UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DESIGN AND IMPLEMENTATION OF MULTIPLE BOX SIZE SORTING SYSTEM USING PROFIBUS / PROFINET INDUSTRIAL NETWORK

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Electrical Engineering Technology (Industrial Automation & Robotics) with Honours.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

By

MUHAMMAD FAHMI BIN YAHAYA

B071710906

961012-14-6537

FACULTY OF ELECTRICAL AND ELECTRONIC ENGINEERING TECHNOLOGY

2020

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

Tajuk: DESIGN AND IMPLEMENTATION OF MULTIPLE BOX SIZE SORTING SYSTEM USING PROFIBUS / PROFINET INDUSTRIAL NETWORK.

Sesi Pengajian : 2020

Saya **MUHAMMAD FAHMI BIN YAHAYA** mengaku membenarkan Laporan PSM ini disimpan di Perpustakaan Universiti Teknikal Malaysia Melaka (UTeM) dengan syarat-syarat kegunaan seperti berikut:

1. Laporan PSM adalah hak milik Universiti Teknikal Malaysia Melaka dan penulis.
2. Perpustakaan Universiti Teknikal Malaysia Melaka dibenarkan membuat salinan untuk tujuan pengajian sahaja dengan izin penulis.
3. Perpustakaan dibenarkan membuat salinan laporan PSM ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. **Sila tandakan (X)

☐	**SULIT***	**Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia sebagaimana yang termaktub dalam AKTA RAHSIA RASMI 1972.**
☐	**TERHAD***	**Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan.**
☒	**TIDAK TERHAD**	

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Yang benar,

.....
MUHAMMAD FAHMI BIN YAHAYA
Alamat Tetap:
Blok 6D-T.04-U.06, Fasa 6,
Presint 9, 62250, W.P.Putrajaya.
Tarikh:

Disahkan oleh penyelia:

MOHAMED AZMI SAID

.....
EN. MOHAMED AZMI BIN SAID
Cop Rasmi Penyelia

TS. MOHAMED AZMI BIN SAID
Pensyarah Kanan
Jabatan Teknologi Kejuruteraan Elektrik
Fakulti Teknologi Kejuruteraan Elektrik dan Elektronik
Universiti Teknikal Malaysia Melaka

Tarikh: 23 FEB. 2021

*Jika Laporan PSM ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh laporan PSM ini perlu dikelaskan sebagai SULIT atau TERHAD.

DECLARATION

I hereby, declared this report entitled DESIGN AND IMPLEMENTATION OF MULTIPLE BOX SIZE SORTING SYSTEM USING PROFIBUS / PROFINET INDUSTRIAL NETWORK is the results of my own research except as cited in references.

Signature: ……

Author : **MUHAMMAD FAHMI BIN YAHAYA**

Date: 23 FEB. 2021

UTeM
اونيۏرسيتي تيکنيکل مليسيا ملاک
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

APPROVAL

This report is submitted to the Faculty of Electrical Engineering Technology of Universiti Teknikal Malaysia Melaka (UTeM) as a partial fulfilment of the requirements for the degree of Bachelor of Electrical and Electronic Engineering Technology (Industrial Automation & Robotics) with Honours. The member of the supervisory is as follow:

Signature: MOHAMED AZMI SAID .....

Supervisor : **EN. MOHAMED AZMI BIN SAID**

TS. MOHAMED AZMI BIN SAID
Pensyarah Kanan
Jabatan Teknologi Kejuruteraan Elektrik
Fakulti Teknologi Kejuruteraan Elektrik dan Elektronik
Universiti Teknikal Malaysia Melaka

