

# 1909752

*by* Jordan Rees

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**Submission date:** 22-Dec-2023 04:45PM (UTC+0000)

**Submission ID:** 220152612

**File name:** 15180\_Jordan\_Rees\_1909752\_182120\_563282964.pdf (892.17K)

**Word count:** 7773

**Character count:** 47750

**Course: BSc (Hons) Electrical and Electronic Engineering**

**Module: SGEL6000 Independent Project**

**Assignment: 1. Project Definition, Research and Quality Planning**

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**Date submitted: 22/12/2023**

**Word count: 3826**

## Contents

|                                                                                                                             |    |
|-----------------------------------------------------------------------------------------------------------------------------|----|
| 1. Executive Summary.....                                                                                                   | 4  |
| 2. Introduction.....                                                                                                        | 5  |
| 3. Project Background and Problem Definition and Constraints.....                                                           | 6  |
| 3.1 background .....                                                                                                        | 6  |
| 3.2 Problem definition .....                                                                                                | 6  |
| 3.3 Ethical Engineering.....                                                                                                | 7  |
| 3.3.1 Identify and analyse ethical concerns and make reasoned ethical choices informed by.....                              | 7  |
| professional codes of conduct.....                                                                                          | 7  |
| 3.4 Sustainability.....                                                                                                     | 8  |
| 3.4.1 Consider societal, user, business and customer needs as appropriate .....                                             | 8  |
| 3.4.2 Consideration of applicable environmental, societal and economic codes of practice..                                  | 9  |
| 3.4.3 Evaluate the environmental, societal and economic impact of the project and minimise any adverse effects .....        | 10 |
| 3.5 Legal / Commercial.....                                                                                                 | 11 |
| 3.5.1 Consideration of applicable health and safety, legislation, commercial codes of practice and industry standards ..... | 11 |
| 3.5.2 Use a risk management process to holistically identify, evaluate and mitigate risks associated with the project.....  | 13 |
| 3.5.3 Consideration of Intellectual Property .....                                                                          | 13 |
| 4. Functional Design Specification.....                                                                                     | 14 |
| 5. Test Plan .....                                                                                                          | 16 |
| 6. Literature Review and Choice of Final Solution.....                                                                      | 18 |
| 6.1 Solution 1.....                                                                                                         | 18 |
| 6.2 Solution 2.....                                                                                                         | 19 |
| 6.3 Solution 3.....                                                                                                         | 20 |
| 6.4 Chosen Solution .....                                                                                                   | 21 |
| 7. Project Planning, Work breakdown and Management Techniques.....                                                          | 22 |

|                                                     |                                     |
|-----------------------------------------------------|-------------------------------------|
| 7.1 WBS.....                                        | 22                                  |
| 7.2 Gantt chart and costing spreadsheet.....        | 22                                  |
| 7.3 Management techniques .....                     | 22                                  |
| 7.4 Risk assessment .....                           | 23                                  |
| 8. Conclusions and Recommendations .....            | 24                                  |
| 9. Citation List.....                               | 25                                  |
| Works Cited .....                                   | 25                                  |
| 10. Appendix .....                                  | 31                                  |
| 10.1 Project proposal .....                         | 31                                  |
| 10.2 Risk Assessment for implementation phase ..... | 32                                  |
| 10.3 Scoring matrix for solutions.....              | 32                                  |
| 10.4 WBS chart .....                                | 33                                  |
| 10.5 Gantt chart.....                               | 33                                  |
| 10.6 Costing spreadsheet .....                      | 34                                  |
| 10.7 Log entries .....                              | <b>Error! Bookmark not defined.</b> |
| 10.8 Literature review.....                         | 35                                  |
| Figure 1: Chosen solution radar diagram .....       | 21                                  |
| Figure 2: WBS chart .....                           | 33                                  |
| Figure 3: Gantt chart.....                          | 33                                  |
| Figure 4: Solutions block diagram .....             | 35                                  |
| Figure 5: (PLC solution 1) .....                    | <b>Error! Bookmark not defined.</b> |
| Figure 6: (solution 1 HMI screen) .....             | <b>Error! Bookmark not defined.</b> |
| Figure 7: (Solution 1 VFD) .....                    | <b>Error! Bookmark not defined.</b> |
| Figure 8: Solution 2 PLC .....                      | <b>Error! Bookmark not defined.</b> |
| Figure 9: Solution 2 HMI .....                      | <b>Error! Bookmark not defined.</b> |
| Figure 10: Solution 2 VFD.....                      | <b>Error! Bookmark not defined.</b> |
| Figure 11: Solution 3 PLC .....                     | <b>Error! Bookmark not defined.</b> |
| Figure 12: Solution 3 HMI .....                     | <b>Error! Bookmark not defined.</b> |
| Figure 13: Solution 3 VFD.....                      | <b>Error! Bookmark not defined.</b> |

## 1. Executive Summary

The vacuum pump control system project built in a meat processing company has replaced a star-delta starter with a variable frequency drive. This was done to enhance energy efficiency, operational flexibility, and overall sustainability within the meat processing operation. Three solutions were <sup>considered</sup> advised, designed from a FDS these solutions had to meet the required criteria from the FDS. The chosen solution, which was solution 1, this came out as the most balanced and cost-effective choice. The collaborative synergy of the Siemens components coupled with the VFD that is designed for pump drives presents a good foundation for the systems success. The aim of this system is to optimise energy consumption, improve process control while aligning with ethical engineering and safety practises. The projects focus is to select the most suitable vacuum pump control system solution which will benefit the company environmentally, ethically and cost effectively.

*Although executive summaries should be written in the past tense, it does not mean it should be written as if the project was complete. This assignment is about completing the planning and design phase.*

## 2. Introduction

With the ongoing need for enhanced energy efficiency and operational efficiency, a project for a vacuum pump control system has been <sup>proposed</sup> done in a meat processing company. The current system on an outdated star-delta starter is being upgraded to a VFD drive system. Background research is done on the system that covers ethical engineering, sustainability and legal/commercial. A FDS of the system is done which sets requirements for the project that will need to be met. From this FDS a test plan is done which will be used to <sup>check</sup> test the project if it has met the requirements that are set. From the test plan 3 solutions are advised which will be compared to find the most suitable solution. The project is then planned out using work breakdown structure and management techniques. A WBS is done which outlined a structured breakdown of the projects implementation stage. From this a Gantt chart is done which implemented a more in depth plan and timescale of the projects implementation stage. Sticking to this plan ensures the project runs smoothly and in a timely manner. Management techniques were discussed that are applied to the implementation of the project. This ensures the aims and objectives of this project are met effectively, ensuring the success of the project while addressing potential challenges and optimizing performance over time. A risk assessment is then done for the implementation stage of the project. This is to ensure the safety of the personnel working on the project by identifying potential hazards

*This is a good introduction that explains the contents of the report.*

### 3. Project Background and Problem Definition and Constraints

#### 3.1 Background

*a short and clear description*

The project is based on a meat processing company in the United Kingdom and Ireland. It is known for its activities in the meat industry, including the processing and distribution of beef and lamb products. The company operated in various sectors of the meat processing industry, including retail, foodservice, and export markets (Meats, n.d.).

In the factory there are a series of production lines where the meat is processed from being cut, weighed, placed onto packs, sealed, metal detected and then labelled. The machine that the project is a part of is a sealing machine where the meat is placed onto a pack and then sealed in a sealing machine. It does this by heating up film pressing it onto the packs this creates an airtight seal it then creates a vacuum in the pack so that all the air is removed out of the pack to prevent the food from spoiling, the pack is then taken from the machine and is taken onto the metal detecting and labelling process. The project is to do with the vacuum system more specifically the controller for the vacuum pump.

