

Final

by Phillip Rowe

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Phillip Rowe

Electrical and electronic engineering

PSDE 5007

Individual project



Prifysgol Cymru

Y Drindod Dewi Sant

University of Wales

Trinity Saint David

Contents

1. Project proposal	3
Company background	3
Summary of project	3
Objectives.....	3
Timescale, budget and training.....	4
2. Background research	4
Coil prep 3	4
PLC/HMI – solution 1	5
Background of PLCS	5
How does a typical siemens PLC work?	5
Relay logic – solution 2	6
What is relay logic?	6
Pic16F877 MICROCONTROLLER – solution 3	7
3. Testing plan and procedure	13
4. Specification.....	14
Project spec.....	14
Electrical specification	14
5. Project plan	14
6. Discussion and conclusions	14
Method 1.....	15
Method 2.....	15
Method 3.....	15
Final decision.....	16
How does my project work?	16
Wiring and implementation	16
Modification to project	18
Testing and fault finding	21
Testing results table.....	25
Discussion and conclusion	26
Harvard Reference list	27

1. Project proposal

Company background

Tata steel was established in India in 1907 and then the first ever ingot of steel was made in Jamshedpur in India in 1912. In the year 1999 Corus was created via a merger of British steel and Koninklijke Hoogovens. Corus was then acquired by the Tata group in April 2007 and then joined the Tata steel firm which then made it one of the world's largest steelmakers which had a major presence in Europe and also Asia. Tata steel. (2010). Tata steel has a wide variety of steel making/rolling sites such as Port Talbot which is a steel making plant compared to Trostre which is a steel rolling site.

At Trostre the steel comes in as 20 ton coils and is rolled out, cleaned, stretched, annealed, tempered, inspected, coated and then either rolled into coils or sheared into desired lengths. Tata steel Trostre provides high quality steel for company's such as Heinz beans, jaguar land rover, Nissan and also Hyundai.

Summary of project

After a discussion with my shift craftsmen and also area engineers I have decided that my HNC project will be to upgrade and replace old start methods of the hydraulic and lubrication pumps on coil prep 3. The current method of starting the pumps is basic DOL starting. This currently takes up a lot of time due to the fact that the craftsmen have to go and do it manually as the crew are not allowed into the electrical sub room. The modification for this will be to rip of the old wiring which is not needed and replace it with PLC control and also a HMI screen in the crews pulpit so they can start the pumps saving craftsmen time. The reason for this project is because it will save vast amount of time once the lines have been down for maintenance. The start-up would usually take about an hour providing there are no faults. Moving forward the area engineer wants to modernise all of the line to make it easier to maintain and also fault find on, by modernising and keeping everything to one standard then it is much easier for craftsmen.

Objectives

The main objectives of this project is to have a smooth transition from the old method of starting the pumps on coil prep 3 into the new method. The aim is to complete the project and cause as little disruption as possible to production. Training will be given at the nearest possible time when the line is down so the crew knows how to operate this new item of kit. Ideally this project will be able to replace all old methods that are currently used to start the pumps without the need to keep the old methods.

mescale, budget and training

The projected will be started on October the 9th 2017 and aimed completion will be April 25th 2018. The gannt chart will be used in order to track this and all progress will be tracked in log entries which will be produced each week. The budget for this project will be £10,000

Any help or training which will be needed will be discussed with the project mentor or the engineer of the area. Also further help manuals are available in electrical control rooms to aid any further help needed. Training will be provided for the production workers also for them to understand the new interface.

Testing procedures will consist of a series of live and dead tests. For example, by using Siemens S7 I will be able to physically see relays and switches energising and then by looking at pilot relays I will also be able to see that the hard wiring is good. Live tests will also be performed in order to check that the pilot relays are bringing in the main motor contactors.

<u>Student Signature</u>	Date:
<u>Lecturers Signature</u>	Date:
<u>Mentor Signature</u>	Date:

2. Background research

Coil prep 3

Coil prep 3 is an inspection line which checks the coils before they are loaded onto the coating lines. They are checking for any imperfections in the strip such as scratching, holes, discolouration and any other imperfection which the customer may not want. They can also trim the coil to a desired width which meets customer specification and also take spools off the coil. CP3 is a small line however it requires a lot of hydraulics and lubrication for the tasks it performs. Below in figure 1 is a photo of the start of the coil prep line and then following in figure 2 is a photo of the AC board which is getting replaced by this project.



(Figure 1)



(Figure 2)

PLC/HMI - solution 1

Background of PLCS

A PLC(programmable logic controller) is something which can use inputs and outputs in order to control something. In this case an internal switch in the programming software can drive an output relay which can then start a pump. A PLC is today's modernised wiring, it takes away all the physical cables and replaces them with a computer program which will perform the same job. The only thing a PLC may need is inputs and outputs in order to perform a physical action. A HMI(Human machine interface) is basically a display screen which can also be programmed to start and stop pumps or maybe just used as a visual feedback for an actuator or sensor. The PLC that would be used would be a Siemens S7-1500 series which is the top of the range and most powerful PLC available in the Siemens series. Because the 1500 is such a good performance PLC it can handle vast amounts of inputs and outputs and also has enormous amounts of processing power.

