Torque Measurement

Printer Realtime Torque Measurement

ELECOMP Capstone Design Project 2021-2022

This project is the continuation of last year's project:
https://web.uri.edu/elecomp-capstone/project-details-by-team/zebra

Sponsoring Company:

Zebra Technologies

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Company Overview:

Zebra empowers those on the front line in retail, healthcare, transportation and logistics, manufacturing, and other industries to achieve a performance edge - an edge that translates to delighted customers, good patient outcomes and superior business results.

As the pioneer at the edge of the enterprise, our products, software, services, analytics, and solutions are used to intelligently connect your people, assets, and data. With decades of industry experience, we design with front-line users and workplaces in mind, giving you the best-action guidance needed to optimize in-motion operations and make business-critical decisions.

With over 10,000 partners across 100 countries, we are committed to delivering industry-tailored solutions that help our customers capture their edge.

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Project Motivation:

Many Zebra mobile printer customers use a wide range of medias that come from a variety of different sources, and some are not Zebra manufactured medias. Typically, adhesives on these medias are not well controlled or documented. We often run into torque issues with some of these medias causing our printers to stall (unable to feed media). We currently do not have a way to measure the system torque while printing a label, we can only do it while feeding blank media. While printing on certain medias the front sides of the labels tend to stick to the printhead. We would like to be able to print a label on a given printer and measure the torque required to move each print line. This would provide peak values and incorporate printhead sticking as well as the adhesive variation. The mobile division in Lincolns designs direct thermal printers, the printhead heats the media to turn it black, the heat and chemical reaction is what causes the sticking issues.

Anticipated Best Outcome:

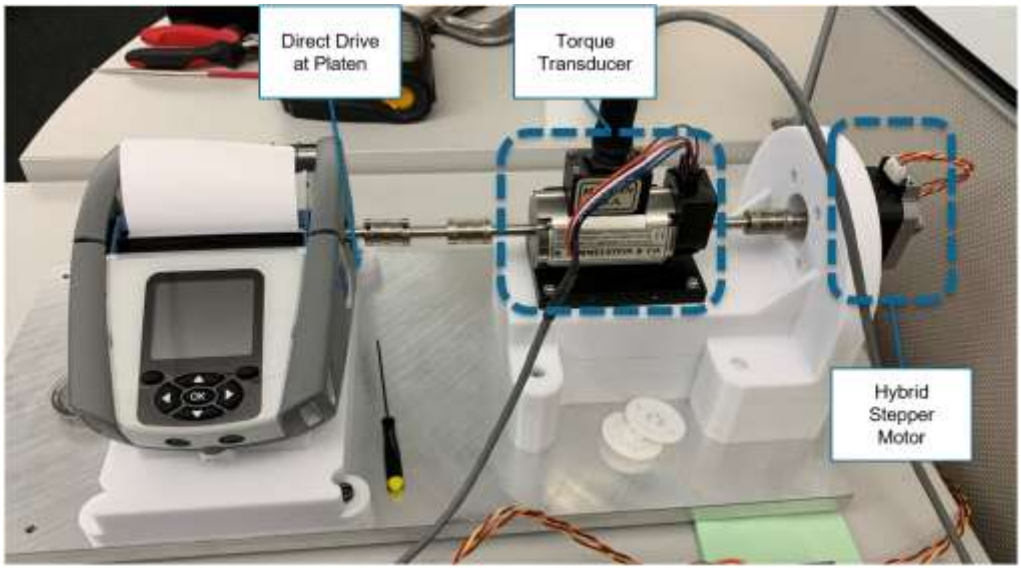
Interface the torque transducer, printer, and external stepper motor driver to one device. The device will sync the torque output with each step signal sent from the printer. A known label would be sent to the printer to initiate the test, An Image of the label will be used as a background of the output for the torque graph, providing a visual aid for torque output vs label content. A GUI would be developed to control the test and provide graphical output of the data.

