

Project final assessment

Nicholas Devoy

by Nicholas Devoy

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Good table of contents and list of figures. The problem definition should come before the spec in contents.

1. Introduction and Background Research

Company background

Tata steel was founded in 1907 and it was the first steel company that was private in Asia. Around 29 million tonnes of steel are produced a year by Tata Steel. Tata steel plants are spread all over the world including, India, Netherlands, UK, Singapore, China and Australia. Plants such as Port Talbot and Trostre are known as Tata Steel Europe but were known as Corus beforehand. The steel from Tata is used for many things in today's industry such as Military services, Aerospace, automotive, packaging and construction. Port Talbot is where the steel is made and Trostre is known as a packaging plant and receive the steel from Port Talbot.

There are many varieties of steel that are made in Trostre such as cold rolled, hot rolled, electro plated steel, narrow strip and metallic coated steel. Trostre is where the project will be designed and made. The project will be made in the basement of ETL 5. The steel from Port Talbot comes in a coil form where it is coated for places to make for example cans. The steel is processed through different lines when it comes into Trostre. It is cleaned on the Pickle line, stretched on the five stand, annealed on the Capl and coated with chrome or tin on one of the ETL lines. The line where the FSA is being made is explained below.

Area 3 is where the ETL 5 is located. ETL stands for Electrolytic Tinning Line, there are numerous sections on the line that all play a part in coating the steel with tin.

The first part of the line is the Cleaning section. Oxides form on the steel when it goes through its process stages and whilst its waiting to go through the next process. The cleaning agents used on this line are mixed together by the chemical manufacturer to form a liquid which are added to the cleaning tanks. These liquids contain sodium hydroxide or caustic soda and sodium phosphates which dissolve oils and grease.

Once the steel has been cleaned, it is ready to go through the plating section. During the electroplating a current travel through the solution causing ions to form. This movement is done by the steel cathode and tin anode.

The next section for the strip is the chemical treatment. The tin develops an oxide layer by reacting with oxygen and will grow even more until is electrochemically treated. Not only does it make it hard to get a good weld onto the strip due to the thickness, but it also doesn't look too appealing to the customer when bought. The treatments are split into 3 types which are called 314, 311 and 300. All the treatments include a chromium film which is very thin, chromium hydroxide and oxides which are also placed onto the surface of the strip, this will stop oxidisation from happening to the strip and alleviate the surface against similar reactions.

The oiler is the last section of the line. An oil lubricant is applied to the strip once it has received the chemical treatment and been rinsed and dried. The reason for adding a mist of oil onto the strip is for feeding and handling operations and to diminish the coil from abrasion damage.

Recently, a lot of ABB drives and Siemens PLC's have been installed to update the lines. Therefore, the new FSA (Functional spares assembly) is important to the plant. The FSA is where motors will go to be tested before going out on the lines. This will enable the motor to be controlled by a drive, a PLC or both, it all depends on the motor's operation.

Introduction and background research is relevant. However there is no need of the extent of word count here. The use of an image would reduce the word count and improve the explanation.

The reason behind carrying out this project is because the current function spare assembly is old and the drives and PLC's need upgrading as the lines are. For example, there is currently an Allen Bradley 1336 plus drive on the FSA and these drives are no longer used on any of the lines. This doesn't conform to site standards. This project must be done as it will allow the lines to run whilst motors or fans are being tested, this means less time is wasted and fault will be able to be discovered and fixed before they go out, this will save the company money also. This can also be used for learning purposes as there will be manuals and guides on how to use them.

AC Drives

An AC drive is a unit that controls the speed of a motor by varying the frequency of the supply to the motor, therefore they can be known as VFD's (Variable Frequency Drives). They control the speed of a motor to improve process control and enhance the operation of several applications relying on motors.

(Johns, 2016)

There are many benefits of an AC drive and are shown below;

- Process control – the process output can be controlled to suit the need, synchronising parts of the process which will secure a smooth flow between other processes, when requirements change, the set up can be easily changed.
- They have a high-power factor
- Have a lower KVA
- Reduction of mechanical and thermal stresses on belts and motors on start up.
- Easy to install

(AC Drives Basics, 2013)

Good argument for this motor as the P.F means better efficiency.

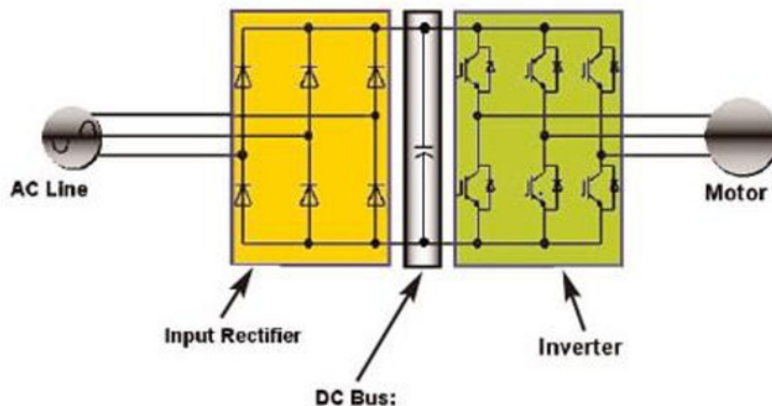


Figure 1: VFD

(AC Drives Basics, 2013)

There are three straightforward sections of an AC drive, these are the Rectifier section, DC Bus and Inverter section. The supply firstly passes through the rectifier unit where it converts it from AC to DC. The DC bus contains a filter section where the harmonics generated throughout AC to DC conversion are filtered. The third and final section of the AC drive consists of six thyristors, this is where the DC

voltage is inverted back to quasi sinusoidal wave form of AC which will be supplied to the motor it is controlling this is like a smoother AC.

Good explanation of the AC drive

(Danfoss, 2014)

The ABB ACS880 is an AC drive that will control the motors than come in. It is rated IP 21 which means it is protected from touch of fingers and objects bigger than 12 millimetres and IP 55 which means it's protected from dusty and wet environments. Its frame size is 409mm in height, a width of 155mm and a depth of 226mm, this drive also weighs 7kg. It has a power rating of 110kW. There are also input/output extension modules that can be added to the drive.

(ABB, 2018)

Good explanations with reference

PLC's

A programmable logic controller (PLC) is an industrial system computer that is always monitoring the state of devices that input and make a choice based on the custom program designed to control the state of the output. There are many different types of PLC's used in today's industry for example, unitary, rack mounted and modular PLC's. There are plenty of manufacturers in today's industry for example, Siemens, Allen Bradley, Festo and Mitsubishi.

(AMCI, 2013)

There are many different types of languages used in the industry today to program PLC's. Every language has its advantages and disadvantages, it all depends on the task that is being carried out. The main five languages are:

- Instruction list
- Function Block
- Ladder diagram
- Sequential Function Chart

(Veeramani, 2007)

PLC's tend to be described as a small industrial computer with components that are modular designed to systematise control processes. There are a lot of components to a PLC but there are three main categories they can be listed under which are:

- Processor
- Inputs
- Outputs

The PLC receives the inputs from a proximity sensors or switch and then the PLC performs its logic on it in the CPU (central processing unit) and either turns the outputs on or off such as a motor or valve based on the logic. This is just a basic overview.

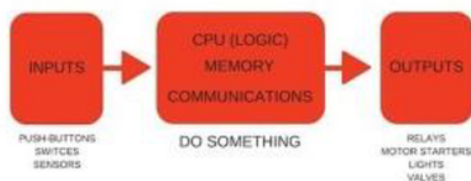


Figure 2: Flow chart PLC

(Automation.com, 2011)

There are many benefits in using PLC's, they are stable and designed to withstand, high temperatures, vibrations, noise and humidity. They have interfacing for outputs and inputs which is already inside the controller. They can also be easily programmed depending on the language used.

(Programmable Logic Controller, 2010)

The PLC (programmable logic controller) being used is a Siemens S7-300 which is compact and modular. The PLC has a CPU (central processing unit) 317-2 DC/DC/DC which can be programmed to run the software. The PLC has analogue IO along with 10 digital inputs and outputs. If required more IO modules can be added to the PLC. There are also three communication ports for various IO devices and for serial communication. There are three L.E.D's on the PLC which represent start/stop, maintenance and error. For the PLC to run it will need to have no error and be in run.

(SIEMENS, 2012)

The HMI screen is Siemens 12" KTP1200 which is a touch and key operated screen. It is heavy duty, so it is ideal for its surroundings. It can be connected by either PROFINET or PROFIBUS and can be easily set up in the TIA Portal. There is also a USB slot where a design can be added straight to the screen. This HMI screen is not intended to be used in residential areas, using this HMI in a residential area could interfere and have a negative influence on TV/radio reception.

