SGEL6000 Independent Project 2020-2021

DOUBLE MARKING SHEET AND COMBINED STUDENT FEEDBACK

Assessment 1 of 4

Assignment 1: Project Definition, Research and Quality Planning

Agreed mark

52

Student Name: Phillip Rowe **Student Number** 1602827

Generic Assessment Criteria	Marks available	Ist Marker (RD)	2nd Marker (MH)	Agreed Mark
1. Engagement with Literature Skills.				
Section 5: Engagement in research, judicial use and critical evaluation sources, depth of literature review of solutions (6/10) There is some evidence of this with some depth displayed. (RD) Evidence of research was demonstrated, with consideration for wider issues such as ethical engineering and H&S. (MH)	10	6	6	6
Sections 3, 5 and 8: Extent of reading, use of credible sources, use of Harvard method for listing and citing (2/5) A good range of sources consulted but Harvard method not always applied correctly. (RD) Good range of relevant and reliable academic sources, citations were limited considering the length of the reference list (MH)	5	3	2	2
Total	15	9	8	8
2. Knowledge and Understanding Skills				
Section 3: Project background and context, commercial, economic and social context (7/10) Some good information provided set the project in context though there is some unnecessary repetition (RD) Project explained as a weld monitoring system on industrial steel coils (MH)	10	6	7	7
Section 3: Project constraints, professional and ethical conduct, codes of practice, standards, security, intellectual property, legal requirements etc. (5/10) Some consideration given though more citations would be helpful (RD) Most aspects covered in the report, although some aspects were generic and did not relate to the project specifically (MH)	10	5	5	5
Section 3: Environmental and sustainability limitations and promotion of sustainable development (2/5) Little consideration given (RD) Generic requirements rather than anything specific to the project (MH)	5	2	2	2
Section 3: Project risks, health and safety etc. (2/5) Some consideration given but no risk assessment provided (RD) Generic requirements rather than anything specific to the project (MH)	5	2	2	2
Total	30	15	16	16

3. Cognitive and Intellectual Skills				
Section 3: Problem Definition (4/5) Clearly defined (RD) An overview of the requirements were given in bulleted list form (MH)	5	**4**	**4**	**4**
Section 4: Functional Design Specification (5/10) Covers lots of areas but some heading and table are unnecessary and could have been written in a more succinct way. Little specified about the software requirements.(RD) Written at a high level as a series of small sub-topics, detail was non-specific and vague (MH)	10	**5**	**4**	**5**
Section 4: Test planning (3/5) A good testing plan giving expected and actual results but not much said about the software requirements (RD) A test plan with was included with performance metrics to gauge success, although tolerance of readings was not given (MH)	5	**3**	**3**	**3**
Section 7: Conclusions and Recommendations (4/5) A good overview of achievement with a clear path going forward. (RD) Clear conclusions were given with recommendations for future developments (MH)	5	**4**	**4**	**4**
Total	25	**16**	**15**	**16**
4. Practical Application Skills				
Section 5: Critical choice and justification of final solution (3/5) Good in parts though not all details considered for solution 2. Too much emphasis given on works preferences and not enough serious consideration given to the other 2 methods. A block diagram should have been given for each solution. (RD) A detailed scoring system was used to compare the 3 solutions, but this was light on detail as to what criteria was used to decide on a number (MH)	5	**3**	**3**	**3**
Section 6: Project Planning, working breakdown structure and management techniques. (4/10) Work break down is rather simple, with little said about software needs. Plan is good but needs more detail in tasks. (RD) A basic WBS was devised and a simple linear Gantt was used to control timings (MH)	10	**5**	**3**	**4**
Total	15	**8**	**6**	**7**
5. Transferable Skills for Life and Professional Practice				
Section 1: Executive summary (2/5) Too generic, nothing specific to the project, could apply to any project and written more little a table of contents. (RD) This didn't really give the reader much idea of the scope of the project (MH)	5	**2**	**1**	**2**
All Sections: Quality of the report – (3/5) Generally good though there are some spelling errors and the appendix should have contained some photos of the existing system. (RD) Generally well written and presented (MH)	5	**3**	**4**	**3**
Word count – (0/5) Exceeded (RD)	5	**0**	**0**	**0**

5533 is significantly above the limit, did you discount the excluded sections such as Executive Summary, annexes etc? (MH)				
Total	15	5	5	5
Grand Total	**100**	**53**	**50**	**52**

Phillip Rowe

by Phillip Rowe

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Assignment: 1. Project Definition, Research and Quality Planning
Name: Phillip Rowe
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Contents

1. Executive summary 4
2. Introduction 5
3. Project background and problem definition and constraints 6
4. Functional Design Specification and test plan 9
4.1. Introduction 9
4.1.1. Requirements 9
4.2. Numbers 9
4.3. Existing System 10
4.4. Terminology 10
4.5. Required skills 11
4.6. Client Summary 11
4.6.1. Executive Summary of Solution ..... **Error! Bookmark not defined.**
4.6.2. Introduction 11
4.6.3. System Functionality Summary 12
4.7. Assumptions 13
4.8. Constraints 14
4.9. Implementation Implications 14
4.9.1. Pre-Requisites 14
4.9.2. Data conversion & Cleansing 15
4.9.3. Legacy System(s) 15
4.9.4. Conversion Strategy 15
4.9.5. Conversion Method 15
4.9.6. Test impacts 15
4.9.7. Test Plans Required 15
4.9.8. Test Environments 16
4.9.9. UAT Requirements 16
4.9.10. Training Impacts 16
4.9.11. Resource Requirements 16
4.10. Functional Overview 17
4.10.1. Process Model 17
4.11. Design Summary 17
4.12. Issues and Questions ..... **Error! Bookmark not defined.**
4.13. Testing Plan 18
4.13.1. Dead testing 18

4.13.2. Live Testing 19
4.13.3. Functional testing 20
5. Literature review 21
6. Project planning, Work breakdown and Management techniques 32
6.1. Project plan ..... **Error! Bookmark not defined.**
6.2. Work breakdown flow diagram ..... **Error! Bookmark not defined.**
7. Conclusions and recommendations 34
8. References ..... **Error! Bookmark not defined.**
9. Appendix 38

Table of figures

Figure 1- Advantages/Disadvantages of current measuring devices – References for figure 1 - (Afzal, 2014) , (Cormer, 2015) , (Manutech, 2020) 22
Figure 2- Pressure transducer table of comparison – References for table data above - (Cheatle, 2019) (Desai, 2020) , (Editor, 2017) 23
Figure 3 - Regulation information – Reference - (onlogic, 2020) 27
Figure 4- Siemens S7 price list - Referenced from - (Siemens, 2020) 30
Figure 5 - Project time plan 32
Figure 6 - Project breakdown plan ..... **Error! Bookmark not defined.**
Figure 7 - Overall costing sheet 33

This summary sayings nothing about the project only the content of the report so it is not a summary (RD)

1. Executive summary

In this assignment, an investigation into a solution for an engineering problem was investigated. The problem was discussed with a client in order to document a project proposal. Based off the project proposal, the background of the project was able to be identified and presented. Along with the problems that could be faced during the development of the project. A functional design specification was then made in order to provide a concrete agreement between the client and the supplier in order to disregard any false claims further down the development stage. The FDS also outlined what criteria the solution must meet and also how to prove that it works/meets the requirements. Once the FDS was presented a literature review was carried out in order to investigate 3 different ways in which the solution could be solved. Comprehensive research was carried out in order to see the advantages and disadvantages of each solution. Then with this information, an in-depth comparison and analysis of each solution was carried out in order to generate the final overall solution. Project planning was also carried out in order to firstly generate an overall project plan, secondly provide a full project breakdown structure which shows all of the little tasks which are responsible for achieving the big tasks. Finally, all conclusions and recommendations were given in order to reflect back on this stage of the project and provide answers as to what went well and what didn't go so well if the project was done again.

2. Introduction

Unnecessary use of words (RD)

An industrial problem will be presented in order to try and engineer the problem out. The problem is within the steel industry, where when making a weld between two coils on a production line, the weld can be faulty which then causes length delays and finical cost to the client. A proposal needs to be put together in order to identify what needs to be done in principle in order to solve this solution. An FDS will be created in order to define what variables the project will need to meet, this is things as methods of testing's, conformities and also costings. The literature review will look in detail at 3 different solutions which are an Arduino, Industrial computer and also an Industrial PLC. Comprehensive analysis will be given in order to decide which one is the best solution. Once a final solution has been chosen, a project implementation plan will be made, along with a project breakdown structure and an overall costing sheet. Finally, the conclusions and recommendations for the project will be provided in order to reflect on the first stage of the project. Any criticisms will be given and alternative routes to solutions will be provided if they are needed.

spelling (RD)

3. Project background and problem definition and constraints

3.1. Project background

This project will be based in Tata steel Trostre, it will be installed in Area 1 on the North cleaning line where in order to keep the line continuous with little delay when switching between different coils, the strip needs to be welded together. The problem occurs when the weld between the two different coils isn't good enough, so when the line tension is enabled the strip breaks under the tension. This leads to lengthy delays of around 4-8 hours depending on the severity of the break which costs a lot of money, around £5000-10,000 an hour. This can also damage customer relations when products are not delivered on time, meaning the company can be liable to produce discounts on late deliveries and also face the possibility of losing the supplier contract if customer demands are not continuously met. The solution needs to be an effective weld monitoring system which looks at the three key elements of a weld. These are heat, speed and pressure. The heat in the weld is dependent on the current. The welder makes use of low voltage very high current in order to cause a seam weld. The pressure is pneumatic which needs to be of an appropriate force in order to hold the strip in place, and also force the top and bottom welder wheels together for a good flow of current. Finally, the speed is controlled via DC Micro drive. If the speed is too fast, then there can be gaps in the weld and too slow can cause burning through the strip, so the speed must be controlled to the correct standard at all times.

The standard is made up of known settings taken when a good weld has been produced. The solution needs to be a system that can detect if any of these criteria have deviated from the standard which is known to produce a good weld, the operator should be informed in order to repeat the weld again to prevent a possible strip break. For engineering support, all monitoring data will need to be mapped into the IBA analyser in order to create a live and historical map of the monitored data.

3.1.2. Constraints and Risks

There are many constraints that fall into this project. One of the major constraints is COVID-19. This has changed the way work is conducted in work so there will have to be some strategy adaptations in order to get the work done. This would be for things like working together with others within 2M, holding meetings and accessing materials. University efficiency could also become a problem as due to current/future lockdowns certain facilities can become hard to obtain. Work colleagues are also being asked to work from home, so if material needed is in work it will not be collected until that individual is rotated in to work which can delay numerous processes.

3.1.3 Ethical issues

There are numerous ethical issues that are arising. The biggest issue is the transparency of companies during their manufacturing process. As a company we want our suppliers to provide a fair-trade price for their employees' labour, meaning suppliers used will not pay below minimum wage for their labour in third world countries.

Use third person (RD)

3.1.4. Legal issues

The legal issues of this project consist of two things. The first being liability, because of this the safety of the system must be impeccable. At any point in time if there is an accident to do with the system, the HSE will look at the safety of the system. So, in order to avoid being held accountable by the HSE and being prosecuted, the correct safety measures will eliminate any possible risk as best reasonably practicable. The other legal issue is copyright issues.

Citations needed (RD)

3.1.5 Environmental issues

What regulations did you consult to be able to state this? Citations needed. (RD)

The biggest environmental issue is to ensure that all components used are as efficient as possible. The idea is to get hardware which will operate at its most optimal level with creating little losses in heat. This will then reduce energy consumption which is effectively more environmentally friendly. Hardware used will also have to have a power saving mode where if it is not used for over 3 hours, it goes into low power mode.

3.2. Professional conduct and codes of practice

The professional conduct will include general understanding of what is a good standard of work within the electrical industry. This means the installation must be acknowledged by others that it is a good standard of work and hasn't been assembled by an unskilled craftsperson. Internal code of practice would be EIS 7 which is a low voltage regulation book for this site. External regulations consist of BS7671 18th edition wiring regulations, BS 7430 Earthing code of practice, BS EN 50110 Operation of electrical installations and BS EN 60529 Specification for degrees of protection provided by enclosures. The final two external regulations would be the general H&S at work act 1974 and the Electricity at work act 1989.

