TEXAS A&M UNIVERSITY-KINGSVILLE

EEEN 4252 Advanced Laboratory

Senior Design Project Proposal:

Digital Pressure Recorder

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Executive Summary:

The purpose of creating a Digital Pressure Recorder is to improve the outdated paper chart recorders that are commonly used still today despite the many disadvantages. We will develop a Digital Pressure Recorder that will collect data using a sensor, upload it to an online database, and have the capability to run simulation pressure values to determine if a value passes the test or not. The main goal is to have a digitalized machine to recorder grease and hydraulic pressure and be able to upload the collected data to an online database. You will be able to access the data from the online database on a website (not in the scope of this project) from anywhere in the world. The following Report will go into detail about the design of the project, background information, design concepts, project analysis, project plan, cost analysis, standards, and project schedule.

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1. Introduction

Our Senior Design project will be developing a Digital Pressure Recorder. The Digital Pressure Recorder will take pressure readings from a transducer sensor and if internet is available, upload the data to an online database, if not then the data will be stored on an internal storage. The goal for the completed project is to have the Digital Pressure Recorder upload data to a cloud database, be able to display the data collect on the screen and can test pressure values to determine if it passes or fails. Theoretically, this device will be used in the oil and gas industry to collect grease and hydraulic pressure from the rig.

We will focus on the set up of the device (connecting all the components together), the retrieval of data, and the computer logic (coding) on what to do with the data. For the device, we are going to have a screen that can display data and other parameters, a PLC which will be our computer, the sensor to collect data, a way to connect to the internet either through WIFI or ethernet, and the case where everything will be stored in. The PLC will be programmed in Python to sort the data and to program the interface the screen will display. With an internet connection and a python code we will be able to upload the collected data to the online database so the data can be viewed anywhere in the world.

The Purpose of this project is to replace the outdated system of chart recorders. Chart recorders have been used since the 1830's to record data and it is still common practice to this day. Although this method of taking data has been around for so long because it is convenient for many reasons it has it disadvantages of the data being separate/not organized and the many parts can malfunction at any time causing wrong data readings.

In the following sections of the paper, we will go more into detail over several aspects of the project such as: background information, design concepts, project analysis, project plan, cost analysis, standards, and project schedule.

2. Background

To understand the problem, we are trying to solve we need to understand a basic chart recorder. A circular chart recorder is a device that reads data and draws the inputs onto a rolling piece of paper. The inputs are entered onto the paper with one or more pens of varying colors. The machine turns the paper either using a mechanical, electromechanically, or electronic system. This specific chart recorder is used for longer lengths of time. All data is recorded on the piece of paper and will need frequent maintenance to change the paper, pens, and to calibrate the machine. Figure 1 displays a typical/popular chart recorder that is used in the oil field industry.

Figure 1: Barton Chart Recorder

This method of taking data using a paper chart recorder has been around for so long because it is convenient for many reasons some being able to instantly view data and the pens/paper chart are easy to replace. On a technical aspect having a machine write data with a pen and paper can have many problems such as running out of ink/paper, machine not calibrated, and the machine not correctly rotating the paper. In this project we will only be concerned with the problems of using a paper chart recorder as the system to collect data. The problem with this outdated method is that all data is spread out on different pieces of papers because of this the data cannot be easily organized nor easily found. The data can also be easily incorrect if one of the internal components of the paper chart recorder are not calibrated or broken. The most important problem is that since it is not a digital reading the measurements of data are less accurate compared to a digital recorder.

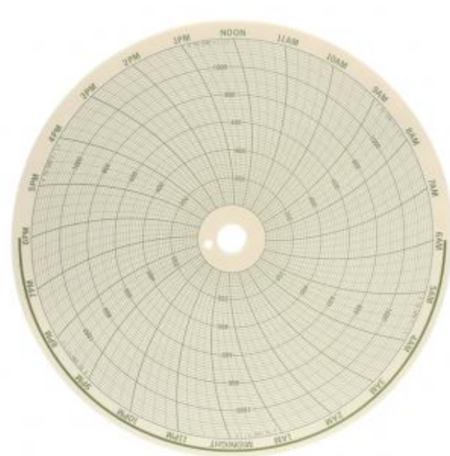

Figure 2: Paper Circle Chart Recorder

A common system to test pressure and other readings are data loggers. Data loggers are small data measuring devices that have storage memory, firmware, and sometimes a separate computer software/interface to facilitate the recording of data values. According to OpsMatters, [15] data loggers use a sensor to collect digital data and then you can either download the data to an external device or use a software to display the data collected. Although data loggers are not usually used to collect pressure in the oil field industry, we can use the two ways they retrieve data in our own design to display the data we will collect from a digital pressure recorder. The image below is an example of a data logger.

