DEVELOPMENT OF PICK AND PLACE SYSTEM USING IRB 1400 ROBOT

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This thesis is submitted as partial fulfillment of the requirements for the award of the
Bachelor Degree of Electrical Engineering (Electronics)

Faculty of Electrical & Electronic Engineering
University of College Engineering & Technology Malaysia

APRIL 2006

"I hereby declared that this thesis titled 'Development Pick & Place System using IRB 1400 ABB Robot' is the result of my own effort except as clearly stated in references the source of reference".

Signature : ______________________________

Name : NORHAYATI BT. MAT NOOR

Date : 28 APRIL 2006

Dedicated to my beloved mother, father, brothers and sister and to all Malaysians.
Aja!!! Aja!!! Fighting!!!

ACKNOWLEDGEMENT

First of all, I would like to take this opportunity to acknowledge Cik Nor Rul Hasma bt. Abdullah as my supervisor for her full support in this project. Without her support and guidance, this project will not be a success. Secondly, I would like to thank to En. Hamdan b. Danial and Cik Mahfuzah bt. Mustafa for their contribution of idea and guideness in order to control and program the IRB 1400 robot.

Thank you, En. Azlan b. Sayuti for his contribution in this project and opening the laboratory till late at night for us to complete the project and borrowing me power window motor, proximity sensor and power supply source for the project. I also would like to thank fellow friends for their contribution of idea and sharing of components to ensure the success of this project. Last but not least, to all people who in one way or another contribute to the success of this project.

Thank you very much. Your sincere help will be remembered for life.

ABSTRACT

Many robots have been built for manufacturing purposes and can be found in factories around the world .The idea behind this project is to reduce the utilization of human energy especially in manufacturing industry. The project involves of development pick and place system a using ABB IRB 1400 industrial robot. In this project, the IRB 1400 robot was program to perform pick and place task. The robot was equipped with robotic sensor to detect the work pieces. Using the ABB robot's Rapid software, the program was downloaded to the robot controller, S4Cplus. By teaching the robot points with the Teach Pendants, we can execute the ABB robot program sequences. In the manufacturing system, conveyor work as a method of work part delivery. Model of small conveyor was constructed to delivery the work pieces from the incoming part. The sensors were mounted to the conveyor, which is to sense the incoming material and also to control the operation of the conveyor motor. The robot that was programmed will pick and place the material in the outgoing part. The operation of the system working continuously since the sensor detected the incoming material.

ABSTRAK

Dewasa ini, pelbagai jenis robot telah banyak di aplikasikan di dalam industri pembuatan dan boleh di dapati di kilang-kilang di seluruh dunia. Matlamat sebenar projek ini ialah untuk mengurangkan tenaga kerja manusia terutamanya di dalam bidang industri pembuatan. Projek ini melibatkan pembinaan sebuah system mengambil dan meletak barang dengan menggunakan robot industri iaitu ABB IRB 1400.Di dalam projek ini, robot IRB 1400 akan di program untuk menjalankan proces mengambil dan meletak barang. Robot akan beroperasi bersama sensor untuk mengesan kehadiran objek. Dengan menggunakan *Software RAPID Language*, program yang telah siap di program akan di muat turun ke dalam robot controller iaitu *S4Cplus*. Robot akan di ajar untuk bergerak mengikut titik yang telah di tetapkan dengan menggunakan *teach pendant.*Di dalam sistem pembuatan, *conveyor* bekerja sebagai sistem penghantaran. Sebuah model *conveyer* telah di bina untuk membawa objek daripada bahagian barangan masuk. Sensor akan dipasang kepada *conveyer* untuk mengesan kehadiran objek dan mengawal operasi motor *conveyer.* Robot di program untuk mengambil dan meletakkan barang tersebut ke dalam bahagian barangan keluar. Sistem ini beroperasi secara berterusan sehingga tiada objek yang akan di kesan oleh sensor.

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GLOSSARY OF ABBREVIATIONS

AGV'S	-	Automated Guided Vehicles
CMM's	-	Co-ordinate Measuring Machine
ASRS's	-	Automated Storage and Retrieval Systems
DC	-	Direct Current
ABB	-	ASEA Brown-Boveri
ISO	-	International Organization for Standardization
OS	-	Operating System
PLC	-	Programmable Logic Control
TCP/IP	-	Transport Control Protocol/ Internet Protocol
TCP	-	Tool Center Point

LIST OF APPENDIXES

CHAPTER I

INTRODUCTION

This chapter describes about the project's introduction. It consists of overview of the project, the project aim, objectives and scopes of the project.

1.1 Robot Overview

There are many definitions of robots. It seems to be of difficulty to suggest an accurate meaning for the word robot, that there are various definitions of this word, different according to the points of view. Some view a robot through the aspect of reprogrammability while others more concern on the manipulation of the robot, behavior, intelligence and so on. The British Robot Association (BRA) defines robot as a programmable device with a minimum of four degrees of freedom designed to both manipulate and transport parts, tools or specialized manufacturing implements through variable programmed motion for the performance of the specific manufacturing task [1].

While the Robotic Institute of America, on the other hand defines the robot as a reprogrammable multifunctional manipulator designed to move material, parts, tools or specialized devices through variable programmed motion for the performance of a variety of tasks [2].

Based on the definition of robot by the two institutes, it can be concluded that a robot must be an automatic machine and be able to deal with the changing information received from the environment.

1.1.1 Word History

The word *robot* comes from the Czech word *robota* (compare with the Russian rabota for "to work") meaning "drudgery", "servitude", or "forced labor", especially the so-called "labor rent" that survived in the Austro-Hungarian Empire until 1848. Isaac Asimov, coined the word robotics as the science of the study of robots, in his science fiction stories about robot in 1940s.Where in Europe, robotics is define as ‘the science of robotology’ and robotology is defines as ‘the means by which robot machines are put together and made to work’.

Many people think of robotics as a single area of technology, but in fact robotics encompasses such diverse areas of technology as mechanical, electrical, electronics, systems, computer, hardware and software and a host of other advanced technology.

1.1.2 The Distinction between 'Automation' and 'Robotics'

'Robots' is only a small sub-set of the technologies covered by the much broader term Automation'. 'Automation' refers to a mode of operation in which any machine or piece of equipment is capable of working without human intervention. Originally, automation was limited in its potential, as automatic machines could only replace physical effort and not mental effort.

Robots are just one example of flexible automation. Other examples in the industrial sector are NC machine tools, automated assembly machines (including automated component insertion machines), automated guided vehicles (AGV's) automated storage and retrieval systems (ASRS's), co-ordinate measuring machines (CMM's) laser / plasma / water jet cutting machines etc.

The terms 'robot' and robotics' both therefore originated in science fiction and the original perception was one of human-like machines or androids. In popular culture, and particularly in films, robots are often considered to have all the human attributes with some capabilities considerably enhanced over that normally found in humans, but in reality current technology is not yet able to match this vision.

1.2 IRB 1400 Industrial Robot

There are many types of robot in this world. In this project, the industrial robot IRB 1400 has being chosen to doing the pick and place task. The robot has being program to doing the task given. The robot is well-proven in arc welding, material handling and process applications with a total of 10,000 installations since 1992. It delivers plenty of performance for the money, ensuring short payback times.

The handling capacity is 5 kg, plus a unique 18 kg supplementary load on the upper arm. Superior levels of control and path-following accuracy provide excellent work quality. The ability to adjust process speed and position means you achieve optimum manufacturing accuracy with little or no rejects. IRB 1400 is known for its stiff and robust construction. This translates into low noise levels, long intervals between routine maintenance and long service life. The robot has a large working area and long reach. The compact design of IRB 1400 is very slim wrist and high performance operation even in difficult and restricted locations.

1.3 Project Aim

The IRB 1400 is an industrial robot, designed specifically for manufacturing industries that use flexible robot-based automation. This project basically to developed the Pick and Place System by using IRB 1400 robot that will implement in industry.

1.4 Objective

The main objective of this project was to design the pick and place program system by using the IRB 1400 robot. There are two secondary objectives to be achieved in order to achieve the main objective stated above. The two secondary objectives were discussed in the following paragraph.

The first objective was to detect the following object by using proximity sensor that had being integrated with the robot.

The second objective was to design and programs the controller of the IRB 1400 by using RAPID languages. In this language, the program for pick and place task was written and loaded to the robot controller S4Cplus.

1.5 Scope Of The Project

The scope of the project includes wiring the I/O Digital Input of the controller in order to integrate the sensor within the robot. The robot was programmed to wait the signal value from the sensor. The robot continued the following instruction when the signal value was correct. Integration between sensor and DC motor was also concentrated in development of this system. The function of relay and the circuitry of

Control Panel Box also were implemented in the project. Finally, the system was combined together to complete the development of the system.

CHAPTER II

LITERATURE REVIEW

This chapter represents several important issues related to ABB industrial robot and its associate technologies in the industries.

2.1 Industrial Robot

An industrial robot is officially defined by ISO as an automatically controlled, reprogrammable, multipurpose manipulator programmable in three or more axes. The field of industrial robotics may be more practically defined as the study, design and use of robot systems for manufacturing.

Typical applications of industrial robots include welding, painting, ironing, assembly, pick and place, palletizing, product inspection, and testing, all accomplished with high endurance, speed, and precision. Manufacturers of industrial robots include ABB (ASEA Brown-Boveri), Intelligent Actuator, Adept, Epson Robots, and Yaskawa-Motoman.

ABB is a leading supplier of robots and automation for automotive, manufacturing and the consumer goods industry. ABB produced its first robot in 1974. At that time, the company's robots were mainly used for machine tending and material handling. Nearly 30 years later, that market accounts for some 30 percent of robots sold worldwide. According to the International Federation of Robotics, welding-spot and arc, particularly in the automotive industry, is today's largest robot application.

2.2 ABB Robot in Manufacturing Field

Many robots have been built for manufacturing purposes and can be found in factories around the world. By using the robots and automation expertise in manufacturing system to pick, pack and palletize a wide range of products and packaging designs with robotic solutions may help the manufacturers more flexibility, reliability of their process and higher uptime.

Now days, changing market requirements for products and packages demands flexible production solutions. The robots will provide solutions to improve our competitiveness, productivity and flexibility. Production lines can be quickly and easily tailored to the changing market demands for our products and packages. Additional products, production lines and functions can be quickly and easily integrated compact than traditional lines. By using robot in production lines also offer substantial space savings.

Figure 2.1 and 2.2 shows the one of types ABB robot in the manufacturing industries. The robot used to move objects one at a time from one location to another with speed and accuracy. Regardless of whether the objects are on moving feeders, placed at random or guided, the robot is both faster and more efficient than any conventional system on today’s market.

Figure 2.1: Arc Welding Process

Figure 2.2: Pick and Place Process

In this project, the ABB IRB 1400 robot is used to complete the pick and place task in the manufacturing system. Figure 2.3 show the one of type ABB robot in the real life manufacturing industries. It shows the operation of the robot in the pick and place system. The ABB robot integrated with the conveyor to pick the boxes on the conveyor and sort the boxes in the outgoing material, as illustrated in Figure 2.4.

Figure 2.3: IRB 6400

Figure 2.4: Boxes in the outgoing material

2.3 Pick, Pack and Palletize for Packaged Food with ABB Robot Solution

Changing market requirements for products and packages, demands flexible production solutions. ABB is the one of leading supplier robot that may provides with the flexibility to pick, pack and palletize a wide range of products and packaging designs with robotic solutions. The inherent flexibility of ABB's solutions mean production lines can be quickly and easily tailored to the changing market demands for your products and packages.

Figure 2.5 shows the ABB FlexPicker robot operation in the packaged food in manufacturing industries.

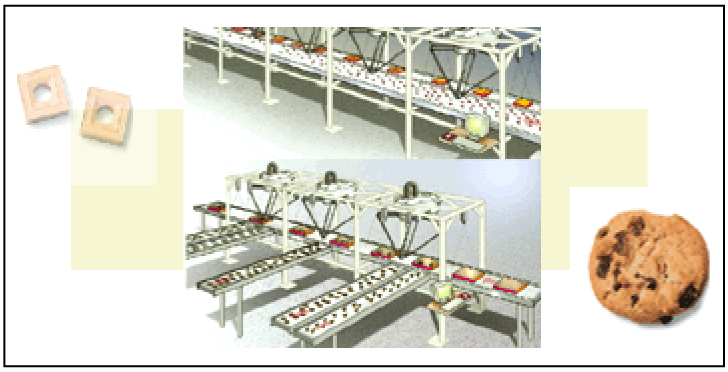


Figure 2.5: ABB FlexPicker in Packaged Biscuits

The ABB FlexPicker robot allows moving objects one at a time from one location to another with speed and accuracy. Regardless of whether the objects are on moving feeders, placed at random or guided, FlexPicker is both faster and more efficient than any conventional system on today's market. Whether it is handling candy, pretzels or syringes, ABB has a robotic solution for manufacturing challenge.

In order to pack products into containers or small sachets into trays or cases as shows in Figure 2.6, ABB offers standard and customized solutions to increase uptime, improve the productivity and throughput and increase the asset utilization. By using robots and automation expertise in food and beverage production, ABB can provide solutions, which will give manufacturers more flexibility, reliability of their process and higher uptime.

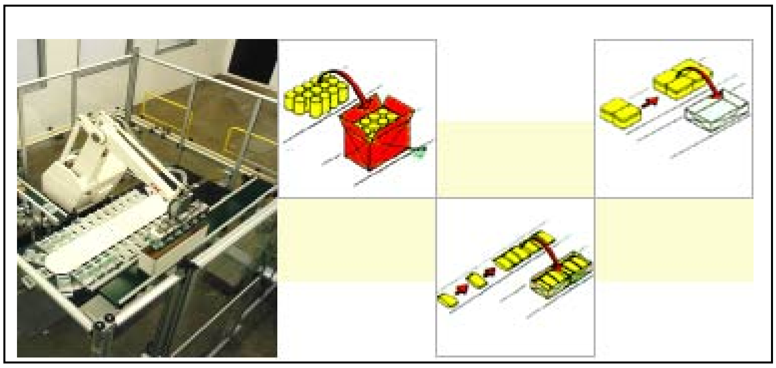


Figure 2.6: Robot pack the product into container

From case packing to labeling to palletizing, ABB robots can handle multiple functions automatically. They're set up to integrate with workflow management, electronic documentation and electronic record systems to improve the access to data, allowing you to track each order through the packaging process.

