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by Joshua Williams

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1. Executive Summary

The project is for a local electronic industrial repair company that is based in South Wales. Specialist repairers in many industry components such as, AC & DC drives, Industrial PLC, Industrial Robot, and PCBs (Printed Circuit Board).

The project will be a loading system for loading the Siemens S120 series of drives. It is needed as it was ^{identified} presented as a service that is not currently offered. The company is always looking for improving the quality of service of a repair. With this in mind, undertaking this project will only add to the evolving test procedures.

The problem definitions were discussed, and two main reasons are outlined. ^{this is part of the previous sentence} Which were,

^{no need for capitals} Elements of the drive will not be proven to run at full capacity without a full load test. Along with, Equipment and Personnel Safety. This is supported by research showing the benefits of implementing a loading system and what happens when this method is not used in a service repair of a drive, along with the implications that are involved without a valid service. Additionally, a number of constraints were researched and how this can have an impact on the project at different stages. Environmental factors such as sustainability were discussed, with a key factor being with the policies promoting requirements to follow environmental legislation, awareness, and recycling.

^{considered (only one was chosen)} The methods chosen were a Dynamometer, a DC machine, and an Eddy Current Brake. Once all methods were researched, a scoring matrix for each solution was tabulated along with a radar diagram. This is to show which solution would be most suited to the application, and the most suited was Solution 2. As it had many advantages whereby the design offers ease of integration into a Siemens controller and the simplicity of the DC drive would prove efficient when manufacturing the project. The other two solutions lacked in manufacturers guidance and effected budget constraints.

It was found that by adding to various testing procedures, the project will be planned and implemented as it would ^{no need to add this justification here} separate the company from their competitors. A drive loading system has many uses within an industrial environment, ^{This belongs earlier} this is designed to be controlled and regulated to apply a suitable load to an electric motor. The drive connected to the motor under a load test would be tested for functionality and component discrepancies. Further benefits are primary parameters which can be tested, such as speed, voltage, current, and horsepower/kilowatts. *This paragraph repeats or adds to what you said earlier*

There are other things you did which you have not mentioned.

2. Introduction

has you should have said "The project incorporates ". Projects shouldn't really evolve.
The project evolved to incorporate a new testing facility, which would be to load test drives specific to the Siemens S120.

don't give a narrative of your tasks

The first task was to compile a project proposal (Appendix 9.1) which would be a real live system manufactured at the company's workshop site. When established, the next stage was to investigate the background, this involved producing evidence on why it was needed, and the suitable regulations required.

The next stage involved a Function Design Specification (FDS) this was produced from the project requirements and discussed with stakeholders involved in the project. From this, the testing plan was constructed, and this will show if the project has met the functional and quality requirements. The literature review involves research of the three solutions that would be most suited for the project application.

reads more like a summary
Once the solution had been chosen, the penultimate phase was the use of management techniques such as work breakdown structure, Gantt chart plan, costing spreadsheet and monitoring various milestones. All these techniques will enable the project to be efficient and to keep tasks on track. The final section of the report will comprise of an overall conclusion and recommendations for the project and the developments.

An introduction should outline the contents of the report and should not be written as a narrative of tasks in the past tense, it reads like a log book.

3. Project Background and Problem Definition and Constraints

3.0 Background

The project will be a load testing machine and a suitable method will be chosen. The company is keen to improve the quality of service of a repair and by undertaking this project, it will only add to the evolving test procedures. This type of drive has been chosen as it is one of the most popular models that is brought into the company. The enquiries for load testing the S120 range has only grown, and as a team a decision was made to devise a project that will undertake the load testing of this model of drive.

3.1 Problem Definition

When repairing drives, certain problems within the modules cannot always be detected unless the drive is put under a load test. Failures and significant damage may occur in drives when reintroduced into production without knowing if the drive can withstand the application load. The two reasons below show that achieving a load test can most certainly be beneficial.

3.1.1 Reason 1: Elements of the drive will not be proven to run at full capacity without a full load test

The drives can range from very simple single board drive with few circuits, to very complex drives with a vast range of circuit boards along with option cards. Despite the variation and complexity, all drives have dedicated circuits to provide an output current to a motor as well as handle the load for the application. When failing to apply a full load, the electronic components such as firing boards, IGBTs (Insulated-Gate Bipolar Transistor) and SCRs (Silicon Controlled Rectifier) will not fully engage without the full load of a motor. The components above are key components of a drive and will not be tested for strength under a no-load test (mechanically unloaded rotating shaft). This is where a full load test will be introduced (Inc., 2023).

The typical load test will cover the following components:

- Output Power Transistors (IGBT)
- DC Bus capacitors
- The Input Bridge / SCR (Silicon Controlled Rectifier)
- Control Power Supply

- Gate Control Circuits (Hartman, 2014).

A S120 drive which is electrically connected to a motor which has a mechanically unloaded shaft will not be tested to full capacity. As the above components will not be fully engaged without a full load on the motor. These are key components of a drive and need to be tested for strength. By doing this test it will usually be taken up to the manufacturer's average rating in amperes as close as possible to prove correct functionality (Inc., 2023). Correctly cited

3.1.2 Reason 2: Equipment and Personnel Safety

It is important that a repaired drive is fully load tested, an issue in a high voltage system must be treated seriously. Due to the imminent safety risks to person(s), potential damage to equipment, threats to system reliability, environmental hazards, and the risk of descending failures. A malfunctioning component within the electrical system could lead to a fault current into unintended places. The current which is misplaced will constitute a major safety threat for the person(s) commissioning the reinstallation. Within an industrial setting, costly equipment may be damaged through faulty components, decrease in production and above all, the safety of employees (Inc., 2023). Spelling Correctly cited

3.2 Constraints

3.2.1 Ethical Constraints

3.2.1.1 Safety Considerations

As the machine will have a safety interlocking system this new industrial machine will have the correct integration for safety for users to prevent accidents and injuries. The design of the system has compliance with the Machine Directive EN60204 as this applies to machines with an integrated control system. The two important terms include:

Machine - assembly that consists of moving parts.

Manufacturer - an individual that designs and manufactures a machine for personal use or trademark that is governed by the directive in question (ABB, 2023). Correctly cited

3.2.1.2 Informed Consent

At the implementation stage of the project, informed consent from the relative person(s) and comprehensive information about the system's benefits and potential risks will be assessed (Engineering, 2011). Correctly cited

3.2.1.3 Conflict of interest

If conflicts occur, problems can arise such as, compromised decision-making, producing an unsafe system, and effecting project outcomes. This must be navigated if the situations arise, emphasising the importance of transparency, disclosure, and adherence to the codes of ethics. Failure to address conflict of interest can result in reduce trust, jeopardise safety and undermine the integrity of the engineering profession (Tech,2023). [Correctly cited](#)

3.3 Ethical Engineering

In automated systems, ethical engineering is an important aspect of designing and developing a system that can operate in a manner that respects human values and rights.

These principles will be considered when embarking on this project.

3.3.1 Honesty and integrity

Engineering personnels require to uphold the highest standards of professional conduct such as fairness, openness, honesty, and integrity (Council, 2023). [Correctly cited](#)

3.3.2 Respect for life, law, the environment and public good

Engineering personnel will have an obligation to obey all applicable laws and regulations and to uphold published standards, facts, and wider public interest (Council, 2023). [Correctly cited](#)

3.3.3 Accuracy and rigour

Engineering personnels are obligated to responsibly acquire and effectively apply expertise, knowledge and skills are essential for execution of the personal responsibilities (Council, 2023). [Correctly cited](#)

3.3.4 Leadership and communication

Engineering personnels have a responsibility to comply with and encourage high standards of leadership and communication (Council, 2023). [Correctly cited](#)

The organisation adheres to the following ethical engineering policies (Table 1):

Company Ethical Policies
Anti-corruption and Bribery Policy, this shows the organisation is accordance with Bribery Act 2010 (Government, 2023).
Anti- Slavery & Human Trafficking Policy shows that as an organisation is consistent with our obligations under the Modern Slavery Act 2015 (CPS, 2022).
Equality, Diversity, and Inclusion Policy shows the organisation is committed to promoting equal opportunities in employment and eliminating unlawful discrimination. The aim is for our workforce to be truly representative of all sections of society and for all to feel respected and valued.

