AUTOMATIC BOOK BINDING MACHINE

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UNIVERSITI MALAYSIA PAHANG

BORANG PENGESAHAN STATUS TESIS

JUDUL **AUTOMATIC BOOK BINDINGH MACHINE**

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DEDICATION

To my beloved mother

Pn. Nor Maniha binti Abdul Ghani

En. Mohd Azlan bin Sayuti

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First of all I am grateful to ALLAH S.W.T for blessing me in finishing my final year project (PSM) with success in achieving my objectives to complete this project.

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ABSTRACT

This thesis describe about the automatic book binding machine. This machine is using the hydraulic system, where the punching process and binding process use hydraulic cylinder. This automatic book binding machine is use a 'puncher' concept, and then compiles all the paper to bind. It can operate in two conditions which is manual and automatic. In manual system, it just use direct wiring, while in auto system, it will be controlled by PLC. The programming in PLC are using ladder diagram. In hydraulic system, the motor that will be used is 3 phase motor where is 3hp. The operation start with, the book will be placed in one basement book and the cylinder 1 will retract and punching process will happened. Then the motor will move the basement book to binding stage and the process will continue. To make the operation become smoothly, it used inductive sensor to detect every station to stop. This machine is using less human energy in binding book. The consumer only just push the button to make this machine functioning

ABSTRAK

Tesis ini menerangkan tentang mesin menjilid buku secara automatik. Mesin ini menggunakan sistem hidrolik, di mana proses menebuk lubang dan menjilid buku dilakukan oleh silinder. Mesin ini juga sebenarnya menggunakan konsep ’puncher’, tetapi ’puncher’ hanya boleh menebuk beberapa kertas sahaja dan kita terpaksa mengumpul semua kertas yang telah ditebuk untuk dibukukan. Manakala dengan mesin menjilid buku ini, kita dapat menebuk dan menjilid buku itu dengan terus dan mesin ini juga dapat menebuk dan menjilid buku-buku yang tebal. Pada amnya, mesin ini dapat beroperasi di dalam dua situasi, iaitu secara manual dan auto. Di dalam sistem manual, ia hanya menggunakan pendawaian secara terus manakala sistem auto di kawal oleh PLC dan segala process berlaku secara sendiri. Program PLC ini menggunakan gambarajah tangga. Motor yang digunakan didalam hidrolik sistem ini adalah jenis 3 fasa yang mempunyai 3 kuasa kuda. Mesin ini beroperasi dengan meletakkan kertas-kertas yang akan dibukukan di tempatnya dan silider 1 akan membawa buku tersebut ke bahagian menebuk lubang dan operasi menebuk lubang dilakukan oleh silinder 2. Selepas itu, motor akan membawa buku tersebut ke bahagian memjilid buku dan proses menjilid buku dilakukan oleh silinder 3. Walaupun PLC digunakan untuk mengawal sistem, pengesan besi juga digunakan supaya dapat melancarkan lagi perjalanan proses sistem ini. Pengesan besi ini digunakan untuk mengesan besi apabila buku itu sampai dari satu stesen ke satu stesen dan berhenti bagi melakukan proses penjilidan. Dengan terhasilnya mesin menjilid buku secara automatik ini, pengunaan tenaga manusia dalam menjilid buku dapat dikurangkan. Mereka hanya perlu menekan suis bagi mengerakkan mesin ini.

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LIST OF ABBREVIATION

PLC	Programmable Logic Control
ELCB	Earth Leakage Circuit Breaker
MCB	Miniature Circuit Breaker
MC	Magnetic Contactor
O/L	Overload
DOL	Direct On Line
DC	Direct Current
AC	Alternating Current

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CHAPTER 1

INTRODUCTION

1.1 Overview of a Book Binding Machine

In the past few decades, the current market has not evolved in producing book binding machine. There are many types of book binding machine available to bind books such as comb binding machine, wire binding machine, stapler binding machine and many more. All those types of book binding machines are designed to bind books manually. It uses human energy to bind the book. Human has limited capabilities and this may lead to lack consumes of energy, thus a good quality of binding is unable to produce; especially for thicker books.

The automatic book binding machine is designed to fulfill customer needs and it can also minimize the usage of human energy in binding the book. In terms of automatic machine, it uses PLC (Programmable Logic Controller). On the other hand, this machine also uses the hydraulic system, to make sure it could bind very thick book. This hydraulic system has high energy to punch and bind the book. However this automatic book binding machine can only bind books with the size of A4 paper.

1.2 Project Objectives

The objectives of this project are to design an automatic book binding machine using PLC as a controller and the machine could bind a book in a range of 10mm to 15mm thickness.

1.3 Project Scope

This project is to design and construct the machine that can bind a book which is in A4 size in the range of 10mm to 15 mm. It can minimize human energy consumption in order to bind thick books.

In order to achieve the objectives, this project must use some elements such as inductive sensor to detect the system operation and give the information to proceed from one stage to another stage. While PLC (Programmable Logic Controller) conducts as a controller to control the movement of all the operation by itself. The hydraulic cylinder is used as an operation to punch and bind the book. Three phase induction motor 25W is used to move the book from one stage to another stage.

1.4 Thesis Outline

Chapter 1 contains explanation on the introduction of the project which consists of the overview of the problem statement, objectives, and scope of the automatic book binding machine project.

Chapter 2 is more focused on literature review which is the research and studies of this project.

Chapter 3 views the methods that are used in completing the project from the beginning to the end. This includes project's flow, analysis, and its implementation.

Chapter 4 discusses on the results obtained and the limitation of the project. All discussions are based on the results and performances of the overall book binding machine.

Chapter 5 concludes the overall of the project and which includes the problem and recommendation for this book binding machine in future development and modification.

CHAPTER 2

LITERATURE REVIEW

2.1 Programmable Logic Controllers (PLC)

A *programmable logic controller (PLC)* is a specialized computer used to control machines and processes. It uses a programmable memory to store instructions and execute specific functions that include on/off control, timing, counting, sequencing, arithmetic, and data handling.

Initially the PLC was used to replace relay logic, but its ever-increasing range of functions means that it is found in many and more complex applications. Because the structure of a PLC is based on the same principles as those employed in computer architecture, it is capable not only of performing relay switching tasks but also of performing other applications such as counting, calculating, comparing, and the processing of analog signals.

Programmable controllers offer several advantages such as:

i) **Increased reliability** – Once a program has been written and tested, it can be easily downloaded to other PLCs. Since all the logic is contained in the PLC's memory, there is no chance of making a logic wiring error. PLC's also offer the reliability associated with solid-state components.

ii) **More Flexibility** – It is easier to create and change a program in a PLC than to wire and rewired a circuit. Originally equipment manufacturers can provide system updates by simply sending out a new program.

iii) **Lower Cost** – PLC were originally designed to replace relay control logic, and the cost savings have been so significant that relay control is becoming obsolete except for power application.

iv) **Communications Capability** – A PLC can communicate with other controllers or computer equipment to perform such functions as supervisory control, data gathering, monitoring devices and process parameters, and download and upload of programs.

v) **Faster Response Time** – PLCs are designed for high-speed and real-time applications. The programmable controller operates in real time, which means that an event taking place in the field will result in the execution of an operation or output.

vi) **Easier to troubleshoot**- PLCs have resident diagnostics and override functions that allow users to easily trace and correct software and hardware problems. [1] (Frank D. Petruzella, 2005)

Many types of PLC are available such as Omron, Mitsubishi, Siemen, Nais and many more. In this project, I am using Nais PLC which has 8 inputs and 6 outputs. This PLC is suitable to control the movement of the hydraulic cylinder.

2.2 Hydraulic System

In the hydraulic system we must consider many types of components such as hydraulic motor, hydraulic cylinder, hydraulic fluids, valves, accumulators and hydraulic pumps.

Hydraulic motors are used for converting hydraulic energy into mechanical energy. Hydraulic motor may be categorized into high speed motors (n = 500 to 10 000 rpm) and slow motors (n = 0 to 1 000rpm). While the power produced by a hydraulic motor is dependent on the flow and pressure drop at the motor. [2](Rudhard Freitag, 1991)

Hydraulic cylinder is the link between the hydraulic circuit and the working machine. Hydraulic cylinder is different to the hydraulic motor which carries out the rotary movement, while hydraulic motor carries out translational (linear) movements, trough which forces are transferred. This hydraulic cylinder can be categorized into two groups which are:

i) Single acting cylinders

Single acting cylinders can only exert force in one direction. The piston can only be returned by a spring, trough the weight of the piston itself or by the action of an external force. Basically single acting cylinders have one effective area.

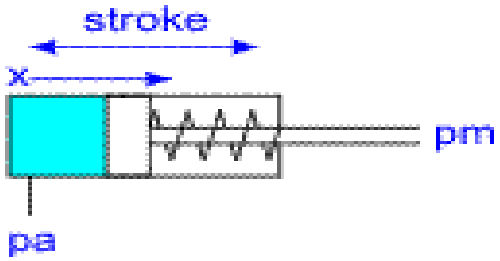

Figure 2.2.1: Single acting cylinder

ii) Double acting cylinders

Double acting cylinders have two opposing effective areas which are of the same or different sizes. They are fitted with 2 pipes ports which are isolated from each other. By feeding fluid via ports "A" and "B", the piston may transfer pulling and pushing forces in both stroke direction. [2](Paul Schwab,1991)

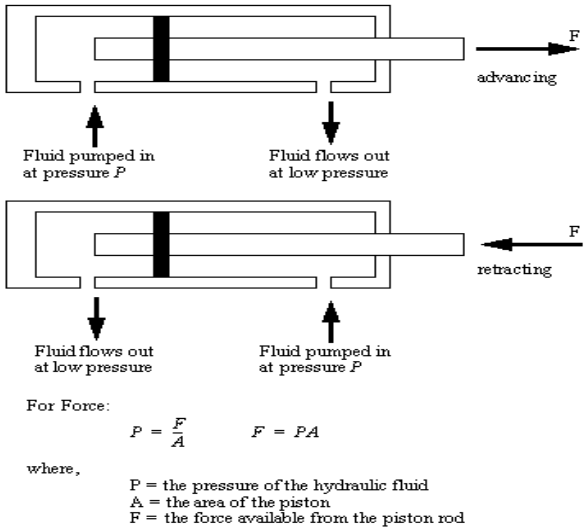

Figure 2.2.2: Double acting cylinder

Hydraulic fluid is a main function in hydraulic system is to transfer forces and movement. Further task and characteristics are required of hydraulic fluid, due to the diverse range of application and installation of hydraulic drives. The most important

when selecting a fluid is viscosity. It is not a measure of the quality of a fluid, but a stead provides information on the behavior of a fluid at the particular reference temperature. [2](Eberhard Sumpf,1991)

