Power Management of the LMP91000 Potentiostat Board

Joseph Mire, Masudul Imtiaz | Department of Electrical and Computer Engineering

Background

The open-source battery-powered LMP91000 potentiostat board uses close to 10 mA in active mode. This drains the small 150 mAh battery quickly. This research presents a power-efficient firmware that puts the device into a low-power mode when not in use, significantly increasing battery life in the field.

Hardware:
- EFR32BG24 Silicon Labs Microcontroller (MCU)
- LSM6DSV Inertial Measurement Unit (IMU)
- LMP91000 Potentiostat Integrated Circuit
- 150 mAh Lithium Battery
- Tag-Connect Debug Header

Link to Firmware:

Implementation

- Power button for full on/off control
- Deep sleep mode with configurable timeout and wake interval
- Reset counter stored in Back-Up RAM
- Motion-triggered wake-up
- Real-time clock (RTC) for data timestamping
- Automatic shutoff on low battery voltage

Interrupts

Interrupts send a signal to the microcontroller to wake up the device from sleep:
- Inertial Measurement Unit
  - Fires an interrupt when motion is detected
  - Boots the system into active mode
- Back-Up Real Time Counter
  - Tracks time in Unix time, a standard that measures the amount of time in seconds from January 1, 1970
  - Allows for time-stamping of data collected by the potentiostat

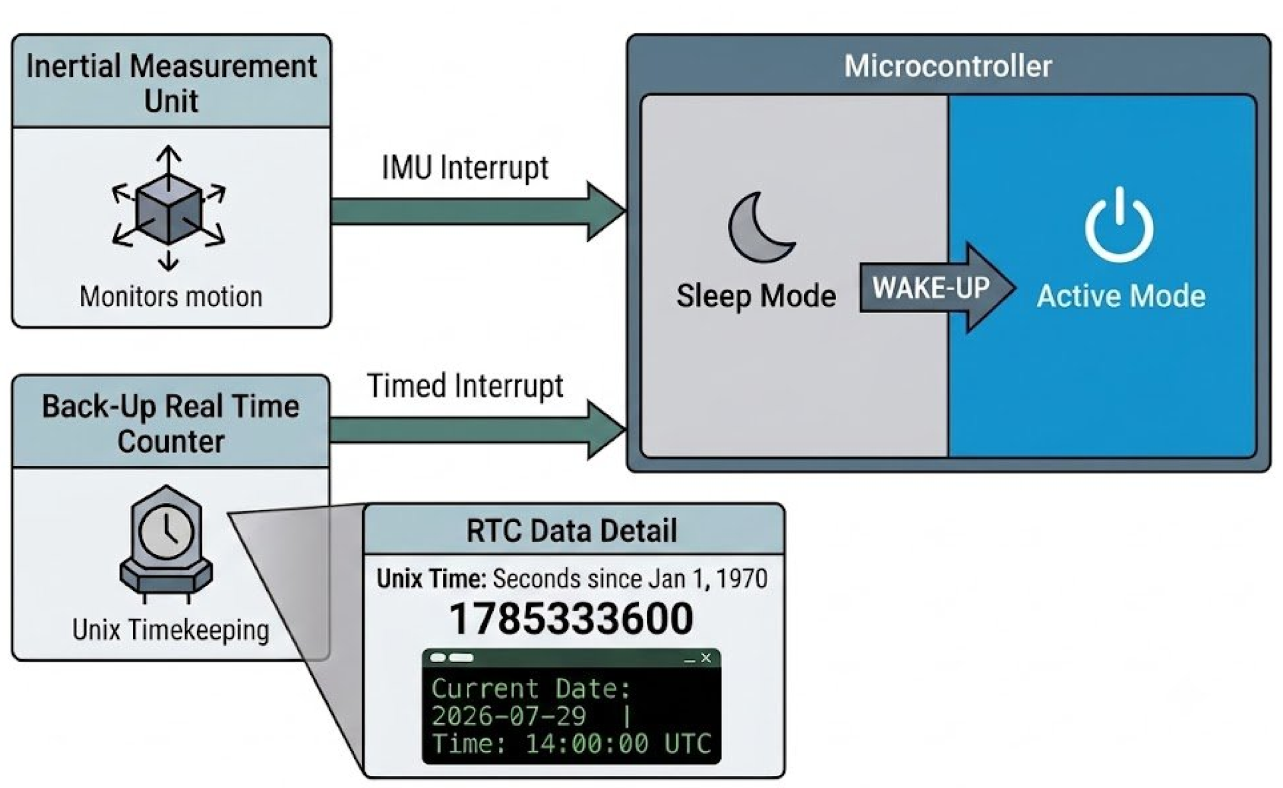

Figure 1: Interrupt Graphic

Experimental Setup

This device was programmed using Simplicity Studio 6 connected to Visual Studio Code, which served as the integrated development environment. The custom potentiostat board was connected to the BRD4002A Wireless Pro Kit. KiCad was used to view schematic files and locate pin numbers.