Table 1 - Ethical Policies

3.4 Environmental & Sustainability

The organisation has an Environmental policy in which all work practices must adhere to. The responsibilities in environmental matters and recognising good environmental management must be an integral and fundamental part of the business. Although the beliefs are that a minimal impact is on the environment, continued improvements for environmental performance are in place. Examples are listed below:

- Complying with the requirements of all environmental legislation.
- Assessing the environmental effects of all business operations.
- Raise awareness, encourage participation, and train employees.
- Expecting similar environmental standards from all suppliers and contractors.
- Actively promoting recycling internally to our staff and externally to our customers and suppliers.
- Monitoring progress and review performance annually (Lipcaneanu, 2023).

Correctly cited

When sourcing components for this project, where appropriate, reconditioned components will be used. Software development will be a main driver in this project as it will make the system more sustainable as operations and changes can be made efficiently without infringing hardware components. The reason being a controller was chosen as the versatility of this piece of equipment can be easily managed in making changes to an automated system.

3.5 Legal / Commercial

In accordance with the Management of Health and Safety at Work Regulations (1999), the company will carry out risk assessments on all activities that present a risk to employees or others. These risk assessments will be carried out in line with Health & Safety Executive guidance, and the procedure for doing so is as follows (Legislation, 2023). Correctly cited

- Identify the significant hazards involved in our activity.
- Decide who might be harmed and how.
- Evaluate the level of risk and decide if existing precautions are sufficient, or if more needs to be done.
- Record the significant findings of the assessment.
- Review the assessment when things change, or there is reason to believe that it is no longer valid (Legislation, 2023). Correctly cited

Management of change process will be deployed for an installation of the new machine. Analysis of this machine will be taken out with relevant documentation to suit the application. This will be approved or denied if Health and Safety regulations and environmental risks were not encountered for. Any changes that were raised in the review and analysis stage will be implemented. All levels of risk to persons and equipment will be ^{accounted} encountered for. As the project will be intended for the ^{UK?} GB market with scope of the relevant UK product safety legislation it must have UKCA conformity marking applied and meet all the other requirements of applicable legislation before being placed into the ^{UK?} GB market (Executive, 2023). Correctly cited

The company's purchasing is in accordance with the Processes and Procedures documentation, with accordance to BS EN ISO 9001: 2015 (Purchasing 7.4). This ensures all purchasing, sourcing strategies, acquiring goods services are transparent, cost-effective, and timeously. Items are purchased by designated Purchasing, Engineers or Commercial staff specified to criteria. The Managing Director purchases significant value items (ISO9001help, 2023). Correctly cited

3.6 Additional Risks

As the current economic climate is very uncertain, the price of components can vary week by week. This means, the ^{cost} budget for each of the components will increase slightly and therefore could impact on the project. Sourcing components within the UK will be the main priority, however, if they are available and significantly cheaper in other countries this would be considered (project-management, 2023). Correctly cited

budget is the total spend allowable which should not increase after the proposal has been agreed

3.7 Machine Safety

At the designing stage of the project, machine interlocks and emergency stops will be implemented where deemed necessary. A risk assessment (Appendix 9.2, Figure 6) will be produced upon the design stage of the project and will provide the PL (Performance Level) rating. The company will have the European Declaration of Conformity certificate to be completed when a full assessment of the machine has been completed. The declaration relates, are in conformity with the following standard(s) or other normative document(s) (Table 2):

European Declaration of Conformity Standards
Machinery Safety Directive 98/37/EC, modified to 98/79/EC and all its amendments.
Electromagnetic Compatibility Directive 2004/108/EC and all its amendments.
Low Voltage Directive 2006/95/EC and all its amendments.
EN61000-6-1, 2019.
EN60204-1; 2018, EN55022 class B; 1998, DIN VDE 0839 part 81-1, EN55014-1, 2006, EN55011, 2004.
We also confirm that the aforementioned equipment is fully in compliance with mandatory EU regulations.

Table 2 - Conformity Standards for Project

4. Functional Design Specification and Test Plan

4.0 Purpose

no need to justify this section

The purpose of this section is to define the functional requirements for the Siemens Sinamics Load test System.

4.1 System Overview

4.1.1 Component Interaction and Data Flow

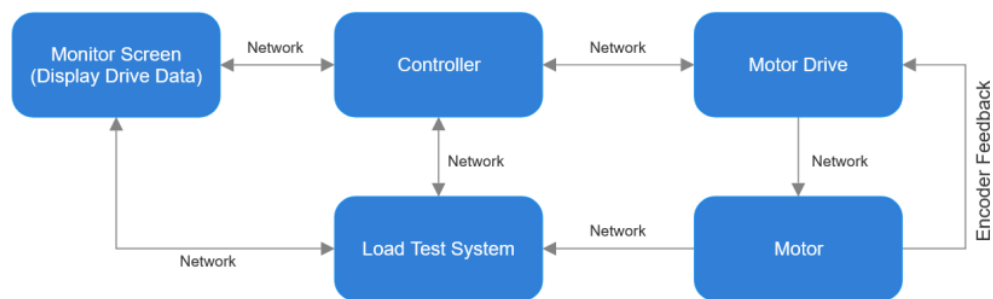


Figure 1 - Block Diagram of System

Figure 1 is showing the representation of the system operation. The arrows represent the network that the system will use to talk to each other. The Controller will be the master in the system, with Monitor screen monitoring drive performance. The drive will be connected to the motor to set speeds and the load system will be connected to the motor that will act as a brake on the motor.

4.2 Functional Requirements

4.2.1 Functional Design Specification (FDS)

The FDS will be made up of references for each element of the specification. Table 3 is showing the descriptive actions that will be produced for each element of the system. The functional design specification will be agreed upon with the Line Manager.

What about your PL rating, how will you assess it and achieve it?

Label	Category
A	Function of Machine
B	Safety Features
C	Display Data Operation
D	Alarm Messages
E	Performance Requirements

Table 3 - FDS Reference Table

Table 4 is listing all the items with the suitable reference numbers for each of the project objectives. This table shows an overview of how the system should operate and behave in different system functions.

Item	Objective
A1.1	The loading device must load a motor up to a required load.
A1.2	At different speeds the loading device must adapt withstand the change of speed specification.
A1.3	The load testing system must work in conjunction with the Siemens Sinamics Test rig.
B1.1	The system must have the correct enclosed guarding for moving parts in accordance with the Machine Directive EN60204.
B1.2	Machine must have the correct interlocking device(s) in accordance with ISO 14119.
B1.3	The machine must have safe isolation of the test rig and loading system.
B1.4	Any fault condition will be displayed on the local control panel (beacon or pilot light flashing 0.5Hz).
B1.5	Prevention in place to stop overheating and overload of the loading system.
C1.1	Performance data displayed of the drive under the load test must be monitored. Parameters required: Speed, Current and Torque.
C1.2	Display data Push button(s) to engage drive control.

C1.3	Different motor speeds must be selected.
C1.4	Machine must only be operable from the location of the HMI and Control panel.
D1.1	A display message showing that all safety device contacts are closed.
D1.2	Upon selection of any engagement of moving components, a second display will appear with a message to make sure the intended operation is correct.
D1.3	A display to inform operator of any faults with any part of the communication system.
E1.1	System should be capable of applying load conditions in a timescale that is accurate amount for testing.
E1.2	The loading system should have required amount of torque that is suitable for the motor that is connected to the drive. The testing range should be: 5.0Nm – 90Nm
E1.3	The loading system should be able to achieve the speed testing range of 500rpm – 3200rpm.
E1.4	The loading system should be required to test the following current range: 4.0A – 18A (motor rating values).
E1.5	The loading system will be capable of testing the power range of 2.1kW to 8.2kW.

Table 4 - Functional Design Specification (FDS)

4.2.2 Test Planning

From the FDS in the previous section, the following test plan will be executed at the implementation stage of the project. Table 5 will provide the evidence to show if the project has been successfully completed.

