Project Emilia

Wireless Enablement of Green Power Technologies for Edge Devices

ELECOMP Capstone Design Project 2023-2024

Sponsoring Company:

Zebra Technologies Corporation
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Company Overview:

Zebra Technologies Corporation and its subsidiaries provide enterprise asset intelligence solutions in the automatic identification and data capture solutions industry worldwide. The company designs, manufactures, and sells printers, which produce labels, wristbands, tickets, receipts, and plastic cards; dye-sublimination thermal card printers, which produce images which are used for personal identification, access control, and financial transactions; RFID printers that encode data into passive RFID transponders; accessories and options for our printers, including vehicle mounts and battery chargers; stock and customized thermal labels, receipts, ribbons, plastic cards, and RFID tags for printers; and temperature-monitoring labels primarily used in vaccine distribution. It also provides various maintenance, technical support, repair, and managed and professional services; real-time location systems and services; and tags, sensors, exciters, middleware software, and application software; as well as physical inventory management solutions, and rugged tablets and enterprise-grade mobile computing products and accessories. In addition, the company offers barcode scanners, RFID readers, industrial machine vision cameras, and fixed industrial scanners, workforce management solutions, workflow execution and task management solutions, and prescriptive analytics solutions, as well as communications and collaboration solutions. It also provides cloud-based software subscriptions and robotics automation solutions. The company serves retail and e-commerce, manufacturing, transportation and logistics, healthcare, public sector, and other industries through direct sales and a network of channel partners. The company was founded in 1969 and is headquartered in Lincolnshire, Illinois.

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Project Motivation:

In pursuit of Zebra's ESG (Environmental and Social Governance) goals, this project is part of an effort whose aim is to significantly improve the power efficiency of Zebra's products through the development and deployment of a specific, advanced power architecture that leverages multiple convergent technologies.

Specifically, this project aims to conceptualize and build out wireless functionality within the overall architecture to enable a rich feature set of advanced capabilities and analytics for our customers.

The project has the potential to positively impact *millions* of devices worldwide, reducing carbon footprints and customer TCO (Total Cost of Ownership) in parallel.

Anticipated Best Outcome:

Fully realize working mockups of a dual WiFi/Bluetooth-based architecture at the test fixture and pre-EVT (Engineering Validation Testing) levels.

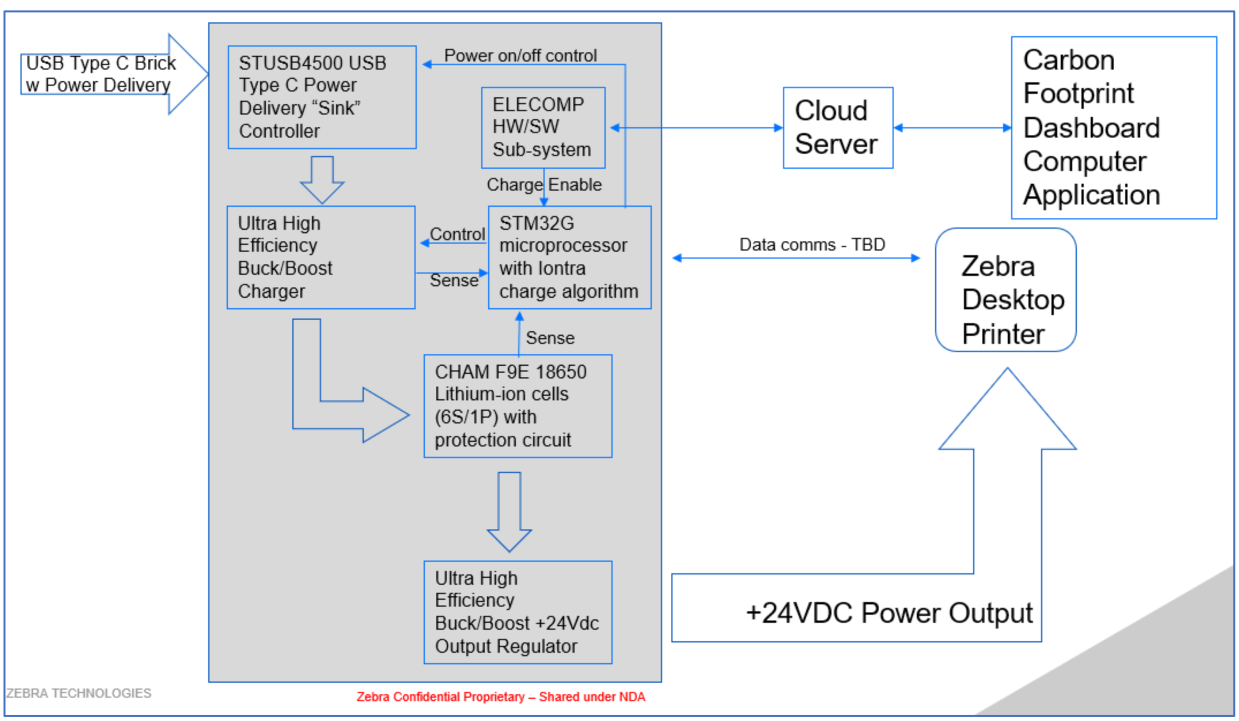
Project Details:

The **high-level system concept** for Project Emilia is to provide customers using Zebra devices a power source subsystem which significantly reduces their carbon footprint.

This footprint reduction will be achieved by preferentially charging the Emilia power source when there is a higher percentage of renewable energy available on the local utility grid. The Emilia power source will convert this stored energy to a +24V DC output voltage and supply it to the Zebra device/s while continuously tracking parameters such as (a) cumulative charge (b), proportion of energy derived from renewable sources versus non-renewable sources, and (c). lifetime amount of energy consumed.