23 FEB. 2021

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

ABSTRAK

Pada masa kini, rangkaian industri adalah komponen yang paling diperlukan untuk berkomunikasi dengan mesin, robot dan komputer. Rangkaian industri boleh meningkatkan produktiviti kerana ciri-cirinya yang menyediakan pemantauan masa nyata, menyekat akses daripada peranti yang tidak dibenarkan dan membenarkan berbilang peranti berkomunikasi dengan cekap supaya robot atau mesin boleh beroperasi dengan kejituan dan kelajuan. Antara pengeluar robot utama didapati menggunakan rangkaian perindustrian ialah ABB Robotics dan digunakan dalam sistem penyusunan tetapi bagi melaksanakan tugas itu peranti komunikasi diperlukan untuk pemindahan data. Hal ini kerana ia adalah proses yang memerlukan kelajuan dan kejituan yang berulang, robot industri ini penting untuk meningkatkan produktiviti. Projek ini memerlukan robot industri ABB IRB 120 untuk melakukan ‘ pick and place ’ untuk operasi menyusun dari ‘ konveyer ’ ke ‘pallets’. Simulasi Robotstudio yang digunakan membolehkan pengguna untuk reka bentuk robot, simulasikan dan penyelesaian beberapa masalah sebelum ujian pada lengan robot yang sebenar. DeviceNet berkomunikasi dengan alat kawalan robot IRC 5 yang berfungsi sebagai memori robot yang menyimpan aturcara dan menentukan bagi melaksanakan sesuatu tugasan. Analisa kuantitatif serta kualitatif telah dilaksanakan bagi penilaian optimum aturcara robot industri bagi tugasan penyusunan dan pemilihan aturcara paling baik untuk mengawal ketepatan dan kelajuan.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

ABSTRACT

Today, industrial networks are the most needed component to communicate with machines, robots and computers. Industry networks can increase productivity because of its features that provide real-time monitoring, restrict access from unauthorized devices and allow multiple devices to communicate efficiently so that robots or machines can operate with precision and speed. One of the leading robots manufacturers using industrial networks is ABB Robotics and is used in the compilation system but in order to perform that task communication devices are required for data transfer. This is because it is a process that requires constant speed and precision, this industrial robot is essential to increase productivity. The project requires ABB industry robot IRB 120 to perform a 'pick and place' for operations from 'conveyor' to 'pallets'. Robotstudio simulation used allows the user to design the robot, simulate and solve some problems before testing on the actual robot arm. DeviceNet communicates with an IRC 5 robot controller that functions as a robot brain that stores programs and decides which program to be executed in a suitable operation. Analysis based on quantitative and also qualitative has been use to evaluate the optimal methods of industrial robot programming for compilation operations and the selection of the best programs to control accuracy and speed.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DEDICATION

The thesis is dedicated to my supervisor, loving parents, family and all my classmate from BEEA for enormous support that encouraged and has helped me to finish this bachelor degree project effectively. I am so grateful to all of them for trusting me.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

ACKNOWLEDGEMENTS

I feel to acknowledge a deep sense of gratitude to my powerful supervisor, Sir Mohamed Azmi bin Said due to his encourages also a lot of guidance for troubleshooting problems in this bachelor degree projects. He also give advice to gather as many knowledge from many sources in order to successfully completed this project and ensure that this project will be a successful final projects.

Besides that, I want like to express my thousands of thanks to all my friend from classes BEEA due to their ideas on how to design my final project and also help to solve a few boundary that occur during the progress of my bachelor degree projects.

Next, to the loving family of mine which are also helping to give me enough moral and financial assistant that I needed in order to successfully complete this final projects. Lastly, I want to thanks for all people that support me in providing many suitable solution to help me completed this final year project according to given timeline.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

TABLE OF CONTENT

		PAGE
LIST OF FIGURES		**xii**
LIST OF TABLES		**xv**
LIST OF APPENDICES		**xvii**
LIST OF ABBREVIATIONS		**xviii**
CHAPTER 1	**INTRODUCTION**	**1**
1.1	Introduction	1
1.2	Project Background	1
1.2.1	**Introduction of Industrial Robot**	**2**
1.3	Problem Statement	3
1.4	Objective of Research	3
1.5	Work Scope of Project	4
1.6	Report Outline	4
CHAPTER 2	**LITERATURE REVIEW**	**5**
2.1	Introduction	5
2.2	Industrial Robot	5
2.2.1	**ABB Robot IRB 120**	**6**
2.2.2	**IRC 5 Controller**	**8**
2.2.3	**End Effector**	**9**