3.3. Legal requirements governing engineering activities

Quotation marks needed (RD)

citation needed (RD)

Any personnel which will work on the project will be governed by the works legal code which states that employees cannot work more than 16 hours per day and must have 2 days off every 2 weeks. If this is not met and an accident occurs, the company can be legally held accountable. General health and safety requirements will apply at all times, this would be covered in the site induction. Since this system is one of a kind, the intellectual property rights will belong to the customer, if the customer finds it necessary then a patent can be filed. Hardware used will have a SIL level of 1. This means that if components fail the likelihood of an accident happening is very low. The liability will be with the supplier of the system. The commercial risk which can occur would be a loss of product to consumers. If the system does not operate properly and does not detect faulty welds, then the strip can break causing these lengthy, expensive delays which will ultimately affect the logistical flow of the product produced.

How did you know it should be 1? (RD)

3.4. Ethical standards and sustainable development

In the current climate it is vital to operate as ethically as possible. Some of the standards should be integrity and transparency. It is vital to have a high level of integrity as this will set the precedent for all work which is carried out. Having a high level of integrity would mean doing something which would cost slightly more because you believe in that product over choosing a cheap alternative which is known to be worse. The project must be development sustainably, this would mean attempting to make use of hardware which has been made using recycled materials or even refurbished hardware, hardware which has power saving modes and also highly efficient hardware. All of this tie into the future sustainable development of the industry the project is for.

What sources did you consult? Citations needed. (RD)

4. Functional Design Specification and test plan

4.1. Introduction

Already stated (RD)

This FDS is for Trostre's North Cleaning line welder. Currently the 40-year-old welder does not have the capability to monitor essential data during a weld. Due to the age of the welder, its performance is deteriorating by mechanical and electrical failures. This FDS is to set the standard for a system to be installed in order to prevent failures, which can lead to numerous logistical and financial troubles.

4.1.1. Requirements

1. The system must be a standalone system.
2. The system must be able to be connected to the works network. *What network is in use? (RD)*
3. Welder speed, current and pressures must be monitored. *Range of values? (RD)*
4. All data must be able to be mapped over into IBA analyzer
5. The installation must coincide with the company's MOC procedure.
6. Safety systems must NOT be interfered with.
7. The installation must be put inside of the existing welder panel.
8. The system must have the capability to be expanded in the future.
9. The monitoring system must be able to alert production of unacceptable welds.
10. The existing welder operation MUST remain the same.
11. The system must have reliable fault finding help procedures.

4.2. Numbers

The system will be used by around 12 people on a daily basis, these will not be the same users each day. It will monitor about 3 welds per hour. The system will need to have the capability to monitor these welds flawlessly at a rapid rate. The system will need to record data in a matter of milliseconds as the weld only takes around 20 seconds to complete. The project budget will be £15,000 for the complete project.

4.3. Existing System

Already stated (RD)

Currently, the welder in question does not have a monitoring system. When the welder system was designed it did not have a monitoring system in place as it was new and electrical/mechanical faults were not an issue. Now that the welder is 40 years into its service, the failure frequency has risen dramatically and is costing the customer big financial losses. So, by monitoring the weld parameters with a monitoring system the customer will be able to prevent these losses. The monitoring system which is being installed will not affect the operation of the operation of the welder, its sole purpose is to monitor the parameters.

An FDS does not need to include background information (RD)

4.4. Terminology

Abbreviation	Word	Meaning
MOC	Management of change	A written procedure which needs to be completed in order to make changes to a system.
BS	British standard	National standards for electrical work.
IP	Ingress protection	Protection effectiveness against different elements.
CPU	Central processing unit	Principal part of a digital computer system.
MSE	Manufacturing Support Engineer	Job title.

4.5. Required skills

These are the skills required in order to complete the development.

Skill	Level required	comments
Electrical Installation	HIGH	Needed in order to produce and install the project.
Software coding	HIGH	Program and write code for the system to work.

4.6. Client Summary

This section is a condensed section of the Function Specification design. This is for the client to understand the ideas behind the solution, implementation details and most of all see if the solution meets their requirements.

4.6.1. Introduction

The solution suggested is a standalone weld monitoring system with a main processing unit which can process analogue data inputted from field devices. Functionally the system should be able to record all data and if needed act upon any deviations that it sees. The data will also be transferred into an external program to be stored in the event of failures. The technology being used will be modern day monitoring devices and the brand-new CPU's to avoid bugs and firmware issues.

Bugs are caused by software
(RD)

4.6.2. System Functionality Summary

The system will comprehensively support:

1. The north cleaning line production team.
2. Electrical shift specialists.

The system will functionally support the business by altering users when welds are faulty, saving financial losses. Full device requirements are defined in section 4.11.

	Function	Description
1	Current monitoring.	Current monitoring on the primary and secondary side of the welder in order to see current trends. From this earthing on the welder will be able to be seen. *Range? (RD)* *Is it AC or DC current? (RD)*
2	Pressure monitoring.	Monitoring the high and low pressure of the welder in order to ensure the heads come together correctly every time. This is also referred to as snubbing pressure. *Range? (RD)*
3	Speed monitoring.	Carriage speed of the welder. The time is calculated from the welder wheels touch the strip, to when they stop touching the strip. *Range? (RD)*
4	Alarm when anomaly seen.	If any parameter is not met and deviates from standard the operator should be informed in the form of an alarm.

4.7. Assumptions

	Assumptions
1	The North Cleaning line's MSE will provide all current drawings, Phillip Rowe to produce drawings for update. Tata Steel's drawing office to then add them into cab-i-net after they make new copies.
2	Site visit will be required in order to discuss installation location.
3	Electrical MSE will provide all spares.
4	Full spares list to be given to Electrical MSE.
5	The electrical MSE will provide labour.
6	The system will be installed on the week of 07/02/2021 to 14/02/2021
7	Training will be provided by Phillip Rowe on the new system.

4.8. Constraints

	Constraint
1	System must be installed and commissioned by 14/02/2021.
2	All new drawings to be made on Microsoft Visio for a paperless system. (Zero carbon footprint)
3	
4	
5	

4.9. Implementation Implications

In this section aspects of the implementation have been defined in order to aid the project manager distribute the correct materials.

4.9.1. Pre-Requisites

	Pre-requisite
1	Welder electrical cubicle
2	Existing supply cables

4.9.2. Data conversion & Cleansing

Since this is a new system, all current drawings will not need to be converted into new types. The new system will be added to the existing drawing to maintain the clients standards. Any software being used must go through the clients data control and cleansing process.

4.9.3. Legacy System(s)

As this is an old system there is no old system which needs to be considered.

4.9.4. Conversion Strategy

Since the system is an addition and not a replacement, the conversion process will be easier to produce.

4.9.5. Conversion Method

The method for the system to be converted onto the existing welder, the client has not defined any restrictions. The only requirement is that when converting the system onto the existing welder, it does not affect the operation in any way.

4.9.6. Test impacts

When testing there will be a function testing document needed as the clients site regulations demand this. When testing the new system, the new installation must not cause any defects to the current operating system. Also any items connected to the client's site network MUST NOT impact the operation of other production lines. Extreme caution should be taken in order to prevent this issue occurring.

4.9.7. Test Plans Required

Two separate test plans will be required. One will be performed with the supplies isolated and the other with the system powered up. These two testing plans exclude the FAT the system will have to pass before being installed.

4.9.8. Test Environments

When live testing is occurring, the area will be bunted off in order to create a safe testing area. The production team will organize multiple dummy welds in order to simulate the real functions, but this will allow the commissioning team to modify any changes needed.

4.9.9. UAT Requirements

The user acceptance test must meet the following requirements:

- Operators to perform normal welder functions.
- Operators must understand new displays.
- Operators must understand new alarms.
- Electrical shift specialists to be able to interrogate new software.
- Electrical shift specialists to be able to isolate systems if needed.

4.9.10.Training Impacts

Training will be given to all personnel needed during normal operation. Training folders to be given as back up. This system does not alter skill of operator.

4.9.11.Resource Requirements

Resource requirements will be as followed:

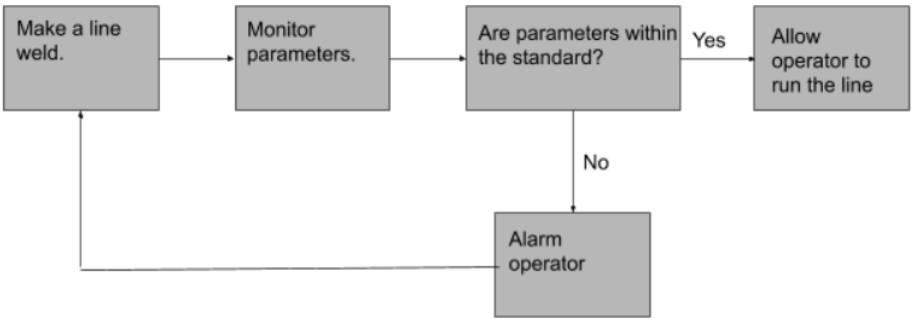
- 1 Electrical craftsman.
- 1 Electrical apprentice.
- 1 programming laptop with suitable software.
- Commissioning documents.
- Materials list - referred in related documents section.

4.10. Functional Overview

The weld monitoring must have the functions to monitor current, speed and pressure during a normal weld. This should generate an alarm if the weld is not up to a suitable standard.

4.10.1.Process Model

This is the process model which the system will mimic.



4.11. Design Summary

Requirement	Component	Type	Sizing
Current monitoring	Current transducer	Fixed	0-10,000A *AC or DC current? (RD)*
Pressure monitoring	Pressure transducer	Panel mount	0-250 BAR
Processing HUB	CPU	TBC	1ms scans/s
Remote I/O	Remove sub-rack	TBC	10 I/O's
Programming station	Central PC	TBC	TBC

4.12. Testing Plan

This testing plan has been derived from the FDS which has been made for this project. The testing plan is split up into three main parts. These are dead testing, live testing and functional testing. The reasoning for having a testing procedure like this is to avoid causing any component damage and to rectify any faults which may be present.

4.12.1.Dead testing

This section is for the pre-functional tests to be carried out. This is to ensure that once powered up no hardware damage will be done.

	Test type	Test method	Expected result	Actual result	Pass/Fail	Amendment requirements
1	Continuity test of power +/- connections.	Continuity test	0.1 ohms			
2	Continuity test of remote I/O device supplies.	Continuity test	0.1 ohms			
3	Continuity test of AI connections	Continuity test	0.1 ohms			
4	Tightness test of all connections	Terminal screwdriver	2.5nm torque setting			
5	Security of all transducers	Physical touch	Secure by hand			

4.12.2.Live Testing

This section will provide the live testing where the power will be turned on BUT there will be no functional testing.

	Test type	Test method	Expected result	Actual result	Pass/Fail	Amendment requirements
1	Power supply voltage tests with MCB's off.	Voltage tester - Multimeter.	20-28v - No circuit break trips.			
2	Power supply voltage tests with MCB's on.	Voltage tester - multimeter.	20-28v - No circuit breaker trips.			
3	Remote devices power cycle check.	Visual	Transducers to power on.			
4	Communications test.	Server PING test.	Reply from controller to programmer.			

4.12.3.Functional testing

This section will be where the operation of the system will be tested providing that all the other test procedures are completed successfully.

	Test type	Test method	Expected result	Actual result	Pass/Fail	Amendment requirements
1	AI signals test	Monitor values	Value range between 0-27648			
2	Scaling of transducers.	Set ranges and adjust as needed	I.e 0-27648 = 0-250 BAR.			
3	Alarm when faulty.	Test alarm	Beacon flash.			

5. Literature review

In this section 3 solution will be looked at in depth in order to determine the best solution. All solutions must meet the requirements which were listed in the FDS.

5.1. Measuring devices used in all 3 solutions.

Although there are 3 different solutions as to which method is used to monitor field devices, the actual field devices will remain the same through each solution.

