GNG 1103 Project Deliverable K: User Manual

Submitted To:

Professor David Knox

Submitted By:

EfficenC4- Rumony Chhom, Haolin Du, Camille Espinola, Kyla Hamilton, Ty Pedersen

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Abstract

The following report shows the different stages of the design for a tracking and uploading system for the clients. Each section of this user manual describes what is done at each design stage and how the product is developed over time. Through needs assessment and creation of a design criteria, a plan of action is developed to best fit the client's needs and time constraints. This manual will also describe how a final chosen design is a system that is broken down into two parts: the tracking system and the calculation upload and display. Nearing the end of this report, the prototypes will be described, the implemented codes as well as the calculations that are necessary to improve and/or replicate project design.

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Introduction

Initially, the client expressed an interest in developing a system that will track the amount of cans going through their canning line at any moment in time, and to determine whether those calculated rates are “optimal” for bottleneck. A bottleneck is the point in the production line where the cans are going through at the slowest rate. In Mill Street’s canning lines, the bottlenecks are the Can Filler and Can Seamer, which can then be cross-referenced with the V-curve. A V-curve is a mathematical theory that refers to each step of a production line either decreasing or increasing at a rate of 10%. Prior to the Can Filler, the machine is required to be decreasing at least 10% per step and after the filler, increasing at the same rate of 10%. It is noted that careful collection of data is deemed necessary as any equipment that is installed onto the production line cannot interfere with pre-existing machines and parts.

Deliverable B: Need Identification & Problem Statement

This section of the project outlines the team's interpreted needs of the client's identified problems from the first meeting within their efficiency line. The client, Mill St. Brewery, requests the creation of a system to monitor the productivity and efficiency of its production line. The usage of bottling machines as a benchmark for maximum productivity and efficiency is proposed - as it is the bottleneck of the system, and basing the calculations for all other machines. The system proposed will determine if the line is up to the correct pace of production, otherwise, any shortcomings where upgrades or repairs can be done will be known, and hence, the team can make further recommendations for solution as needed to the throughput of the entire line. Lastly, the product line capabilities will be measured in cbm, bpm and kph. In which case a problem statement summarizes the aforementioned.

Problem Statement

A need exists for Mill St. Brewery to monitor the productivity and efficiency of its production line remotely with a reliable system that is applicable to various machines, providing an accurate measurement of throughout the entire line.

Number	Need	Importance (3 being of highest, 1 being lowest)
	Low maintenance	3
	Remote	2
	Cost effective	1
	Easy to use	2
	Accurate data	3
	Real time information	2
	Safety	1
	System that functions with various machines and bottle/can types	3

Table 1. Client Needs and Importance

Deliverable C: Design Criteria and Target Specifications

A ranked design criteria aids in defining a set of functional and non-functional requirements that subsequently reveals project constraints so that the team will be better equipped to satisfy user demand. A list of requirements, constraints for the product, and a summary of benchmarking is provided as follows:

Functional Requirements

- Count number of units passing through each part of the assembly line (cpm, bpm and kph)
- Ability to report back any inefficient numbers and flag the source of error in the line
- On call data with minimal delay(s)
- Data to be stored
- Easily trainable (min)
- Will alert of any abnormalities in numbers
- Quick setup(s)
- Data is viewable within the facility at, a minimum, one location where it is compiled

Constraints

- Minimal interference with pre-existing machines(m^3)
- Cost($)
- Interface several different types of machines
- Parts are easily sourced and replaceable(original equipment manufacturing parts)

Non-functional requirements:

- Product lifespan (years)
- Reliability
- Aesthetics

Summary of Benchmarks

1. IoT Solution Bottling Line Capper Head Calibration and Monitoring System

The use of a "Dummy Bottle" to calibrate the systems and improve efficiency.

- Mechanics are able to calibrate the capper heads accordingly using the dummy bottle
- Displays the data in real time on a GUI (graphical user interface), mechanics can make adjustments accordingly
- Uploads all data to cloud
- 9 different force and position sensors and WIFI interface
- Measuring the forces give insights to calibrating the production line and which then allows analysis of the quality of the capping operation to occur
- System starts the data acquisition automatically
- Application communicates with bottle and collects data in real time
- Production manager can alter the pre-configured thresholds if necessary

2. Domestic Beverage Plant - Filling Line Monitoring System

Increasing efficiency using a production control system performing monitoring and operation of filling lines in a beverage production plant.