Figure 3: An Example of a Data Logger

A Great example is DARTT Recorder Pressure Testing. This device was specifically made for the oil and gas industry to test pressure and temperature [16]. It is composed of two components a sensor and laptop. The sensor is used to test the pressure of the machines and all the data is then uploaded into the laptop. The laptop outputs all the data on a single interface while displaying figures and graphs of the data. The image below is DARTT Recorder Pressure Testing machine.

Figure 4: DARTT Recorder Pressure Testing machine

As mentioned earlier, data loggers either come with a software or you must physically download the data to analyze the collected material. DARTT machine took a better approach, you can see the data instantly once it is collected in the form of a laptop screen. Our team decided to take a different approach on how the data should be displayed and analyzed. Similarly, to DARTT machine we will have a laptop kind of setup that will display the data once it is collected. But we wanted to add an extra feature of uploading the data to on online data base to be access on a website (not in the scope of our project) from any location. If there is not internet, then the data will be stored on a local storage until internet connection is available. This seemed like a better option since most locations where pressure data is collected (in the oil industry) are in remote locations so this approach makes it easier for the user to access anywhere.

3. Design

The design of the entire system will be rugged enough to match industry standards. For the hardware such as the PLC and monitor we will use a military-grade weatherproof case to house the components. This is a must due to the harsh conditions that this pressure recorder will be used. In addition, we will also have another case to hold the cables and the pressure transducer(s) sensor. As far as other components we will also use a heavy-duty extension cord for power and appropriate sized power/signal wires for the entire system where needed.

Figure 5: Weather-Proof Case

Table 1: Click PLC Technical Attributes	
Ladder Memory	8k steps
User Data Memory	16 KB
Programming Language	Ladder
Communication Port and Connection Type(s)	(1) Ethernet 10/100Base-T (RJ45) (1) RS-232 (RJ12) (1) RS-485 (3-pin terminal)
Port Protocol(s)	Modbus TCP Client/Server Modbus RTU Master/Slave ASCII In/out EtherNet/IP explicit messaging adapter EtherNet/IP implicit messaging adapter programming and monitoring
Port Speed(s)	10/100 Mbps up to 115.2k baud
Real Time Clock/Calendar	Yes
Retentive Memory	Yes
Battery Backup	Yes
Maximum Expansion Modules Allowed	8
External Power Requirement	External Power Requirement
Number of Discrete Input Points	8

Nominal Input Voltage	120 VAC
Voltage Type	AC
Number of Isolated Discrete Input Commons	2
Number of Points per Discrete Input Common	4
Number of Discrete Output Points	6
Nominal Output Voltage	6-240 VAC/6-27 VDC
Discrete Output Type	Relay
Relay Configuration	(6) Form A (SPST) relays
Load Current	1A/point
Number of Isolated Discrete Output Commons	2
Number of Points per Discrete Output Common	4/2
Maximum Number of PID Loops	8

For the PLC we decided to go with the Click PLC due to its Valuable technical attributes. More importantly, all CLICK PLC units have a non-volatile FLASH ROM to store the downloaded ladder program and project file. The FLASH ROM will store the ladder program indefinitely.

Figure 6: Click PLC

For the pressure transducer we are still not sure with what specific one we want to use. This is regarding price and availability. However, we do know that we need one that will read anywhere from 0 to 10,000 psi.

Figure 7: Pressure Transducer

For the information screen we want to use this C-more touch screen. This is due to its great technical attributes as can be found in table 2 below.

