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" I hereby declare that I have read through this report entitle Development of Experimental Control Strategy Setup For The Labscale Winding Tension System and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Mechatronic Engineering"

Signature : …..……………………………………………

Supervisor's Name : EN MOHAMAD RIDUWAN BIN MD NAWAWI

Date : …….……..……………………………………

DEVELOPMENT OF EXPERIMENTAL CONTROL STRATEGY SETUP FOR THE LABSCALE WINDING TENSION SYSTEM

FAZLY BIN ABD RAHMAN

A report submitted in partial fulfillment of the requirements for the Bachelor of Mechatronics Engineering (Hons..)

Faculty of Electrical Engineering

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DECLARATION

I declare that this report entitle Development of Experimental Control Strategy Setup For The Labscale Winding Tension System is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ….……………………………………………

Name : FAZLY BIN ABD RAHMAN

Date : ….…..……………………………………………

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ABSTRACT

The highlight of this project is to install the physical model for cable winding tension system and to control the speed of the wind up winder and the take up winder to get the optimum range for the pendulum dancer position for optimum tension for the wire based on PLC based system. This is the pre-development of the winding tension system to know the behavior of the pendulum dancer during the experiment. The result can be used as the initial setting for the implementation the PID controller in the future. To control the speed of wind up and take up winder during the operation, a sensor will be used as it functions to give the feedback based on pendulum dancer position. If the cable loose, the motor will speed up and while the cable stretch, the motor will slow down. There is a problem that will occur during the winding process which is the alignment of the cable at the spool. If the motor do not run with the proper speed, the neatness of the cable will be not properly winded. The Midori Green Pot Conductive Precision Sensor is used to detect the change of angle in pendulum dancer. It will give the signal to the PLC. The PLC will give signal to the inverter. The inverter will control the speed of the motor in three level of speed which is low, medium and high speed. The parameter need to be control is the speed and the torque of the motor in order to maintain the optimum range for the pendulum dancer position. The optimum range for pendulum dancer position is at quadrant 4 between 0º-36°. The ratio speed is used 3:1 in order to maintain the position of the pendulum dancer at optimum range.

ABSTRAK

Pemasangan model untuk sistem penggulungan kabel dan mengawal aturan kelajuan motor untuk kili keluaran dan kili terima untuk mendapatkan kendudukan yang sesuai bagi bandul penari menjadi keutamaan di dalam projek ini. Projek ini merupakakn proses awal dalam penggulungan kabel sistem untuk mengetahui tingkah laku bandul penari semasa eksperimen dijalankan. Keputusan dari eksperimen boleh digunakan sebabgai aturan awal bagi pengabadian PID sebagai system kawalan di masa hadapan. Untuk mengawal kelajuan motor kili terima, sensor digunakan sebagai maklum balas kepada system. Ketika kabel longgar, motor akan laju dan ketika cabel terlalu tegang kelajuan motor diperlahankan. Sekiranya kelajuan motor tidak sesuai dengan kabel, berkemungkinan kekemasan kabel tidak dapat dicapai semasa proses penggulungan. Sensor Midori Green Pot Presicion angle digunakan untuk mengesan perubahan sudut bandul penari semasa operasi dan memberi arahan kepada PLC. PLC akan memberi arahan kepada inverter. Inverter digunankan untuk mengawal kelajuan motor dalam tiga aturan laju. Parameter yang diperlukan untuk mengawal kedudukan bandul penari adalah kelajuan dan tork motor. Sudut sesuai bagi mengawal ketegangan kabel adalah di quadrant 4 antara 0º-36°. Ratio kelajuan yang diguakan adalah 3:1 untuk mengawal kedudukan bandul penari dikedudukan sesuai.

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CHAPTER 1

INTRODUCTION

1.1 Research Background

Typically, a winder tension system winds a material including metal wire, thread, paper, spool, or bobbin. There are several different types of winder tension system, from simple manual feed machines to complex computer-numeric-control (CNC) machines. Some of the common uses for winder tension system are coil winding, rope winding, and continuous filament winding. Many industries use these devices such as textile, electronics, and wire industries. A manual winder tension system usually has a core on a spindle and the user need to feeds wire, rope, or other material onto the core. The user controls the spindle speed and feeds the material through their hand, guiding it to control the tension and load pattern. These simple machines may be of the bench-top size or large stand-alone winder.