Section	Test Number	Reference	Test Description	Expected Result	Actual Outcome	Pass/Fail	Evidence
A. Function of the machine.	1	A1.1	Verify the loading device can load a motor up to the required load.	Meets the required load specification. The range of 5.0Nm – 90Nm.			
	2	A1.2	Ensure the loading system adapts to different speeds during the test. <i>list the speeds</i>	The loading system adapts to the speed changes.			
	3	A1.3	Ensure the loading system adapts to different speeds during the test.	Confirmed communication and the machine works cohesively.			
B. Safety Features.	4	B1.1	Verify enclosed guarding for moving parts. <i>how will this be done?</i>	Guarding effectively protects moving parts.			
	5	B1.2	Ensure the system has the correct	Interlocking devices work correctly and			

				interlocking device(s) per ISO 14119.	conform with the regulation.			
	6		B1.3	Safe isolation of the test rig and loading system.	Safe isolation is confirmed.			
	7		B1.4	Any fault condition will be displayed on the local control panel.	Fault condition is labelled and displayed appropriately.			
	8		B1.5	Verify prevention measures for overheating and overloading.	Heating and overloading protection is effective.			
C. Display Data Operation								
	9		C1.1	Performance data displayed of the drive under the load test: • Current (A). • Torque (Nm). • Speed (RPM).	Performance parameters are displayed.			
	10		C1.2	Engage drive control.	Push button engages drive control.			
	11		C1.3	Confirm the selection of different motor speeds.	Different motor speeds can be selected.			
	12		C1.4	Verify the operability of the	The machine successfully			

					machine only from the location of the HMI and Control panel.	operates from the HMI and control panel.			
D. Alarm Messages									
	13		D1.1		Confirm the display message showing that all safety device contacts are closed.	Safety device contacts close with display shown.			
	14		D1.2		Test the appearance of a second display message upon the selection of moving components to ensure the intended operation is correct.	The prompt is displayed upon selection.			
	15		D1.3		Confirm the display informing the operator of any faults in the communication system.	Display information appears as expected.			
E. Performance Requirements									
	16		E1.1		Confirm the system's ability to apply load conditions within	Load conditions are applied accurately in the specified			

				an accurate timescale.	timescale.				
17	E1.2			Loading system should have the required amount of torque that is suitable for the motor that is connected to the drive.	Torque is suitable for the motor.				
18	E1.3			The loading system should be able to achieve the speed testing range of 500rpm – 3200rpm.	The loading system confirms the required range of RPM.				
19	E1.4			The current range of 4.0A – 18A (motor rating values) can be achieved.	The system can safely load to the following current range.				
20	E1.5			The power range of 2.1kW to 8.2kW can be tested.	The loading system can handle the power range.				

some of the above tests could be split up into bottom and top of ranges

Table 5 - Testing Table

How do you know if you have achieved your PL rating?

5. Literature Review and Choice of Final Solution

5.0 Purpose

The three solutions for the loading system that are considered are in the following sections.

5.1 *Solution 1 – Dynamometer for the loading system*

This solution comprises of a dynamometer which is a measuring device that uses force tension applications and weight or pull forces for measurement. It is employed to assess the torque, force, speed, and power needed to operate a motor, measurements of both torque and rotational speed taken together (Iqsdirectory, 2023). Correctly cited

Calibration will be a critical aspect of this solution as it comes with various methods to ensure proper calibration for accurate and precise readings (Iqsdirectory, 2023). Correctly cited

5.1.1 Method of Solution 1

This will have a PLC (Programmable Logic Controller) to control a load testing dynamometer that is employed to assess the performance of the motor and drive under load. The load conditions will be varied by an HMI (Human-machine-interface).

5.1.2 Operation of Solution 1

- **Setup (Figure 2):** The motor will be connected to the dynamometer, ensuring correct alignment. A torque sensor would be used to measure the torque and the motor's speed.
- **Controller:** The type of controller will be PLC (Siemens S7-1200 – CPU 1214C) and will be programmed to the specified parameters for testing speed profiles, load conditions and test durations. This controller will have integrated safety features into to program to immediately halt the test if abnormal conditions occur.
- **Load Testing:** The PLC system will initiate the load testing sequence. The dynamometer will apply a variety load to the motor with the pre-programmed conditions. The real-time data such as speed, torque and other relevant data will be inputted into the PLC (Bishop, 2005). Correctly cited

- **Safety Measures:** The PLC will monitor the specified parameters to ensure the motor and drive run within the incorporated safety limits. Emergency stops and interlocks are integrated to stop the test if any dangerous conditions are detected.
- **Analysis and Results:** Once testing is completed the data is collected and analysed to evaluate the drives performance under different load conditions. The results will be reported in a graphical form through the HMI.

5.1.3 Functional Diagram Overview of Solution 1

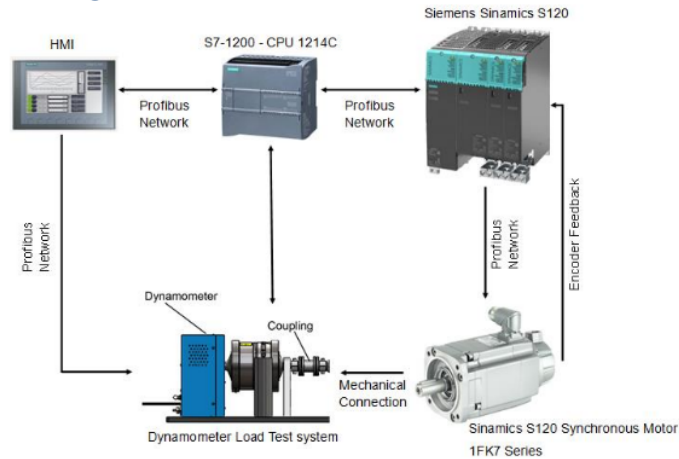


Figure 2 - Overview of Solution 1

5.1.4 Benefit of Solution 1

- **Automation:** The S7-1200 will automate the testing procedure, reducing the need for mechanical intervention and reduce on hardware as many functionalities can be produced within the S7-1200. This is the most suitable option as it can be integrated into an S120 efficiently.
- **Accuracy:** The loading system being a dynamometer and controlled by a PLC, ensures precision and different load conditions can produce reliable results.
- **Other factors:** This is a proven method with this type of loading technique and aesthetically more suited due to the physical size.

5.2 Solution 2 – Dynamic Braking with a DC Machine as the loading system

This solution uses the technique of dynamic braking, this is employed for electrical motor braking. The mechanical energy is converted into electrical or heat energy, this will then slow and stop the load (Emmo, 2023). The DC shunt machine is often used in this application as their flexibility in both stopping and starting. The rotating armature generates a back

electromotive force (EMF), and this energy is dissipated as heat in the resistor. The shunt field would remain connected to the line meaning that the motor would act as a generator, this is driven by the stored energy in the load (Rader, 1943). Correctly cited

5.2.1 Method of Solution 2

This will have a PLC to control the DC machine braking system that will control the engagement of a dynamic braking resistor, and this is when deceleration is detected. The 1FK7 motor will be connected to this via a mechanical coupling. The load conditions will be monitored through the HMI and control changes will be made.

5.2.2 Operation of Solution 2

This DC drive will probably be able to performance regenerative braking to save you using the resistor

- **Setup (Figure 3):** The DC machine would be connected to the test motor through a mechanical system. The PLC would control different components to operate the DC drive for the DC machine and the PLC will be programmed to control the S120. This will both work in conjunction to achieve the loading operation.
- **Controller:** A Siemens S7-1200 with the CPU 1214 would be the most suitable option for the ease of integration for the S120. Relevant safety measures would be incorporated into the PLC to bring the system to a failsafe.
- **Load testing:** The machine will be acting as a generator and is converting mechanical energy into electrical energy and supplying power to a load. As the load system represents the electrical load this would be with a resistive load that would use a load resistor. The loads will be adjusted creating different demands on the generator (Daware, 2014). Correctly cited
- **Safety Measures:** Emergency stop, and interlocking switches will be implemented where suitable. Ventilation would have to be installed as the dissipate heat generated by the DC machine.
- **Analysis and Results:** This will be monitored by a HMI with the torque, speed and current measurements displayed with relevant trend graphs.