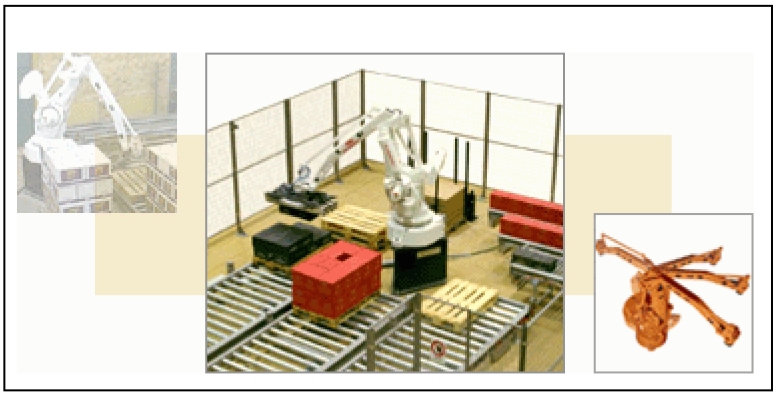


Figure 2.7: ABB robot in palletizing system

Figure 2.7 shows the ABB robot in the palletizing system. These robots deliver flexibility, reliability, and capacity far beyond the limitations of traditional, manual, dedicated palletizes.

CHAPTER III

THEORETICAL BACKGROUND

This chapter provided the theoretical background of the project implementation in order to Develop Pick and Place System using the IRB 1400 Industrial Robot.

3.1 ABB IRB 1400 Industrial Robot

The IRB 1400 comes from a background of success, with over 60,000 robots installed worldwide, in every type of application, providing millions of hours of operational reliability.

3.1.1 Structure of the Robot

The IRB 1400 have a fast and reliable work cycles that boost productivity. The robot is well-proven in arc welding, material handling and process applications. It delivers plenty of performance for the money, ensuring short payback times. The handling capacity is 5 kg, plus a unique 18 kg supplementary load on the upper arm. Superior levels of control and path-following accuracy provide excellent work quality.

IRB 1400 is known for its stiff and robust construction. This translates into low noise levels, long intervals between routine maintenance and long service life. The robot has a large working area and long reach. The robot is compact design, very slim wrist and high performance operation even in the difficult and restricted locations.

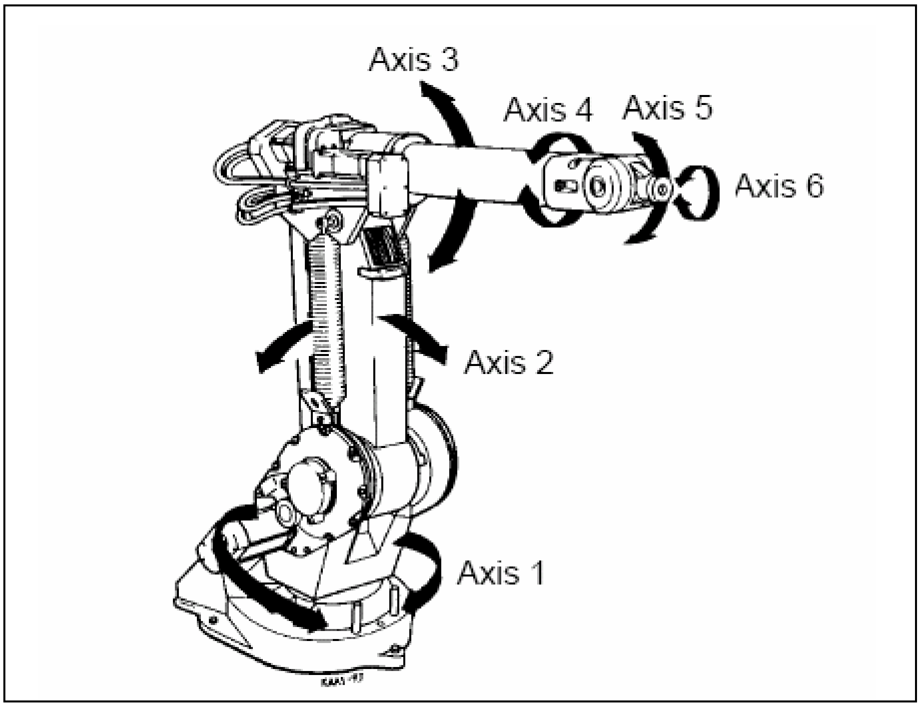
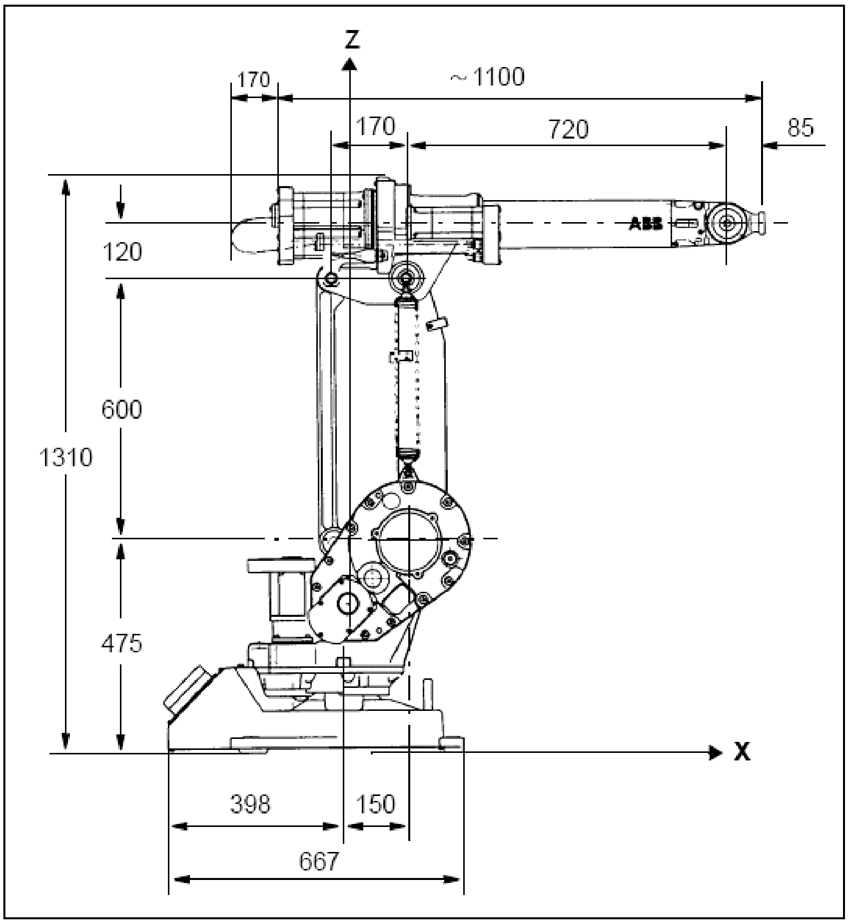


Figure 3.1: IRB 1400 Robot

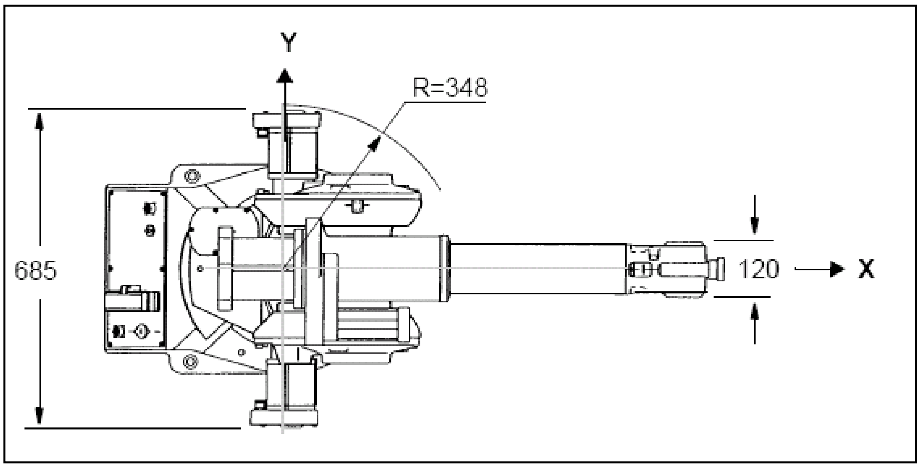
IRB 1400 is a 6-axis industrial robot as illustrated on Figure 3.1 is designed specifically for manufacturing industries that use flexible robot-based automation. The robot has a structure that is specially adapted for flexible used, and can communicate extensively with external systems. The robot is equipped with the operating systems BaseWare OS. BaseWare OS controls every aspect of the robot, like motion control, development and execution of application programs communication etc .For additional functionality, the robot can be equipped with optional software for application support for example gluing and arc welding, communication features, network communication and advance functions such as multitasking, and sensor control. The IRB 1400 is available in two different versions as shown in Table 3.1.

Table 3.1: Two difference version of IRB 1400

Version of robot	Description
IRB 1400 for floor mounting IRB 1400H for inverted mounting	Weight of manipulator : 225kg Airborne noise level : the sound pressure level outside the working space, <70dB



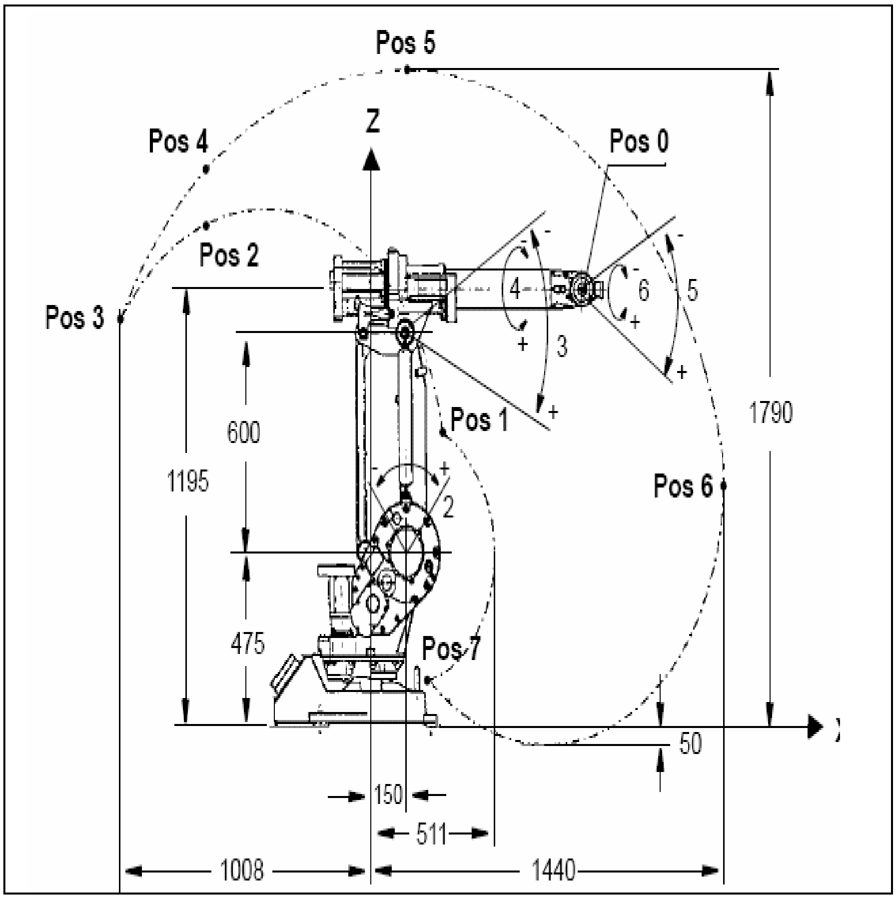
(a)



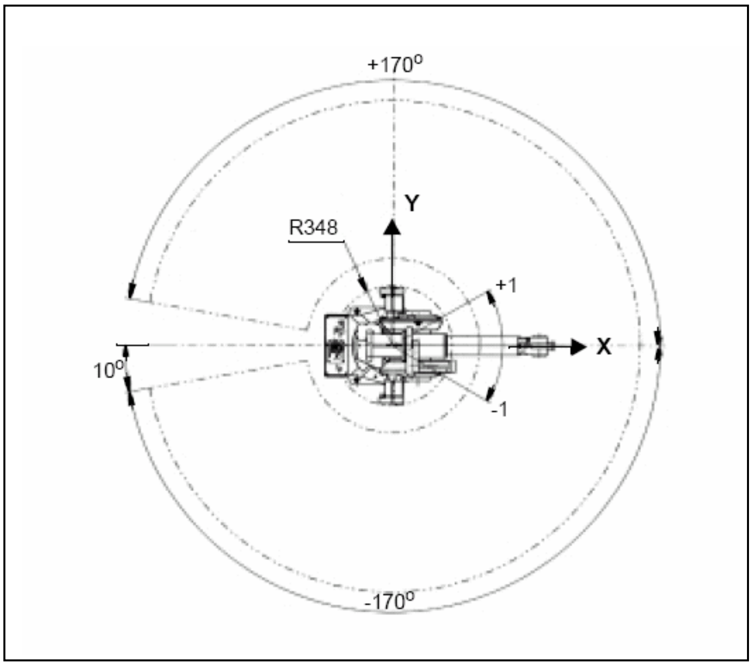
(b)

Figure 3.2: View of the manipulator (floor mounted version) with dimension in mm (a) from the site (b) from the above.

Figure 3.3 illustrated the extreme positions of the robot arm. The positions at wrist centre were measured in mm and the angle position was in degree.