<u>Current measuring devices</u>

There are many ways in which current can be measured. There are usually two reasons for measuring current, these would be you either want to know how much current is flowing or is there too much current flowing. A signal to indicate the "how much" condition and the "too much" condition is available in a variety of measurement methods:

use third person (RD)

1. Resistive (Direct)

2. Magnetic (Indirect)

3. Transistor (Direct) (Yarborough, 2018)

For this project the route taken is the magnetic indirect route however two methods of doing this were explored. The first method is to use a current transformer, the second is to use something called the Rogowski Coil. Current Transformers produce an output in proportion to the current flowing through the primary winding as a result of a constant potential on the primary (Smith, 2019)). A Rogowski coil is an 'air-cored' toroidal coil placed round the conductor. The alternating magnetic field produced by the current induces a voltage in the coil which is proportional to the rate of change of current (Evans, 2020). Although both of these devices are very similar they both do have separate advantages and disadvantages. These can be seen below in figure 1.

Measuring device	Advantages	Disadvantages
Rogowski coil	• Non-intrusive or lossless measurement • Low cost • Flexibility	• AC Current Only • Very sensitive compared to a CT
Current transformer	• High immunity to electromagnetic interferences. • Larger dynamic range • Low voltage outputs- compatible with ADCS • Fast transient response	• May require heat sink • Low efficiency if input-output difference is large • Higher cost

Figure 1- Advantages/Disadvantages of current measuring devices – References for figure 1 - (Afzal, 2014) , (Cormer, 2015) , (Manutech, 2020)

Looking at both the advantages and disadvantages of both devices the Rogowski coil just edges the competition as in this project the current device needs to be very flexible as it is on a moving copper shunt.

Pressure monitoring devices

Pressure transducers have a sensing element of constant area and respond to force applied to this area by fluid pressure (Anon., 2019). This force applied deflects the diaphragm inside the device, this is then measured and then this measurement is given out in the form of a voltage/current.

There are six primary pressure sensor technologies used to sense pressure. These are Potentiometric pressure sensors, Inductive pressure sensors, Capacitive pressure sensors, Piezoelectric pressure sensors, Strain gauge pressure sensors and Variable reluctance pressure sensors (Edwards, 2019).The two-best fit for purpose to use in this system are the capacitive sensor and the variable reluctance sensor.

Following below in figure 2 is the comparison table for the two different types of pressure sensor.

Measuring device	Advantages	Disadvantages
Capacitive sensor	• The sensitivity of capacitive transducer is high. • The capacitive transducer is useful for small system. • It has good frequency response. • It requires small power to operate. • The loading effect is less due to high input impedance.	• The capacitive transducers are temperature sensitive. • It gives non-linear behaviour. • The output impedance depends upon the frequency used. • The capacitance may get changed by dust particle and moisture which produce error.
Variable reluctance sensor	• Measurement of very low pressures • Low power consumption • Wet/Wet differential measurements • Suited for high levels of vibration	• Large size • Limited range • Low sensitivity

Figure 2- Pressure transducer table of comparison – References for table data above - (Cheatle, 2019) (Desai, 2020) , (Editor, 2017)

Using figure 2 above and comparing both the advantages and disadvantages of both types of sensors, the sensor which is going to be used is the variable reluctance sensor. The biggest reason for this is because the operating temperature in the area where the sensor is placed can get very hot and also

temperature range? (RD)

there is a lot of dust/foreign bodies in the system which could lead to faulty readings and on a system, which needs to be critically right all the time, the VR sensor is the clear winner.

5.2. Solution 1 - Industrial Arduino -

Arduino is a low-cost open-source electronic board system that is capable of controlling just about any DIY hardware project, from robotics to art projects and just about everything in between (Electronics, 2020). These Arduino boards have endless expansion possibilities and come with free C/C++ software for coding. An industrial Arduino closely mirrors an entry level PLC. (Reneker, 2017) states "If it's possible to buy an Arduino for as little as $20, why spend hundreds on a PLC? ". Since the purpose of this project is to monitor analogue values, it is vital that the Arduino can successfully achieve this. The arduino has a built in ADC which can convert the analogue signal into a digital value which is known as a function. This function converts the value of the voltage on an analogue input pin and returns a digital value from 0 to 1023, relative to the reference value (Youngblood, 2015). The known default reference number is either 5v or 3.3v depending on which type of board is used.

Wrong method of citation, Reneker should not be in brackets and page number should be supplied for direct quotes. (RD)

FA-DUINO-32TA

The above ardunio board has been chosen for this solution as it has all the required analogue inputs as well as the correct relay outputs in order to generate an alarm. This type of board has the following features:

- Program memory: 256KB
- SRAM: 8KB
- EEPROM: 4KB
- Clock Speed: 16MHz
- 16 - 24VDC Inputs (pins 30~45)
- 8 - 10A Relay Outputs (pins 22~29)
- 2 - RS-232C Communication Port
- 1 - RS-485 Communication Port

- 4 - 0~10V Analog Inputs
- 4 - 0~20mA Analog Inputs
- 10-bit ADC (0~1023)
- Powered by 24VDC
- Operating Temperature: 0 ~ 60°C
- Operating Humidity: 35 ~ 85% RH

Above data obtained from (Technology, 2020) *Wrong citation method (RD)*

Looking at the specification of the board, it can be seen that there are more than enough analogue inputs that can be used, there are enough relay outputs in order to set off an alarm and the power supply is low power/low wattage. Another major advantage of this board is that if needed, it can convert analogue signals into digital ones with a decent range of 0-1023. The board also comes with various different protection elements such as fuses, EMI filter, Spark killer circuit and an upload protection circuit. Another key element of this board is that it is din rail mounted so the installation will be simple. Some of the drawbacks with this board are that there is no RJ45 communication port, so this means the RS-232C port will have to be used with another convertor in the middle which converts this into USB. This in the long run just adds another component which can fail. Finally, the operating temperature and humidity ranges are rather low, especially because of the type of environment the system will be located in which has a very high humidity and temperature due to steam usage and caustic fumes.

In order to make a fair analysis between all of the solutions, as well as the technical details which have been listed the cost and ethical points need to be taken into consideration. Total cost of the board with an RS-232C to USB cable and the 24v power supply included would be £102. (REFERENCE 17) *Not a Harvard style citation (RD)* Also the overall dimensions of the board are 154mm X 98mm X 30mm. So, this is a reasonable size to fit inside the existing enclosure. The overall wiring of this board is relatively simple to make and it comes with a comprehensive wiring diagram. One of the drawbacks with this solution would be the programming software. The supplier of the board also offers a range of support lines and since this board is used for a vast range of applications, there are many forums that can be used in order to answer any queries. The free C/C++ software is not the chosen package which the customer uses, so this leads to a range of issues with regards to the maintenance and fault-finding aspect of the system. With all these considerations considered, a table will be drafted at the end of the section in order to compare and contrast the three solutions and pick the best one by giving factual evidence.

5.3. Solution 2 - Industrial computer

This solution is compiled of multiple different aspects in order to achieve the same goal. The computer of choice is the Onlogic Helix 610 Intel Comet Lake Industrial Edge Computer. There are many differences between a normal computer and industrial one, these are things like better Enclosure form factors, higher IP ratings, higher level protection against impacts, industrial grade components and the highest filtration systems (Rees, 2019). There are also numerous other advantages such as the pure reliability factor and also the support network provided by the supplier. Industrial embedded computers typically align with industry standards for temperature ranges (-40°C to +85°C is typical) and shock and vibration, where a standard like IEC 68-2-27 looks at various aspects of shock in industrial equipment (Hiliard, 2019)

In order to register the inputs and outputs a PICkit 2 18-pin demo board would be used and microcontroller is a PIC1827. Finally, the software program which would be used would be MPLAB x.

The onlogic helix is an industrial computer which has some very good specifications. The processor used in this computer is an Intel Comet Lake Core i9. this is one of the fastest processors **Intel** has introduced to date (Jonnalagadda, 2020). This means that it will be able to process data in the require 1m/s scan rate time. Other features of this computer include a 64GB hardrive, 4 Gen 2 USB 3.2 ports, numerous expansion I/O slots and the computer can actually be mounted to din rail (TECHNOLOGY, 2020)One major thing with using computers in industry is that they must conform to certain standards before they can be installed, in this particular case the manufacturer has ensured that this computer does indeed conform with these regulations. This can be seen below in figure 3.

Regulatory Information	FCC 47 CFR Part 15 CE WEEE Directive (2002/96/EC) Low Voltage Directive (2014/35/EU) Electromagnetic Compatibility Directive (2014/30/EU) Radio Equipment Directive (2014/53/EU) - For configurations with wireless transmitters RoHS 3 (2015/863/EU) REACH EN 55024 EN 55032 EN 55035 EN 60950-1 EN 61000-3-2 EN 61000-3-3 EN 61000-4-2 EN 61000-4-3 EN 61000-4-4 EN 61000-4-5 EN 61000-4-6 EN 61000-4-8 EN 61000-4-11 EN 62368-1

Figure 3 - Regulation information – Reference - (onlogic, 2020)

How would the PIC be connected to the Onlogic Helix

Now taking a detailed look at the PIC1827, two of these micro controllers would need to be used in order to achieve the required analogue inputs needed. The most important factor with this micro controller is the processing speed, it needs to be able to handle multiple instructions every second. This type of controller has a processing speed of 8MIPS, information taken from (Microchip, 2020). (Techterms, 2020) states that “MIPS stands for "Million Instructions Per Second." It is a method of measuring the raw speed of a computer's processor. “So, with this processing speed this controller is more than capable of meeting the required specification. The controller also has numerous other good specifications like 8 and 16-bit timers, watchdog timers, 10-bit ADC’s and a low operating temperature of 1.8-5.5v. The controller also offers a good operating temperature range of -40 to +125 degrees Celsius.

Finally, MPLAB X would need to be used in order to get the analogue values into the computer for data processing. The package offers a range of helpful data processing techniques such as data visualisation, I/O viewer and a helpful design resource. The data visualizer offers real time streaming data to be viewed in the data visualizer. I/O view allows the pin states to be verified and also manipulated when using the I/O view tool. The design resource makes use of links, software libraries and data sheets which can also provide user guides automatically.

Taking all these separate items into account, the price for the system will now need to be worked out in order to evaluate this solution. The industrial computer comes out to around about £1020. The total cost of the controller system is around £127. Finally, the software comes to just over £100 for a year's license. These prices can be found via references (onlogic, 2020) , (Techterms, 2020) , (Microchip, 2020).

Whilst the advantages of this system are vast ranging from high speed processing power, sound reliability, prime operating temperatures and good support networks. There are some very daunting disadvantages to having this type of system. One of the biggest disadvantages is the sheer cost of this system, coming in at around £1230 which is well below budget, for just a simple monitoring system that is not a good investment. Also, the expansion of this system would be relatively hard as every time new inputs may be needed there would have to be adaptations which then would mean management of change documents would have to be done every time which can cause lengthy delays to the addition being made. Again, the advantages and disadvantages will be put into a table at the end from major comparison with the other two solutions.

5.4. Solution 3 - Industrial PLC

A PLC is a programmable logic controller which is capable of controlling/monitoring any form of system. There are a range of techniques used by the PLC in order to achieve the desired outcome. With multiple different programming languages there is a standard for every industry.

Siemens S7-1513 and ET 200MP I/O

For this solution the CPU 1513 and ET 200MP remote I/O rack have been chosen. The reasoning for this is due to the possible future expansion of the system and the shear reliability of this type of system. This system offers many benefits such as –Standard, for typical applications, Compact, for applications where space and cost are a concern, Fail-Safe, for fail-safe applications. (REFERENCE 26). This system is totally integrated, the system makes use of profinet communications to pass information onto remote devices, but it can also be easily added to a works network for remote access. This system has already been proven to be easily integrated into IBA analyzer, which is a key element to the project.

This is not a Harvard citation (RD)

The product specification for the S7-1513 is very high, its processing speed is 0.04 milliseconds (graham, 2020). Which is well above the required demand for this project. The CPU is mounted on a 1500 specific special din rail, which is only 800mm long and 300mm high so it doesn't take up a lot of space. In order to store the program on the PLC an additional memory card is needed, which the chosen one would be a 12KB to provide space for future updates. The ET200MP is the expansion module for the 1500 PLC series. This expansion rack once built can offer a range of different analogue inputs. The general analogue input card can be changed in the program to read both voltage and current input. The only thing which will then change is the way in which the input is wired into the card. Finally, the totally integrated S7 TIA portal will be used in order to write the code for this system. TIA is known as one of the simplest programming software to use, with its extensive help prompts and folders. Since this is highly used a lot of helpful information can also be found on manufactures forums where problems are solved by siemens personnel.