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2.3 Industrial Network 10

2.3.1 Profibus 11

2.3.2 Profinet 13

2.3.3 DeviceNet 15

2.4 Sorting system 19

2.5 Software 20

2.5.1 Robotstudio 20

2.5.2 Solidworks 22

CHAPTER 3 METHODOLOGY 23

3.1 Introduction 23

3.2 Preliminary Research 25

3.3 Design DeviceNet Input & Output 25

3.4 Design system and smart component 35

3.5 Program robot using RAPID and Robotstudio GUI 39

3.6 Flowchart of project simulation 40

3.7 Rapid code of simple pick and place operation 41

3.8 Simulation, Optimization and Troubleshooting 43

CHAPTER 4 RESULT AND DISCUSSION 44

4.1 Introduction 44

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

4.2 Result 44

4.2.1 System Model 44

4.2.2 Simulation 47

4.2.3 Simulation Result 50

CHAPTER 5 CONCLUSION & FUTURE WORKS 54

5.1 Introduction 54

5.2 Project Summary 54

5.3 Future Works 54

5.4 Conclusion 55

REFERENCES 57

APPENDIX 59

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

LIST OF FIGURES

Figure 1.1: Usage of robot with DeviceNet configuration by sector worldwide 2

Figure 2.1: IRB 120 robot manipulator axis 6

Figure 2.2: ABB IRB 120 robot dimension 7

Figure 2.3: Example setup of ABB IRC5 controller connection 8

Figure 2.4: Schunk Gripper 9

Figure 2.5: Vacuum End Effector 9

Figure 2.6: Profibus Network Address 12

Figure 2.7: Profinet differences type of Network Address 14

Figure 2.8: DeviceNet in 7 layer of OSI Model 16

Figure 2.9: DeviceNet cable combination 17

Figure 2.10: Five types of DeviceNet Cable 17

Figure 2.11: DeviceNet Terminating Resistor 18

Figure 2.12: DeviceNet Network Topology 19

Figure 2.13: Robotstudio Software Logo 20

Figure 2.14: Software Environment of Robotstudio 21

Figure 2.15: Solidworks Logo 22

Figure 3.1: Project Main Part 23

Figure 3.2: Work flow for programming the robot 24

Figure 3.3: Create solution 26

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Figure 3.4: Selection of DeviceNet in industrial network 26

Figure 3.5: Robot appear in workstation 27

Figure 3.6: Instance editor for editing industrial network 28

Figure 3.7: Configuring digital Input signal 29

Figure 3.8: Configuring digital Output signal for Conveyer 29

Figure 3.9: Configuring digital output signal for sensor activator 30

Figure 3.10: Configuring digital output signal for Vacuum Gripper 30

Figure 3.11: Controller digital input and output signal 31

Figure 3.12: DSQC setup 31

Figure 3.13: DSQC 652 implemented in system of DeviceNet 32

Figure 3.14: DSQC circuit 32

Figure 3.15: IRB 120 and conveyer imported from library 35

Figure 3.16: Vacuum Gripper attached to robot arm 36

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Figure 3.17: Vacuum Gripper Smart component design 36

Figure 3.18: High box Smart component design 37

Figure 3.19: Low box Smart component design 37

Figure 3.20: Conveyer high sensor Smart component design 38

Figure 3.21: Conveyer low sensor Smart component design 38

Figure 3.22: Station logic connection 39

Figure 3.23: Flowchart of pick and place for sorting operation 40

Figure 3.24: RAPID code of simple pick and place operation 42

Figure 4.1: Modelling of the station 44

Figure 4.2: Modelling of conveyer in SolidWorks 45

Figure 4.3: Position of High Sensor 46

Figure 4.4: Position of Low Sensor 46

Figure 4.5: Start simulation 48

Figure 4.6: Robot Arm Pick High Box 48

Figure 4.7: Robot Arm Place High Box 48

Figure 4.8: Low Box Arrive at Low Sensor 49

Figure 4.9: Robot Arm Pick Low Box 49

Figure 4.10: Robot Arm Place Low Box 50

Figure 4.11: Graph Zone VS Accuracy 53

UTeM
اونيۏرسيتي تيکنيکل مليسيا ملاك
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