The **goal** of this proposed Capstone Project is to design a hardware/software subsystem to be integrated into the Emilia power source. This subsystem will determine the optimal time to charge the Emilia power source based on when renewable energy on the local utility grid is at a maximum. When the Emilia power source is charging, the subsystem will track and record the amount of energy charged into Emilia along with the ratio of renewable to nonrenewable energy. The subsystem will periodically upload this information to a cloud service provider such as AWS. Also included in this hardware/software subsystem is a separate computer application which will provide a customer dashboard that displays the total energy consumed, ratio of renewable to non-renewable energy, and estimated carbon footprint. The customer shall be able to pick a start date and an end date that they want for the data to be displayed.

Block Diagram:



Hardware/Electrical Tasks – Develop an electrical subsystem which:

1. Measures, in real-time, the voltage and current sourced at "DC-IN," which is the node where external power enters the Emilia power platform (A/D bit resolution TBD.)
2. Has a real time clock to provide date timestamp information to the subsystem.
3. Has a WiFi transceiver.
4. Has a Bluetooth transceiver.
5. Minimizes quiescent power drawn from "DC-IN" to maximize overall efficiency of Emilia. This will likely require modalities such as active mode, sleep mode, ship mode, etc.
6. Has a microprocessor that can boot off an image stored in nonvolatile memory.
7. Has a watchdog timer that can reset the subsystem microprocessor in case of latch-up.
8. Has a voltage regulator which steps down DC-IN voltage to the appropriate voltage/s required by the subsystem hardware components.
9. Allows a nearby Bluetooth-capable system to update the firmware of the subsystem's microprocessor stored in nonvolatile memory.

Firmware/Software/Computer Tasks – Develop a system which:

1. Calculates the amount of energy (watt-hours) consumed by the Emilia power platform and continuously sums that energy consumption, periodically recording the sum to nonvolatile memory (storage size TBD) along with date timestamps.
2. Uses WiFi to connect to the internet, download the renewable energy forecast from the local utility grid operator or another reliable entity, and predict the optimal time to charge in the next (settable) interval (ex.: 12 hours).
3. Uses Bluetooth to communicate with nearby Bluetooth-capable computer/s for accessing real-time voltage, current, power, renewable/non-renewable energy ratio, charge status, time since charging began (if applicable), timestamp of when the last charge was completed, WiFi connection status, charge enable status, and other information stored in nonvolatile memory.
4. Sends a charge-enable logic high signal to a STM32G microprocessor based on when the subsystem's software predicts it is an optimal time to charge.
5. While charging, monitors the real-time renewable/non-renewable energy ratio via WiFi connection to the local utility grid operator, averages that ratio, and stores it to nonvolatile memory at the same periodicity as the data recorded in hardware item #1.

6. Monitors the current level at DC-IN and determines when charging is complete, and, after charging is complete, sets the charge enable logic signal to low, uploading the data in nonvolatile memory to a cloud server via WiFi.

7. Consists also of a computer application which interfaces with the subsystem's microprocessor via Bluetooth, with the application displaying real time voltage, current, power, renewable/non-renewable energy ratio, charge status, time since charging began (if applicable), timestamp of when the last charge was completed, WiFi connection status, charge enable status, and other information stored in nonvolatile memory. The application will also support firmware upgrading of the subsystem's microprocessor.
8. Consists also of a web-based dashboard which accesses the data stored in the cloud and displays in graphical form the total energy consumed, ratio of renewable to non-renewable energy consumed, timestamp of when the last charge was completed, total number of charge events, and estimated carbon footprint. The customer shall be able to pick a start date and an end date that they want for the data to be displayed.

Composition of Team:

2-3 Electrical Engineers (ELE) & 3-4 Computer Engineers (CPE)

(Looking for an electrical engineer who will take on the computer engineering tasks)

Skills Required:

Electrical Engineering Skills Required:

- Low power microprocessor selection and configuration
- Precision voltage regulator design
- Precision current measurement design
- Low quiescent power design
- WiFi and Bluetooth wireless transceiver selection and configuration
- PCB layout, board power-up, and troubleshooting/debugging
- Nonvolatile memory selection and PCB data line routing

Computer Engineering Skills Required:

- Generate code that performs electrical measurements in real time
- Generate code to run on a low-power microprocessor architecture
- Generate code that allows a microprocessor to access and download information on the internet via WiFi connection
- Generate code that allows a microprocessor to communicate with an application running on a mobile computer (i.e. laptop) via Bluetooth connection
- Create an HTML web-based dashboard which graphically displays information downloaded from a cloud server and allows a user to select the historical timespan of data to be displayed
- Create a Microsoft PC-based application which communicates with a hardware device via Bluetooth and displays hardware device status

Anticipated Best Outcome's Impact on Company's Business, and Economic Impact

In support of the United Nations call for all countries to reach Net Zero by the year 2050, successful project execution would significantly reduce the carbon footprint of hundreds of thousands to millions of Zebra's products per year while reducing the electricity usage paid for by customers to power the products. Product differentiation from competitors would increase, and market share would be expected to increase as more and more prospective buyers are prioritizing TCO and emissions in their decision-making processes.

Broader Implications of the Best Outcome on the Company's Industry:

A "greening up" of the industries in which Zebra operates would be the best possible outcome in the authors' opinions, and this project could meaningfully catalyze green transformations within those industries. This Capstone project will provide Zebra and its customers tangible data for verifying carbon reduction and set a positive example of transparency to industry.