Project Emilia (Phase 2)

Wireless Enablement of Green Power Technologies for Edge Devices

ELECOMP Capstone Design Project 2024-2025

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 based in Lincolnshire, Illinois.

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THE UNIVERSITY OF RHODE ISLAND

THINK BIG WE DO

Project Motivation:

In pursuit of Zebra's ESG (Environmental and Social Governance) goals, this project is part of an effort to significantly improve the power efficiency of Zebra's products by developing and deploying a specific, advanced power architecture leveraging multiple convergent technologies.

Specifically, this project aims to build out wireless functionality within that 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 (1) when renewable energy on the local utility grid is at a maximum and (2) customer-specific use patterns and charging needs. 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 (Google). Also included in this hardware/software subsystem is a separate computer application which will provide a customer dashboard that displays data such as total energy consumed, ratio of renewable to non-renewable energy, and estimated carbon footprint.

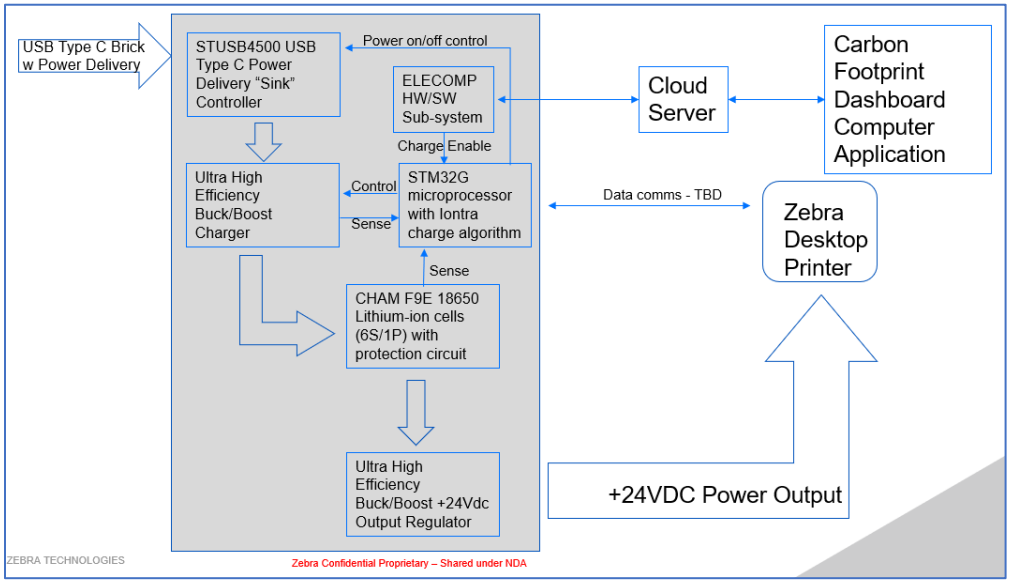
Tasks for this Emilia Phase 2 project:

1. Use Nordic DK to provide the following.
    a. Battery energy consumption logs over time, stored in local memory and uploaded to Google Cloud via WiFi for carbon footprint calculation.
    b. A charge wakeup signal to boot the microprocessor of our charge control software partner.
    c. A charge enable signal, based on grid emissions forecasts from the cloud via WattTime, user-selected CO2 emissions thresholds, charge time required, and total time available to charge.
    d. A power-on (run) signal to +24Vdc power switch based on a user scheduler feature.

2. Implement an app connecting a laptop to the Nordic DK via Bluetooth to do the following.
    a. Show status of wakeup signal, charge enable signal, and +24Vdc power on signal, allowing manual user toggling of each.
    b. Show real-time and cumulative energy consumption data (in watt-hours) over time.
    c. Provide a calendar scheduler feature for users to set 'off' and 'use' times.
    d. Allow users to set emissions thresholds (ex.: 'charge only when grid renewables ratio is >X%').

3. Implement a cloud-based dashboard showing CO2 emissions and other green impacts over time.

Block Diagram from Phase 1, shown here for reference:



Hardware/Electrical Tasks from Phase 1, shown here for reference:

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. a WiFi transceiver, a Bluetooth transceiver, a microprocessor that can boot off an image stored in nonvolatile memory, a watchdog timer that can reset the subsystem microprocessor in case of latch-up, and a voltage regulator which steps down DC-IN voltage to the appropriate voltage/s required by the subsystem hardware components.
4. 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.
5. Allows a nearby Bluetooth-capable system to update the firmware of the subsystem's microprocessor stored in nonvolatile memory.

Composition of Team:

1 Electrical Engineer & 3-4 Computer Engineers

Skills Required:

- Generate code that performs electrical measurements in real time, runs on a low-power microprocessor architecture, and allows a microprocessor to (a) access and download information on the internet via WiFi connection and (b) 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.

Electrical Engineering Skills Required from Phase 1, shown here for reference:

- Low power microprocessor configuration; precision voltage regulator, precision current measurement, and low quiescent power design; WiFi and Bluetooth wireless transceiver selection and configuration; PCB layout, board power-up, and debugging; nonvolatile memory selection and PCB data line routing

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.