The major advantages of this solution are that its already industry proved, meaning that industry recognise it as a standard operating system, the processing power is above and beyond current needs but leads a lot of room for future improvements and additions, the system is easily expandable as the I/O cards clip in and out and only require little wiring, since this is already an accepted standard there

is no need for complete retraining on a new system and finally the warranty supplied with the products is outstanding. Some of the disadvantages are that the system is very expensive, since siemens are seen as market leaders this is reflected in the price of components, siemens have made its own brand products essential meaning things like memory cards cannot be other brands, they must be siemens specific cards and finally the system is often bought in various different pieces so there would be multiple different components needed in order to make the system functional.

Coming to the costing side of things, since Siemens sell everything separately there are a lot of components needed in order to build the total system, unlike these solutions given where the majority of the stuff comes as a package. To make this simple a table of components has been created below in Figure 4.

Component	Quantity	Price
S7 CPU 1513	1	£1450
12kb memory card	1	£179
S7 1500 Power supply	1	£100
1500 din rail	2	£166
ET200MP	1	£220
Power supply	1	£306
AI Cards	3	£840

Figure 4- Siemens S7 price list - Referenced from - (Siemens, 2020)

The total price just to build the system without the wiring would be £3261. Since it is just purely the systems that are being compared, the wiring and installation has been left out of the price at this time in order to just purely compare the system prices.

Final conclusion and comparison

In order to find the best solution a table has been made in order to clearly see all the advantages and disadvantages of each system. These will then be critically analysed and the best solution will be chosen. All scores have been based on specifications which have been stated in the previous analysis.

	1. Arduino	2. Industrial computer	3.S7- PLC
Cost (1-10)	8	7	3
Efficiency (1-10)	6	7	9
Reliability (1-10)	5	7	9
Support (1-10)	8	8	9
Speed (1-10)	7	8	10
Protection (1-10)	4	9	8
Total score (Higher the better)	38/60	46/60	48/60

Using the above table, there is a very close comparison between solution 2 and 3 however solution 3 just about edges it. All the ratings were generated from facts which have already been discussed in the individual solution sections. Although solution 3 is more expensive than the other solutions, the S7 PLC has a proven track record in industry for control systems hence why the reliability is so much higher in comparison to the other solutions. Using solution 1 or two would be a new innovative idea, however this would lead to teething issues regarding the installation and also the normal operation of the system. All the solutions offer a vast wide range of support which is ideal for this industry. Clearly none of the solutions lack processing power speed as this was proved with the factual evidence provided, however solution 3 is in a different league at this current point in time. Overall solution 3 is just the better option since it scored the highest overall in the categories and also it is actually the preferred standard for this client.

6. Project planning, Work breakdown and Management techniques

6.1. Work breakdown flow diagram

Following below is the work breakdown structure diagram. This shows the 3 parts to the project and then the sub-sections that fall under these main parts.

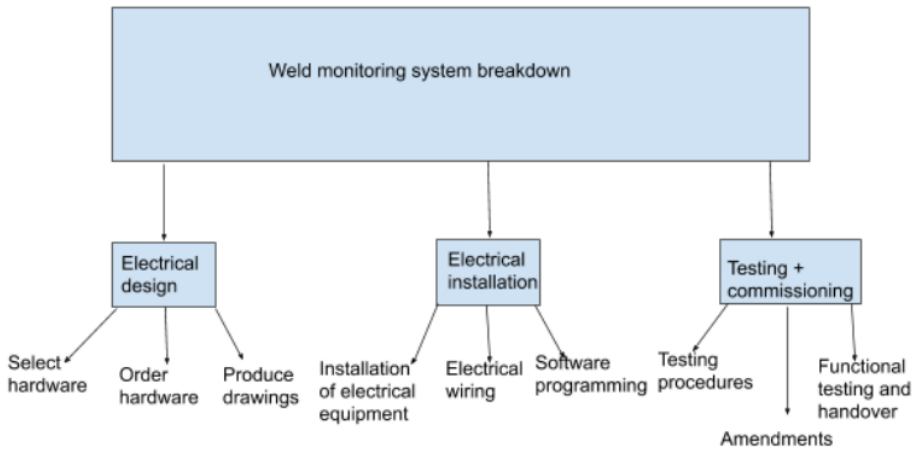


Figure 5 - Project breakdown plan

Not enough breakdown given for software development, simulation and testing (RD)

6.2. Project plan

Following below is the Gantt chart plan for the implementation of the project. This can be seen in figure 5.

Shouldn't there be a hardware design stage?

What about the software design (RD) simulation and testing (RD)

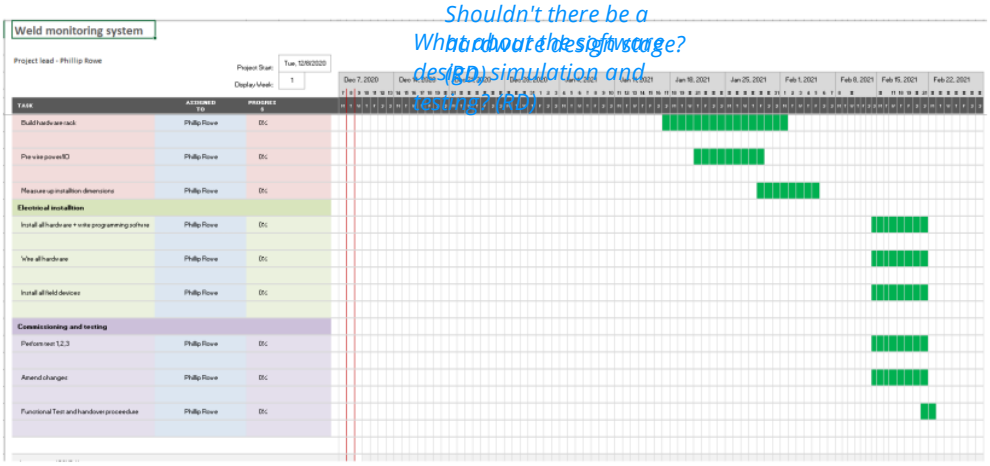


Figure 6 - Project time plan

Management techniques

The two management techniques which will be used in this project are Autocratic management and collaborative. Autocratic is a top-down approach which makes communication flow one way from bosses to employees. The reason for this approach is to keep a close eye over the project, ensuring that all decisions are made via the project lead. This approach also allows the project to be done in its intended way as the employees are not encouraged to ask questions or share ideas, it's more of a command/request relationship between manager and employer. The collaborative technique will be mostly used in the installation phase as the project manager for this project will closely monitor the progress in order to ensure it is being done correctly.

Following below in figure 7 is the general costing sheet which has been generated for the chosen solution.

What does this mean, spillover?

Cost catogory	Total estimate cost		Spillover amount	
Electrical installation	£	6,000.00	£	500.00
Electrical design	£	500.00	£	50.00
Electrical consumables	£	1,000.00	£	200.00
Hardware components	£	6,000.00	£	1,000.00
Commisioning variables	£	500.00	£	50.00
Total estimated cost	£	14,000.00	£	1,800.00
Amount spare	£	1,000.00	£	15,800.00
Total budget available	£	15,000.00	£	800.00

How can this figure be greater than the budget? (RD)

Figure 7 - Overall costing sheet

7. Conclusions and recommendations

Concluding on this phase of the project, the correct solution based off the research and analysis was definitely chosen. The Siemens S7 system scored the highest in the comparison table and through all the analysis provided the best possible outcome for this project. A large reason for this was because both the industrial computer and the Arduino have not been fully proven in industry and many people are reluctant to deviate from a known/proven good standard of doing things. This was shown in the research as there wasn't many case examples of where these two solutions had been used before to do something similar to this project. Whereas with the Siemens S7, there was plenty to read and write about as this type of system has been used multiple times and also has previous generations of controllers which could do the same thing in around about the same way. This meant people are still familiar with the technology and it is easier to adapt to.

There are some recommendations that would be essential if this was carried out again. Firstly, time management would need to be monitored with a finer eye. Although there have been no major delays with regards to time management, a more structure time plan for this design phase would be beneficial as it would ensure that no work is being rushed, which would then mean every single detail would be present in the report and there would be no risk of missing anything out. This is very important as if anything is overlooked at the development stage, this could potentially pose massive either financial losses, legal losses or even reputation losses in the future. So, this is why time management is vital in order to ensure nothing is overlooked or forgotten about in the design stages. Secondly, if there was more time it would be ideal to look at sub solutions in the three main solutions. This would mean taking each one of the three solutions so for example the industrial PLC solution, and then look into the different types of PLC which could be used. Since there wasn't a massive amount of time to develop all of these different ideas the literature review had to be concise however, it would prove very beneficial to look at other hardware components which would come under the same solution. By doing this it would then be totally apparent that the absolute correct solution has been chosen, but also the correct hardware selection has been made. Thirdly the final suggestion would be to possibly integrate the building of the project within this section of the project plan. Front loading the project would save time in the long run and would speed up the development of the project, especially if there are other working parties awaiting parts to do their bit, it would apply slightly more pressure for work to be carried out in a faster manner. This could also help any teething problems being caught in the earliest stages rather than towards the end.

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9. Appendix

PROJECT PROPOSAL DOCUMENT

Student Name: Phillip Anthony Rowe
Project Title: Weld Monitoring System
Date: 02/10/2020
Budget: £15,000

Description of Project
This project will be based in Tata steel Trostre; it will be installed in Area 1 on the North cleaning line where in order to keep the line continuous with little delay when switching between different coils, the strip needs to be welded together. The problem occurs when the weld between the two different coils aren't good enough, so when the line tension is enabled the strip breaks under the tension. This leads to lengthy delays of around 4-8 hours depending on the severity of the break which costs a lot of money, around £5000-10,000 an hour. This can also damage customer relations when products are not delivered on time, meaning the company can be liable to produce discounts on late deliveries and also face the possibility of losing the supplier contract if customer demands are not continuously met. The solution needs to be an effective weld monitoring system which looks at the three key elements of a weld. These are heat, speed and pressure. The heat in the weld is dependent on the current. The welder makes use of low voltage very high current in order to cause a seam weld. The pressure is pneumatic which needs to be of an appropriate force in order to hold the strip in place, and also force the top and bottom welder wheels together for a good flow of current. Finally, the speed is controlled via DC Micro drive. If the speed is too fast, then there can be gaps in the weld and too slow can cause burning through the strip, so the speed must be controlled to the correct standard at all times.

The standard is made up of known settings taken when a good weld has been produced. The solution needs to be a system that can detect if any of these criteria have deviated from the standard which is known to produce a good weld, the operator should be informed in order to repeat the weld again to prevent a possible strip break. For engineering support,all monitoring data will need to be mapped into the IBA analyser in order to create a live and historical map of the monitored data. The project lead will be Phillip Rowe who will plan, design, build, test, install and commission the project. The client will be the North cleaning lines electrical engineer John Shannon. The budget allocated for this project is £15,000, this has been agreed between Phillip Rowe and John Shannon. The project must be designed and ready for installation on the annual maintenance which is the week commencing on the 07/02/2021 and ending on the 14/02/2021. The project must comply with internal company standards but also national regulations. External regulations consist of BS7671 18th edition wiring regulations, BS 7430 Earthing code of practice, BS EN 50110 Operation of electrical installations and finally BS EN 60529 Specification for degrees of protection provided by enclosures. The internal regulations which must be followed are the company's management of change procedure, internal factory acceptance testing regulations and finally, the production ownership acceptance test. It has been agreed that Phillip Rowe will produce a FAT test to present to John Shannon, once the internal FAT test has been passed, Phillip Rowe will then organise the ownership acceptance test where the production team will take ownership of the newly installed equipment. Finally, training will be arranged for the engineering team to be trained on how to use the new system when fault finding and suitable documentation is provided.