#### 3.2 Problem definition

Currently the vacuum pump is controlled by a star delta starter which is outdated and not very efficient. This is because in a star delta starter the vacuum pump can only run at a high speed which is wasting a lot of energy. This is costing the company money and is also bad for the environment. The purpose of the project is to remove the star delta starter and replace it with a variable frequency drive (VFD) (Group, n.d.).

The VFD has many advantages compared to a star delta starter which makes it a worthwhile investment such as:

- **Energy Efficiency:** It allows to vary the speed of the pump motor based on the actual demand. This means the motor only consumes the energy needed for the required output, which can lead to significant energy savings when compared to running the motor at a fixed speed (Brunner, 2011). Correctly cited
- **Extended Equipment Life:** By starting the vacuum pump motor at a lower speed and gradually ramping it up, VFDs reduce the mechanical stress on the pump. This can lead to longer equipment life and fewer maintenance requirements (Group, n.d.). Correctly cited

- **Improved Process Control:** VFDs provide precise and continuous control of the vacuum level, making it easier to maintain the desired pressure or vacuum level. VFDs can respond to changes in process demand in real-time, which is valuable in applications with varying vacuum requirements (Jacott, 2016). Correctly cited
- **Reduced Noise and Vibration:** Operating the vacuum pump at lower speeds can reduce noise levels and vibration, creating a quieter and more comfortable working environment (wisconsinpublicservice, n.d.). Correctly cited
- **Soft Starting:** VFDs enable soft starting and stopping of the vacuum pump, which minimizes inrush current and mechanical shock, further extending the life of the equipment.
- **Better Process Consistency:** VFDs ensure that the vacuum pump operates consistently at the desired speed, resulting in improved process consistency and product quality.

### 3.3 Ethical Engineering

#### 3.3.1 Identify and analyse ethical concerns and make reasoned ethical choices informed by

##### professional codes of conduct

**Energy efficiency:** To identify the ethical concerns of energy efficiency the VFD must be set up to increase energy efficiency. If the VFD is not set up to be energy efficient it would be wasting energy which could be seen as ethically irresponsible. This is because wasting energy is bad for the environment because it contributes to pollution and is a waste of resources. The VFD will need to be set up to be energy efficient this will align with ethical principles of environmental responsibility (SERVICES, 2018). Correctly cited

**Maintenance and Safety:** To identify the maintenance and safety risks the vacuum system must be examined to ensure there are maintenance procedures in place and if there are any safety protocols in place. When building the project safety must be a top priority of the worker for himself and everyone around. Interlocks and guards must be built where needed to ensure the system is safe. Safety and maintenance procedures must be adhered to, to align with ethical principles of employee well-being and safety (HSE, 2023).

**Compliance with Regulations:** The VFD must be set up so that it complies with the relevant regulations and standards. Non-compliance with these regulations can be an ethical concern. If regulations are not followed it can lead to legal issues and harm to the environment and health (A.Fathima, 2021).

*only the surname of the author is needed*

**Professional Codes of Conduct:** To identify the ethical concerns the professional codes of conduct must be reviewed, such as those from engineering or industrial organizations, to identify specific guidelines that apply to the use of VFDs and vacuum pumps. When building the project these codes of conduct must be followed. If there is a violation of these codes, it can be an ethical concern (Ethics, 2023). [Correctly cited](#)

### 3.4 Sustainability

#### 3.4.1 Consider societal, user, business and customer needs as appropriate

##### **Societal Needs**

**Energy Efficiency:** Using a VFD to control a vacuum pump takes into consideration societal needs due to it being energy efficient, using a VFD will contribute to resource conservation which aligns with societal expectations for energy-efficient technologies, contributing to overall sustainability goals (BEECH, 2023). [Correctly cited](#)

**Environmental Impact:** Society increasingly values environmentally friendly practices. Using a VFD can reduce the carbon footprint by optimizing energy consumption, demonstrating a commitment to environmental responsibility (BEECH, 2023). [Correctly cited](#)

##### **User Needs**

**Operational Flexibility:** Users, such as machine operators and maintenance workers, benefit from the operational flexibility offered by a VFD. It allows them to adapt the vacuum pump's speed to specific process requirements, increasing overall efficiency (electric, 2023). [Correctly cited](#)

**User-Friendly Interface:** Designing a user-friendly interface for the VFD control system ensures that operators can easily adjust settings and monitor performance, which makes the system easy to use (Whitsitt, 2022).

##### **Business Needs**

**Cost Savings:** From a business perspective, energy-efficient technologies contribute to cost savings. Implementing a VFD can result in reduced energy consumption, lowering operational costs and improving the overall financial sustainability of the company (Europa, 2023). [Correctly cited](#)

**Process Optimization:** A VFD allows for better control over vacuum levels, potentially improving product quality and reducing production inefficiencies (Vermont, 2023). [Correctly cited](#)

## Customer Needs

**Product Quality:** Customers expect high-quality products. The precise control provided by a VFD can contribute to maintaining consistent product quality, meeting customer expectations, and enhancing the company's reputation (electric, 2023). Correctly cited

**Sustainability Awareness:** In an era where customers are increasingly environmentally conscious, showcasing a commitment to sustainability by implementing energy-efficient solutions like a VFD can be a competitive advantage (BEECH, 2023). Correctly cited

### 3.4.2 Consideration of applicable environmental, societal and economic codes of practice

#### Environmental codes of practice

*This is another good section showing the breadth of your reading*

#### Energy efficiency and emissions control

By using a VFD to control a vacuum pump it covers the "ISO 14001" this emphasises the implementation of practices that reduce the impact on the environment, optimise energy use and promote sustainability (ISO, 2023). Correctly cited

"IEC 61800-2" is an international standard that specifies the requirements for adjustable speed electrical power drive systems. When using a VFD it outlines the general requirements and test methods for ensuring energy efficiency of these drive systems (IEC, 2021). Correctly cited

#### Societal Codes of Practice

**Resource conservation:** Societal codes of practice often cover responsible resource management, due to a VFD being energy efficient it directly corresponds to resource conservation aligning with societal expectations for sustainable and responsible industrial practices. This follows the corporate social responsibility guidelines (FERNANDO, 2023). Correctly cited

**Technological innovation:** Societal codes encourage innovative technologies by implementing a VFD for controlling a vacuum pump shows commitment to technological advancement, meeting societal expectations for continuous improvement and progress (FERNANDO, 2023). Correctly cited

## Economical Codes of practice

There are no specific economical codes of practice in the sense of formalized standards, the principles mentioned align with widely recognized frameworks and best practices in the fields of operational efficiency and industry-specific standards. For example:

**Lean Manufacturing Principles:** Lean manufacturing principles aim to minimize waste, optimize processes, and improve efficiency this directly contributes to cost effectiveness (manufacturing, 2016). Correctly cited

**ISO 9001 - Quality Management Systems:** Although this code of practice does not directly focus on economical codes of practice, its principles that include continuous improvement and efficiency resonate with operational efficiency standards. This contributes to cost effectiveness (ISO, 2015). Correctly cited

### 3.4.3 Evaluate the environmental, societal and economic impact of the project and minimise any adverse effects

#### Environmental Impact:

Implementing a Variable Frequency Drive (VFD) to control a vacuum pump can significantly reduce the environmental impact. VFDs optimize energy consumption by adjusting the speed of the pump based on actual demand, preventing unnecessary power usage. This leads to a decrease in overall energy consumption, lowering carbon emissions. Also, the extended lifespan of the equipment due to controlled operations can reduce the need for frequent replacements, minimizing the environmental footprint associated with manufacturing and disposal (BEECH, 2023).

#### Societal Impact:

The societal impact of using a VFD in vacuum pump control is beneficial in many ways. Energy-efficient technologies align with societal expectations for responsible resource management and sustainability. By reducing energy consumption, the implementation of a VFD contributes to a broader societal goal of minimizing the environmental footprint of industrial processes. It showcases a commitment to technological innovation (FERNANDO, 2023).