A coil winder tension system is a system for winding coil onto a spool, bobbin and many more. This coil winder tension system is one of types of winder tension system that available in industries today. The coil winders may be classified according to their speed levels and capacity. From multi speeded machines to medium until large and extra-large machines, these machines come in various types and categories, performing a range function. The common applications for a coil winder tension system are to wind coils for transformer, inductors, motor and chokes. Coil winder tension system design is dictated by a coil's complexity, material tension limitations, machine versatilities, and automation or operator intervention, production volume and budgetary considerations. Complete types of winder tension system ideal for educational institutes, small and medium enterprise.

That might be some problem may occur in the winder tension system. The speed of the motor that control the cable delivery during the winding process must be suitable with the cable condition and performance. If the speed is to slow or fast, the quality of the winder cable will not fulfill the standard that required and also the cable will broke during the operation.

1.2 Project Motivation

The achievement of this project can be used in the future to produce a control winding tension system with the effective result. Commonly this system is used as last procedure before packaging and sent to the customer, therefore the quality and neatness of the winding product need to follow the standard which is demanded by the customer. Lots of industries today spend high cost to buy and maintain the winding system because it played an important role in marketing their products.

Winding process in EDM wire manufacturing at Hitachi, Senai, Johor is the last process before the product sent to the customer. Therefore, it is important to make sure no product rejected in the process to avoid company loss in profit.

1.3 Problem Statement

To have a good quality of the cable winding, the system required the proper speed and torque of motor in order to control the tension of the cable. When the speed of the take up winder is too slow, the cable might be too loose during the winding process and the alignment of the cable will not fulfill the standard. Meanwhile, when the speed of the take up winder is too fast the cable might be broken. Therefore, fabrication of winder tension system will be proposed in this project which is controlled by the Midori Green Pot Precision sensor using the PLC based system as the controller. The sensor will relocate the dancer pendulum and give the signal that will control the speed of the motor based on the dancer pendulum. If the dancer pendulum moves upward, the sensor will give the signal to the PLC to slow down the speed of the motor. To create the new controller must ensure that the minimum and maximum reading of the position of pendulum dancer that detected by the sensor is suitable for the cable resistance and performance.

1.4 Objective

Basically these projects are listing three main objectives. This project being conducted to achieve the following objectives:

i. To develop the physical module of winding tension system in lab scale.

ii. To identify the required parameters setup for the winding tension system.

iii. To design the speed and the torque controller of the wind up motor and take up motor for optimum tension through PLC based system.

1.5 Scope and Limitation

The scope of this project is to design the control strategy setup for winding tension system where it is the initial required setup for the winding tension system. The tension system in lab scale consists of two main spools and four pulleys. The middle pulley is used as pendulum dancer where the sensor is place behind the dancer pendulum. The position sensor that uses to control the speed of the motor is the Midori Green Pot Precision Angle sensor. Mitsubishi FX Series PLC system is used as the based system. The ladder diagram is design by using GX-Developer-FX software. Two AC motor is used as take up motor and wind up motor.

CHAPTER 2

LITERATURE REVIEW

2.1 Winder Tension System

Nowdays, advancements in technology for manufacturing become the major trend. To fulfill the gap caused by intense competitions become the first priority of any manufacturers in order to compete with each other. Manufacturing machinery needs to be designed with greater precision, higher stability and lower cost to meet the same goal by manufacturers.

Automatic machinery became important element for today industries such as sensor and microcontroller. The combination both of it with the process required power will create the automatic processes free from intensive labor. Winder tension system or winder machine is one of the common processes that being used in the manufacturing today. Many industries use these devices, including textile, electronics, and cable manufacturer industries. Before automatic machinery exists, a manual winder tension system usually has a core on a spindle and the user feeds wire, rope, or other material onto the core. The user controls the spindle speed and feeds the material through user hand, guiding it to control the tension and load pattern. These simple machines may be of a bench-top size or large stand-alone winder [2].

A winder tension system becomes one of important winding machine in industries today. The coil winders can be classified according to their speed levels and capacity. From multi speeded machines to medium, large and extra-large machines, these machines come in various types and categories, performing a range of function. The common applications for a winder tension system are to wind coils for transformer, inductors, motor and chokes. Coil winder tension system design is dictated by a coil's complexity, material tension limitations, machine versatilities, operator intervention, production volume and limitation of cost. Complete types of winder tension system ideal for educational institutes, small and medium enterprise [3].

2.2 Tension Control System

For this research project, a winder tension system is designed then to be implemented for the Hitachi Cable Sdn Bhd at Senai Johor. The winder tension system will be used to control the Electrical Discharge Machining (EDM) wire. The important factors that will become the priority are tension control and the neatness of the winder cable at the end of the process. The required control properties involved in controlling the speed of the motor can be very complex. The tension of the EDM wire will be controlled by using the Mitsubishi PLC. The Mitsubishi will control the speed of the motor in order to maintain the proper tension of the EDM wire.

Tension control is most important parameter during the assembly process in order to maintain the quality of the rolling material. The wire required right tension tolerances to achieve the quality winder wire. There will be slightly problem will occur during the process if the consistency of the tension cannot be achieved.

Many studies and researches are conducted related to tension control. For example, a problem might be occurs as the excessive tension can cause to change the wire characteristics and damage the bobbin's surface during winding process. Coil that randomly wounded in the same number of turn will produce different wire lengths. If a coil is wounded with good tension it is compact and it has exact length of wire on it compared to a coil wound with incorrect low tension that results in a coil with longer total length of wire [2].

Refer to [14] there are many sources of distubance such as roller non circulatory, roller change, web sliding, change of web-elasticity due to the strong coupling between web velocity and web tension can result in a web break or fold. Research by [15] tension should be remain constant in the film winding process cause it will determine the winding quality. They build a tension control system by using a sensor to control the tension of the roller. According to the value of changing in tension, the transducer will adjust the speed of the traction roller following the set value so that the tension film can be constant. Figure 2.1 show the tension control system using sensor.

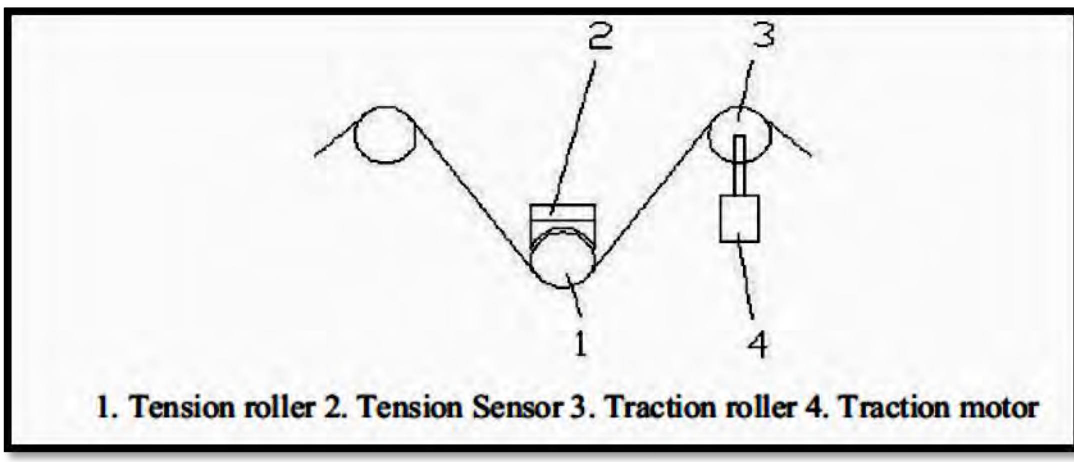

Figure 2.1: Tension control system [15]

Besides, rewinder is used to rewind rolls of board, and technologically is placed after the board machine. The process of rewinding consists of placing a roll on an unwinder, placing a spool on a winder, inserting a web, rewinding and taking off the rewound roll. Rewinder consist of two main parts which are winder, which perform winding with demand speed and unwinder which provide required web tension. Rewinder which was the object of reconstruction has the tangent winder, consisting of two drums with separate drives were replaced with induction motor supplied from frequency converters. The disposition of the rewinder parts is presented in Figure 2.2 and there are slitters for cutting off the paper in longitudinal direction, drive for transversal moving of the parent reel for unwinding, pneumatic drive, pair of presductors which serves for measuring and automatic control of web tension [3].

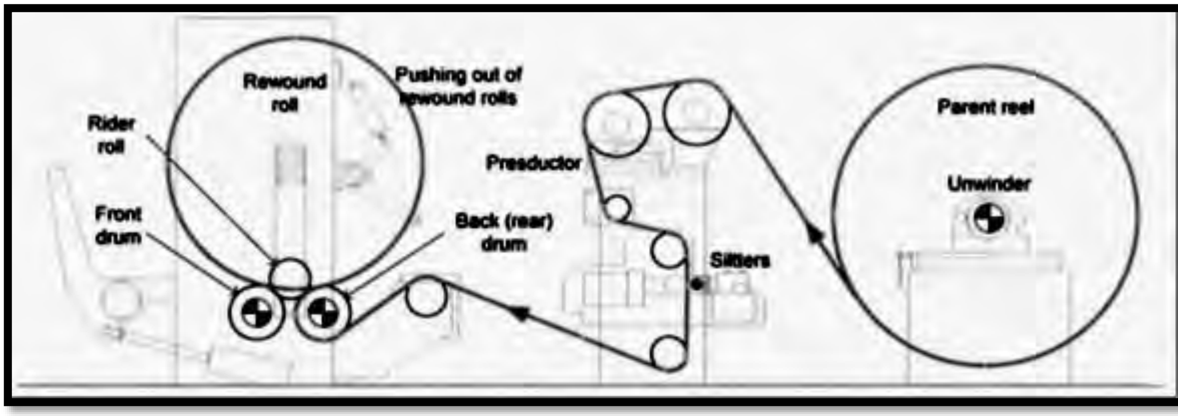

Figure 2.2: Scheme of Tangent Rewinder in Board Factory "UMKA" [3]

In [4], the rolling device is develop with a very stable rolling machine condition for web material. In this example, the web material required a constant tension to maintain material stability. However, the rolling speed and tension will change due to the change in both the diameter of the input and the output roller when sheet material moves from one roller to another. Such changes can cause both under-tension, which can cause waves and ribbons on the surface of the finish product, and over-tension, which can cause ripening due to excessive deformation. Extremely under-tension rolling can even cause the sheet material to drop and drag on the bottom floor, and sabotage the whole continuous process. Here the solution is to control the speed of the roller. Due to the nonlinear change in diameter of both the input and the output rollers, one needs a higher end controller like the combination of a PLC, a microprocessor and a PC-based controller to program and control tension.

2.3 Programmable Logic Controller (PLC)

The first Programmable logic controller (PLC) was created and developed by group of engineers when they looking the alternative system to replace the complex relay control system. The new requirements that have to meet in order to create the new control system was simple programing, no internal changing during reprogram the system, smaller, simple and low cost maintenance. Therefore, they succeed in creating the new control system that meets the requirements above which is Programmable logic controller (PLC) [12].

PLC is a specialized computer used to control machine and process. The programmable memory is used to store the instructions and execute specific function that include on and off control, timing, counting, sequencing, arithmetic and data handling. The PLC role is to monitor the state of the system through feedback signal from the feed device. Figure 2.3 show the process in PLC system [12].

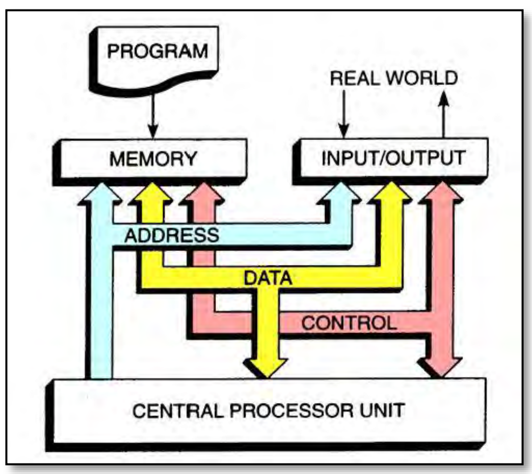

Figure 2.3: Flow of process in PLC system [12]

Invention by [16] a programmable controller connected to receiving the external numerical data from a date setter to the central control unit. Data sets in a numerical data setter can be used as the time data in a timer instruction and count data in a counter instruction when the prescribed code is used and the user program is executed. Figure 2.4 is a block diagram showing the electrical configuration of the PL of the present invention. Therefore, it is different from the conventional types of controller, relatively frequent changes of the instruction in the program can be performed only by the data setting operation at the external numerical data setters instead of using any input device for making changes.

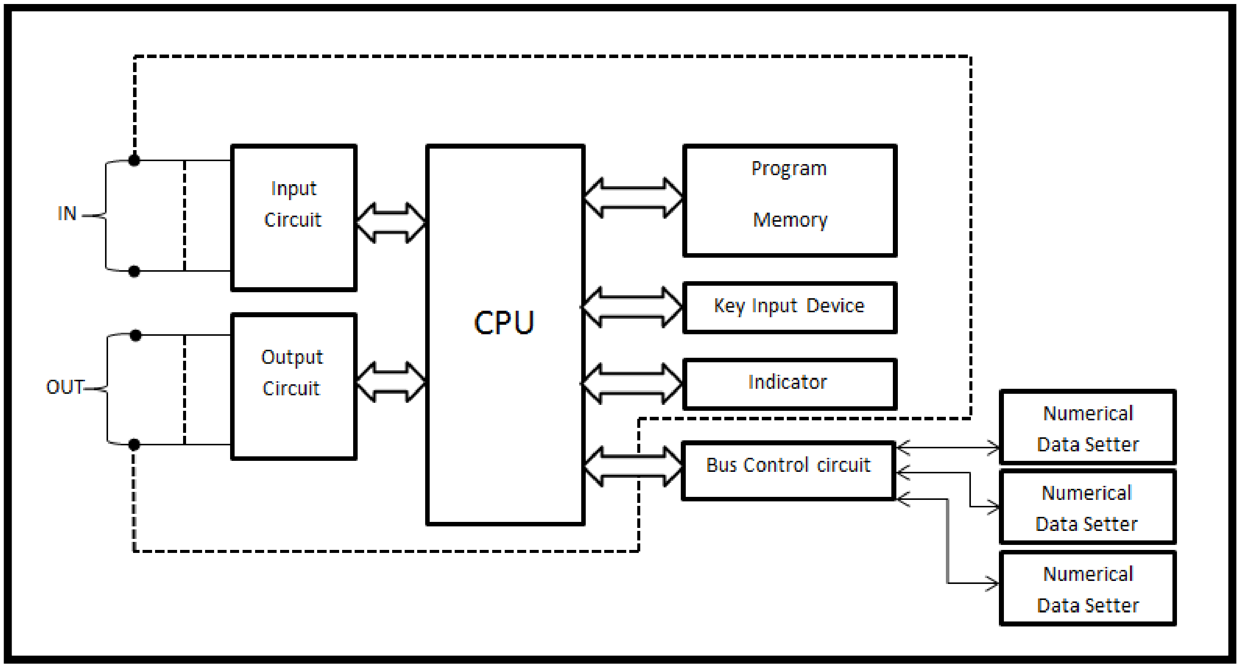

Figure 2.4: Block diagram of electrical configuration of PLC [16]

PLC will be used as control system in winder tension system. The advantages of PLC can be seen from it design perspective which is simple combination of two basic type of control system. The two control systems are distributed system and integrated system. When both system can be combined, components such as sensor and actuator can be connected via digital/analog input and output modules or through communication channel. The PLC also can handle the relative complex and difficult ways of control and technical diagnostics [3].

Based on the previous research [6], fiber winding tension influence the quality of winding product directly and the tension control is a key technique in fiber winding technique. PLC with function modules as its control device introduces a closed-loop tension control system. The system adopts a scheme with a center drive and outward-draw fiber configuration. Output torque of AC digital servo motor is in directly proportional to fiber tension force and scroll radius, therefore the output torque should decrease as the scroll radius decreases to obtain a constant fiber tension. The change of the scroll radius can be measured by a radius following device and the sampled radius change is passed through an analog-digital converter and is sent to the PLC. The radius and tension force are calculated with the preset calculating algorithm by reading the desired value of the tension force. The servo motor's speed and torque are measured by the pulse encoder and sent feedback to the PLC system to compose a closed loop system. This system used PLC as a controller to control the speed of the servo motor and also the tension force because an ideal tension control system should provide stable and adjustable tension during the winding process [6]. Figure 2.5 is showing the principle of tension control system.