LIST OF TABLES

Table 1: Connection to connector X1 33

Table 2: Connection to connector X2 33

Table 3: Connection to connector X3 34

Table 4: Connection to connector X4 34

Table 5: Methods of modelling and features 45

Table 6: Sorting of a high box using velocity V10 49

Table 7: Sorting of a high box using velocity V100 49

Table 8: Sorting of a high box using velocity V1000 50

Table 9: Sorting of a low box using velocity V10 50

Table 10: Sorting of a low box using velocity V100 50

Table 11: Sorting of a low box using velocity V1000 51

Table 12: Accuracy test for robot arm 51

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

LIST OF APPENDICES

APPENDIX	TITLE	PAGE
1	The Rapid Code of pick and place for sorting high and low box using Vacuum Gripper.	59
2	Gantt chart PSM 1	63
3	Gantt chart PSM 2	64

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

LIST OF ABBREVIATIONS

ABBREVIATIONS

PLC	**Programmable Logic Circuit**
CAD	**Computer Aided Design**
IRB	**Industrial Robot**
DOF	**Degree of freedom**
IRC	**Industrial Robot Controller**
GUI	**Graphical User Interface**
DEVICENET	**Device Network**
CAN	**Controller Area Network**
LAN	**Local Area Network**
PROFIBUS	**Process Field Bus**
PROFINET	**Process Field Net**
MovL	**Move Link**
MovJ	**Move Joint**
ODVA	**Open DeviceNet Vendors Association**
OSI	**Open System Interconnection**
CIP	**Common Industrial Protocol**
PID	**Proportional Integral Derivative**
PC	**Personal Computer**
IEEE	**Institute of Electrical and Electronics Engineers**

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

TCP	**Transmission Control Protocol**
UDP	**User Datagram Protocol**
IP	**Internet Protocol**
HMI	**Human Machine Interface**
MAC	**Media Access Control**
EDS	**Electronic Data Sheet**
DSQC	**Deterministic Secure Quadrant Controller**
LED	**Light Emitting Diode**
DP	**Decentralized Periphery**
PUO	**Profibus User Organization**
PCI	**Peripheral Component Interconnect**

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

CHAPTER 1

INTRODUCTION

1.1 Introduction

In the chapter of introduction it will introduce the development of the project that includes this project's additional background, problems statements, objective and the work scope of this project. The introduction also will elaborate the purpose of this project and indicate the importance of this project.

1.2 Project Background

In this project it involved a networking system which requires two or maybe more device that are connected with each other for sharing resources, provide secure electronic communication or transfer of files. The device on a certain networks may be connected using cable, radiowave, satellite or beams of infrared. Network type can be divided into two which is public and private networks. Public network are network where anyone can access while private networking are access restricted to certain people such as corporate network, school network and industrial network. Many industrial network uses DeviceNet to communicate with other devices. It was communication tools for allowing logical talk between many controlled device and PLC. It is developed by Allen Bradley or also known as Rockwell Automation. DeviceNet is a network manage by Open DeviceNet Vendors Association (ODVA). ABB is one of the company that uses DeviceNet to communicate between PLC and robot arm.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

1.2.1 Introduction of Industrial Robot networking system

An industrial robot is used in many automation system covering the entire world. The Industrial robot consist of robotic electrical and mechanical system which can be modified with many different program to achieve consistency, precision and also accuracy when performing dangerous and cycle tasks, the robots is increasingly used on a variety of industries or applications. However most industrial robot uses DeviceNet to communicate with other devices. Without proper communication the robot cannot perform task successfully so this is where DeviceNet fit in because it was popular networking system for real time applications. Besides that, the DeviceNet utillize Controller Area Network or also known CAN to acts as the important technologies that defines application layer covering variety of devices type. The figures below shows the usage of robot with DeviceNet configuration worldwide.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