**Economic Impact:**

The economic impact of the project is substantial, with potential cost savings and improved efficiency. The controlled speed of the vacuum pump through the VFD allows for better process optimization, potentially reducing operational costs. The initial investment in the VFD is often justified by the long-term economic benefits, including energy savings and decreased maintenance costs. Also the enhanced efficiency can lead to increased productivity and competitiveness, positively influencing the economic sustainability of the organization (Vermont, 2023).

**Adverse Effects Minimization:**

To minimize adverse effects, careful planning and implementation strategies should be used. Adequate training for personnel involved in the installation and operation of the VFD is important to ensure proper usage. Regular maintenance schedules should be used to identify and address any issues. Ongoing monitoring of energy efficiency and system performance will help identify areas for continuous improvement and optimization (MOSTERD, 2020).

### 3.5 Legal / Commercial

#### 3.5.1 Consideration of applicable health and safety, legislation, commercial codes of practice and industry standards

**Health and safety**

**Personnel training:** The personnel involved with the installation, operation and maintenance of the VFD are adequately trained. This training should cover safety protocols, emergency procedures and proper handling of equipment.

**Safety Standards:** Safety standards and guidelines must be adhered to such as electrical safety, installation requirements and personal protective equipment.

*To which standards are you referring to?*

## Legislation

**Compliance:** The VFD implementation <sup>will</sup> must align with local and national legislation. This includes regulations related to electrical systems, workplace safety and environmental impact. These legislations include “Electricity at work regulations 1989” (HSE.gov, 2015). “Health and safety at work act 1974” (HSE.gov, 1974). Correctly cited

**Certifications:** The VFD <sup>will</sup> must carry necessary certifications to meet the requirements. For example. “IEC 61800” this is the international standard for adjustable speed electrical power drive systems. This applies to the project because it verifies that the VFD complies with global standards for performance and safety of adjustable speed electrical power drive systems (IEC, 2021). Correctly cited

## Commercial Codes of Practice

**Quality assurance:** This ensures that the VFD and the related components meet industry accepted standards. For example. <sup>no need for double quotation marks as your are not quoting</sup> “ISO 9001 - Quality Management System” This standard outlines the criteria for a quality management system. Adhering to ISO 9001 ensures that the manufacturing, testing, and quality control processes related to the VFD align with globally recognized quality management standards (ISO, 2015). Correctly cited

## Industry Standards

**IEC standards:** International Electrotechnical Commission (IEC) standards such as IEC 61800 is applicable to the project. These standards <sup>will</sup> must be followed for the design installation and operation of the VFD to ensure its compatible and safe (IEC, 2021).

*Have you read the standard? If so, which parts apply?*

### 3.5.2 Use a risk management process to holistically identify, evaluate and mitigate risks associated with the project

#### 1. Risk Identification

Recognize risks such as equipment failure, electrical hazards, operational interruptions, and harmonic distortions.

#### 2. Risk Evaluation

Assess likelihood, severity, impact on operations, and compliance risks associated with each identified risk.

#### 3. Risk Mitigation

Implement preventive maintenance, safety measures, redundancy planning, harmonic filters, training programs, and compliance assurance.

#### 4. Continuous Monitoring and Review

Utilize monitoring systems, incident reporting, and regular audits for real-time risk assessment and continuous improvement.

#### 5. Documentation

Maintain a risk register and document SOPs for VFD operation, maintenance, and emergency response.

#### 6. Communication and Training

Establish clear communication channels, regularly update training programs, and ensure users are informed of risk management protocols (compliancequest, 2023).

### 3.5.3 Consideration of Intellectual Property

When utilizing a Variable Frequency Drive (VFD) to control a vacuum pump, intellectual property considerations are important. Vendor IP rights <sup>will</sup> must be respected, ensuring compliance with patents and trademarks. If developing custom software, protect it through patents or copyright. Clearly define IP ownership in collaborative projects. Patenting innovative technologies and trademarking unique branding. Implement confidentiality agreements for sensitive information. Train users on IP awareness, maintain detailed records (evaluateserve, 2023).

*Your use of "must" gives the sense that you are instructing your reader.*

## 4. Functional Design Specification

For the vacuum pump control system, a FDS is made which will cover criteria that the project will need to meet.

Table key: *In this section, its OK to use the word "must" as you are setting out the project requirements.*

F= Function

S= Safety

M= Measureables

P= Performance

E= Environmental

Below is a table of the FDS (Table 1 FDS)

| Criteria | Requirement                                                   |
|----------|---------------------------------------------------------------|
| F.1      | Start through HMI                                             |
| F.3      | Stop through HMI                                              |
| F.3      | Remote start control from machine                             |
| F.4      | Manual start control from HMI                                 |
| F.5      | Manual start light display on HMI                             |
| F.6      | Manual stop light Display on HMI                              |
| F.7      | Auto light display on HMI                                     |
| F.8      | Fault light display on HMI                                    |
| S.1      | E-Stop on panel                                               |
| S.2      | Isolator on panel                                             |
| M.1      | Vacuum level displayed on HMI                                 |
| M.2      | Oil level of pump displayed on HMI                            |
| M.3      | Pump temperature displayed on HMI                             |
| E.1      | Pull vacuum for demand only                                   |
| E.2      | Idle mode for vacuum pump after time period                   |
| P.1      | System must pull vacuum to required setpoint at least 10mbar. |
| P.2      | Leak back after 40s must be no more than 100mbar.             |
| Budget   | Is the project within budget                                  |

| Timescale | Is the project within timescale |
|-----------|---------------------------------|
|-----------|---------------------------------|

Table 1: FDS

Generally, this is also a good section but see comments below

## 5. Test Plan

Below is a test plan to prove that the FDS criteria has been met (Table 2 test plan)

| Criteria   | Requirement                       | Test Description                                             | Expected outcome                                                                           | Actual outcome | Decision P/F | Evidence |
|------------|-----------------------------------|--------------------------------------------------------------|--------------------------------------------------------------------------------------------|----------------|--------------|----------|
| <b>F.1</b> | Start through HMI                 | Press start button on HMI                                    | System starts when start button is pressed on HMI                                          |                |              |          |
| <b>F.3</b> | Stop through HMI                  | Press stop button on HMI                                     | System stops when stop button is pressed on HMI                                            |                |              |          |
| <b>F.3</b> | Remote start control from machine | Press Switch on HMI for remote start (Auto mode)             | System turns on remotely from start button on sealing machine                              |                |              |          |
| <b>F.4</b> | Manual start control from HMI     | Press Switch on HMI for manual start                         | System goes into manual mode                                                               |                |              |          |
| <b>F.5</b> | Manual start light display on HMI | When in manual and start is pressed start light is displayed | Manual start display turns on HMI screen                                                   |                |              |          |
| <b>F.6</b> | Manual stop light Display on HMI  | When in manual and stop is pressed stop light is displayed   | Manual stop display turns on HMI screen                                                    |                |              |          |
| <b>F.7</b> | Auto light display on HMI         | When machine is in auto, auto display light comes on         | Auto display light turns on HMI screen                                                     |                |              |          |
| <b>F.8</b> | Fault light display on HMI        | When fault in the system fault light display is on           | Fault light on when system in fault                                                        |                |              |          |
| <b>S.1</b> | E-Stop on panel                   | Press E-stop on panel                                        | E-stop safety fault appears                                                                |                |              |          |
| <b>S.2</b> | Isolator on panel                 | Turn isolator switch on/off                                  | When isolator switch off there is no power to panel when turned on there is power to panel |                |              |          |