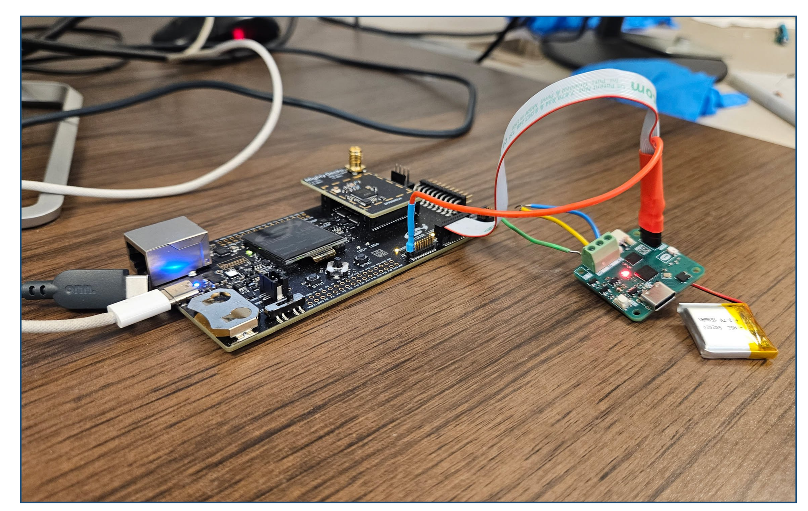

Figure 2: BRD4002A Wireless Pro Kit Connected to the Custom Potentiostat Board

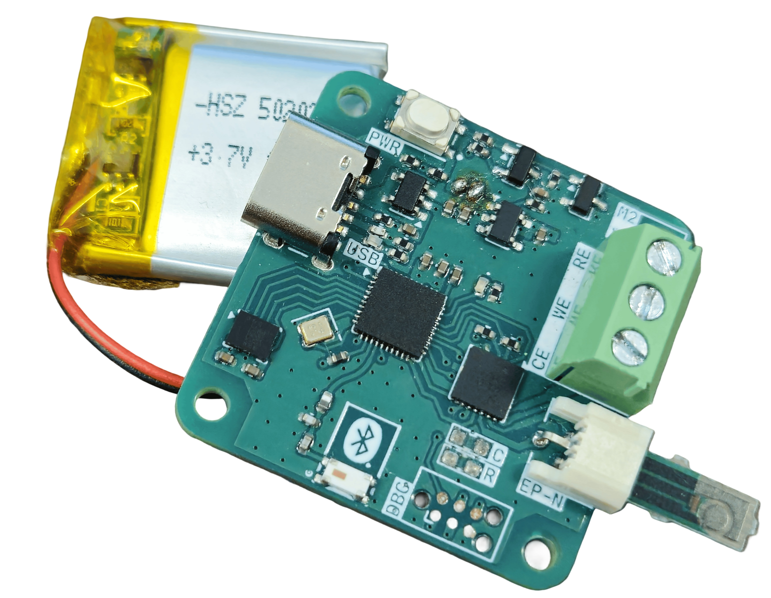

Figure 3: Custom Potentiostat Board Connected to a 150 mAh Lithium Battery.

Results

Board current draw is about 0.70 mA in sleep mode and approximately 9.38 mA in active mode. Duty-cycled sleep extends battery life from **16 hours to 8.6 days**, enabling multi-day field experiments.