Figure 8, 9, 10 & 11: HMI (Human Machine Interface) C-more Touch Panel

Table 2: HMI Technical Attributes	
Touch Screen	Yes
Display Size	7 in.
Viewable Size	7 in.
Display Type	Color TFT LCD
Widescreen	Yes
Display Maximum Colors	64K colors
Display Resolution	800 x 480 pixel
Display Video Standard	WVGA
Touch Panel Type	Analog resistive
Brightness	350nits
Viewing Angle	80/85/85/85

Display Orientation	Landscape/portrait
Backlight Type	LED
CPU Clock Speed	800 MHz
External Power Requirement	12-24 VDC
Housing Rating	NEMA 4/4X
IP Rating	IP65
Communication Port and Connection Type(s)	(1) Ethernet 10/100Base-T (RJ45) (1) RS-232/422/485 (DB15 female) (1) USB A (1) USB B
Port Protocol(s)	Allen-Bradley DH485/AIC/AIC+ Allen-Bradley DF1 half duplex Allen-Bradley DF1 full duplex Allen-Bradley EtherNet/IP Server Allen-Bradley EtherNet/IP Client Modbus RTU Modbus TCP/IP GE SNPX 90/30 GE SNPX 90/70 GE SNPX Micro 90 GE SNPX VersaMax Micro GE SRTP Ethernet Mitsubishi FX Direct Mitsubishi Q Mitsubishi QnA serial Mitsubishi QnA Ethernet Omron Host Link Omron FINS Siemens PPI Siemens Ethernet ISO over TCP

	AutomationDirect Productivity Series serial AutomationDirect Productivity Ethernet AutomationDirect Do-more/BRX serial AutomationDirect Do-more/BRX Ethernet AutomationDirect CLICK Modbus AutomationDirect DirectLOGIC K-Sequence AutomationDirect DirectLOGIC DirectNET AutomationDirect DirectLOGIC Ethernet Koyo addressing Modbus
Port Speed(s)	up to 38.4k baud 10/100 Mbps
Removable Media Type	MicroSD card slot

3.1 System context diagram

Figure 12 is a system context diagram for out Digital Pressure Recorder. When analyzing it we can see all the contributors or benefiters that will affect the Digital Pressure Recorder in some way.