(a)



(b)

Figure 3.3: The extreme positions of the robot arm (a) view from the side (b) view from the above

3.2 S4Cplus Robot Controller

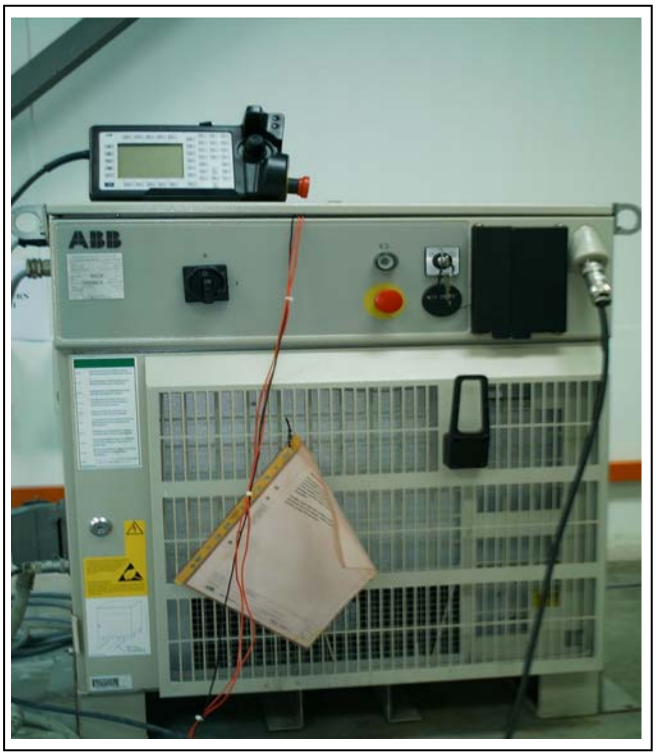


Figure 3.4: S4Cplus Controller

S4Cplus M2000/BaseWare OS 4.0 as show in Figure 3.4 is specifically designed to control robot the manipulator, external axes and peripheral equipment. It features dynamic model based control, QuickMove for short cycle times, and the TrueMove function for high precision path following ability independent of robot speed. The S4Cplus system configuration capability and the powerful programming language RAPID make it easy to set up the controller for a wide range of applications. The controller itself enables quick integration of additional hardware. The unit is adaptable for use in harsh environments and offers a high level of reliability and user safety. S4Cplus is used with all ABB robots.

S4Cplus offers extensive communications possibilities to reduce installation costs and facilitate integrated solutions. Two built-in Ethernet channels provide for easier service and factory networking. There are field bus and serial channels for PLC and PC connections. The controller supports TCP/IP, DNS and other protocols. A dedicated robot protocol, RAP, is available for control and monitoring. Superior performance and easy maintenance are assured by extensive monitoring of fans, battery, and temperature and supply voltages. Robot movements are monitored continuously.

3.2.1 Structure of the Controller

The controller in Figure 3.2 contains the electronics required to control the manipulator, external axes and peripheral equipment. The controller also contains the system software, i.e. the BaseWare OS (operating system), which includes all basic functions for operation and programming.

Table 3.2: Controller description

Controller	**Description**
Controller weight	250 kg
Controller volume	950 x 800 x 620 mm
Airborne noise level	The sound pressure level outside the working space <70dB

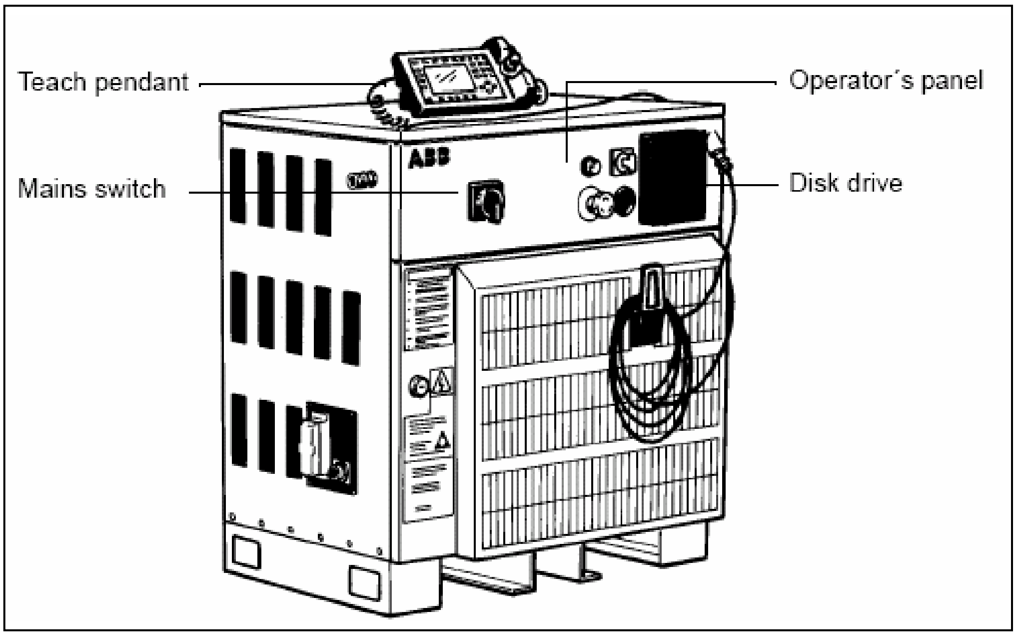


Figure 3.5: The S4Cplus Controller

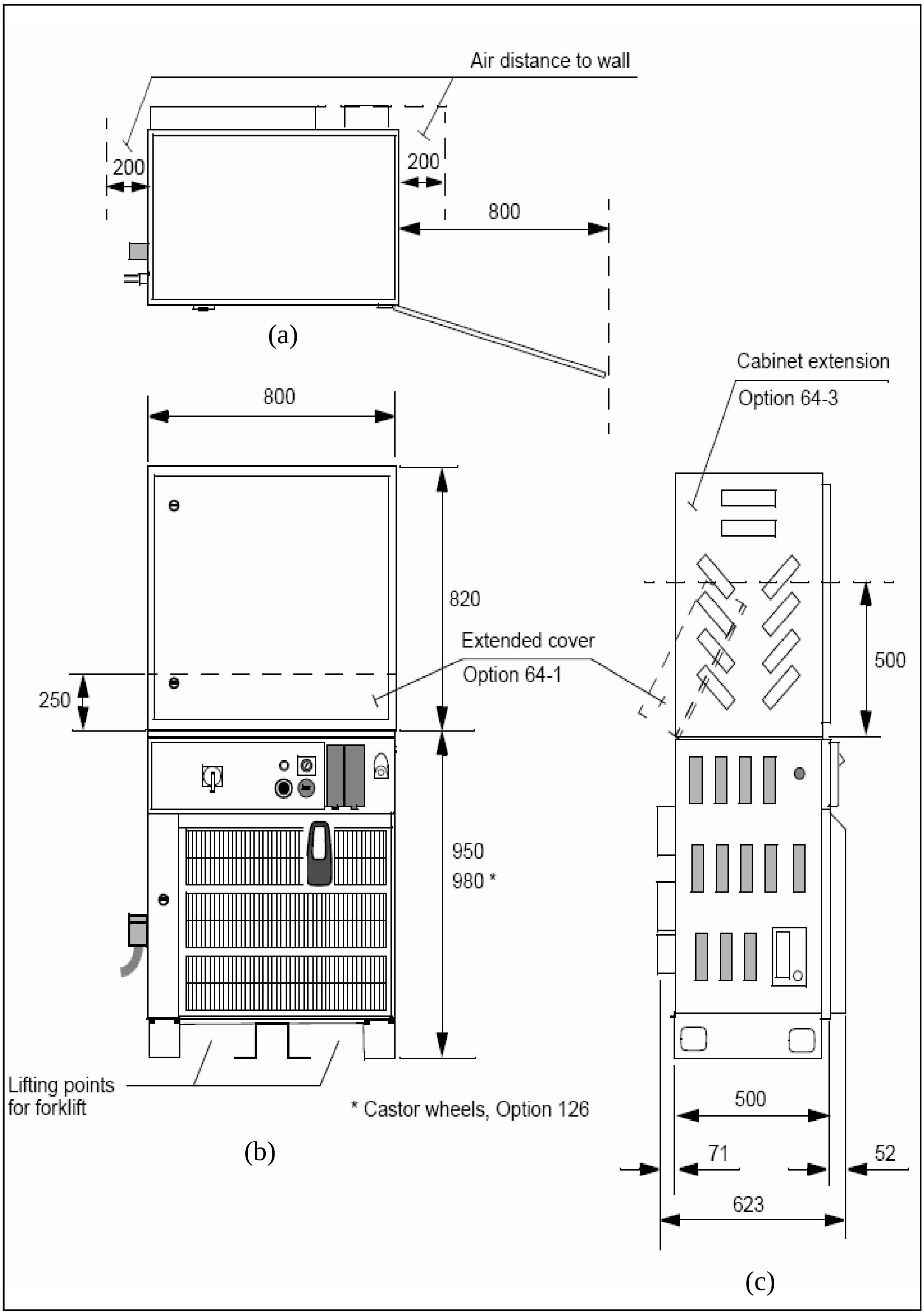


Figure 3.6: View of the controller (a) from the above (b) from front and (c) from the side (dimension in mm)

3.2.2 Portable Teach Pendant

All operation and programming carried out using the portable teach pendant and operator panel as shown in Figure 3.7 and Figure 3.8. Information is presented on a display using windows, pull-down menus, dialogs and function keys. No previous programming or computer experience is required to learn how to operate the robot. All operations can be carried out from the teach pendant, which means that an additional keyboard is not required. The teach pendant is equipped with a large display, which display prompts, information, error message and other information in plain English.

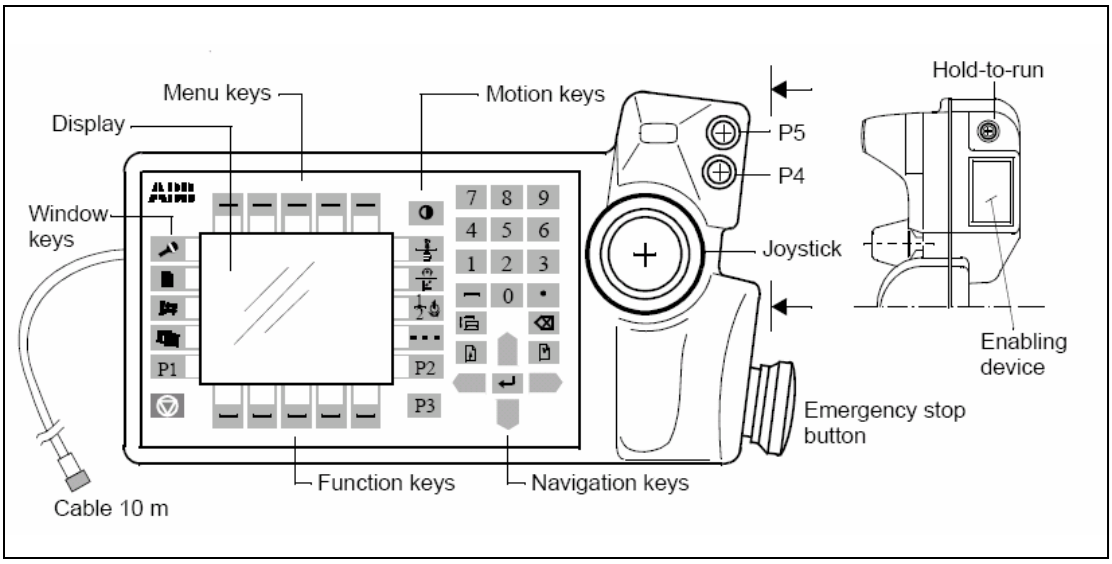


Figure 3.7: The teach pendant

Table 3.3: The lists of available key in the teach pendant

Keys	**Description**
Display	Displays all information during programming, to change programs, etc. 16 text lines with 40 characters per line.
Motion keys	Select the type of movement when jogging
Navigation keys	Used to move the cursor within a window on the display and enter data.
Menu keys	Display pull-down menus
Function keys	Select the commands used most often.
Window keys	Display one of the robot's various windows. These windows control a number of different functions: - Jog (manual operation) - Program, edit and test a program - Manual input/output management - File management - System configuration - Service and troubleshooting - Automatic operation
User-defined keys (P1 –P5)	Five user-defined keys that can be configured to set or reset an output for example open/close gripper or to activate a system input.
Hold- to- run	A push button which must be pressed when running the program in manual mode with full speed.
Enabling device	A push button which, when pressed halfway in, takes the system to MOTORS ON. When the enabling device is released or pushed all the way in, the robot is taken to the MOTORS OFF state.
Joystick	The joystick is used to jog (move) the robot manually; e.g. when programming the robot.

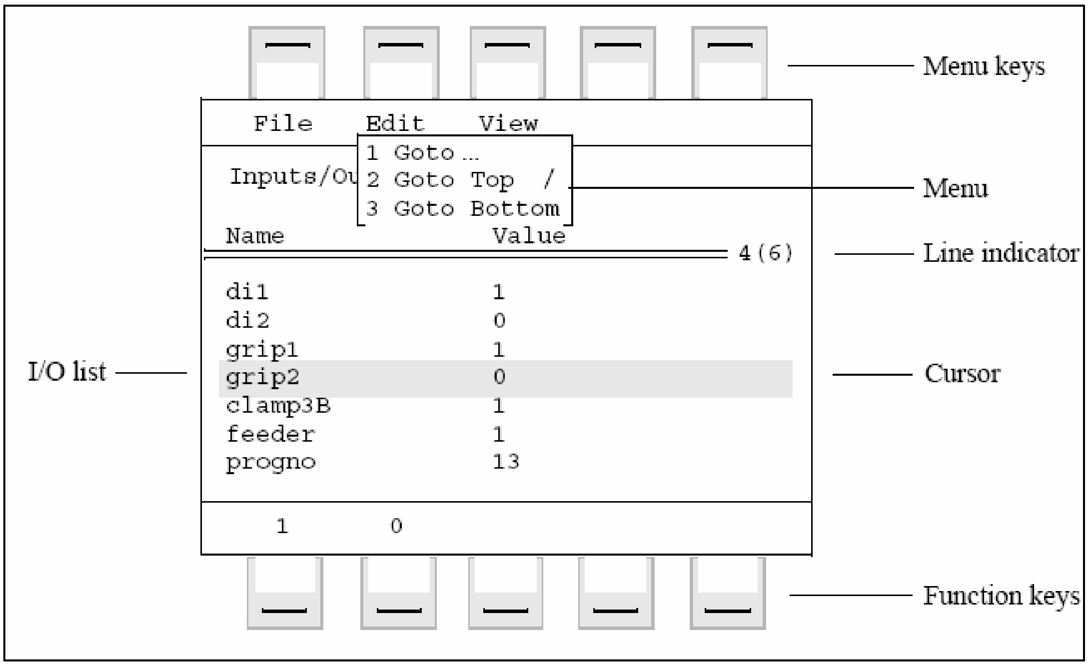


Figure 3.8: Window for manual operation of input and output signal

Using the joystick, the robot can be manually jogged (moved). The user determines the speed of this movement; large deflections of the joystick will move the robot quickly, smaller deflections will move it more slowly. The robot supports different user tasks, with dedicated windows for:

a) Production
b) Programming
c) System setup
d) Service and installation

3.2.3 Operator Panel's

The operator panel on the controller is used when programming the robot. There are four button that equipped in the Operator Panel's which are indicating lamp, operating mode selector, emergency stop button and duty time counter.