There are many types of valve in hydraulic system. One of them is directional valve where the most function is used. This directional valve is used to control the start, stop, and direction of flow a fluid. There are three types of directional valve, which vary in how they are constructed:

i) Directional spool valves
ii) Directional poppet valves
iii) Rotary directional valves

[2](Dr. Harald Geis, Johann Oppolzer,1991)

The main task of an accumulator is to take a specific amount of fluid under pressure from the hydraulic system and store it until it is required within the system. As fluid is under pressure, accumulators are treated as pressure vessels and must be designed taking into account the max. operating pressure. In order to store energy in accumulators, the fluid in an accumulator is weight or spring loaded or pressurized by gas.[2](Martin Reik, 1991)

Hydraulic pumps should convert mechanical energy into hydraulic energy. When choosing a pump, many points must be taken into account such as operating medium, required range of pressured, expected range of speeds, minimum and maximum operating temperature, maximum and minimum viscosities, installation, types of drives, expected life-time, maximum level of noise, ease of servicing, and maximum cost. [2](Rudhard Freitag,1991)

All these types of components are very important to consider when we want to achieve good result in this project. This is because the movement of the book and the punching and binding process were using hydraulic system.

2.3 Inductive sensor

Inductive sensor is an electronic proximity sensor, which detects metallic object without touching them. These inductive proximity detectors operate on the principle that the inductance of a coil is considerably changed in the presence of a metal core. The presence of metal closed to the coil will thus cause a bridge output off–balance condition or a change in the tuned frequency that can be sensed. The change is normally used to operate a switching circuit by way of a transistor or a Triac, so that the output is suitable for controlling a load. The predominant switch action is normally open (NO) that is no part of the switch need to touch the object being sensed.

This inductive proximity sensor only detect metallic object, and with a sensitivity that depends on the types of metal used. The sensitivity is quoted in terms of average sensing distance for an object of mild steel and, depending on the type of detector; this distance is of the order of 0.8-2mm for mild steel. Other metals lower the sensitivity, to 70% for stainless steel, 40% for brass, 35% for solid aluminum, and 30% for copper. Most inductive proximity sensors are DC operated, with the choice of current source or current sink action. A current-source type will pass current into a load; a current-sink type will accept (to ground) current from a load. Current ratings are in the 100-200mA region at DC voltage levels of 5-30V. [3](Ian R.Sinclair, 2001)

This is a good choice because all mechanical parts of the book binding machine are metal-based.

CHAPTER 3

METHODOLOGY

3.1 Introduction

In order to make this project runs smoothly, this methodology is the one of important element to take the action. Methodology is a guide to make sure that the project goes according to the flows. It is a framework for a project.

The overall of the project can be overviewed by supervisor only by referring to the methodology. The progress of the project can be examined from time to time. The elements of the methodology of this project can be referred to the flow chart below.

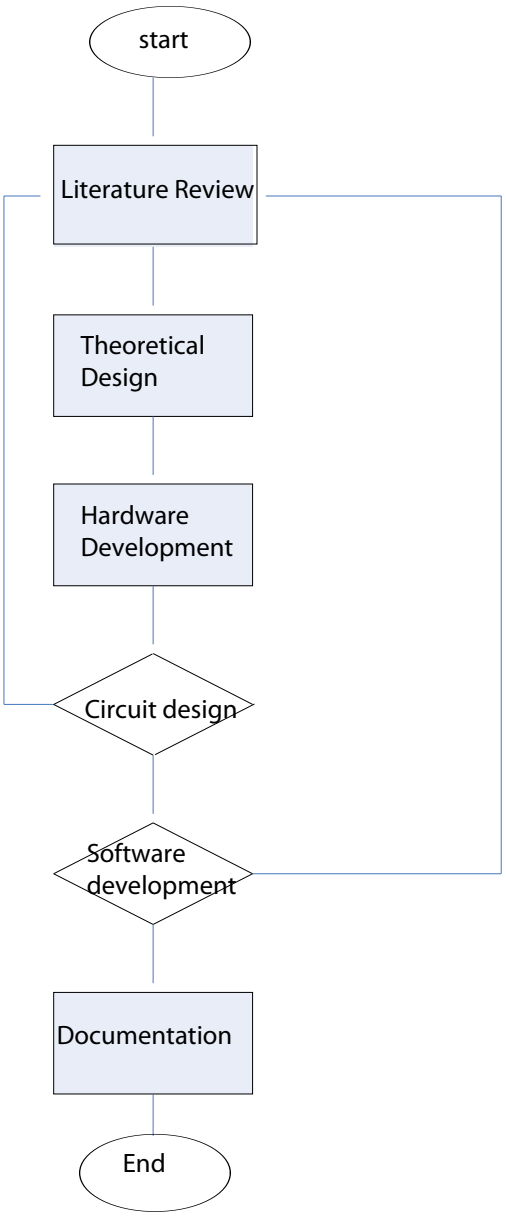

Figure 3.1: Flowchart of Methodology

In order to achieve the objective of this project, the project begins with choosing the title and discusses the problem statement of the project with supervisor. After the problem statement is understood, the objectives and scope of the project come out.

3.1.1 Literature Review

Before start the project, the second process is conducted that is; doing the research about this project and get information as much as can to learn about the previous method of the project and the components that is used in this project. The research is very important to make us clear about the project scope and it is the first layer to get the idea to design and develop the project. In this literature review, all the research comes from book, the Internet, journals and discussions with the experienced person. Those entire books are from the UMP library and borrow from someone who is very familiar with the hydraulic system.

3.1.2 Theoretical Design

After all the information is collected, then the theoretical design is developed. In the theoretical design, it considers the material that need to be used in the project that could hold the hydraulic system. Also, in this section I begin constructing the design for the size of the machine and shape of the machine.

3.1.3 Hardware Development

Then, the project continues with the hardware development which is after the theoretical design is made. This hardware development is based on the design that is made before. In completing the mechanical part, lots of work has been done such as drilling, welding metals and rivet.

3.1.4 Circuit Design

After the hardware development and the body of the machine is completed, the circuit is then designed to fulfill the project's requirements. In designing the circuit, all safety precautions are taken. Wiring process took place after circuit designing complete. Any error occurs; the process will go through the troubleshooting process and if it could not solved, the process will goes back to the literature review to search for the answer.

3.1.5 Software Development

Once all the hardware development and circuit design is completed, then the process continues with the software development. Here, the programming was constructed for automatic mode. The programming is using the FPWIN which is the software for the NAIS PLC.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Introduction

This automatic book binding machine consists of mechanical part and electrical part. Thus, workloads are compiled. All parts of the body for this automatic book binding machine are metal-based. The metals are used in the process to construct the body of this machine; such as angle iron, ½ inch iron, rode iron, and iron block. Angle iron is used for the stand and more can be seen on the body of the machine. While ½ inch irons, round iron and the block are for the base of the book to move from one stage to another stage.

The automatic book binding machine is in an appropriate size which is suitable for users to use it. At the bottom of the machine there are six wheels attached to make it easier to move from one place to another.

The construction of the figure of the body makes it user friendly. This is because the tank of the hydraulic is too heavy. If we do not attach the wheels, it would make it difficult to move the machine. The book-placed based is designed for A4 paper size. The punching and binding processes are taken by hydraulic cylinder where the eye of punch is placed at the rod cylinder to make the hole.

Figure 4.1: Automatic Book Binding Machine

Many steps are taken to build the machine as constructed above (**refer to figure 4.1**), the works done by drilling, welding, riveting, and cutting the metal using
jigsaw. To join the iron to each other, the join is weld by using the welder. All safety precautions are taking to avoid any accidents.

The automatic book binding machine could not achieve 100% objective. It can only bind books about 4mm thickness because the hardware of this project is not strong enough.

4.1.1 Book Basement

This book-place basement is designed to place the book for the punching and binding process. This book basement is in the margin of A4 size, so that only A4 size paper can be used. It has two holes because the machine using the concept of 'puncher' to bind the book. The book-place basement is placed on the rail to make it easy to move from left to right, and the rail is going through the iron block. The book basement is made from angel iron and ½ inch iron and the rail is from the rode iron.

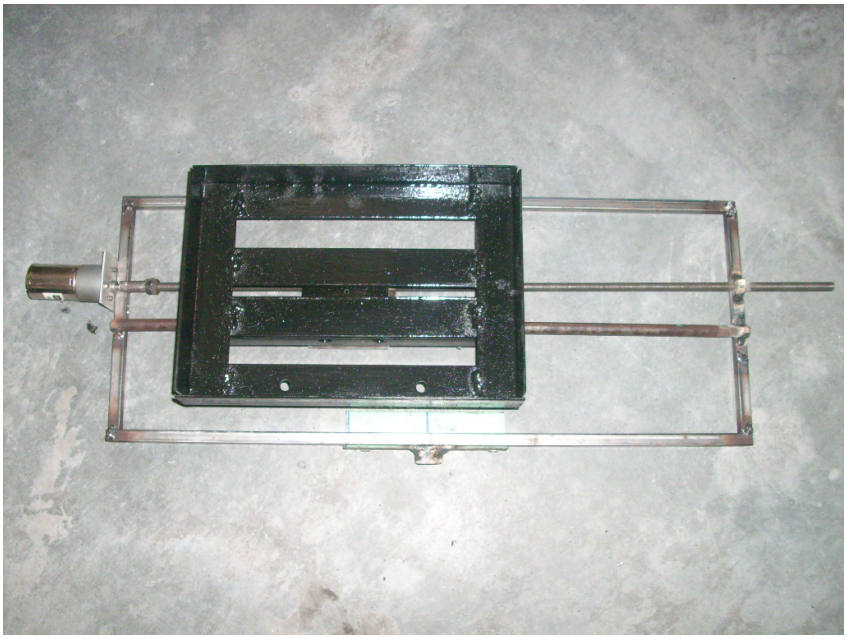

Figure 4.1.1: Book Basement

4.1.2 Hydraulic Tank Base

The Hydraulic tank basement is made from the angle iron because it is more stable to hold the tank as it is too heavy. This is because the tank is filled with the hydraulic fluid. Moreover, on top of the tank there are valve, induction motor and hydraulic pump. These components make the hydraulic tank becomes heavier.