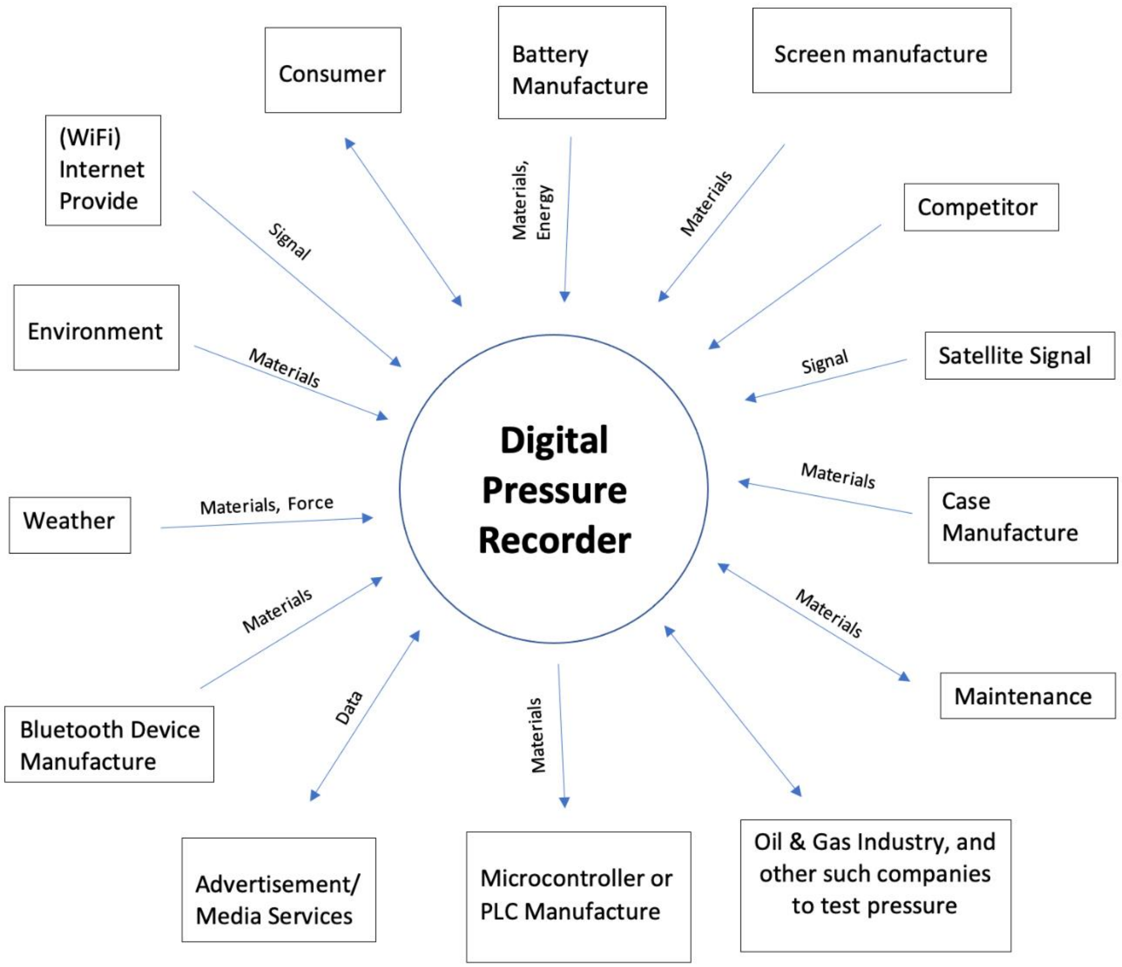

Figure 12: System Context Diagram

3.2 Functional diagram

In Table 3 we have the Functional Diagram for the Digital Pressure Recorder. The functional diagram shows the inputs the machine will take, the functions of those inputs, how those inputs transform into the output function, and finally the outputs we will be left with.

Functional Diagram: Digital Pressure Recorder				
Inputs	**Input Functions**	**Transform Functions**	**Output Functions**	**Outputs**
Sensor Readings	Takes pressure readings from machine	Transducer sensor to computer	Collects pressure data from machine	Collected pressure data
Test Pressure	Pressure test with inputted number	Test the inputted number on computer	Pass or failing test score	Completed tested pressure data
Internet Connection	If Internet, then Connects to cloud Database	Collects data and Uploads data to computer	Collected data is added in cloud database	Updated / Completed Database
No Internet Connection	If no internet, then there is no connection	Collects data and uploads data to computer	Collected Data Stored on Local Storage	Stored pressure data on device

Table 3: Functional Diagram for Digital Pressure Recorder

3.3 Block diagram

Figure 13 is a block diagram explaining the process of collecting data for our Digital Pressure Recorder. First a pressure sensor will collect pressure readings form the accumulator, the accumulator will then send the collected data to the pressure sensor. The pressure sensor will send the data to the PLC controller to analyze and sort through the data. If there is a stable internet connection, then the data will be uploaded to the online database. If there is no internet connection, then the data will be uploaded to the internal storage on the Digital Pressure Recorder.

Figure 14 is a block diagram explaining the process of testing pressure values for our Digital Pressure Recorder. We will manually input a selected value that will then go into the PLC Controller. This will then trigger the code to test the inputted data if the value is okay or not. These result will then display onto the screen.

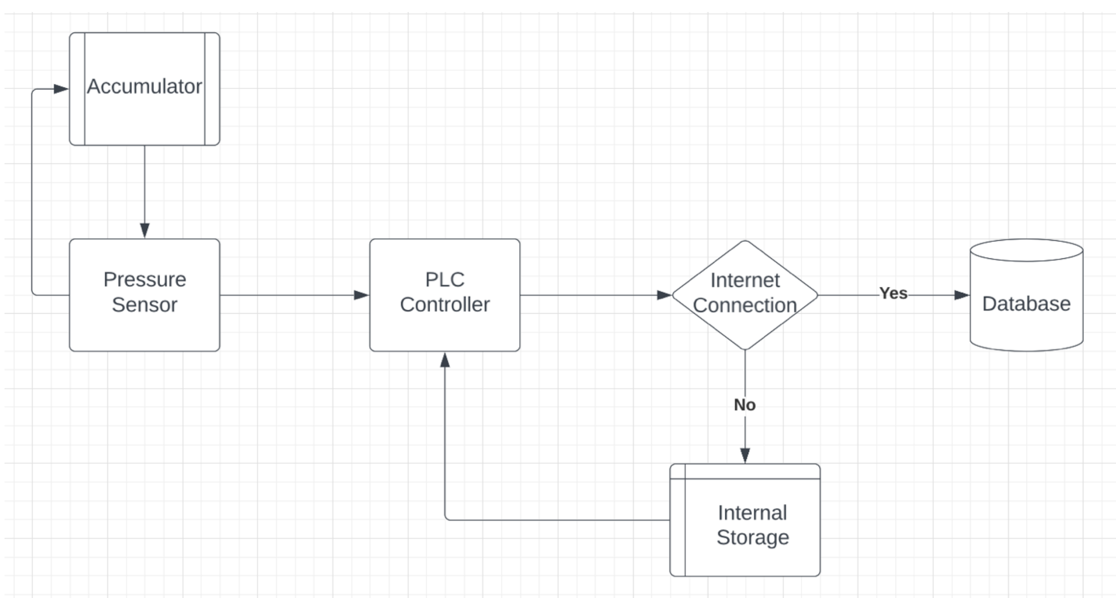

Figure 13: Block Diagram for Collecting Data and Uploading the Data

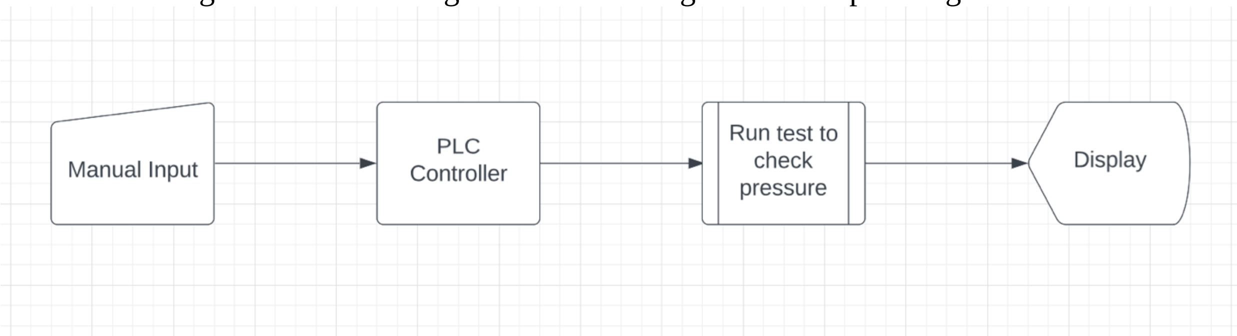

Figure 14: Block Diagram for Testing Pressure Values

3.4 System design requirements, constraints, and specifications

The practical and realistic quantitative and qualitive constraints for the system can be found in table 4. As now the listed constraints are our groups minimum design concept. In a later time, we will gradually add more constraints to have a more complete design.

Table 4: Practical and Realistic Quantitative and Qualitative Constraints

Quantitative Constraints	**Qualitative Constrains**
+/-1.5% accuracy on the systems data	Durability of case and components
Operates for minimum of 5-8 hours	Ruggedness of case
No bigger than 14 in x 9 in x 6 in	Light/portable design
Operates over a temperature range of 0 C to 60 C	Visually appealing design

Applicable standards that associate with our project design can be found in table 5. These standards come from industry, federal government standards and regulations, and OSHA.

Table 5: Applicable Standards

Standard Code	**Standard**
OSHA 1926.441	Batteries and battery charging
RTA IEC 61131-3	Syntax, semantics, and display for PLC programming languages
OSHA 1910.305	Wiring methods, components, and equipment for general use.
OSHA 1910.269	Electric power generation, transmission, and distribution

When designing the current design of our Digital Pressure Recorder we consider the constraints, requirements, and standards. The constraints and requirements helped us realize what type of battery to use, type of sensor with a high accuracy reading and a small compact size container that can withstand extreme weather and temperature. The standards helped use realize what language to use for the PLC, how we can design the case around a battery, how to properly wire all the equipment and components together and understanding the importance of safely handling components that we are qualified to do.

3.5 Design alternatives

There have been no alternatives designs the team came up with as of now. This section of the paper will be updated in a later time.

3.6 Updated design

In this point of time there is not enough specifications and/or data to complete this section. This section will be updated in another point of time when the necessary data or specifications are collected.

3.7 Calculations and theory

In this point of time there is not enough specifications and/or data to complete this section. This section will be updated in another point of time when the necessary data or specifications are collected.

3.8 Circuits

In this point of time there is not enough specifications and/or data to complete this section. This section will be updated in another point of time when the necessary data or specifications are collected.

3.9 Program Pseudocode, UML Diagram or Flowchart

In this point of time there is not enough specifications and/or data to complete this section. This section will be updated in another point of time when the necessary data or specifications are collected.