- Flexible so that the customer can make their own adjustments to the system when improvements are required
- Remote monitoring features, can perform monitoring and operation from a building remote from the site, when equipment abnormalities occur, they can be quickly fixed
- Real-time alarm is displayed on monitoring screen when there are malfunctions in the equipment or system, supporting early discovery of abnormalities
- A trend display to to manage operational status and fault signals
- Trend display can show real time data as well as historical data

3. Utilizing IoT Solutions to Monitor Beverage Bottling Assets on the Production Line

- Smart mesh IP (data relay system)
- Using Wzzard nodes(takes sensor data and turns sends it to the gateway)
- C1D2 (safety system)
- IP 67 (waterproof)
- Scada and IIot solutions (real time updates)

- Uses lasers and photographic sensors on the line
- Funnels data through Advance tech SmartSwarm 342 gateway (live data updates to devices using wifi or ethernet)
- Nodes connected to 24v digital I/O ports
- Funnels data through

4. Keg Line Monitoring System

Increase efficiency of the keg line by monitoring various data of the whole production line.

- Monitor energy efficiency
- Detect pulse of filling line
- Measure filling volume and faults
- Measure status inside the keg like temperature and steam
- Display real-time data on a screen
- Data be transferred to PC through Bluetooth
- Easy to access through PC software application

5. *Real-time Monitoring of Can and Bottle Filling*

Using RFID system with an antenna produces an electromagnetic field and with tags on each can or bottle to be scanned by the scanner to monitor the motion and location of cans.

- Monitor the real-time motion of each can or bottle in the line
- Monitor the location and distance between each cans
- Make alerts when a can or bottle is missing or the distance is abnormal
- Check the shape of the cans or bottles to detect damages
- Enable tracing can or bottles moving in high speed
- Able to measure the filling level of cans or bottles to detect faults during filling

Deliverable D: Conceptual Design

Team members have compared their generated top ideas by using a criterion matrix bearing in mind the provided constraints. After comparison, the best ideas from each section are deemed as the following: tracking the product with a laser scanner, using Excel for calculations, using a website as the user interface, and storing all of the data on a cloud service. Information goes through in order as follows: Sensor → Ethernet Cable → Wifi Modem → Cloud.

green = 3 points yellow = 2 points red = 1 point

Constraints (multiplies values by 1 to 4 based on overall importance)	Cost 2x multiplier	Interference w/ Pre-Existing System 4x multiplier	Parts are easily sourced 4x multiplier	Interface several different types of machines 3x multiplier	Total points (higher numbers are better)
Laser scanner	3	3	2	2	32
Gate ticker	2	1	3	1	23
Weight sensor	2	1	2	3	25

Table 2. Sensor Type Rating

green = 3 points yellow = 2 points red = 1 point

Constraints (multiplies values by 1 to 4 based on overall importance)	**Cost** 2x multiplier	**Interference w/ Pre-Existing System** 4x multiplier	**Parts are easily sourced** 3x multiplier	**Interface several different types of machines** 4x multiplier	**Total (higher is better)**
Excel Calculations	**3**	**3**	**3**	**2**	**35**
Calculator program for each line	**2**	**3**	**2**	**3**	**34**

Table 3. Calculation Program Rating

green = 3 points yellow = 2 points red = 1 point

Constraints (multiplies values by 1 to 4 based on overall importance)	**Cost** 2x	**Interference w/ Pre-Existing System** 4x	**Parts easily sourced** 3x	**Interface several different types of machines** 2x	**Data easily viewable** 3x	**Total (higher is better)**
App	**3**	**3**	**3**	**3**	**2**	**39**
Website	**2**	**3**	**3**	**3**	**3**	**40**
Accessible monitors in factory	**1**	**2**	**3**	**3**	**3**	**34**

Table 4. User Interface Rating

Deliverable E: Project Plan and Cost Estimate

This part of the design process is to establish a concrete prototyping plan in order to develop next steps subsequently. A budget of all materials are needed and contingency plans are put in place.

Input system

Hardware to read the number of cans going through the system. These numbers can then be uploaded and subsequently put through calculations to determine the rates. The use of a laser tripwire is a simple and easily readable way to input data into a formula.

Required components

- Photoresistor
- Laser diode
- Power source
- Solderless breadboard(as least for prototyping)
- Male to female breadboard jumper cables
- Male to male breadboard jumper cables
- Cans and bottles
- Resistor(ohms to be determined)
- Arduino UNO
- Container for micro board

Red laser is connected to a power source and constantly on. Photoresistor is hooked up to the breadboard, using f-m cables, and then onwards to the arduino using m-m.