5.2.3 Functional Diagram Overview of Solution 2

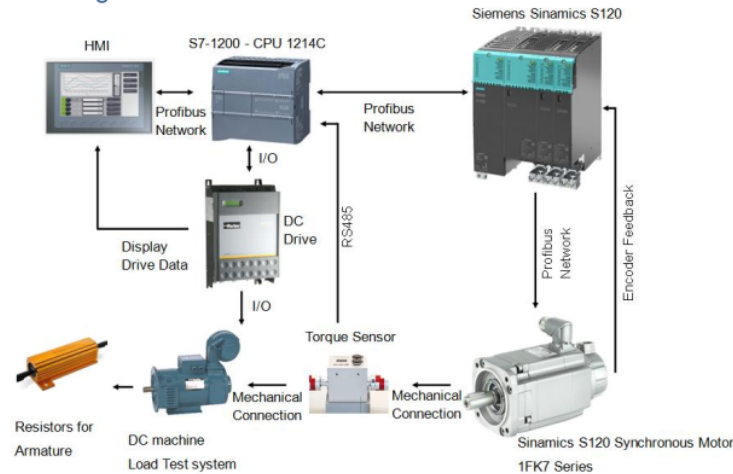


Figure 3 - Overview of Solution 2

5.2.4 Benefit of Solution 2

why not use regenerative braking in the DC drive?

- **Automation:** Safe system practices can be easily implemented due to being an automated system. Mechanical interventions are needed less due to the hardware the controller has. The Sinamics drive can be implemented into an automated system efficiently.
- **Accuracy:** Being a DC machine, it offers good efficiency over range of speeds. Using this as a generator allows for a variety of speeds. As it is a small application, it will have a relatively simple design (Portescap, 2021). Correctly cited

5.3 Solution 3 – Mechanical loading system with an Eddy Current Brake

The function of an eddy current brake is based on friction and kinetic energy, unlike mechanical brakes. Eddy current brakes rely on electromagnetism to stop objects from moving. For eddy currents to be produced a conductor passes through the magnetic field, in turn creating opposing forces that spin inside the conductor. Lenz's law states, an eddy current produces a magnetic field that is in opposition to the magnetic field that produced it. Meaning eddy currents are an inverse response to the source magnetic field. This reaction makes ideal conditions for a clean deceleration (Smith, 2019) Correctly cited

5.3.1 Method for Solution 3

Siemens S7-1500 PLC will be connected to the DSP7000 controller, controller will be connected to the eddy current brake, torque transducer to measure torque and through the software control of the test rig, will measure performance. The Siemens Sinamics drive will be connected to 1FK7 motor that will be mechanically connected to the torque sensor and eddy current brake.

5.3.2 Operation of Solution 3

- **Setup (Figure 4):** PLC using, I/O to the DSP7000 controller will be connected to the eddy current brake through a serial link. The torque transducer also connected through serial will measure the torque on the rotating shaft. Through a USB connection this will be connected to a specific software (M-TEST) compatible with the DSP7000. This will monitor and run the performance parameters required.
- **Controller:** Siemens S7-1500 PLC connects to the Siemens Sinamics and the DSP7000 controller. This can be controlled through an HMI.
- **Load Testing:** Using the DSP 7000 the eddy current brake will be adjusted for power, torque, speed and set points for each can be chosen. The data will be fed back through the I/O to PLC/HMI.
- **Safety Measures:** As many applications are connected to the system. A suitable safety circuit must be designed to suit all stopping needs. Requires water cooling for brake due to manufacturer's datasheet (over 15Nm).
- **Analysis and Results:** The results will be recording on the M-TEST software.

5.3.3 Functional Overview Diagram

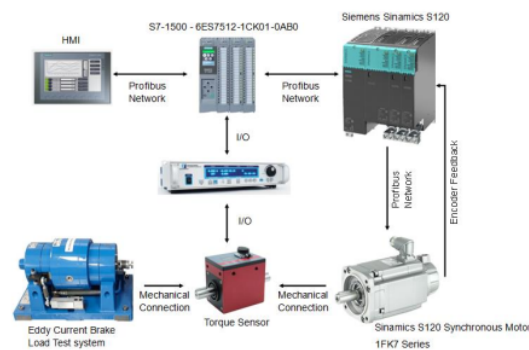


Figure 4 - Overview of Solution 3

5.3.4 Benefit of Solution 3

- **Automation:** As the method applies different methods of software development a reduction in hardware and manual intervention.
- **Accuracy:** The eddy current is accurate in measurement as it is frictionless, being finely controlled and free of pollution and noise (Forrister, 2019). Correctly cited
- **Analysis and Results:** Monitored through the M-TEST software and the Siemens Sinamics drive will be monitored through the PLC and HMI.

5.4 Costing for each Solution

Each of the tables (Appendix 9.6) shows each component cost for each solution. This will be one of the sections to be implemented into a scoring system that will determine the most suitable solution.

5.5 Solution Comparisons

Solution 1 has advantages as it has a simple design and is within budget. It will produce sufficient results but the integration into the S7-1200 PLC would prove to be difficult. This being that the software and controls of the dynamometer calibration, as the manufacturer does not offer the suitable guidance. Solution 2 advantages are that the design offers ease of integration into a Siemens S7-1200 and an HMI for efficient data visualisation. The DC drive has simple I/O and analogue speed reference that can be inputted into the PLC. The other advantage is that the torque sensor in this method has RS485 communication and data can be inputted into the PLC. Solution 3 has an advantage in overall accuracy and will be best suited to the application, however, due to the budget constraints and integration disadvantages suggests that it would not be sufficient. Also, the inclusion of water cooling for the brake addresses specific machine requirements for safety and regulations. Table 6 is showing an overview comparison of solutions.

	Advantages	Disadvantages
Solution 1	- Simple Design - Within Budget - Accuracy of results - Size of system	- Integration Difficulties - Insufficient guidelines on installing the dynamometer
Solution 2	- Ease of integration into the siemens S7-1200 - Efficient calibration - Torque sensor uses RS485 communication. - DC drive has simple I/O and analogue speed reference	- Aesthetic of the overall machine - Limited capabilities
Solution 3	- Overall accuracy the best - Aesthetics are pleasing. - Size of the system	- Not within budget - Integration capabilities within the timeframe - Water cooling for brake would prove difficult to implement

Table 6 - Solution Comparison Table

5.6 Solution Scoring System

The table (Appendix 9.3, Table 7) shows a scoring system for each of the solutions. These have specified targets that each solution should meet. A scoring system from 1 - 10 and 10 being the best. From the results, a radar diagram (Figure 5) was produced. This shows a good overall comparison of the characteristics of each target. Solution 2 has the best score and is also best seen from the radar diagram (Figure 5). From this matrix it will be chosen for the final implementation. The main benefit of choosing this solution is because the implementation is efficient, the accuracy of this method proves substantial, and the cost savings compared to the others is also an advantage.

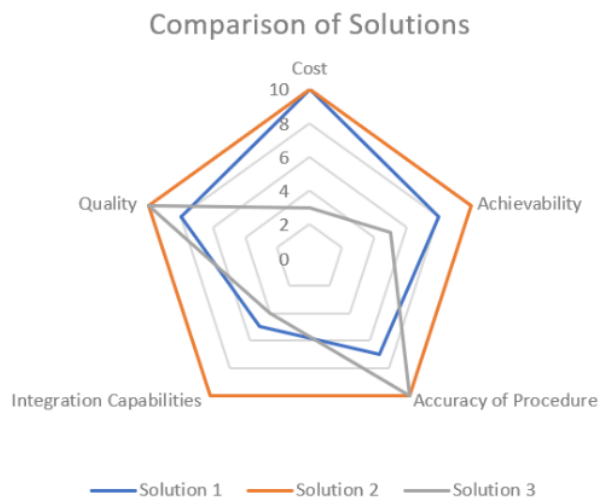


Figure 5 - Radar Diagram for Scoring Matrix

6. Project Planning, Work breakdown and Management Techniques

6.0 Work Breakdown Structure (WBS)

The Work breakdown structure is shown to clearly show project variables. The breakdown is divided into sub sections. This structure is a helpful project management tool for many reasons. As it breaks the project down into bite-size components, this makes it less overwhelming and more manageable (Christine Organ, 2023). Project managers apply this management approach to divide complex projects to get things done faster and efficiently. Breaking down projects suggests that work can be done by different employees. Increasing productivity and improving project management (Kukhmarov, 2023). This management technique is employed to this project and the structure is shown in the WBS in Appendix 9.4, Figure 7.