|                |                                                                 |                                                                                                              |                                                                                                                        |  |  |  |
|----------------|-----------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------|--|--|--|
| <b>M.1</b>     | Vacuum level displayed on HMI                                   | Run system and check vacuum level on HMI                                                                     | Vacuum level on HMI should read accurately.                                                                            |  |  |  |
| <b>M.2</b>     | Oil level of vacuum pump displayed on HMI                       | Run system and check oil level on HMI                                                                        | Oil level on HMI should read accurately                                                                                |  |  |  |
| <b>M.3</b>     | Vacuum pump temperature displayed on HMI                        | Run system and check temperature level on HMI                                                                | Vacuum pump temperature on HMI should read accurately <i>How do you define accurately? should be +/- %</i>             |  |  |  |
| <b>E.1</b>     | Pull vacuum for demand only                                     | Run system and check vacuum reaches setpoint                                                                 | Vacuum setpoint is reached.                                                                                            |  |  |  |
| <b>E.2</b>     | Idle mode for vacuum pump after time period                     | Run system for a prolonged period without using sealing machine                                              | System goes into idle mode                                                                                             |  |  |  |
| <b>E.3</b>     | Power consumption test                                          | Test power consumption using equation.<br>$[P = \sqrt{3} \times V_{line} \times I_{line} \times \cos(\phi)]$ | Get reading for power consumption and compare with old system<br><i>This reads like a test not an expected outcome</i> |  |  |  |
| <b>P.1</b>     | System must pull vacuum to required setpoint of at least 10mbar | Run system and check vacuum level                                                                            | Vacuum level should reach setpoint                                                                                     |  |  |  |
| <b>P.1/P.2</b> | Leak back after 40s must be no more than 100mbar.               | Vacuum test will be done where the sealing head will close and system will pull vacuum and hold for 40s      | The vacuum should reach the required set point of at least 10mbar and should not leak back more than 100mbar after 40s |  |  |  |

Table 2: Test plan

## 6. Literature Review and Choice of Final Solution

### 6.1 Solution 1 *There should be 3 block diagrams, one for each solution*

The first solution for using a VFD to control a vacuum pump will be shown by (figure 4: Solutions block diagram).

In this solution the setpoint will come from the HMI which will feed into the PLC controller giving input to the VFD run the vacuum pump. The speed of the pump will depend on the setpoint. There is a feedback loop from the vacuum pump which will feed back into the PLC, this will tell the PLC if the pump needs to run faster or slower. The VFD will adjust the frequency of the pump depending on the setpoint given from the PLC. This change in frequency is what will alter the speed of the pump. Below in (table 3) are the components that will be used for solution 1. *This table belongs in the appendix, this section should begin with the block diagram*

| Component                                                                           | Price            | Reference  |
|-------------------------------------------------------------------------------------|------------------|------------|
| <b>Siemens SIMATIC S7-1200 Series</b>                                               | £512.40          | (UK, 2023) |
| <b>Siemens KTP 700 Series Touch Screen HMI - 7 in, TFT Display, 800 x 480pixels</b> | £877.20          | (UK, 2023) |
| <b>Mitsubishi Inverter Drive, 22 kW, 3 Phase, 400 V ac, 47 A, FR-F800 Series</b>    | £3,087.60        | (UK, 2023) |
| <b>Total Cost:</b>                                                                  | <b>£4,477.20</b> |            |

*Table 3: Solution 1 components*

Overall this solution provides a good way to build the project. With the PLC and HMI being Siemens they are compatible which will make it easier for communication between each unit. With the units being within one manufacturer, online and technical support will be easier to manage. The cost of this solution is well in budget. The building and installation for this solution is straightforward. Using a PLC with an HMI it will be easy to operate by users. The VFD is one that specializes in pump drives which will make it more effective.

*The block diagram could be different as the block titles would have different component names  
Also, the links between the blocks could be different, such as analogue, digital, profiNet or ProfiBus*

## 6.2 Solution 2

Solution 2 block diagram is the same as solution 1 (shown in figure 4) but the components used will be different, using alternative components can offer a different way for set up and different benefits. Below in (table 4: solution 2 components)

| Component                                                                                  | Price            | Reference  |
|--------------------------------------------------------------------------------------------|------------------|------------|
| <b>Siemens SIMATIC S7-1200 Series-6ES7217-1AG40-0XB0</b>                                   | £1,114.80        | (UK, 2023) |
| <b>Siemens TP900 Series Touch Screen HMI - 9 in, TFT Display, 800 x 480 pixels</b>         | £2,626.80        | (UK, 2023) |
| <b>Schneider Electric Variable Speed Drive, 22 kW, 3 Phase, 690 V, 26 A, ATV630 Series</b> | £5,431.22        | (UK, 2023) |
| <b>Total Cost:</b>                                                                         | <b>£9,172.82</b> |            |

Table 4: Solution 2 components

With the components selected for solution 2 the performance of the system will be better with a lot more room for expansion for example if more pumps and inverter drives needed to be added, the PLC will be capable of doing so. The HMI is a larger screen with a 10MB onboard memory which means it has a quick response time to any inputs to the screen. The VFD has many set up modes/parameters which can be used for getting the most performance out of the drive such as a fast response time. Overall this solution is very performance based and will be very flexible during setup. It is also very costly shown from (table 4) above.

### 6.3 Solution 3

Solution 3 will have the same block diagram as solution 1 and 2 but it will use the VFD for the PID loop and setpoint and the PLC will be used for inputs such as sensory feedback which will be displayed on the HMI. Using this setup the PLC can be slightly cheaper but the VFD will need PID control imbedded. The block diagram is shown in (Figure 4).

| Component                                                                      | Price            | Reference  |
|--------------------------------------------------------------------------------|------------------|------------|
| Siemens SIMATIC S7-1200 Series PLC-6ES7211-1BE40-0XB0                          | £252.00          | (UK, 2023) |
| Siemens KTP 400 Series Touch Screen HMI - 4.3 in, TFT Display, 480 x 272pixels | £483.60          | (UK, 2023) |
| Siemens Inverter Drive, 22 kW G120X Series                                     | £2,578.25        | (UK, 2023) |
| <b>Total Cost:</b>                                                             | <b>£3,061.85</b> |            |

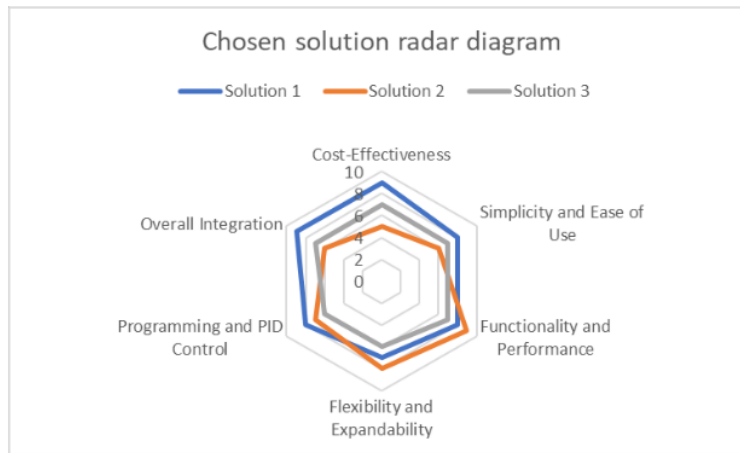
Table 5: Solution 3 components

The PLC and HMI chosen for this solution are a cheaper alternative of solution 1 and 2. Due to the VFD being used for the PID control there is less work for the PLC therefore a cheaper option is taken to be more cost effective. Using the VFD for the PID loop can be more difficult to program and in hand might not be as effective as using the PLC for the PID control.

## 6.4 Chosen Solution

To compare solutions a table of comparison of the three solutions was done shown in (Table 6 in the appendix). Each solution is scored on different criteria out of 60. Solution 1 has the highest score at 50/60.

A radar diagram is shown in (figure 1) below. This <sup>no need for brackets</sup> ~~diagram~~ <sup>redundant word</sup> is used to give an understanding of how each solution performs across various criteria <sup>namely:</sup> such as cost-effectiveness, simplicity, functionality, flexibility, programming, and overall integration. Which will help on choosing with solution is best.