Uploading system

The uploading system integrates the raw data from sensor with a microcontroller and cloud server. This system is based on the board and software of Arduino, as well as a selected cloud server platform. The main function of this system is to enable raw signals from sensors that are being processed by the microcontroller and are sent to the cloud server through WiFi.

Block diagram

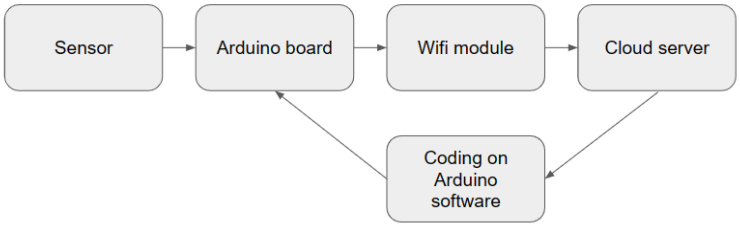

Figure 1. Block Diagram of Tracking System

Process specification

- Sensor records the raw signal which can imply the status of the production line.
- Analog signal from sensor being sent to Arduino board through wires.
- Arduino microcontroller amplifies the analog signal and converts it into digital signal.
- Digital signal from the output of the Arduino board being sent to a WiFi module through wires.
- WiFi module converts the digital signal into radio signal and sends the signal out.
- Select a cloud service platform like Thingspeak or Google cloud.
- On Arduino software, install the libraries of selected cloud platforms and add related codes to enable the uploading process.
- The signal can then be sent out by the hardware and received by the cloud platform.

Required components for Upload System

- Sensors
- Arduino board
- WiFi module
- Arduino software
- Cloud service platform like Thingspeak of Google cloud

Detailed Design Drawing

There is no need to create a detailed drawing of the laser and sensor since we are not designing or buying a new laser for this project. The team has utilized the lasers that are already in use at the Mill St. Brewery factory. Figure 2 displays the user interface of the website that can be accessed through a computer or a tablet. It will have the 3 following pages: the current data, historical data, and alerts.

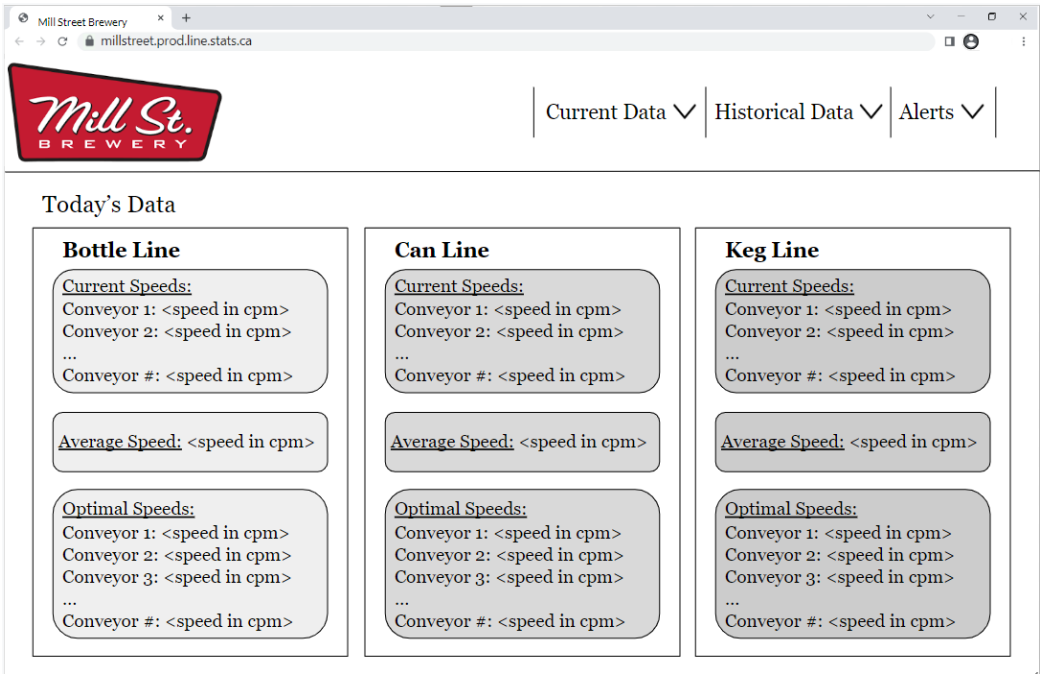

Figure 2. Website Design displaying the 'Current Data' tab.

