Development of an ultralow-power battery-operated data logger

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1. Introduction

Accurate environmental monitoring underpins climate science, ecological investigation, and agricultural optimization; however, extant data-logging instruments are often prohibitively expensive, necessitate frequent battery replacement, and exhibit limited resilience in adverse outdoor settings. This proposal outlines the **Development of an Ultralow-Power, Battery-Operated Data Logger** for sustained field deployment. The architecture integrates an energy-efficient microcontroller, a factory-calibrated temperature and humidity sensors, and firmware optimized through deep-sleep operation, clock scaling, and adaptive duty cycling to minimize energy consumption. A smart power-budget algorithm, in concert with either rechargeable (Li-ion) or primary cell chemistries and ultra-low-leakage voltage regulation, facilitates autonomous operation exceeding one month on a single charge. Recorded data are preserved in onboard nonvolatile memory with precise timestamps, while the IP65-rated enclosure with sealed connectors and corrosion-resistant push button to ensure mechanical robustness. Collectively, these design choices yield a maintenance-free, rugged solution for long-term environmental data acquisition in challenging field environments.

2. Targets

The main targets to be achieved to complete the project are,

- Accurately measure and record ambient temperature.
- Measure and record relative humidity.
- Operate autonomously for at least one month on a single battery charge.
- Buffer and organize time-stamped data in non-volatile local storage.
- Monitor battery voltage and gracefully shut down before depletion.
- Withstand outdoor conditions with a waterproof, rugged enclosure.

3. Methodology

The ultralow-power data logger is predicated on a microcontroller that remains in deep-sleep until awakened by an RTC alarm or timer-interrupt, at which point it acquires temperature and humidity measurements from a factory-calibrated sensor (e.g., AHT2415C) and assesses the battery voltage. Upon wakeup, the device records these time-stamped readings to nonvolatile memory before promptly returning to its low-power state. Quiescent current is minimized using an ultra-low-leakage LDO, while optimized firmware algorithms further reduce active-mode energy consumption. A GPIO-controlled resistor divider, which engages only during voltage measurement to eliminate idle current draw, scales the battery pack voltage for ADC conversion and dynamically adjusts the data-collection interval to extend operational longevity. The push button, status LED and USART interface will be used to allow users to interact with the firmware to change certain settings. The Power is replenished via a waterproof charging interface that accommodates a Li-ion charger and battery-management system (BMS), ensuring cell protection. Collectively, these design features facilitate over more than one month of autonomous, maintenance-free outdoor operation on a single battery charge.

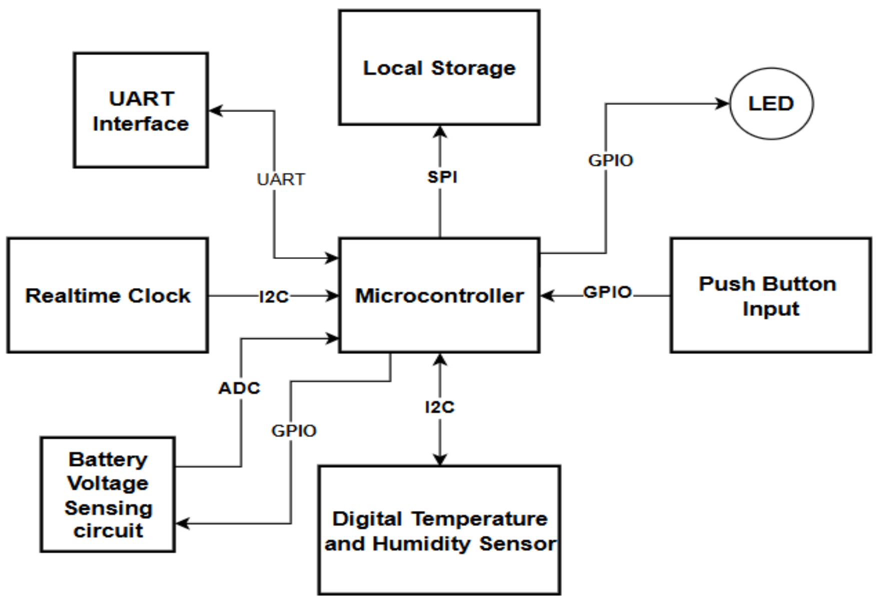

Figure 3.1: Block Diagram of the System

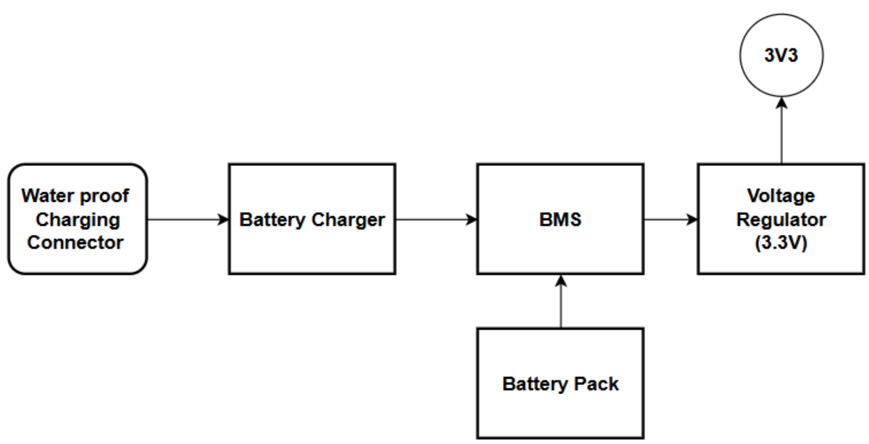

Figure 3.2: Block Diagram of the power supply