*I agree, solution 1 seems the best with the highest score and the widest coverage.*

Figure 1: Chosen solution radar diagram

Solution 1 is chosen as the chosen solution for controlling a vacuum pump using a VFD due to its cost-effectiveness, simplicity, integration. The Siemens SIMATIC S7-1200 Series PLC serves as a reliable central controller, easily communicating with the Siemens KTP 700 Series Touch Screen HMI, offering a user-friendly interface for easy operation.

The Mitsubishi Inverter Drive from the FR-F800 Series, designed for pump drives, ensures efficient and precise control of the vacuum pump's speed. The feedback loop from the pump to the PLC enables real-time adjustments, ensuring the system responds to changes in the vacuum level.

<sup>all solutions should be within budget</sup>  
This solution is not only within budget but also benefits from the compatibility of Siemens components, facilitating easy communication and technical support. The building and installation process are simple, making it accessible for users. Additionally, the PLC-HMI <sup>drive</sup> ensures user-friendly control, while the specialized VFD for pump drives increases the systems effectiveness. Overall, Solution 1 is a well-rounded balance between functionality, affordability, and user-friendliness.

## 7. Project Planning, Work breakdown and Management Techniques

### 7.1 WBS

In (figure 2) in the appendix is the WBS. This WBS provides a structured breakdown of the project into phases and tasks. The WBS helps in organizing and understanding the various components of the project, facilitating better project management, planning, and execution.

### 7.2 Gantt chart and costing spreadsheet

In (figure 3) in the appendix is the Gantt chart. Each task is defined along with its start and end dates, duration. The timeline is presented in a linear fashion, with tasks organized under each milestone (Design, Planning, Installation, Handover). In (table8) in the appendix is the costing spreadsheet for the control system.

### 7.3 Management techniques

#### **Project Management:**

A project management methodology is employed to plan and execute the VFD implementation. Tasks may include VFD selection, system design, procurement, installation, and commissioning. A well-structured project plan ensures that the project stays on schedule (bhat, 2023). Correctly cited

#### **Risk Management:**

Potential risks associated with VFD implementation <sup>will</sup> must be identified, such as compatibility issues or unexpected operational challenges. Mitigation plans must be developed to address these risks and minimize their impact on the vacuum pump control system (Paul R. Amyotte, 2006).

#### **Change Management:**

Change management practices must be implemented to smoothly transition from the existing control system to the VFD-based solution. Communicate changes, address concerns, and provide necessary training for users (Power, 2021). Correctly cited

#### **Quality Management Systems (QMS):**

Integrate a QMS to ensure that the VFD installation and control system meet quality standards. Regularly assess the performance, reliability, and safety of the vacuum pump control system, making continuous improvements based on quality metrics (nibusinessinfo, 2023).

**Continuous Improvement:**

Regularly evaluate the efficiency and performance of the VFD-controlled vacuum pump. Implement improvements based on data to optimize energy consumption, reduce downtime, and improve overall system reliability (businessmap, 2023). [Correctly cited](#)

**Commercial Awareness:**

The commercial implications must be considered of implementing a VFD-controlled vacuum pump. Analyse the economic benefits, such as energy savings and reduced maintenance costs, to justify the investment (businessmap, 2023). [Correctly cited](#)

**Intellectual Property Rights:**

Ensure that unique features associated with the VFD technology are properly protected. Adhere to intellectual property laws and agreements to safeguard the innovation behind the VFD-controlled vacuum pump (evalueserve, 2023). [Correctly cited](#)

**Legal Compliance:**

Adhere to relevant legal requirements, including safety standards and regulations associated with VFD usage. Ensure that the installation and operation of the VFD comply with industry-specific guidelines and local laws to mitigate legal risks (A.Fathima, 2021).

**7.4 Risk assessment**

In (table 6) of the appendix is a risk assessment for the installation of the control system. This risk assessment is used to identify potential hazards and ensuring the safety of personnel involved in the project.

*This is a good section, looking forward to seeing it implemented.*

## 8. Conclusions and Recommendations

The project to upgrade the vacuum pump control system is a step towards efficiency, sustainability, and ethical engineering practices. By deciding to replace the star-delta starter with a vfd control system shows a commitment to innovation, energy conservation and adherence to industry best practices. The chosen solution including the Siemens PLC and HMI paired with a Mitsubishi Inverter Drive, stands out as the most effective solution. By being cost effective, its simplicity and easy integration makes it the most optimal solution for controlling the vacuum pump.

This project shows a commitment to ethical engineering principles. The focus on energy efficiency through using a VFD aligns with environmental responsibility. It does this by being able to adjust the speed of the vacuum pump based on the demand. This ensures that energy consumption is optimized. This contributes to a reduced carbon footprint and cost savings. This shows a effort to industrial progress and ecological considerations.

The emphasis on safety and maintenance aligns with ethical concern and employee wellbeing. The implementation of emergency protocols, safety standards and regular maintenance procedures shows a dedication to create a secure working environment. By having safety and a priority it ensures compliance with regulations and shows an importance to responsibility and care.

Sustainability in the context of societal and business is a big driver for this project. The operational flexibility offered from the control system enables the adaptation of the vacuum pumps speed to the process requirement promoting efficiency. The societal impact of the project is evident by the contribution of resource conservation and reduced environmental impact.

The economic impact of the project are significant. The initial investment of the project is substantial, the long term benefit in energy saving, reduced maintenance costs and improved operational efficiency showcases the project to be an economical viable decision. The focus on cost effectiveness is important to ensure the project is sustainable and has a good return on investment.

For the longevity of the project the continuous improvement will be key. Assessment of the control systems performance along with proactive risk management and adherence to quality management systems will be a large factor into the projects long term success.

Wide range of sources correctly listed and cited in the main text.

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## 10. Appendix

### 10.1 Project proposal

#### SGEL6000 INDEPENDENT PROJECT

##### PROJECT PROPOSAL DOCUMENT

Student Name: Jordan Rees  
Project Title: Vacuum Pump Control System  
Date: 13/10/23  
Budget: £10000

##### Description of Project

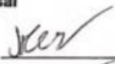
The project will be carried out by myself based in a local meat processing plant.

The main purpose of the project is to use a variable frequency drive (VFD) to control a vacuum pump to increase the efficiency of the pump which will reduce the amount of energy used while producing the same amount of vacuum stability which will save the company money and will be better for the environment. The lifespan of the vacuum pump and the lifespan of wearable parts inside the vacuum pump will also increase while using a VFD. This will reduce the cost of maintaining the vacuum pump. The amount of noise pollution produced by the vacuum pump is less with a VFD controlled pump due to the pump not needing to run at high speeds.

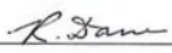
Currently the vacuum pump is controlled by a star delta starter which keeps the pump running at a constant high speed which is not energy efficient. By using a VFD to control the vacuum pump the speed of the motor can be lowered dependant on vacuum levels. A pressure sensor is installed in the vacuum line which will feedback to the VFD and the VFD will change the speed of the vacuum pump accordingly to reach the desired vacuum level.

The project should be completed by April 2024.

##### **Agreement for project proposal**

Student Signature:  Date: 19/10/23

Industrial Supervisor Signature:  Date: 19/10/23.