Agreement for project proposal

Student Signature: P.Rowe Date: 10/10/2020

Industrial Supervisor Signature: J.Shannon Date: 10/10/2020

Academic Tutor Signature: _R. Davies_____ Date: _06/11/2020

Phillip Rowe

GRADEMARK REPORT

FINAL GRADE

52/100

GENERAL COMMENTS

Instructor

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PAGE 3

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PAGE 37

PAGE 38

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GRADING FORM: NEW CSG-RUBRIC

PHILLIP ROWE	**52**

1. ENGAGEMENT WITH LITERATURE

Section 5: Engagement in research, judicial use and critical evaluation sources, depth of literature review of solutions (6/10) There is some evidence of this with some depth displayed. (RD) Evidence of research was demonstrated, with consideration for wider issues such as ethical engineering and H+S. (MH) Sections 3, 5 and 8: Extent of reading, use of credible sources, use of Harvard method for listing and citing (2/5) A good range of sources consulted but Harvard method not always applied correctly. (RD) Good range of relevant and reliable academic sources, citations were limited considering the length of the reference list (MH)

8

2. KNOWLEDGE AND UNDERSTANDING

Section 3: Project background and context, commercial, economic and social context (7/10) Some good information provided set the project in context though there is some unnecessary repetition (RD) Project explained as a weld monitoring system on industrial steel coils (MH) Section 3: Project constraints, professional and ethical conduct, codes of practice, standards, security, intellectual property, legal requirements etc. (5/10) Some consideration given though more citations would be helpful (RD) Most aspects covered in the report, although some aspects were generic and did not relate to the project specifically (MH) Section 3: Environmental and sustainability limitations and promotion of sustainable

16

development (2/5) Little consideration given (RD) Generic requirements rather than anything specific to the project (MH) Section 3: Project risks, health and safety etc. (2/5) Some consideration given but no risk assessment provided (RD) Generic requirements rather than anything specific

3. COGNITIVE AND INTELLECTUAL

Section 3: Problem Definition (4/5) Clearly defined (RD) An overview of the requirements were given in bulleted list form (MH) Section 4: Functional Design Specification (5/10) Covers lots of areas but some heading and table are unnecessary and could have been written in a more succinct way. Little specified about the software requirements. (RD) Written at a high level as a series of small sub-topics, detail was non-specific and vague (MH) Section 4: Test planning (3/5) A good testing plan giving expected and actual results but not much said about the software requirements (RD) A test plan with was included with performance metrics to gauge success, although tolerance of readings was not given (MH) Section 7: Conclusions and Recommendations (4/5) A good overview of achievement with a clear path going forward. (RD) Clear conclusions were given with recommendations for future developments (MH)

16

4. PRACTICAL APPLICATION

Section 5: Critical choice and justification of final solution (3/5) Good in parts though not all details considered for solution 2. Too much emphasis

7

given on works preferences and not enough serious consideration given to the other 2 methods. A block diagram should have been given for each solution. (RD) A detailed scoring system was used to compare the 3 solutions, but this was light on detail as to what criteria was used to decide on a number (MH) Section 6: Project Planning, working breakdown structure and management techniques. (4/10) Work break down is rather simple, with little said about software needs. Plan is good but needs more detail in tasks. (RD) A basic WBS was devised and a simple linear Gantt was used to control timings (MH)

5. TRANSFERABLE SKILLS

Section 1: Executive summary (2/5) Too generic, nothing specific to the project, could apply to any project and written more little a table of contents. (RD) This didn't really give the reader much idea of the scope of the project (MH) All Sections: Quality of the report – (3/5) Generally good though there are some spelling errors and the appendix should have contained some photos of the existing system. (RD) Generally well written and presented (MH) Word count – (0/5) Exceeded (RD) 5533 is significantly above the limit, did you discount the excluded sections such as Executive Summary, annexes etc? (MH)

5

SECOND MARKER - MH

Course: BSc (Hons) Electrical and Electronic Engineering
Module: SGEL6000 Independent Project
Assignment: 1. Project Definition, Research and Quality Planning
Name: Phillip Rowe
University number: 1602827
Date submitted: 11/12/2020
Word count: 5533

SIGNIFICANTLY OVER (3950 MAX)

DID YOU EXCLUDE SECTIONS WHERE WORD COUNT DOESN'T APPLY?

Contents

1. Executive summary 4
2. Introduction 5
3. Project background and problem definition and constraints 6
4. Functional Design Specification and test plan 9
4.1. Introduction 9
4.1.1. Requirements 9
4.2. Numbers 9
4.3. Existing System 10
4.4. Terminology 10
4.5. Required skills 11
4.6. Client Summary 11
4.6.1. Executive Summary of Solution ..... **Error! Bookmark not defined.**
4.6.2. Introduction 11
4.6.3. System Functionality Summary 12
4.7. Assumptions 13
4.8. Constraints 14
4.9. Implementation Implications 14
4.9.1. Pre-Requisites 14
4.9.2. Data conversion & Cleansing 15
4.9.3. Legacy System(s) 15
4.9.4. Conversion Strategy 15
4.9.5. Conversion Method 15
4.9.6. Test impacts 15
4.9.7. Test Plans Required 15
4.9.8. Test Environments 16
4.9.9. UAT Requirements 16
4.9.10. Training Impacts 16
4.9.11. Resource Requirements 16
4.10. Functional Overview 17
4.10.1. Process Model 17
4.11. Design Summary 17
4.12. Issues and Questions ..... **Error! Bookmark not defined.**
4.13. Testing Plan 18
4.13.1. Dead testing 18

4.13.2. Live Testing 19
4.13.3. Functional testing 20
5. Literature review 21
6. Project planning, Work breakdown and Management techniques 32
6.1. Project plan ..... **Error! Bookmark not defined.**
6.2. Work breakdown flow diagram ..... **Error! Bookmark not defined.**
7. Conclusions and recommendations 34
8. References ..... **Error! Bookmark not defined.**
9. Appendix 38

Table of figures

Figure 1- Advantages/Disadvantages of current measuring devices – References for figure 1 - (Afzal, 2014) , (Cormer, 2015) , (Manutech, 2020) 22
Figure 2- Pressure transducer table of comparison – References for table data above - (Cheatle, 2019) (Desai, 2020) , (Editor, 2017) 23
Figure 3 - Regulation information – Reference - (onlogic, 2020) 27
Figure 4- Siemens S7 price list - Referenced from - (Siemens, 2020) 30
Figure 5 - Project time plan 32
Figure 6 - Project breakdown plan ..... **Error! Bookmark not defined.**
Figure 7 - Overall costing sheet 33

1. Executive summary

SPECIFY.

In this assignment, an investigation into a solution for an engineering problem was investigated. The problem was discussed with a client in order to document a project proposal. Based off the project proposal, the background of the project was able to be identified and presented. Along with the problems that could be faced during the development of the project. A functional design specification was then made in order to provide a concrete agreement between the client and the supplier in order to disregard any false claims further down the development stage. The FDS also outlined what criteria the solution must meet and also how to prove that it works/meets the requirements. Once the FDS was presented a literature review was carried out in order to investigate 3 different ways in which the solution could be solved. Comprehensive research was carried out in order to see the advantages and disadvantages of each solution. Then with this information, an in-depth comparison and analysis of each solution was carried out in order to generate the final overall solution. Project planning was also carried out in order to firstly generate an overall project plan, secondly provide a full project breakdown structure which shows all of the little tasks which are responsible for achieving the big tasks. Finally, all conclusions and recommendations were given in order to reflect back on this stage of the project and provide answers as to what went well and what didn't go so well if the project was done again.

MORE A NARRATIVE OF CARRYING OUT A PROJECT IN GENERAL

2. Introduction

An industrial problem will be presented in order to try and engineer the problem out. The problem is within the steel industry, where when making a weld between two coils on a production line, the weld can be faulty which then causes length delays and finical cost to the client. A proposal needs to be put together in order to identify what needs to be done in principle in order to solve this solution. An FDS will be created in order to define what variables the project will need to meet, this is things as methods of testing's, conformities and also costings. The literature review will look in detail at 3 different solutions which are an Arduino, Industrial computer and also an Industrial PLC. Comprehensive analysis will be given in order to decide which one is the best solution. Once a final solution has been chosen, a project implementation plan will be made, along with a project breakdown structure and an overall costing sheet. Finally, the conclusions and recommendations for the project will be provided in order to reflect on the first stage of the project. Any criticisms will be given and alternative routes to solutions will be provided if they are needed.

3. Project background and problem definition and constraints

3.1. Project background

This project will be based in Tata steel Trostre, it will be installed in Area 1 on the North cleaning line where in order to keep the line continuous with little delay when switching between different coils, the strip needs to be welded together. The problem occurs when the weld between the two different coils isn't good enough, so when the line tension is enabled the strip breaks under the tension. This leads to lengthy delays of around 4-8 hours depending on the severity of the break which costs a lot of money, around £5000-10,000 an hour. This can also damage customer relations when products are not delivered on time, meaning the company can be liable to produce discounts on late deliveries and also face the possibility of losing the supplier contract if customer demands are not continuously met. The solution needs to be an effective weld monitoring system which looks at the three key elements of a weld. These are heat, speed and pressure. The heat in the weld is dependent on the current. The welder makes use of low voltage very high current in order to cause a seam weld. The pressure is pneumatic which needs to be of an appropriate force in order to hold the strip in place, and also force the top and bottom welder wheels together for a good flow of current. Finally, the speed is controlled via DC Micro drive. If the speed is too fast, then there can be gaps in the weld and too slow can cause burning through the strip, so the speed must be controlled to the correct standard at all times.

The standard is made up of known settings taken when a good weld has been produced. The solution needs to be a system that can detect if any of these criteria have deviated from the standard which is known to produce a good weld, the operator should be informed in order to repeat the weld again to prevent a possible strip break. For engineering support, all monitoring data will need to be mapped into the IBA analyser in order to create a live and historical map of the monitored data.

3.1.2. Constraints and Risks

There are many constraints that fall into this project. One of the major constraints is COVID-19. This has changed the way work is conducted in work so there will have to be some strategy adaptations in order to get the work done. This would be for things like working together with others within 2M, holding meetings and accessing materials. University efficiency could also become a problem as due to current/future lockdowns certain facilities can become hard to obtain. Work colleagues are also being asked to work from home, so if material needed is in work it will not be collected until that individual is rotated in to work which can delay numerous processes.

3.1.3 Ethical issues

There are numerous ethical issues that are arising. The biggest issue is the transparency of companies during their manufacturing process. As a company we want our suppliers to provide a fair-trade price for their employees' labour, meaning suppliers used will not pay below minimum wage for their labour in third world countries.

NOTHING MORE SPECIFIC TO THE PROJECT ITSELF?

3.1.4. Legal issues

The legal issues of this project consist of two things. The first being liability, because of this the safety of the system must be impeccable. At any point in time if there is an accident to do with the system, the HSE will look at the safety of the system. So, in order to avoid being held accountable by the HSE and being prosecuted, the correct safety measures will eliminate any possible risk as best reasonably practicable. The other legal issue is copyright issues.

3.1.5 Environmental issues

The biggest environmental issue is to ensure that all components used are as efficient as possible. The idea is to get hardware which will operate at its most optimal level with creating little losses in heat. This will then reduce energy consumption which is effectively more environmentally friendly. Hardware used will also have to have a power saving mode where if it is not used for over 3 hours, it goes into low power mode.

3.2. Professional conduct and codes of practice

The professional conduct will include general understanding of what is a good standard of work within the electrical industry. This means the installation must be acknowledged by others that it is a good standard of work and hasn't been assembled by an unskilled craftsperson. Internal code of practice would be EIS 7 which is a low voltage regulation book for this site. External regulations consist of BS7671 18th edition wiring regulations, BS 7430 Earthing code of practice, BS EN 50110 Operation of electrical installations and BS EN 60529 Specification for degrees of protection provided by enclosures. The final two external regulations would be the general H&S at work act 1974 and the Electricity at work act 1989.

3.3. Legal requirements governing engineering activities

Any personnel which will work on the project will be governed by the works legal code which states that employees cannot work more than 16 hours per day and must have 2 days off every 2 weeks. If this is not met and an accident occurs, the company can be legally held accountable. General health and safety requirements will apply at all times, this would be covered in the site induction. Since this system is one of a kind, the intellectual property rights will belong to the customer, if the customer finds it necessary then a patent can be filed. Hardware used will have a SIL level of 1. This means that if components fail the likelihood of an accident happening is very low. The liability will be with the supplier of the system. The commercial risk which can occur would be a loss of product to consumers. If the system does not operate properly and does not detect faulty welds, then the strip can break causing these lengthy, expensive delays which will ultimately affect the logistical flow of the product produced.