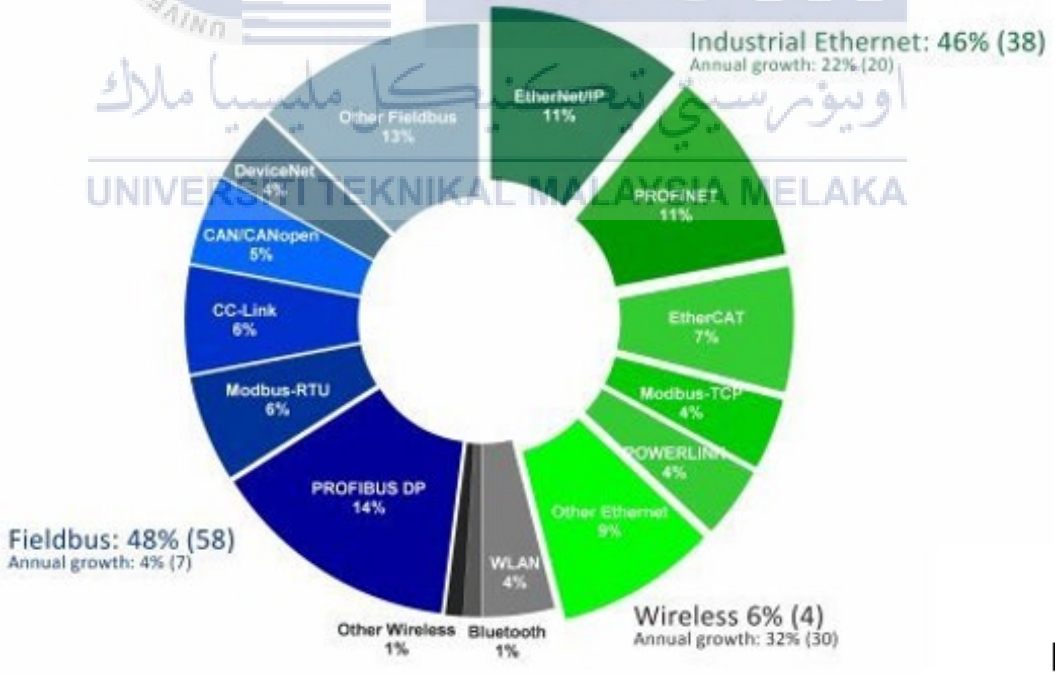

Figure 1.1: Usage of robot with DeviceNet configuration by sector worldwide

The figure above which is figure 1.1 shows the number of robot demand increases by sector and will continue to increase in the future. The ABB is one of the top company for manufacturing industrial robot in variety of type for different task. One of the popular robot is ABB IRB 120 which is the smallest in size for industrial robot designed by ABB that can support load up to 3kg and robot only weight at 25kg. The IRB 120 are used for this projects together with DeviceNet.

1.3 Problem Statement

Sorting task is a repetitive process and requires stable speed but it must avoid misplaced so that production will not loss and product will not ship to wrong place. By using normal workers it will takes many hour for this sorting task and probably will causes certain problems that will affect productivity of company and without using the proper communication device the sorting process will be difficult.

1.4 Objective of Research

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

The objective for this final project are explained below:

1. To create and analyze the output of pick and place by industrial robot for sorting purposes using ABB IRB 120 which are integrated with conveyor.
2. To fabricate and assemble the component used for communication with pick and place by industrial robot.
3. To run RAPID program for specific task that used in pick and place industrial robot by using Robotstudio simulation software.
4. To test run the program on the actual IRB 120 to pick and place for sorting box from conveyor system.

1.5 Work Scope of Project

The scopes of this project are as follows:

1. The project use simulation of ABB Robotstudio before test run in actual ABB IRB120 industrial robot arm.
2. The project use actual ABB IRB120 industrial robot to obtain the output which is sorting box according to size.

1.6 Report Outline

The structure and layout for this thesis are as follows:

Chapter 1 – Introduction: This chapter will provide a concise explanation of the implementation of this project, including the statement of problems, objectives and scope of the project.

Chapter 2 – Literature Review: This chapter will discuss the industrial robot, the software environment, and ABB Robotstudio.

Chapter 3 – Methodology: This chapter will describe the methodology for this project, which will explain the details of each method used to develop this project and the procedure used to complete this project..