(SIEMENS, 2014)

*A good
argument for
PLC's
supported by
references
and a
block
diagram.*

2. Specification

For this part of the assignment a detailed specification will be derived with technical provisions. These tasks will be completed during the time that has been given.

No need to
define what
a spec is.

The Problem

After some discussion with the engineers and craftsmen a decision has been made for the HNC project to design and update a function spare assembly for PLC's, drives and HMI screens. This assembly is key to the plant as devices that will get tested and set up there ready for its operation. The reason for the update is that all the PLC's and drives that are currently there are either discontinued or not being used on plant, the update will include makes like ABB for the drives and Siemens for the PLC's as these are frequently used around plant. The sort of tasks you will be able to carry out from the FSA would be tests on motors or fans, but with motors the speed will be controlled from the drive and PLC with them both communicating together.

The reason decided to design and develop this project is because it allows for continuous testing for motors and devices that come into plant to be used. The benefit of the FSA is that you can test motors and devices without stopping the line its getting added to, this will prove that the motor is working ready to be placed on the line when there is a shutdown next, this means less down time which also means saving money and time.

The deliverables for the project are:

- PLC software and alarms.
- AC Drives
- HMI / Skada screen for testing
- I/O list for basic operations
- iFix
- PD's
- Limit switches

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The project will be completed between September 18th 2018 to 2019, this will be tracked by the use of a Gantt chart used to record all project related activities during this time period. Logbooks/entries will be created covering each week of the project, this will state the amount of work done that week along with what work needs to be done in the imminent future. The budget for this project will be around £6500.

3. Planning

This is where the project will be discussed and planned with the time scale that has been given and the physicality of the project. There are 3 main procedures for the tests, these will be the electrical side, process side and the design of the prototype. This will keep on getting updated until the final project has been designed.

Process Test Plan

A detailed test procedure will be typed on how the final prototype will be tested and whether the prototype is within the specification and working.

The prototype must do the following to achieve the specification:

- Accurately monitor and control the speed of a motor.
- Feedback speed to the PLC and HMI screen.

Electrical Test Plan

The electrical aspects of the prototype will be discussed in this section. Whilst designing the final prototype these specifications will be met. An HMI screen will be designed to control the operations.

To attain the electrical specification the prototype must:

- An HMI screen will be used for a realistic approach and ease of use
- PLC will control the program
- E-stop will be added into the circuit for safety reasons
- All 18th edition wiring regulations will be complied with where applicable.

Prototype Test Plan

The physical aspects will be looked at in this part of the report. It will include the size of the testing units and other physical aspects. The prototype must be safe to use and user friendly so these factors will be taken seriously. Emergency stops is an example of a safety feature that is being used. Heat will be taken into consideration and a thermocouple will be used for a thermal cut out which will be used as an input in the PLC programming.

To reach the specification set the prototype must:

- Must fit within the dimensions which is undecided
- User friendly and safe to use
- Everything must be mounted correctly and safely to assure nothing comes loose and falling.
- All cables going from the motor into the drive and from the drive into the PLC must be hidden away in trunking to prevent a tripping hazard and electrical shock.

Project Management

The next part is to plan the timing scale given for the whole project. A Gantt chart will be made to have an up to date plan with the timing. Different length of times has been giving to different jobs. On the Gantt chart the time that was given by myself can be seen in red and the actual time it took to complete a task can be seen in green.

Microsoft Excel was used to make the Gantt chart which proved to be suitable and useful. Altogether the project pretty much matched the set timing. There were 1 or 2 tasks that took longer and shorter than predicated. Originally 1 week was set to decide on the project that was going to be designed but due to engineers being busy meeting were unable to go through, so it took a week

Do not use first person terms.

longer than predicted. On the other hand, the research took less time than originally set. Instead of 8 weeks, it took 6 instead which was a bonus as I could create my specification earlier which took 3 weeks to do. On the 11th week 3 weeks were dedicated to the 3 solutions that could have been used and started the interim report for the engineer which took 2 weeks. After the 2 weeks break a component list was made and the following week everything was ordered. Everything that was ordered was in stock which was very fortunate, there were a lot of components in stores also which saved time and money. It took 4 weeks to build the project with the drives, PLC and isolators, it didn't take as long because there was already a power supply and just came off the fuses that were already there. Setting up the drives their motors and getting them to communicate to the PLC is where most of the time was spent because there was a problem with paring the PLC to the drives. The ABB drive weren't set up to be paired so that was changed by navigating through the menus and enabling them to pair. The instruction book that came with the drive proved to be very helpful and user friendly. The PLC on the other hand wasn't as easy to set up, before the problem was diagnosed there was a decision to ring Siemens but they refused to help as we were using an ABB drive and not Siemens so the next step was to find a data sheet or pdf on the PLC online which was successful.

There is far too much explanation here.

The Gantt chart tells the story and only requires a simple explanation

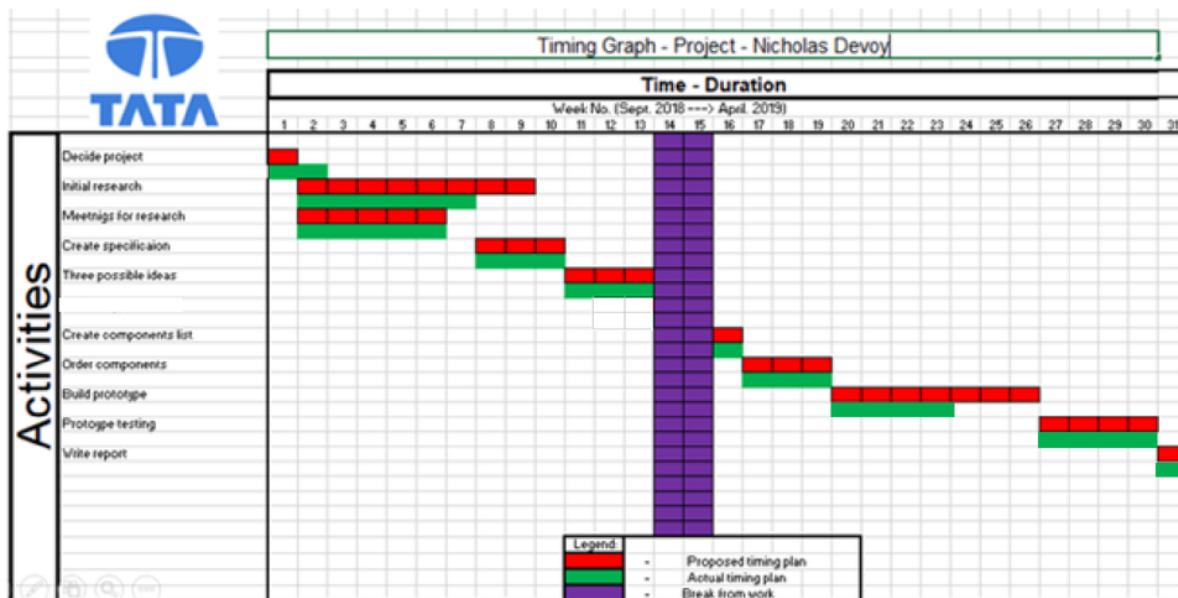


Figure 3: Gantt chart

Good use of Gantt chart

4. Solutions Considered

It was next time to come up with 3 solutions to solve the problem. All the solutions can be seen below.

Solution 1

Microcontroller – 8bit 16F877 type MCU

A microcontroller is an integrated compact circuit which is designed to administrate a precise procedure in an embedded system. A standard microcontroller includes the following things.

- Memory
- Processor
- Inputs
- Outputs

Microcontrollers can be used for many things such as robots, vehicles, office machines, medical devices, radios, home appliances and vending machines among other devices. They can be used for simple operations which can range from 4-16-bit processors to much more complex operations ranging from 32-64-bit processors.

Using an 8bit 16F877 type MCU Microcontroller for this project would prove to be successful as there are many benefits to using them. They can come with a keypad LCD display which means set points and other parameters can be entered with ease, it also allows the person operating to see the real values for example, the speed that motor is running at. This means the operator can compare the real-data to the set-data. C programming can be used to program this microcontroller which comes as a benefit as it shows that it's diverse but there are a lot of more simplistic program languages that can be used. The MCU is very cheap to buy, from carrying out research online the price of this MCU was found and is £4.54. This is a bargain considering the industry its being used it and how reliable these chips are. Even though there a lot of benefits from using a microcontroller with an 8bit 16F877 type MCU, there are also some disadvantages which can prove to deviant. This solution requires good programming knowledge as mentioned above there are easier languages to use over C programming, it can also be difficult to set up registers. Due to this not being heavy duty, it is not suitable for the place of work as there are different liquids and heavy operations used on site such as oils, acid, heavy machinery and loads. It will also require substantial interface circuitry to make it compatible with external components. Interface circuitry using transistors or mosfets will be needed for the drive part at the outputs. With a PLC these are already built in for example, a relay or DC outputs (dc is transistor or mosfet), this MCU will not satisfy the industrial regulations.