Academic Tutor Signature:  Date: 19/10/23

## 10.2 Risk Assessment for implementation phase

| Hazard Description                                                   | Likelihood | Severity | Risk Level | Control Measures                                                                      |
|----------------------------------------------------------------------|------------|----------|------------|---------------------------------------------------------------------------------------|
| Electrical shock during control system installation                  | Low        | High     | Medium     | Follow electrical safety protocols and use proper personal protective equipment (PPE) |
| Noise hazards from vacuum pump operation                             | Medium     | Moderate | Medium     | Provide hearing protection for personnel working in noisy areas                       |
| Moving parts and pinch points during installation                    | Medium     | Moderate | Medium     | Ensure proper machine guarding                                                        |
| Control system or vacuum pump malfunction leading to process failure | Low        | high     | Medium     | Implement regular maintenance schedules                                               |
| Slips, trips, and falls during installation                          | Low        | Medium   | Low        | Keep work areas clean and organized                                                   |

Table 6: Risk assessment

## 10.3 Scoring matrix for solutions

| Criteria                      | Solution 1 | Solution 2 | Solution 3 |
|-------------------------------|------------|------------|------------|
| Cost-Effectiveness            | 9/10       | 5/10       | 7/10       |
| Simplicity and Ease of Use    | 8/10       | 6/10       | 7/10       |
| Functionality and Performance | 8/10       | 9/10       | 7/10       |
| Flexibility and Expandability | 7/10       | 8/10       | 6/10       |
| Programming and PID Control   | 8/10       | 7/10       | 6/10       |
| Overall Integration           | 9/10       | 6/10       | 7/10       |
| Total Score (Out of 60)       | 49/60      | 41/60      | 40/60      |

Table 7: Scoring matrix for solutions

## 10.4 WBS chart

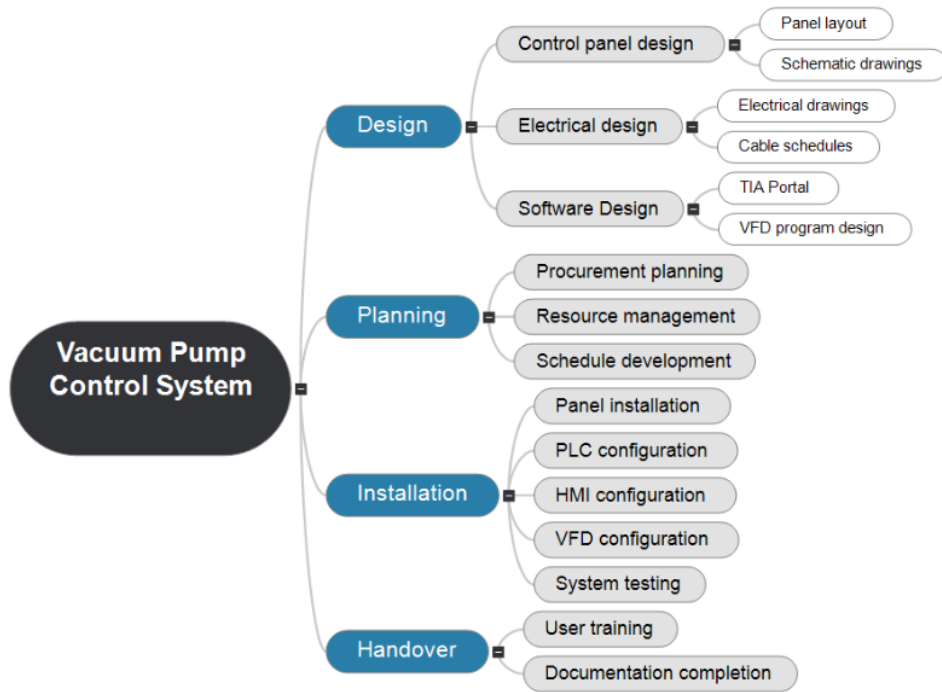


Figure 2: WBS chart

## 10.5 Gantt chart *A detailed plan*

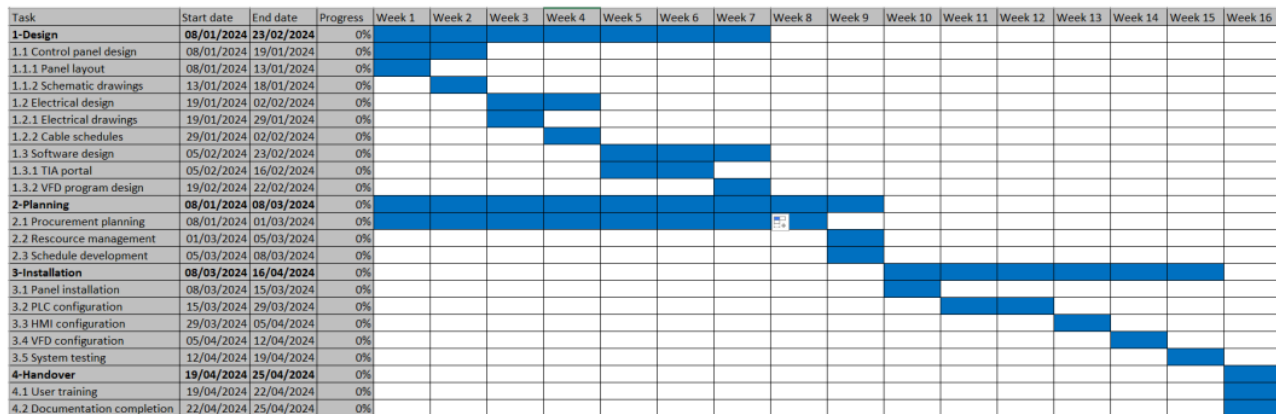


Figure 3: Gantt chart

*This is quite linear and nothing shown about contingencies*

another column is need to show actual spend

## 10.6 Costing spreadsheet

| Item | Component                                       | Units              | Cost       |
|------|-------------------------------------------------|--------------------|------------|
| 1    | Siemens Simatic S7 1200 Series                  | 1                  | £512.40    |
| 2    | Siemens KTP 700 Series Touch Screen HMI - 7 in  | 1                  | £877.20    |
| 3    | Mitsubishi Inverter Drive, 22 kW, 3 Phase       | 1                  | £3,087.60  |
| 4    | RS PRO Steel wall box                           | 1                  | £176.96    |
| 5    | Siemens LOGO!POWER power supply                 | 1                  | £96        |
| 6    | Labour <i>what is your estimate for labour?</i> |                    | ###        |
|      |                                                 | <b>Total cost:</b> | <b>###</b> |

Table 8: Costing spreadsheet

## 10.8 Literature review

*There should be 3 block diagrams, one for each solution*

*What are the signals that link the block together - analogue, discrete digital, ProfiNet, ProfiBus or Wifi?*

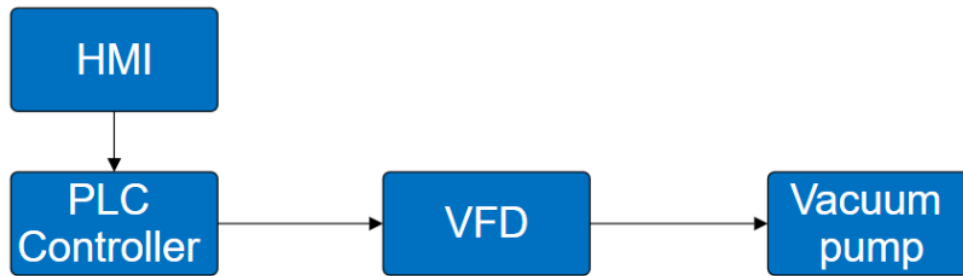


*Figure 4: Solutions block diagram*

SGEL6000

Independent Project

# Log Book

*This is a good log book but some entries could have a lot more detail*

Jordan Rees

Vacuum Pump Control System

2023-2024

## Summary of Entries

| Log Entry | Date     | Brief Description of Activity                                              | Duration (hrs) | Accumulated time (hrs) |
|-----------|----------|----------------------------------------------------------------------------|----------------|------------------------|
| 1         | 29-09-23 | Discussion with employer about project ideas.                              | 3              | 3                      |
| 2         | 06-10-23 | Discuss with my college lecturer about my project idea.                    | 3              | 6                      |
| 3         | 13-10-23 | Work on project proposal and background research.                          | 6              | 12                     |
| 4         | 20-10-23 | Work on project background and sign off project proposal                   | 6              | 18                     |
| 5         | 27-10-23 | Work on project background and source a vacuum pump for the project        | 4              | 22                     |
| 6         | 03-11-23 | Work project background                                                    | 3              | 25                     |
| 7         | 10-11-23 | Work on project background and discuss with facilities manager the project | 5              | 30                     |
| 8         | 17-11-23 | Work on project background                                                 | 4              | 34                     |
| 9         | 24-11-23 | Work on project background and discuss with lecturer about writing out FDS | 6              | 40                     |
| 10        | 01-12-23 | Work on FDS and make changes to project background                         | 4              | 44                     |
| 11        | 08-12-23 | Finish off FDS and test planning start on literature review                | 6              | 50                     |
| 12        | 15-12-23 | Work on literature review                                                  | 10             | 60                     |
| 13        | 22-12-23 | Finish off assignment                                                      | 10             | 70                     |