Chapter 4 – Result & Discussion: This chapter will justify the results of the simulation software output data and analyze the data..

Chapter 5 – Conclusion & Recommendation: This chapter will conclude on the whole project and will be recommended for future work.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The Literature Review is a systematic analysis of previous research on a specific topic. This tells the researcher what is known and what is not yet known about this topic, thereby providing a justification or need for a new investigation. This chapter is written on the basis of a previous research, essay, thesis, journal or other type of published knowledge in a circle within the scope of the project. To ensure this project is successfully design, several studies and some analysis have been explored in order to find the correct details on the sorting system using ABB robot IRB 120.

2.2 Industrial Robot

At first industrial robot are used to perform simple task such as pick and place. Industrial robots are combination of mechanical system, electronic system and programmable devices that are built to help human in manufacturing process. They substituted human beings for many process such as monotonous, repetitive, hard, and dangerous activities. When robots were able to achieve more accurate position and also the ability of variety sensors, more complex applications can be achieved. In general terms, the uses of industrial robotic today are categorized into three type of group which is handling material, process operation and manufacture (Johanna Wallen, 2008) [1]. For this project Industrial robots are typically used for sorting purposes to reduce costs, maximize performance, improve the quality of the product and remove hazardous activities.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2.2.1 ABB Robot IRB 120

The IRB120 is the industrial robot being used in this project. This is the smallest size robot designed by ABB. The robot are build with six degree of freedom (6 DOF), weighted at 25 kg, support load of 3 kg and designed for a horizontal distance of 580 mm. Consist of lightweight aluminium structures and equipped with powerful compact motor. The robot can achieve precision and reliability to a wide range of applications (Amanda Lima, 2018) [2]. This project is using IRB 120 for sorting purposes because it is easy to integrate, fast, accurate and agile.

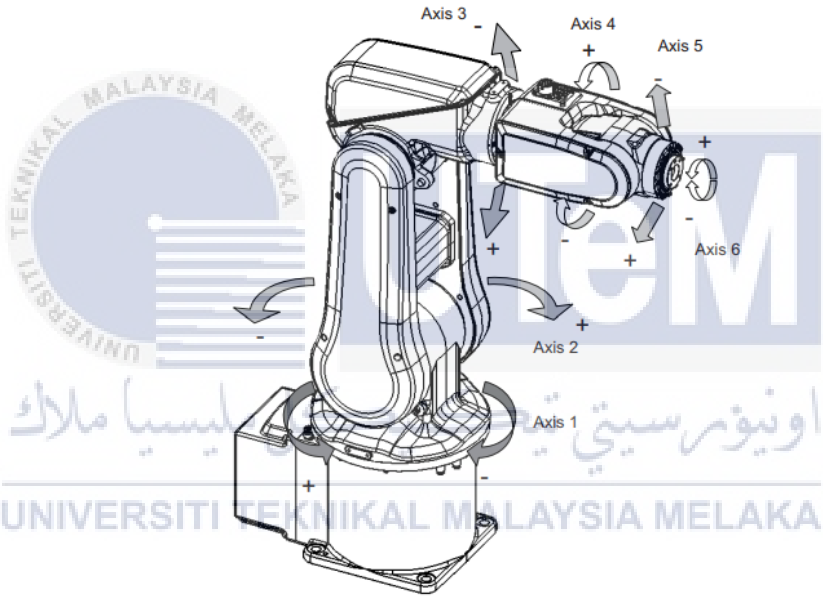

Figure 2.1: IRB 120 robot manipulator axis

By using IRB 120 robot with equipped manipulator that has six degree of freedom will make it easier to pick and place object for sorting purposes. This robot arm, which is controlled by a microcontroller, solid base, elbow, shoulder, a functional gripper and wrist rotation. The robot gripper was built to acts as an end-effector that is able to capturing diverse object from within the arm's work space. The aim of the design is to allow fine manipulation in performance of pick and place tasks. The PID's controller is implemented on each of the motor. The device microcontroller uses forwards kinematics and control position of DC motors that is accurate.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA