UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DESIGN OF SAFETY SYSTEM FOR COMAU ARTICULATED ROBOT

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for Bachelor Degree of Manufacturing Engineering (Robotics and Automation) with Honours.

by

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DECLARATION

I hereby, declared this report entitled Design of Safety System for COMAU Articulated Robot is the results of my own research except as cited in references.

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Date : ……

APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Robotics and Automation) with Honours. The member of the supervisory committee are as follow:

……

(Project Supervisor)

(PROF. DR. BASHIR MOHAMAD BIN BALI MOHAMAD)

ABSTRACT

This project report presents the work done on the design of safety system for COMAU Articulated Robot in the Robotics and Automation Laboratory of Faculty of Manufacturing Engineering, Universiti Teknikal Malaysia Melaka. The objectives of this project are to design the safety system and to develop a soft prototype of the design. Two ideas of design are proposed. The ideas are compared using some criterias in order to select the best idea. The selected idea is developed using the proposed methodology. The software for designing the safety system is chosen based on the author knowledge and experience in using the software. The chosen idea has been developed using CATIA software. The safety system design requirement is based on the condition where the robot is installed. The list of all the parts need to be fabricated and the standard parts to be purchased are presented in this report. Detail parts and their specifications are presented in solid model with the dimensions which fulfills the requirement for future fabrication. All the project objectives are managed to be achieved. For further work it was suggested to fabricate, install, and test the safety system and also improved the design of the safety system (if necessary) based on the test result.

ABSTRAK

Laporan projek membentangkan kerja yang dilakukan pada reka bentuk sistem keselamatan untuk Robot COMAU Articulated dalam Makmal Robotik dan Automasi Fakulti Kejuruteraan Pembuatan, Universiti Teknikal Malaysia Melaka. Objektif projek ini adalah untuk mereka bentuk sistem keselamatan dan untuk membangunkan reka bentuk prototaip. Dua idea reka bentuk yang dicadangkan. Idea-idea ini berbanding menggunakan beberapa kriteria untuk memilih idea yang terbaik. Idea dipilih dibangunkan menggunakan metodologi yang dicadangkan. Perisian untuk mereka bentuk sistem keselamatan yang dipilih berdasarkan pengetahuan penulis dan pengalaman dalam penggunaan perisian. Idea dipilih telah dibangunkan dengan menggunakan perisian CATIA. Keperluan reka bentuk sistem keselamatan adalah berdasarkan kepada keadaan di mana robot dipasang. Senarai semua bahagian perlu direka dan bahagian-bahagian yang standard yang akan dibeli dibentangkan dalam laporan ini. Bahagian terperinci dan spesifikasi mereka dibentangkan dalam model pepejal dengan dimensi yang memenuhi keperluan untuk fabrikasi masa depan. Semua objektif projek yang berjaya akan dicapai. Untuk kajian lanjut ia dicadangkan untuk mereka, memasang, dan menguji sistem keselamatan dan juga menambah baik reka bentuk sistem keselamatan (jika perlu) berdasarkan keputusan ujian.

DEDICATION

Specially dedicated to my beloved family Hj. Mohd Nawi bin Isa and Wan Kasmani bt Mohd Yusoff, who has supported me. I also dedicated this report to my lecturer, technician, and my friends for helping during the research activities. There is no doubt in my mind that without their continued support and counsel I could not have completed this process.

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Furthermore, I would also like to acknowledge with much appreciation the crucial role of the staff of Mr. Ahmad Faizul, who gave the permission to visit the Robotics Laboratory to make further study on the Comau Articulated Robot to complete my project on safety system. A special thanks goes to all my team mates, who help me assemble the parts and gave suggestion about the project. I have to appreciate the guidance given by the panels, especially in my project presentation that has improved my presentation skills. Thanks to their comment and advices.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

COMAU	-	COnsorsio Machine Utensil
CAD	-	Computer-Aided Design
CNC	-	Computer Numerical Method
CATIA	-	Computer Aided Three-Dimensional Interactive Application
3D	-	Third Dimension
ANSI	-	American National Standards Institute
ISO	-	International Organization for Standardization
RIA	-	Robotic Industries Association
OSHA	-	Occupational Safety and Health Administration

CHAPTER 1

INTRODUCTION

1.1 Introduction

Today, robots are used in many different fields and applications, and their safety-related problems have grown significantly. A robot system is more than the hardware; it includes any devices interfaced to the robot to manipulate of the work cell. Each new field and application may call for particular precautions for operators, maintenance workers, robot systems, and so on. Both manufacturers and users did not receive a lot attention about robot safety in the previous. This situation is converting over the last few years, which is an accident of robot could be one of the parameters. In fact, safety standards for industrial robots are under discussion in several countries, and the International Organization for Standardization (ISO) has already used a lot of work in this direction. (B. S. Dhillon, 1991).

This project is fulfill to figure out the latest pattern and fresh form of safety system for COMAU Articulated Robot. The latest technology on safety system will be explored and searched such as the latest sensor and the problem faced by existing workplace.

1.2 Problem statement

The problem of the existing COMAU Articulated Robot is that the safety system is not fully protect the users or people from being injured by the robot. It can be dangerous to the users and becoming a problem with the robot for performing tasks. This is a serious situation where to solve this problem, a fully protected safety system need to be designed to protect robot users that nearby the workspace.

Figure 1.1 : The workspace area of COMAU Articulated Robot in Robotics Laboratory, UTeM.

1.2 Objectives

i. To design a safety system for the COMAU Articulated Robot.

ii. To develop a soft prototype of the above designed safety system.

1.3 Scope of the Project

a) To design a safety system for COMAU Articulated Robot based on several criterias in order to meet the following requirements:
   i. To safeguard the robot operator, robot maintenance staff and visitors.
   ii. To safeguard the robot from being damaged in the case of accident.

b) To develop a soft prototype of the designed safety system using a suitable software.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

There are many condition where the robot accidents can happen, such as through in programming, program touch-up, services, repairing, setup, examining, or modifying. During these operations, the related person such as the operator, a programmer, or maintenance personnel may be injured if they are working within the robot's working envelope (OSHA, 1999). Safety results from a detailed plan to operate in a secure way; as a result, safety consideration must be part of every machine and work-cell design. Introduction of safe robot operating procedures is very important at the start of any robot study.

In this new era, industrial robot includes the machine from lightweight units to large machines which are sufficient to command and move around the objects which weighted 1000 kg. It can be seen clearly the consequences depend a lot along the certain robot and its application, so the originating point for safeguarding a robot will always be a risk assessment. In several robot diligences, the relevant method for severe injury is comparatively increased, then it is consequential to construct-out the hazards as far as it can. Thus, safety must be occur during the early stage of preparation and the design process in the robotic system.

In all aspects in safety of machine, involving robot programming, the following ranking approach should be applied:

a) Obseve the hazards
b) The hazards that cannot be planned away is offered
c) Making use of the personal protective equipment, training, and employment of the safety system in order to lower the residual risks.

2.2 COMAU Robots

The SMART NS robots in the case study are from the COMAU family of robots that are plotted to linear applications.

The main robot characteristics are listed below:

i) Pre-engineered for determination with a sort of optional devices;
ii) All reducers are oil lubricated, except axis 6, where lubricating grease is put on rather;
iii) The option of linking electrical and pneumatic services to the forearm;
iv) Decreased wrist proportions enable high capacity, orientation in small distances;
v) Large work area, received by bringing axis 2 forward in intercourse to axis 1;
vi) High repeatability;
vii) Stage of security (IP67 for the wrist body and IP65 for the rest of the robot);
viii) No particular devices for axis recompense.

Axis movements are driven by brushless motors, while gesture is only transmitted via mechanical gear reducers.

The vital robot fittings involved:

i. An appropriate welding dressing;

ii. An internal pneumatic line with upper association on the back of the forearm;

iii. Wiring that incorporates a service line with a connector on the upper plate next to the pneumatic connection;

iv. Flat surfaces and threaded holes on the upper part of the forearm that can be used to gather fixtures;

SMART NS robots covers various type of aspects in order to suit the application demands. COMAU Robot that involved in this case study are SMART NS 12-1.85 and SMART NS 16-1.65 as shown in Figure 2.1 and Figure 2.2.

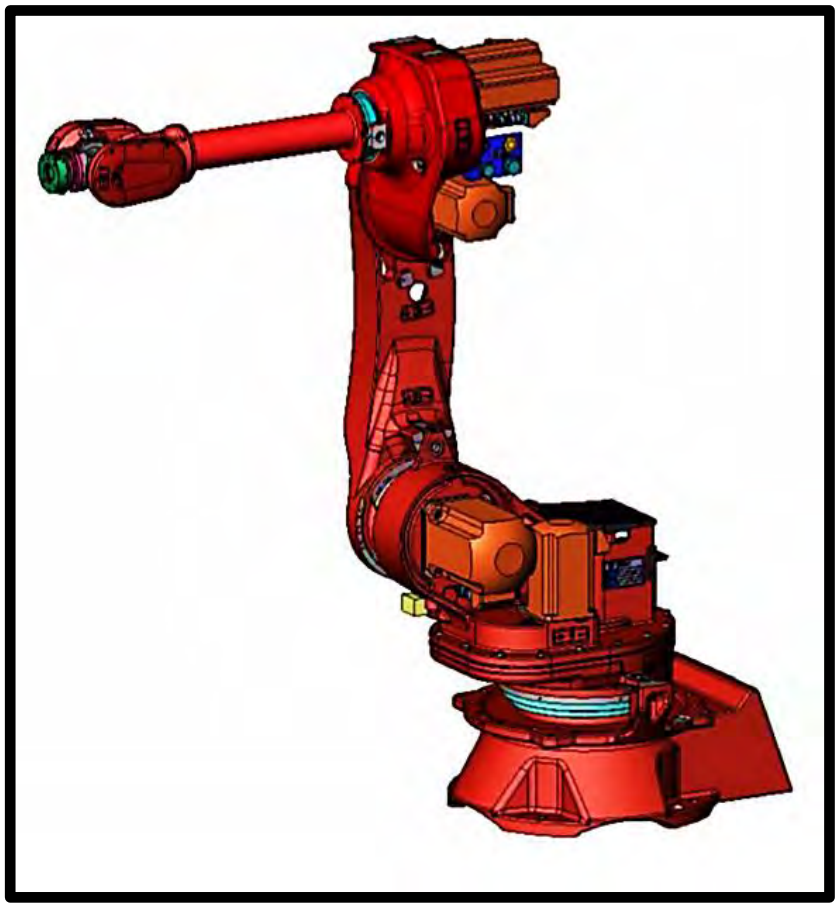

Figure 2.1 : SMART NS 12-1.85, COMAU Articulated Robot (COMAU Robot Manual, 2005)

