisition (DAQ) system for measuring and analyzing power consumption of microcontrollers is presented. DAQ system consists of current measurement circuit using potentiostat technique, DAQ device based on system on chip PSoC 5LP and Python PC program for the analysis, storage and visualization of measured data. Both Successive Approximation Register (SAR) and Delta-Sigma (DS) ADCs contained in the PSoC 5LP are used for measuring voltage drop across the shunt resistor. SAR ADC samples data at 10 times higher rate than DS ADC, so input range of DS ADC can be adjusted based on data measured by SAR ADC, thus enabling the extension of current measuring range by 38%. Implemented DAQ device is connected with computer through USB port and tested with developed Python PC program.

Keywords — DAQ, Microcontrollers, Power consumption, PSoC.

I. INTRODUCTION

POWER management is an actual topic for both stationary and mobile electronic systems [1], [2]. In stationary systems it can be used to reduce generated heat and environmental impact as well as to reduce the electricity bills. In addition, the increased power dissipation increases the probability of device failure, and leads to an increase in prices due to the introduction of a system for cooling and packaging. In wide range of portable electronic devices for computing, communication, biomedical and many other applications, power consumption represents extremely important issue. Reducing power consumption when devices are battery powered allows the use of light batteries and longer device operation between the charging cycles. Many design methodologies are implemented to achieve energy-efficient electronic system [3]–[7]. For power management to be effective, power consumption of power managed system

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Corresponding Strahinja P. Janković is Ph.D. candidate at the School of Electrical Engineering, University of Belgrade, Bul. kralja Aleksandra 73, 11120 Belgrade, Serbia (e-mail: jankovic@etf.bg.ac.rs)

Strahinja P. Janković and Vujo R. Džundarević are with the School of Electrical Engineering, University of Belgrade, Bul. kralja Aleksandra 73, 11120 Belgrade, Serbia.

needs to be accurately measured [8].

Power consumption of an embedded system depends on operating voltage and current. In order to measure and visualize voltage and current in real-time, oscilloscopes and data acquisition (DAQ) systems can be used. Oscilloscopes have high precision and allow real-time visualization and analysis of measured data. DAQ systems consist of sensor, DAQ device connected to a computer and PC software for data acquisition, visualization and analysis running on that computer [9].

When measuring power consumption of an embedded system, voltage is kept at a certain operating value (for the system to be functional) and current consumption is measured. If current is sampled at predefined time intervals, average energy and power consumption data can be obtained.

In this paper new DAQ system for measuring microcontroller power consumption is presented.

This paper is organized in the following way: the section *Measurement principles* provides concepts and details of measuring current with high dynamic range, since microcontroller current consumption exhibits similar behavior. The section *System implementation* focuses on presenting three integral parts of the proposed solution: Programmable System on Chip (PSoC 5LP), Data acquisition device and Python PC program. Experimental results are presented in section *Results and Discussion*. Finally, the conclusions are given in the last section.

II. MEASUREMENT PRINCIPLES

Current measurement using shunt is widely used technique [10]. However, problem with shunt is the burden voltage effect [11], which affects operating voltage of the system whose power consumption is being measured. That is especially noticeable if current rapidly changes in time as a result of system activity and if dynamic range of changes is several orders of magnitude.

Several shunt-based current measurement techniques exist which solve the problem with burden voltage [12]–[14]. One solution to the problem of burden voltage is to use current mirror (Fig. 1a).

As can be seen from Fig. 1a, current flowing through system whose power consumption is measured is mirrored and shunt is placed in the mirrored branch. Thus the operating voltage remains constant, but accuracy of measurement is affected by the transistors and matching of those transistors. Also, power consumption of the whole system is increased and calibration is required.

Another possibility is to use the potentiostat technique

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1. Understanding the eBook Microcontroller Power Consumption Measurement Based On Psoc
 - The Rise of Digital Reading Microcontroller Power Consumption Measurement Based On Psoc
 - Advantages of eBooks Over Traditional Books
2. Identifying Microcontroller Power Consumption Measurement Based On Psoc
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Microcontroller Power Consumption Measurement Based On Psoc
 - User-Friendly Interface
4. Exploring eBook Recommendations from Microcontroller Power Consumption Measurement Based On Psoc
 - Personalized Recommendations
 - Microcontroller Power Consumption Measurement Based On Psoc User Reviews and Ratings
 - Microcontroller Power Consumption Measurement Based On Psoc and Bestseller Lists

5. Accessing Microcontroller Power Consumption Measurement Based On PsoC Free and Paid eBooks
 - Microcontroller Power Consumption Measurement Based On PsoC Public Domain eBooks
 - Microcontroller Power Consumption Measurement Based On PsoC eBook Subscription Services
 - Microcontroller Power Consumption Measurement Based On PsoC Budget-Friendly Options
6. Navigating Microcontroller Power Consumption Measurement Based On PsoC eBook Formats
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 - Microcontroller Power Consumption Measurement Based On PsoC Enhanced eBook Features
7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Microcontroller Power Consumption Measurement Based On PsoC
 - Highlighting and Note-Taking Microcontroller Power Consumption Measurement Based On PsoC
 - Interactive Elements Microcontroller Power Consumption Measurement Based On PsoC
8. Staying Engaged with Microcontroller Power Consumption Measurement Based On PsoC
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Microcontroller Power Consumption Measurement Based On PsoC
9. Balancing eBooks and Physical Books Microcontroller Power Consumption Measurement Based On PsoC
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Microcontroller Power Consumption Measurement Based On PsoC
10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
11. Cultivating a Reading Routine Microcontroller Power Consumption Measurement Based On PsoC
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 - Carving Out Dedicated Reading Time
12. Sourcing Reliable Information of Microcontroller Power Consumption Measurement Based On PsoC
 - Fact-Checking eBook Content of Microcontroller Power Consumption Measurement Based On PsoC
 - Distinguishing Credible Sources
13. Promoting Lifelong Learning

- Utilizing eBooks for Skill Development
 - Exploring Educational eBooks
14. Embracing eBook Trends
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