Figure 4.1.2: Hydraulic tank basement

4.1.3 Hydraulic Cylinder Stand

The hydraulic cylinder stand is constructed to place the whole body of the machine onto it. It is made from angle iron as angel iron is stronger and able to hold the pressure produced by the cylinder.

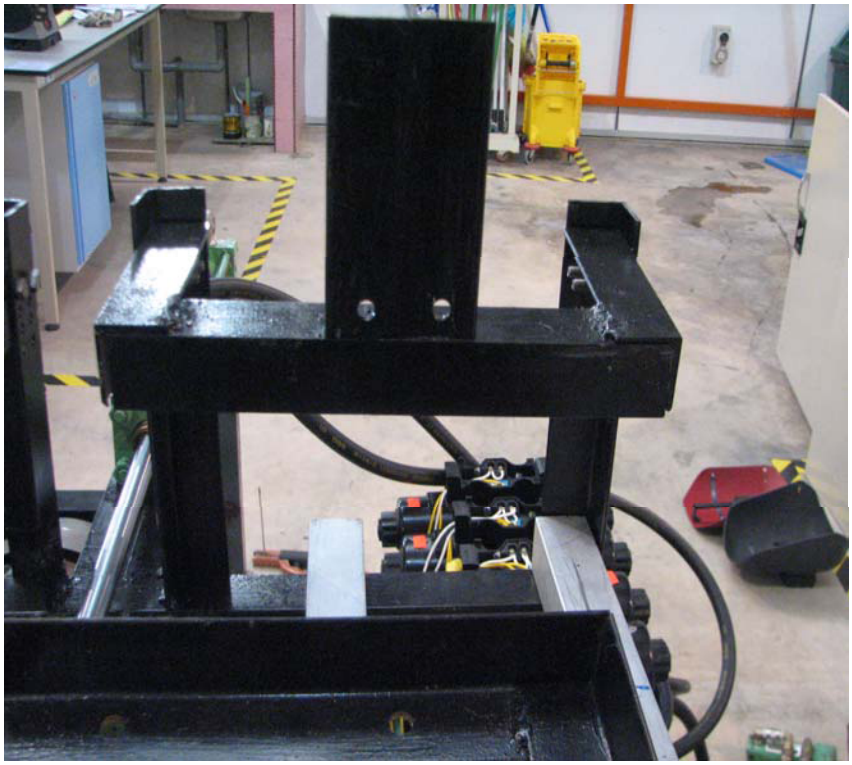

Figure 4.1.3: Hydraulic cylinder stand

4.2 System Design

This automatic book binding machine uses the hydraulic system for its operation. PLC is used to ensure operation of the system runs in automatic condition, where the PLC acts as the controller. Eventually, this machine may be operated manually and automatically. The manual system is turned on as back-up system once the automatic system fails to run. This will help users to continue using the machine without interference. This manual system is used to assemble or setting the operation before switching to automatic system. It uses direct wiring and all operations and movement are controlled by switches. This machine is equipped with an emergency stop button, in case of any interference or problems occurred in the middle of operation. The design of this machine has considered all the safety needs.

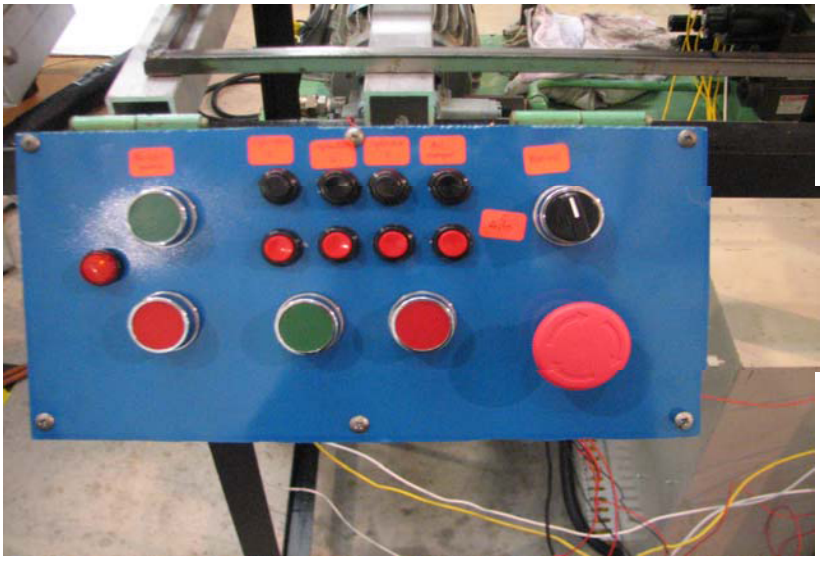

Figure 4.2: Switch Panel

4.3 Hydraulic System

Focusing on the hydraulic system, it consists of elements of control such as tank, induction motor, pump, filter, pressure gauge, oil-air cooler, valve, and cylinder. Hydraulic system functions to move the cylinder during the punching and binding process. Entire elements in this system are very important as it resembles the movement of the cylinder as well as safety needs of the system.

4.3.1 Hydraulic Pumps

A hydraulic pump is one of the elements in hydraulic system. This hydraulic pump functions to convert mechanical energy to hydraulic energy. The operation of this pump based on the displacement concept, where the fluid is transferred from the suction port of the pump to the pressure port. These pumps operate at a high system pressure because there is no direct connection between these two ports.

There are many types of hydraulic pumps such as gear pump, worm gear pump, vane pump, radial piston pump, and axial pump. All these pumps are set according to their displacement type. There are three types of displacement; gear, vane, and piston. All these types have their own model. Gear pump has three models; external gear pump, internal gear pump, and gear ring pump. Worm gear pump model is called screw pump. Vane pump has two models which is single chamber and double chamber. Radial piston pump has two types of models. There are eccentric cylinder block and eccentric shaft and for the axial piston pump, the models are bent axis and swashplate.

The pump that is being used in this project is variable vane pump. The type of model used is the single chamber type. This type of pump is operating where the movement of the stroke of the vanes is limited by a ring with a circular internal form.

Due to the off-centre position of the ring respect to the rotor, the volume is changed with the displacement chamber. [2] The maximum pressure of this pump is 35kg/cm2 and the speed is 1800rpm.

Figure 4.3.1: Vane variable pump

4.3.2 Induction motor

This project used the three phase induction motor with 3hp. The connection for this motor is delta connection (high voltage) which interprets the input for this motor of 415V. If the motor switch the connection to star connection and that the input is 240V, the starting current will rise up to 56.7A. This will trigger the control circuit to trip because of overload current. Starting current with the input of 415V, is only 2.2A. This shows that the motor used for the project must apply the delta connection. Compared to the theory, delta-connection is equal to three times star-connection, as followed:

$$Z_{\Delta} = 3Z_{Y} \qquad (3.1)$$

From the equation above, it is stated that the current will go high if the star-connection is used. The function of this motor is to activate the pump to pump the oil from tank to valve.

Figure 4.3.2: Induction motor

4.3.3 Hydraulic Cylinder

Hydraulic cylinder can be divided into two; single acting and double acting cylinder. It is the connector between hydraulic circuit and the working machine which it converts hydraulic energy to mechanical energy. This project used double acting cylinder where it enables the punching and binding process. The process begins when the cylinder extends. It has two ports to enable it to extend and retract. These two ports are connected to the valve by using the pipe, fitted to the port. Three double acting cylinders are being used. Two of them are short cylinders and the one left is a long cylinders. The long cylinder is used to move the book from one stage to another stage, while the short cylinder is used to enable the punching and binding process.

Figure 4.3.3: Double acting hydraulic cylinder

4.3.4 Hydraulic Valve

In the valve section, three types of valve are being used which are 4/3 way directional valve, twin throttle check valve and double check valve. The 4/3 way directional valve is used to control start, stop and the in-flow direction of the fluid. The function of the twin throttle check valve is to change the velocity of an actuator which is the main flow limitation and the double check valve functions to guarantee safe closing of both valves poppet. In controlling the speed of the hydraulic cylinder, the twin throttle valve has the adjustment element.

Figure 4.3.4: Hydraulic valve

4.3.5 Pressure Gauge

Pressure gauge is a pressure measuring device. There are two types of pressure gauges, they are pressure measuring device with bourdon tube and pressure measuring device with diaphragm. This project uses pressure measuring device with bourdon tube. This type is suitable to measure the pressure in fluid. It measures the velocity of the fluid into the valve which is about 400bar. This bourdon tube cannot be used in the medium with a high viscosity because it will easily damage.

Figure 4.3.5: Pressure gauge

4.3.6 Oil-air Cooler

The oil-air cooler is a device used to solve the heating problems. This oil-air cooler is the most important parameter in hydraulic system in order to decrease any power loss occurred. Cooler have a connection with hydraulic pump and tank.

During the cooling process, the cooler will maintain the temperature of fluid to be as equal to the fluid in tank. When the pump is sucking, the fluid temperature will rise up because of the rotation and pressure that occurs inside the pump which is connected to the induction motor.

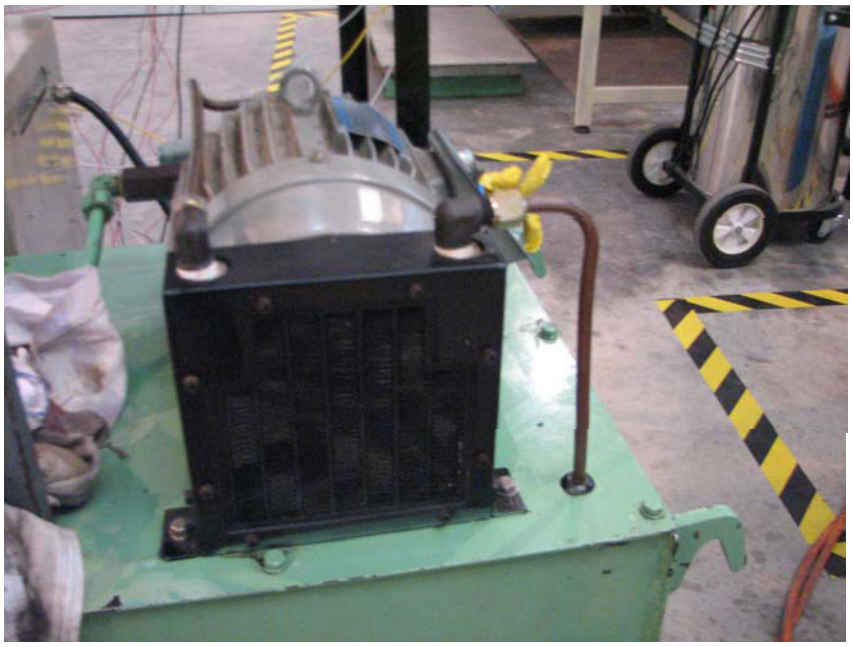

Figure 4.3.6: Oil-air Cooler

4.3.7 Hydraulic Tank

Hydraulic tank is one of the important elements in the hydraulic system. It is the container fills with hydraulic fluid. Inside, it has hydraulic fluid and filter. Hydraulic fluid has its own viscosity because every viscosity has the maximum temperature that is used as a reference for the cooling system. The parameter of hydraulic fluid in this project is defined as below:

Viscosity : 32-55Cst

Max. temperature : 38°C

The hydraulic tank has a filter in order to separate solid particles from the fluid. There are many types of filter but in this project, the breather with filling sieve model is used. This type of model is for small tank. The filter is so important because it immense danger of very contaminated fluid entering the tank.

4.4 Circuit Design

All the wiring circuit designs are compiled in this section. Here, the wiring circuit includes the D.O.L (Direct on Line) circuit, electro hydraulic circuit, motor forward reverse circuit and PLC circuit. Every design has considered the safety needs.

DOL circuit contains power circuit and control circuit. The control circuit will control the power circuit and determine the running of motor. The motor that used in this DOL circuit is induction motor. There are three lights to determine different process. They are red, green and yellow lights. When the machine is in running process the green light will be switched on and when the operation stops the red light will be switched on. If the machine trips, the yellow light will be switched on and this means that error occurs in the machine. In order to ensure that this automatic book binding machine stays in a stay condition, two emergency stop buttons are placed at the switch panel and control panel. The start and stop buttons function to start and stop the operation of induction motor.

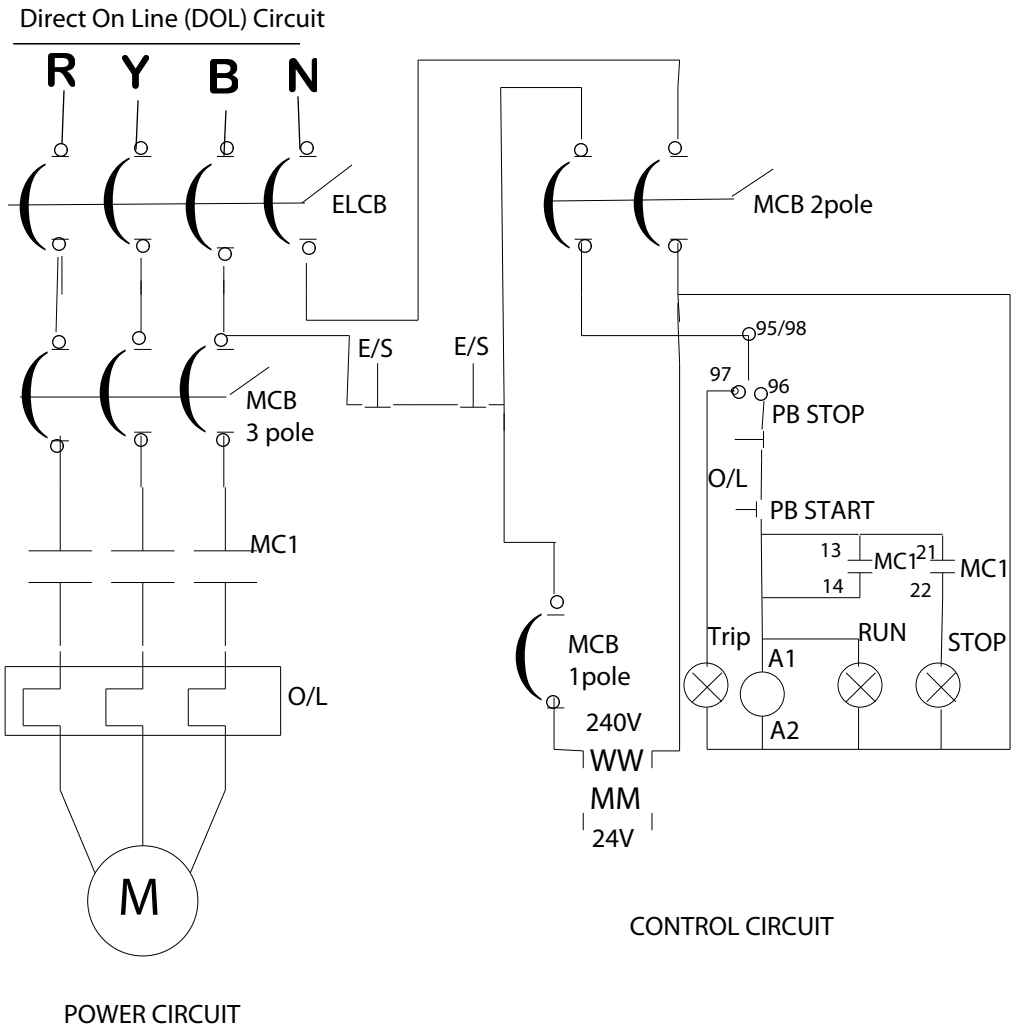

Figure 4.4.1: Direct on Line Circuit

The electro hydraulic circuit consists of all the wiring for hydraulic cylinder to extend and retract manually. Each cylinder is controlled control by two switches; one to extend and the other to retract the cylinder. Once a button is pressed to extend the cylinder, and a button is pressed to retract the cylinder at the same time, the circuit will interlock. This is because the process cannot be operated.

For forward reverse motor circuit, it is also designed similar to the electro hydraulic circuit which is to enable the three phase motor to forward and reverse rotation. This circuit functions to move the book basement from punching process to binding process. This circuit also connected to the transistor inverter. The function of transistor inverter is to up the voltage from 240V to 400V. This transistor inverter can control the rotation speed of motor by controlling the frequency value.