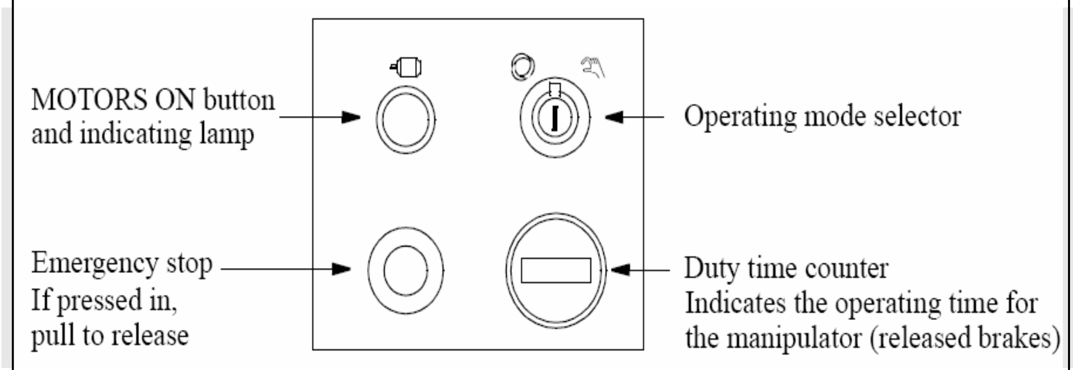


Figure 3.9: Operator Panel's of the controller

a) Motor ON

The motor of the controller in the ON state when the ON button is pressed and the indicating lamp on the Operator Panel's will be lighting.

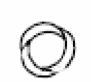
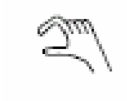
Table 3.4: Indicating Lamp mode

Indicating Lamp	**Description**
Continuous Light	Ready for program execution
Fast Flashing Light (4Hz)	The robot is not calibrated or the revolution counters are not updated.
Slow Flashing Light (1Hz)	One of the safeguarded space stops is active

b) Operating mode selector

By using a keys switch, the robot can be locked in two or three different operating modes depending on chosen mode selector as indicate in Table 3.5. The operating mode is selected using the operator's panel on the controller.

Table 3.5: Operating Mode Selector

Symbol	Operating Mode Selector	Description
	Automatic mode	Running production
	Manual mode at reduce speed	Programming and setup Max. Speed 250mm/s (600 inches/min.)
	Manual mode at full speed Equipped with this mode, the robot is not approved according to ANSI/UL	Testing at full program speed

3.3 RAPID Language

The RAPID language is a language for robot programming. It is a well balanced combination of simplicity, flexibility and powerfulness. The program consists of a number of instructions which describe the work of the robot. Thus, there are specific instructions for the various commands, such as one to move the robot, one to set an output, etc.

The instruction generally has a number of associated arguments which define what is to take place in a specific instruction. For example, the instruction for resetting an output contains an argument which defines which output is to be reset, for example, reset do1. These arguments can be specified in one of the following ways:

Table 3.6: Arguments of RAPID language

Types	**Example**
Numerical value	*5 or 4.6*
Reference to data	*reg1*
Expression	*5+ reg1*2*
Function call	*Abs(reg1)*
String value	*"Production part A"*

In this structure of the language, there are three types of routines. There are procedures, functions and trap routine. A procedure is used as a subprogram. A function returns a value of a specific type and is used as argument of an instruction. Trap routines provide a means of responding to interrupts. A trap routine can automatically executed if that particular interrupt occurs.

Information can also be stored in the data, e.g. tool data (which contains all information on a tool, such as its TCP and weight) and numerical data (which can be used, for example, which describe different types of information, such as tools, positions and loads. There are three kinds of data; there are constants, variables and persistent. A constant represents a static value and can only be assigned a new value manually. A variable can also be assigned a new value during program execution. A persistent can be described as a "persistent" variable. When a program is saved the initialization value reflects the current value of the persistent.

3.4 Proximity Sensor

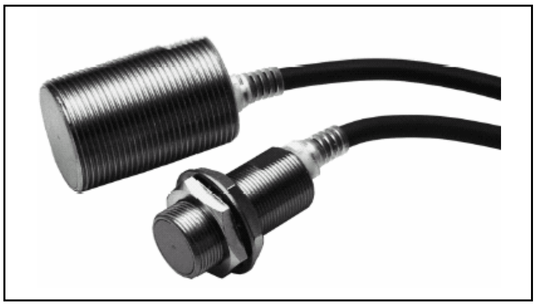


Figure 3.10: Proximity Sensor

Sensor will make robot more intelligent. But the associated robotic software must have the ability to receive data from the sensors and to process the necessary real time information and commands needed for the decision making. Inductive proximity sensor was being chosen in this project to integrate with the IRB 1400 robot as illustrated in Figure 3.10. The inductive proximity sensors were used in place of limit switches for on contact sensing of metallic objects.

In this project, the inductive proximity sensor was mounted to the conveyor part and it used to detected the incoming metallic work pieces before the robot completed the pick and place task. It also gave output to the DC motor to operate.

3.5 DC Motor

DC motor or direct current motor is the most common of all motors. There are many types of DC motors like brushless motor, coreless motor, fix magnet motor, 5-pole motor, servomotor and many more manufactured to cater for a wide range of usage. DC motors take direct current voltages as input and convert it into rotation movement.

DC motors generally have two wires, and can be powered directly from a battery or other DC power supply. DC motor can also be powered through driver circuits that can also regulate the speed and directions of the motor. DC motors are reversible by reversing the polarity of the voltage supplied to the motor. The usual voltage of DC motor use in robotics is 6V and 12V motor. The current rating depends on the make of the robot but it is usually between 1Amp and 3Amp.

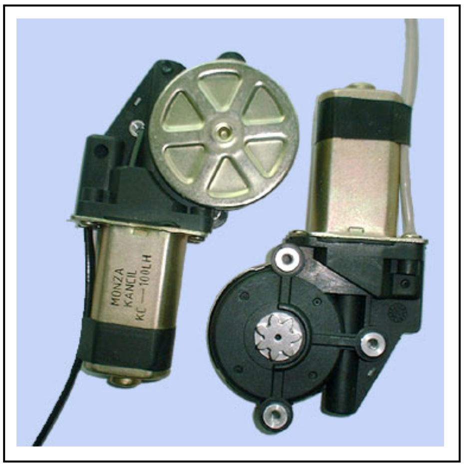


Figure 3.11: Power Window Motor

Varying the voltage input into the motor will vary the speed of the motor accordingly. DC motors have the ability to turn at high revolution per minute but has low torque. The most significant limitation of DC motors is the low output torque. Although the output speed can be reduced and the torque increased by adding a gear train to the output shaft it is still not adequate to actuate a biped robot using DC motors.

The purpose of this motor as indicated in the Figure 3.11 in this project is to running the conveyor belt where the work part is moved continuously along the conveyor at constant speed.

3.6 Relay

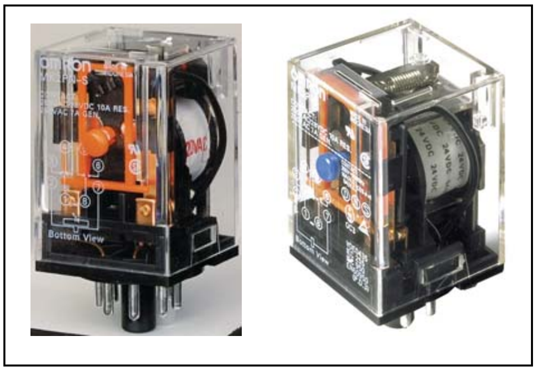


Figure 3.12: OMRON MK2P-I Relay

Relay is an electrically controlled mechanical device that opens and closed electrical contacts when voltage (or current) is applied to a coil. A relay provides isolation of control signals from switch signal. Octal Base General Purpose Relay was being chosen in this project as show in Figure 3.12 to open and close electrical contacts when the sensor senses the incoming object from the conveyor.

3.7 Power Supply

Figure 3.13: DC Power Supply

Power supply for the DC motor as indicated in the Figure 3.13 is of most important because without power supply, the motor cannot operate. There are two major power supplies for a motor that can be used, namely internal supplies, which are batteries and external power supplies via direct intake or via DC power supply. In this project, DC power supply was used to give supplies to the motor in order to run the conveyor.

CHAPTER IV

RESULT AND DISCUSSIONS

This chapter describes the integration of proximity sensor with the IRB 1400 robot by programming the robot using RAPID language. This chapter also discussed on mechanical design of the conveyor and control panel box.

4.1 Robot Work Cell Layout

The robot work cell design deals with the physical design of the work cell, the control system to coordinates the various components in the cell and evaluating the anticipated performance of the design. There are many types of robot work cell layouts. It can be classify them into three main configurations. There are robot-centered work cell, in-line robot work cell and mobile robot work cell.

In this project, robot- centered work cell layout type was used in order to develop pick and place system. This arrangement is suitable for installations where a single robot is servicing one or more production machine. In this configuration, the IRB 1400 robot was positioned at the approximate centre of the work cell. Other components and equipment such as conveyor and pallets was arranged in a partial circle around the robot as show in Figure 4.1. The method of work part delivery such as conveyor that was used in this project must presents parts in a known location and orientation.

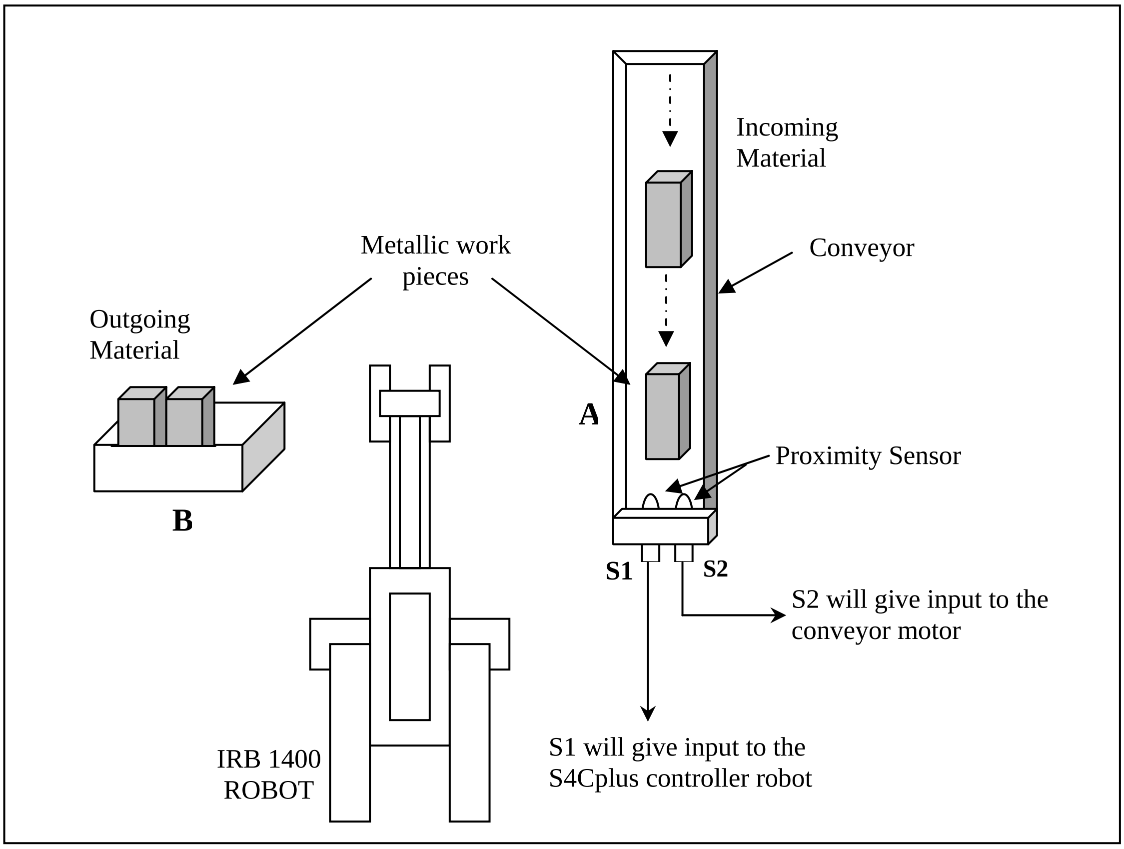


Figure 4.1: Robot Centered Cell

Figure 4.1 shows the whole operation of the development of this project generally. The sensor senses the incoming work pieces. When the sensor 2 (S2) detected the following work pieces, it gave the input to the conveyor motor to stop. At the same time, sensor 1 (S1) detected the incoming work piece and gave the input to the S4Cplus controller robot. Robot was programmed to pick the work pieces and placed it in the outgoing material box. The block diagram in Figure 4.2 shows the process of the system.