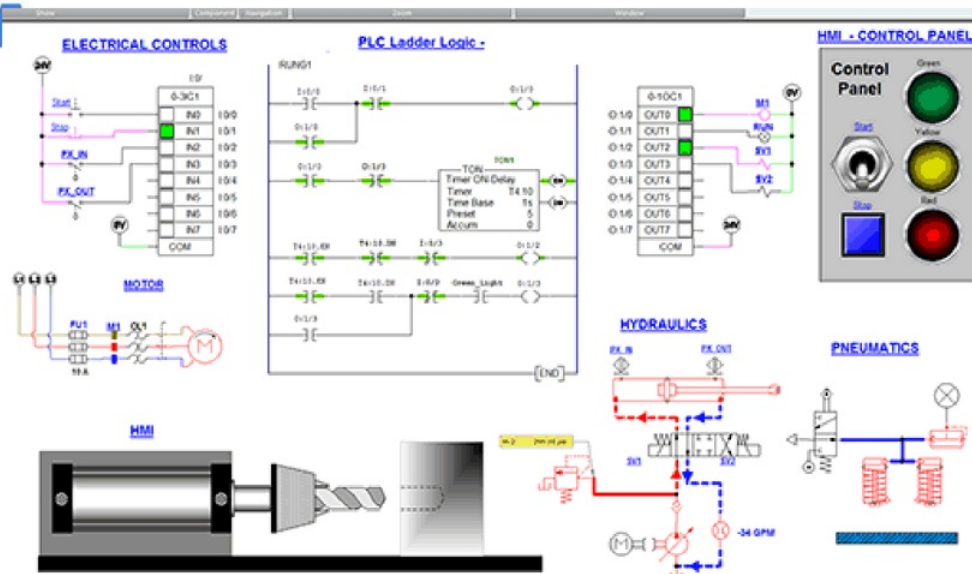
How does a typical siemens PLC work?

A programmable logic controller is a specialized computer used to control machines and processes. It therefore shares common terms with typical PCs like central processing unit, memory, software and communications. Unlike a personal computer though the PLC is designed to survive in a rugged industrial atmosphere and to be very flexible in how it interfaces with inputs and outputs to the real world. (sunnykmichael.) (2012).

The components that make a PLC work can be divided into three core areas.

- The power supply and rack
- The central processing unit (CPU)
- The input/output (I/O) section

Following below in figure 3 is an example of a PLC screen with the ladder logic and also other controls alongside it.



(Figure 3)

Relay logic - solution 2

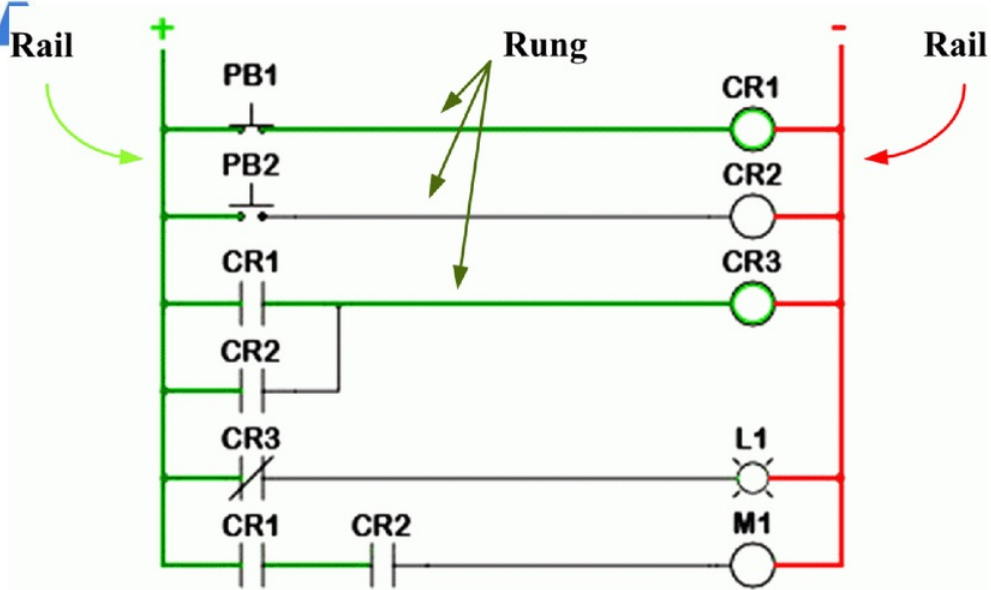
What is relay logic?

In simple terms a relay is an electrically operated switch. You could find a lot of information on this link: [Relay](#). There are different types, and the more sophisticated relays are purely electronics. You could also refer to more complex devices as the Motor Control Relays that are used to fully control an electric motor. Ariel Pérez Verde-Ramo, . (2016).

Simple relay logic is making up of a switch or sensor in order to energise a coil of a relay which then will have auxiliary contacts on to drive outputs. Timers also would also be used to try and solve this problem, a timer is basically a relay however the outputs of that timer can either come on or off after a set amount of time so in this situation they would come on after 3 seconds.

There are numerous advantages about the use of relay logic, since relay logic has been around in Trostre Steelworks for decades the methods of fault finding on it have been nailed. Sometimes switching from a good reliable method can be risky however, looking at the amount of wiring, space and also cost savings that can be made it is worth taking into consideration these other solutions.

