

Applied PLC's report

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Introduction

Programmable logic controllers are used to connect Input devices such as various types of sensors, with various types of outputs such as motors. The programmable aspect of this equipment allows for a logic to be applied to those inputs and outputs to allow for a series of actions to be performed depending on the state of input conditions. As many of the input devices that are available to use with PLC systems are related to safety, a PLC system not only makes a system safer but also improves the efficiency and productivity of factory.

To develop the hardware configuration, there are many software packages available that allow for the development of layout and value of the many input and output devices that can be involved with a system. To fulfil this role Factory IO was used to complete this project, this was used to build the virtual factory and to assign the inputs and outputs. Using this software package, it is also capable of running a simulation to incorporate a ladder logic to the simulated factory.

The Siemens package can be used in conjunction with the Factory IO software to develop the ladder logic that applies to the virtual factory that has been developed. The Siemens program can develop a ladder in a logical manner that makes the program easier to fault find and develop the program to incorporate improvements and changes to the program. Using this software in conjunction with the Factory IO package allows for a live simulation of the program, this is visualised in the Siemens software by displaying each of the ladder rungs showing which of the inputs are energised. This feature is an effective method to fault find and develop the system; the live simulation helps to understand if an output isn't energising when expected. Using the Factory IO for its simulation feature allows for a the program to be displayed more visually, this shows each of the components (i.e conveyor belts, actuators) operating physically giving a more visual indication of issues.

Available types of PLC's

There are many suppliers of PLC's available on the market that can be purchased depending on the needs and price range. For this report, the two suppliers that will be looked for this report are Rockwell automation (formerly known as Allen-Bradley) and Siemens. These two suppliers hold a large market share as the products being offered meet many of the requirements of the market at different price points which allow them to be popular suppliers.

Rockwell (Allen-Bradely)

Allen-Bradly units allow for a much easier interface between components as this allows for the import of third-party tags. The importing of 3rd party tags is important as it means they can be controlled within the same program as the other components and can be interlocked with all the components available resulting in a safer system. The interlocks and inclusion of all components in one program is important as if they were separate, one program can continue to run independently of the other meaning that some components will not shut down in emergency situations such as the E-stop being activated.

This type of system requires additional components known as 'cards' that allow the for the capabilities to be expanded, this includes a power supply card and communication card required for the operation of the PLC providing power and communication capabilities to the processing unit. This results in a more basic installation and setup for the system as there are more components to install but the system is more basic and fundamental. Although this limits the capabilities of the system, this allows it to be more easily understood and means some of the maintenance and fault-finding activities can be carried out by the users and technicians. Depending on the complexity and location of the installation, this can be a suitable supplier, Rockwell has a large market share in North America and as it is the most popular system, this increases the level of field support that is available if located in this region.

Siemens

Siemens requires a more complicated program to operate which needs a more experienced program composer to ensure that it is written to operate correctly and to include all the safety components within the system. Siemens does not integrate as successfully with 3rd party components and tags, this is possible but, in many cases, this requires two different programs to be written, one for the siemens systems and components, another for the 3rd party components. This setup requires a more complex program to account for the tags to be used effectively in each program.

The hardware available for each system differs as the Siemens system interfaces much more effectively as this can be attached to a 24V DC power supply with an integrated communications port allowing it to communicate with other systems on the network, this is a benefit to using the Siemens system. Siemens has more complex capabilities and can be used for larger systems in larger factories for applications that require the control and monitoring of many components and sensors. However, the increased complexity of the system has an impact on the knowledge level required to operate, maintain and to configure the system which increases the costs incurred by the company. This skill requirement also increases the necessity of field service from the manufacturer, this is available along with technical support for the end-user.

Both suppliers have qualities that make them more suitable for each application making it difficult to determine which system is better as this is subject to the application and needs of the business. To determine which type of system is more suitable for to purchase for a business, there are several selection criteria that should be considered that will make the selection of system more accurate. When selecting the system, is should be determined which features have a higher impact on the functionality of the site to provide information to allow an accurate cost/benefit analysis to take place, as cost is an important factor in such decisions. An accurate cost benefit analysis is required to produce a business case that is used to source the funding, this will include the total costs, and a breakdown of the merits included in the installation of the system. Below, some of the selection criteria has been listed to ensure that the correct factors are considered when selecting a system.

Selection criteria

The selection criteria is important once the type of PLC has been selection to choose amongst the many brands and models of PLC to gain the correct specification.

Safety – It is very important that the PLC is ideal for the environment and in which it will be operating. The variables that should be considered are things such as moisture, dust or ruggedness. If this criteria is not explored properly then the maintenance costs of the PLC can be very high and can make the equipment unsafe to use.

Functionality – The functionality of the PLC is clearly and important factor that should be considered, this is how fit for purpose the equipment is. Considering whether the PLC has the capability to perform the task whilst also giving the consumer the ability to extend and upgrade as the technology advances.

Communication – The communication also is applicable to the ability of the PLC to have a usable interface for the human users to operate it easily and efficiently. The interfaces for the human interaction to the PLC can be drastically so it is important to decide what is required.

Compatibility - communication is a factor that should be considered as it is important to know how the equipment communicates with each other whilst also being capable of communicating with a network of other PLC's if required.

Environment – The environment in which the PLC will be operating is very important as this could severely affect the functionality and safety of the equipment. Many factors should be considered such as electrical interference, vibration, magnetic fields, moisture, dust and danger of being knocked.

Reliability – the reliability is very important as many uses for the PLC will put the equipment under serious pressure and responsibility. An example of this is as part of the machinery in a power station which could have a drastic impact if the PLC failed at any point so is therefore important to have back-up systems in place and to ensure the equipment is sufficiently maintained.

Cost – as in many aspects of manufacturing, the cost of the equipment can be extremely important as this will determine what is possible within the system and what the company can afford. PLC systems have proved cost effective in the medium to long term but do require a high initial cost to purchase and install the equipment including training/re-training of employees.

The two most common suppliers of PLC used within industry in the western nations are Rockwell and Siemens. The following table collates the main features of a PLC system and how these features are represented by each of the supplier companies, the criteria for this comparison is chosen using the selection criteria outlined above, along with the features that have proved important to the end user.

Comparison criteria	Siemens	Rockwell	Justification
Safety		✓	Both systems allow the incorporation of safety components, but the Rockwell system has a lower reporting latency
Functionality	✓	✓	Both systems rated equally in a survey of 96 users of each system
Compatibility	✓		Siemens system allows for an easier upgrade

			process, including integrating new components
Pricing flexibility	✓		Both companies offer systems of different price points, Siemens offer a wider price range
Supporting software	✓		Siemens has well-supported software packages including 3 rd party providers with intuitive use