Cost estimates

Excel Sheet Link: Cost estimates

Deliverable (F-G) Prototype (1, 2) and Customer Feedback (1, 2)

This part of the design process is grouped together since the team only ever had one prototype made. The team simply improved the prototype each week. As for the test plan, the team took the plan from the previous weeks and made it more precise to better fit the current prototype. Furthermore, the team's customer feedback remained unchanged between the three deliverables.

Client Feedback (1, 2) Summary

In the client meeting, a few pieces of feedback are given. The client meeting is more of a presentation of several ideas to get confirmation from the client of what works best for them. At the time, the team have very few specifics as to measurement methodology. The team was not aware whether the client had previous infrastructure, what the process lines looked like, and how many cans the team were to be reading at the same time. Despite the fact that the team had several possible design ideas, each had no idea which could be integrated into their pre-existing conveyors. The client gave clarification and lasers became the preferred proposed method. This is because it is a method that can span across several different types of conveyor lines as the cans may not be moving in a single file, and the laser can span that far and still be triggered. If the system is to be implemented, Mill St. Brewery already has a similar type of laser detection system in place, though, it is just not as thorough and is not interfacing the inputted data. After the client meeting, the team finalized the decisions of how the information were to be inputted, uploaded via wifi link, stored using a cloud based software (ThingSpeak), and how it would be presented (website).

Prototype Components

Critical Component/ System	**Analysis**
Input/Upload System /Laser Sensors	- Made up of laser sensor that are used to track the cans on the conveyor

	- The numbers that are received from the lasers are uploaded to the cloud software - Using a WIFI module - Transfers data between devices using WIFI, in our cases the two devices would be the machines and the cloud server - Takes raw data from input - For prototyping, we're using an Arduino UNO R3 to connect the laser sensors to the program with the formulas
Cloud Software	- Using ThingSpeak, a cloud server that uploads every second (with the student version), the free version takes 15 seconds to upload which isn't ideal for this project since we need frequent uploads to maximize efficiency - Can be connected to Matlab to analyze data - With the analyzed data, it can be put into the formulas to calculate the most efficient speeds

Calculation Software	- Using excel for formulas
	  - Excel is a software that allows users to organize data with formulas and functions
	  - Taking an average from the given data from user to create the formulas
	- Once we have formulas, they will be input into a program that will automatically calculate the most efficient speeds at each part of the production line
	- It’s modeled after the v curve theory

User Interface	- Using a website that will only be able accessed by Mill Street - The uploading system and the user interface are connected, an extension of one another - The interface just displays the information to the users

Table 5. Prototype Components

Test Plan (1&2)

Test ID	Test name	Test objective	Method of tracking	Goal
1	Light levels	To determine the light levels when the laser gets blocked	Breaking the laser with hand and observing what the light levels diminish to	To find an accurate light value to integrate into the code (light < number = tally)
2	Laser distance	To determine the at what laser sensor can function without lowering functionality	Begin at a distance of 1 can; break the laser with hand note results repeat process until the code stops working properly	To find the max distance the laser can function without inaccurate data. This will help keep the results of future tests more controlled
3	Cpm Cross reference	To determine the cans per minute being pushed through the lasers	Push soda cans through laser and calculate a cpm rate manually	To make sure the cpm rate found manually is equivalent to the cpm tracked via cpu
4	Data transfer accuracy	To determine if the data real-time data is the same as the data being stored on the cloud	Have cans break the laser and manually note down the values. After a few attempts cross-examine the values written to the values on the cloud	To make sure the data transfer system is functioning properly
5	Data transfer Accuracy	To determine if the data real-time data is the same as the data being	Have cans break the laser and manually note down the values. After a	To make sure the data transfer system is functioning properly (

	(2)	stored on the cloud	few attempts cross-examine the values written to the values on the cloud	this test is the same test as above just using different speed to ensure the results are consistent