ELECTRO HYDRAULIC CIRCUIT

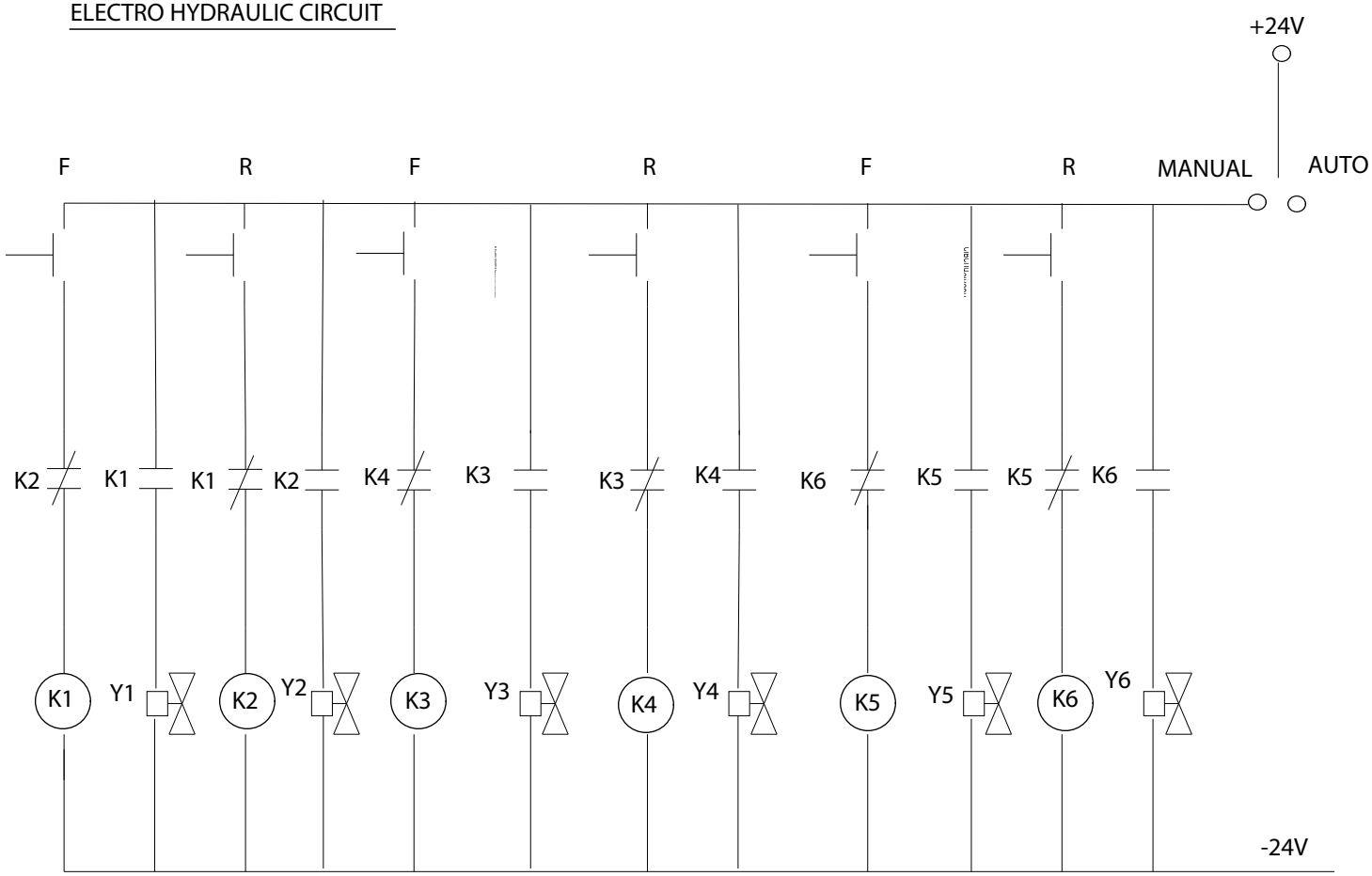

Figure 4.4.2: Electro Hydraulic Circuit

Motor Forward Reverse circuit diagram

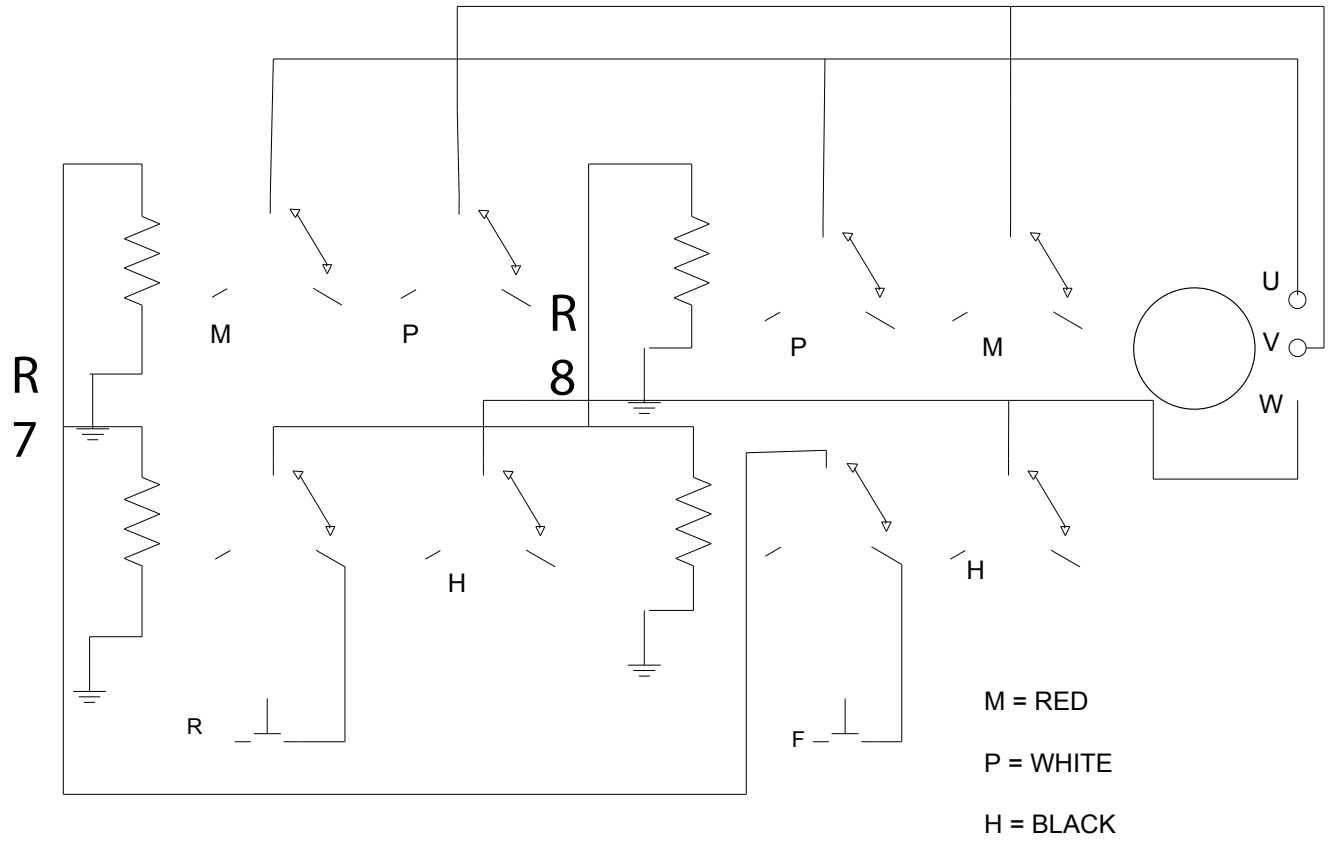

Figure 4.4.3: Motor Forward Reverse Circuit

4.5 Software Design

In designing the software part to control all the movement of this machine by itself, PLC is used. NAIS PLC is used where it has 8 inputs and 6 outputs. Two NAIS PLC are used to complete all the operations. For PLC 1, the programming is on the hydraulic system and for PLC 2 is on forward reverse motor three phase. The PLC 1 and PLC 2 cannot integrate with each other because there are no connectors to interface them. Even though both PLC cannot integrate each other but the programming still can communicate. The program is designed to enable the machine runs in automatic mode. The automatic mode can be operated when users select the automatic mode at the selector. In order to run the machine in automatic condition, the user must push the start button and all the operation will begin. A light on switch panel indicates the operation of machine stated in manual mode or automatic mode. All operations will stop when user push the stop button.

Inductive sensor is used to send information of operation whether to stop or continue with the operation. This type of sensor only detects metal, thus it is suitable and fixed to this machine because the whole body of this machine used metal. The programming of both PLC can be described by the flowchart below:

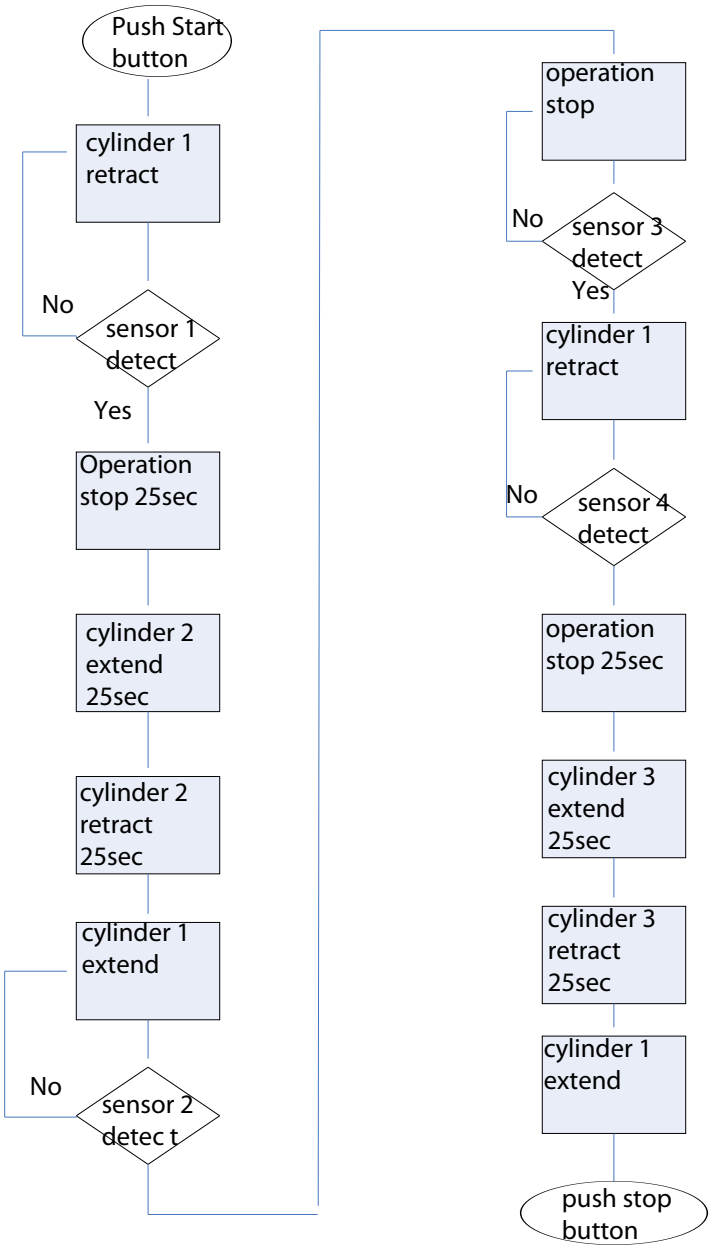

Figure 4.5.1: Flowchart PLC 1

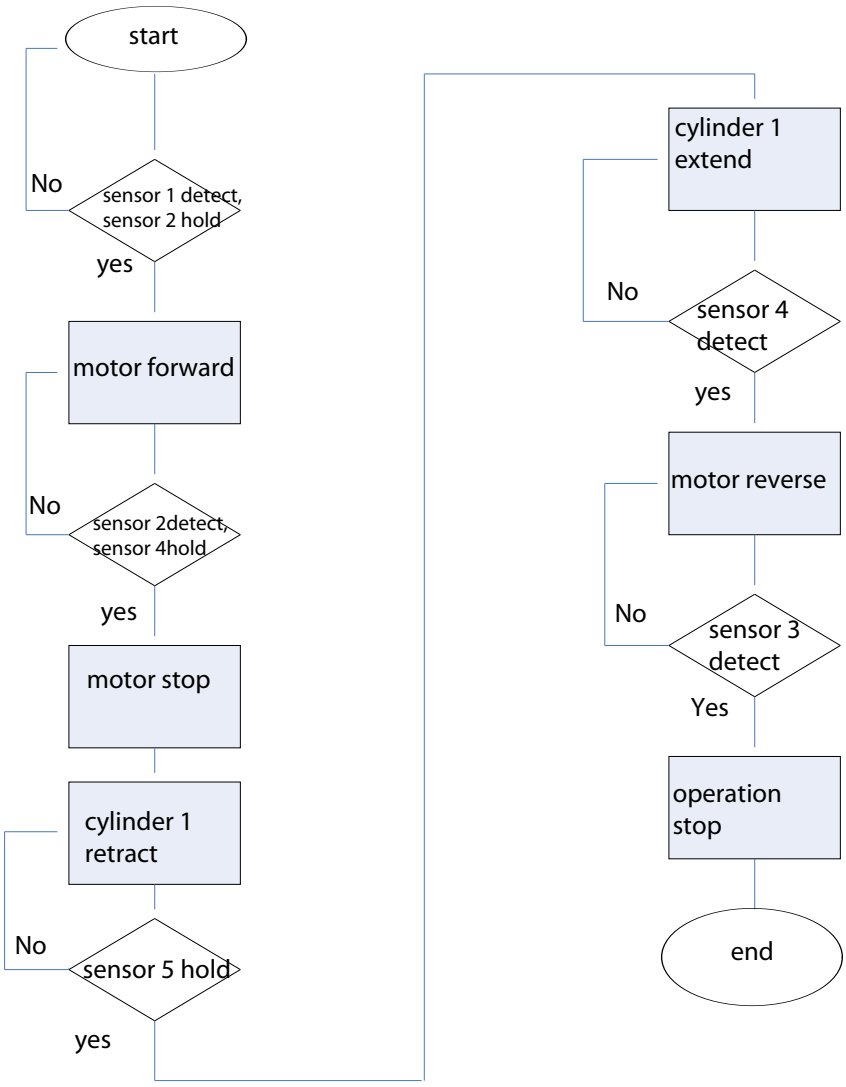

Figure 4.5.2: Flowchart PLC 2

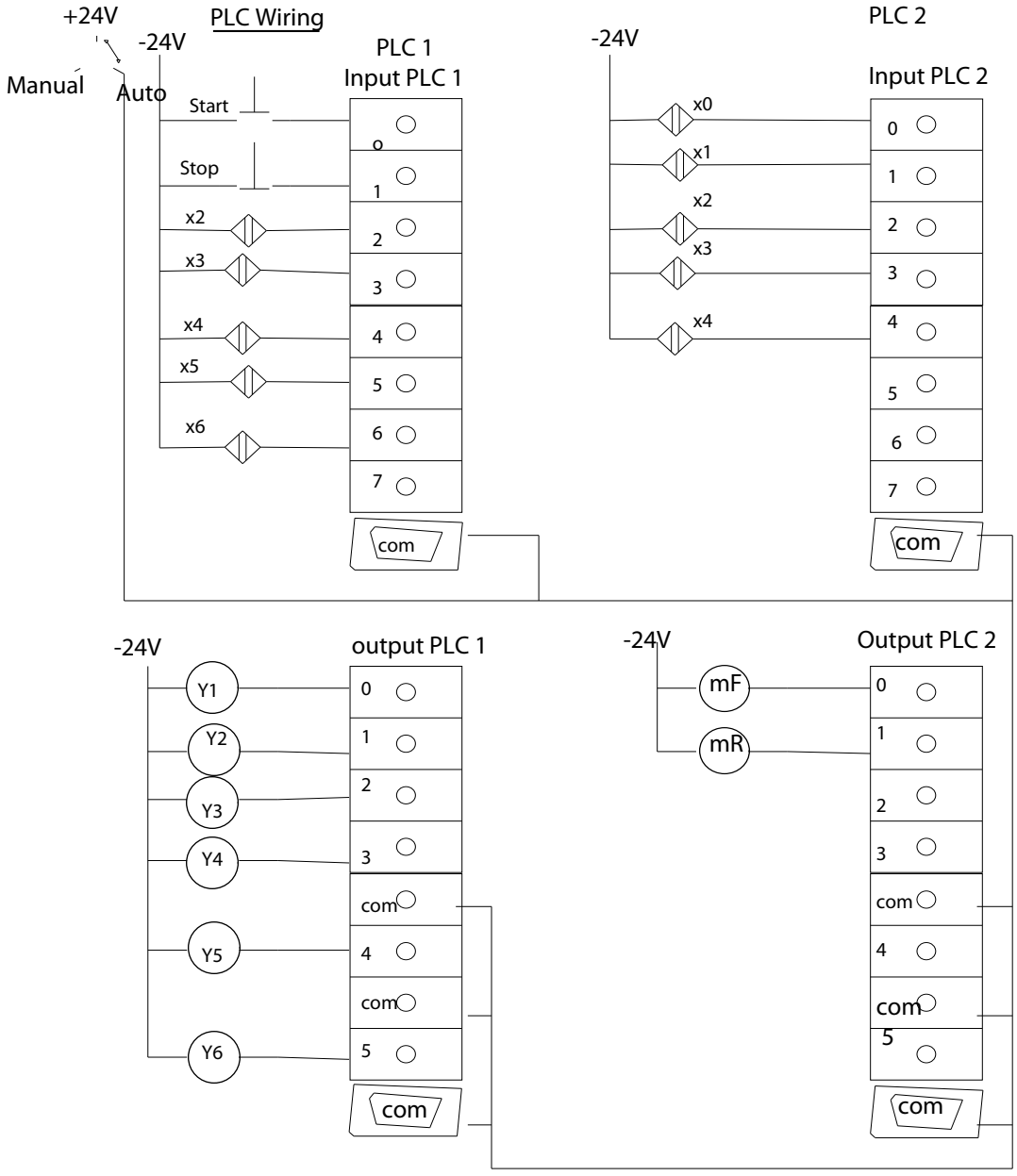

Figure 4.5.3: PLC Wiring Diagram

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

This project does not achieve 100% objectives because it can only bind books with about 4mm thickness. On the other hand, the objective to control the operation by using the PLC as a controller is achieved. Thus project used two PLCs as controller but both of them cannot integrate with each other. However, in order to make the PLC 1 and PLC 2 able to communicate with each other, the programming is designed to function continuously.

It took about five months to complete the project and achieve the expected results. Various processes of developing and research have been implemented to get the best result. In completing the mechanical part, to construct the body of the machine, the process such as welding, drilling and sawing has been applied.

5.2 Project Recommendation

Referring to previous studies and researches, this project has accomplished the objective of inventing an automatic book binding machine. Still, there are lots of news ideas and changes could be implemented to improve the project as well as creating a more user-friendly machine. It is recommended that this idea could be developed by adapting various sizes of book that could operated by this machine. Another idea to develop this project is using a cylinder to make the system of book-place basement moving faster. More than that, use ½ inch metal which is full metal so that it can hold the cylinder. In binding process, it can use a magnetic metal to fill the binding holder in order to make this machine become fully automatic. Lastly, in future recommendation, they can upgrade the PLC program to make this automatic book binding machine become more users friendly.

5.2.1 Costing and commercialization

In completing this project, many component are comes from FKKE laboratory. However it still has the costing in order to complete the hardware part. Costing for this project is as stated in table below:-

Component	**Cost**
Angle Iron	RM66.00
½ inch metal	RM15.00
1.5 wiring duct	RM40.00
TOTAL	**RM121.00**

Table 5.2.1: Costing project

This project has potential to be commercialized and marketable in automation industry. To make sure this project can use in most of book binding company; the input must change from 415V to 240V.

REFERENCES

[1] Petruzella, Frank D. (2005), “Programmable Logic Controllers”.McGraw-Hill

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[4] John W.Webb, Ronald A. Reis (1999) “Programmable Logic Controller, Principles and Applications”

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[6] http://en.wikipedia.org/wiki/inductive_sensor

[7] http://en.wikipedia.org/wiki/Programmable_logic_controlle

[8] Alexander, Sadiku(2002) “Fundamental of Electric Circuit”. Second Edition, McGraw Hill

[9] Nais, Programmable Controller, FP0, Programming Manual

APPENDIX A:

JUSPEED-F

Small-Capacity Analog Transistor Inverter

APPENDIX A

Small-Capacity Analog Transistor Inverter

8.2 CAUSES FOR FAULT LAMP (MILK-WHITE) ACTIVATION AND REMEDIAL ACTIONS

If JUSPEED-F malfunctions, fault lamp (milk-white) lights Depending on the type of malfunction, the lamp will blink When the lamp blinks, check for continuous or intermittent blink and whether the operation switch is ON or OFF

Table 9 Failure Indication of JUSPEED-F

Protection Function	Operation of Fault Lamp	Cause	How to Check	What to Do
Motor Burnout Protection	n = number of blinking times n = 1 time	• DS1 switch No 5 ON when external thermal overload relay does not function • Motor overheated	Check the motor load status	• Set Switch No 5 to OFF position • Improve motor cooling capability • Reduce motor load • Change V/f pattern
Instantaneous Overcurrent Protection	n = 2 times	• JUSPEED-F output circuit shorted or ground fault	• Remove JUSPEED-F output terminals and measure the resistance across motor leads or motor leads and ground	Correct the short-circuit conditions
		• Accel/decel time set too short	• Extend the accel/decel time and operate the motor	• Extend the accel/decel time
		• Load too heavy	• Run motor without load • Check load conditions	• Change V/f pattern • Reduce load
		• Power factor correction capacitor connected to JUSPEED-F output	—	Remove
		• Incorrect V/f pattern selection	• Run motor with frequency set at 5Hz, and V/f pattern selector switch at notch ③ or ⑦	• Select the optimum V/f pattern
Regenerative Overvoltage Protection	n = 3 times	• Decel time set too short	• Extend the decel time and operate the motor	• Extend the decel time
Undervoltage Protection	n = 4 times	• Supply voltage too low • Momentary power loss (15 ms or more)	Measure supply voltage with voltmeter, and restart the motor	• Eliminate the cause of voltagae drop
Inverter Ground Fault Alarm	n = 5 times	• Ground fault • Transistor module damaged	Remove all JUSPEED-F terminals and check continuity across any one of motor leads and ground	Eliminate the cause of ground fault
Noise Alarm	n = 6 times	• Microcomputer malfunction due to noise	Check to see if noise source exists at inverter input/output	Separate the control signal leads from power cables to prevent erroneous operation caused by noise interference Use the twisted-pair shielded leads