# Log Entry Sheet

|                        |          |
|------------------------|----------|
| Log Number             | 1        |
| Date                   | 29-09-23 |
| Duration (hrs)         | 3        |
| Accumulated time (hrs) | 3        |

## Record of activities and achievements

Phone call with my employer discussing projects. Came up with the idea of changing the star delta starter for a vacuum pump to a variable frequency drive. A meeting was arranged with my employer when I am back in work to finalise what project I will be doing.

## Plans for next week

Speak with my college lecturer and propose the idea of changing the start delta starter to variable frequency drive.

Signed \_\_\_\_\_ *R. Davies*

Signed \_\_\_\_\_ J.REES

# Log Entry Sheet

|                        |         |
|------------------------|---------|
| Log Number             | 2       |
| Date                   | 6-10-23 |
| Duration (hrs)         | 3       |
| Accumulated time (hrs) | 6       |

## Record of activities and achievements

Discussed the proposed idea about changing the star delta starter to a variable frequency drive and how it would be beneficial for the company such as saving energy. Another project that was proposed was creating an automated fan that would change speed depending on temperature.

## Plans for next week

Have a meeting with my employer about what project I will be doing and propose the automated fan project.

Signed \_\_\_\_\_ *R. Davies*

Signed \_\_\_\_\_ J.REES

# Log Entry Sheet

|                        |          |
|------------------------|----------|
| Log Number             | 3        |
| Date                   | 13-10-23 |
| Duration (hrs)         | 6        |
| Accumulated time (hrs) | 12       |

### Record of activities and achievements

Finished project proposal and source estimated budget cost. Did background research on Using VFD to control a vacuum pump to give me an idea of what method to use.

Looked into implementing a PLC into the system, looked at getting a Siemens SIMATIC S7-1200 Series. This is because the VFD might not have an analogue input for a PID loop system implemented. Therefore a PLC can be used to create the PID loop to create a speed setpoint and take the speed setpoint output from the PLC and put it into the speed setpoint input of the VFD.

<https://uk.rs-online.com/web/p/plcs-programmable-logic-controllers/8624477>

<https://uk.rs-online.com/web/p/inverter-drives/2362540?gb=s>

[https://ceur-ws.org/Vol-1498/HAICTA\\_2015\\_paper25.pdf](https://ceur-ws.org/Vol-1498/HAICTA_2015_paper25.pdf)

### Plans for next week

Present proposal to my manager and do further research into different methods that will be best suited for my project, budget of £10,000.

Signed            *R. Davies*

Signed \_\_\_\_\_ J. REES

# Log Entry Sheet

|                        |          |
|------------------------|----------|
| Log Number             | 4        |
| Date                   | 20-10-23 |
| Duration (hrs)         | 6        |
| Accumulated time (hrs) | 18       |

## Record of activities and achievements

Set up structure for the main report and started working on project background such as the background of the company, what sort of system is currently in place and the new system that is going to be implemented and why it will be beneficial for the company.

I also went through the final proposal with my boss and signed the document.

Went through the ethics part of project background task with my lecturer and what references to use.

## Plans for next week

Finish off project background, work on what VFD is needed and get a block diagram of the vacuum system that is already in place.

Signed \_\_\_\_\_ *R. Davies*

Signed \_\_\_\_\_ J. REES

# Log Entry Sheet

|                        |          |
|------------------------|----------|
| Log Number             | 5        |
| Date                   | 27/10/23 |
| Duration (hrs)         | 4        |
| Accumulated time (hrs) | 22       |

## Record of activities and achievements

Worked on project background and sourced a vacuum pump that can be used to implement my project. The vacuum pump sourced was a 22kw pump that currently uses a star delta starter system that feeds vacuum to a sealing machine.

## Plans for next week

Continue with project background for constraints

Signed \_\_\_\_\_ *R. Davies*

Signed \_\_\_\_\_ J.REES

# Log Entry Sheet

|                        |          |
|------------------------|----------|
| Log Number             | 6        |
| Date                   | 03-11-23 |
| Duration (hrs)         | 3        |
| Accumulated time (hrs) | 25       |

## Record of activities and achievements

Sourced more websites for a wider range of sources for project background to give myself a better understanding of how the system can be implemented.

## Plans for next week

Have a meeting with the facilities manager that maintains the vacuum systems and work on project background.

Signed \_\_\_\_\_ *R. Davies*

Signed \_\_\_\_\_ J. REES

# Log Entry Sheet

|                        |          |
|------------------------|----------|
| Log Number             | 7        |
| Date                   | 10-11-23 |
| Duration (hrs)         | 5        |
| Accumulated time (hrs) | 30       |

## Record of activities and achievements

Had a meeting with the facilities manager and discussed my project and he is happy with the project and is supplying the pump for the VFD to be implemented. Worked on the project background for sustainability.

## Plans for next week

work on project background and work on FDS

Signed \_\_\_\_\_ *R. Davies*

Signed \_\_\_\_\_ J.REES

# Log Entry Sheet

|                        |          |
|------------------------|----------|
| Log Number             | 8        |
| Date                   | 17-11-23 |
| Duration (hrs)         | 4        |
| Accumulated time (hrs) | 34       |

## Record of activities and achievements

Worked on project background using various resources for references.

## Plans for next week

Work on project background and start planning FDS.

Signed *R. Davies*

Signed \_\_\_\_\_ J. REES

# Log Entry Sheet

|                        |          |
|------------------------|----------|
| Log Number             | 9        |
| Date                   | 24-11-23 |
| Duration (hrs)         | 6        |
| Accumulated time (hrs) | 40       |

## Record of activities and achievements

Worked on project background and had a discussion with my lecturer about planning FDS such as how it should be laid out and what should be implemented in the FDS.

## Plans for next week

Finish off project background and work on FDS.

Signed *R. Davies*

Signed \_\_\_\_\_ J. REES

# Log Entry Sheet

|                        |          |
|------------------------|----------|
| Log Number             | 10       |
| Date                   | 01-12-34 |
| Duration (hrs)         | 4        |
| Accumulated time (hrs) | 44       |

## Record of activities and achievements

Work on FDS which includes what criteria the project should meet and make changes to project background.

## Plans for next week

Work on FDS and test planning.

Signed *R. Davies*

Signed \_\_\_\_\_ J. REES

# Log Entry Sheet

|                        |          |
|------------------------|----------|
| Log Number             | 11       |
| Date                   | 08-12-23 |
| Duration (hrs)         | 6        |
| Accumulated time (hrs) | 50       |

## Record of activities and achievements

Finished off FDS and test planning. Started literature review doing first solution by creating a block diagram and explaining the process

## Plans for next week

Carry on with literature review.