Figure 4:Microcontroller

(How Microcontrollers work, 2018)

Reasonable argument for the MCU. This could be explained better using images and less words.

There are spelling and grammar errors which make the reading difficult.

The screenshot below shows program Proteus 8 Professional which was designed to prove the microcontroller could run a motor with selected speeds. It has a keypad, LCD screen and motor. As you can see there is a set point of 300rpm that has been set on the LCD screen by entering it on the keypad. There is a value under the motor which tells the user what actual speed the motor is running at. It is running at 297rpm which is very close to the set point.

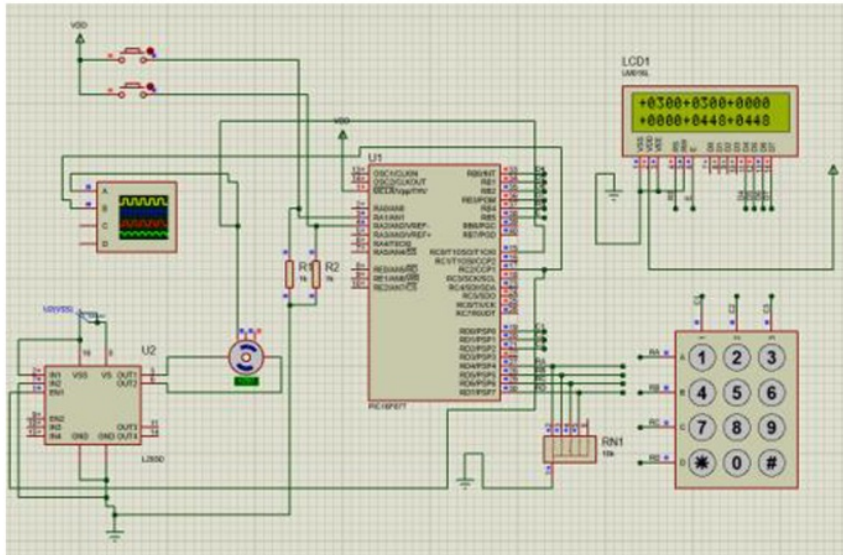


Figure 5: Proteus 8 Professional example

A good example of how a system could work.

The test on the motor with feedback for speed control is a good test.

The screen shot below shows the set point is 200rpm and the motor is running at 199rpm. This proves this solution would work from the simulation as the set points have been changed and the motor has responded by changing its speed.

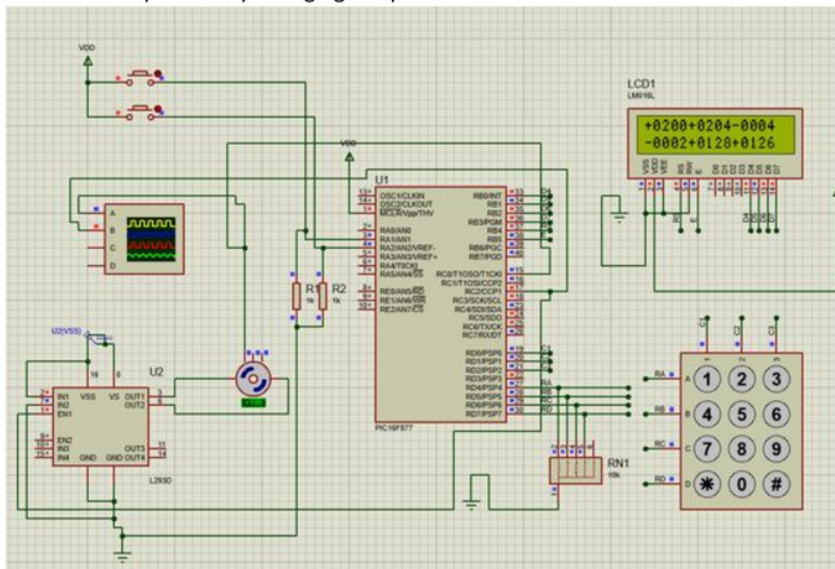


Figure 6: Proteus 8 Professional example

The set point values are set using the keypad shows how flexible the system can be.

Solution 2

Basic Drive and Allan Bradley PLC

The next solution was to use a basic drive. A basic drive is a simple start/stop controller that will be able to control a DC/AC motor. As there is no encoder slot on the drive the encoder would have to be fed back to a PLC this will then allow us to get speed feedback. If the motor was controlled by only the basic drive the speed would be varied by the 0-10 voltage for example, if the max speed of the motor was 720rpm that value would be at 10volts and 0volts would mean the motor is not turning at 0rpm so to get the motor to turn at 360rpm the voltage would have to be adjusted to 5volts. This becomes more complicated when a precise speed is needed as there is no speed feedback. If you run it like this, you will never know if the motor is running at its correct speed unless there is an encoder which can be connected to a PLC, if there is no encoder a proximity device could be added by the shaft which will pick up the certain point of the shaft and it could be implemented with the PLC with a counter function (the same would have to be done with an encoder), this will tell you the speed of the motor.

A basic drive is a cheap alternative and is easier to set up and install than a Microdrive. There is also *Do not use first* no current feedback slot on a basic drive. Overall this solution would be suitable for my project as *person terms*. would be able to carry out a speed test but with using other devices and a PLC. The price of a basic drive all depends on the company and size. Even though these are very reliable its operation is basic and isn't very diverse.

As a PLC will need to be used to be able to see the feedback of the motor the price of this solution will rise. An Allen Bradley PLC can be used, there are many Allen Bradley PLC's being used all oversite so this would be ideal as they are compatible. Depending on the type of PLC that is bought different languages can be used but for this solution ladder logic would be used. The only downside to using an Allen Bradley PLC is that are being replaced all over site to Siemens.



(DriveTech, 2009)

Figure 7: Basic drive

*Good arguments for this method.
There are many spelling and
grammar errors here.*

Solution 3

ABB complex drives and Siemens PLC

This is the final solution for controlling the motors. An ABB drive and Siemens PLC can be used to monitor and control the motors. There many different makes of AC/DC complex drives and PLC's but ABB and Siemens comply with Trostre works standards. As time goes on the old drives and PLC's are getting replaced with ABB and Siemens so this would be a realistic approach for the future. The difference between the basic drive mention above and the ABB complex drives is that there are slots for speed, current and torque feedback. This is much beneficial for anyone using as if a motor was needed to be tested quickly, it can be connected straight to the drive and will get all the readings from that rather than connect the drive to the PLC and using proximity device to count the rotations per minute. The set up on an ABB drive is very simple and user friendly, from being an apprentice there have been on AC and DC drive courses and ABB was used both times, this means there is more knowledge on these than any other drives around the plant and will only increase for employees coming in.

A Siemens PLC is very suitable to use as there are many currently operating on site and a lot more are coming into replace old ones such as Alspa and GEM 80. It is also known that Siemens is compatible with ABB drives. Siemens is also user friendly and is simple to set up, it also gives you a variety of languages you can use such as SCL, ladder diagram, structured text and sequential function block. This is useful as many people find different languages easier than others. Even though this solution is the most expensive, it's also the most reliable. These drives and PLC's are so diverse and allow easy control.

The PLC can be connected to an HMI screen which will enable a good visual of what is happening with the control of the motor. A start and stop button can be put in the circuit but with an HMI screen a memory input can be added so when the button is pressed on the HMI you can start or stop the motor from there. The inputs and outputs can be hardwired which is called handshaking communication.

The PLC will be modular, a modular PLC contains inputs, outputs and CPU modules. The power supply will be supplied separately will rises the price a little more. This type of PLC is very useful and practical as sometime in the future you may need to add on to it the possibility is there.

The S7-300 is an example of a modular PLC. It contains a 317-2 CPU which can process data at high speeds, it has 10 digital outputs and 14 digital inputs and 2 analogue outputs (0-10V DC). Even though a unitary PLC will work a modular will be used as its processor is more powerful and has more memory.



(Oatwell, 2014)

The explanation is far too long. Fewer words with a diagram would be much better. The spelling and grammar errors make reading difficult.

Hardware costing

The cost of the project can be seen below, ranging from back plates, nuts and bolts and PLC modules. It was ensuring that everything was ordered off either Siemens, ABB, RS online unless it was available in stores, the reason for this is because this website is mostly used by stores and if any problems were to arise, they could be resolved quickly, and the delivery can be tracked. TATA steel also gets 20% discount off anything bought on there which saved a lot of money.

Material	Supplier	Quantity	Total Cost
Wall box 250x250x100mm	Tata stores	2	£0
Wall box 500x600x100	Tata stores	1	£0
Isolator	Tata stores	3	£0
Nuts, bolts and fastenings	Tata stores	N/A	£0
DIN rail 160x35x7.5	RS Online	1 length	£4.00
Plugs and screws	Tata stores	2 bags of 50	£0
Terminal blocks	RS Online	25 normal 10 earth	£48.00
PLC CPU	RS Online	1	£389
Power supply	SIEMENS	1	£120
Digital output module	RS Online	1	£200
Digital input module	RS Online	1	£150
Analogue input module	RS Online	1	£180
ABB drive 800	ABB	1	£1000
ABB drive 550	ABB	1	£4000
Plastic trunking 50x50mm L2m	RS Online	2 lengths	£14
HMI screen	SIEMENS	1	£300
			Total = £6405

*A comprehensive costing analysis.
This could be in the appendix and
referred to from the main report.*

5. Final solution and Implementation

From all of the solutions, number three was chosen and that was to use a drive and a Siemens PLC. This was down to the fact that this is future proof and compatible with the work force and to the lines themselves overtime as they are slowly replacing all the old equipment for example GEM 80. The PLC and drive are versatile, and many inputs and outputs can be implemented if needed.

Prototype

The final prototype was completed by using all the components bought. Problems did occur for example, the Ethernet cable ordered wasn't long enough as the PLC was re-positioned further up the wall. Some components took longer to come than others. The trunking ordered took the longest to come which was a bit of set back as the wiring couldn't be done until the trunking was set down around the FSA.

Another problem was that on start up the rig kept on tripping. This meant that a fault-finding operation had to be carried out. After a while the problem was diagnosed, and it was being caused by a loose connection into the main isolator. Even though this was set back, it was also a valuable lesson and good experience to fault find.

The final chosen solution can be split up into separate parts which are the PLC design, the drive set up and parameters entered and HMI screen.

Three new panels were installed containing two isolators which will feed the drive and PLC and the third panel contains all the components terminal blocks for the PLC. There was a point where the PLC was going to put into a panel, but it was soon dissipated due to ease of connecting and use. From the terminal blocks the HMI will be connected with the PLC. This will allow control on the direction of the motor.

When comparing both the prototype specification and the prototype itself, most of the criteria has been met with some alterations and errors. The size and weight of the drive is as specified. The biggest difference was HMI screen as there were no alarms implemented into the design. The prototype can be seen below.



Good image which shows the layout of the components.

Figure 8: Overall view of Project

Choice of materials

The components chosen and used in this design were in their required position. Everything including the drives, PLC's isolators and panels were mounted by DIN rail, this was done to make sure they all had a secure fitting and wouldn't come loose. The PLC is connected from the connector blocks in the panel. As there is no temperature device used it didn't matter how long the run was or what cable was used. This could be an idea for the future. The fan in the drive can run off 24v which is the output of the DI PLC being used. Another recommendation could be to use a separate supply for the fan which can be fed into a MOSFET circuit which will allow you to run two 12v fans with the 24volt supply if needed.



Figure 10: Panel 1



Figure 9: Panel 2

Good images and a brief outline here is enough.

There are three separated isolators which are used separately for the two drives and PLC. Before that there is a main isolator which can switch everything off at once. The terminal blocks are in the new panels fitted for protection.

Choice of PLC, modules and Drive

The program of the PLC was designed using TIA portal 13. This is commonly used on site. A program will be designed on here to get the motor to turn in forward a reverse direction and to control the speed by getting the PLC and drive to communicate. This will be fed back to an HMI screen where control can be gained of the operation. The HMI screen is Siemens 12" KTP1200 which is a touch and key operated screen. It is heavy duty, so it is ideal for its surroundings. It can be connected by either PROFINET or PROFIBUS and can be easily set up in the TIA Portal. Here the direction and speed can be seen and changed.

A Siemens S7 300 series which corresponds with work as a lot are used on site. The main operation over the next few years is to replace all the PLC's to Siemens purely for their superiority over other manufactures. The module of the PLC being used is versatile will be able to handle any problems that may occur on any of the lines. If the same PLC is used all round site, then it will save space in stores as there won't be any manufactures.

The 317-2 CPU was chosen primarily because it's a lot more efficient than any other program out there and it's affordable. The best thing about the CPU it has room to control other devices if

HMI image and a brief explanation is all that is needed here. The explanation is far to extensive.

needed and more modules can be added. This CPU was decided upon as it will save us from buying other CPU's so it's a good investment.

The digital input that is used is 16x24v. The reason for this was because there are so many devices and signals it offers for example, a fan which isn't used within the PLC itself and controlled by another source.

The digital output used for the project was 16x24v. If needed a larger version can be added purely for expansion and to expand on the digital inputs.



Figure 11: PLC

PLC program

TIA portal was used to design the program and can be seen below. In the image below the PLC configuration can be seen. This is where modules are added or removed. As you can see there is a module for digital inputs and digital outputs.

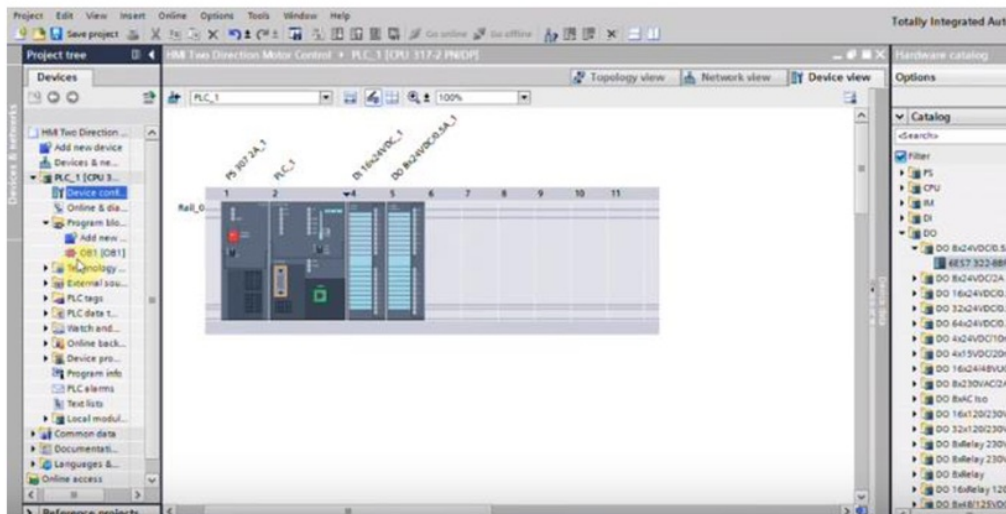


Figure 12: PLC

The image below shows the connection of the HMI and PLC. Profinet was used for the HMI to connect to the PLC using Ethernet cable.

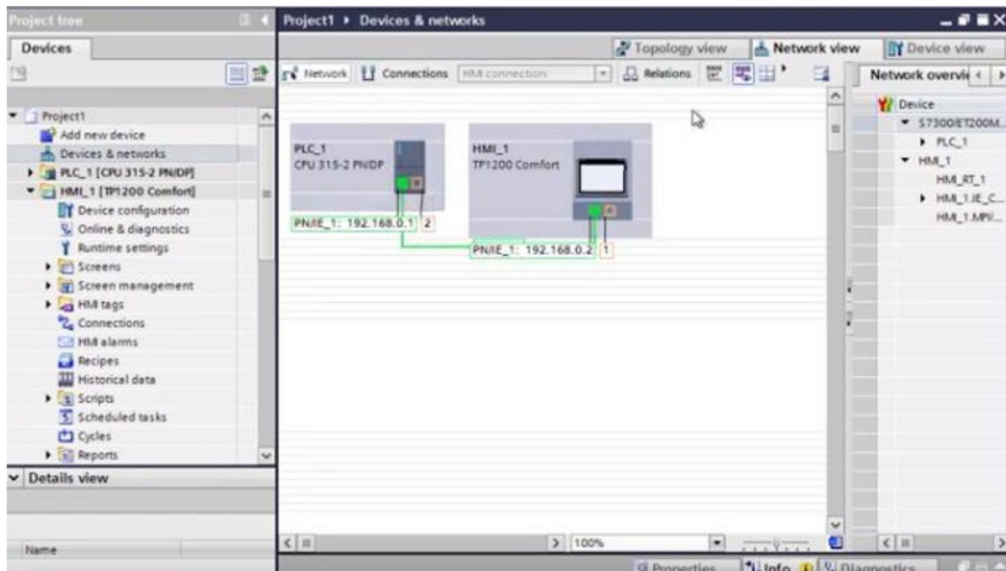


Figure 13: PLC HMI connection

Forward start	Bool	%I0.0	☐	☒	☒	☒
Reverse start	Bool	%I0.1	☐	☒	☒	☒
Stop/Reset	Bool	%I0.2	☐	☒	☒	☒
Motor Forward	Bool	%Q0.0	☐	☒	☒	☒
Motor Reverse	Bool	%Q0.1	☐	☒	☒	☒

Figure 14: PLC tags

In the network 1 which can be seen below, for the “forward direction” output to be energised, the start “forward direction” normally open input must be activated. There is a normally closed “stop rotation” input which will open when activated and will de-energise the coil. There is also a “reverse direction” normally closed input in series which is the electrical interlock so both outputs cannot be energised at the same time.