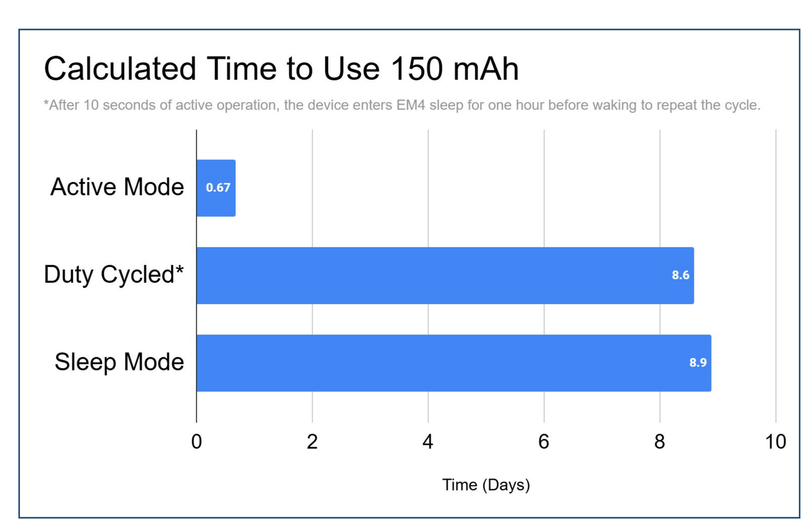

Figure 4: Calculated Time to Use 150 mAh of Charge

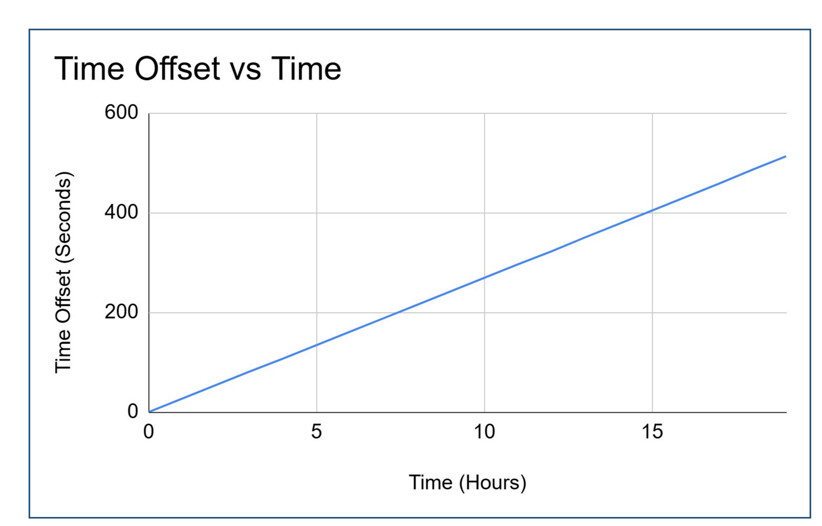

Figure 5: Time Offset vs Real Time for LFRCO RC Oscillator at Room Temperature

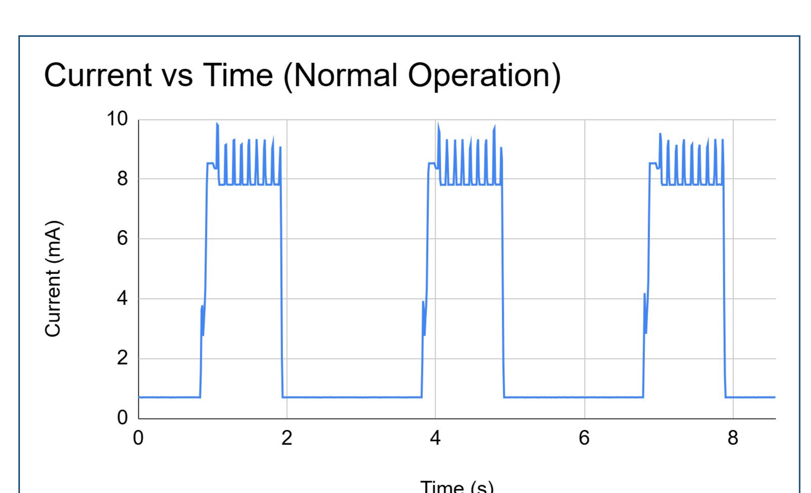

Figure 6: Current vs Time Chart of PCB in Normal Mode

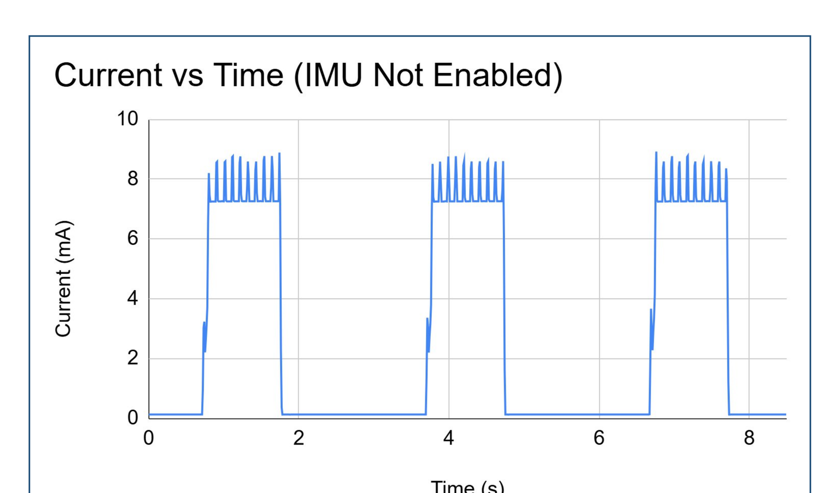

Figure 7: Current vs Time Chart of PCB with IMU not Enabled

Battery Management

- Two 100 kΩ resistors form a voltage divider to measure battery voltage at the MCU
