DESIGN AND DEVELOPMENT OF IoT BASED POWER MONITORING SYSTEM USING PSoC4 BLE

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ABSTRACT
The increasing demand for power-efficient system has led to the development of IoT-based power monitoring system that enable real-time monitoring of power consumption. IoT-based power monitoring systems have emerged as a useful tool for enabling energy conservation, reducing costs, and improving overall efficiency. In this paper we present an IoT-based power monitoring system that utilizes the PSoC4 BLE microcontroller to enable real-time monitoring. The system is capable of measuring various electrical parameters such as voltage, current, and power consumption in real-time. The system collects and analyzes data from various sensors, and then uses Bluetooth Low Energy(BLE) to transmit this information to a mobile device. The system is designed to be low-cost, compact and energy efficient, making it suitable for deployment in various settings such as homes, offices, and industrial environments. The proposed system is easy to use, cost-effective, and scalable, making it an ideal solution for a wide range of applications.

INTRODUCTION
An important step in achieving effective and intelligent power management in homes and buildings is the design and development of an IoT-based power monitoring system using PSoC4 BLE. In order to design and develop an IoT-based power monitoring system utilizing PSoC4 BLE that is effective, dependable, and user friendly, it is necessary to combine hardware, software, and communication protocols. Sensors, microcontrollers are common examples of hardware components. Firmware, drivers, cloud-based platforms for data storage and analysis are examples of software components.

Introduction to IoT
IoT Technology which has completely changed how devices are connected and handled, has enormous potential for energy management. The Internet of Things(IoT) idea enables things to communicate by sharing data across wired or wireless connections. Smart homes, healthcare, transportation, manufacturing, power management, and environmental monitoring are just a few of the many uses for IoT. It is anticipated that as IoT technology develops, it will have a substantial impact on how people live and work, leading to more efficient ways of carrying out tasks.

Introduction to Power Monitoring System
The system's brain, the PSoC4 BLE microcontroller, is responsible for processing data from sensors. The microcontroller analyses the real-time data on power usage that the voltage and current sensors offer. Users can track their power usage from any location thanks to Bluetooth Low Energy(BLE) technology, which transmits the data to a mobile device.

Real-time power monitoring power usage analysis, and other functions are among the system's primary characteristics. Users may monitor their power usage in real-time and make the required modifications to reduce wastage. The power usage analysis offers useful information on trends and patterns in power consumption, assisting users in making wise choices regarding power management.

Innovative solutions have been developed in number of fields as a result of the IoT Technology's quick development. The capacity of IoT to track power consumption in real time is one of its most important advantages. The design and implementation of a PSoC4 BLE-based IoT-based power monitoring system are

presented in this work.

LITERATURESURVEY

An developing technology called the Internet of Things(IoT) has the power to completely change how we work and live. Power monitoring systems are one of the IoT's most exciting potential uses. In this Literature survey, we investigate the most recent developments in PSoC4 BLE-based IoT-based power monitoring systems. To pinpoint the most recent trends, difficulties, and possibilities in this area, we specifically review the most recent IEEE papers on the subject.

An essential component of energy management, especially in industrial and commercial settings is power monitoring. Yet, typical power monitoring systems are frequently expensive, complex, and difficult to install and maintain. IoT technology's introduction has created new opportunities for power monitoring by permitting the use of inexpensive, wireless sensors. In particular, the development of power monitoring systems that are both affordable and simple to deploy has been made possible by the use of PSoC4 BLE technology.

[1]Long Zhao, Igor Matsuo, Yuhao Zhou, Wei-Jen Lee proposed "Design of an industrial IoT-Based Monitoring System for Power Substation". A thorough analysis of the design and implementation of an Industrial Internet of Things(IIoT)-based power monitoring system for power substations is presented in this paper. The concept of IIoT and its applications in the power industry are introduced in this paper. To ensure the security and dependability of the power grid, authors talk about how crucial power substation is. The authors provides a detailed evaluation of monitoring system for power substations, including performance metrics such as throughput and energy consumption. This paper provides a valuable contribution to the field of IIoT and power substation monitoring, and it is recommended for researchers and practitioners working in this area.

[2] M.Li and H.J. Lin proposed "Design and Implementation of Smart Home Control Systems Based on Wireless Sensor Networks and Power Line Communications". This paper proposes a smart home and control system that combine WSNs(Wireless Sensor Networks) and PLC(Power Line Communication) to provide a reliable and efficient method of controlling various appliances and devices in a home. The system consists of several wireless sensors and actuators, which are connected to the power lines in the home using a power line communication module. The system also includes a central controller, which communicates with the sensors and actuators through a wireless network. The proposed system utilizes a communication protocol that ensures reliable communication between various devices in the network. The protocol uses a hybrid approach, combining a TDMA(Time Division Multiple Access) protocol for the wireless network and a CSMA/CA(Carrier Sense Multiple Access/Collision Avoidance) protocol for the power line network. The hybrid approach ensures that data is transmitted efficiently and reliably, while minimizing the risk of collisions and other communication errors. This system represents an important step towards the development of smart home control systems that are practical, efficient and easy to use.

[3]The paper by Bedi et al.(2018)[3] provides a comprehensive review of the Internet of Things(IoT) in the context of electric power and energy systems. The concept of IoT and its importance in the energy sector are first introduced by the authors. Then they provide a thorough overview of the various IoT technologies utilized in power systems, including sensors, actuators, and communication protocols. The authors provides IoT's many energy-related applications, including distributed energy resources, smart grid, smart metering and demand response. Overall this paper offers a thorough and current analysis of IoT in power systems, covering a variety of subjects from fundamental ideas to recent advancements. The author's critical analysis of the challenges and opportunities associated with IoT in power systems makes this paper an important resource for researchers, practitioners in the energy sectors.

[4] R. Gore and S. P. Valsan proposed "Big Data Challenges in smart Grid IoT(WAMS) deployment".

The authors emphasizes the necessity for big data analytics to process and analyze the substantial amounts of data created by modern power systems while highlighting the increasing significance of WAMS(Wide Area Monitoring Systems).The architecture of WAMS and its various parts such as communication networks, data centers are covered by authors. This work is a valuable resource for practitioners and policymakers in energy industry because of authors critical review of current methods and new developments.

Overall, these papers demonstrate the potential of IoT-based power monitoring systems using PSoC4 BLE reference in various applications, including smart homes, energy-efficient buildings and smart grids. The proposed system can monitor the power consumption of various devices which can lead to significant energy savings and cost reductions.

PROPOSEDSYSTEM

The following proposed system was used to design the power monitoring system. Implementation of power monitoring system is a combination of both hardware and software.

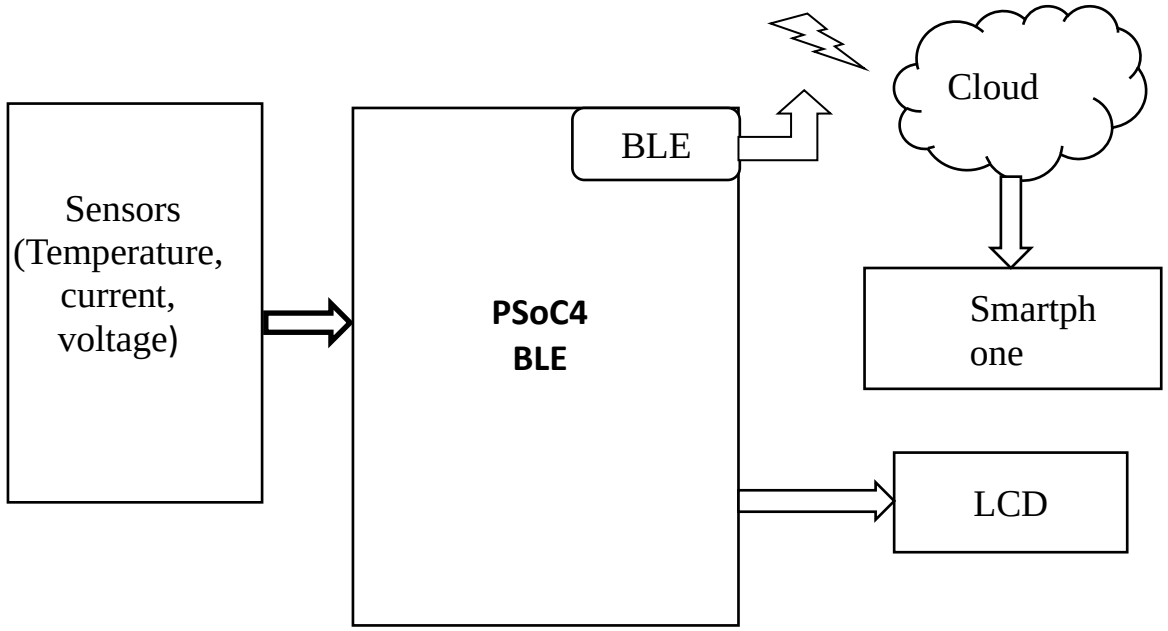

Figure 1. Block Diagram of Power Monitoring System

Hardware Components

PSoC4 BLE: Cypress semiconductor PSoC4 BLE is a robust and highly integrated System-on-Chip(SoC) architecture that integrates an ARM Cortex-M0 CPUwith analog and digital logic as well as BLE wireless connection. The PSoC4 BLE is made for IoT(Internet of Things) applications that need high performance, flexibility and low power consumption. A variety of power management capabilities on the PSoC4 BLE enable designers to maximize the power utilized to measure the current flowing through a circuit.

Temperature Sensor LM35: The LM35 is a precise temperature sensor that produces a linear output voltage that is exact and proportional to the temperature. Due to its great precision, low cost, and simplicity of use, it is a popular option for temperature measurement applications. The LM35 sensor has a linear output voltage of 10mV/^{0}C and can monitor temperatures between -55^{0}C and 150^{0}C.

Current Sensor: A current sensor is an electrical device that gauges the flow of current via a wire. Many different applications such as power and energy monitoring, make use of current sensors.

Voltage Sensor: A voltage sensor is a piece of electronic equipment that gauges the voltage of an system. Voltage Sensors are employed in a variety of tasks, such as battery management and power monitoring.

LCD(Liquid Crystal Display): A widely utilized display technology in a variety of electronic gadgets is the LCD. As they require less power, have a great resolution, and are simple to operate, LCDs are chosen for Internet of Things applications. An LCD display can be used in a power monitoring system to show real-time data on a system's power usage. The LCD can clearly and easily readably display a number of parameters, including voltage, current and power usage.

Software components:

PSoC Creator: Powerful and adaptable software called PSoC Creator is used to design and create IoT-based power monitoring systems. The C programming languages can be used by users to create firmware, and

PSoC creator IDE offers an debugger and simulator for testing and debugging programmes. PSoC creator comes with a library that has drivers for variety of peripheral devices, including LCD screen, Sensors, actuators as well as communication protocols like I2C, SPI and UART. Hence PSoC creator can be used to create hardware and firmware configurations that can measure parameters in IoT-based power monitoring systems.

METHODOLOGY

The power monitoring system consists of a PSoC4 BLE microcontroller, an power monitor and a mobile application. The PSoC4 BLE acts as a central hub, receiving data from power monitor and transmitting it to the mobile application via Bluetooth Low Energy. The power monitor is connected to the power supply and measures power consumption of the system in Real-time.

The IoT-based power monitoring system is composed of a PSoC4 BLE microcontroller, current sensors and voltage sensors. The microcontroller is responsible for acquiring data from the sensors and transmitting it to a remote server using BLE technology. The sensors are connected to the PSoC4 BLE microcontroller which reads the sensors data and process it. The processed data is then transmitted wirelessly to remote server using BLE technology.

The remote server is responsible for receiving data from microcontroller, processing it and storing it in a database. The data is then displayed on a mobile, which enables users to monitor power consumption in real-time.

RESULTSANDDISCUSSIONS

To implement PSoC4 BLE with a power monitoring system and to display power consumption values on the mobile phone need to follow these steps:

At initially, the PSoC4 BLE development board with sensors. Generally, to do this, the power, ground, and signal pins of the sensors are connected to the corresponding pins on the PSoC4 BLE Board. Create firmware using PSoC creator that can monitor and measure the parameters from attached sensors, and then configure the firmware to determine power usage based on measured voltage and current. The firmware should then be configured to wirelessly transfer dataand parameters to a BLE module, and a user interface on an LCD should then be used to display real-time data such as voltage, current and power usage. BLE communication should be implemented using PSoC creation software.

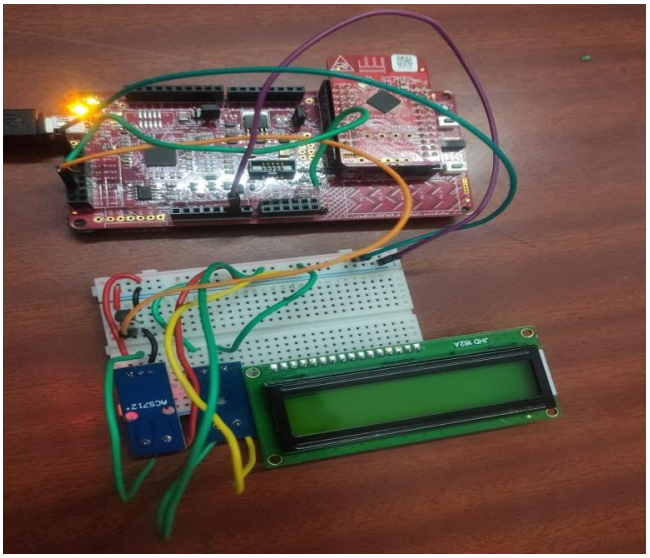

Figure 2. Interfacing of Sensors

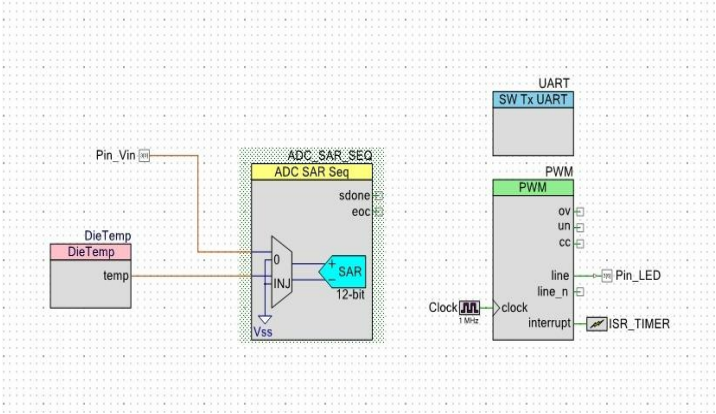

Figure 3. Schematic Diagram of Interfacing modules

The proposed IoT-based power monitoring system was tested in a real world environment, and the results demonstrated its effectiveness in monitoring power consumption. The system was able to acquire data from sensors and transmit it wirelessly to a remote server in real-time. The user interface provided real-time power consumption monitoring, data analysis and power consumption prediction features. The results of the system's performance shown in figure 4 &5.

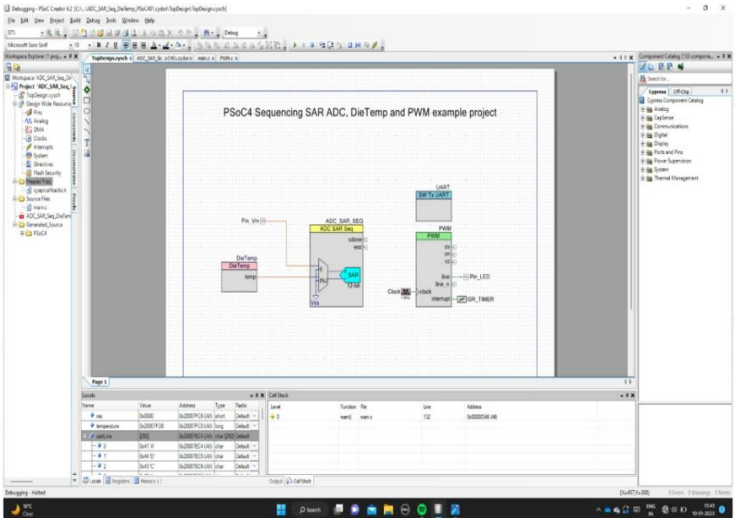

Figure 4. Output of Interfacing modules

Name	Value	Address	Type	Radix
res	0x0000	0x20007FC6 (All)	short	Default
temperature	0x20007FD8	0x20007FC8 (All)	long	Default
uartLine	[250]	0x20007EC4 (All)	char [250]	Default
0	0x35 '5'	0x20007EC4 (All)	char	Default
1	0x06 '\006'	0x20007EC5 (All)	char	Default
2	0x00 '\000'	0x20007EC6 (All)	char	Default
3	0x00 '\000'	0x20007EC7 (All)	char	Default
4	0x04 '\004'	0x20007EC8 (All)	char	Default
5	0x03 '\003'	0x20007EC9 (All)	char	Default
6	0x00 '\000'	0x20007ECA (All)	char	Default
7	0x00 '\000'	0x20007ECB (All)	char	Default
8	0x00 '\000'	0x20007ECC (All)	char	Default
9	0x00 '\000'	0x20007ECD (All)	char	Default
10	0x00 '\000'	0x20007ECE (All)	char	Default
11	0x41 'A'	0x20007ECF (All)	char	Default
12	0xDE '\336'	0x20007ED0 (All)	char	Default
13	0x51 'Q'	0x20007ED1 (All)	char	Default
14	0x3B ';'	0x20007ED2 (All)	char	Default
15	0x95 '\205'	0x20007ED3 (All)	char	Default
16	0x41 'A'	0x20007ED4 (All)	char	Default
17	0x44 'D'	0x20007ED5 (All)	char	Default
18	0x43 'C'	0x20007ED6 (All)	char	Default
19	0x20 ' '	0x20007ED7 (All)	char	Default
20	0x6D 'm'	0x20007ED8 (All)	char	Default
21	0x65 'e'	0x20007ED9 (All)	char	Default
22	0x61 'a'	0x20007EDA (All)	char	Default
23	0x73 's'	0x20007EDB (All)	char	Default
24	0x75 'u'	0x20007EDC (All)	char	Default
25	0x72 'r'	0x20007EDD (All)	char	Default
26	0x65 'e'	0x20007EDE (All)	char	Default
27	0x64 'd'	0x20007EDF (All)	char	Default
28	0x20 ' '	0x20007EE0 (All)	char	Default
29	0x76 'v'	0x20007EE1 (All)	char	Default
30	0x6F 'o'	0x20007EE2 (All)	char	Default
31	0x6C 'l'	0x20007EE3 (All)	char	Default

Figure 5. Power Values output

CONCLUSION

Overall, the IoT-based power monitoring system using PSoC4 BLE has shown great impact in the field of power management. The system is highly effective in monitoring power consumption, and the real-time updates provided by the mobile application make it easy for users to identify areas where energy could be conserved. The system is also highly reliable, making it a great option for residential and commercial settings alike. As such, we believe that this system could play a key role in promoting power efficiency in the future.

FUTURESCOPE

The design and development of IoT based power monitoring system using PSoC4 BLE have the potential to revolutionize the way we manage and consume power. The future scope of such systems is quite broad and here are some potential areas of application:

Smart Homes: IoT based power monitoring system can be integrated with smart home systems to provide real-time power usage data, enabling house owners to make informed decisions about power consumption and efficiency.

Smart Grids: The integration of IoT based power monitoring systems into smart grids can enable better management of energy distribution, reduce energy waste and improve overall efficiency of the grid.

Industrial Automation: IoT based power monitoring systems can be integrated can be used to industrial automation system to provide real-time monitoring of power usage in factories, allowing for more efficient power management and cost savings.

Electrical Vehicle charging: IoT based power monitoring system can be used to monitor electrical vehicle charging stations, enabling more efficient use of energy and better management of charging process.

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