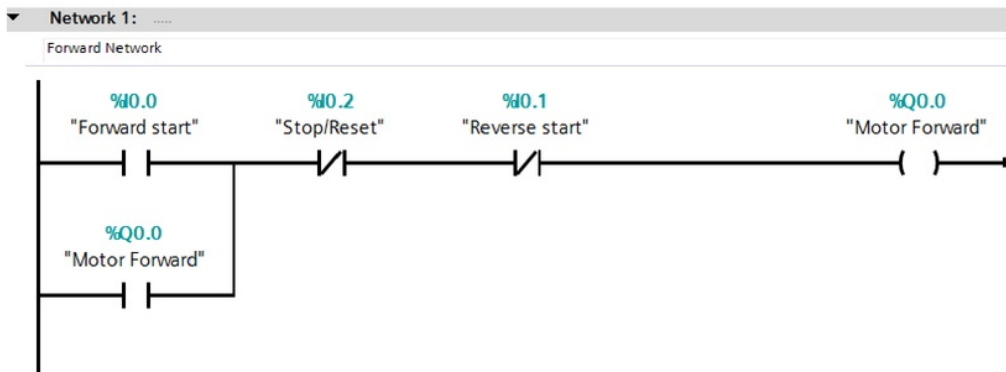


Figure 15: Network 1

In network 2 below you can see that for the “reverse direction” output to be energised, the “start reverse direction” normally open input must be activated. There is a normally closed “stop rotation” input which will open when activated and will de-energise the coil. There is also a “forward direction” normally closed input in series which is the electrical interlock so both outputs cannot be energised at the same time.

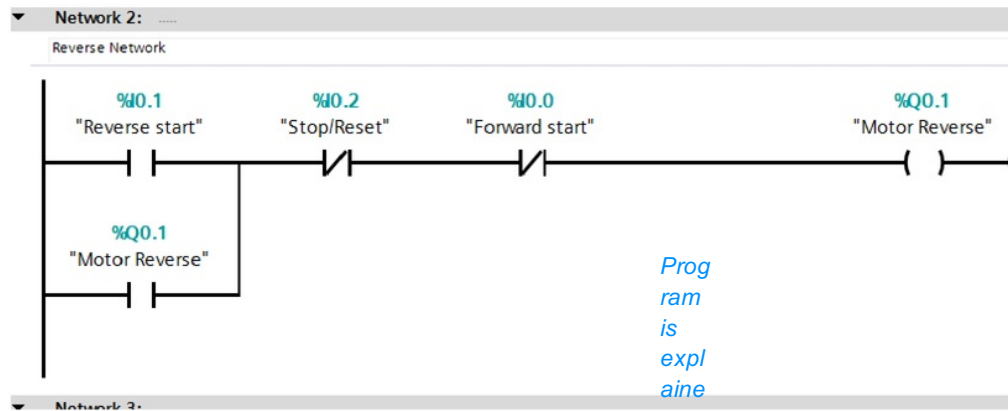


Figure 16: Network 1

ABB drive set up

In the bottom left hand side of the drive there is a key pad that can switch operation from remote or local. What this means is that



Figure 17: ABB drive set up

Below is the main menu which can be selected by pressing the right key pa. The parameters from the motor that need to be entered go into this setting which is highlighted.



Figure 18: ABB drive set up

Macro 99 is where all the data from the name plate is entered. This menu is very big as you can see it offers fault histories which is useful in case the same fault keeps on occurring.

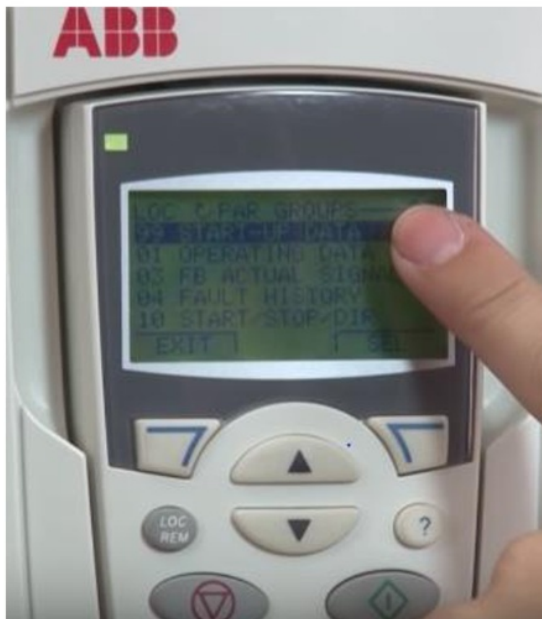


Figure 19: ABB drive set up

The data entered to the drive will be derived from the name plate from the motor which can be seen below. There are key parameters that are needed, and they are the max rpm, current rating, nominal voltage and the frequency.



Figure 20: Name plate

When all the required data is entered from the name plate, the start button can be pressed. When this button is pressed the arrow in the top left corner will start turning representing which direction the motor is turning in.



Figure 21: ABB drive set up

At the top right of the screen is the command speed. This is the set point, underneath is the actual frequency the motor is at which represents the actual speed, the ramp up time can be edited within the menus. You can also see the current that is being drawn from the motor and the torque percentage being produced by the motor.



The functions of the motor or drive are clearer

Figure 22: ABB drive set up

PLC and drive communication

The image below shows the connection of the HMI and PLC and drive. Profinet was used for the HMI to connect to the PLC and the drive using ethernet cable.



Figure 23: PLC, drive and HMI connection

Good topology of the network link

The next step was to enter all the parameters from the motor into the PLC. This is similar to what was entered into the ABB drive, but more info was needed.



Figure 24: parameters of motor

The project tree below shows that the drive has been confirmed and connected to the PLC. This can now be dragged and dropped into the main program and a function block will appear.



Figure 25: Project tree drive

The network below shows how the speed can be controlled from the PLC from getting the drive to communicate with it. When either forward or reverse start it will set the output “motor forward” or “motor reverse”. To reset the function block, the “stop/reset” button must be pressed.

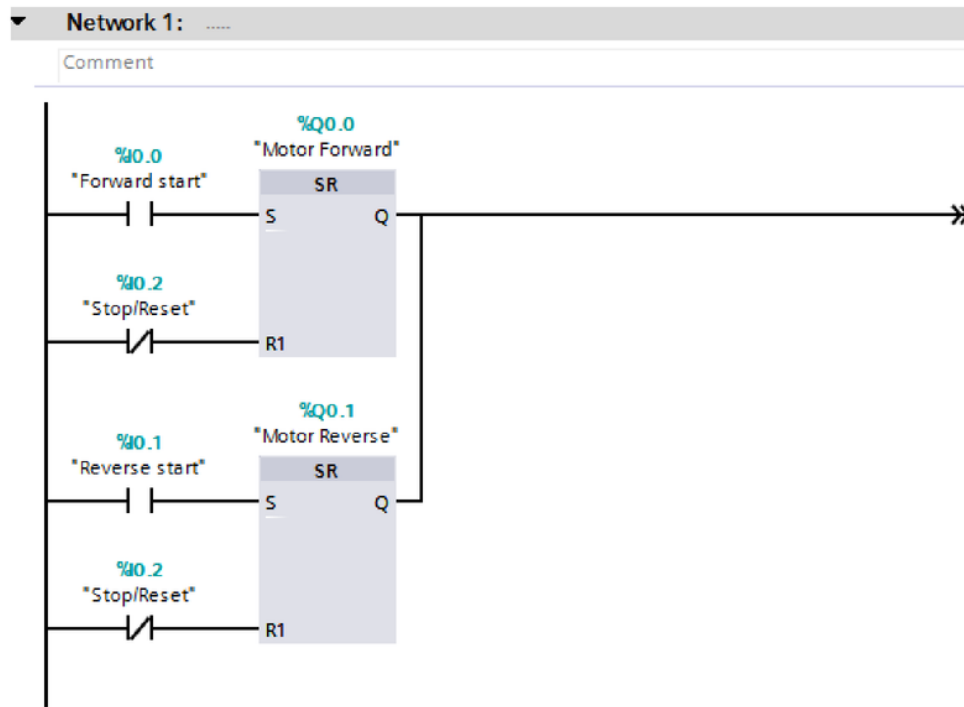


Figure 26: FC set point speed run

When the outputs “motor forward” or “motor reverse” have been set in the previous network, the normally open contacts coming off the outputs will close which enables the pulse width modulator function block will be enabled. This will enable operator to control the speed of the motor.