4. Feasibility Analysis and Project Justification

4.1 Economic

According to the McKinsey Global Institute, the business sector in the U.S. contributes to around 72 percent of GDP in the Organization for Economic Co-operation and development [13]. Industrial cooperation's play a big part on keeping the U.S. economy running smoothly and our products in check. Keeping up with times and technology is crucial for companies to stay efficient and balanced. Companies spending money on outdated techniques instead of investing it on new reliable, efficient, and cost-effective can hurt companies and in result hurt the economy. Our product is a new and innovative idea for industrial companies to invest in newer technology that can benefit all of us. Our budget is $5,000 for the entire project. However, we have almost all the supplies and resources for our project in house due to the availability of equipment granted to us by Meyer. Any material that we must buy from outside resources will be written down in the future. We have a business plan that is stated in section 5.7 of this report what we plan as a team to do once we finish our product. If our product is approved by the NRTL, OSHA, and other necessary associations we can move on to the next step about discussing the value and cost of our product.

4.2 Environmental

Our project is a more efficient way to measure and record grease pressure of all sorts of systems than what was used before. You'll be using a computer and plug in sensor to measure and record all the data that will be uploaded to a cloud. Going digital and paperless can save dozens of trees a year and cut down gas emissions that are hurting our planet. The Barton style chart method involves using a lot of paper that at some point will be later thrown out adding to the waste printing paper does to our environment. Since Barton style chart is the industry standard for companies to measure and record pressure in the U.S. all the paper that is used to print out the data will accumulate into one single spot, landfills. According to Toner Buzz, the pulp and paper industry releases over 100 million kilograms of toxic pollution to the environment every year [11]. The process paper is made is using toxic chemicals like nitrogen oxides and sulfur oxides that are constantly released into the air that greatly contribute to climate change.

4.3 Sustainability

Digitalizing the readings of grease pressure of systems is a safe and simple way for securing important data online. These readings can be accessed safely at any moment and any time for future diagnosis. If a system is offline and cannot upload data at the time, then the data will be uploaded to a local storage drive to later be uploaded to the cloud. This method can be done over-and-over again with basically no limitations.

4.4 Manufacturability

The materials used on our Digital pressure recorder are complex electrical systems that some can only be found online, and others can be found in stores. The weatherproof case and battery can be found in local hardware stores since they are multipurpose items. Both items are crucial they are of high-quality materials that can withstand rugged environments for the safety of the rest of the sensitive components. HMI displays can only be found in specific online stores since the only market for them are industrial businesses and not the average consumer. PLCs are also usually found online with a broader range of online stores selling them since they have a wider range of uses. These components are usually readily available to buy unless they need special specifications, which is not in our case.

4.5 Technical

The digital pressure recorder is made up of complex electrical components that if damaged in any way can give wrong readings and measurements. A damaged pressure transducer sensor or PLC will give inaccurate data to the user if it's damaged. Inaccurate data can lead to harm to the machine and workers if not handled with properly. It's crucial for these electrical components to be kept in perfect shape for accurate readings and reports.

4.6 Ethical

This product was made following all NSPE code of ethics for engineers [12]. We developed this product to help engineers and workers have a more efficient way of getting data from a wide range of industrial systems. Even though this product is meant to help the industrial industry, engineers or staff can still intentionally misuse our product resulting in consequences that can range depending on the severity. Proper use and experience are crucial for a safe and efficient working environment using this product.

4.7 Social

Our product does not directly affect society or any social issues in any way, shape, or form.

4.8 Health and Safety

The digital pressure recorder is a low-risk product that is made up of components that are designed to with handle roughed environments. The only component that can pose a risk to an individual's health is the battery. Low quality or misused lithium-ion batteries can cause burns and irritation to a person's skin or eyes. A simple first-aid kit or a trip to the hospital can treat injuries sustained by batteries depending on the severity. Our team will make sure the battery used in our product is of high-quality materials, lives up to our standards, and is well protected from any sort of outside factor. All other components will pose little to no risk.

4.9 Political

Our product does not directly affect any political issues in any way, shape, or form.

5. Project Plan

5.1 Project Team Management

Every person in this group has a responsibility for different parts of the project such as designing, assembly, and testing. As of now we are in the designing phase, and we all get together once a week to brainstorm and work together on different topics withing the designing phase.

5.2 Plan of Work, Action/Activity Plan

The plan now is to wrap up on all the design so that we may start ordering necessary equipment that we lack so we could start the assembly phase. We have been doing lots of preparations now that way we could have a smooth execution with the assembly.

5.3 Timeline

Figure 15 is an estimated timeline / project overview with dates. As mentioned, this is only an estimated timeline since these dates and duration of days can always change next semester.