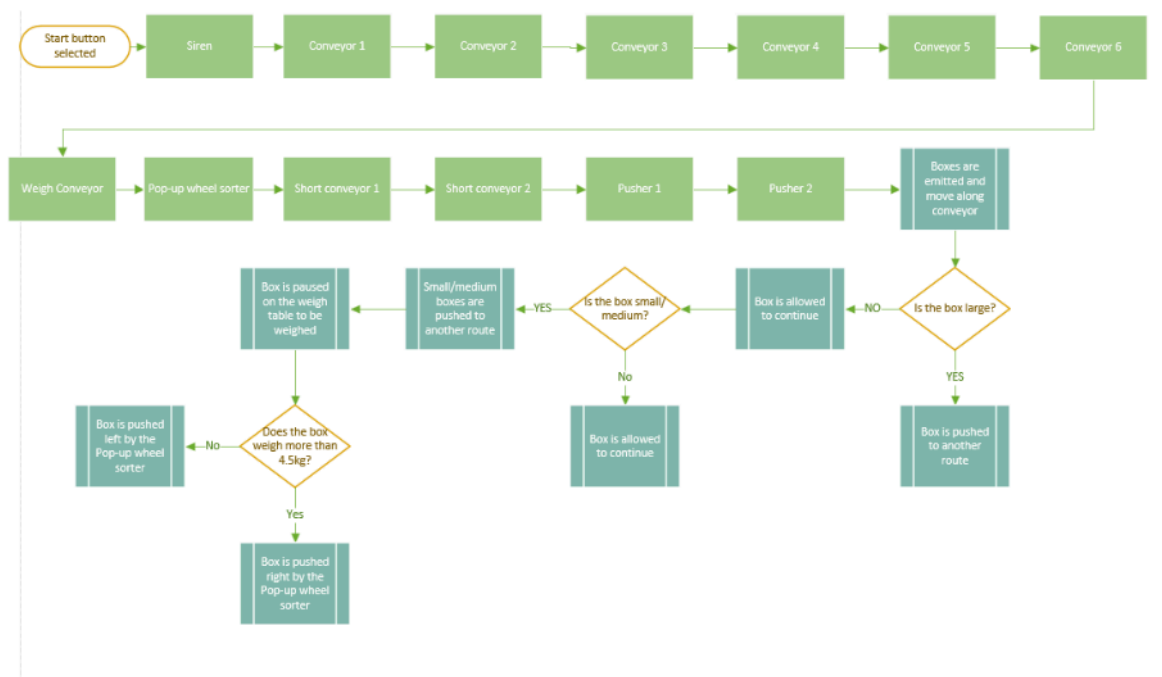
[1]

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I have more experience working with Siemens than Rockwell systems although I have used both systems, I find the Siemens system much easier to use to program. The supporting software for Siemens is a much more intuitive with a user-friendly interface that can be used to live simulate and monitor the program before being uploaded to the PLC system to ensure that the program is safe and operational before being used on real equipment. The process of installing and wiring the equipment in previous installations proved to be a reasonably straight forward task and I would be happy to work the with system and manufacturers products again.

Flow diagram



Project report

Detailing a report surrounding PLC's and their use, it was helpful to outline the types of PLC systems that are available including Brick type and rack type. The brick type system is considered a more dated system as it required more hard wiring of components, this can be a more difficult method when trying to network components, or when increasing the size of the network. A Rack type is a system that allows more networking capabilities, where the network can be expanded more easily, this also makes the troubleshooting slightly more complicated as networking adds an additional layer of complexity that requires a different skillset to fault-finding hard-wired systems.

This gave more of an insight when discussing and evaluating the different systems that are available within the market, when discussing the features and performance of each of the leading brands it gave insight into not only my own preferences but also the perspective of the users. This provided not only my own subjective opinion but also the opinion of the users which describes experience from purchase to in-service support. This provides the full experience of using each of the leading brands, this outlined the Siemens being the leader of the brands in terms of the subjective ratings in key criteria that gives perspective that challenges my opinion in many different areas of describing the advantages of using different systems. This report required a combination of my personal subjective view being combined with the specifications provided by the manufacturers, and finally the opinions of the end users allowing me to conclude that for the current project using Factory IO, Siemens was a good selection.

Producing a Factory IO virtual factory

Using factory IO, a system was built using a series of conveyor belts to sort for different types of boxes:

- Large boxes
- Medium boxes
- Small boxes
- Pallet boxes

To separate the large boxes initially, a diffuse sensor was used at a tall height that would only be intercept the large boxes. This uses a laser and reflection to recognise if there is an object passing, using the height of the large boxes to differentiate them. This is then separated by a pusher as it moves down the conveyor belt pushing the large boxes onto another conveyor belt separating them from the stream of packages.