Summary:

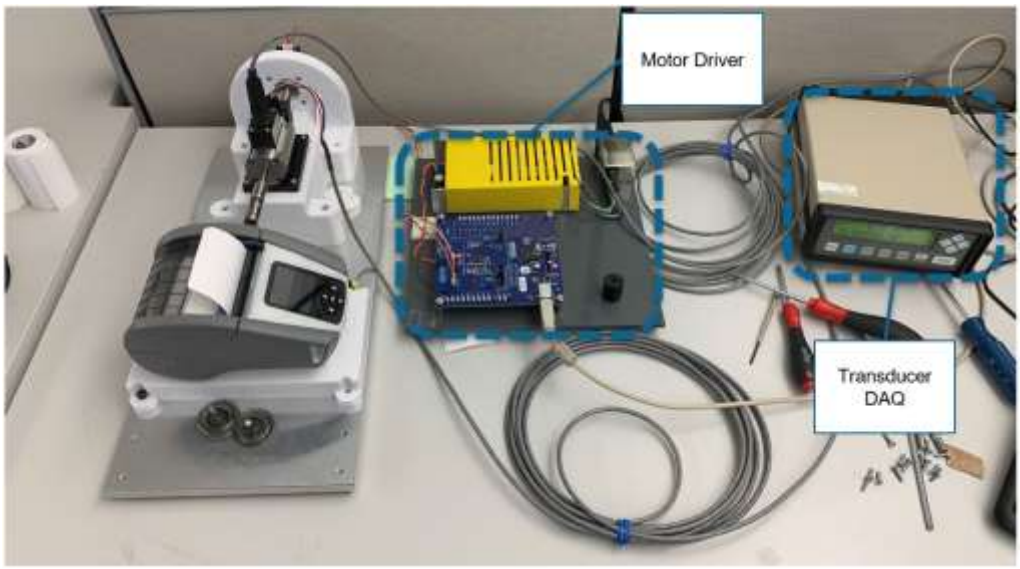
- All peripherals connected to and controlled by one device
- GUI to perform testing
- Processing of data and outputting graph / summary report for archive
- Test should be able to be completed by test technician

Project Details:

The current test bed we are using can be seen in the image below. It has a large external stepper motor driving our printer platen which feeds the paper. The torque transducer is coupled in between the printer and the motor.