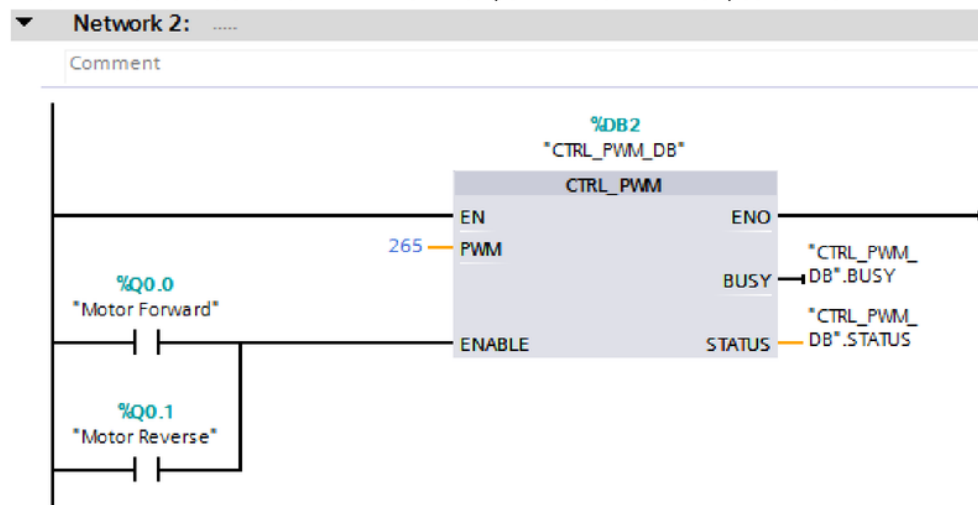
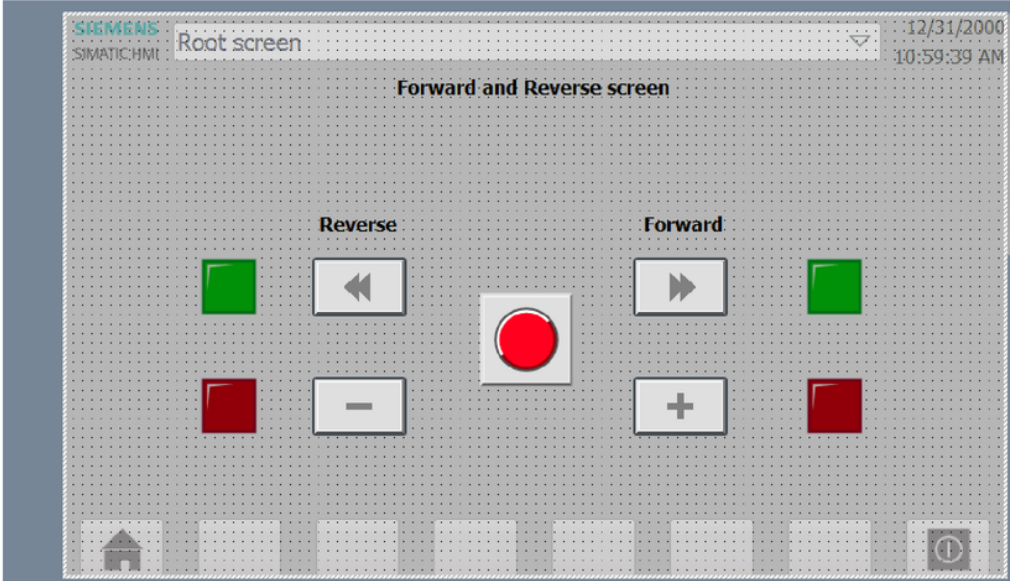


Figure 27: pwm network

program
explained
well

Below, is the HMI screen and a minus and plus button has been added which are both linked with the lights next to each other. When the minus button is pressed the speed of the motor will reduce and the light next to will come on. When the plus button is pressed the rpm of the motor will increase and the red light next to that will come on.



HMI is good and clearly indicates the operation.

Figure 28: HMI screen

6. Testing and Results

This part of the report will be about the testing of the project with its corresponding results. A testing table will be designed. There are two types of tests carried out, these will be process tests and preliminary tests. This will show the main operation of the project and how the PLC and drive control the motor. Slight changes will need to be made to the program values. The scaling values will change.

Preliminary testing

Each part that is used will be tested in the preliminary testing. This is to prove that every component used can do its job. If any failed, they would need to be replaced with a new spare. The test table/plan can be seen below.

Component	Expected result	Actual result	PASS/FAIL	Comments
AC Drive	Apply 110v AC to drive to see if its working Navigate through parameters and macros.	AC drive turned on when 110v was applied. Successfully navigated through the menus	PASS	No comment to be made.
Siemens PLC	When the Siemens PLC turns on there should be a green L.E.D showing that	The green light came on representing healthy.	PASS	No comment

	everything is healthy.			
Isolator for AC drive	When isolator is switched off the AC drive should turn off.	When isolator was switched the drive turned off.	PASS	We know the isolator works when switching on as the drive came on in previous test.
Isolator for PLC	When isolator is switched off the PLC shouldn't turn off.	When isolator was switched the PLC turned off.	PASS	We know the isolator works when switching on as the PLC came on in previous test.
Fuses	When tested with multi-meter with settings on ohms, there should be continuity between each end of the fuse.	When fuses were tested the continuity was very close to 0ohms. There were a few that had an over current and ruptured the fuse wired inside causing an open circuit. These fuses were replaced.	PASS	No comment.
E-stop	When E-stop is pressed in, everything should turn off and have to be re-set.	The power was completely cut off and reset.	PASS	The E-stop won't be used all the time, this was just for test purposes.
Cooling fan of drive	Cooling fan should come on when power is supplied.	Cooling fan didn't come on straight away but came on after adjusting settings.	PASS	When power was supplied the cooling, fan didn't come on. From navigating through the menu, it was seen that the fan would only come on when the drive had hit a certain temperature, so the switching point was lowered to 5 degrees and the fan came on.

Table of
results
explains
the test
outcomes
and
assumptions

PLC testing

When it came to test the PLC there were some slight problems such as downloading the PLC to TIA portal, the system could not be found when searched, this problem was solved by connecting an Ethernet cable straight into the PLC. This was used for most of the testing procedure. The motor also couldn't be found on the PLC, this meant that some fault-finding techniques were used to diagnose the problem and it was found. The problem was that the wiring was wrong going into one of the terminal blocks.

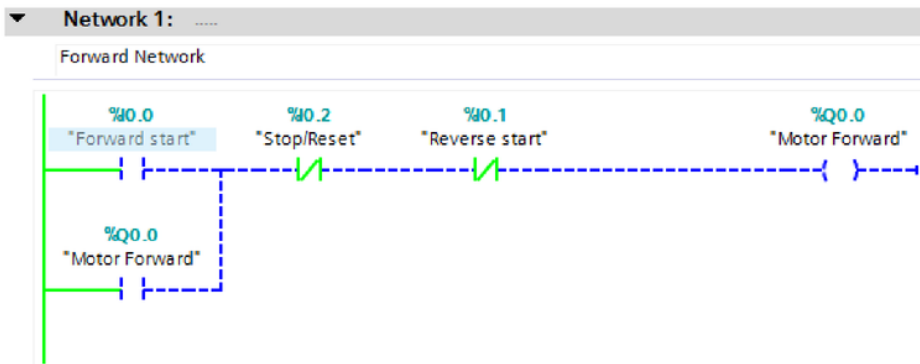
Issues and outcomes
are explained

PLC program testing

For this part of the program the main function was to get the motor to turn in forward and reverse direction. You can see that the stop button is a closed input and so is the reverse input. This means

Figure 29: Network 1

the network is waiting for the “start forward direction” to be pressed so the motor can turn in the forward direction.



As you can see below, the output for the forward direction has energised when the forward start button has been pressed. This means that the motor is turning in the forward direction. The open input from the motor is a latch and will keep the motor turning when the output is energised and can be stopped by pressing stop rotation.

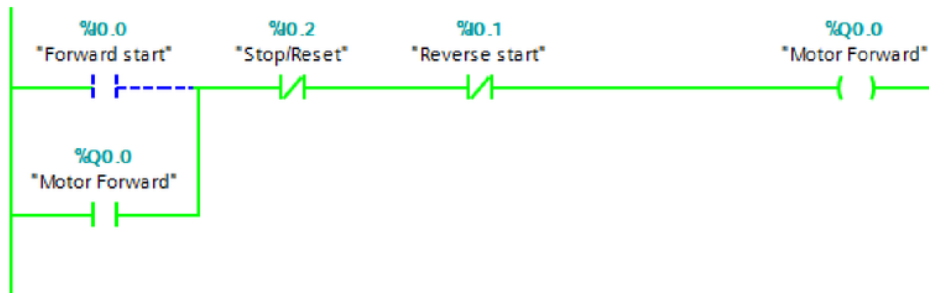


Figure 30: forward network

To get the motor to turn in the reverse direction a similar network will be written to the previous. Instead the forward input is now closed for the interlock and the reverse input is open. This means that the program is waiting for the reverse button to be pressed to turn the motor in that direction.