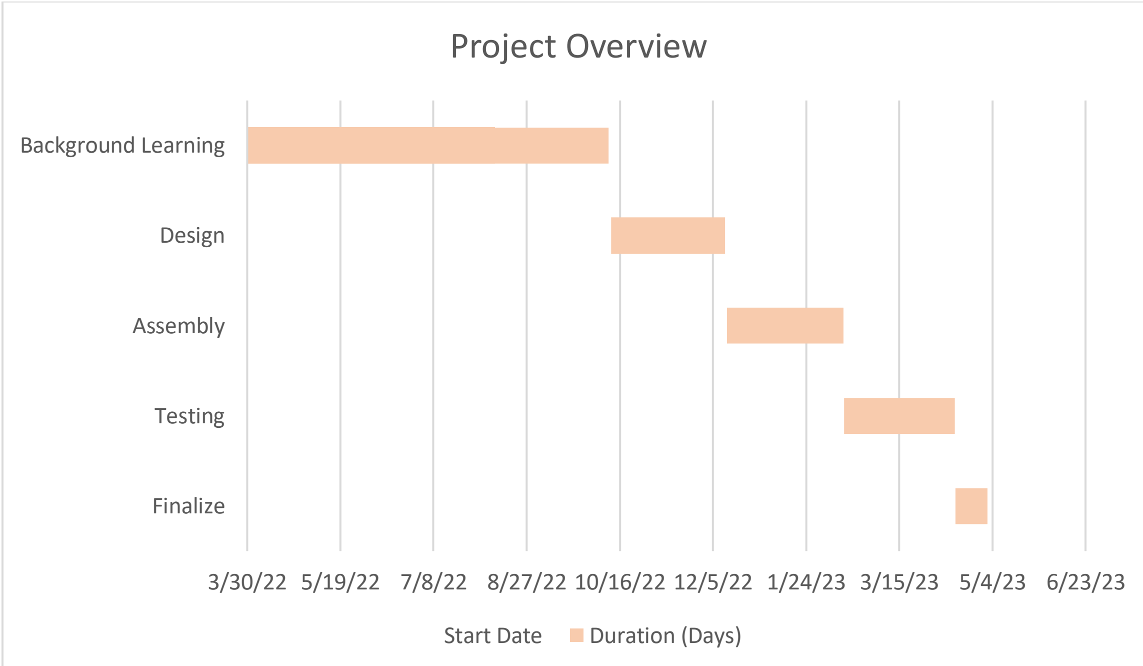

Figure 15: Diagram of Estimated Project Overview Dates

5.4 Resources Allocation and Loading

What our team has created is a weekly in person meeting to update on what everyone has done as far as working towards the project. Much of it is just verbal but we do track each other's progress.

5.5 Test and Evaluation Plan

To test our design after assembly we will visit a company in Corpus Christi, TX named, "Meyer" that will allow us to test our equipment under a safe supervision.

5.6 Risk Management Plan

The main risk that we will be up against is time. We need to have everything dialed in and completed before the final deadline of this project which will be in late April/early May of 2023. The plan for everything to be completed is to have a strong management set in place to make sure everyone is on task and doing what is expected to be done. Another risk with this is parts. Availability is very tough to find now due to the circumstances in today's world. There is still a large shortage of microchips and other important electronic parts that we will need to find to create our design.

5.7 Business Plan

The plan after the creation of our design is to try and get it certified with the Nationally Recognized Testing Laboratory (NRTL) to get it approved by the Occupational Safety and Health Administration (OSHA) and possibly getting it a US patent. We then plan on sharing information about it more specifically to the oil and gas industry. We will present how this will solve the long process of testing certain equipment and how our invention will make it more appropriate for today's evolving digital industries.

6. Cost Analysis and Justification

Our budget is $5,000 for the entire project. However, we have almost all the supplies and resources for our project in house due to the availability of equipment granted to us by Meyer.