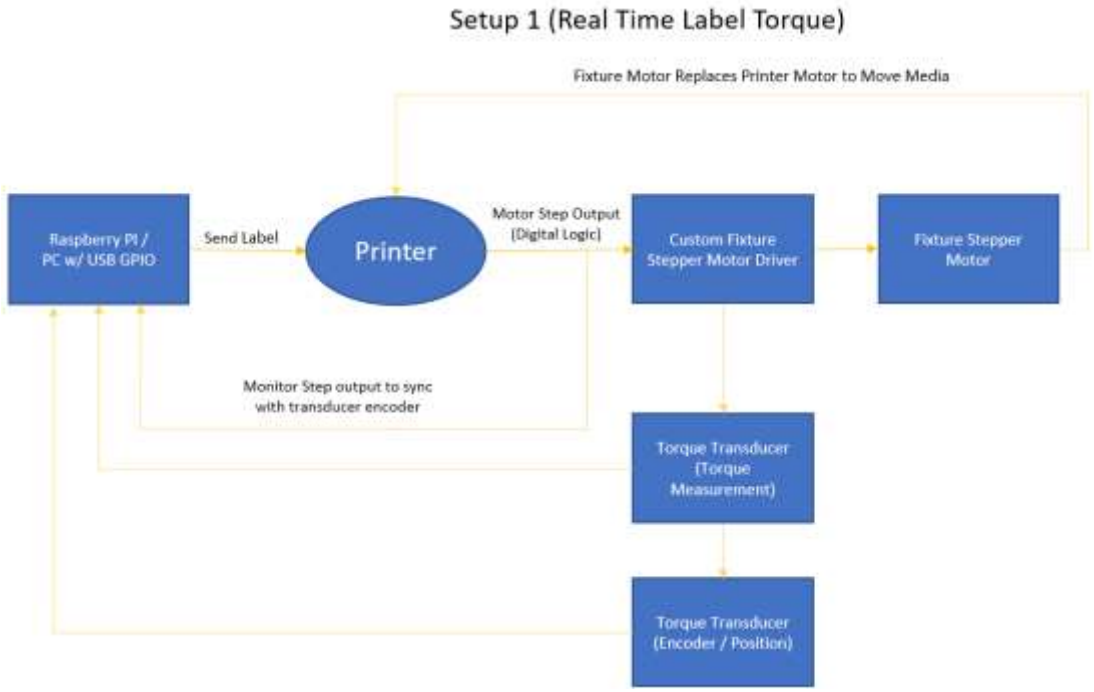


There is a Texas Instruments motor driver which is controlled by software on the attached PC. There is also a Transducer data acquisition unit for the transducer which runs on the same PC with different software.

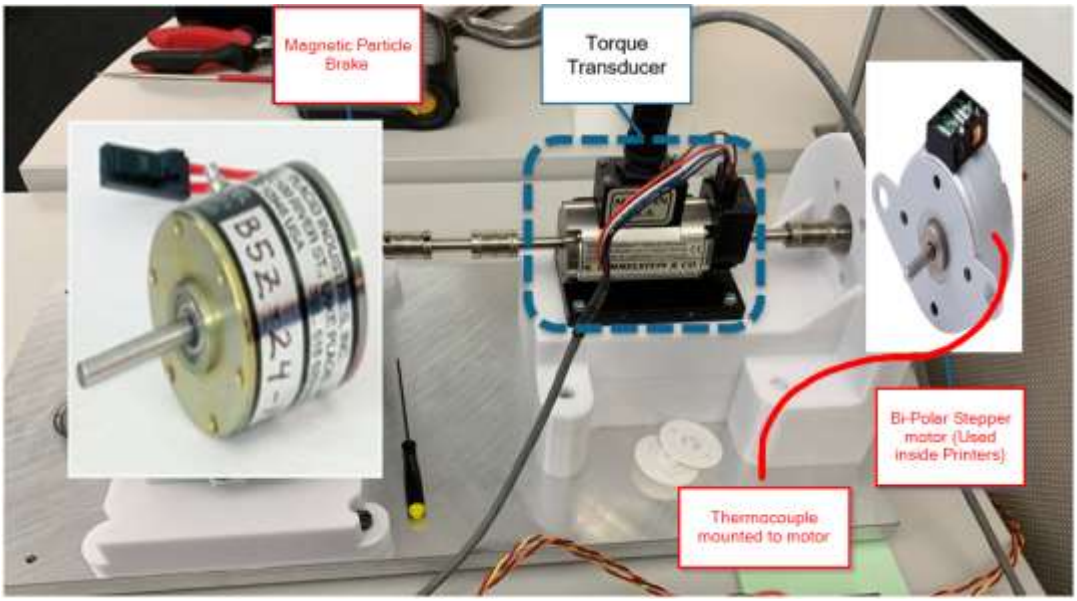


Currently we setup the motor driver software to run at our target speeds, and we begin feeding blank paper, and start the Torque transducer. With the current setup we get good information, but we do not capture the effects of the printhead sticking to the paper.

The new project will be constructed with a similar setup but will have a new torque transducer. All peripheral equipment will be hooked up to one device, either a PC or a small single board computer (Raspberry Pi). We will need GPIO connections to control the stepper motor driver and connect to the torque transducer data acquisition unit and function with their provided API interface. There should be a GUI setup to integrate the different peripherals and be controlled in one package, for ease of running the tests. A label will be sent down from the printer, and the step signal will be wired out of the printer and into the external motor driver, with that we can drive the external motor to capture the torque while we print in real time.