Notes
1 If fault lamp blinks, set RUN/STOP switch to STOP, find the cause, and turn off MCCB and MC
2 If the cause cannot be found, disconnect leads from JUSPEED F and motor
3 For any problem which cannot be corrected locally, contact your Yaskawa representative

Juspeed-F S300 Ratings and Specifications

THREE-PHASE, 400V CLASS (STANDARD)

Model CIMR-	Analog	F04AS3	F08AS3	F15AS3	F22AS3	F37AS3	F55AS3	F75AS3
Max Motor Output		3/4HP (0.4kW)	1HP (0.75kW)	2HP (1.5kW)	3HP (2.2kW)	5HP (3.7kW)	7.5HP (5.5kW)	10HP (7.5kW)
Rated Capacity		1kVA	1.5kVA	2.5kVA	3.5kVA	6kVA	9kVA	12kVA
Rated Current		1.5A	2.3A	4.0A	5.5A	9.0A	11.0A	17.5A
Input Power Supply		3-phase 342 to 484V 50Hz (±5%) 342 to 506V 60Hz (±5%)						
Max Output Voltage		3-phase 342 to 506V						
Output Control Element		IGBT (Insulated Gate Bi-polar Transistor)						
Carrier Frequency		1 to 4kHz						
Control Method		Sinusoidal sine wave PWM						
Output Frequency Range		2 to 120Hz (0.1 to 360Hz available)						
Frequency Resolution		0.01Hz (2 to 60Hz), 0.02Hz (2 to 120Hz)						
Frequency Accuracy		±0.5 % (−10 to +40°C, +14 to +104°F)						
Allowable Overload Capacity		200% for 30 seconds, 150% for 2 minutes						
Accel/Decel Time		0.1 to 30 sec (16 selections available independently of accel/decel)						
Braking		Braking by charging capacitor and discharging resistor, or D.C. injection braking for less than 2Hz (100% braking torque)						
Approx. Mass		2.2kg	2.2kg	2.6kg	2.6kg	5.6kg	7.6kg	7.8kg
Munsell Notation		7.5R 3/12, dull finish						
Enclosure		Enclosed type with operator panel, enclosed-type without operator panel, built-in type						
Input Signal	Run and Stop	Command by NO contact or open collector signal, Mode A or B selectable (Mode A: RUN/STOP, FOW/REV, Mode B: FOW/RUN, REV/RUN)						
	Forward/Reverse Run							
	Frequency Setting	Analog Frequency setting pot or any of 0 to 10V, 1 to 5V, 4 to 20mA selectable						
	Multi-speed	3-step speed selected by external input signal. Frequency selectable in the range of 2 to 120Hz by variable potentiometers VR1 to VR3 on the printed board						
	Reset	Reset command of protective function by NO contact, or open collector signal (alarm reset)						
Output Signal	Frequency Synchronization Signal, During Run Signal	Signal output or open collector output Vcc = 35V max, Ic = 50mA max						
Protective Functions	Instantaneous Power Loss	Protective circuit functions if power loss is detected						
	Undervoltage	Stopped at 330V or less						
	Overcurrent	Stopped by overcurrent caused by short circuit and/or ground fault						
	Overvoltage	Stopped by overvoltage when regeneration						
Environmental Conditions	Location	Indoor (free from corrosive gases and dust)						
	Ambient Temperature	−10 to +40°C (+14 to +104°F) for enclosed type −10 to +50 °C (+14 to +122°F) for built-in type						
	Humidity	95% max. relative (non-condensing)						
	Elevation	3300 feet max. (1000 meters)						
	Vibration	4.9m/s² (0.5G) max. at 10 to 55Hz						

Note: 0.1 sec. or less accel/decel time available as an option. For details, contact your YASKAWA representative.

Juspeed-F P300 Ratings and Specifications

THREE-PHASE, 400V CLASS (LOW-NOISE)

Model CIMR-	Analog	F04AP3	F08AP3	F15AP3	F22AP3	F37AP3	F55AP3	F75AP3
Max Motor Output		3/4HP (0.4kW)	1HP (0.75kW)	2HP (1.5kW)	3HP (2.2kW)	5HP (3.7kW)	7.5HP (5.5kW)	10HP (7.5kW)
Rated Capacity		0.8kVA	1.3kVA	2.2kVA	3.3kVA	5kVA	9kVA	12kVA
Rated Current		1.5A	2.3A	4.0A	5.5A	9.0A	11.0A	17.5A
Input Power Supply		3-phase 342 to 484V 50Hz (±5%) 342 to 506V 60Hz (±5%)						
Max Output Voltage		3-phase 342 to 506V						
Output Control Element		IGBT (Insulated Gate Bi-polar Transistor)						
Carrier Frequency		14 to 15kHz						
Control Method		Sinusoidal sine wave PWM						
Output Frequency Range		2 to 120Hz (0.1 to 360Hz available)						
Frequency Resolution		0.01Hz (2 to 60Hz), 0.02Hz (2 to 120Hz)						
Frequency Accuracy		±0.5% (−10 to +40°C, +14 to +104°F)						
Allowable Overload Capacity		200% for 30 seconds, 150% for 2 minutes						
Accel/Decel Time		0.1 to 30 sec (16 selections available independently of accel/decel)						
Braking		Braking by charging capacitor and discharging resistor, or D.C. injection braking for less than 2Hz (100% braking torque)						
Approx. Mass		2.2kg	2.2kg	2.6kg	2.6kg	5.6kg	7.6kg	7.8kg
Munsell Notation		7.5R 3/12, dull finish						
Enclosure		Enclosed type with operator panel, enclosed-type without operator panel, built-in type						
Input Signal	Run and Stop	Command by NO contact or open collector signal, Mode A or B selectable (Mode A: RUN/STOP, FOW/REV, Mode B: FOW/RUN, REV/RUN)						
	Forward/Reverse Run							
	Frequency Setting	Analog Frequency setting pot or any of 0 to 10V, 1 to 5V, 4 to 20mA selectable						
	Multi-speed	3-step speed selected by external input signal. Frequency selectable in the range of 2 to 120Hz by variable potentiometers VR1 to VR3 on the printed board						
	Reset	Reset command of protective function by NO contact, or open collector signal (alarm reset)						
Output Signal	Frequency Synchronization Signal, During Run Signal	Signal output or open collector output Vcc = 35V max, Ic = 50mA max						
Protective Functions	Instantaneous Power Loss	Protective circuit functions if power loss is detected						
	Undervoltage	Stopped at 330V or less						
	Overcurrent	Stopped by overcurrent caused by short circuit and/or ground fault						
	Overvoltage	Stopped by overvoltage when regeneration						
Environmental Conditions	Location	Indoor (free from corrosive gases and dust)						
	Ambient Temperature	−10 to +40°C (+14 to +104°F) for enclosed type −10 to +50 °C (+14 to +122°F) for built-in type						
	Humidity	95% max. relative (non-condensing)						
	Elevation	3300 feet max. (1000 meters)						
	Vibration	4.9m/s² (0.5G) max. at 10 to 55Hz						

Note: 0.1 sec. or less accel/decel time available as an option. For details, contact your YASKAWA representative.

Juspeed-F S300 Ratings and Specifications

THREE-PHASE, 200V CLASS (STANDARD)

Model CIMR-	Analog	04AS3	08AS3	15AS3	22AS3	37AS3	55AS3	75AS3
Max Motor Output		3/4HP (0.4kW)	1HP (0.75kW)	2HP (1.5kW)	3HP (2.2kW)	5HP (3.7kW)	7.5HP (5.5kW)	10HP (7.5kW)
Rated Capacity		1kVA	1.5kVA	2.5kVA	3.5kVA	6kVA	9kVA	12kVA
Rated Current		3.0A (2.0A)*	4.5A (3.0A)*	7.5A (4.5A)*	10.5A (7.5A)*	17.5A (10.5A)*	24.0A	33.0A
Input	Power Supply	Three-phase 180 to 242V 50Hz (±5%) 180 to 253V 60Hz (±5%)						
	Current	4.6A	6.6A	10.2A	13.8A	21.1A	26.4A	36.6A
Max Output Voltage		3-phase 180 to 253V						
Output Control Element		BT (Bi-polar Transistor)						
Carrier Frequency		1 to 4kHz						
Control Method		Sinusoidal sine wave PWM						
Output Frequency Range		2 to 120Hz (0.1 to 360Hz available)						
Frequency Resolution		0.01Hz (2 to 60Hz), 0.02Hz (2 to 120Hz)						
Frequency Accuracy		±0.5 % (−10 to +40°C, +14 to +104°F)						
Allowable Overload Capacity		200% for 30 seconds, 150% for 2 minutes						
Accel/Decel Time		0.1 to 30 sec (16 selections available independently of accel/decel)						
Braking		Braking by charging capacitor and discharging resistor, or D.C. injection braking for less than 2Hz (100% braking torque)						
Approx. Mass		0.8kg	1.1kg	1.3kg	2.8kg	3.8kg	7.6kg	7.8kg
Munsell Notation		7.5R 3/12, dull finish						
Enclosure		Enclosed type with operator panel, enclosed-type without operator panel, built-in type						
Input Signal	Run and Stop	Command by NO contact or open collector signal, Mode A or B selectable (Mode A: RUN/STOP, FOW/REV, Mode B: FOW/RUN, REV/RUN)						
	Forward/Reverse Run							
	Frequency Setting	Analog Frequency setting pot or any of 0 to 10V, 1 to 5V, 4 to 20mA selectable						
	Multi-speed	3-step speed selected by external input signal. Frequency selectable in the range of 2 to 120Hz by variable potentiometers VR1 to VR3 on the printed board						
	Reset	Reset command of protective function by NO contact, or open collector signal (alarm reset)						
Output Signal	Frequency Synchronization Signal, During Run Signal	Signal output or open collector output Vcc=35V max, Ic=50mA max						
Protective Functions	Instantaneous Power Loss	Protective circuit functions if power loss is detected						
	Undervoltage	Stopped at 170V or less						
	Overcurrent	Stopped by overcurrent caused by short circuit and/or ground fault						
	Overvoltage	Stopped by overvoltage when regeneration						
Environmental Conditions	Location	Indoor (free from corrosive gases and dust)						
	Ambient Temperature	−10 to +40°C (+14 to +104°F) for enclosed type −10 to +50 °C (+14 to +122°F) for built-in type						
	Humidity	95% max. relative (non-condensing)						
	Elevation	3300 feet max. (1000 meters)						
	Vibration	4.9m/s² (0.5G) max. at 10 to 55Hz						

• Parenthesized values are for single-phase power input

Notes 1 When a single-phase power supply is used, connect to terminal L1(R) and L2(S).