- Continuous monitoring of battery voltage against a 3.35 V threshold
- Automatic shutdown at 3.35 V, which releases the power latch and powers off the circuit
- Battery-state awareness for user-timed charging in wearable applications

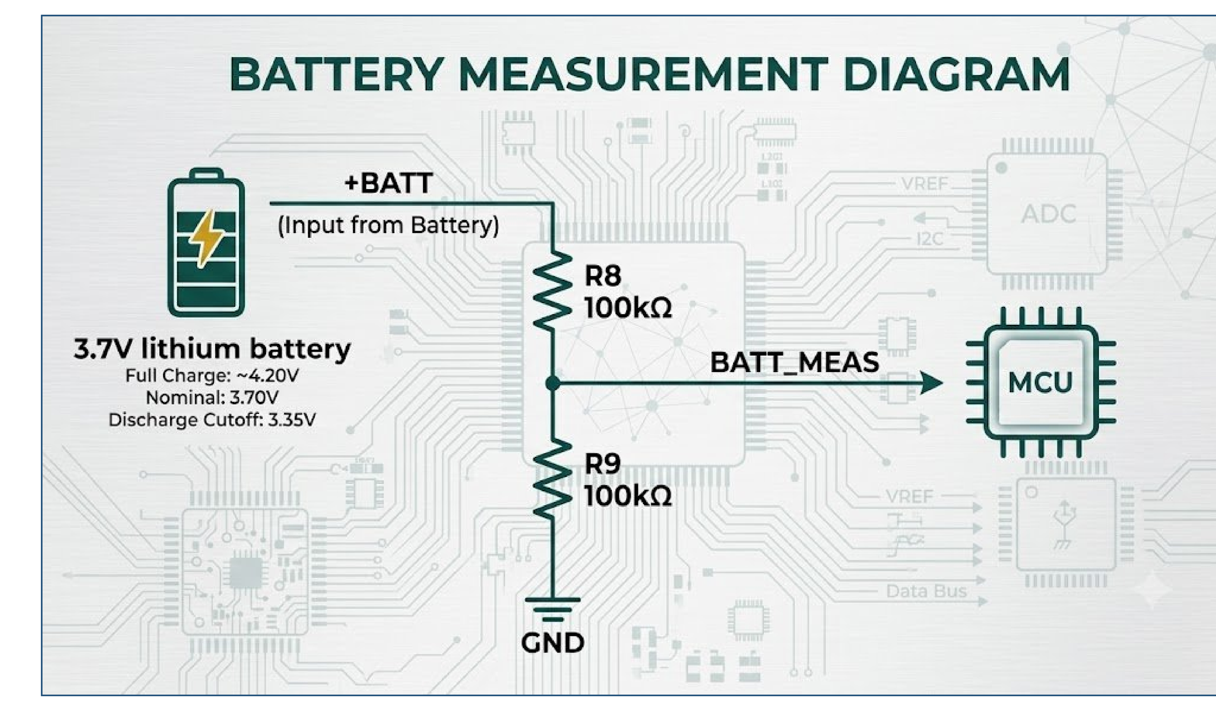

Figure 8: Battery Measurement Schematic

Power States

The EFR32BG24 has five distinct power modes from EM0 being the highest power, most active mode to EM4 being the lowest power, least capable mode.