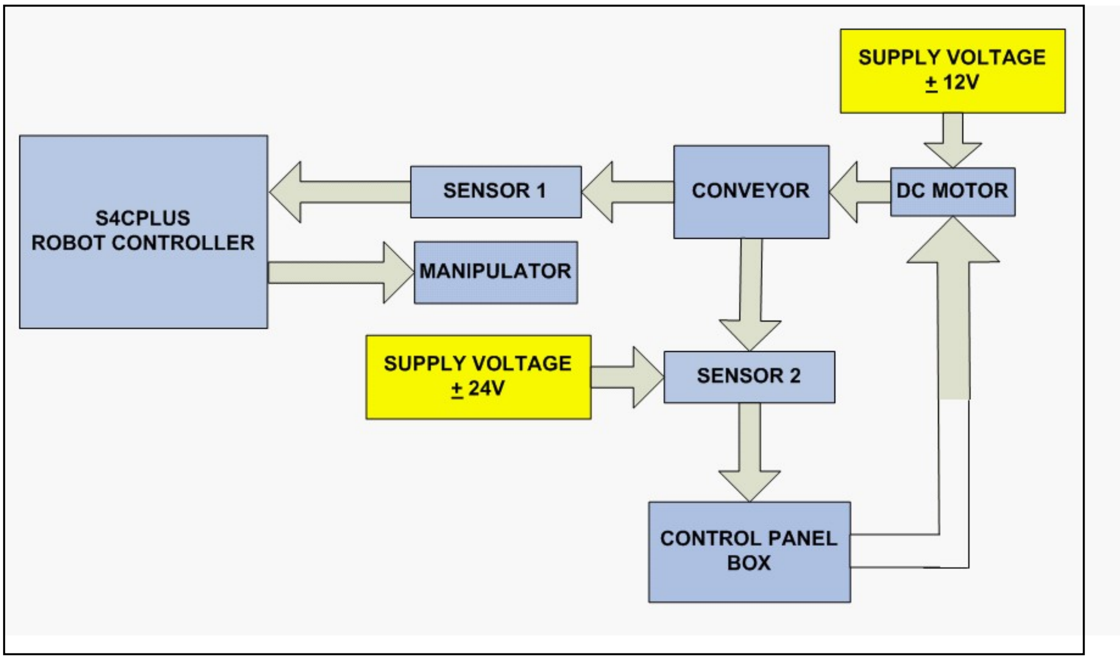


Figure 4.2: Block diagram of Pick & Place System

4.1.2 Starting Up the Robot

A robot is made up of two principle part. There are controller and manipulator that connected by two cables. The robot can communicated by using a teach pendant unit and the operator's panel that located on the controller.

Before switched on the power supply, the space around the robot will be checked to ensure no workers in the safeguarded space. The main switch was switched ON and the robot hardware then automatically checked. When the checked was completed and if no error was detected, the massage was appeared on the teach pendant unit as shown in Figure 4.3.

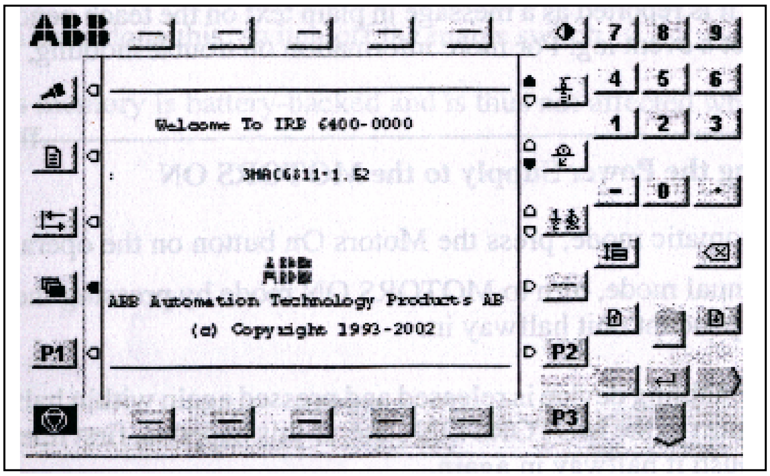


Figure 4.3: The welcome message after start-up

The robot is started up with the same status as when the power was switched off. The program pointer remains unchanged and all the digital outputs were set to the value before the power off or to the value specified in the system parameters. When the program was restarted, this is considered to be a normal stop-start. This is because, when the robot is restarted it's program, it moved back slowly to the programmed path and then continued on the program path. The motions settings and data of the robot also automatically set to the same value as before the power off and the robot continued to react the interrupts. Same situation to the mechanical unit of the robot that was active before power off was automatically being activated at program start.

4.1.3 Selecting the Operating Mode

As mentioned in the previous chapter, the robot can be locked in three difference operating modes depending on chosen mode selector that was selected using the operator's panel on the S4Cplus controller. The manual mode with reduced speed was being chosen when programming and working in the robot working area. By chosen the programming mode, the robot can be jogged using the joystick on the teach pendant unit.

4.1.4 Linear Jogging Robot

Operating programming mode had being chosen in order to jog the robot by using the joystick. There were two motion keys on the teach pendant that had being chosen, motion unit key and motion types key as shown in Figure 4.4. With the motion unit key, it can be choose wherether to used operating the robot or operating with some other unit connected to the controller. In this project, the robot was programmed by choosing motion unit key as operating the robot with the controller. With the motion type key, the way of movement robot can be assigned. In this particular project, linear movement was used.

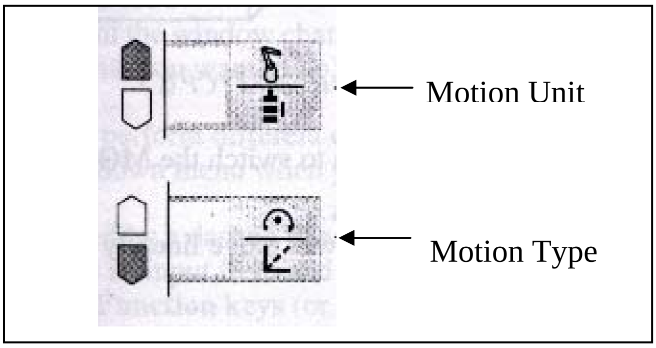


Figure 4.4: Motion keys

The enabling device was pressed halfway in to switch the MOTOR ON. Now, the robot can be jogged using the joystick. The robot was jogged in the directions corresponding to X, Y and Z by using the joystick as shown in Figure 4.5.

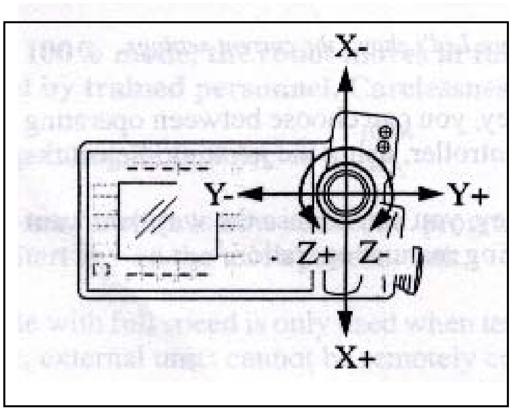


Figure 4.5: Robot movement with difference joystick movement

4.1.5 Programming a Position using RAPID language

After the robot was set in a linear motion movement, the robot was programmed to set the position, P in the work space area in the Pick and Place System as shown in Figure 4.6.

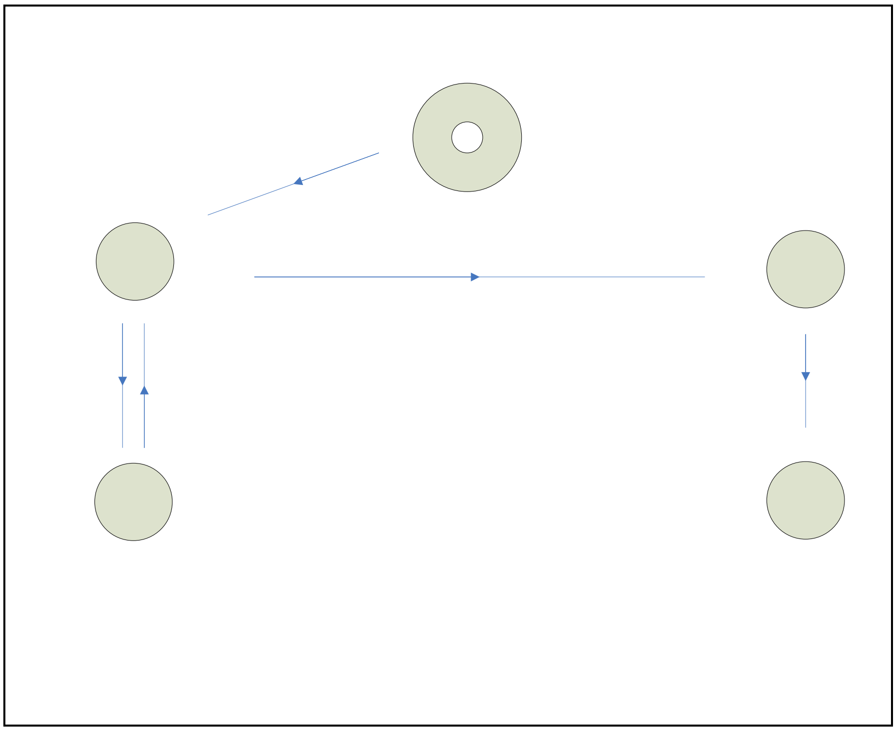


Figure 4.6: Robot movement point in the Pick and Place System

Table 4.1: Position and robot movement in the system

Jogging	Position, P	Movement of robot
1	P20	Robot will moved from the home position to point P20
2	P10	Robot had being set to gripped the incoming object on the conveyor
3	P20	Robot picked the object and moved back to point P20
4	P30	Robot moved to point P30
5	P40	Robot had being set to ungripped the object and place it in the box

In programming a position of the robot, the robot had being jog to the desired position. For the first position of the point, the robot was jogged to the position P20. The positioning instruction was called up by choosing IPL1 menu in the appear window as shown in Figure 4.7.

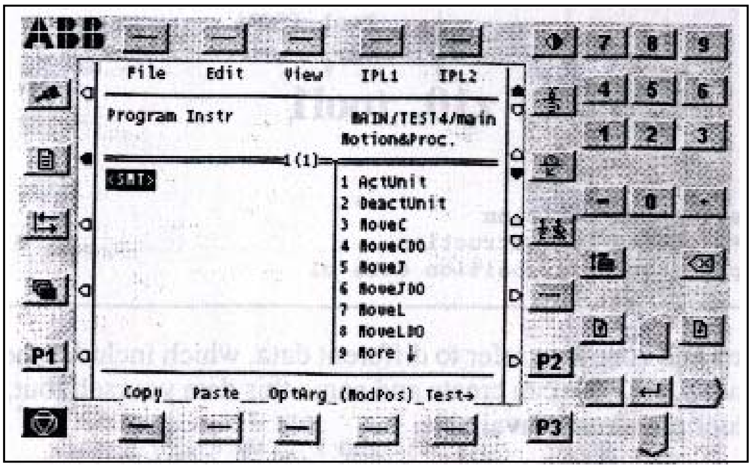


Figure 4.7: The dialog box used to program the positioning instruction

The instruction was added directly to the program as illustrated in Figure 4.8. The arguments were set automatically. If the correct argument was chosen, the instruction is now ready for used.

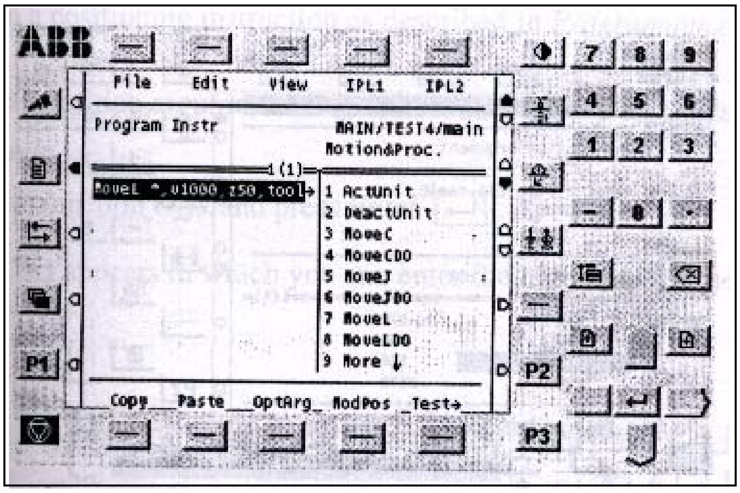


Figure 4.8: A positioning instruction is added directly to the program

A positioning instruction contains the following in formation as show in Table 4.2. For example instructions that had being used “MoveL P20, v1000, z10, tool1”

Table 4 .2: Position Instruction of RAPID Language

Instruction	Description
MoveL MoveJ	Types of path for instance linear motion. Types of path for joint motion
P20 *	Destination stored in position data in p1 Destination position stored in instruction
v1000	Speed specified in the speed data v1000 = 100mm/s
z10	Zone size specified in the zone data z10 = 10mm
tool1	Tool (TCP)

The speed and zone size of the instruction refer to the difference data which includes the desired speed and zone size in mm/s. The TCP of the tool was moved to the specified destination position when the instruction is executed. The robot jogging step by step until it completes all the movement point (P10 until P40) that had being set.

4.2 Integration within sensor and S4Cplus controller

Inductive proximity sensor as shown in Figure 4.9 and Figure 4.10 is used in place of limit switches for on contact sensing of metallic object. In this project, therewere two proximity sensor that had being used; for the first sensor (S1) was used to detect the following incoming object and gave the digital input signal for the robot to pick the object from the conveyor. The second proximity sensor (S2) was used to control ON/OFF of the conveyor motor.