Table 6. Test Plan for Prototype 1 and 2

Codes used in prototype 1 & 2

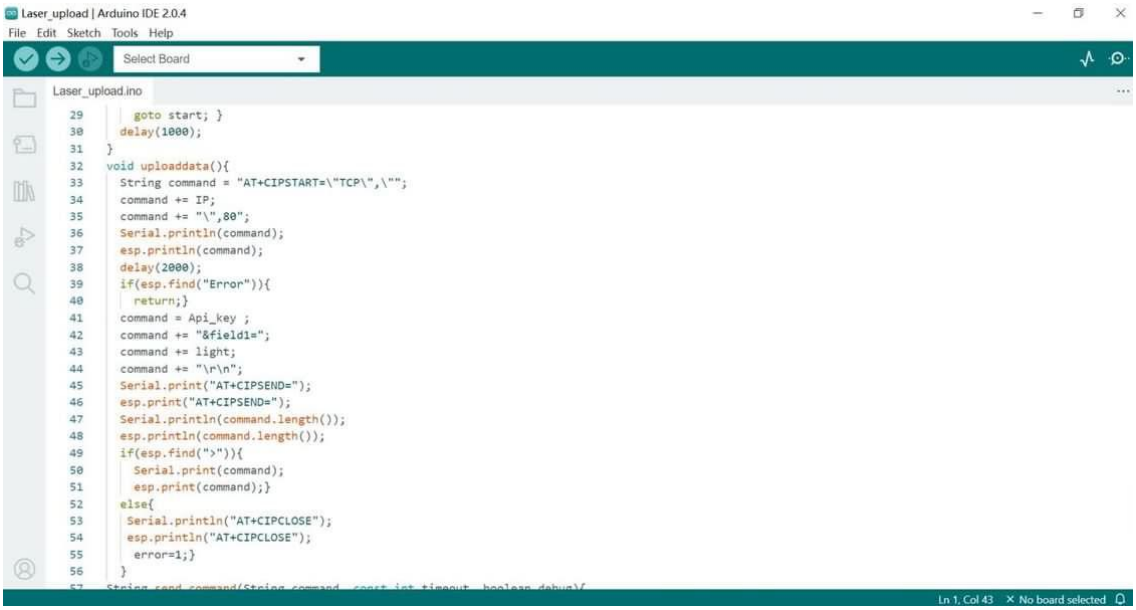

Figure 3. Screenshot of Arduino Code for Tripwire

Calculations used for prototype 1 & 2

Calculations prototype 1&2

Deliverable (H) Prototype (3) and Customer Feedback

Customer feedback

We were able to ask questions and receive clarification on the accuracy threshold of the system and what the flagging percent are for the errors. If the production line is anywhere below 5% of the theoretical data, the system will flag the number. Overall, the team was now able to move forward and continue prototyping to iron out the kinks in numbers and fully set up the data collection system.

Updated Prototyping Test Plan

Test ID			
2	To determine at what light level laser sensor can function without lowering functionality	Begin at a distance of 1 can; break the laser with hand note results repeat process until the code stops working properly	To find the max distance the laser can function without inaccurate data. This will help keep the results of future tests more controlled
3	To determine the cans per minute being pushed through the lasers	Push soda cans through laser and calculate a cpm rate manually	To make sure the cpm rate found manually is equivalent to the cpm tracked via cpu
4-5	To determine if the data real-time data is the same as the data being stored on the dw cloud	Have cans break the laser and manually note down the values. After a few attempts cross-examine the values written to the values on the cloud	To make sure the data transfer system is functioning properly (this test is the same test as above just using different speeds to ensure the results are

			consistent
6	Once all the other test are a complete test to find what is the best light level that minimizes faults	Break laser with hand and find the average light level and add about 15% to that number	This test will prevent a scenario where the light levels will get low and count as a can even though the laser wasn't broken

Table 7. Updated Prototype Test Plan

Code used in prototype

What is shown is the most recent prototype. It functions using a laser and photoresistor as a tripwire with the following code:

```
int photoPin = A0;

void setup() {
  Serial.begin(9600);
}

void loop() {
  int light = analogRead(photoPin);
  if(light<150){
  Serial.println(light);
  delay(200);
  }
}
```

Figure 4. Code for Photoresistor that sends data when light levels are below 150

The wifi module part of the device takes the data and uploads it to a website using the following code:

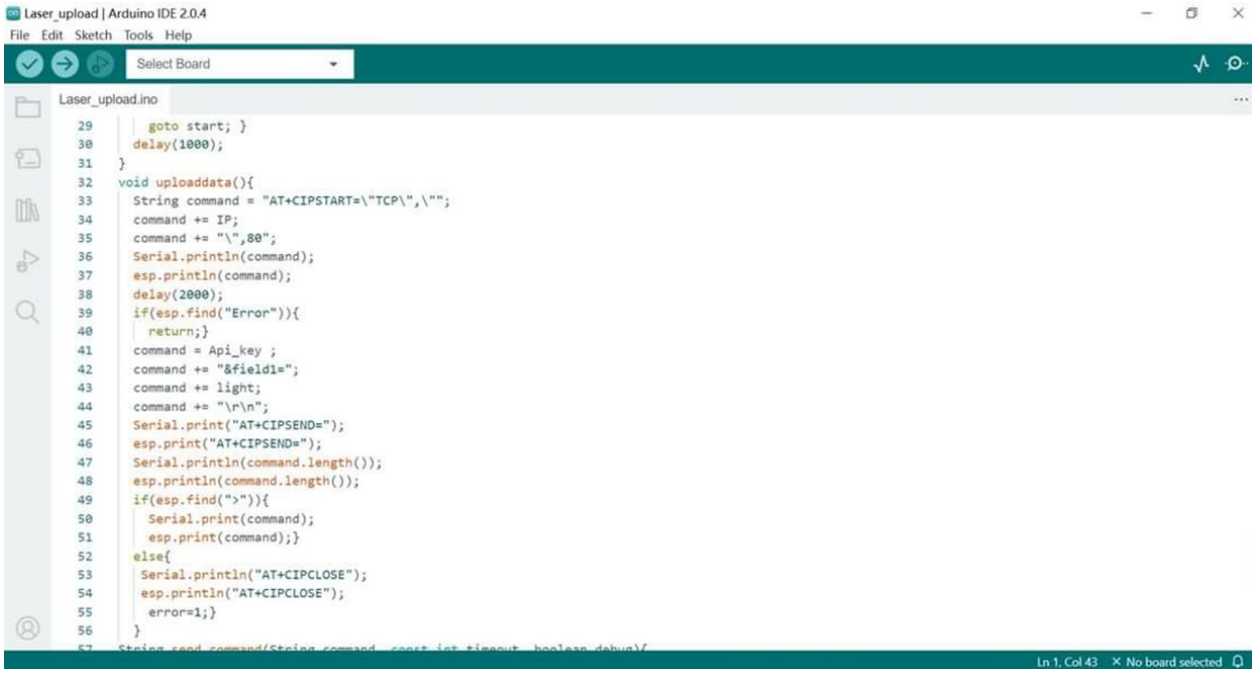

Figure 5. Code of Data Exportation

Physical prototype

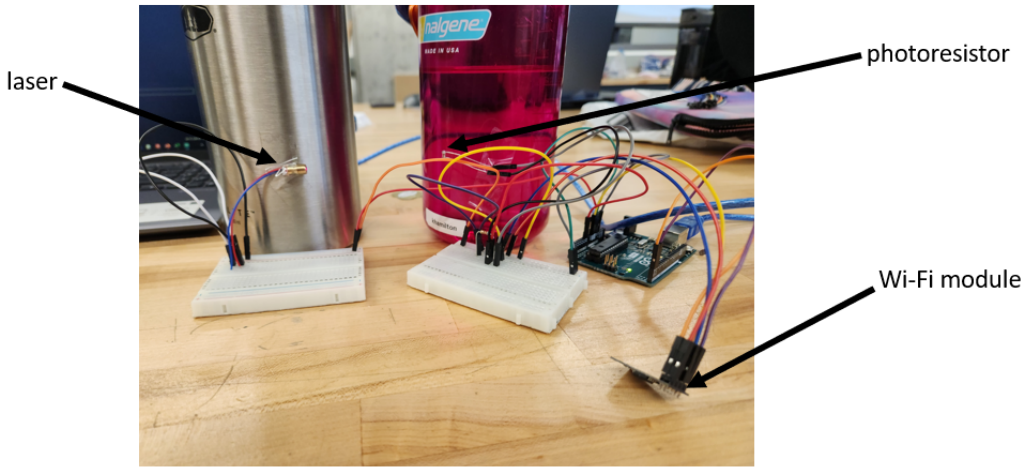

Figure 6. Physical Prototype

Calculation Breakdown

Due to the fact that their current set up and adjusted rates on their production line are over performing with regards to the V-curve theory, as seen in Figure 7.

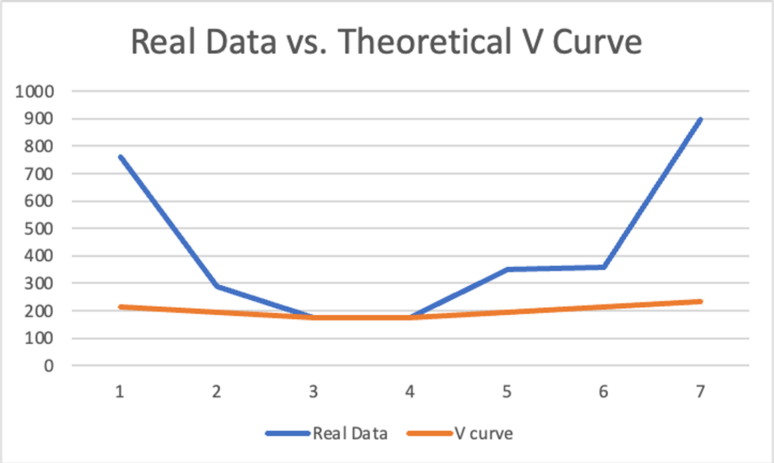

Figure 7. V-Curve Graph comparison of the real rates(blue) and the V curve based on the bottleneck.