3.4. Ethical standards and sustainable development

In the current climate it is vital to operate as ethically as possible. Some of the standards should be integrity and transparency. It is vital to have a high level of integrity as this will set the precedent for all work which is carried out. Having a high level of integrity would mean doing something which would cost slightly more because you believe in that product over choosing a cheap alternative which is known to be worse. The project must be development sustainably, this would mean attempting to make use of hardware which has been made using recycled materials or even refurbished hardware, hardware which has power saving modes and also highly efficient hardware. All of this tie into the future sustainable development of the industry the project is for.

SOME SPECIFIC EXAMPLES WERE NEEDED HERE.

4. Functional Design Specification and test plan

4.1. Introduction

This FDS is for Trostre's North Cleaning line welder. Currently the 40-year-old welder does not have the capability to monitor essential data during a weld. Due to the age of the welder, its performance is deteriorating by mechanical and electrical failures. This FDS is to set the standard for a system to be installed in order to prevent failures, which can lead to numerous logistical and financial troubles.

4.1.1. Requirements

1. The system must be a standalone system.
2. The system must be able to be connected to the works network.
3. Welder speed, current and pressures must be monitored.
4. All data must be able to be mapped over into IBA analyzer
5. The installation must coincide with the company's MOC procedure.
6. Safety systems must NOT be interfered with.
7. The installation must be put inside of the existing welder panel.
8. The system must have the capability to be expanded in the future.
9. The monitoring system must be able to alert production of unacceptable welds.
10. The existing welder operation MUST remain the same.
11. The system must have reliable fault finding help procedures.

4.2. Numbers

The system will be used by around 12 people on a daily basis, these will not be the same users each day. It will monitor about 3 welds per hour. The system will need to have the capability to monitor these welds flawlessly at a rapid rate. The system will need to record data in a matter of milliseconds as the weld only takes around 20 seconds to complete. The project budget will be £15,000 for the complete project.

4.3. Existing System

Currently, the welder in question does not have a monitoring system. When the welder system was designed it did not have a monitoring system in place as it was new and electrical/mechanical faults were not an issue. Now that the welder is 40 years into its service, the failure frequency has risen dramatically and is costing the customer big financial losses. So, by monitoring the weld parameters with a monitoring system the customer will be able to prevent these losses. The monitoring system which is being installed will not affect the operation of the operation of the welder, its sole purpose is to monitor the parameters.

4.4. Terminology

Abbreviation	Word	Meaning
MOC	Management of change	A written procedure which needs to be completed in order to make changes to a system.
BS	British standard	National standards for electrical work.
IP	Ingress protection	Protection effectiveness against different elements.
CPU	Central processing unit	Principal part of a digital computer system.
MSE	Manufacturing Support Engineer	Job title.

4.5. Required skills

These are the skills required in order to complete the development.

Skill	Level required	comments
Electrical Installation	HIGH	Needed in order to produce and install the project.
Software coding	HIGH	Program and write code for the system to work.

4.6. Client Summary

This section is a condensed section of the Function Specification design. This is for the client to understand the ideas behind the solution, implementation details and most of all see if the solution meets their requirements.

4.6.1. Introduction

The solution suggested is a standalone weld monitoring system with a main processing unit which can process analogue data inputted from field devices. Functionally the system should be able to record all data and if needed act upon any deviations that it sees. The data will also be transferred into an external program to be stored in the event of failures. The technology being used will be modern day monitoring devices and the brand-new CPU's to avoid bugs and firmware issues.

4.6.2. System Functionality Summary

The system will comprehensively support:

1. The north cleaning line production team.
2. Electrical shift specialists.

The system will functionally support the business by altering users when welds are faulty, saving financial losses. Full device requirements are defined in section 4.11.

	Function	Description
1	Current monitoring.	Current monitoring on the primary and secondary side of the welder in order to see current trends. From this earthing on the welder will be able to be seen.
2	Pressure monitoring.	Monitoring the high and low pressure of the welder in order to ensure the heads come together correctly every time. This is also referred to as snubbing pressure.
3	Speed monitoring.	Carriage speed of the welder. The time is calculated from the welder wheels touch the strip, to when they stop touching the strip.
4	Alarm when anomaly seen.	If any parameter is not met and deviates from standard the operator should be informed in the form of an alarm.

4.7. Assumptions

	Assumptions
1	The North Cleaning line's MSE will provide all current drawings, Phillip Rowe to produce drawings for update. Tata Steel's drawing office to then add them into cab-i-net after they make new copies.
2	Site visit will be required in order to discuss installation location.
3	Electrical MSE will provide all spares.
4	Full spares list to be given to Electrical MSE.
5	The electrical MSE will provide labour.
6	The system will be installed on the week of 07/02/2021 to 14/02/2021
7	Training will be provided by Phillip Rowe on the new system.

4.8. Constraints

	Constraint
1	System must be installed and commissioned by 14/02/2021.
2	All new drawings to be made on Microsoft Visio for a paperless system. (Zero carbon footprint)
3	
4	
5	

4.9. Implementation Implications

In this section aspects of the implementation have been defined in order to aid the project manager distribute the correct materials.

4.9.1. Pre-Requisites

	Pre-requisite
1	Welder electrical cubicle
2	Existing supply cables

4.9.2. Data conversion & Cleansing

Since this is a new system, all current drawings will not need to be converted into new types. The new system will be added to the existing drawing to maintain the clients standards. Any software being used must go through the clients data control and cleansing process.

4.9.3. Legacy System(s)

As this is an old system there is no old system which needs to be considered.

4.9.4. Conversion Strategy

Since the system is an addition and not a replacement, the conversion process will be easier to produce.

4.9.5. Conversion Method

The method for the system to be converted onto the existing welder, the client has not defined any restrictions. The only requirement is that when converting the system onto the existing welder, it does not affect the operation in any way.

4.9.6. Test impacts

When testing there will be a function testing document needed as the clients site regulations demand this. When testing the new system, the new installation must not cause any defects to the current operating system. Also any items connected to the client's site network MUST NOT impact the operation of other production lines. Extreme caution should be taken in order to prevent this issue occurring.

4.9.7. Test Plans Required

Two separate test plans will be required. One will be performed with the supplies isolated and the other with the system powered up. These two testing plans exclude the FAT the system will have to pass before being installed.

4.9.8. Test Environments

When live testing is occurring, the area will be bunted off in order to create a safe testing area. The production team will organize multiple dummy welds in order to simulate the real functions, but this will allow the commissioning team to modify any changes needed.

4.9.9. UAT Requirements

The user acceptance test must meet the following requirements:

- Operators to perform normal welder functions.
- Operators must understand new displays.
- Operators must understand new alarms.
- Electrical shift specialists to be able to interrogate new software.
- Electrical shift specialists to be able to isolate systems if needed.

4.9.10.Training Impacts

Training will be given to all personnel needed during normal operation. Training folders to be given as back up. This system does not alter skill of operator.

4.9.11.Resource Requirements

Resource requirements will be as followed:

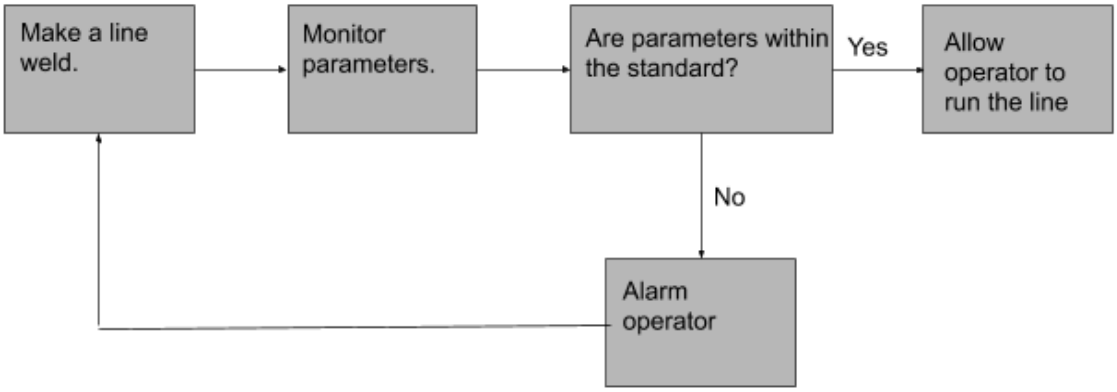
- 1 Electrical craftsman.
- 1 Electrical apprentice.
- 1 programming laptop with suitable software.
- Commissioning documents.
- Materials list - referred in related documents section.

4.10. Functional Overview

The weld monitoring must have the functions to monitor current, speed and pressure during a normal weld. This should generate an alarm if the weld is not up to a suitable standard.

4.10.1.Process Model

This is the process model which the system will mimic.



4.11. Design Summary

Requirement	Component	Type	Sizing
Current monitoring	Current transducer	Fixed	0-10,000A
Pressure monitoring	Pressure transducer	Panel mount	0-250 BAR
Processing HUB	CPU	TBC	1ms scans/s
Remote I/O	Remove sub-rack	TBC	10 I/O's
Programming station	Central PC	TBC	TBC

4.12. Testing Plan

This testing plan has been derived from the FDS which has been made for this project. The testing plan is split up into three main parts. These are dead testing, live testing and functional testing. The reasoning for having a testing procedure like this is to avoid causing any component damage and to rectify any faults which may be present.

4.12.1.Dead testing

This section is for the pre-functional tests to be carried out. This is to ensure that once powered up no hardware damage will be done.

	Test type	Test method	Expected result	Actual result	Pass/Fail	Amendment requirements
1	Continuity test of power +/- connections.	Continuity test	0.1 ohms			
2	Continuity test of remote I/O device supplies.	Continuity test	0.1 ohms			
3	Continuity test of AI connections	Continuity test	0.1 ohms			
4	Tightness test of all connections	Terminal screwdriver	2.5nm torque setting			
5	Security of all transducers	Physical touch	Secure by hand			

TOLERANCE.

4.12.2.Live Testing

This section will provide the live testing where the power will be turned on BUT there will be no functional testing.

	Test type	Test method	Expected result	Actual result	Pass/Fail	Amendment requirements
1	Power supply voltage tests with MCB's off.	Voltage tester - Multimeter.	20-28v - No circuit break trips.			
2	Power supply voltage tests with MCB's on.	Voltage tester - multimeter.	20-28v - No circuit breaker trips.			
3	Remote devices power cycle check.	Visual	Transducers to power on.			
4	Communications test.	Server PING test.	Reply from controller to programmer.			

4.12.3.Functional testing

This section will be where the operation of the system will be tested providing that all the other test procedures are completed successfully.

	Test type	Test method	Expected result	Actual result	Pass/Fail	Amendment requirements
1	AI signals test	Monitor values	Value range between 0-27648			
2	Scaling of transducers.	Set ranges and adjust as needed	I.e 0-27648 = 0-250 BAR.			
3	Alarm when faulty.	Test alarm	Beacon flash.			

5. Literature review

In this section 3 solution will be looked at in depth in order to determine the best solution. All solutions must meet the requirements which were listed in the FDS.

5.1. Measuring devices used in all 3 solutions.

Although there are 3 different solutions as to which method is used to monitor field devices, the actual field devices will remain the same through each solution.

Current measuring devices

There are many ways in which current can be measured. There are usually two reasons for measuring current, these would be you either want to know how much current is flowing or is there too much current flowing. A signal to indicate the “how much” condition and the “too much” condition is available in a variety of measurement methods:

1. Resistive (Direct)

2. Magnetic (Indirect)

3. Transistor (Direct) (Yarborough, 2018)

For this project the route taken is the magnetic indirect route however two methods of doing this were explored. The first method is to use a current transformer, the second is to use something called the Rogowski Coil. Current Transformers produce an output in proportion to the current flowing through the primary winding as a result of a constant potential on the primary (Smith, 2019)). A Rogowski coil is an 'air-cored' toroidal coil placed round the conductor. The alternating magnetic field produced by the current induces a voltage in the coil which is proportional to the rate of change of current (Evans, 2020). Although both of these devices are very similar they both do have separate advantages and disadvantages. These can be seen below in figure 1.