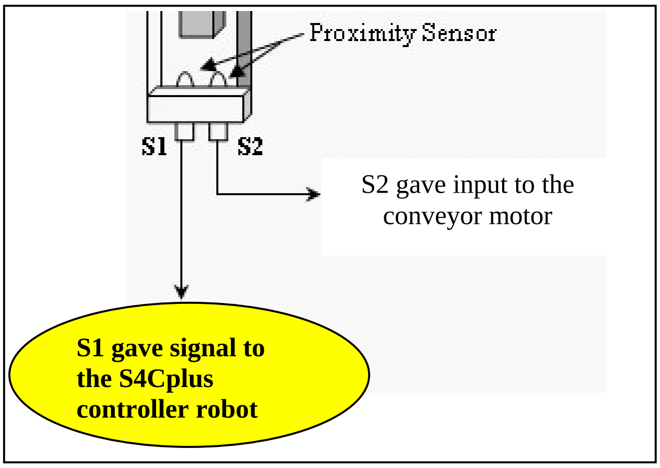


Figure 4.9: Integrating S1 with controller

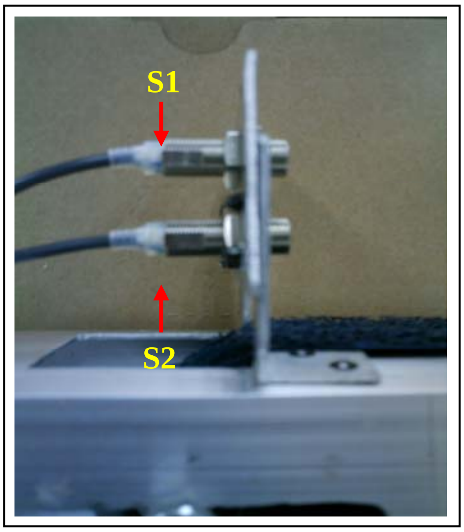


Figure 4.10: Proximity Sensor mounted with conveyor

4.2.1 Proximity Sensor Operating

The proximity sensors have 4 basic elements as shows in Figure 4.11. There are sensor coil and ferrite core, oscillator circuit, detector circuit and solid-state output circuit. The oscillator circuit generates a radio-frequency electromagnetic field that radiates from a ferrite core and coil assembly. The field is centered around the axis of the ferrite core, which shapes the field and directs it at the sensor face. When a metal target approaches and enters the field, eddy currents are induced into the surfaces of the target. This results in a loading effect, or “damping”, that causes a reduction in amplitude of the oscillator signal. The detector circuit detects the change in oscillator amplitude. The detector circuit will switch ON at specific operate amplitude. This ON signal generates a signal to turn ON the solid-state output.

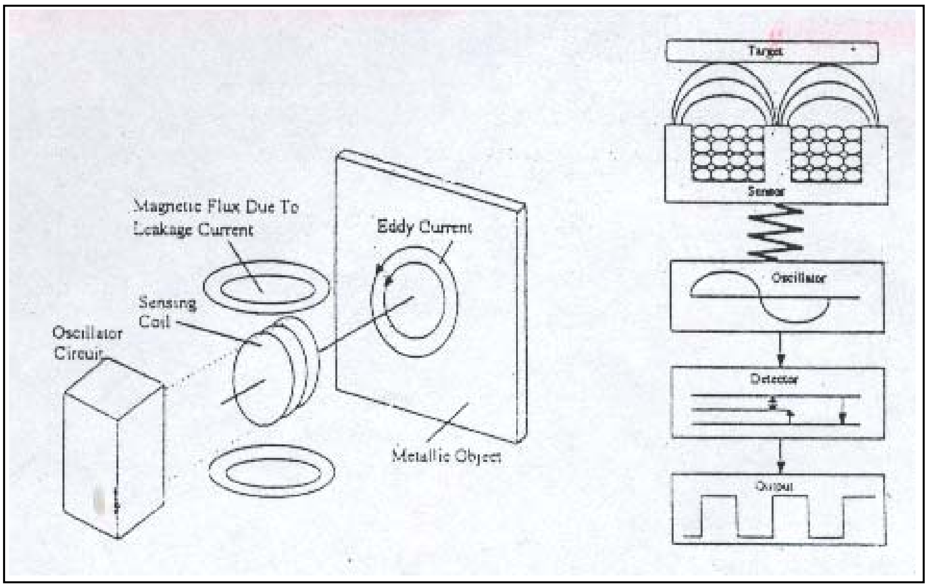


Figure 4.11: Induced Eddy Current & Operating Principles of Inductive Proximity Sensor

In this project, the E2E-X2F1-N proximity sensor with PNP output was used. It has three terminal wires with different color and the connection of each wire is shown in Table 4.3. This type of sensor was a digital one bit sensor as show in Figure 4.12. The operating range of this sensor is 1mm to 2.5 mm from the detection object.

Table 4.3: Sensor Connection

Color of wire	**Connection**
Brown	Supply DC voltage (-12V to +24V)
Black	Connection to load
Blue	Ground wire (-12V to 24V)

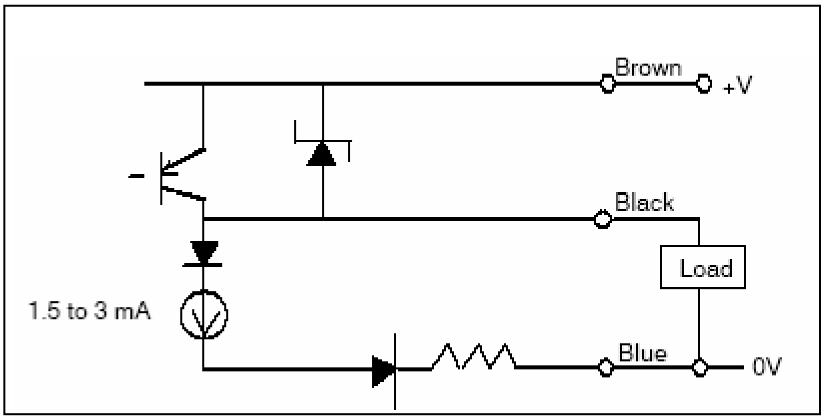


Figure 4.12: Output circuit for the E2E-X2F1-N Proximity Sensor

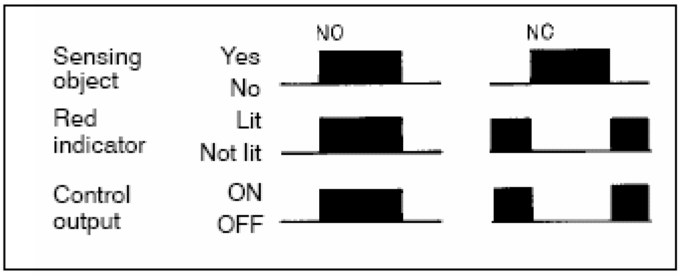


Figure 4.13: Detection Cycle of the Sensor

4.2.2 Digital I/O DSQC 328

The Digital I/O DSQC 328 is the one of optional digital unit inside S4Cplus controller. The proximity sensor was connected to digital I/O unit to integrate with the robot. The digital I/O unit has 16 inputs and outputs divided up into groups of eight as shown in Figure 4.14 and Figure 4.15. It has four customer connections unit functions, X1 to X4. In order to integrate the sensor within the controller, the X3 unit function had being used as digital input where the X1 used as the digital output. All the groups was galvanically isolated and supplied from the cabinet 24V I/O supply, XT31.

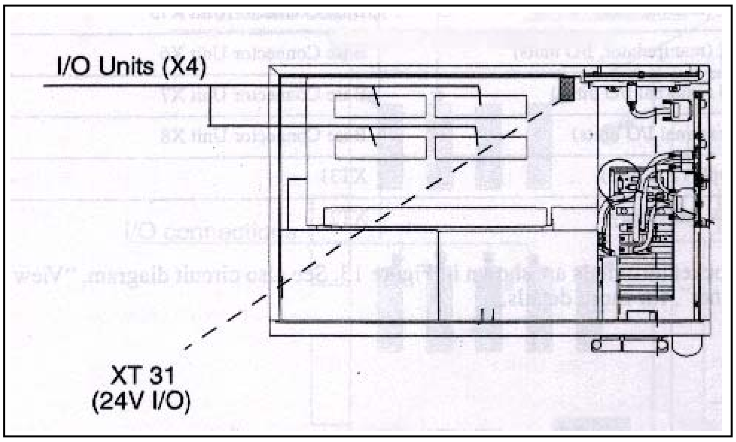


Figure 4.14: Cabinet view from above

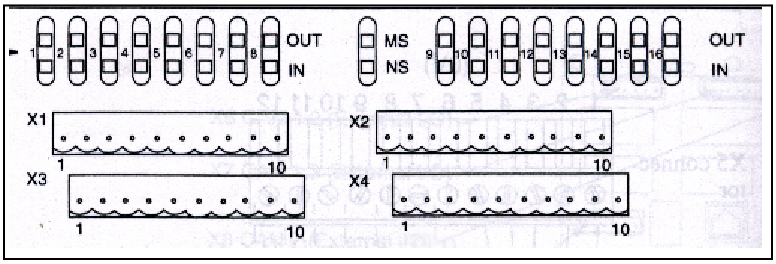


Figure 4.15: Customer connection X1-X4

	X1
Signal name	Pin
Out ch 1	1
Out ch 2	2
Out ch 3	3
Out ch 4	4
Out ch 5	5
Out ch 6	6
Out ch 7	7
Out ch 8	8
0V for out 1-8	9
24V for out 1-8	10

0V

+24V From XT31

Figure 4.16: Connection on X1 digital output units

	X3
Signal name	Pin
Out ch 1	1
Out ch 2	2
Out ch 3	3
Out ch 4	4
Out ch 5	5
Out ch 6	6
Out ch 7	7
Out ch 8	8
0V for in 1-8	9
Not used	10

Input from sensor

0V to sensor

+24V to sensor

Figure 4.17: Connection on X3 digital input units

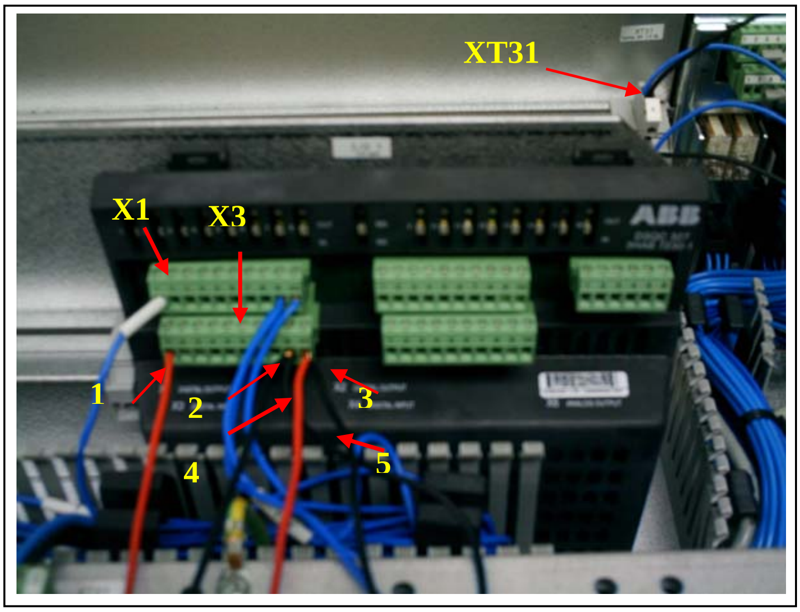


Figure 4.18: Wiring the I/O units

The connection of digital I/O units X3 consists of:

1. Channel 1 connected to the input of Proximity Sensor
2. Channel 9 connected to 0V sensor
3. Channel 10 connected for +24V supplies to sensor
4. Supplied from the cabinet 0V I/O, XT31
5. Supplied from the cabinet +24V I/O, XT31

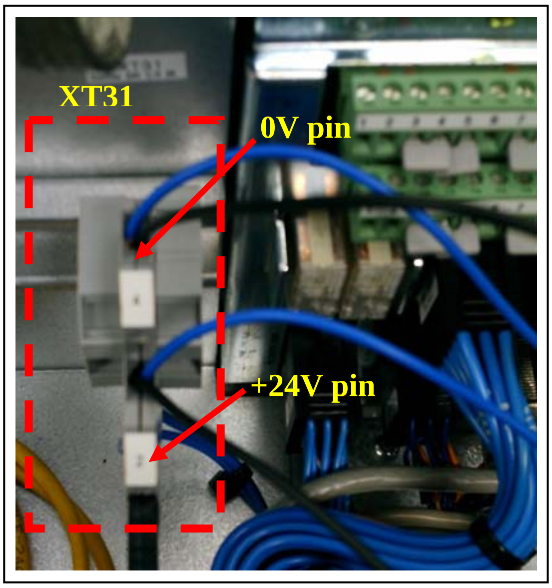


Figure 4.19: Supplied from the cabinet 24V I/O supply, XT31

4.2.3 Programming an I/O Instruction

The sensor was connected to the controller of the robot. To integrate between sensor and the robot in the system, the I/O instruction was used. When the sensor detected the following object, it gave the signal level high, '1' to the digital input unit of X3, as shown in Table 4.4.

Table 4.4: Signal Level of Proximity Sensor

Signal Level of the Sensor	**Output**
High "1"	Give signal to robot to start the program execution.
Low "0"	No signal to robot

The program of Programming a Position in Section 4.1.5 was added with I/O instruction to integrate the proximity sensor that had being connect to the Digital I/O unit in the controller. By choosing the IPL1: IO in appear window on teach pendant, the waiting for an input instruction was added directly to the program as illustrated in Figure 4.20.

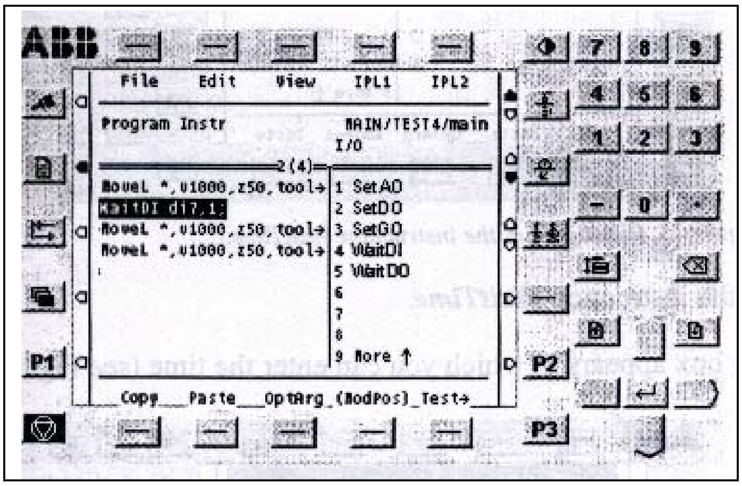


Figure 4.20: Instruction WaitDI inserted in the program

WaitDI (Wait Digital Input) was used to wait until a digital input is set. When the sensor detected the incoming object, the signal value of the robot shows logic High ‘1’. “WaitDI D110_1, High” instruction had being used in the program.

Table 4.5: Waits Instruction

Instruction	Description
WaitDI	Waiting Digital Input
D110_1	The name of signal
High	The desired value of the signal

If the value of the signal is correct, when the instruction is executed, the program simply continues with the following instruction. If the signal value is not correct, the robot enters a waiting state and when the signal changes to the correct value, the program continues. Now, the sensor was successfully integrated with the robot. It gave the input to the robot to continue the following instruction. The flow chart in Figure 4.21 shows the operation of robot in the system.

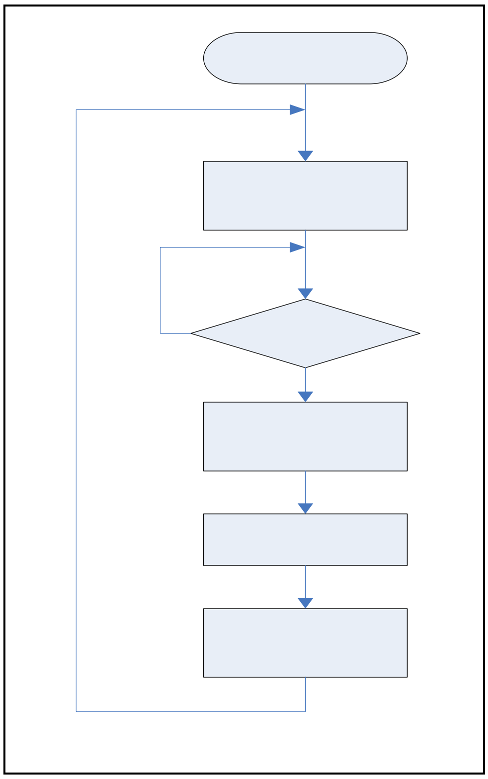


Figure 4.21: Flow Chart of Program Robot

4.3 Integration within Sensor and Motor Control Panel Box

DC motor or direct current motor is the most common of all motors. There are many types of DC motors like brushless motor, coreless motor, fix magnet motor, 5-pole motor, servomotor and many more manufactured to cater for a wide range of usage. In this project, power window motor with 24V DC had being chosen to run the conveyor belt. The S2 Proximity Sensor was used to give the input to the motor to stop running automatically when it detect the following object, as shown Figure 4.22.

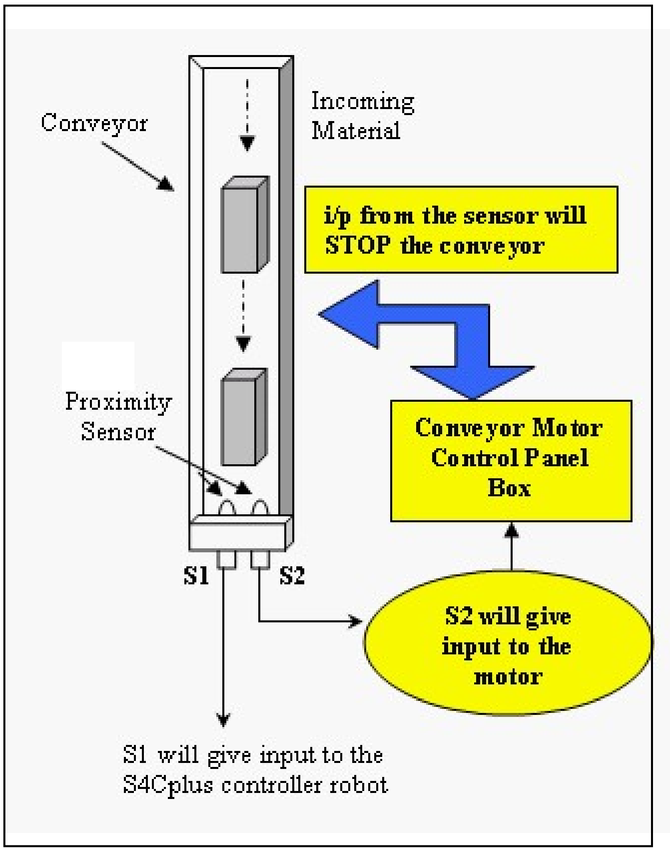


Figure 4.22: Integrating S2 with motor

Figure 4.23 shows the connecting circuit of control panel box. Two Octal Base General Purpose Relay was used in the wiring the circuit. Relay is electrically controlled mechanical devices that opens and close electrical contacts when voltage (or current) is applied to a coil. When the push button ON is pressed, the coil from the relay 1, R1 was energized. The motor was switched ON and the conveyor belt will be running. The sensor, S2 detected incoming object on the conveyor and gave input to the relay 2, R2 to energize. Coil R2 was energized and the contact of the relay changed and automatically STOPS the motor.

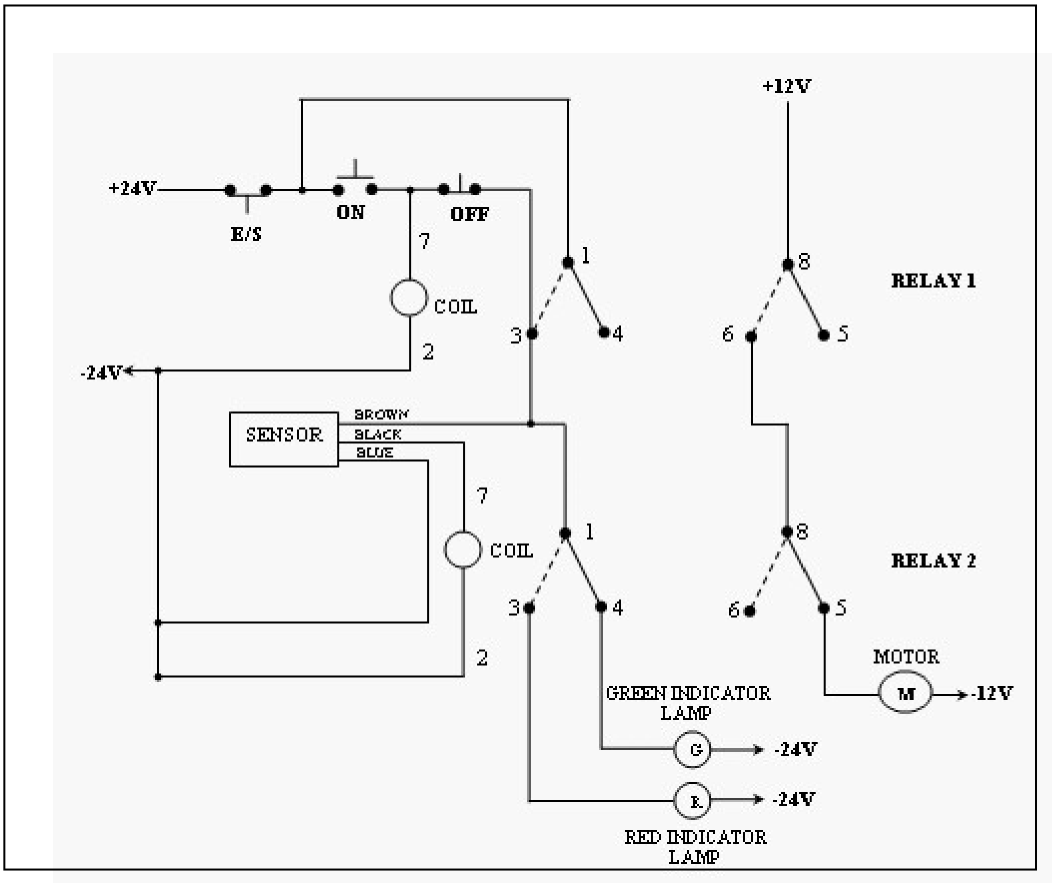


Figure 4.23: Control Panel Box connection circuit

Table 4.6: Operation of relays

Relay 1 (R1)	**Relay 2 (R2)**
Switch ON the motor	Switch OFF the motor
Green indicator lamp may lighting	Red indicator lamp may lighting

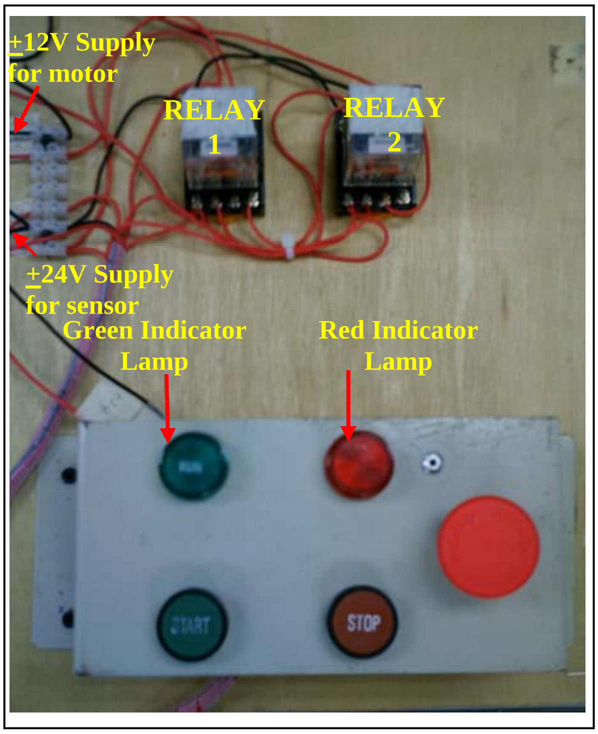


Figure 4.24: Control Panel

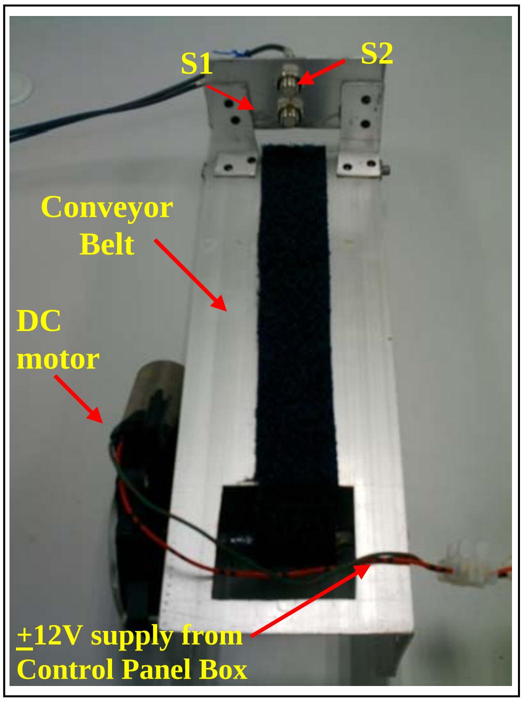


Figure 4.25: Conveyor construction

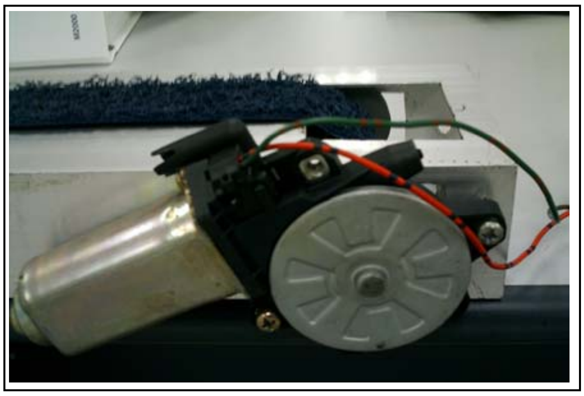


Figure 4.26: Power Window DC motor mounted with conveyor

The flow chart in Figure 4.27 shows the operation of conveyor in the system. Conveyor automatic STOP when the sensor detected the following object and continued ON if there was no incoming object to sensor detected.

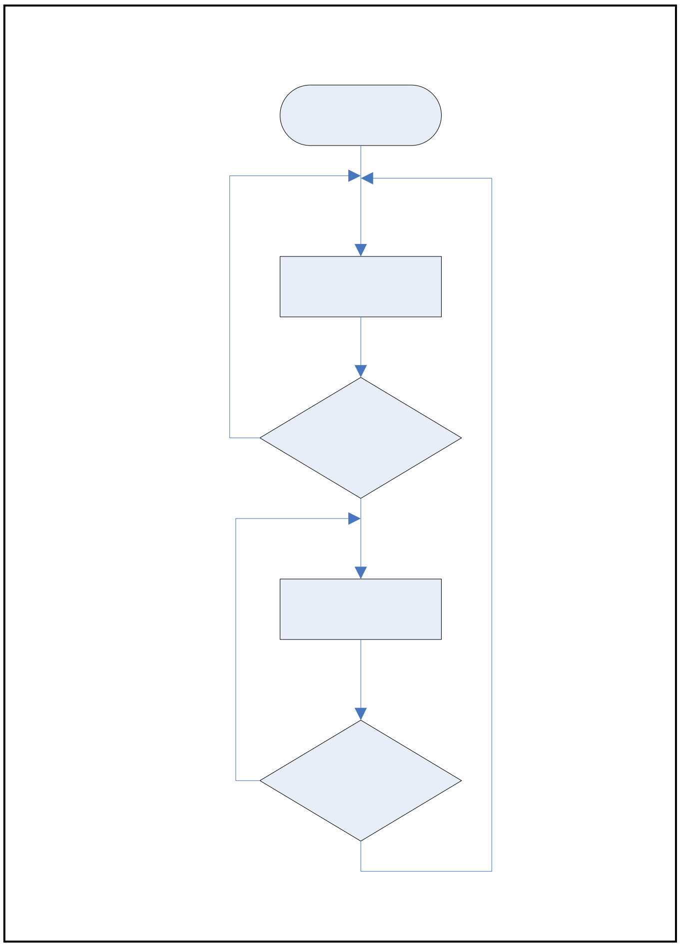


Figure 4.27: Flow Chart of Conveyor Operation

4.4 Combination of the Systems

Development of Pick and Place System using IRB 1400 consists of two parts. There are integration within sensor and control of robot and integration the sensor within a conveyor motor and Control Panel Box.