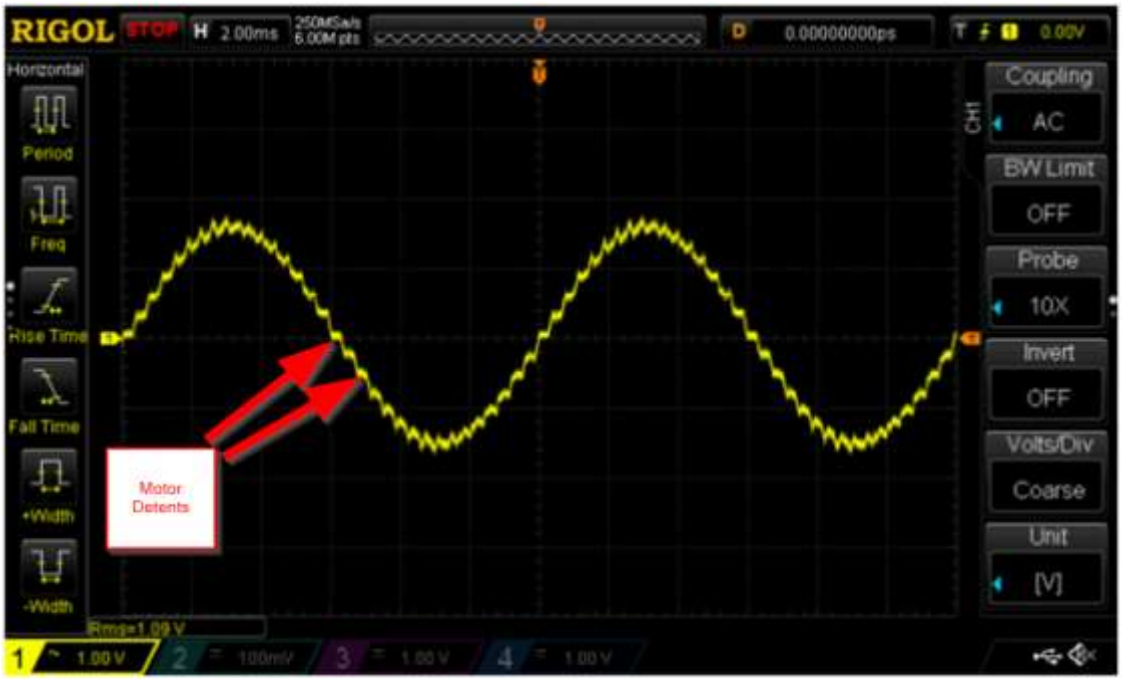


There will also be a second configuration of the fixture setup, that will be used to test stepper motor torque output. This setup will mount a small bipolar stepper motor that is used inside of our printers, and a magnetic particle brake on each side of the transducer. The stepper motor will be driven, and a load will be applied with the particle brake.