6.1 Gantt Chart

A Gantt chart is being used in to show each of the tasks that need to be completed, at what timescales and deadlines. This was compiled from the WBS in section 6.0. The benefit of using this method is that it provides: Big Picture Visualisation, tracking progress, manageability, team, and resource management (Stepanov, 2023). Shown in Appendix 9.5, Figure 8 is the Gantt chart that has been compiled and will be monitored and edited throughout the duration of the project.

6.2 Costing Spreadsheet

The cost sheet in Appendix 9.6.4, Table 11 will be tracked throughout any of the purchasing in the project, showing each of the components needed and average costing. The importance of having this cost sheet will help with cost control and cost reduction, providing individuals involved with pricing of goods and aiding to adhere to the project budget (Srivastava, 2023).

6.3 Project Milestones and Task Timeline

This project milestone timeline (Appendix 9.7, Figure 9) will be used as the markers signify a milestone at each stage of the project development. This is an important component for understanding and provides everyone involved with the progress tracking, clarity, and

productivity. Each milestone will be treated as checkpoints throughout the course of the project, ensuring that each stage has been completed and keeping the project in the right direction (Calibey, 2023). Correctly cited

7. Conclusions and Recommendations

The first objective was to consider the constraints regarding the effects on project outcomes along with adhering to the different regulations. It was noted how the project will promote environmental and sustainability engineering, by using reconditioned components testing repaired drives.

The key aspects of the project aims were researched alongside design, financial, planning and management techniques. Once the FDS was presented and agreed, it was tabulated to show each variable that is going to be delivered for the machine, along with performance and safety requirements. The FDS body was implemented into three design solutions, with one solution being identified as the most suitable. From the comparisons, all solutions were analysed against the criteria. It was concluded that Solution 2 (using a Dynamic Braking with a DC Machine as the loading system) would be the most suitable. Evidence suggests that it has a proven track record of being a good system for the application as it offers good adaptability and efficiency over a range of speeds. Additionally, it has a simple design meaning it can be implemented within the project time frame. The other solutions were not capable due to the time requirements, as it required additional research into the manufacturing of the machine because of the lack of support from the manufacturers surrounding the technology.

Upon deciding the solution through a scoring system, management techniques were researched and implemented into a Work Breakdown Structure (WBS). This utilises a sub section approach which will make the project less overwhelming and more manageable. From the WBS, three further components were derived. Firstly, a Gantt chart to track the progress through the duration of the project and making sure it is delivered on schedule. Secondly, a costing spreadsheet to track purchases and observe cost control and reduction. Thirdly, project milestones will be monitored and treated as checkpoints throughout. The testing table that was produced will be used when the implementation and validation task is completed. This will then be evaluated to see if the project outcomes have been met.

The recommendations are to monitor each structure to track each of the tasks. Regular assessments will be conducted to ensure it is on schedule, this is to promote continuous monitoring and evaluation. The adaptability of the project plan will be vital if unpredicted challenges arise, given the outcomes to achieve. Effective risk management, identifying challenges within the chosen solution and executing contingencies ^{what were they?} will be vital. Promoting open communication among the team members and stakeholders, ensures the project outcomes are achieved. Implementation of Environmental impact assessments promote the

project sustainability goals. Post-implementation phase, a review and testing results will provide an analysis of the outcomes to the criteria and will identify successes, areas for improvement and provide data for future projects. Following these recommendations it enhances the repair service quality, customer satisfaction, and overall project efficiency and sustainability.

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9. Appendix

9.1 Project Proposal

SGEL6000 INDEPENDENT PROJECT

PROJECT PROPOSAL DOCUMENT

Student Name: Joshua Williams
Project Title: The Load Testing of Servo Drives
Date: 06/10/23
Budget: £10000

Description of Project

This project will be a real live system that is based at the company site. This will be a test rig to load test servo Siemens AC drives (specific to the Siemens Sinamics). The Siemens Sinamics S120 series was chosen as this is the most popular servo drive that is repaired. The project will consist of a load testing method to load Siemens servo drives. The Siemens S120 drive will communicate over a network to a PLC and HMI. The HMI will gather relevant information of the drive's performance under the load test. The data to be monitored will be speed and current of the drive that will be performing under the load test. By doing this the customer can receive details on their drive performance under load.

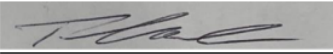
The project will be based in the company's workshop site. The project is required to meet customer requirements, as the company has requests from customers for load testing this type of servo drive. The other reason is that our competitors do not really offer this service so this will be our USP (unique selling point) for this drive series.

The persons involved in the project will be the Author and the R&D Engineer Matthew Robinson.

The project must be completed by April 2024.

Agreement for project proposal

Student Signature: _____ JW _____ Date: 06/10/23

Industrial Supervisor Signature:  Date: 20/12/23

Academic Tutor Signature: _____ RD _____ Date: 22/12/23

9.2 Risk Assessment for Implementation Phase

What about your PL rating, what is it and how did you assess it?

LOAD TEST RIG FOR SERVO DRIVES RISK ASSESSMENT

PROJECT ID	PROJECT NAME	PROJECT AUTHOR	ASSESSED BY
1	LOAD TEST RIG FOR SERVO DRIVES	J.Villiams	J.Villiams
PROJECT DESCRIPTION			
The project has a loading system that will be testing the S120 series of drives.			
APPROVED BY			
J.Villiams			

PROBABILITY KEY		IMPACT KEY	
1	Unlikely	1	Low
2	Likely	2	Medium
3	Very Likely	3	High

Rate Probability and Impact Levels on a scale of 1 to 3

REF ID	HAZARD DESCRIPTION	PROBABILITY	IMPACT	SCORE	RISK LEVEL	CURRENT RISK MITIGATION AND CONTROL MEASURES	ACTION PLAN	STATUS	COMPLETION DATE	RATING MATRIX					RATING_NAME	
										LEVEL		RA				
001	Impact from Moving Motors and Mechanical Components	1	3	3	LOW	Components in an enclosure with interlock guards.	To continue investigation of new interlock methods.	TBC	01/04/2024	1	3		3	6	9	1
002	Electrocution	2	3	6	MEDIUM-HIGH	Safe isolation practices and only trained personnel to operate test rig.	Implement an inspection of equipment and lookout tags when rig is not in use.	TBC	01/04/2024	2	2	2	4	6	2	VERY LOW
003	Lifting repaired components onto test rig	3	2	6	MEDIUM-HIGH	Undertake any unnecessary manual handling.	Emphasise to personnel the importance of handling.	TBC	01/04/2024	3	1	1	2	3	3	LOW
004	Use of chemicals such as cleaning and lubrication fluids.	2	1	2	VERY LOW	Quantities kept to a minimum. Chemicals kept in dedicated storage.	Keep the COSHH assessments up to date.	On-going	01/04/2023			1	2	3	4	MEDIUM LOW
005	Noise - Operation of the load system.	3	3	9	HIGHEST	Wear ear protection when operating, if noise level exceeds recommended.	When the machine is operational, complete a noise level reading.	TBC	01/04/2023						6	MEDIUM HIGH
006	Combining the workings of the two test rigs.	2	2	4	MEDIUM LOW	Make sure the connections of the two are secure. Safe isolation of the two are in place.	State in the manual a clear procedure for combining the two safely and within the scope of UKCA.	TBC	01/04/2024						9	HIGHEST
007	Slips, Trips and Falls	2	2	4	MEDIUM LOW	Make sure all cables are not on the floor. No motors are left on floor and secure on test bench.	Point of work risk assessment to be completed prior any testing activity.	TBC	01/04/2024							
008	PPE - eye protection, gloves, steel toe cap boots.	2	3	6	MEDIUM-HIGH	PPE is required when operating machinery.	Enforce the current PPE required to operate the	TBC	01/04/2024							

Figure 6 - Risk Assessment for Implementation Phase

9.3 Scoring Matrix for Solutions

Target	Solution 1	Solution 2	Solution 3
Cost	10	10	3
Achievability	8	10	5
Accuracy of Procedure	7	10	10
Integration Capabilities	5	10	4
Quality	8	10	10