After all the system successfully done, the two parts of the system was combining together to develop a Pick and Place System. The IRB 1400 robot was programmed to pick the incoming material from the conveyor and place it in the box.

Process of the complete system is illustrated in the Figure 4.28. Both of the sensors that mounted with the conveyor operated at same time. When the S1 and S2 detected the following object, S1 gave the signal to the controller for robot and the robot continued the following instruction while S2 energized the coil of relay 2 to stop the motor of the conveyor automatically. The system was operated continuously until there was no incoming object for sensor to sense.

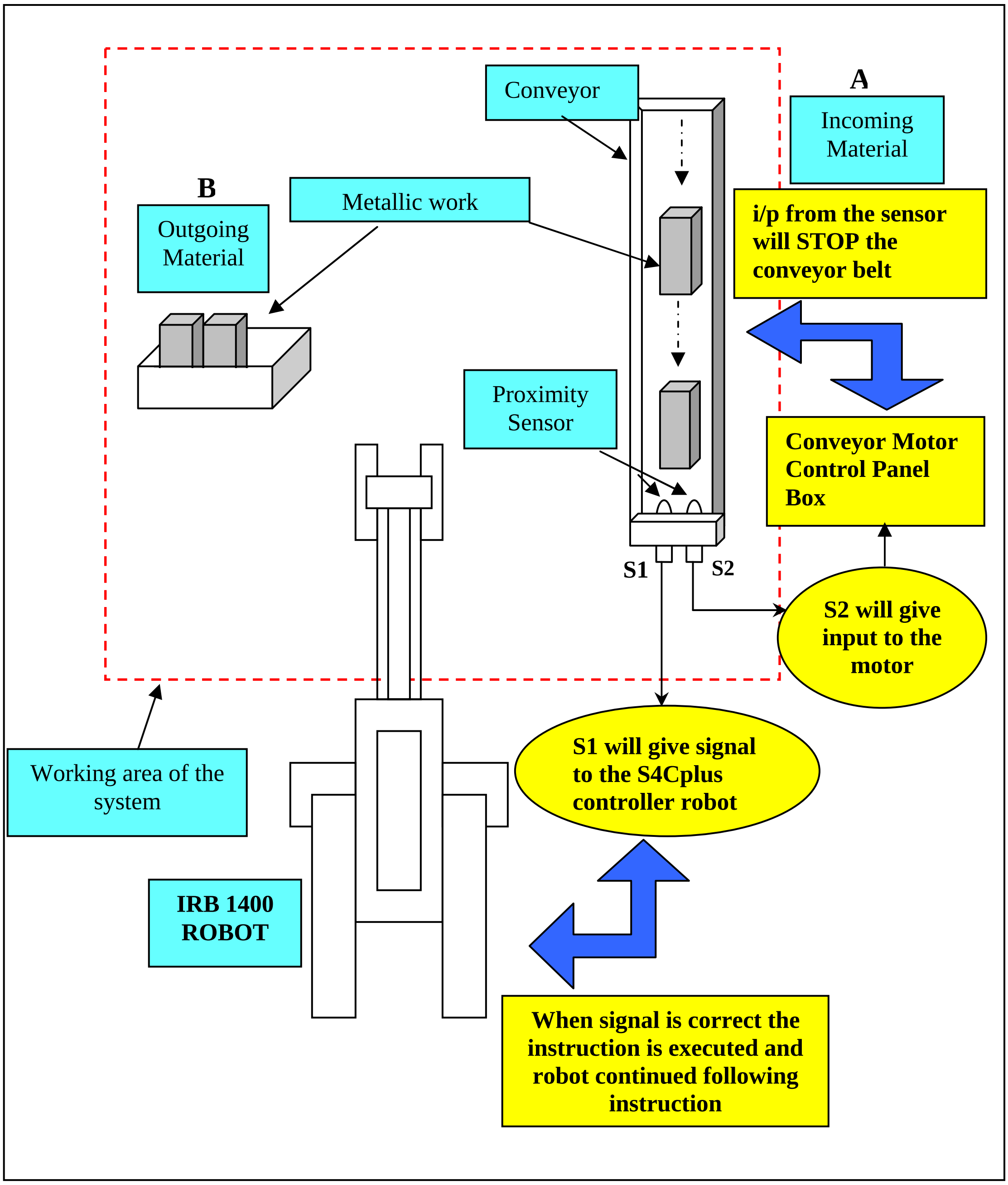
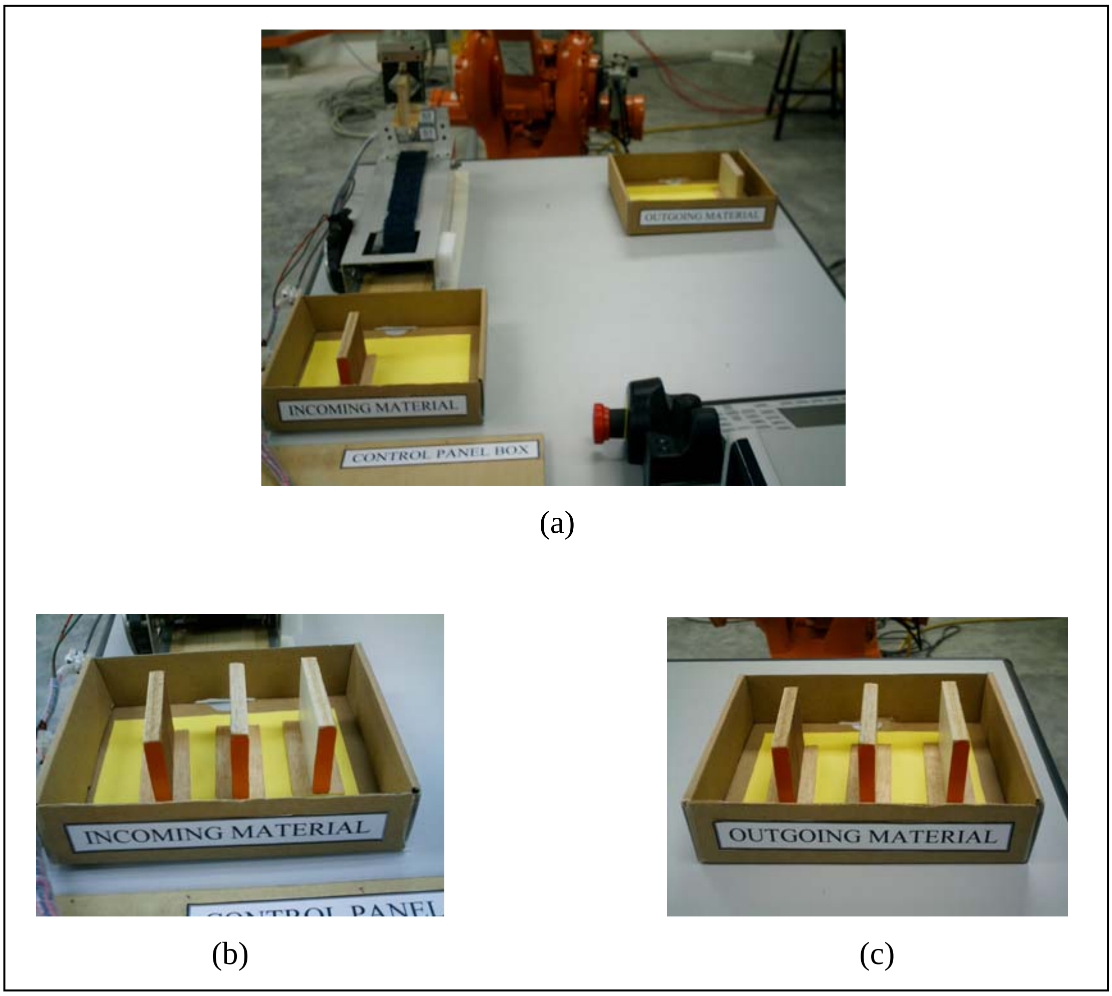


Figure 4.28: Pick and Place System Layout using IRB 1400 Robot

The critical part when building the pick & place system is the integration between the software and hardware. Meaning that, both of the system must operated at the accurate time and speed in order to complete the smooth operation of moving objects one at a time from one location to another in the system. Figure 4.29 shows the working area of the pick and place system. The robot automatically picked the object from the conveyor when the sensor detected the material as shown in Figure 4.30.



(a) (b) (c)

Figure 4.29: Working area of the Pick & Place System (a) Robot pick the material on the conveyor (b) Incoming material box (c) Outgoing material box

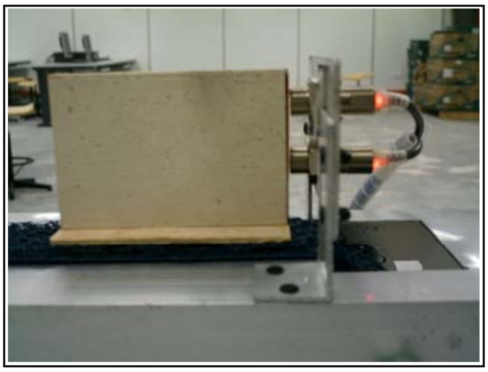


Figure 4.30: Sensor detected the incoming object

The process in Figure 4.31 showed the overall operation of Pick and Place System by using ABB IRB robot. The robot was programmed to pick and placed the material into the outgoing box.

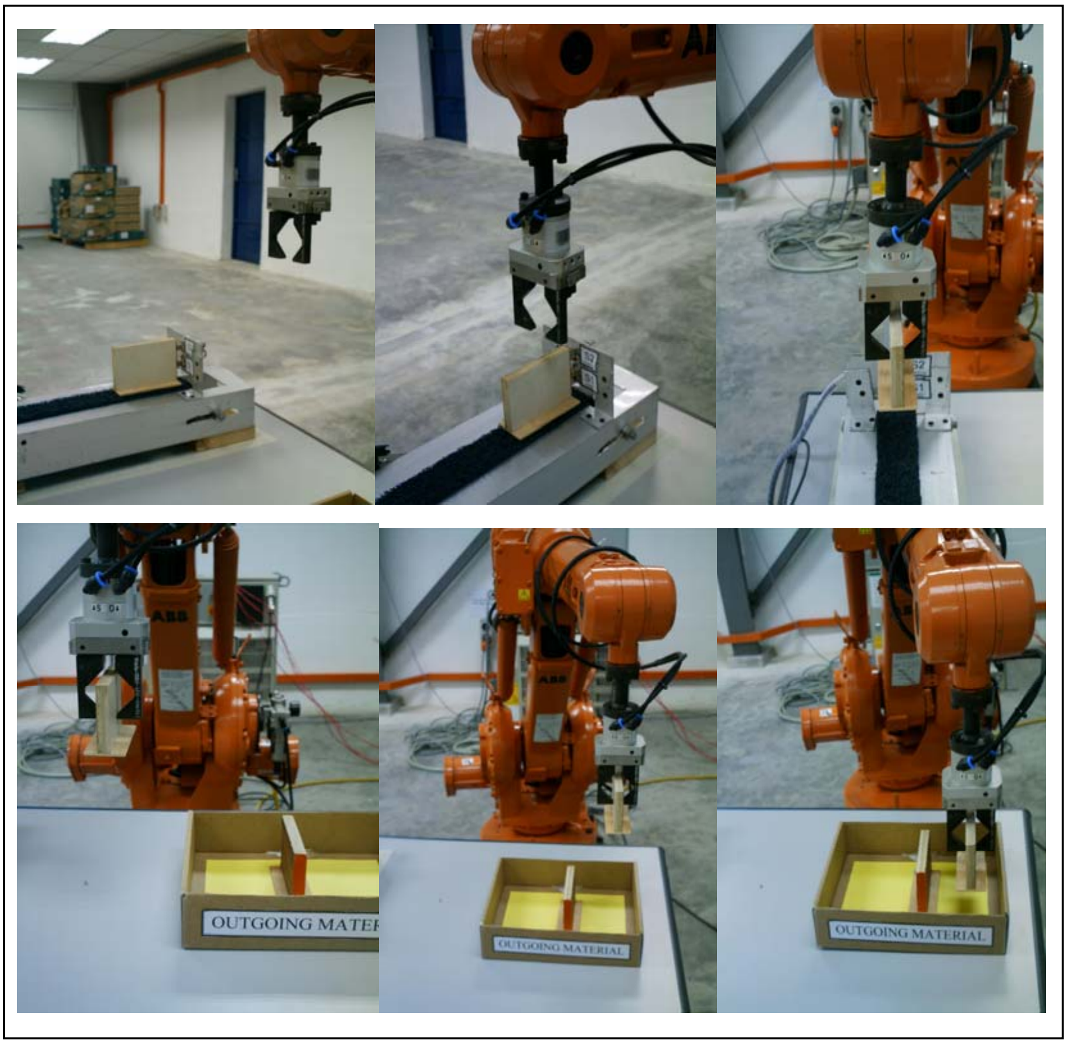


Figure 4.31: The operation of the IRB 1400 robot in the system

CHAPTER V

CONCLUSION & SUGGESTIONS

5.1 Conclusion

As for conclusion, the project's objective is to develop Pick and Place System using IRB 1400 robot was successfully achieved. The IRB 1400 Industrial Robot was able to integrate with the proximity sensor in order to complete the system. The Digital I/O DSQC 328 was the one of optional digital unit inside S4Cplus controller that used to integrate between the controller robot and the sensor. This optional digital unit was important in order to integrate the robot with other system and to enhance the application of robot in the industry.

This project will give idea and suggestions to develop the multi-purpose handling in the manufacturing industry by using ABB IRB 1400 Robot.

5.2 Future Recommendation

There are many ideas and suggestion can be added towards developing this system in the future especially in the manufacturing industry. Robots are being used today to do the tasks that are too dirty, dangerous, difficult, repetitive or dull for humans. This usually takes the form of industrial robots used in manufacturing lines.Manufacturing remains the primary market where robots are utilized.

As one of the recommendations is the robot can be attached with variation of sensor to make it work in multi complex task such as to detect color or differentiate the shape of object. There are many sensors nowadays and the choices of sensors could be varied, but the selection of the sensors must be applicable to the robot.

It is hoped that the suggestions for further work on IRB 1400 Robot will be given an idea to interested students to continue improving the robot until it attained commercial value.