To separate the medium and small boxes, the same method as the large boxes is used to separate the medium and small boxes. Using a diffuse sensor at a height the is triggered by the small and medium boxes triggers a pusher then diverts them down another conveyor belt. After this pushing mechanism has taken place, the smallest box type (pallet boxes) is left to continue down the conveyor belt. As this conveyor then contains two different types of boxes that need separating, this is done using a weigh table. The conveyor carries the medium and small boxes to a weigh table where a diffuse sensor triggers the weigh conveyor to stop to allow them to be weighed, then transports them further. The weight of the box receives from the weigh table which differentiates the weight of the medium and small boxes. As the boxes move forward onto

moving pop-up wheels, the boxes are diverted in two different directions that is determined by the weight, this results in the medium and small boxes being separated.

This system built using factory IO has the capability of being provided with 4 types of boxes and results in them being separated and differentiated, this utilises two different methods of differentiating boxes. There are more diffuse sensors used within the system, these are used to count each type of box. The counting aspect of the system is made of different triggers, the counters are triggered by diffuse sensors and the pushers activating. The total number of boxes is counted at the beginning of the system using a diffuse sensor, whilst the large are boxes count increase is triggered when the pusher activates. The small/medium boxes are counted using the pusher activating and finally the pallet boxes are counted using a diffuse sensor.

The factory IO program uses many additional components, this includes:

- Control box – this is placed to contain all the control aspects of the system.
- Start button – located on the control box is the start button used to initiate the PLC program to run.
- Stop button - located on the control box is the stop button used to stop the program running.
- Emergency stop button - located on the control box is an emergency stop button which removed power from all the components to stop the system if an injury or failure of machinery occurs, this is placed on the control box to ensure that operators have access to the stop.
- Stack lights – these light columns located on the box have three different colour lights that are used to indicate three different statuses
 - Green indicates the system is operated as designed
 - Yellow indicates that the conveyor belts and other equipment are in the start up procedure
 - Red indicates that the equipment has stopped in a controlled way using the stop button
- Siren – the siren is placed on the control box as it will sound when the start button is pressed, this indicates that the conveyor belt and other equipment is energising to ensure that operators are aware of the hazard.
- Warning beacon – The beacon light is used to indicate that the emergency stop button has been activated, this allows a visual indication that a hazard has been identified and warns other operators not to attempt energising the equipment whilst the emergency stop is activated.

Generating a program using Siemens TIA

To allow the system in Factory IO to perform operations, a program is required to allow the inputs and outputs to interact together. The drivers in the Factory IO allow the inputs and outputs to be assigned to specific addresses which allows them to be referenced in the ladder program. The ladder program allows for a logic system to applied to the inputs and outputs of the system, the logic outlines that and output should be energised when specified conditions are met with the information provided by the inputs. A brief breakdown of the operations is provided below:

- The equipment is energised and latched using the start button, the on the control box. The start button initiates the program and energises an output labelled 'Operate' which is used to latch the start button and used as a flag in many other aspects of the program.
- There are On-delays that give additional start delays to the conveyors to ensure that there is not a large surge in current if all the conveyor motors power at the same time, this instructs the conveyors to energise at 500ms intervals.
- The pushers are then included within the program where the diffuse sensor activated is followed by timed delay so that the pusher energises at the correct time to push the box onto another conveyor. The pushing actuators require some fine-tuning to ensure that the delay between the diffuse sensor and the pusher activated, the pusher also needs to be adjusted to ensure that the action of the pusher is set to operate quickly to ensure that it retracts before interfering with the other boxes.
- Alarms are then included to ensure that if an alarm is active, then this information is relayed to the Human Machine Interface and active alarms can be used as conditions later in the program. Some alarms are cautionary and do not have a direct impact on the system operating whereas some are warnings that directly impact the operation and must be resolved immediately.
- Counters are then used to count the number of boxes. This is done using an up counter where the trigger of the diffuse sensor causes the counter value to increase by one. The count is used to understand metrics but also to monitor if any packages have been lost in the system, this can be due to falling from the conveyor belt so ensuring that the numbers on each of the counters can be used to identify missing packages.
- The weigh scale is used to weigh each of the medium and small boxes are weighed to differentiated. The direction of the pop-up wheel sorter is dictated by the value input by the analogue weigh sensor, the pop-up wheel sorter defaults to directing boxes directly ahead but the wheels turn left or right to direct the boxes depending on their weight.
- The final aspect of the program was to program the stack lights and the amber beacon to be activated by the program. The purpose of the lights within the program is to indicate to the operators to the current condition of the system, this is used to reduce the risk of injury or damage to equipment.

