Electronic Door Closer Adjustment System(EDCAS)

PURDUE POLYTECHNIC

Team # 6

Team Members: Jacob Rice, Danny Gemignani, Jadon Moore, Justin Chan

Sponsored by Allegion

Customer Background

Allegion PLC, a global leader in security and access solutions, manufactures a range of door control products under its LCN brand, including the 4040XP — one of the industry's most durable and widely used heavy-duty door closers. Known for its reliability in high-traffic and demanding environments, the 4040XP must perform consistently across millions of open/close cycles.

To enhance quality assurance and performance monitoring, our team is developing a sensor system designed specifically to test and evaluate the 4040XP door closer. This sensor will help Allegion gather real-time data on door closer operation, such as:

- Force and torque measurements during opening and closing
- Door angle
- Speed and latching verification

By integrating this sensor into Allegion's testing process, the goal is to provide more accurate, automated, and early detection of potential product issues. This innovation will support Allegion's commitment to delivering the highest quality door control solutions to its customers worldwide.

Problem Statement / Scope of Work

Our client's product, the 4040XP Series, is a standard issue door closer that is prone to error. Our client wants to improve their standardized method of adjusting the door closing speeds when climate and wear and tear cause variation. This variation results in inconsistent speeds between the different settings as the technicians tasked with manually calibrating the door can make mistakes. Our team will assemble a sensor package capable of measuring the force to open the door, the position of the door relative to either open (90 degrees) or closed position (0 degrees), and the timing of those positions. The sensor box will be detachable, taking less than one minute to attach and then detach. It will have options to attach to all doors of different surfaces and temperatures.

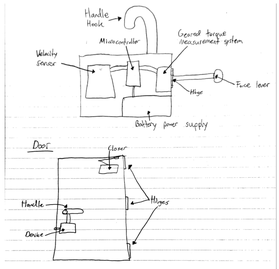
Using the information from the sensors, we will give technicians the necessary adjustments needed in the form of clear instructions. These instructions will be regarding adjustments of the four output screws on the outside of the product: Spring, Main, Latch, and Back. Executing our adjustments will keep the door in spec with ADA specifications and save technicians time and effort in the process. Technicians will use our sensor box to get these instructions by following clear, written instructions to use the device.

By the end of the first semester, our group will finalize a sensor box prototype design, have the inputs, outputs, and functions planned for the algorithm, and order the relevant sensors and other things needed for this project. By February, our group will be working with the sensors and algorithms together to start to see what algorithm changes need to be made and be comfortable with receiving the data. By the end of the project, we will accomplish all our deliverables seen below.

Requirements Matrix

Req #	Requirement	Description	Test
1	Detachable from the door	Attach and detach from the door in under 1 minute	<60 seconds
2	Battery powered	Our sensor box must be a wireless and battery powered	Battery powered? Wireless?
3	Sensors can measure the time for the door to get to various zones	5 data points per second measuring position and 5 data points per second measuring time	>= 5 data points/sec for position and time
4	Sensors can record data for total testing period	We need data to recorded for at least 40 seconds	>40 seconds recording?
5	Sufficient battery life	Power for at least 1hr	>1hr?
6	Force sensor can measurements accurately	Measure up to 20lbs	>20lbs +/- 1lb

Experimentation / Concept Exploration

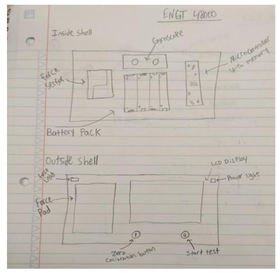


Down Selection Process — PURDUE POLYTECHNIC

Component Description	Enhanced Door Closer Adjustment System
Project Title	Enhanced Door Closer Adjustment System
Team Number	6
Team Members	Danny, Jacob, Jadon, Justin
Date	October 9, 2024