Measuring device	Advantages	Disadvantages
Rogowski coil	• Non-intrusive or lossless measurement • Low cost • Flexibility	• AC Current Only • Very sensitive compared to a CT
Current transformer	• High immunity to electromagnetic interferences. • Larger dynamic range • Low voltage outputs- compatible with ADCS • Fast transient response	• May require heat sink • Low efficiency if input-output difference is large • Higher cost

Figure 1- Advantages/Disadvantages of current measuring devices – References for figure 1 - (Afzal, 2014) , (Cormer, 2015) , (Manutech, 2020)

Looking at both the advantages and disadvantages of both devices the Rogowski coil just edges the competition as in this project the current device needs to be very flexible as it is on a moving copper shunt.

<u>Pressure monitoring devices</u>

Pressure transducers have a sensing element of constant area and respond to force applied to this area by fluid pressure (Anon., 2019). This force applied deflects the diaphragm inside the device, this is then measured and then this measurement is given out in the form of a voltage/current.

There are six primary pressure sensor technologies used to sense pressure. These are Potentiometric pressure sensors, Inductive pressure sensors, Capacitive pressure sensors, Piezoelectric pressure sensors, Strain gauge pressure sensors and Variable reluctance pressure sensors (Edwards, 2019).The two-best fit for purpose to use in this system are the capacitive sensor and the variable reluctance sensor.

Following below in figure 2 is the comparison table for the two different types of pressure sensor.

Measuring device	Advantages	Disadvantages
Capacitive sensor	• The sensitivity of capacitive transducer is high. • The capacitive transducer is useful for small system. • It has good frequency response. • It requires small power to operate. • The loading effect is less due to high input impedance.	• The capacitive transducers are temperature sensitive. • It gives non-linear behaviour. • The output impedance depends upon the frequency used. • The capacitance may get changed by dust particle and moisture which produce error.
Variable reluctance sensor	• Measurement of very low pressures • Low power consumption • Wet/Wet differential measurements • Suited for high levels of vibration	• Large size • Limited range • Low sensitivity

Figure 2- Pressure transducer table of comparison – References for table data above - (Cheatle, 2019) (Desai, 2020) , (Editor, 2017)

Using figure 2 above and comparing both the advantages and disadvantages of both types of sensors, the sensor which is going to be used is the variable reluctance sensor. The biggest reason for this is because the operating temperature in the area where the sensor is placed can get very hot and also there is a lot of dust/foreign bodies in the system which could lead to faulty readings and on a system, which needs to be critically right all the time, the VR sensor is the clear winner.

5.2. Solution 1 - Industrial Arduino -

Arduino is a low-cost open-source electronic board system that is capable of controlling just about any DIY hardware project, from robotics to art projects and just about everything in between (Electronics, 2020). These Arduino boards have endless expansion possibilities and come with free C/C++ software for coding. An industrial Arduino closely mirrors an entry level PLC. (Reneker, 2017) states "If it's possible to buy an Arduino for as little as $20, why spend hundreds on a PLC? ". Since the purpose of this project is to monitor analogue values, it is vital that the Arduino can successfully achieve this. The arduino has a built in ADC which can convert the analogue signal into a digital value which is known as a function. This function converts the value of the voltage on an analogue input pin and returns a digital value from 0 to 1023, relative to the reference value (Youngblood, 2015). The known default reference number is either 5v or 3.3v depending on which type of board is used.

<u>FA-DUINO-32TA</u>

The above ardunio board has been chosen for this solution as it has all the required analogue inputs as well as the correct relay outputs in order to generate an alarm. This type of board has the following features:

- Program memory: 256KB
- SRAM: 8KB
- EEPROM: 4KB
- Clock Speed: 16MHz
- 16 - 24VDC Inputs (pins 30~45)
- 8 - 10A Relay Outputs (pins 22~29)
- 2 - RS-232C Communication Port
- 1 - RS-485 Communication Port
- 4 - 0~10V Analog Inputs
- 4 - 0~20mA Analog Inputs
- 10-bit ADC (0~1023)
- Powered by 24VDC

- Operating Temperature: 0 ~ 60°C
- Operating Humidity: 35 ~ 85% RH

Above data obtained from (Technology, 2020)

Looking at the specification of the board, it can be seen that there are more than enough analogue inputs that can be used, there are enough relay outputs in order to set off an alarm and the power supply is low power/low wattage. Another major advantage of this board is that if needed, it can convert analogue signals into digital ones with a decent range of 0-1023. The board also comes with various different protection elements such as fuses, EMI filter, Spark killer circuit and an upload protection circuit. Another key element of this board is that it is din rail mounted so the installation will be simple. Some of the drawbacks with this board are that there is no RJ45 communication port, so this means the RS-232C port will have to be used with another convertor in the middle which converts this into USB. This in the long run just adds another component which can fail. Finally, the operating temperature and humidity ranges are rather low, especially because of the type of environment the system will be located in which has a very high humidity and temperature due to steam usage and caustic fumes.

In order to make a fair analysis between all of the solutions, as well as the technical details which have been listed the cost and ethical points need to be taken into consideration. Total cost of the board with an RS-232C to USB cable and the 24v power supply included would be £102. (REFERENCE 17) Also the overall dimensions of the board are 154mm X 98mm X 30mm. So, this is a reasonable size to fit inside the existing enclosure. The overall wiring of this board is relatively simple to make and it comes with a comprehensive wiring diagram. One of the drawbacks with this solution would be the programming software. The supplier of the board also offers a range of support lines and since this board is used for a vast range of applications, there are many forums that can be used in order to answer any queries. The free C/C++ software is not the chosen package which the customer uses, so this leads to a range of issues with regards to the maintenance and fault-finding aspect of the system. With all these considerations considered, a table will be drafted at the end of the section in order to compare and contrast the three solutions and pick the best one by giving factual evidence.

5.3. Solution 2 - Industrial computer

This solution is compiled of multiple different aspects in order to achieve the same goal. The computer of choice is the Onlogic Helix 610 Intel Comet Lake Industrial Edge Computer. There are many differences between a normal computer and industrial one, these are things like better Enclosure form factors, higher IP ratings, higher level protection against impacts, industrial grade components and the highest filtration systems (Rees, 2019). There are also numerous other advantages such as the pure reliability factor and also the support network provided by the supplier. Industrial embedded computers typically align with industry standards for temperature ranges (-40°C to +85°C is typical) and shock and vibration, where a standard like IEC 68-2-27 looks at various aspects of shock in industrial equipment (Hiliard, 2019)

In order to register the inputs and outputs a PICkit 2 18-pin demo board would be used and microcontroller is a PIC1827. Finally, the software program which would be used would be MPLAB x.

The onlogic helix is an industrial computer which has some very good specifications. The processor used in this computer is an Intel Comet Lake Core i9. this is one of the fastest processors **Intel** has introduced to date (Jonnalagadda, 2020). This means that it will be able to process data in the require 1m/s scan rate time. Other features of this computer include a 64GB hardrive, 4 Gen 2 USB 3.2 ports, numerous expansion I/O slots and the computer can actually be mounted to din rail (TECHNOLOGY, 2020)One major thing with using computers in industry is that they must conform to certain standards before they can be installed, in this particular case the manufacturer has ensured that this computer does indeed conform with these regulations. This can be seen below in figure 3.

Regulatory Information	FCC 47 CFR Part 15 CE WEEE Directive (2002/96/EC) Low Voltage Directive (2014/35/EU) Electromagnetic Compatibility Directive (2014/30/EU) Radio Equipment Directive (2014/53/EU) - For configurations with wireless transmitters RoHS 3 (2015/863/EU) REACH EN 55024 EN 55032 EN 55035 EN 60950-1 EN 61000-3-2 EN 61000-3-3 EN 61000-4-2 EN 61000-4-3 EN 61000-4-4 EN 61000-4-5 EN 61000-4-6 EN 61000-4-8 EN 61000-4-11 EN 62368-1

Figure 3 - Regulation information – Reference - (onlogic, 2020)

Now taking a detailed look at the PIC1827, two of these micro controllers would need to be used in order to achieve the required analogue inputs needed. The most important factor with this micro controller is the processing speed, it needs to be able to handle multiple instructions every second. This type of controller has a processing speed of 8MIPS, information taken from (Microchip, 2020). (Techterms, 2020) states that “MIPS stands for "Million Instructions Per Second." It is a method of measuring the raw speed of a computer's processor. “So, with this processing speed this controller is more than capable of meeting the required specification. The controller also has numerous other good specifications like 8 and 16-bit timers, watchdog timers, 10-bit ADC’s and a low operating temperature of 1.8-5.5v. The controller also offers a good operating temperature range of -40 to +125 degrees Celsius.

Finally, MPLAB X would need to be used in order to get the analogue values into the computer for data processing. The package offers a range of helpful data processing techniques such as data visualisation, I/O viewer and a helpful design resource. The data visualizer offers real time streaming data to be viewed in the data visualizer. I/O view allows the pin states to be verified and also manipulated when using the I/O view tool. The design resource makes use of links, software libraries and data sheets which can also provide user guides automatically.

Taking all these separate items into account, the price for the system will now need to be worked out in order to evaluate this solution. The industrial computer comes out to around about £1020. The total cost of the controller system is around £127. Finally, the software comes to just over £100 for a year's license. These prices can be found via references (onlogic, 2020) , (Techterms, 2020) , (Microchip, 2020).

Whilst the advantages of this system are vast ranging from high speed processing power, sound reliability, prime operating temperatures and good support networks. There are some very daunting disadvantages to having this type of system. One of the biggest disadvantages is the sheer cost of this system, coming in at around £1230 which is well below budget, for just a simple monitoring system that is not a good investment. Also, the expansion of this system would be relatively hard as every time new inputs may be needed there would have to be adaptations which then would mean management of change documents would have to be done every time which can cause lengthy delays to the addition being made. Again, the advantages and disadvantages will be put into a table at the end from major comparison with the other two solutions.

5.4. Solution 3 - Industrial PLC

A PLC is a programmable logic controller which is capable of controlling/monitoring any form of system. There are a range of techniques used by the PLC in order to achieve the desired outcome. With multiple different programming languages there is a standard for every industry.

Siemens S7-1513 and ET 200MP I/O

For this solution the CPU 1513 and ET 200MP remote I/O rack have been chosen. The reasoning for this is due to the possible future expansion of the system and the shear reliability of this type of system. This system offers many benefits such as –Standard, for typical applications, Compact, for applications where space and cost are a concern, Fail-Safe, for fail-safe applications. (REFERENCE 26). This system is totally integrated, the system makes use of profinet communications to pass information onto remote devices, but it can also be easily added to a works network for remote access. This system has already been proven to be easily integrated into IBA analyzer, which is a key element to the project.

The product specification for the S7-1513 is very high, its processing speed is 0.04 milliseconds (graham, 2020). Which is well above the required demand for this project. The CPU is mounted on a 1500 specific special din rail, which is only 800mm long and 300mm high so it doesn't take up a lot of space. In order to store the program on the PLC an additional memory card is needed, which the chosen one would be a 12KB to provide space for future updates. The ET200MP is the expansion module for the 1500 PLC series. This expansion rack once built can offer a range of different analogue inputs. The general analogue input card can be changed in the program to read both voltage and current input. The only thing which will then change is the way in which the input is wired into the card. Finally, the totally integrated S7 TIA portal will be used in order to write the code for this system. TIA is known as one of the simplest programming software to use, with its extensive help prompts and folders. Since this is highly used a lot of helpful information can also be found on manufactures forums where problems are solved by siemens personnel.

The major advantages of this solution are that its already industry proved, meaning that industry recognise it as a standard operating system, the processing power is above and beyond current needs but leads a lot of room for future improvements and additions, the system is easily expandable as the I/O cards clip in and out and only require little wiring, since this is already an accepted standard there

is no need for complete retraining on a new system and finally the warranty supplied with the products is outstanding. Some of the disadvantages are that the system is very expensive, since siemens are seen as market leaders this is reflected in the price of components, siemens have made its own brand products essential meaning things like memory cards cannot be other brands, they must be siemens specific cards and finally the system is often bought in various different pieces so there would be multiple different components needed in order to make the system functional.

Coming to the costing side of things, since Siemens sell everything separately there are a lot of components needed in order to build the total system, unlike these solutions given where the majority of the stuff comes as a package. To make this simple a table of components has been created below in Figure 4.