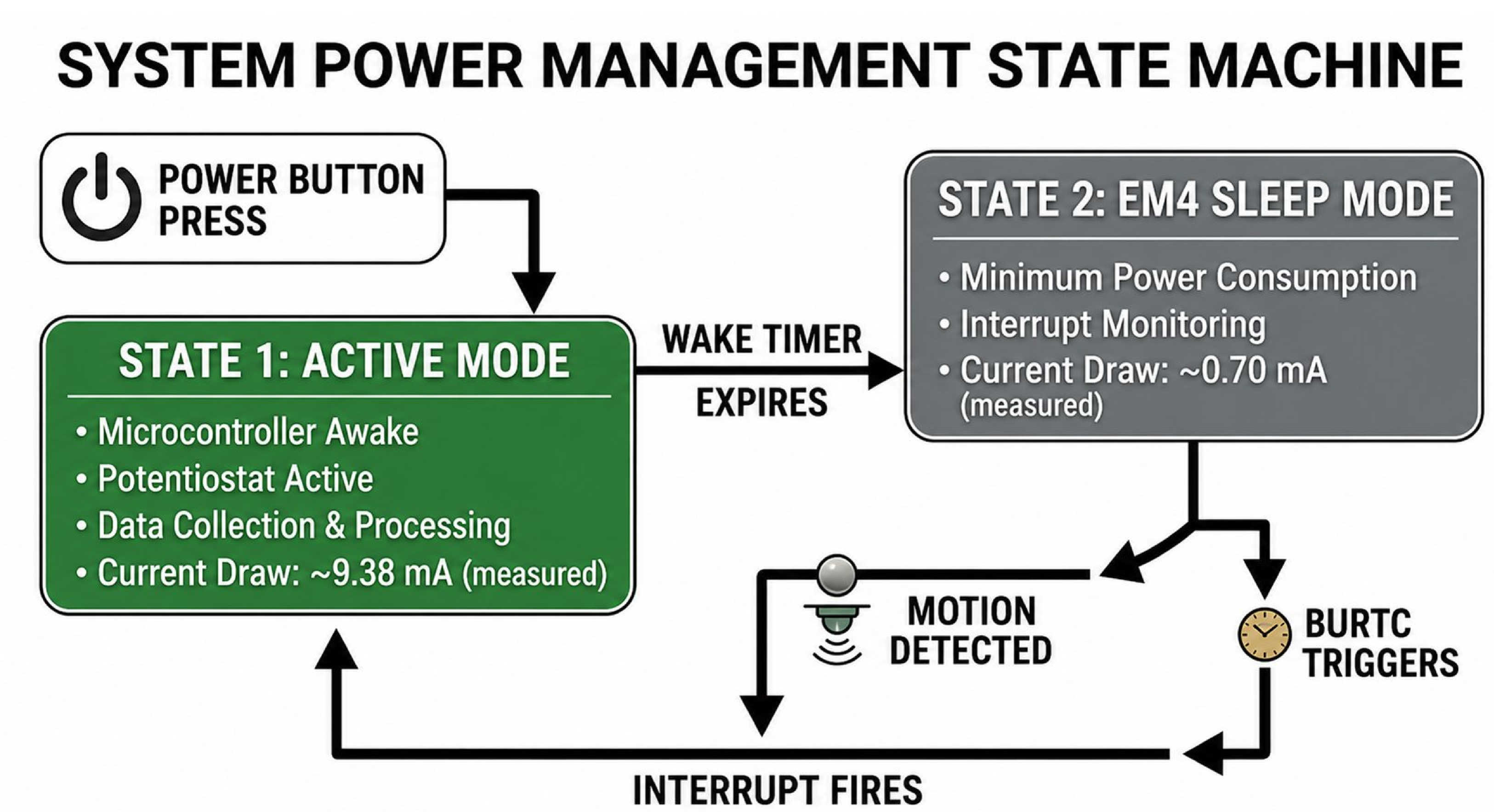

Figure 9: Power Management State Machine

Acknowledgments

This project was part of a Research Experience for Undergraduates program (REU) at Clarkson University in Potsdam, New York, funded by the National Science Foundation (NSF).
This project is a continuation of the open-source lmp91000 project on GitHub by Sigmond Kukla.