Table 7 - Scoring Table

9.4 WBS Chart

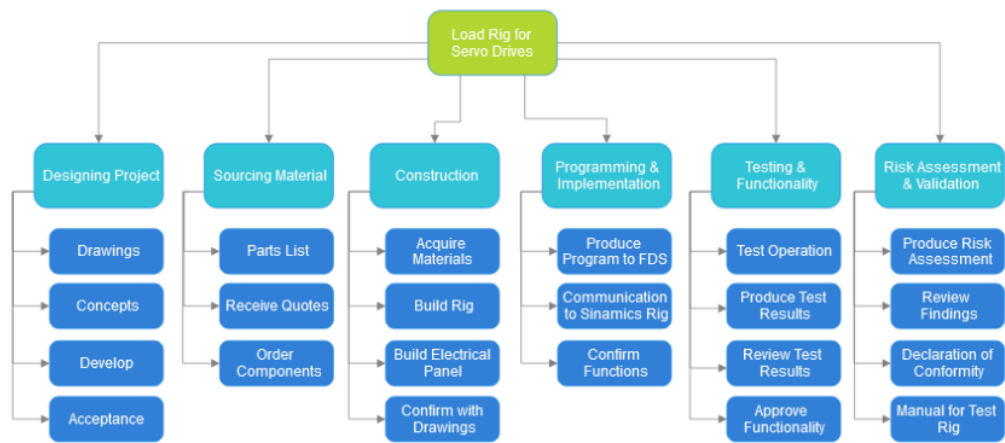


Figure 7 - Work Breakdown Structure

Good level of detail

9.5 Gantt Chart

Load Test Rig for Servo Drives Project Planner

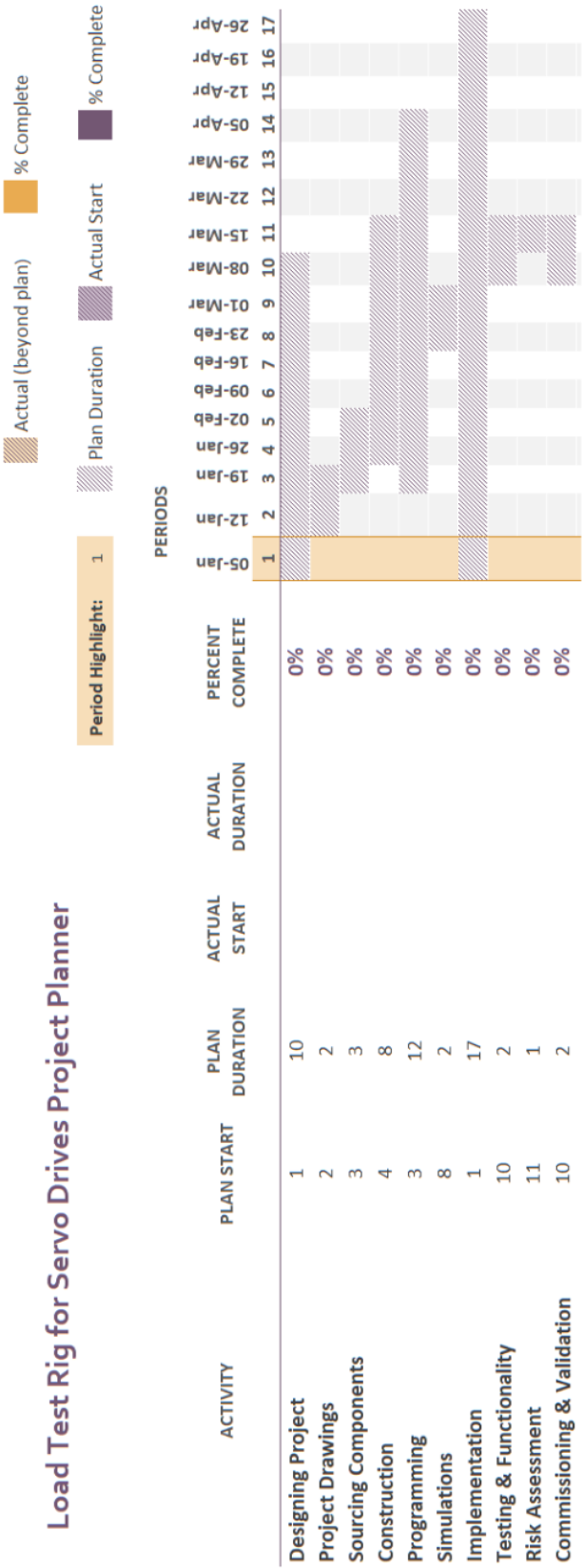


Figure 8 - Gantt Chart

Each of the tasks and subtasks of the WBS should be included in this chart

What are your contingencies?

9.6 Costing Spreadsheets

9.6.1 Solution 1 Cost

Component	Cost
Siemens HMI	£500
S7-1200 (CPU 1214C)	£600
Siemens S120 1FK7 Series Motor (18A)	£1750
Siemens S120 1FK7 Series Motor (5A)	£1200
Siemens Profibus Master Module	£400
Dynamometer Loading System	£3350
Electrical Components	£1000
Rexroth Aluminium Profile	£700
Foamex and Clear Acrylic Panels	£300
Total Cost	£9800

Table 8 - Cost for Solution 1

9.6.2 Solution 2 Cost

Component	Cost
Siemens HMI	£500
S7-1200 (CPU 1214C)	£600
Siemens S120 1FK7 Series Motor (18A)	£1750
Siemens S120 1FK7 Series Motor (5A)	£1200
Siemens Profibus Master Module	£400
DC Drive	£550
DC Motor	£1500
Torque Sensor	£750
Electrical Components	£1000
Rexroth Aluminium Profile	£700
Foamex and Clear Acrylic Panels	£300
Total	£9500

Table 9 - Cost for Solution 2

9.6.3 Solution 3 Cost

Component	Cost
Siemens HMI	£500
S7-1500 (6ES7512-1CK01-0AB0)	£2000
Siemens S120 1FK7 Series Motor (18A)	£1750
Siemens S120 1FK7 Series Motor (5A)	£1200
Siemens Profibus Master Module	£400
Eddy Current Brake	£1000
DSP7000 – High Speed Controller	£7000
Torque Sensor	£750
Electrical Components	£1000
Rexroth Aluminium Profile	£700
Foamex and Clear Acrylic Panels	£300
Total	£16600

Table 10 - Cost for Solution 3

9.6.4 Final Solution Costing Sheet

Project Name: Load Rig for Servo Drives

RUNNING WEIGHTED AVERAGE TOTAL:

£9,508.33

DETAILS		THREE-POINT COST ESTIMATE SCENARIOS			WEIGHTED AVERAGE	ADDITIONAL INFORMATION / NOTES
DATE	ITEM / TASK DESCRIPTION	BEST-CASE	MOST LIKELY / REALISTIC	WORST-CASE		
19/01/2024	Siemens 1BA \$120 Drive Motor	£1,200.00	£1,750.00	£2,500.00	£1,753.33	Can be sourced from used suppliers
19/01/2024	Siemens 5A \$120 Drive Motor	£1,000.00	£1,200.00	£2,000.00	£1,300.00	Can be sourced from used suppliers
19/01/2024	Siemens \$7-1200 PLC (CPU1214)	£400.00	£600.00	£800.00	£600.00	Can be sourced from used suppliers and model number can change.
19/01/2024	Siemens HMI with PROFIBUS	£300.00	£500.00	£700.00	£500.00	Can be sourced from used suppliers and model number can change.
19/01/2024	Siemens Profibus Master Module	£250.00	£400.00	£550.00	£400.00	Can be sourced from used suppliers
19/01/2024	Panel with accessories	£800.00	£1,000.00	£1,500.00	£1,050.00	
19/01/2024	Reuroth Aluminium Profile (KJN992425)	£500.00	£700.00	£900.00	£700.00	
19/01/2024	Foamex and Clear Acrylic panels	£200.00	£300.00	£400.00	£300.00	
19/01/2024	DC Motor	£1,200.00	£1,500.00	£2,200.00	£1,566.67	Can be sourced from used suppliers
19/01/2024	DC Drive	£400.00	£550.00	£750.00	£558.33	Can be sourced from used suppliers
19/01/2024	Torque Sensor	£500.00	£750.00	£1,000.00	£750.00	