Component	Quantity	Price
S7 CPU 1513	1	£1450
12kb memory card	1	£179
S7 1500 Power supply	1	£100
1500 din rail	2	£166
ET200MP	1	£220
Power supply	1	£306
AI Cards	3	£840

Figure 4- Siemens S7 price list - Referenced from - (Siemens, 2020)

The total price just to build the system without the wiring would be £3261. Since it is just purely the systems that are being compared, the wiring and installation has been left out of the price at this time in order to just purely compare the system prices.

Final conclusion and comparison

In order to find the best solution a table has been made in order to clearly see all the advantages and disadvantages of each system. These will then be critically analysed and the best solution will be chosen. All scores have been based on specifications which have been stated in the previous analysis.

	1. Arduino	2. Industrial computer	3.S7- PLC
Cost (1-10)	8	7	3
Efficiency (1-10)	6	7	9
Reliability (1-10)	5	7	9
Support (1-10)	8	8	9
Speed (1-10)	7	8	10
Protection (1-10)	4	9	8
Total score (Higher the better)	38/60	46/60	48/60

Using the above table, there is a very close comparison between solution 2 and 3 however solution 3 just about edges it. All the ratings were generated from facts which have already been discussed in the individual solution sections. Although solution 3 is more expensive than the other solutions, the S7 PLC has a proven track record in industry for control systems hence why the reliability is so much higher in comparison to the other solutions. Using solution 1 or two would be a new innovative idea, however this would lead to teething issues regarding the installation and also the normal operation of the system. All the solutions offer a vast wide range of support which is ideal for this industry. Clearly none of the solutions lack processing power speed as this was proved with the factual evidence provided, however solution 3 is in a different league at this current point in time. Overall solution 3 is just the better option since it scored the highest overall in the categories and also it is actually the preferred standard for this client.

6. Project planning, Work breakdown and Management techniques

6.1. Work breakdown flow diagram

Following below is the work breakdown structure diagram. This shows the 3 parts to the project and then the sub-sections that fall under these main parts.

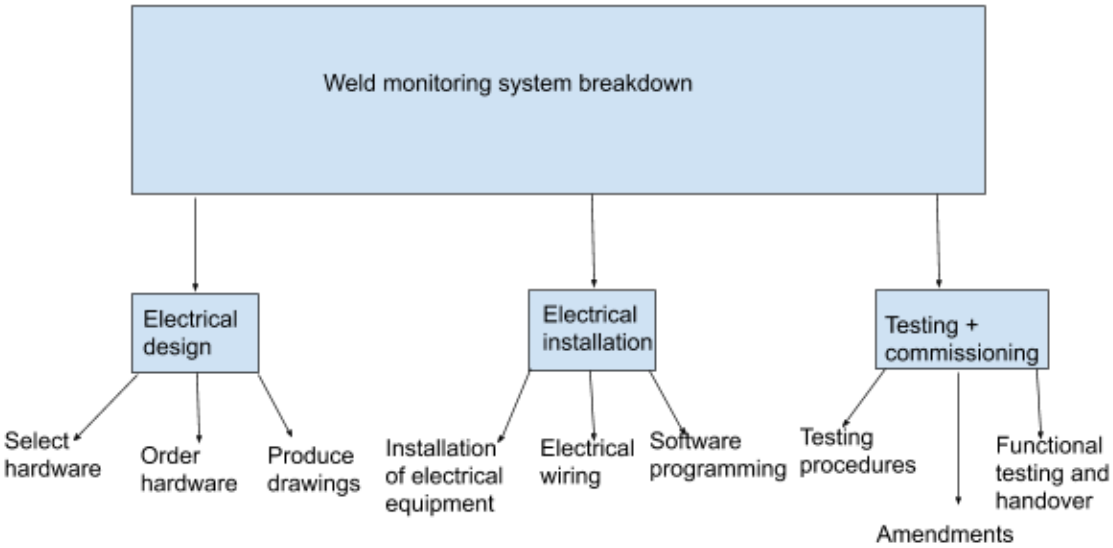


Figure 5 - Project breakdown plan

6.2. Project plan

Following below is the Gantt chart plan for the implementation of the project. This can be seen in figure 5.

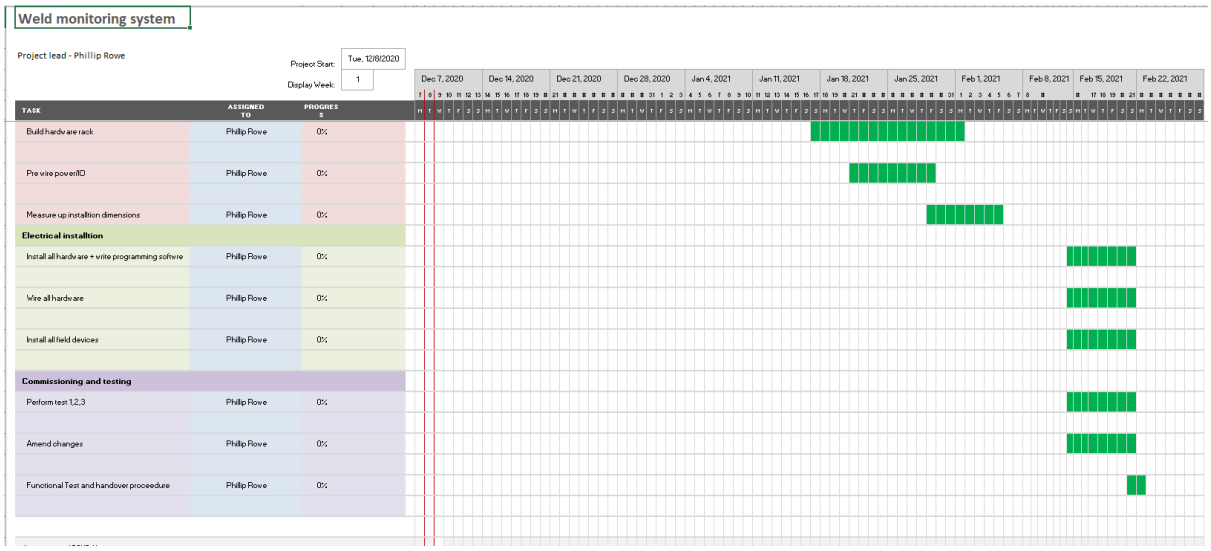


Figure 6 - Project time plan

ONLY COVERS 2 MONTH.

Management techniques

The two management techniques which will be used in this project are Autocratic management and collaborative. Autocratic is a top-down approach which makes communication flow one way from bosses to employees. The reason for this approach is to keep a close eye over the project, ensuring that all decisions are made via the project lead. This approach also allows the project to be done in its intended way as the employees are not encouraged to ask questions or share ideas, it's more of a command/request relationship between manager and employer. The collaborative technique will be mostly used in the installation phase as the project manager for this project will closely monitor the progress in order to ensure it is being done correctly.

Following below in figure 7 is the general costing sheet which has been generated for the chosen solution.

Cost catogory	Total estimate cost		Spillover amount	
Electrical installation	£	6,000.00	£	500.00
Electrical design	£	500.00	£	50.00
Electrical consumables	£	1,000.00	£	200.00
Hardware components	£	6,000.00	£	1,000.00
Commisioning variables	£	500.00	£	50.00
Total estimated cost	£	14,000.00	£	1,800.00
Amount spare	£	1,000.00	£	15,800.00
Total budget available	£	15,000.00	£	800.00

Figure 7 - Overall costing sheet

7. Conclusions and recommendations

Concluding on this phase of the project, the correct solution based off the research and analysis was definitely chosen. The Siemens S7 system scored the highest in the comparison table and through all the analysis provided the best possible outcome for this project. A large reason for this was because both the industrial computer and the Arduino have not been fully proven in industry and many people are reluctant to deviate from a known/proven good standard of doing things. This was shown in the research as there wasn't many case examples of where these two solutions had been used before to do something similar to this project. Whereas with the Siemens S7, there was plenty to read and write about as this type of system has been used multiple times and also has previous generations of controllers which could do the same thing in around about the same way. This meant people are still familiar with the technology and it is easier to adapt to.

There are some recommendations that would be essential if this was carried out again. Firstly, time management would need to be monitored with a finer eye. Although there have been no major delays with regards to time management, a more structure time plan for this design phase would be beneficial as it would ensure that no work is being rushed, which would then mean every single detail would be present in the report and there would be no risk of missing anything out. This is very important as if anything is overlooked at the development stage, this could potentially pose massive either financial losses, legal losses or even reputation losses in the future. So, this is why time management is vital in order to ensure nothing is overlooked or forgotten about in the design stages. Secondly, if there was more time it would be ideal to look at sub solutions in the three main solutions. This would mean taking each one of the three solutions so for example the industrial PLC solution, and then look into the different types of PLC which could be used. Since there wasn't a massive amount of time to develop all of these different ideas the literature review had to be concise however, it would prove very beneficial to look at other hardware components which would come under the same solution. By doing this it would then be totally apparent that the absolute correct solution has been chosen, but also the correct hardware selection has been made. Thirdly the final suggestion would be to possibly integrate the building of the project within this section of the project plan. Front loading the project would save time in the long run and would speed up the development of the project, especially if there are other working parties awaiting parts to do their bit, it would apply slightly more pressure for work to be carried out in a faster manner. This could also help any teething problems being caught in the earliest stages rather than towards the end.

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9. Appendix

PROJECT PROPOSAL DOCUMENT

Student Name: Phillip Anthony Rowe
Project Title: Weld Monitoring System
Date: 02/10/2020
Budget: £15,000

Description of Project
This project will be based in Tata steel Trostre; it will be installed in Area 1 on the North cleaning line where in order to keep the line continuous with little delay when switching between different coils, the strip needs to be welded together. The problem occurs when the weld between the two different coils aren't good enough, so when the line tension is enabled the strip breaks under the tension. This leads to lengthy delays of around 4-8 hours depending on the severity of the break which costs a lot of money, around £5000-10,000 an hour. This can also damage customer relations when products are not delivered on time, meaning the company can be liable to produce discounts on late deliveries and also face the possibility of losing the supplier contract if customer demands are not continuously met. The solution needs to be an effective weld monitoring system which looks at the three key elements of a weld. These are heat, speed and pressure. The heat in the weld is dependent on the current. The welder makes use of low voltage very high current in order to cause a seam weld. The pressure is pneumatic which needs to be of an appropriate force in order to hold the strip in place, and also force the top and bottom welder wheels together for a good flow of current. Finally, the speed is controlled via DC Micro drive. If the speed is too fast, then there can be gaps in the weld and too slow can cause burning through the strip, so the speed must be controlled to the correct standard at all times.

The standard is made up of known settings taken when a good weld has been produced. The solution needs to be a system that can detect if any of these criteria have deviated from the standard which is known to produce a good weld, the operator should be informed in order to repeat the weld again to prevent a possible strip break. For engineering support,all monitoring data will need to be mapped into the IBA analyser in order to create a live and historical map of the monitored data. The project lead will be Phillip Rowe who will plan, design, build, test, install and commission the project. The client will be the North cleaning lines electrical engineer John Shannon. The budget allocated for this project is £15,000, this has been agreed between Phillip Rowe and John Shannon. The project must be designed and ready for installation on the annual maintenance which is the week commencing on the 07/02/2021 and ending on the 14/02/2021. The project must comply with internal company standards but also national regulations. External regulations consist of BS7671 18th edition wiring regulations, BS 7430 Earthing code of practice, BS EN 50110 Operation of electrical installations and finally BS EN 60529 Specification for degrees of protection provided by enclosures. The internal regulations which must be followed are the company's management of change procedure, internal factory acceptance testing regulations and finally, the production ownership acceptance test. It has been agreed that Phillip Rowe will produce a FAT test to present to John Shannon, once the internal FAT test has been passed, Phillip Rowe will then organise the ownership acceptance test where the production team will take ownership of the newly installed equipment. Finally, training will be arranged for the engineering team to be trained on how to use the new system when fault finding and suitable documentation is provided.

Agreement for project proposal

Student Signature: P.Rowe Date: 10/10/2020

Industrial Supervisor Signature: J.Shannon Date: 10/10/2020

Academic Tutor Signature: _R. Davies_____ Date: _06/11/2020