Universal Printhead Fixture

ELECOMP Capstone Design Project 2025-2026

Sponsoring Company:

Zebra Technologies Corporation
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http://www.zebra.com

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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Project Motivation:

This project is part of an effort to significantly improve the development cycle related to qualifying new thermal printheads used in Zebra's products by developing electronics and related software necessary to drive any available thermal printhead regardless of voltage requirements or number of data channels.

Specifically, this project aims to leverage existing mechanical hardware, develop new electronics hardware and related firmware/software required to allow basic printhead functionality necessary for early printhead development and qualification.

Anticipated Best Outcome:

Fully realize working electronics and firmware/software necessary to control mechanical fixture and drive any available or anticipated future thermal printhead.

Project Details:

The **high-level system concept** for Project Universal Print Fixture is to provide a test fixture for Zebra development engineering for use in the development and qualification of new thermal printheads used in Zebra's printer products.

This fixture will leverage existing mechanical test fixture architecture, will develop new electronics necessary for control of the existing mechanical architecture, will develop new electronics to control any available thermal printhead, and will develop new software necessary to control the electronics.

The **goal** of this proposed Capstone Project is to design a hardware/software fixture capable of use by engineering lab technicians for the development and qualification of thermal printheads.

Tasks for this Universal Printhead Fixture project:

1. Develop electronics and firmware/software necessary to drive a stepper motor
    a. A motor control circuit capable of driving stepper motors of a wide range of sizes, step angles, and step modes.
    b. A software interface to control the motor speed by inputting the desired platen roller speed in inches per second.

c. A software interface to set the gear reduction value between the motor and platen roller.
d. A software interface to apply a speed correction factor to the desired platen speed from 1.a.

2. Develop electronics and firmware/software necessary to control a sensor
    a. Control a generic transmissive or reflective sensor to detect the beginning of a label.
    b. A calibration routine to calibrate the sensor.
    c. Provide the ability to control stepper motor motion using the sensor (advance motor).

3. Develop electronics and firmware/software necessary to control a thermal printhead
    a. Provide a power supply to allow for any variants of thermal printhead power requirements.
    b. Provide electronics/firmware/software capable of sending data to the thermal printhead to support any anticipated print speed.
    c. Provide image correction variables to be used in development to compensate for thermal latency such that a uniform density image may be printed.

4. Provide a software interface capable of sending a bitmap image to the thermal printhead.

Composition of Team:

2 Electrical Engineers & 1 Computer Engineer

Skills Required:

1. **Stepper Motor Control**:
    - **Motor Control Circuit Design**: Ability to design motor driver circuits capable of handling a variety of stepper motors. Familiarity with H-bridge drivers, PWM control, and micro stepping techniques.
    - **Firmware Development**: Skills in programming microcontrollers to implement motor control algorithms, typically in C or C++.

- **Software Development**: Experience in developing user interfaces, likely requiring skills in high-level programming languages (e.g., Python, C#, or Java) to create software that can set parameters like speed, gear ratio, and correction factors.

2. **Sensor Control and Calibration**:
   - **Sensor Interface Design**: Knowledge of interfacing with optical sensors, both transmissive and reflective types, and integrating them with microcontrollers.
   - **Calibration Algorithm Development**: Ability to develop and implement calibration routines to ensure accurate sensor readings.
   - **Feedback Control Systems**: Skills in designing control systems where sensor inputs are used to adjust motor operation dynamically.
3. **Thermal Printhead Control**:
   - **Power Electronics Design**: Expertise in designing adaptable power supply circuits that meet various thermal printhead power requirements.
   - **Data Transmission to Printhead**: Knowledge of communication protocols suitable for sending data to printheads, potentially involving parallel data buses or serial communication methods.
   - **Thermal Management and Image Correction**: Understanding of thermal dynamics in printheads and techniques for compensating for thermal latency to achieve consistent print quality.
4. **Software Interface Development**:
   - **UI/UX Design**: Skills in designing user-friendly software interfaces for controlling the fixture and sending bitmap images to the printhead.
   - **Image Processing**: Basic knowledge of image processing to convert bitmap data into a format suitable for the printhead.
   - **Software Engineering**: Experience in creating robust, maintainable software systems, possibly with cross-platform capabilities if required.
5. **General Skills**:
   - **Embedded Systems**: Strong background in embedded systems design, including both hardware and software integration.
   - **Prototyping and Testing**: Skills in building and testing prototypes, using tools such as oscilloscopes, logic analyzers, and multimeters.
   - **Project Management**: Ability to plan and manage project timelines, ensuring timely delivery of each component.
   - **Collaboration and Communication**: Effective communication skills for working with multidisciplinary teams and stakeholders, ensuring that all aspects of the project are aligned.

This project requires a combination of advanced technical skills, creativity in problem-solving, and the ability to integrate various system components into a cohesive whole.

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

The anticipated best outcome for the Project Universal Print Fixture would be the successful development and deployment of a fully functional and versatile test fixture that meets the specified goals and requirements. Here is a more detailed breakdown of what constitutes the best outcome:

1. **Functional Prototype**:
    - **Reliable Operation**: The fixture operates reliably under various conditions, accurately controlling stepper motors, sensors, and thermal printheads.
    - **Versatility**: Capable of interfacing with a wide range of stepper motors and thermal printheads, accommodating different sizes, power requirements, and performance specifications.
2. **User-Friendly Software**:
    - **Intuitive Interface**: The software interface is intuitive and easy to use by engineering lab technicians, with clear instructions and controls for setting parameters like speed, gear ratios, and correction factors.
    - **Advanced Features**: Provides advanced features such as image correction and calibration routines, enhancing the development and qualification processes of printheads.
3. **Robust Electronics Design**:
    - **Efficient Power Management**: The electronics are designed for efficient power management, ensuring all components receive the necessary power without overheating or overloading.
    - **Modular Architecture**: A modular design that allows for easy upgrades and maintenance, facilitating future modifications or expansions.
4. **Enhanced Development Capabilities**:
    - **Improved Testing and Qualification**: The fixture significantly improves the testing and qualification processes for new thermal printheads, leading to faster development cycles and higher quality products.

5. **Successful Project Completion**:
    - **On-Time Delivery**: The project is completed within the designated timeline and budget, meeting all predefined objectives and milestones.
    - **Positive Feedback**: Receives positive feedback from users and stakeholders, validating its effectiveness and usability in real-world applications.
6. **Documentation**:
    - **Comprehensive Documentation**: All aspects of the fixture, including hardware schematics, software code, and user manuals, are well-documented for future reference and training.

Achieving these outcomes would mean the project not only meets its immediate goals but also provides long-term value to Zebra's development engineering teams, facilitating innovation and quality assurance in their printer products.

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

Broader Implications

- **Faster Development of New Printheads:** By enabling rapid qualification and development of new thermal printheads, Zebra (and, by extension, its competitors and partners who adopt similar approaches) can dramatically shorten the time it takes to bring new products to market.
- **Reduced R&D Costs:** A versatile, modular test fixture reduces the need for custom rigs for every new printhead, saving engineering resources and reducing capital expenditure.
- **Efficient Use of Talent:** Engineers can focus on higher-value tasks (innovation, optimization) rather than repetitive, manual test setups.
- **Enhanced Product Testing:** The ability to run more comprehensive and automated tests results in higher-quality, more reliable printheads and printers. This leads to better end-user experiences, fewer recalls, and reduced warranty costs.
- **Facilitating Advanced Features:** With better test capabilities, new printhead technologies (higher speeds, higher resolution, novel materials) can be validated more thoroughly before market release.