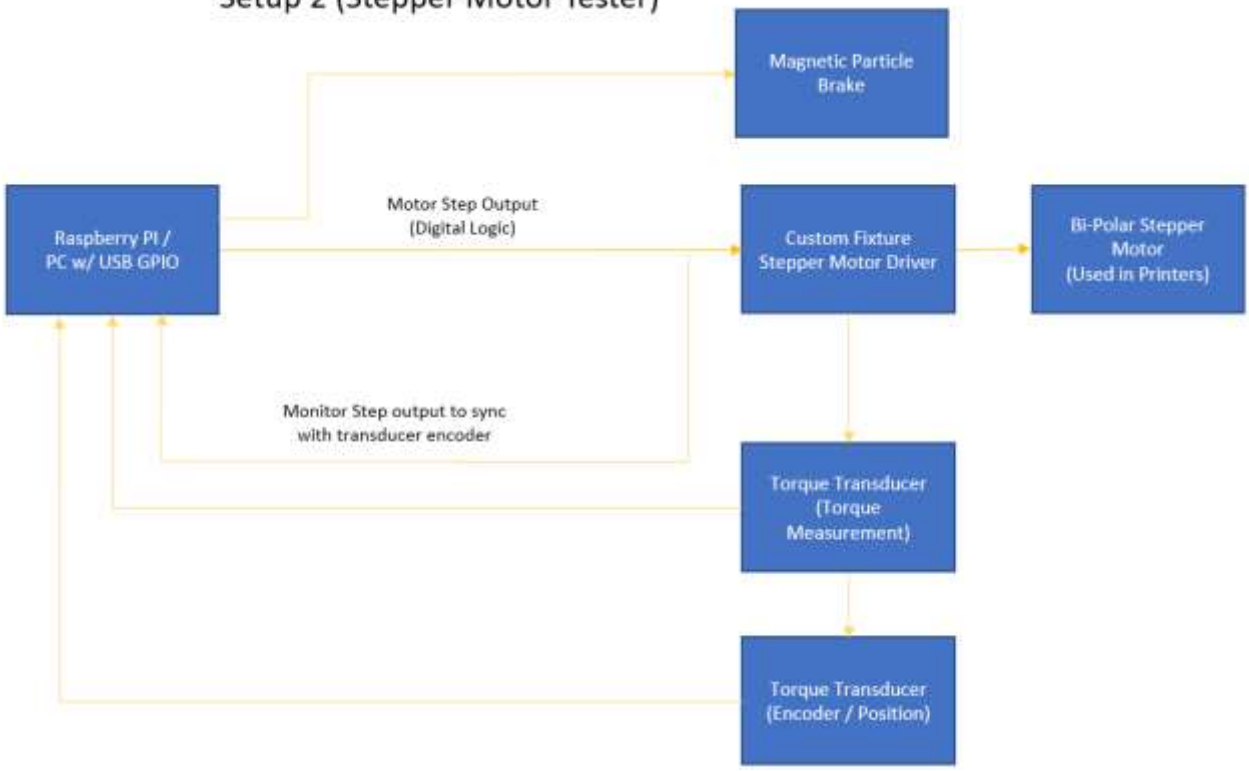
A custom board will be designed for the stepper motor drivers. This will include an adjustable motor voltage boost, as well adjustable current control. These two parameters are the main drivers of motor torque and speed. There should be software controls to adjust both voltage and current and set a group of parameters to run consecutively. An example would be to run at a boost voltage of 10V, 12V and 14V with motor currents of 650ma and 750ma at all three voltages and report the results. The board should also include support for the Allegro A4988, TI DRV8846, and a third spot for future drivers to be added. This type Click Here of stepper motor driver is regularly used on 3D printers, and can be found easily on Digi key. This interface may be good to use as the boards are readily available online already but can be determined later. There should be a board-to-board interface to easily swap drivers in and out as they constantly change in the future. There should be software toggles in the GUI to choose which motor driver to use. The load, and the rate of which the load is applied by the particle brake should also be controlled in the GUI. We have an existing (very old) setup in our lab now that runs this type of test, that can be referenced as a starting point for the particle brake loads and rates. There will also be a thermocouple mounted to the stepper motor, this will allow us to check the temperature of the motor before running the test and to report it. When running multiple tests and higher currents and voltages the motors get hot and this needs to be monitored to avoid damaging the fixture.