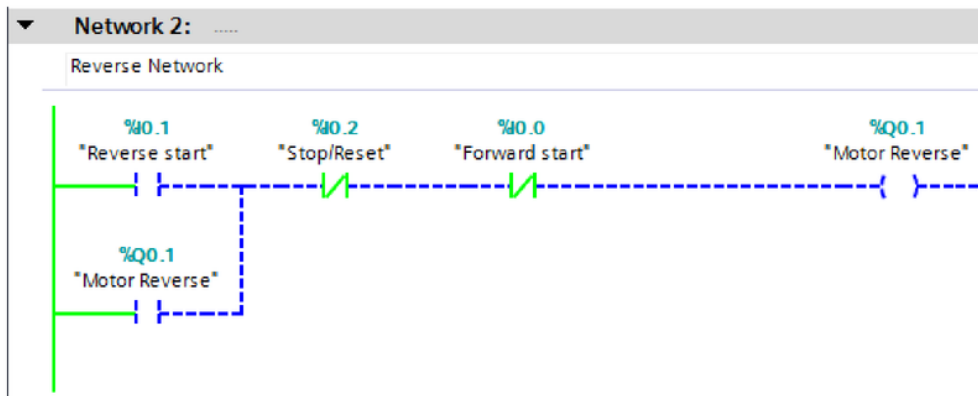


Figure 31: Reverse network

As you can see, the output coil has been energised due to the start reverse direction being pressed. This will start the motor in reverse direction. The open input from the motor is a latch and will keep the motor turning when the output is energised and can be stopped by pressing stop rotation.

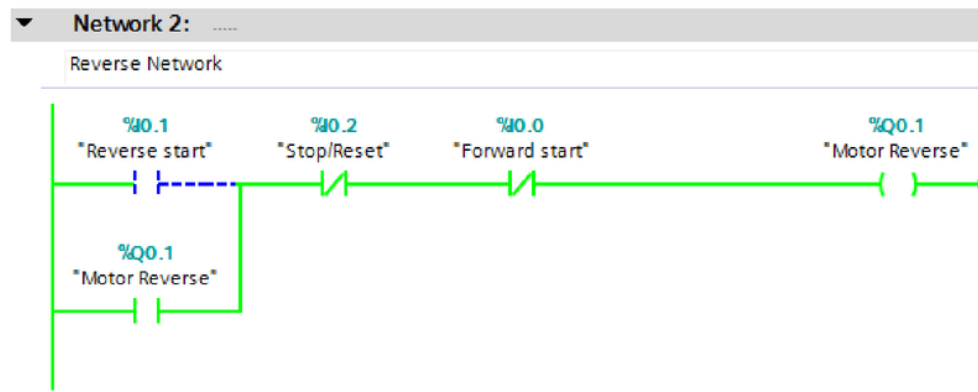


Figure 32: Reverse test

HMI testing

For the forward and reverse program of the motor a simple HMI screen was designed to operate and display the function. The screen consists of 3 buttons to get the motor to turn in reverse and forward direction and there is a reset button. There are also two pilot lights to indicate which direction the motor is turning in.

The print screen below shows the HMI screens green pilot light turned on to represent the motor turning in the forward direction. This will happen when the green button is pressed on the HMI screen. This is done by using the set and reset bit on Siemens.

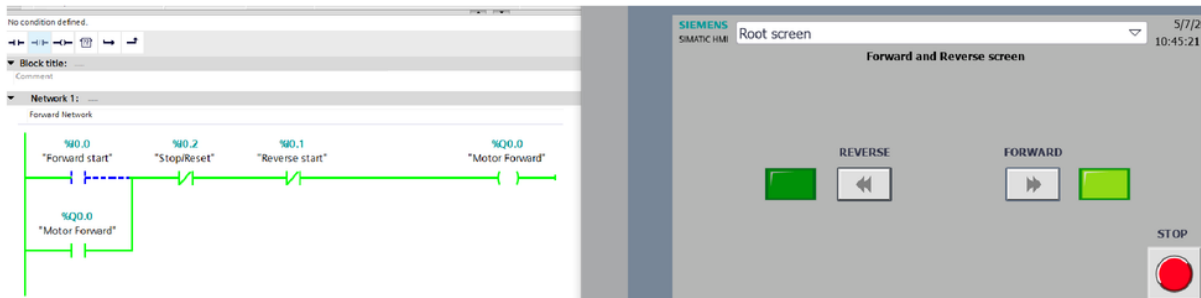


Figure 33: HMI forward test

The print screen bellows shows the red pilot light on to represent the motor is turning in reverse direction. This will happen when the red button is pressed on the HMI screen. This is done by using the set and reset bit on Siemens. Trying to fit the HMI screen and monitoring the network on one screen proved to be difficult hence the quality.

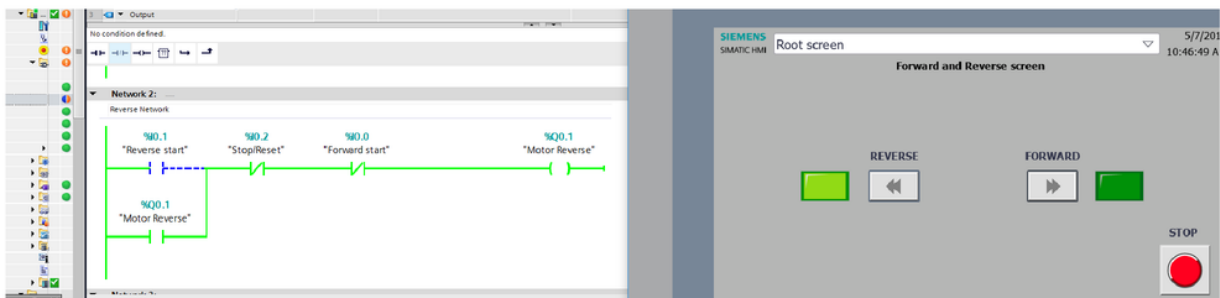


Figure 34: HMI reverse test

This section is much better and gets to the point.

Shown below you can see the reset button at the bottom left of the HMI screen. When this is pressed both networks will look like this. Both networks have now been reset and are ready for one of the buttons to be pressed.

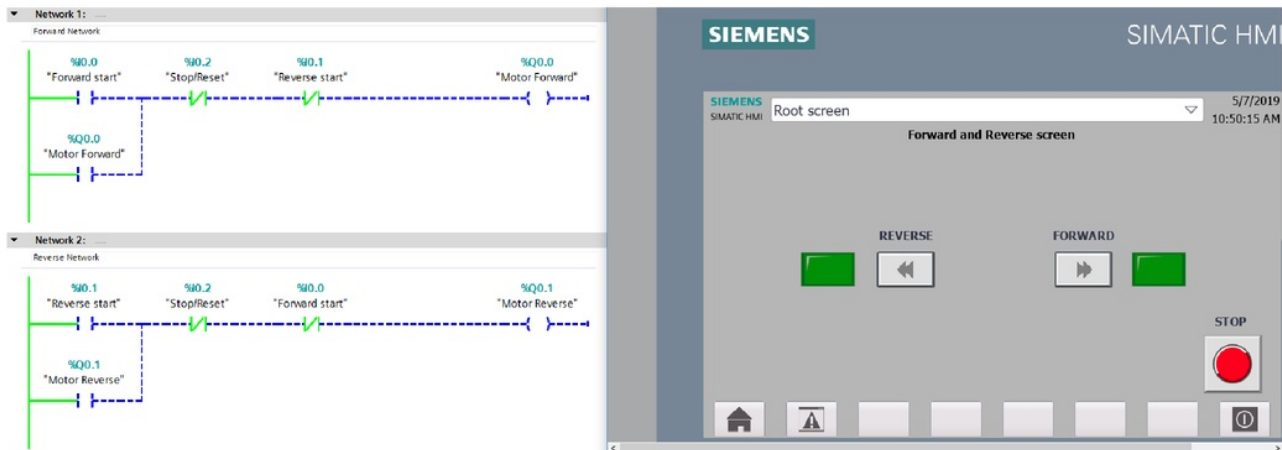


Figure 35: Reset HMI test

AC drive testing

Once the motor parameters from the name plate had been entered into the drive. It was time to see if the drive could control the motor by adjusting the frequency. At the top right of the screen you can see the command speed, this is the set point. You can also see that the drive is running the motor at the command speed which is 11.6Hz and can be seen in the centre of the screen. In this you can also see that the motor is turning in the forward direction due to the 'F' in the top left position. This can be changed by pressing on the keypad.