Following below is some simple relay logic in the form of a schematic drawing. In figure 1 below it displays simple relay logic using start buttons to energise relay coils. This would be sort of like how the hydraulic pumps are started on coil prep 3 in Trostre steelworks however their logic is a little bit more complex as there are various safety interlocks which are on the rungs.

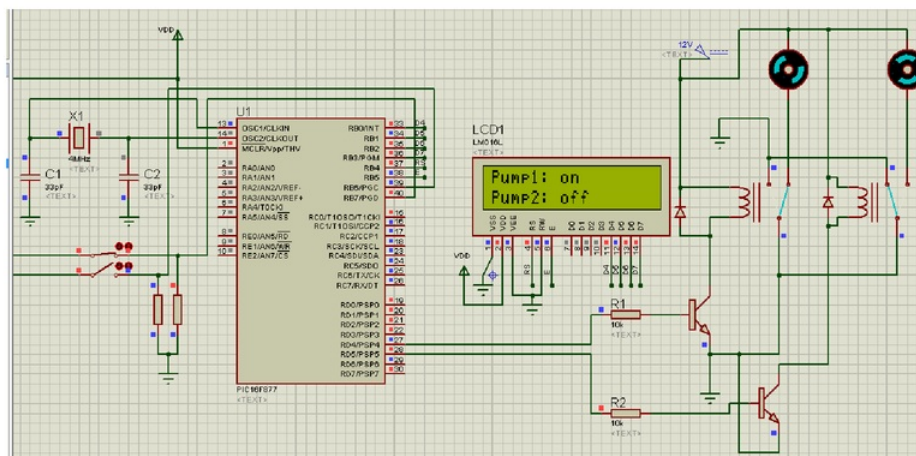


(Figure 4 - Indexxit. (2010).)

Pic16F877 MICROCONTROLLER – solution 3

This is based on the PIC16F877 controller which is capable of performing the same task as the final chosen solution using an industry standard PLC.

Pump 1 switched on with pump 2 switched off

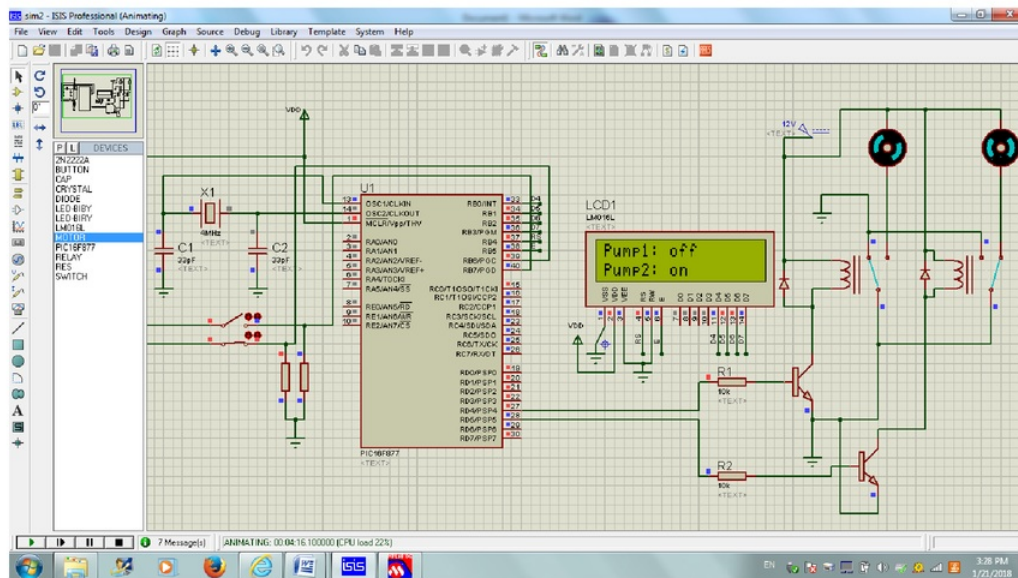


(Figure 5)

The image in figure 5 shows the operation of the two pumps where pump 1 is switched on and pump 2 off as indicated by the message in the LCD display. The display is the feedback for the pump conditions. The system operates on the condition that only one pump is on at any given time.

The circuit consists of the 16f877 microprocessor that has 2 input select switches for pump selection. The output consists of two 12V relays which are switched using a transistor interface. The output relays coils are energised by a permanent 12V supply with a controlled ground from the microprocessor output.

Pump 2 switched on with pump 1 switched off



(Figure 6)

The image in figure 6 shows the operation of the two pumps where pump 2 is switched on and pump 1 off as indicated by the message in the LCD display. The display feedback indicates the pump conditions.

Testing was carried out to test the functionality of the circuit meets the specification. The following results were observed.

Test No	Switch 1	Switch 2	Pump 1	Pump 2	Pass / Fail
1	off	off	off	off	pass
2	on	off	on	off	pass
3	off	on	off	on	pass

Table 1

Table 1 shows the results of running the CAD software and operating the circuit conditions. This is indicated by the feedback messages from the LCD display which alters its condition when each pump condition changes.

In this CAD design the pumps are indicated by animated motors which run when the required conditions are applied from the microprocessor.

The relays provide the necessary interface requirements for the motors. The control for the microprocessor is a C program which has been developed for this circuit.

The circuit has been designed using Proteus CAD software which enables the design and run functionality of the circuit. The C program can be downloaded into the PIC within Proteus and run. The microprocessor will behave according to the program instructions.

C program for pump switching

```
#include <pic.h>
#include "LCD.h"

void DisplayPump1(int line);
void DisplayPump2(int line);
//Function prototypes

void DisplayState(int line);

void Delay(int t);
//Function prototype

int state=0, i, j, pump1, pump2;
//global variables

////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////
void main(void)
{
    TRISA = 0xFF;
    TRISB = 0xC0;
    TRISC = 0x00;
    TRISD = 0x00;
    ADCON1= 0x07;

    LCD_Startup();

    //Configure port A = 1111 1111
    //Configure port B = 1000 0000
    //Configure port C = 0000 0000
    //all outputs
    //Config ADCON1 = 0000 0111

    //Function header, runs function in LCD.c
}
```

```

while(1)                                     //Start super-loop
{

    if (RB7==1) {                             //settings for feedback message pump1
    pump1 = 1;

    }

    else{

    pump1 = 0;

    }

    if (RB6==1) {                             //settings for feedback message pump2
    pump2 = 1;

    }

    else{

    pump2 = 0;

    }

    DisplayPump2(1);                          // displays
    the state on line 1 of LCD
    DisplayPump1(0);

    switch(state)                             //set state for
    pumps
    {
        case 0:
            if (RB7 == 1)                     //set pump1 on
            {
                RD4 = 0;
                RB6 = 0;
            }
            else{                             //pump1 off
                RD4 = 1;
            }

            if (RB6 == 1)                     //pump2 on
            {
                RD5 = 0;
                RB7 = 0;
            }
            else{                             //pump2 off
                RD5 = 1;
            }
        }
    }

```

```
        break;                //This breaks out from each case
    }

}

////////////////////////////////Function prototype for delay////////////////////////////////

void Delay(int t)
{
    for(i=0;i<t;i++) // Outer loop
    {
        for(j=0;j<50;j++); // inner loop

    }
}

////////////////////////////////Funtion prototype to display the state////////////////////////////////

void DisplayState(int line)
{
    char state_string[10] = {0, 0, 0, 0, 0, 0, 0, 0, 0, 0};
    state_string[0] = 'S';
    state_string[1] = 't';
    state_string[2] = 'a';
    state_string[3] = 't';
    state_string[4] = 'e';
    state_string[5] = ':';
    state_string[6] = ' ';
    state_string[7] = (char) state + 48;
    state_string[8] = 0;

    DisplayString(line, state_string);
}

void DisplayPump1(int line)
{
    char pump_string[11] = {0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0};
    if(pump1==0)
    {
```

```
pump_string[0] = 'P';
pump_string[1] = 'u';
pump_string[2] = 'm';
pump_string[3] = 'p';
pump_string[4] = '1';
pump_string[5] = ':';
//pump_string[6] = (char) pump + 48;
pump_string[6] = ' ';
pump_string[7] = 'o';
pump_string[8] = 'f';
pump_string[9] = 'f';
pump_string[10] = 0;
}

if(pump1==1)
{
    pump_string[0] = 'P';
    pump_string[1] = 'u';
    pump_string[2] = 'm';
    pump_string[3] = 'p';
    pump_string[4] = '1';
    pump_string[5] = ':';
    //pump_string[6] = (char) pump + 48;
    pump_string[6] = ' ';
    pump_string[7] = 'o';
    pump_string[8] = 'n';
    pump_string[9] = ' ';
    pump_string[10] = 0;

}

    DisplayString(line, pump_string);
}

void DisplayPump2(int line)
{

    char pump_string[11] = {0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0};
    if(pump2==0)
    {
        pump_string[0] = 'P';
        pump_string[1] = 'u';
        pump_string[2] = 'm';
        pump_string[3] = 'p';
```

```

pump_string[4] = '2';
pump_string[5] = ':';
//pump_string[6] = (char) pump + 48;
pump_string[6] = ' ';
pump_string[7] = 'o';
pump_string[8] = 'f';
pump_string[9] = 'f';
pump_string[10] = 0;
}

if(pump2==1)
{
pump_string[0] = 'P';
pump_string[1] = 'u';
pump_string[2] = 'm';
pump_string[3] = 'p';
pump_string[4] = '2';
pump_string[5] = ':';
//pump_string[6] = (char) pump + 48;
pump_string[6] = ' ';
pump_string[7] = 'o';
pump_string[8] = 'n';
pump_string[9] = ' ';
pump_string[10] = 0;

}

    DisplayString(line, pump_string);
}

```

The program shown consists of function calls which are called from the main program loop. The conditioning is provided by the 'if else' statements and the LCD functions are provided via inheritance using 'Header' files.

The function prototypes provide the arrays that enable the data to be displayed on the LCD.

The program is commented to help understand the sequence operation and conditioning. The ascii table values are used to print characters on the LCD.

Good work here

3. Testing plan and procedure

The testing for this project will be simple in order to test the hard wiring modifications a multimeter will be used in order to check for continuity between any modified wires and then in order to test the PLC program side of things I will be running live tests with the monitoring mode enabled in order to see coils and switches energising and being switched. In the event of there being a fault then fault finding procedures will be applied in order to find the fault.

4. Specification

The problem with the current starting method is that it takes up time which can be saved and the line is in need of an upgrade. The start buttons for the pumps are all in the electrical sub room which only authorised personnel are allowed to go into. So say if the electrician responsible for coil prep 3 is busy and coil prep 3 pumps need starting then this can cause a delay so by giving the crew the power to start the pumps is a lot more convenient and also more cost effective.

Project spec

The project must:

- Start all the pumps individually and have HMI display when running.
- Pilot relays to actually start the pumps from the HMI.
- Selector switches for standby and main pumps.

Electrical specification

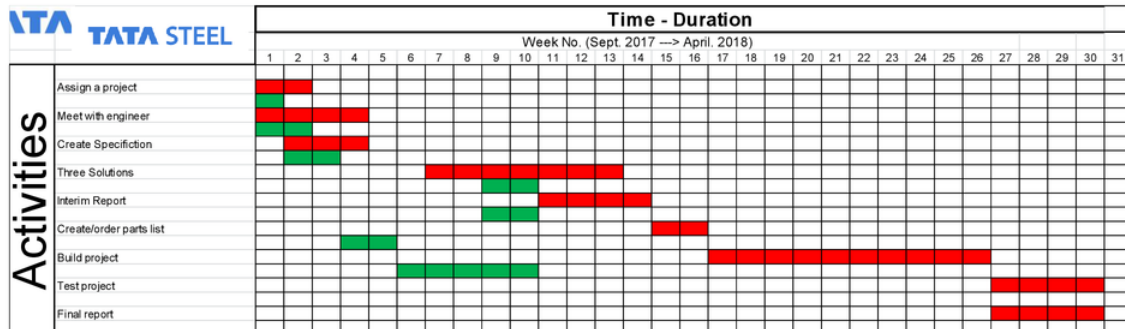
The electrical requirements for this project are:

- PLC and HMI communication.
- PLC program controlling the pumps.
- HMI screen for crew to turn pumps on/off.
- Follow the 17th edition wiring regulations and Tata internal regulations

All the electrical installation must be up to a good standard meaning all cables are secured and also all panel cables are ferruled and also crimped.

5. Project plan

In order to keep track of the timing in this project a Gantt chart will be created and an index will be used in order to plan what should be done when and if the time plan is being met or not. If it is not met then it will be displayed on the Gantt chart.



6. Discussion and conclusions

For this project there has to be 3 solutions in which the problem can be solved. These will be discussed giving the advantages and disadvantages of doing each method.

Method 1

PLC and HMI screen to energise pilot relays to start the pumps. This method will require a PLC with I/O units and also a panel with pilot relays in order to start the pumps. This method is modifying the current wiring taking out what is not needed and replacing physical start with an interface one on the HMI screen.

Advantages:

- Solves the problem and allows crew control.
- Easier to fault find on.
- More modern and will take up less space.
- Provides feedback if pumps are on.

Disadvantages

- Slightly expensive.
- Need a portable programmer to write PLC program.

Although this method may have a slight expense this method is the one which is the easiest to fault find on, easy to install and has the best timescale for the volume of work. Therefore this is the method that will be used.

Method 2

This method would be hard wiring start/stop buttons into their desks in their pulpit. Although there are already start/stop buttons existing due to the fact the crew cannot access the control room they are in there is still an issue so wiring buttons to their desks is a suitable solution.

Advantages:

- Provides easy starting method.
- Not much can go wrong with them.

Disadvantages:

- Very expensive.
- Not easy to get multiple cables to pulpit.
- Takes up too much space.
- Very time consuming

Although this is a good idea this is old technology and doesn't live up to current days development. Also the amount of time and money it would take in order to make this happen just wouldn't have the same return as method 1.

Method 3

The final method is to use the micro controller in order to perform the required tasks however although the microcontroller is quite cheap and easy to install the industry/site standard is more aimed towards PLC's and HMI screens so due to this this method is out of the question.

So after looking after all of the advantages and also disadvantages and also talking to engineers on site the choice has been made to go ahead and choose method 1. This choice has been made due to the fact that it is the way the industry control is heading in the next couple years and at Trostre steelworks the engineers have decided to have one plant standard.

How does my project work?

Don't use first person

So basically what this project is going to do is with the use of a PLC, HMI, digital inputs, digital outputs and finally pilot relays my project will replace old physical relay logic. So using Siemens TIA portal S7 ladder logic will be written so that the operator will start/stop the pumps by clicking the HMI screen and what that does is by using ladder logic it will energise a pilot relay from the digital output card of the Siemens 1500 PLC and then start the pump. The pilot relay will retain while the pump is running making its auxiliary normally open contact stay closed until the operator presses stop and it opens the contact again.

Wiring and implementation

So the first step was to collect all of the components and mount them into the panel that I had been given. I coordinated with my engineer and my mentor to come up with parts lists which is included in the log books.

As the parts came in they were mounted and the wiring was started. So as shown in figure 7 and 8 below this is a photo of the panel after a session of mounting components and also wiring a certain amount of things such as the pilot relays.



(Figure 7)



(Figure 8)

As time progressed the wiring was continued and built upon. As shown below in figure 9 and 10 is a mid-point of wiring the panel.



(Figure 9)



(Figure 10)

Finally the wiring was complete and was ready for testing, However following the completion of the wiring myself and my mentor spoke and thought about the bigger picture of this project and we came to the conclusion that we had left some vital safety features out. The two problems we had were that say the control circuit for starting the pumps lost supply then obviously the pumps would stop, however when the supply voltage is restored then the pumps would start instantly due to the fact that the start pilot relay was always on until someone pressed stop. So if the operator forgot to press stop after the pumps had stopped then they would start automatically without human interaction. This was therefore deemed very unsafe. So to overcome this I had to rethink the way the project worked.

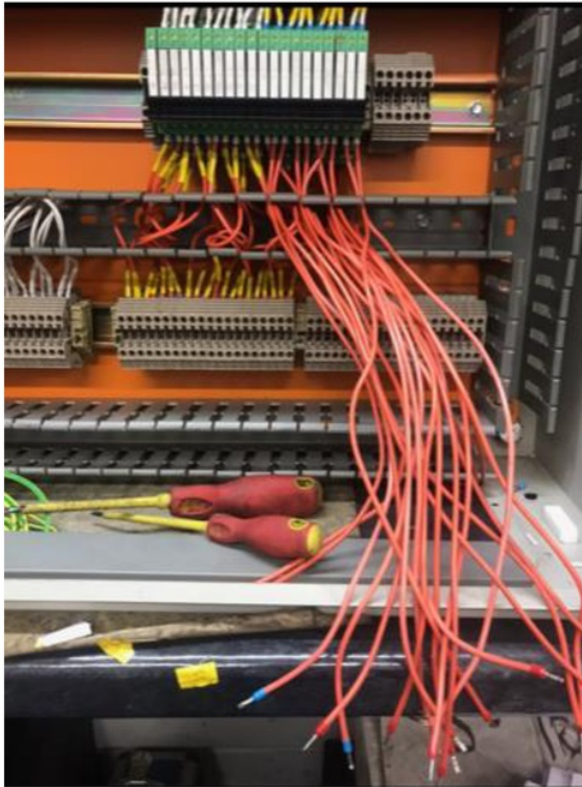
Modification to project

So I had finally decided how to overcome this problem. The idea was to add an additional 10 digital outputs and an additional 10 pilot relays so there would be 10 start pilot relays and 10 stop pilot relays. The ladder logic also needed to be modified so what I done was when the operator presses start on his HMI that energises an internal memory bit which will then energise the pilot relay, but then there was a timer in the circuit so after 3 seconds the start pilot relay would drop out and the auxiliary contact off the main contactor for the pump would retain itself. Then when the operator pressed stop on his HMI then it would energise another pilot relay which would then open in the control circuit of the pump de-energising that pump and stopping it.

So the extra components were added and the additional wiring was added as shown below in figures 11, 12 and 13.



(Figure 11)

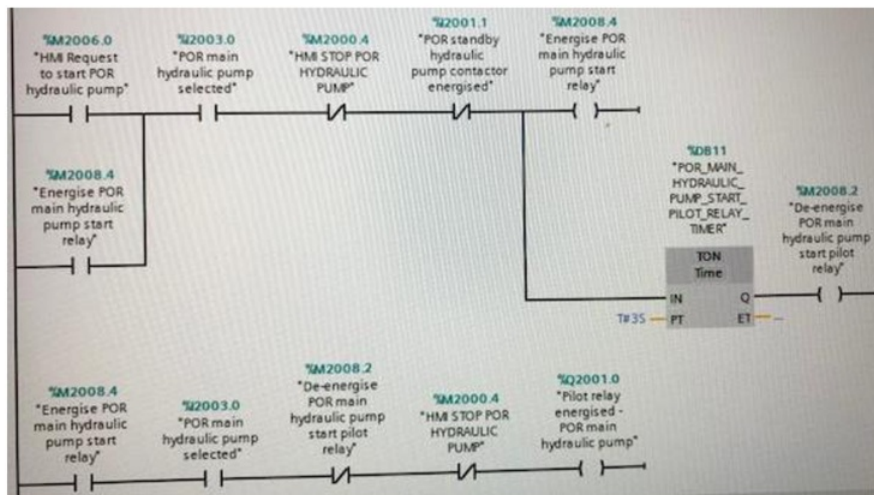


(Figure 12)



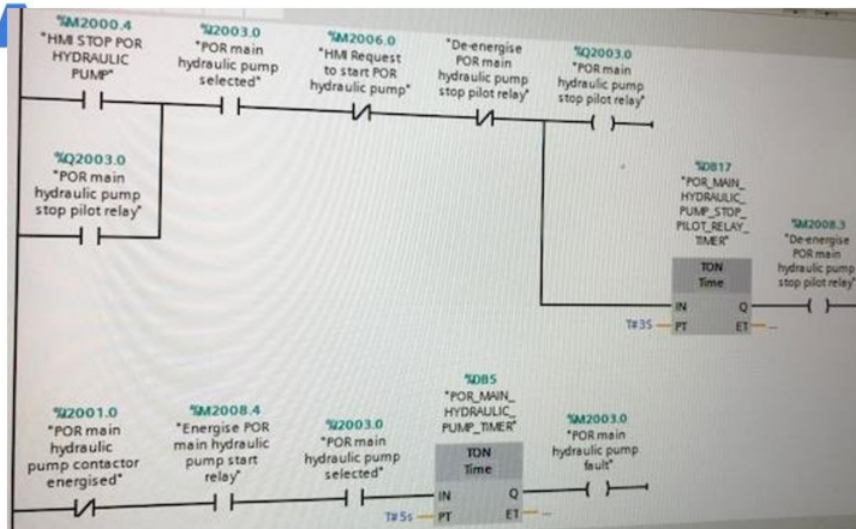
(Figure 13)

Now all of the wiring was completed it was time to modify the ladder logic so it worked for the new wiring. This meant also adding new tags to the tag table and also editing the HMI. Following below in figures 14, 15 and 16 is the final ladder logic. The figures below only show 1 out of the 10 pumps however all of the ladder logic is the same the only thing that changes is the addresses of the contacts everything else is the same.

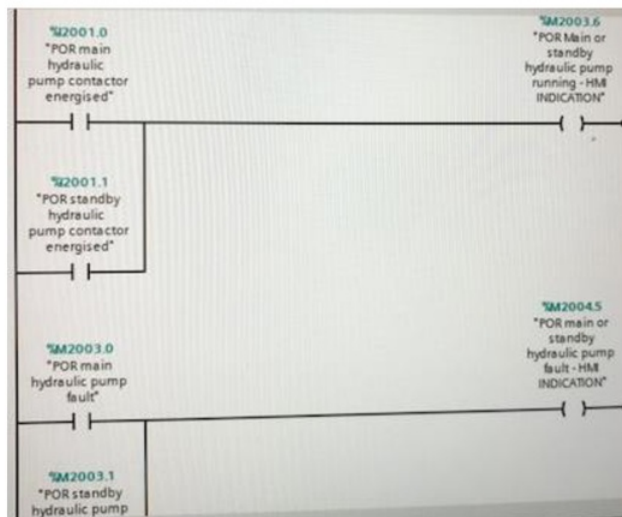


(Figure

14)



(Figure 15)



(Figure 16)

Good annotated program makes it easy to follow.

Testing and fault finding

So since the wiring and program ladder logic had been completed it was not time to test to see if the project was functioning as it should be.

The first test was to see if the start/stop relays would energise when the start or stop button is pressed on the HMI. The relay should stay on for 3 seconds and then de-energise. A check that also needed to be done was to check if the auxiliary contact for the relay was closing. This was done using a multimeter. An indication that pilot relays were energising is that the LED would illuminate when it is energise. Below in figures 17, 18, 19, 20 and 21 Are photos of the testing which include

continuity testing the auxiliary contacts of the pilot relay, checking to see if the pilot relay indication light came on and also checking to see if the digital output card LED was coming on. Also since the inputs which provide contactor feedback were not receiving anything then it would be expected on the HMI screen that the circle indication would appear to be green inside with a larger white circle on the outside. This can also be seen in the figures below.



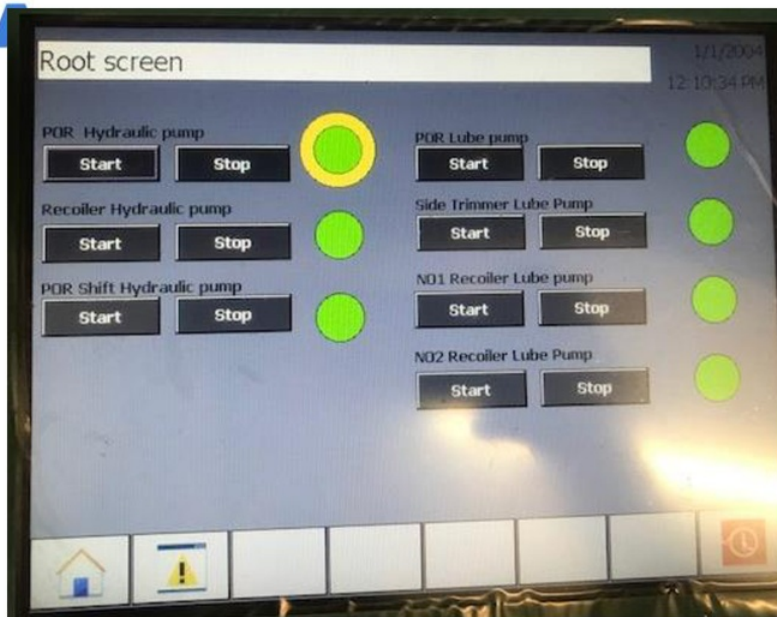
Good evidence of testing

(Figure 17)



(Figure 18)





(Figure 21)

The second part of testing is to check that the inputs work. So a short was put on the POR hydraulic input once the start button had been pressed. The first check was to see if on the input card if the LED had illuminated. The second check was to see if on the HMI screen that the small green circle had changed to red (GREEN = the pump is stopped, RED = pump is running.) Below in figures 22 and 23 are the testing evidence for this.



(Figure 22)



Implementation looks good

(Figure 23)

Testing results table

This testing table is for every individual pump so this test was repeated 10 times in order to make sure that the sequence worked.