Table 11 - Costing Spreadsheet for Final Solution

9.7 Project Milestone and Task Timeline

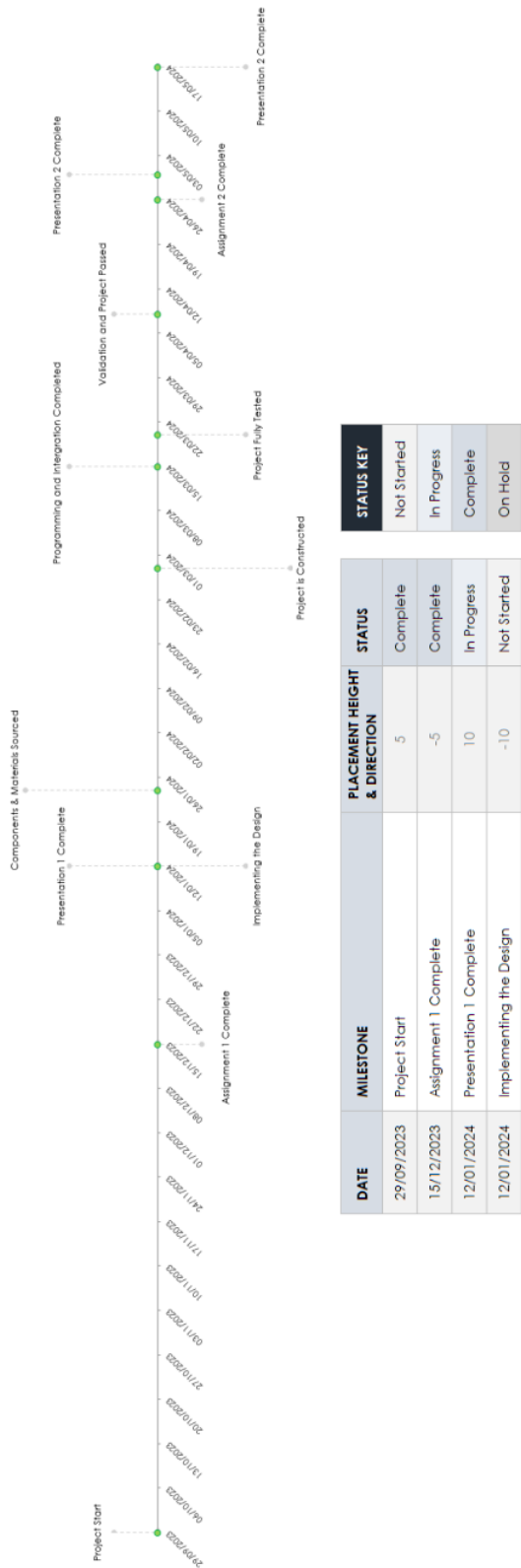


Figure 9 - Project Milestone Timeline

SGEL6000
Independent Project
Log Book

Joshua Williams
Load Test Rig for Servo Drives
2023-2024

Summary of Entries

Log Entry	Date	Brief Description of Activity	Duration (hrs)	Accumulated time (hrs)
1	29/9/23	Introduction to Project Requirements	2	2
2	06/10/23	Sourcing Project and Producing Proposal	4	6
3	13/10/23	Investigating Project software and components	4	10
4	20/10/23	Project Background Report Writing	4	14
5	27/10/23	Constraints Report Writing	6	20
6	3/11/23	Meetings and Report Writing	6	26
7	10/11/23	Reflected and amendments to report	2	28
8	17/11/23	Producing FDS and Test planning	8	36
9	24/11/23	Producing 3 solutions for the Literature Review	4	40
10	01/12/23	Report writing and research into 3 solutions	10	50
11	08/12/23	Report writing for Project Planning	30	80
12	15/12/23	Report writing for the conclusion	20	100
13	22/12/23	Finalising Report	10	110
14				
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30				

Log Entry Sheet

Log Number	1
Date	29/09/23
Duration (hrs)	2
Accumulated time (hrs)	2

Record of activities and achievements

Introduced to the expected outcomes of each task in Assignment 1. A better understanding of what the project must consist of at each stage.

From the discussions, the projects in mind can be put forward to the Supervisor to narrow down the appropriate project to meet the assignment needs. By doing this the proposal can be ready next week.

Project Ideas:

Load testing AC drives.

Plans for next week

Project Proposal needs to be completed, handed in and signed off by next week.

Signed ____ *R. Davies*

Signed ____ J. Williams ____

Log Entry Sheet

Log Number	2
Date	06/10/23
Duration (hrs)	4
Accumulated time (hrs)	6

Record of activities and achievements

Had a meeting with the Manager and R&D Engineer to discuss project ideas. As a collective we produced a project idea to load test servo drives. This was a good solution as the company's customer requests have increased for load testing these types of drives. The method of testing the load was discussed along with how to measure the data.

Upon this meeting a proposal for this project was produced.

Plans for next week

To discuss a suitable budget for the project that will meet the project demands.

Work on gathering suitable components list for the project.

Signed _____ *R. Davies*

Signed _____ J. Williams _____

Log Entry Sheet

Log Number	3
Date	13/10/23
Duration (hrs)	4
Accumulated time (hrs)	10

Record of activities and achievements

Accessed the most popular drives (30A,18A and 5A) that have been into the workshop to spec up the motors required for the project.

Gathering information from the drive datasheets on motor sizes required for each drive.

Compare the Siemens software starter and sizer to see which is most suitable for the project.

Researched and listed the dynamometers that could be suitable for the loading of the servo drives.

Plans for next week

Finalising the motor(s) spec and costings that are required for the project.

To narrow down the options for the dynamometer.

Signed *R. Davies*

Signed J. Williams

Log Entry Sheet

Log Number	4
Date	20/10/23
Duration (hrs)	4
Accumulated time (hrs)	14

Record of activities and achievements

Average budget has now been completed for the project and components required for the project.

Task 4 of the assignment has now been started, with project background and problem definition tasks being in progress.

Gathering evidence for the constraints element on task 4.

Plans for next week

Complete the task 4 section of the report.

Discuss the standards for the constraints section with the relevant person in the workplace.

Signed ____ *R. Davies*

Signed ____ J. Williams ____

Log Entry Sheet

Log Number	5
Date	27/10/23
Duration (hrs)	6
Accumulated time (hrs)	20

Record of activities and achievements

Seeked guidance from the H&S person to gather evidence on company policies on each constraint headings. We discussed what relevant information is required for the report and how the company operates each policy. We went into detail about how the project can be introduced into the European Declaration of Conformity certificate accreditation and the commissioning checklist was shown to me to give ideas on what requirements would be needed.

From the information gathered I had a better understanding on what each element of the constraints section requires from a company standpoint.

Plans for next week

Have the Task 4 section of the report finalised with changes from the feedback from tutors.

Gather information for the FDS and start building this section of the report.

Signed *R. Davies*

Signed J. Williams

Log Entry Sheet

Log Number	6
Date	03/11/23
Duration (hrs)	6
Accumulated time (hrs)	26

Record of activities and achievements

Finalised the task 4 section of the report with the guidance from both tutors and the H&S person in the workplace.

Had a meeting with the R&D Engineer to write down actions and needs for the FDS document. We discussed each function that the load testing machine would require.

Plans for next week

With evidence gathered from discussions, start writing the FDS section.

Signed _____ *R. Davies*

Signed _____ J. Williams _____

Log Entry Sheet

Log Number	7
Date	10/11/23
Duration (hrs)	2
Accumulated time (hrs)	28

Record of activities and achievements

Upon guidance, I need to add some elements to the ethical engineering constraints section of the report.

Wrote a draft of the points needed for the FDS.

Plans for next week

Completed the block diagram of the machine layout.

FDS needs to be written and completed.

Signed ____ *R. Davies*

Signed _____ J. Williams _____

Log Entry Sheet

Log Number	8
Date	17/11/23
Duration (hrs)	8
Accumulated time (hrs)	36

Record of activities and achievements

Amended task 4 of the report from the feedback given.

From the FDS draft points, a formal tabulated FDS was produced. This was devised from the specification required for loading a specific series of drives.

Now that the FDS is produced. From this the test planning table was produced, devised into certain sections for better understanding of the points.

Plans for next week

From the feedback, adjust the FDS and test planning tasks.

Produce solutions for the literature review section of the report.