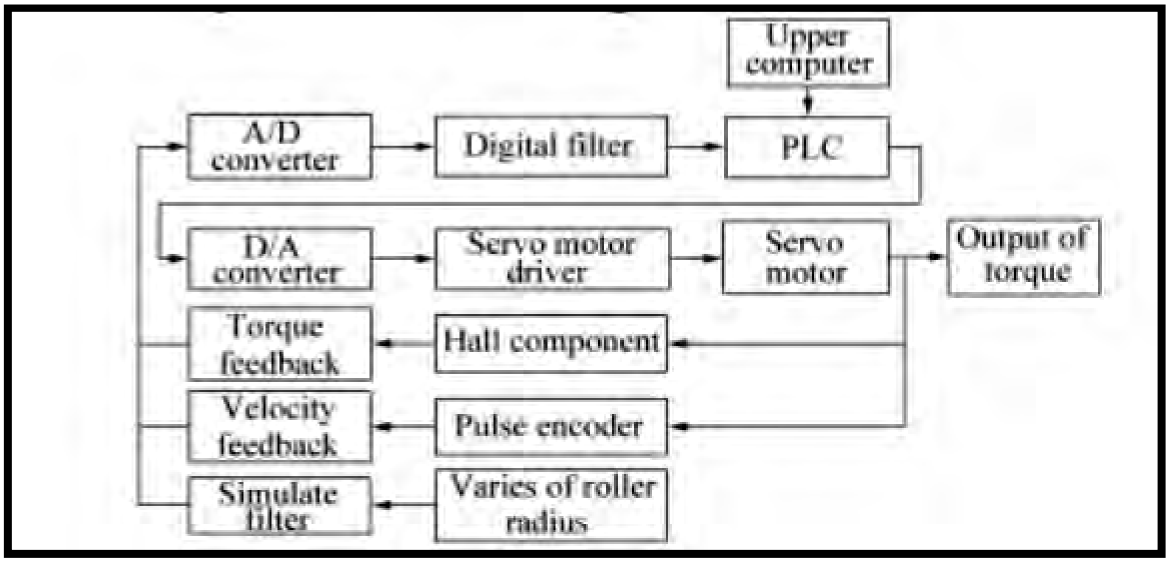

Figure 2.5: Principle of tension control system [6]

From previous research by [15], in process of winding the speed should be constant. The traction roller is the active roller, the speed which is controlled by the transducer, it is evenly driven by PLC. Two tensions are installed on each end of the tension roller, then the tension sensor input the collected signal to the PLC. It will take the average as a real-time tension value and through the intelligent control algorithm compiled in the PLC, taking the tension value as the input and speed of the traction roller as the output, the PLC gives a real-time speed value to the traction roller. The framework of hardware is shown in Figure 2.6.

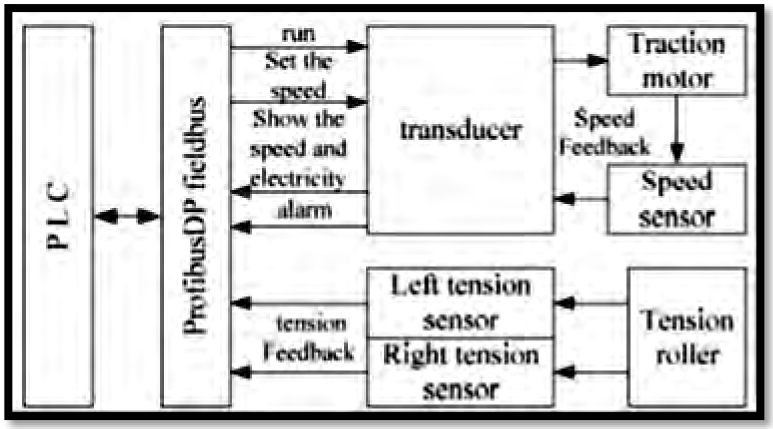

Figure 2.6: Framework of hardware [15]

However, every control systems have their own disadvantages including PLC. The PLC controller response time has the limitation in processing data speed when it is required to be process faster. The ability of microprocessor within the PLC in sending out the effective feedback signals may be too slow and causing the inefficient controlling result [3].

CHAPTER 3

METHODOLOGY

3.1 Project Overview

The aim of this project is to develop physical module of winder tension system in lab scale. The dimension of the winder tension system is not as the exact industrial scale that will use in Hitachi Cable at Senai, Johor. However, the scale of the system is suitable to test the controller system and to see how the winder tension works. Secondly, the other aims to run the experimental control strategy for winding tension system in PLC system. The PLC will work based on the sensor that detect the changes of the pendulum dancer. The PLC will be used to control and adjust the speed of the motor. The PLC will give the signal or command to the Mitsubishi inverter D700 when the change of the tension is detected by the Midori sensor. The PLC will control the speed of the motor when change of the pendulum dancer is detected. When the dancer is move upward, the speed of motor will slow down. If the dancer moves downward, the speed of the motor will become faster. The speed of the motor will work in the range of speed that suitable for the wire.

The focus in this project is experimental the required setup for the winding tension system. This controller is able to control the speed of the motor in the winder tension system. This controller is expected to be implemented in Hitachi Cable Sdn Bhd at Senai, Johor.