Test performed	Expected result	Actual result
Start/stop operations and indication.	Start/stop relays should energise for 3 seconds then turn off, indication of relay should illuminate green, digital output card should show indication that an output has been switched, green circle should show on HMI with yellow circle around the outside. Auxiliary contact should indicate a resistance across the contact when relay is on.	Relay became energised for correct amount of time, HMI indication was correct and also output cards were clearly displaying that an output was on when start was pressed. Used multimeter to check across auxiliary contacts and found reading of 0.15ohms which is correct.
Input feedback works and related indication changes on input cards and HMI.	When short is put on PLC input card LED should light up and then on HMI running indication should change to red and when	Input card changed from not lit, to lit and green, HMI indication changed from green to red and then back to green when short

	taken off go back to green.	taken off.
Checking that the ladder logic is working using monitor mode.	All ladder logic should work to the specification creating outputs when it needs to and using inputs when it needs to.	All of the code worked as it should and functioned to the specification.

Good test results.

Discussion and conclusion

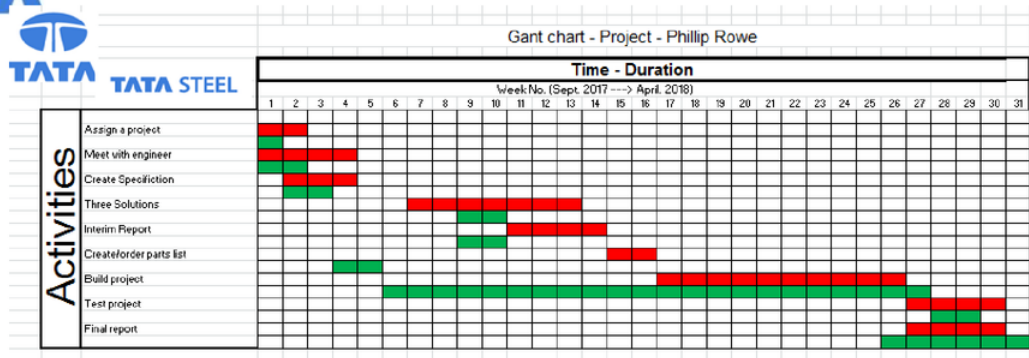
Following the completion of the project all, I notified my engineer that the project is complete and it is ready to install. Due to circumstances which are beyond my control I will be moving areas within trostre steel works and won't be able to install the project. So following a meeting with my engineer the decision has been made to handover the project to him and he will take the project forward and install it.

There were some problems during this project as I inherited it off another electrician I had to try to really drive this project forward. There was no set time limit for this project as it was an upgrade it was not needed instantly. One of the problems during this project was getting all of the components at the same time in order to finish the panel as quickly as possible, however due to things that are out of the companies control this could not be achieved. The second major problem was since this was my first time doing a major industrial project by myself I did not take into consideration many aspects of requirements such as safety, fail safe and also back up plans. This was actually a good thing at the end of the project as it developed me as a project engineer. Firstly when thinking about safety I didn't take in to account that if a fault occurs such losing supply voltage on the control side of things, initially the first draft of the project would have let the pumps start by themselves and that could be very dangerous however after some consideration about other aspects this was resolved. Much like the back-up plan side of this project. The initial choice was to rip out all of the physical start and stops however following a discussion with my engineer and my mentor even though we both firstly thought that it would be a good idea to get rid of them, I was later decided it was better to keep them just in case of the slim chance that the PLC fails then the line has a backup plan.

Do not use first person.

To conclude this project was very successful. The specification was met after a little bit of trial and improvement. Although the first method was not how the project finished it was the process of personal development which resulted in the success of this project. I have learnt a lot from the project as it has taught me a lot about the different aspects you have to think about when making a industrial project. Although the specification has been achieved if this project was to be done again the improvements that would be made would be to have a much more structured plan. So at the start when the specification is given really sit down and think about all the different things such as safety, back up plans and ordering of components first. Doing this in future would prevent alterations being made. Another thing I would change would be the way I manage my time. Parts of this would out of my control due to work courses and other commitments inside of work forcing me not to have as much time I would of liked to some days on the project however one improvement would be to arrange with the engineer in charge to have pre-arranged time in order to work on the project. Referring to the Gant chart below some of the tasks were done either on time or before their time however the last 2 objectives weren't completed on time but were completed in the end, so if the project was done again then time keeping should be improved.

Better to focus on the actual results / evaluation of the overall project in the conclusion rather than personal gains.



Good use of Gant chart. Should use a key for the colour code meanings.

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Final

GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

Instructor

63/100

PAGE 1

PAGE 2

PAGE 3

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PAGE 7

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PAGE 13

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PAGE 21

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PAGE 22

Text Comment. Good evidence of testing

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PAGE 25

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PAGE 26

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PAGE 27

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GRADING FORM: CSG-RUBIC

PHILLIP ROWE

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RESEARCH-INFORMED LITERATURE

-  Introduction and background research is good.
There is some good relative information.- 7.5/10
References are good - 7.5/10

15/20

KNOWLEDGE AND UNDERSTANDING

-  Specification covers the technical requirements including the Siemens PLC type.- 7/10 Solutions considered are very good with good explanations.
One alternative is also tested.- 8/10

15/20

ANALYSIS

-  Testing and results are substantial and plenty of evidence.- 8/10 Conclusion is a little weak.- 5/10

13/20

PRACTICAL APPLICATION AND DEP.

-  Considerable effort made with 3 solutions. - 3.5/5
Final solution implementation with good explanations is evident.- 7.5/10 Quality of work is very good.- 3/5

14/20

SKILLS FOR PROFESSIONAL PRAC.

-  The report was good and a good structure. - 7/10

7/20