Signed *R. Davies*

Signed _____ J. Williams _____

Log Entry Sheet

Log Number	9
Date	24/11/23
Duration (hrs)	4
Accumulated time (hrs)	40

Record of activities and achievements

From the feedback the FDS and test planning have now been amended with ranges of specific values for each of the performance requirements. The 3 solutions were discussed for the literature review and were chosen. The research into each method can now be produced.

Plans for next week

Research and produce supporting evidence for each project solution.

Complete Task 7 - Literature Review of the report.

Signed *R. Davies*

Signed ____J. Williams_____

Log Entry Sheet

Log Number	10
Date	01/12/23
Duration (hrs)	10
Accumulated time (hrs)	50

Record of activities and achievements

Researched 3 different solutions for the project which were, dynamometer braking, DC dynamic braking and Eddy current brake. Provided supporting evidence for each of the solutions with relevant arguments for each. A comparison of all solutions were completed and along with a scoring table. The scoring table was then produced into a radar diagram to show an outline of the best solution.

Plans for next week

From feedback make amendments to the literature review.

Complete task 8 of the report.

Signed *R. Davies*

Signed ____J. Williams____

Log Entry Sheet

Log Number	11
Date	08/12/23
Duration (hrs)	30
Accumulated time (hrs)	80

Record of activities and achievements

Researched the management techniques that are needed for Task 8. Produced the relevant tables and diagrams for each section of task 8. Wrote each of the sections in the report from the research.

The next stage of the report wrote the overall conclusion of the report, along with recommendations. Once this was completed, compiled the whole document as one whole assignment.

Plans for next week

From Feedback make any necessary changes.

Report must be finished.

Signed _____ *R. Davies* _____

Signed _____ J. Williams _____

Log Entry Sheet

Log Number	12
Date	15/12/23
Duration (hrs)	20
Accumulated time (hrs)	100

Record of activities and achievements

From the feedback in section 8, I changed the necessary points to improve. Once this was completed, the conclusion and recommendations report writing started. Managed to finish this section of the report and submitted for review. Produced a risk assessment for the implementation stage as this was outstanding from earlier on in the sections of the report. Used the suitable risk assessment method as this would be most suited to the machine. The report is now completed of all the tasks.

Plans for next week

From feedback edit the report to suit.

Compile the report together and template the report according to the brief.

Finalise the report ready for submission next week.

Signed *R. Davies* Signed J. Williams

Log Entry Sheet

Log Number	13
Date	22/12/23
Duration (hrs)	10
Accumulated time (hrs)	110

Record of activities and achievements

Finalised the report with the conclusion now completed. Edited the document to suit the specification of the brief with the correct headings and figures.
The executive summary and research was produced with relevant feedback for these areas.
The report is now submitted.

Plans for next week

To produce ideas for the presentation.

Signed *R. Davies*

Signed J. Williams

1451789

GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

79/100

PAGE 1

PAGE 2

QM

Good Structure

Report is structured exactly as stated in the assignment brief.

PAGE 3

PAGE 4

PAGE 5

Text Comment. identified

Strikethrough.

Text Comment. this is part of the previous sentence

Text Comment. no need for capitals

Text Comment. considered (only one was chosen)

Text Comment. no need to add this justification here

Text Comment. This belongs earlier

Text Comment. This paragraph repeats or adds to what you said earlier

Text Comment. There are other things you did which you have not mentioned.

PAGE 6

Text Comment. you should have said "The project incorporates ". Projects shouldn't really evolve.

Text Comment. has

Text Comment. ^

Text Comment. don't give a narrative of your tasks

Text Comment. reads more like a summary

Text Comment. An introduction should outline the contents of the report and should not be written as a narrative of tasks in the past tense, it reads like a log book.

PAGE 7

Text Comment. a

PAGE 8

QM

Correctly cited

Citation method conforms to Harvard standard, well done.

QM

Spelling

Spelling error

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

QM

Correctly cited

Citation method conforms to Harvard standard, well done.

QM

Correctly cited

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Correctly cited

Citation method conforms to Harvard standard, well done.

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Correctly cited

Citation method conforms to Harvard standard, well done.

QM

Correctly cited

Citation method conforms to Harvard standard, well done.

PAGE 10

Text Comment. to

Strikethrough.

QM

Correctly cited

Citation method conforms to Harvard standard, well done.

PAGE 11

QM

Correctly cited

Citation method conforms to Harvard standard, well done.

QM

Correctly cited

Citation method conforms to Harvard standard, well done.

Text Comment. accounted

Text Comment. UK?

Text Comment. UK?

QM

Correctly cited

Citation method conforms to Harvard standard, well done.

QM

Correctly cited

Citation method conforms to Harvard standard, well done.

Text Comment. cost

QM

Correctly cited

Citation method conforms to Harvard standard, well done.

Text Comment. budget is the total spend allowable which should not increase after the proposal has been agreed

PAGE 12

PAGE 13

Text Comment. no need to justify this section

Text Comment. What about your PL rating, how will you assess it and achieve it?

PAGE 14

PAGE 15

PAGE 16

Text Comment. one test needed for each size drive

Text Comment. list the speeds

Text Comment. how will this be done?

PAGE 17

PAGE 18

PAGE 19

Text Comment. some of the above tests could be split up into bottom and top of ranges

Text Comment. How do you know if you have achieved your PL rating?

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.

Text Comment. This DC drive will probably be able to performance regenerative braking to save you using the resistor

QM

Correctly cited

Citation method conforms to Harvard standard, well done.

Text Comment. why not use regenerative braking in the DC drive?

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 26

PAGE 27

QM

Correctly cited

Citation method conforms to Harvard standard, well done.

QM

Correctly cited

Citation method conforms to Harvard standard, well done.

PAGE 28

QM

Correctly cited

Citation method conforms to Harvard standard, well done.

PAGE 29

Text Comment. what were they?

PAGE 30

PAGE 31

PAGE 32

PAGE 33

PAGE 34

PAGE 35

Text Comment. What about your PL rating, what is it and how did you assess it?

PAGE 36

PAGE 37

Text Comment. Good level of detail

PAGE 38

Text Comment. Each of the tasks and subtasks of the WBS should be included in this chart

Text Comment. What are your contingencies?

PAGE 39

PAGE 40

PAGE 41

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PAGE 53

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GRADING FORM: NEW CSG-RUBRIC

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
Excellent engagement with lots of sources considered. (8/10)
Sections 3, 5 and 8: Extent of reading, use of credible sources, use of Harvard method for listing and citing
Wider range, correct method used. (8/10)

16

2. KNOWLEDGE AND UNDERSTANDING



Section 3: Project background and problem definition
Clear explanation given with some detail. (4/5)
Section 3: Project constraints: Ethical.
Good explanation given (4/5)
Section 3: Project constraints: Sustainability
Good explanation given (4/5)
Section 3: Project constraints: Legal/Commercial
Good explanation given (4/5)

16

3. COGNITIVE AND INTELLECTUAL



Section 4: Functional Design Specification
Very good levels of detail with a clear itemization system. PL rating has not been considered. (4/5)

16

Section 4: Test planning
Very good but some tests of ranges could have one test at each extent. (4/5)

Section 5: Evaluation of solutions and justification of final solution
Very good explanation given. However, you have not considered regenerative braking as a possible option that could save use of the resistor. (4/5)

Section 7: Conclusions and Recommendations
Excellent conclusions but few recommendations (4/5)

4. PRACTICAL APPLICATION



Section 6: Project Plan
A good planning system with a milestone chart. However, each of the tasks and subtasks of the WBS should be included in the Gantt chart which should also contain contingencies. (4/5)

15

Section 6: Working breakdown structure, costing exercise and management techniques
Good level of detail. (3/5)

Appendix: Risk assessment for implementation phase
Good level of detail. (4/5)

Appendix: Planning phase log-book entries.
All entries present but could be more detailed.
(4/5)

5. TRANSFERABLE SKILLS



Section 1: Executive summary
Contains some unnecessary information and repetition and some information is missing.
Remember, this is supposed to summarise everything. (3/5)

16

All Sections: Presentation quality of the report, diagrams, charts, tables, figure numbering, page, and section numbering etc
Excellent overall quality and presentation etc (5/5)

All Sections: Quality of the writing style, use of punctuation and grammar
Generally good but some sentences are awkward and belong to the previous sentence. (3/5)

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