Signed *R. Davies*

Signed \_\_\_\_\_ J.REES

# Log Entry Sheet

|                        |          |
|------------------------|----------|
| Log Number             | 12       |
| Date                   | 15-12-23 |
| Duration (hrs)         | 10       |
| Accumulated time (hrs) | 60       |

## Record of activities and achievements

Work on literature review

## Plans for next week

Finish off assignment

Signed \_\_\_\_\_ *R. Davies*

Signed \_\_\_\_\_ J. REES

# Log Entry Sheet

|                        |          |
|------------------------|----------|
| Log Number             | 13       |
| Date                   | 22-12-23 |
| Duration (hrs)         | 10       |
| Accumulated time (hrs) | 70       |

## Record of activities and achievements

Finished off assignment

## Plans for next week

Prepare for assignment 2

Signed \_\_\_\_\_ *R. Davies*

Signed \_\_\_\_\_ J. REES

FINAL GRADE

GENERAL COMMENTS

# 74/100

PAGE 1

PAGE 2

PAGE 3

PAGE 4

**Text Comment.** considered

**Text Comment.** Although executive summaries should be written in the past tense, it does not mean it should be written as if the project was complete. This assignment is about completing the planning and design phase.

PAGE 5

QM

**Spelling**

Spelling error

**Text Comment.** proposed

**Text Comment.** check

**Text Comment.** This is a good introduction that explains the contents of the report.

PAGE 6

**Text Comment.** a short and clear description

QM

### Correctly cited

Citation method conforms to Harvard standard, well done.

QM

### Correctly cited

Citation method conforms to Harvard standard, well done.

PAGE 7

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QM

### Correctly cited

Citation method conforms to Harvard standard, well done.

QM

### Correctly cited

Citation method conforms to Harvard standard, well done.

QM

### Correctly cited

Citation method conforms to Harvard standard, well done.

**Text Comment.** only the surname of the author is needed

PAGE 8

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QM

### Correctly cited

Citation method conforms to Harvard standard, well done.

QM

### Correctly cited

Citation method conforms to Harvard standard, well done.

QM

### Correctly cited

Citation method conforms to Harvard standard, well done.

QM

### Correctly cited

Citation method conforms to Harvard standard, well done.

QM

### Correctly cited

Citation method conforms to Harvard standard, well done.

QM

### Correctly cited

Citation method conforms to Harvard standard, well done.

PAGE 9

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QM

**Correctly cited**

Citation method conforms to Harvard standard, well done.

QM

**Correctly cited**

Citation method conforms to Harvard standard, well done.

**Text Comment.** This is another good section showing the breadth of your reading

QM

**Correctly cited**

Citation method conforms to Harvard standard, well done.

QM

**Correctly cited**

Citation method conforms to Harvard standard, well done.

QM

**Correctly cited**

Citation method conforms to Harvard standard, well done.

QM

**Correctly cited**

Citation method conforms to Harvard standard, well done.

PAGE 10

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QM

**Correctly cited**

Citation method conforms to Harvard standard, well done.

QM

**Correctly cited**

Citation method conforms to Harvard standard, well done.

PAGE 11

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**Text Comment.** will be

**Text Comment.** To which standards are you referring to?

PAGE 12

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**Text Comment.** will

QM

**Correctly cited**

Citation method conforms to Harvard standard, well done.

**Text Comment.** will

QM

**Correctly cited**

Citation method conforms to Harvard standard, well done.

**Text Comment.** no need for double quotation marks as your are not quoting

QM

**Correctly cited**

Citation method conforms to Harvard standard, well done.

**Text Comment.** will

**Text Comment.** Have you read the standard? If so, which parts apply?

PAGE 13

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**Text Comment.** will

**Text Comment.** Your use of "must" gives the sense that you are instructing your reader.

PAGE 14

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**Text Comment.** In this section, its OK to use the word "must" as you are setting out the project requirements.

PAGE 15

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PAGE 16

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**Text Comment.** Generally, this is also a good section but see comments below

PAGE 17

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**Text Comment.** How do you define accurately? should be +/- %

**Text Comment.** This reads like a test not an expected outcome

**Text Comment.** There should be 3 block diagrams, one for each solution

**Text Comment.** This table belongs in the appendix, this section should begin with the block diagram

**Text Comment.** The block diagram could be different as the block titles would have different component names

**Text Comment.** Also, the links between the blocks could be different, such as analogue, digital, profiNet or ProfiBus

**Text Comment.** no need for brackets

**Text Comment.** redundant word

**Strikethrough.**

**Text Comment.** namely:

**Text Comment.** I agree, solution 1 seems the best with the highest score and the widest coverage.

**Text Comment.** all solutions should be within budget

**Text Comment.** drive

**Text Comment.** 's



**Correctly cited**

Citation method conforms to Harvard standard, well done.

**Text Comment.** will

**Text Comment.** will

QM

**Correctly cited**

Citation method conforms to Harvard standard, well done.

PAGE 23

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QM

**Correctly cited**

Citation method conforms to Harvard standard, well done.

QM

**Correctly cited**

Citation method conforms to Harvard standard, well done.

QM

**Correctly cited**

Citation method conforms to Harvard standard, well done.

PAGE 24

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**Text Comment.** This is a good section, looking forward to seeing it implemented.

PAGE 25

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**Text Comment.** Wide range of sources correctly listed and cited in the main text.

PAGE 26

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PAGE 27

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PAGE 28

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PAGE 29

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PAGE 30

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PAGE 31

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PAGE 32

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PAGE 33

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**Text Comment.** A detailed plan

**Text Comment.** This is quite linear and nothing shown about contingencies

**Text Comment.** another column is need to show actual spend

**Text Comment.** what is your estimate for labour?

**Text Comment.** There should be 3 block diagrams, one for each solution

**Text Comment.** What are the signals that link the block together - analogue, discrete digital, ProfiNet, ProfiBus or Wifi?

**Text Comment.** This is a good log book but some entries could have a lot more detail

**1. ENGAGEMENT WITH LITERATURE**

Sections 3 and 5: Engagement in research, judicial use and critical evaluation sources for project constraints and literature review of solutions  
There is good evidence of use of literature relevant to the project (7/10)  
Sections 3, 5 and 8: Extent of reading, use of credible sources, use of Harvard method for listing and citing  
Very good use of the Harvard method from a wide range of sources, cited and listed correctly. (8/10)

**15****2. KNOWLEDGE AND UNDERSTANDING**

Section 3: Project background and problem definition  
Clearly explained for your reader to understand although a few photos or diagrams would have helped. (3/5)  
Section 3: Project constraints: Ethical.  
Well covered (4/5)  
Section 3: Project constraints: Sustainability  
Well covered (4/5)  
Section 3: Project constraints: Legal/Commercial  
Well covered (4/5)

**15****3. COGNITIVE AND INTELLECTUAL**



Section 4: Functional Design Specification  
A good section with some detail (3/5)

15

Section 4: Test planning  
Generally good, with clear methods of testing and expected results (4/5)

Section 5: Evaluation of solutions and justification of final solution  
Good review of solutions although your block diagrams should contain more information about signals. (3/5)

Section 7: Conclusions and Recommendations  
A very good section (5/5)

#### 4. PRACTICAL APPLICATION



Section 6: Project Plan  
A detailed plan but no contingencies (4/5)

14

Section 6: Working breakdown structure, costing exercise and management techniques  
A good detailed diagram and good references to techniques (4/5)

Appendix: Risk assessment for implementation phase  
A good section but could be more detailed (3/5)

Appendix: Planning phase log-book entries.  
All log entries present but some are very brief (3/5)

## 5. TRANSFERABLE SKILLS



### Section 1: Executive summary

Although executive summaries should be written in the past tense, it does not mean it should be written as if the project was complete. Could be more detailed. (2/5)

**15**

All Sections: Presentation quality of the report, diagrams, charts, tables, figure numbering, page, and section numbering etc  
Very good (4/5)

All Sections: Quality of the writing style, use of punctuation and grammar  
Generally, very good with few mistakes in spelling and punctuation. (4/5)

Word count limit not exceeded  
Not exceeded (5/5)