The team developed their own method of calculating for the theoretical values as well in addition to the V-curve. This has occurred by taking the real-data that is given by the client and dividing each part's rate by the bottleneck to determine a factor. These two factors, from the two tests, are then averaged for each part of the production line. Now, when a bottleneck rate is inputted, it is multiplied by the factors at each step to give all of the theoretical rates for that bottleneck rate.

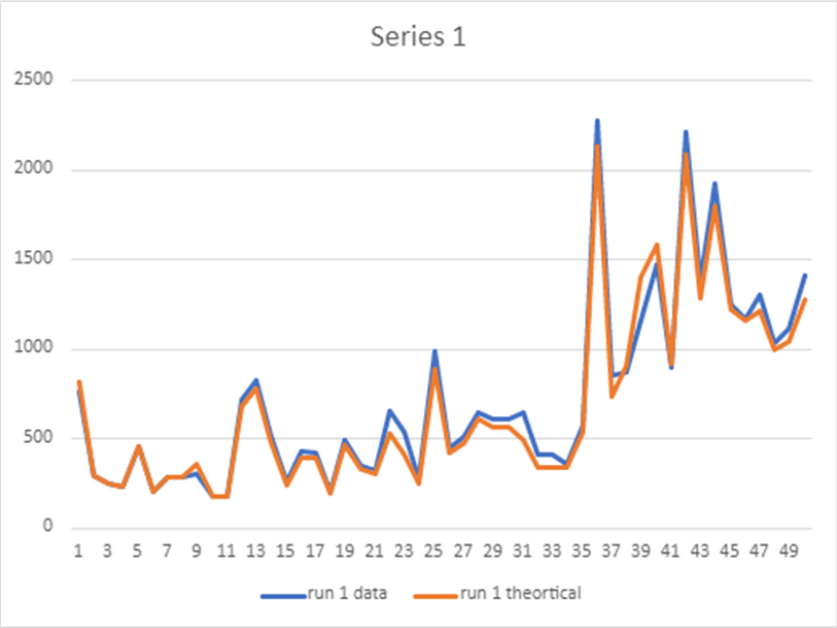

Figure 8. Run 1 Theoretical vs Real Data Graph

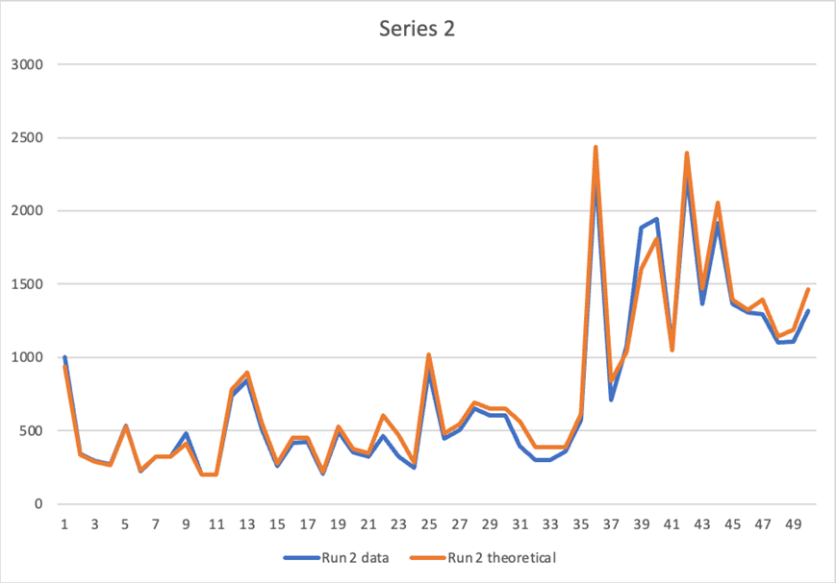

Figure 9. Run 2 Theoretical vs Real Data Graph

The following link will take you to the final spreadsheet: [FINAL MATH]