Figure 36: ABB drive test

Below you can see that the direction of the motor has changed by pressing the keypad on the left. When the direction keypad is pressed the speed will ramp down to zero before it changes direction and will ramp back up to the desired speed. You can also see that the torque percentage at the bottom of the screen is negative, this is because it's producing negative torque due to going in the opposite direction.



Figure 37: ABB drive test

7. Discussion, Conclusions and Recommendations

There were three solutions to decide from. Every solution was heavily examined, looked at how they would be implemented, how realistic the price of the solution would be, advantages and disadvantages of every solutions and how effective the chosen solution would be to solve the current problem.

Solution 1- Microcontroller – 8bit 16F877 type MCU

Advantages:

- Size of the circuit can be reduced significantly
- Reliable
- Cheap
- LCD Screen

Disadvantages:

- Not very suitable for place of work (not heavy duty)
- Requires good programming knowledge
- Limited I/O
- Specific spares required

A Microcontroller was a very good original solution, but they are not suitable for the place of work as they are delicate circuits. Also, as time goes on, they are being replaced with new drives and soon the works will predominately drive/PLC run.

Solution 2 - Basic Drive and Allen Bradley PLC

Advantages:

- Cheap
- Easy to Install
- Suitable for place of work
- Able to control speed of motor on the 0-10volts
- Allen Bradley PLC ladder logic easy to understand

Disadvantages:

- Won't have accurate speed control due to no encoder slot
- Allen Bradley PLC's being replaced with Siemens
- It won't have a tension loop to accurately control the tension of a process line
- Setting up drive with PLC will need additional equipment
- To accurately control speed using proximity device.

This original solution was also very good idea but mainly due to the old Allen Bradley PLC and basic drive, it wasn't worth the money as many drives are being changed to new complex ABB drives and eventually all the PLC's being used will be changed to Siemens. Also, an external device is needed to offer continuous monitoring of the rpm of the motor so the drive wouldn't be very appropriate for the task in hand.

Solution 3- ABB complex drives and Siemens PLC

Advantages:

- Siemens S7 300 is versatile
- Both conform with site standards
- The work force is familiar with both ABB and Siemens
- I/O modules can be added
- Easy to operate
- Easy to set up
- Local/Remote control available with drive
- Compatible with Siemens PLC
- Encoder slot
- Has a built-in fan for cooling operations
- Program can be written in many different languages

Disadvantages

- More expensive than other solutions

The final solution was using an ABB complex drive and Siemens PLC to control the motor, the main reason for this solution being the decided one was due to the fact it conforms with site standards and that the work force is familiar with both as many courses have been taken. This solution is also future proof as most drives and PLC's will be changed to these in the future.

Even though the project proved to be successful there were a few minor problems and errors. There were some minor errors with the prototypes specification and some parts did not work out as

planned. Also, at the start, there was a little problem with the contacts of the PLC as when operating in monitor mode some outputs were showing made when they weren't, this problem was resolved.

There were a few little problems with the electrical specification even though the motor was successfully controlled from the PLC's HMI screen. Feed back into the drive proved to be successful as the drive was able to adjust the speed of the motor by pressing up and down on the keypad.

One of the biggest problems was being able to control the speed by connecting the drive up to the PLC using analogue inputs. Due to the time it took for the PLC to come in, the laptop with the program on it was being used for jobs on the lines it and moving areas on plant, it proved to be difficult to complete this task and was unable to actually test the programming. Even though this will eventually be accomplished, next time there will have to be more thorough organising with the laptop with TIA portal or could even buy and download the software to another laptop which would save waiting around to use it.

There are recommendations that could be considered about this project. Several languages could have also been used to write the start stop program in the PLC for learning purposes. Not all deliverables from task two were able to be included into the project as it was a bit too much to do for the time that was given. This is something that can be investigated for the future and would be a great help to Trostre works.

The conclusion should consist of the performance of the chosen solution and whether it met the criteria from the spec. The solution comparisons has already been made and does not belong in the conclusion. The recommendations are valid and relevant.

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*A good reference list
with dates accessed
included.*

Project final assessment Nicholas Devoy

GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

Instructor

61 / 100

PAGE 1

PAGE 2

PAGE 3

Text Comment. Good table of contents and list of figures. The problem definition should come before the spec in contents.

PAGE 4

PAGE 5

Text Comment. Introduction and background research is relevant. However there is no need of the extent of word count here. The use of an image would reduce the word count and improve the explanation.

Text Comment. Good argument for this motor as the P.F means better efficiency.

PAGE 6

Text Comment. Good explanation of the AC drive

Text Comment. Good explanations with reference

PAGE 7

Text Comment. A good argument for PLC's supported by references and a block diagram.

PAGE 8

Text Comment. No need to define what a spec is.

Text Comment. The need for the project is clear and a good spec which defines the requirements.

PAGE 9

PAGE 10

Text Comment. Do not use first person terms.

Text Comment. There is far too much explanation here.

Text Comment. The Gantt chart tells the story and only requires a simple explanation

Text Comment. Good use of Gantt chart

PAGE 11

Text Comment. Reasonable argument for the MCU. This could be explained better using images and less words.

Text Comment. There are spelling and grammar errors which make the reading difficult.

PAGE 12

Text Comment. A good example of how a system could work.

Text Comment. The test on the motor with feedback for speed control is a good test.

Text Comment. The set point values are set using the keypad shows how flexible the system can be.

PAGE 13

Text Comment. Do not use first person terms.

Text Comment. Good arguments for this method. There are many spelling and grammar errors here.

PAGE 14

Text Comment. The explanation is far too long. Fewer words with a diagram would be much better. The spelling and grammar errors make reading difficult.

Text Comment. A comprehensive costing analysis.

Text Comment. This could be in the appendix and referred to from the main report.

Text Comment. Good image which shows the layout of the components.

Text Comment. Good images and a brief outline here is enough.

Text Comment. HMI image and a brief explanation is all that is needed here. The explanation is far to extensive.

Text Comment. Program is explained reasonably well

Text Comment. The functions of the motor drive are clear

Text Comment. Good topology of the network link

Text Comment. program explained well

Text Comment. HMI is good and clearly indicates the operation.

Text Comment. This section should be condensed because the explanations are excessive.

PAGE 27

Text Comment. Table of results explains the test outcomes and assumptions

Text Comment. Issues and outcomes are explained

PAGE 28

PAGE 29

PAGE 30

Text Comment. This section is much better and gets to the point.

PAGE 31

Text Comment. Good test results

PAGE 32

PAGE 33

PAGE 34

Text Comment. The conclusion should consist of the performance of the chosen solution and whether it met the criteria from the spec. The solution comparisons has already been made and doe not belong in the conclusion. The recommendations are valid and relevant.

PAGE 35

Text Comment. A good reference list with dates accessed included.

GRADING FORM: CSG-RUBIC

NICHOLAS DEVOY

0

RESEARCH-INFORMED LITERATURE



The research and sources are relevant to the project. However there should be more academic sources included. There is evidence of extensive background research in the report. The explanations are excessive in parts. 6/10 The number of references is appropriate for the report. The online refs should include the date accessed. This is the Harvard spec. 7/10

13/20

KNOWLEDGE AND UNDERSTANDING



The specification could be clearer as to what the task is. Needs to get to the point here. There is nothing about sustainability or environmental issues. 5/10 Solutions considered shows a good comprehensive understanding of what is needed for the system and alternative methods. There are images used so the word count here could have been reduced. The effort made here is very good with images of tested solutions to support the argument. This should have been rounded off by a table of comparison. 7/10

12/20

ANALYSIS



Testing and results are explained well with visual evidence to back up the explanation claims. Good use of tables for results. 7/10 There is no need to extensively explain the comparison of solutions in the conclusion when this has been covered in the

12/20

solitons part of report. It should explain the outcomes and if the spec was satisfied. This could have been much better. 5/10

PRACTICAL APPLICATION AND DEP.



The planning using Gant chart is good but the explanations are far too excessive here. There are many spelling and grammatical errors in this section which has far too many words. 3/5 There solutions considered have been researched and there are good arguments for all the alternatives. However the main issue is that the explanations are too long as far as word count.6.5/10 Implementation is good and there is evidence to support this including the PLC program and HMI. 6.5/10

16/20

SKILLS FOR PROFESSIONAL PRAC.



The report has far too many spelling and grammatical errors and explanations are excessive to the point where it makes reading difficult. All the relevant technical content was present in the report but the quality of the flow of the report could have been better.

8/15