7. Implementation Plan

Our project is to create a prototype digital pressure recorder that will accurately measure and record data of industrial systems. Our goal is to provide a new and improved way to store and collect crucial data from industrial machines. We start off by assigning a category of the project to individuals who are familiar with the subject. Our project is broken down into two main categories which include the physical design and software design. The physical design is outlining and integrating the physical components of our system. These items include important electrical components that must be outlined appropriately for the entire system to work properly. The software design involves all the computer programming and coding which gives a computer specific instruction to perform certain tasks. Once everyone was assigned a category, we moved on to finding recourses that can improve our skills that can help us with our objectives. We found a website called Udemy that is essentially a coding online learning and teaching marketplace. The lesson we choose from Udemy was a coding class that teaches Python. We all agreed we will use this website to improve our skills throughout the semester to then move on to the next phase of our project. Throughout the semester we've also been looking at ways on how to start building our product in the coming weeks. Working together as a team and discussing any issues or concerns is crucial for a successful project. We plan to start building our project starting around Christmas break where our product can be our main focus. Some of us can focus on building the physical product while others can focus on building the software. Since the Digital pressure recorder involves using industrial grade machines most of our testing in the future will be in a company called "Meyer". This phase of our project will most likely take the longest since we know we'll make errors and mistakes along the way. It's important we test our product within this company's grounds for reasons like safety and valuable resources. Once our product is complete at the end of Spring 2023 semester, we will finally present it to the university.

8. Expected Results and Deliverables

We expect to have our project completed and available for use with all the desired deliverables listed below:

- A working prototype recorded system.
- Ability to organize data by work order, serial number, setting test pressure etc.
- +/-1.5% accuracy on the systems data.
- A visual output like the Barton style chart recorder is desirable but not required
- A local storage in the case that there is no network connection.

9. Test Plan, Data and Results

In this point of time there is not enough specifications and/or data to complete this section. This section will be updated in another point of time when the necessary data or specifications are collected.

10. Relevant Standards

The standards that we will integrated in our design such as using high quality and reliable components is import because of the environment that it will be used in. It is a requirement that we have been given from the initial proposal. Not to mention, using the correct gauge wiring to make sure not to overload any circuit. Next, we will create a safe and well-organized logic system in order to follow proper safety principles.

All electrical equipment or systems have to pass specific government codes for it to be available in a field. According to their website, OSHA is part of the United States Department of Labor that ensures safe and healthful working conditions for workers by setting and enforcing standards [2]. We've included 4 safety codes that play a crucial part of the design of our product. OSHA 1926.441 is about taking proper precautions using a battery [1]. A battery can be a dangerous component that if not used properly can cause serious injury. OSHA 1910.269 is about workers safety and responsibility in the field [9]. Its important workers have proper training with the equipment they work in, and if new technology, or changes in procedures necessitate the use of new safety-related work practices. OSHA 1910.305 is about proper wiring methods, components, and equipment for general use [10]. Having a proper wiring design is important for systems to work properly. The quality of materials that make up the wire is important for them not to overheat and burn. RTA IEC 61131-3 provided a standardized programming interface that can help users reduce the cost of program maintenance and training across computer programming applications [3].

11. Evaluation Plan

For the evaluation of everyone in the group we will continue to have weekly meetings and daily discussions on the project. Each member will take turns discussing what they have done in the previous days regarding the project weather it has been researching, designing, and/or completion of specific parts. We will also share a file (Word/Excel) to help write down and track everyone's progress.

12. Accomplished Work

As of now we have almost completed the design for the entire system. Most of our time however has been put into learning specific coding languages such as python, and ladder logic.

13. Remaining Work

The remaining work we have is to wrap up our design and start gathering materials to being assembly. We plan to start assembly in early December, and have it almost completed by the middle of January before we start the spring semester.

Next, we will begin to work with the computer science team to finish the assembly and collaborate with the first phase of testing. This first phase of testing will involve some simple communication checklists and simple run throughs to make sure we have no bugs within the communications of the device and software. If we do have any problems, we will immediately address them before we begin phase 2 of testing.

This next phase of testing will include both teams going Meyer’s headquarters to safely test our device with their equipment in a safe environment. After testing and debugging we will begin the finalization of the entire project which is intended to be around late April of 2023.

14. Professional Goals and Necessary Skills

As a team we all must become familiar with various software’s such as Python, Ladder Logic, and AutoCAD. Our goal is to gain as much knowledge as possible from this entire capstone to become well rounded individuals so that when we enter the workforce, we will have background knowledge and experience to show for ourselves.

15. Conclusion

The progress of our project currently is done with the background learning of the digital pressure recorder. Our next step is to complete the design by the end of the semester then we will be able to start assembling the parts. Current updates were finalizing the requirement, standards, and constraints of the project. With all the finalizations we were able to get a good understanding on what a first protype will look like. This semester was spent fully understanding the concepts of our project so next semester will include working on assembling, testing, and finalizing the digital pressure recorder.

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