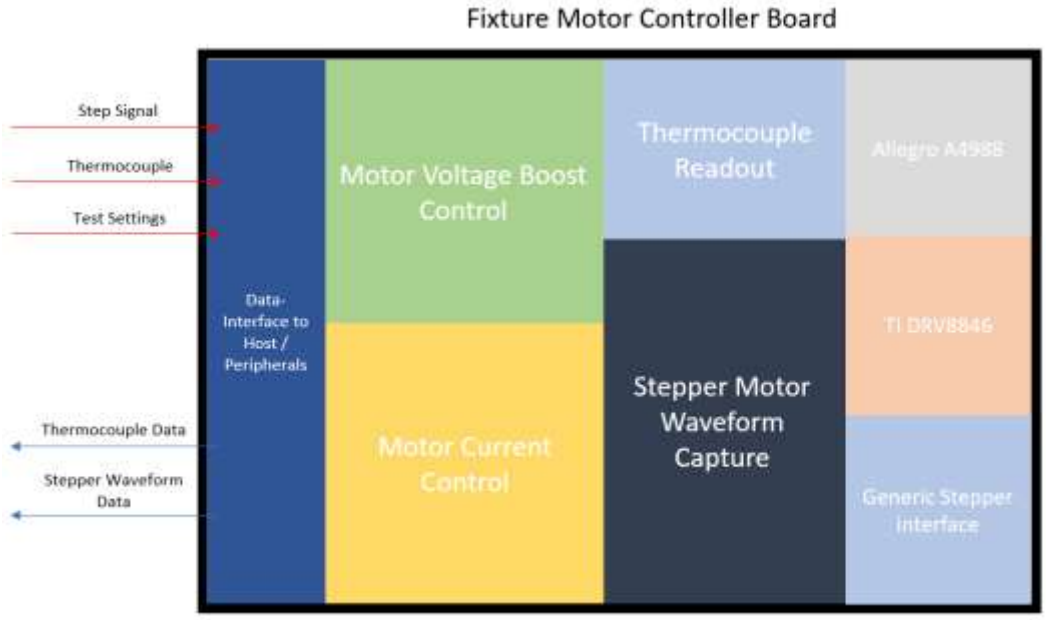
The stepper motor waveform should also be captured, analyzed, and output to the report for documentation purposes. An example of what a stepper motor waveform will look like when it is running is below:



For each step there is a small flat portion of the form when the stepper motor stops in a specific detent (we print during this time). We want to analyze this waveform and make sure we are in each detent for a certain amount of time (too be determined later). As you begin to try and step the motor to fast the wave form begins to look like a sawtooth pattern with a lower amplitude and you begin to miss steps (this would affect Print quality). If we begin to move too fast, we would cancel the motor test and report back that the waveform is not acceptable.

Setup 2 (Stepper Motor Tester)





Hardware/Electrical Tasks:

- Understand how each electrical interface will work between all item in the system
- Design custom motor controller board
    - Test will define, Voltage Boost, Motor Current and which driver is chosen to run the test
    - Analyze stepper motor waveform for missed steps
    - Choose thermocouple and magnetic particle brake
- Create blank generic interface to accept daughter board to test future stepper motor drivers
- Define best data interface between Raspberry PI and motor controller board
- Spec out GPIO interface board / Raspberry Pi to connect peripherals
    - Ensure we have bandwidth to capture data

Firmware/Software/Computer Tasks:

- Create graphical user interface for test
- Post processing torque data, and overlaying on top of label image
- Convert bipolar step rate to hybrid motor step rate
- Software toggles for all motor parameters on motor controller board

Key Accomplishments from Last Year:

- Microprocessor Eval Board selected that met needs of the project
- Motor voltage boost circuit was designed and integrated into setup
- Interface with the printer was designed and proven to be working
    - Step conversion table was also completed
- Demo was created at the end of the semester showing a label could be sent to the printer and printed while hooked up to the fixture.

Composition of Team:

1-2 Electrical Engineers & 1-2 Computer Engineers

Skills Required:

Electrical Engineering Skills Required:

- Knowledge of use of lab equipment, Oscilloscope, and logic analyzer
- Knowledge of stepper motors and driver IC's
- Working knowledge of USB / Serial communication protocols

Computer Engineering Skills Required:

- Experience creating graphical user interfaces
- Python Experience
- Knowledge of data analysis (Fourier Transforms)

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

Updating the torque measurement fixture will allow Zebra engineers to collect better system data faster and more reliably. It would take far less time to setup the test and provide more accurate data that will reduce issues coming up later in our development cycle. This will also allow us to troubleshoot customer issues much quicker than we currently can, and determine whether or not we will ever be able to print under the customer conditions, and determine if we can make customer specific adjustments to accommodate unknown printing conditions.

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

Zebra is the market leader in mobile printing technology. Continually advancing our data collection and test procedures helps us improve our quality. It is very difficult to predict all the printing conditions we will encounter due to third party uncontrolled and undocumented media. This will allow us to also be agile and respond to customer issues quickly.