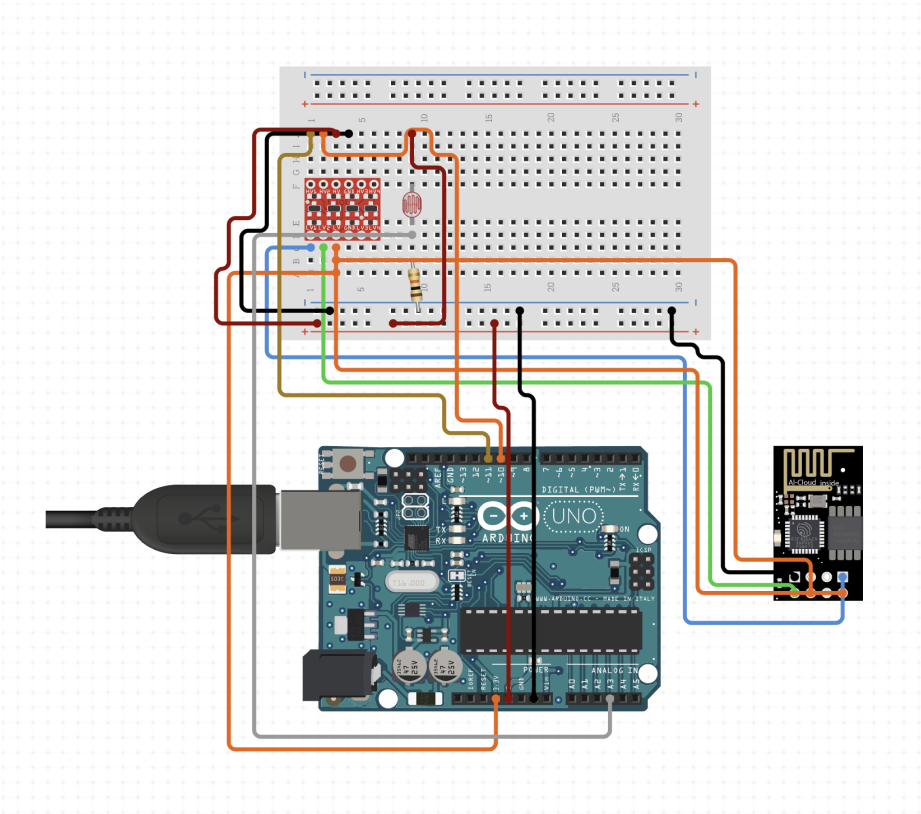

Figure 10. Arduino Setup

Conclusion

User manuals are essential as they provide instructions and guidelines to product users. It documents project design well enough so that another individual can take the archived material for reproduction. The user manual that is produced can help clients understand how the product will work and/or how it can be used in the most efficient way as it gives in-depth project information, commentaries on troubleshooting/ errors, maintenance, as well as any precautions deemed necessary to better improve the product. It is created based on the specific needs of the client, therefore, individuals that wish to reproduce the project can be rest assured the user manual is tailored to meet such requirements and can further aid in ensuring clients will have a positive experience with the project's product.

References

1. *IOT solution bottling line Capper Head Calibration and Monitoring System*. Gadgeon Europe. (n.d.). Retrieved February 4, 2023, from https://www.gadgeon.eu/iot-solution-bottling-line-capper-head-calibration-and-monitoring-system/
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Appendix

Conveyor section	Multiplication factor
pd cnv1	1.6781196
pd cnv2	1.42948575
pd cnv3	1.3316445
pd cnv4	2.6321805
pd cnv5	1.1490075
pd cnv6	1.62249225
pref cnv	2.0621925
posf cnv1	3.90913425
posf cnv2	4.47678075
posf cnv3	2.745576
posf cnv4	1.37563125
prep cnv1	2.26071825
prep cnv2	2.2541955
prep cnv3	1.0887975

prep cnv4	2.64924
posp cnv 1	1.736055
posp cnv 2	3.029232
posp cnv 3	2.331465
posp cnv 4	1.4099175
posp cnv 5	5.089752
posp cnv 6	2.40555675
posp cnv 7	2.71864875
posp cnv 8	3.46725975
posp cnv 9	3.24314475
posp cnv 10	3.24314475
prem cnv 1	2.82318
prem cnv 2	1.931403
prem cnv 3	1.9290615
posm cnv1	3.0765303
posm cnv2	12.1780077

pred cnv 1	4.195299
pred cnv 2	5.175384
pred cnv 3	8.0290035
pred cnv 4	9.0606015
posd cnv 1	11.959713
posd cnv 2	7.3434792
posd cnv 3	10.283199
FG cnv 1	6.974325
FG cnv 2	6.60972
FG cnv 3	6.954924
FG cnv 4	5.705232
FG cnv 5	5.954769
FG cnv 6	7.322874

Table 8. Conveyor Lines and Rates