2 0.1 sec. or less accel/decel time available as an option. For details, contact your YASKAWA representative.

3 Where the inverter is used as the EN standard product, the enclosure is IP00.

Juspeed-F P300 Ratings and Specifications

THREE-PHASE, 200V CLASS (LOW-NOISE)

Model CIMR-	Analog	04AP3	08AP3	15AP3	22AP3	37AP3	55AP3	75AP3
Max Motor Output		3/4HP (0.4kW)	1HP (0.75kW)	2HP (1.5kW)	3HP (2.2kW)	5HP (3.7kW)	7.5HP (5.5kW)	10HP (7.5kW)
Rated Capacity		0.8kVA	1.3kVA	2.2kVA	3.3kVA	5kVA	9kVA	12kVA
Rated Current		2.4A (2.0A)*	4.0A (3.0A)*	6.5A (4.5A)*	9.5A (7.5A)*	14.5A (10.5A)*	24.0A	33.0A
Input	Power Supply	Three-phase 180 to 242V 50Hz (±5%) 180 to 253V 60Hz (±5%)						
	Current	4.6A	6.6A	10.2A	13.8A	21.1A	26.4A	36.6A
Max Output Voltage		3-phase 180 to 253V						
Output Control Element		IGBT (Insulated Gate Bi-polar Transistor)						
Carrier Frequency		14 to 15kHz						
Control Method		Sinusoidal sine wave PWM						
Output Frequency Range		2 to 120Hz (0.1 to 360Hz available)						
Frequency Resolution		0.01Hz (2 to 60Hz), 0.02Hz (2 to 120Hz)						
Frequency Accuracy		±0.5% (−10 to +40°C, +14 to +104°F)						
Allowable Overload Capacity		200% for 30 seconds, 150% for 2 minutes						
Accel/Decel Time		0.1 to 30 sec (16 selections available independently of accel/decel)						
Braking		Braking by charging capacitor and discharging resistor, or D.C. injection braking for less than 2Hz (100% braking torque)						
Approx. Mass		0.8kg	1.1kg	1.3kg	2.8kg	3.8kg	7.6kg	7.8kg
Munsell Notation		7.5R 3/12, dull finish						
Enclosure		Enclosed type with operator panel, enclosed-type without operator panel, built-in type						
Input Signal	Run and Stop	Command by NO contact or open collector signal, Mode A or B selectable (Mode A: RUN/STOP, FOW/REV, Mode B: FOW/RUN, REV/RUN)						
	Forward/Reverse Run							
	Frequency Setting	Analog Frequency setting pot or any of 0 to 10V, 1 to 5V, 4 to 20mA selectable						
	Multi-speed	3-step speed selected by external input signal. Frequency selectable in the range of 2 to 120Hz by variable potentiometers VR1 to VR3 on the printed board						
	Reset	Reset command of protective function by NO contact, or open collector signal (alarm reset)						
Output Signal	Frequency Synchronization Signal, During Run Signal	Signal output or open collector output Vcc = 35V max, Ic = 50mA max						
Protective Functions	Instantaneous Power Loss	Protective circuit functions if power loss is detected						
	Undervoltage	Stopped at 170V or less						
	Overcurrent	Stopped by overcurrent caused by short circuit and/or ground fault						
	Overvoltage	Stopped by overvoltage when regeneration						
Environmental Conditions	Location	Indoor (free from corrosive gases and dust)						
	Ambient Temperature	−10 to +40°C (+14 to +104°F) for enclosed type −10 to +50 °C (+14 to +122°F) for built-in type						
	Humidity	95% max. relative (non-condensing)						
	Elevation	3300 feet max. (1000 meters)						
	Vibration	4.9m/s² (0.5G) max. at 10 to 55Hz						

* Parenthesized values are for single-phase power input

Notes 1. When a single-phase power supply is used, connect to terminal L1(R) and L2(S).
2. 0.1 sec. or less accel/decel time available as an option. For details, contact your YASKAWA representative.
3. Where the inverter is used as the EN standard product, the enclosure is IP00.

Juspeed-F S300, P300 Ratings and Specifications

SINGLE-PHASE, 100V CLASS AND 200V CLASS

Type		Standard		Low-Noise	
Model CIMR-	Analog	J04AS3-1	J08AS3-1	J04AP3-1	J08AP3-1
Max Motor Output		3/4HP (0 4kW)	1HP (0 75kW)	3/4HP (0 4kW)	1HP (0 75kW)
Rated Capacity		1 0kVA	1 5kVA	0 8kVA	1 3kVA
Rated Current		3 0A	4 5A	2 4A	4 0A
Input Power Supply		Single-phase 90 to 121V 50Hz/60Hz (±5%) 180 to 242V 50Hz/60Hz (±5%)			
Max Output Voltage		3-phase 180 to 242V			
Output Control Element		BT (Bi-polar Transistor)		IGBT (Insulated Gate Bi-polar transistor)	
Carrier Frequency		1 to 4kHz		14 to 15kHz	
Control Method		Sinusoidal sine wave PWM			
Output Frequency Range		2 to 120Hz (0 1 to 360Hz available)			
Frequency Resolution		0 01Hz (2 to 60Hz), 0 02Hz (2 to 120Hz)			
Frequency Accuracy		±0 5 % (−10 to +40°C, +14 to +104°F)			
Allowable Overload Capacity		200% for 30 seconds, 150% for 2 minutes			
Accel/Decel Time		0 1 to 30 sec (16 selections available independently of accel/decel)			
Braking		Braking by charging capacitor and discharging resistor, or D C injection braking for less than 2Hz (100% braking torque)			
Approx Mass		0 5kg	0 8kg	0 5kg	0 8kg
Enclosure		Built-in type			
Input Signal	Run and Stop	Command by NO contact or open collector signal, Mode A or B selectable (Mode A RUN/STOP, FOW/REV, Mode B FOW/RUN, REV/RUN)			
	Forward/Reverse Run				
	Frequency Setting	Analog Frequency setting pot or any of 0 to 10V, 1 to 5V, 4 to 20mA selectable			
	Multi-speed	3-step speed selected by external input signal Frequency selectable in the range of 2 to 120Hz by variable potentiometers VR1 to VR3 on the printed board			
	Reset	Reset command of protective function by NO contact, or open collector signal (alarm reset)			
Output Signal	Frequency Synchronization Signal, During Run Signal	Signal output or open collector output Vcc = 35V max, Ic = 50mA max			
Protective Functions	Instantaneous Power Loss	Protective circuit functions if power loss is detected			
	Undervoltage	Stopped at 80V or less			
	Overcurrent	Stopped by overcurrent caused by short circuit and/or ground fault			
	Overvoltage	Stopped by overvoltage when regeneration			
Environmental Conditions	Location	Indoor (free from corrosive gases and dust)			
	Ambient Temperature	−10 to +40°C (+14 to +104°F) for enclosed type −10 to +50 °C (+14 to +122°F) for built-in type			
	Humidity	95% max relative (non-condensing)			
	Elevation	3300 feet max (1000 meters)			
	Vibration	4 9m/s² (0 5G) max at 10 to 55Hz			

Notes 1 0 1 sec or less accel/decel time available as an option For details, contact your YASKAWA representative
2 Model CIMR-J04AP1-1 and CIMR-J08AP1-1 are available on order
3 Two main circuit capacitors separately installed are required See page 4
Types HCGF3A2D222IS (Verticaly monuted type)
HCGF3A2D222SS (Horizontaly monuted type)

APPENDIX B:

DATA SHEET

Three phase 380V-400V

APPENDIX B

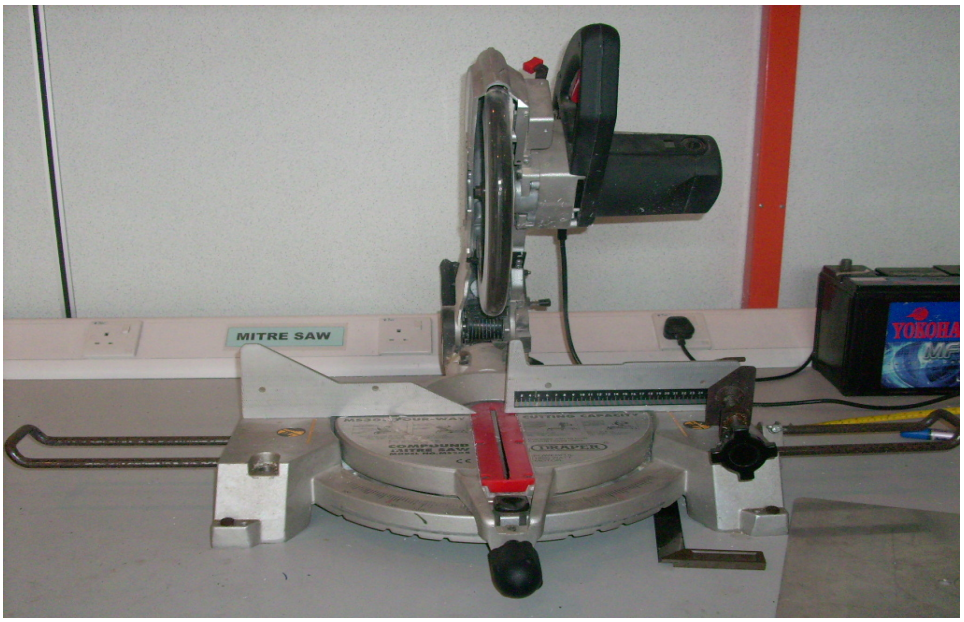
Data Sheet

APPENDIX C:

Equipment & Work Progress

APPENDIX C

Equipment & Work Progress

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DRESSING TOOL
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