The ladder format allows for logic to be used to outline the parameters required to assist the program in its operation. This type of logic program is intuitive to a competent engineer and increases the accessibility of program writing to those who are not competent with writing complex software types but are competent with logic processes and the inputs/outputs involved in the system.

Generating a Human Machine Interface within Siemens TIA

A Human Machine Interface (HMI) is a digital display that allows the operators to interact with the system by giving inputs or interrogating data/metrics. The HMI in this circumstance requires several different components that make the system more intuitive and user friendly, to meet the

requirements for the HMI in this system there were three different screens that were produced for the users to interact with. Each screen has a Home button which redirects the user to the Root screen, along with navigational arrows to navigate through the various screens available including the warning screen and the engineers' screens. Below, each of the screens are detailed with the available components and the method used to generate them:

Root Screen

The Root Screen has several components although there is a tag on the PLC program, a list of tags much be generated for the HMI for it to operate and perform functions. firstly, there are the Start, Stop and emergency stop buttons located in the top-right corner of the screen. These are tagged to HMI tags that are then linked to the tags within the main PLC program, this gives them functionality of the of the physical pushbuttons located on the control box. The root screen also contains a digital version of the stack lights that display the status of the system, these are directly tagged to the stack lights within the PLC program. The count values from the up counters within the PLC program are displayed on the root screen which displays the number of each box-type counted using the diffuse sensors, along with a button that has been programmed to restart the counters.

Warning screen

The warning screen contains the warnings and alarms that can be triggered by the system, these default as green lights but will illuminate red when an alarm or warning becomes active. In addition to this, there is an LED that will indicate that the E stop is active. The warning are programmed to trigger the Master Alarm which will stop the program and system from functioning, stopping the conveyors and components from energising which helps to reduce any damage to equipment or injury to the operators.

Engineers screen

The Engineers screen has a button that when selected, it will clear the master alarm. This allows for the system to be energised after the fault has been cleared, this function is necessary to ensure that only qualified personnel are able to clear the alarm and restart the system. The risk involved if the operators were able to clear the alarms could result in damage to equipment or injury to operators, this ensures that the system is checked before power is restored.

The HMI is a useful tool to the operators for them to have an additional method of controlling the system remotely but provides the count data for each of the box types. This also provides the warning and alarm data to the engineers to fault find the system and to control the ability to restart this system after a fault has occurred.

References

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Applied PLC's report

GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

68/100

PAGE 1

PAGE 2

PAGE 3

PAGE 4

PAGE 5

PAGE 6

PAGE 7

PAGE 8

PAGE 9

GRADING FORM: SMU GENERIC_GJ

ELLIS ASHTON

67.70

RESEARCH-INFORMED LITERATURE

- 
- Reasonable literature review of PLCs on the market, could have been improved with a few more devices and some images 62%

6.2

KNOWLEDGE AND UNDERSTANDING

- 
- The factory looks good with all of the required components included plus a few others. Your factory operates well and demos very well. 75%

22.5

ANALYSIS

- 
- Your ladder logic program is comprehensive and well documented throughout with an alarm strategy. Although the alarm strategy does not appear to function fully 66%

19.8

PRACTICAL APPLICATION AND DEP.

- 
- Your HMI screens are well laid out and informative for the operator but the engineer screen is a little to busy and could be confusing initially. 66%

13.2

SKILLS FOR PROFESSIONAL PRAC.

- 
- The report is well presented but without the network operations being described . The

6

illustrations are good and clear. A limited selection of references. 60%