Development of a Smart Solar Energy Harvesting System

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Abstract – Solar panels enable the acquisition of energy from the environment that can be stored for Energy Harvesting purposes. The objective of this work is to design, simulate and characterize different configurations in the harvesting stage, constituted by solar panels for energy harvesting systems of low consumption, identifying the most adequate arrangement to achieve the highest amount of energy together with the conversion stage. The methodology used has has been design, simulation in Matlab-Simulink software and characterization with mini solar panels. The system developed consists of 3 stages which are: energy harvesting, DC-DC converter, and storage, focusing on the Energy Harvesting stage. From the simulation obtained is 4.8V and 160 mA; from measurement 4.60V and 134.5mA, resulting that the mixed configuration is the one that provides better results both in the voltage and in the current, so the results conclude that very close the simulated and measured values with an error of 0.05% and 0.16% on voltage and current respectively with an output voltage of the converter up to 26V. Finally, very promising results for Energy Harvesting applications.

Keyword:- ESP32, Internet of Things, online Monitoring, solar energy, Blynk

INTRODUCTION

Nowadays, low-cost, smart electronic systems and wireless sensor network technologies are experiencing fast growth. They are currently being deployed worldwide into both home [1] and industry environments [2,3]. On the one hand, they will improve the quality of people’s lives: environment, health and well-being, security, comfort, education and entertainment [4]. On the other hand, future smart industry and factories will become more efficient, intelligent, and connected [5]. This is due to the fact that smart sensors, with embedded intelligence for controlling, communication and interoperability can be integrated within enterprise business systems, thus constituting a change of system architecture in automation and control process [3].

Besides, there is an increasing interest in green electronics [6] and among other characteristics, for an electronic system to be green, it must have a contained price and be energy efficient [7]. Thus, electronic devices or systems with wireless capabilities are increasingly popular because they do not need to be connected to the mains power grid [8]. In this context, energy harvesters become a proper alternative for gathering energy from the environment and provide answers to some of the aforementioned technical challenges [9,10], because energy harvesters are, essentially, transducers devised to extract, not only a sample of the physical phenomena the aim for, but the maximum feasible amount of energy [11].

OBJECTIVE

The objective of this project is to develop a solar energy monitoring system that tracks the voltage and current levels of a battery charged by a solar cell. Using an ESP32 microcontroller along with a voltage sensor, current sensor, and 16x2 LCD display, the system uploads real-time data to the Blynk platform, enabling remote monitoring and management.

RELATED WORK

1. The paper focuses on solar energy harvesting photovoltaic (PV) self-powered applications and their importance in solving energy supply issues as well as curtailing environmental degradation. It evaluates PV electricity generation, system architecture, significant features including maximum power point tracking (MPPT) skills, and multiple applications including transportation as well as portable devices. The paper finishes with some queries giving direction to further studies marketing

enhancement of MPT and managing power systems intelligently.

2. This research investigates the structure and performance of photovoltaic (PV) energy harvesting technologies in the case of the ‘wearable device’ category in particular considering a sleeve equipped with flexible solar cells panels. It marks the dependence of energy generation on the inverse circumferential radius of the panel and the angle of the incident light, suggesting that the first factor affects the energy generation the most, however, the second one has proven more critical. The study establishes that two or more smaller panels can perform better than one and larger as high as 94mW and so eliminates battery consumption without posing any hazard to the user.

3. This paper is based on an extensive survey of solar energy harvesting systems integrated into wireless sensor networks (WSNs) focusing on the scenario where there is energy depletion in the nodes placed at inaccessible areas. Various components like Solar panels, Energy storage, DC-DC converters, Maximum power point tracking (MPPT) and others have been investigated. The paper presents recent applications in which smart street lights and environmental monitoring were utilized, while recommending relevant future researches to be conducted in order to increase energy efficiencies and adoptability with cutting edge technologies.

4. In order to withstand a variety of external parameters, a photovoltaic energy harvesting system is proposed which can be modified accordingly. It examines an individual DC/DC converter supporting photovoltaic cell and performs analysis on its efficiency, power and voltage with changing illumination and temperature respectively. After achieving an optimal device selection and performed simulations, targeting the efficient management and conversion of energy for development of sustainable energy system for integration into smart electronics.

5. This research focuses on designing, simulating, and characterizing an energy harvesting system that uses solar panels to supply low-power electronic devices. The study evaluates different configurations of solar panels (series, parallel, and mixed) to optimize energy collection and conversion, demonstrating that the mixed configuration yields the best results with minimal error in voltage and current measurements.

6. Various solar energy monitoring systems have been developed in recent years, focusing on tracking parameters like battery voltage, current, and overall system efficiency. Some systems utilize IoT platforms, such as Blynk or Thingspeak, to provide real-time data. These monitoring solutions are essential in applications where solar energy is harvested to ensure optimal energy usage, detect faults, and manage load effectively.

7. Ahmad Dahlan UAD present a project on renewable energy which present an Internet of Things (IoT) based monitoring system for photovoltaic (PV) parameters utilizing the NodeMCU ESP8266. This system is designed to track important metrics such as solar irradiance, ambient temperature, and PV output voltage and current to enhance efficiency and maintenance of solar energy systems

Problem statement in solar energy harvesting system

In solar energy harvesting systems, it’s crucial to monitor the battery’s voltage and current to prevent overcharging and ensure efficient energy storage. Without real-time data, it becomes challenging to detect fluctuations that could impact battery health, system efficiency, or lead to energy loss. A reliable monitoring system is required to ensure the longevity of the battery and maximize the energy harvested from solar cells.

METHODOLOGY

In this project we are trying make to analyse the parameters of solar cell for which we have to construct a hardware model to collect the ambbed energy and convert it into electrical energy. And a software program to display the parameters of the solar cell

Step 1: Use an ESP32 microcontroller to interface with voltage and current sensors connected to the battery charged by a solar cell.

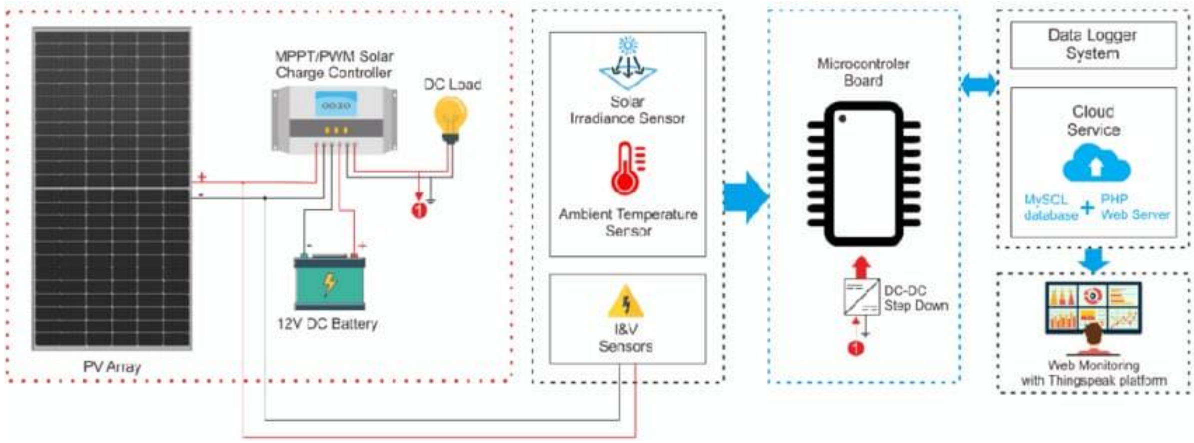
Step 2: Continuously monitor voltage and current data from the sensors.

Step 3: Display the data on a 16x2 LCD for local reference.

Step 4: Integrate the ESP32 with the Blynk platform to upload sensor data, enabling remote monitoring.

Step 5: Analyze and interpret data on the Blynk app to make informed decisions on battery health and energy management.

BLOCK DIAGRAM



EXPLANATION OF DAIGRAM

Solar Cell:
Captures sunlight and converts it into electrical energy.
Connected to a charge controller (not explicitly shown) to regulate the voltage and current.
Output is connected to the battery.

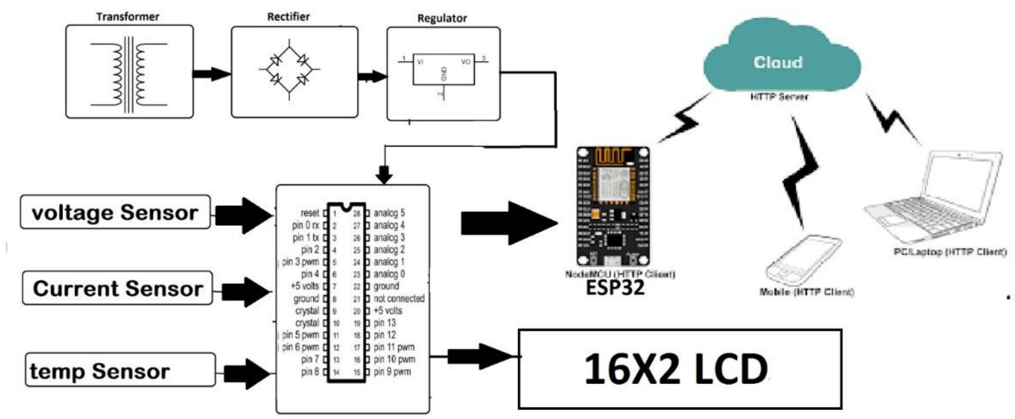
Battery:
Stores electrical energy from the solar cell.
Provides power to the system when there's insufficient sunlight.
Connected to the power input of the ESP32 and the LCD.

Voltage and Current Sensors:
Measure the voltage and current output of the solar cell/battery.
Analog output is connected to the analog input pins of the ESP32.

ESP32:
Microcontroller that processes the sensor data.
Reads sensor data from the analog input pins.
Processes the data and sends it to the Blynk cloud platform via Wi-Fi.
Controls the LCD to display relevant information.

LCD:
Displays information such as voltage, current, battery level, etc.
Receives control signals and data from the ESP32.

Blynk:
Cloud platform that allows remote monitoring and control of the system.
Receives data from the ESP32.
Provides a user-friendly interface to visualize and interact with the data.



Key Points:

The ESP32 is the central processing unit that coordinates all the components.

The battery ensures a continuous power supply, especially during low-light conditions.
The sensors provide real-time data on the system's performance.

The LCD displays local information for immediate reference.
Blynk enables remote monitoring and control, making the system more flexible and accessible

OUTPUT

SOFTWARE OUTPUT:

LCD HARDWARE OUTPUT:

REFERENCE

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