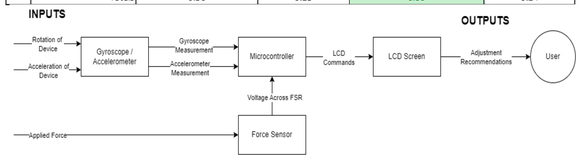
Weighted Score

	Criteria	Raspberry Pi 4B	Arduino Mega 2560	Raspberry Pi Pico 2	Arduino Micro
1	Price ($)	0.05	0.00	0.15	0.08
2	GPIO Pins (#)	0.09	0.15	0.03	0.00
3	RAM (KB)	0.10	0.00	0.00	0.00
4	Coding Ease	0.00	0.30	0.00	0.30
5	Power Consumption	0.00	0.23	0.15	0.30
	Totals	0.23	0.68	0.33	0.68

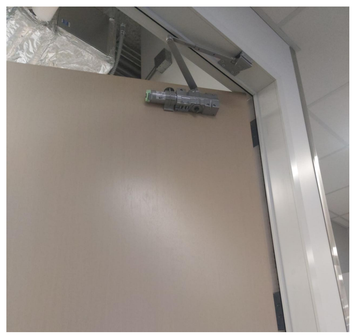


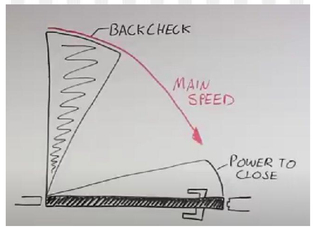
Weighted Score

	Criteria	PLA Plastic	ABS Plastic	Polycarbonate	PETG Plastic
1	Service Temp. (F)	0.21	0.04	0.30	0.00
2	Cost per oz. ($)	0.07	0.08	0.00	0.10
3	Tensile Strength (kpsi)	0.06	0.00	0.25	0.02
4	Friction coefficient	0.03	0.00	0.05	0.01
5	Hardness (Rockwell R)	0.00	0.02	0.30	0.12
	Totals	0.36	0.15	0.90	0.24



Final Design





Failure Modes and Effect Analysis

Focus Element									
Focus Element Function	Failure Effects (FE)	Severity	Failure Mode (FM)	Prevention Control	Occurrence	Detection Control	Detection	DFMEA AP	Action
Takes input from sensors and uses algorithm to perform calculations	Data not recorded	8	Calculations can not be completed	Robust design of the sensor package box	3	Voltage test	6	M	Standard drop test
Obtain positional data	Data not recorded	8	No/improper positional data taken	Clear written user instructions	6	Range of degrees test	8	H	Verification Function in Code
Obtain force data	Data not recorded	8	No/improper force data taken	Clear visual instructions	5	Inspection	6	M	Verification Function in Code
Provide power	Data not recorded	8	Does not obtain power	Clear visual instructions	4	Human Inspection	6	M	N/A
Display Information	No recommendations are given	8	No visual communication with user	Robust design of the sensor package box	4	Inspection	6	M	Standard Drop Test

Testing

Req #	Test Name	Test Description	Test Results
1	LCD Display & General Program Flow	The device was turned on, and after waiting for the LCD and values to reset, a jumper wire was used to simulate a button press. Proper LCD readouts were confirmed after each jumper connection. .	LCD functions within expected requirements.
2	Force Measurement Ranges	In this test, the force sensor was evaluated using various applied pressures. The device was turned on, a serial monitor was enabled, and a small amount of pressure was applied to confirm force values less than 5 pounds.	Plot of weight (pounds) vs. conductance was found successful with power-order equation for the relationship
3	Arduino Setup	Using previously working programs, utilize the Arduino Micro in various scenarios to ensure full functionality of the device.	Arduino MICRO works as expected. All programs run, and pin functions remain.
4	ACC/Gyro Calibration	Run an ACC/Gyro program on the module to ensure proper readouts of default angle and speed values. Compare angle values with protractor.	Acc/Gyro functions as expected. Angle measurements are accurate.
5	Regular Operation	The device should be placed onto a door and operated to its full extent, output several messages to the user that the door closer is NOT within required specifications. This test should be repeated until the results output are	Device output the correct "door is bad" strings to the LCD display.