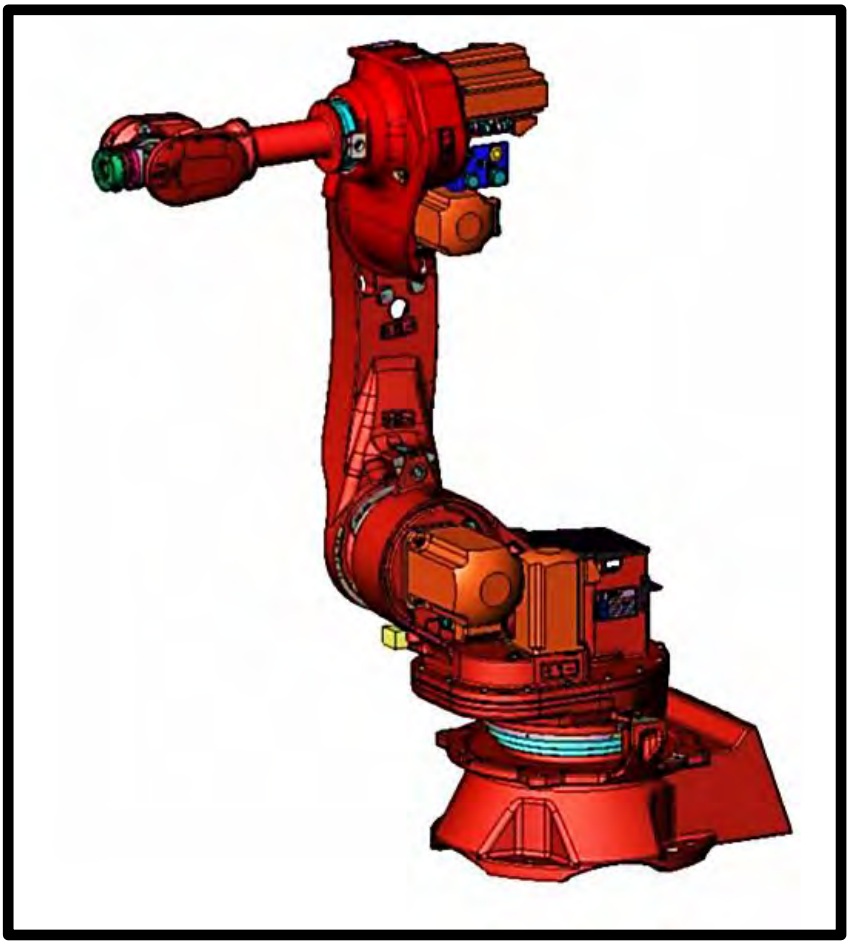

Figure 2.2 : SMART NS 16-1.65, COMAU Articulated Robot (COMAU Robot Manual, 2005)

There are several features of COMAU robot such as payload, working envelope and reachable area which are different in certain conditions but it is proved that they are typically same based on the similar functioning rules.

Table 2.1 shows the available versions of SMART NS robots.

Table 2.1 : SMART NS Version Available (COMAU Robot Manual, 2005)

Version	**Payload**	**Reach**
SMART NS 12-1.85	12 kg (26.45 lb)	1850 mm (72.83 in)
SMART NS 16-1.65	16 kg (35.27 lb)	1650 mm (64.96 in)

2.2.1 Technical Characteristics

Figure 2.3 shows the characteristics and performance of the SMART NS robots.

VERSION		NS 12-1.85	NS 16-1.65
Structure / n° axes		Anthropomorphous / 6 axis	Anthropomorphous / 6 axis
Load at wrist		12 kg *(26.45 lb)*(1)	16kg *(35.27lb)*(1)
Additional load on forearm [kg]		10kg 22.04lb(2)	10kg 22.04lb(2)
Torque axis 4		39 Nm	41 Nm
Torque axis 5		39 Nm	41 Nm
Torque axis 6		20 Nm	23 Nm
Stroke / (Speed)	Axis 1	+/- 180°(155°/s)	+/- 180° (155°/s)
	Axis 2	+155°/-60°(155°/s)	+155°/-60°(155°/s)
	Axis 3	+110°/-170°(170°/s)	+110°/-170°(170°/s)
	Axis 4	+/- 2700° (360°/s)	+/- 2700°(360°/s)
	Axis 5	+/- 125°(350°/s)	+/- 125°(350°/s)
	Axis 6	+/- 2700°(550°/s)	+/- 2700°(550°/s)
Maximum horizontal reach		1850 mm *(72.83in)*	1650 mm *(64.96in)*
Repeatability [mm]		+/- 0.05 mm *(0.0019in)*	+/- 0.05 mm *(0.0019in)*
Robot weight		335 kg *(738.54lb)*	335 kg *(738.54lb)*
Tool coupling flange		ISO 9409-1-A63	ISO 9409-1-A63
Motors		AC brushless	AC brushless
Position measurement system		with encoder	with encoder
Total power installed		3 kVA / 4,5 A	3 kVA / 4,5 A
Protection class		IP65 / IP67 (3)	IP65 / IP67 (3)
Working temperature		0 [°C]÷ +45[°C] *+32[°F]÷+113 [°F]*	0 [°C]÷ +45[°C] *+32[°F]÷+113 [°F]*
Storage temperature		- 40[°C] ÷ + 60[°C] *-40[°F]÷ +140 [°F]*	- 40[°C] ÷ + 60[°C] *-40[°F]÷ +140 [°F]*
Colour of robot (standard)		Red RAL 3001	Red RAL 3001
Assembly position		Floor Ceiling Tilted (45°)	

Figure 2.3 : Characteristics and Performance of the SMART NS Robots (COMAU Robot Manual, 2005)

2.2.2 Working Envelope of SMART NS 16-1.65

Figure 2.4 shows the working envelope of SMART NS 16-1.65 robot, with the values of A= 1.951 mm, B= 1.651 mm, C= 950 mm, D= 957 mm, E= 685 mm.

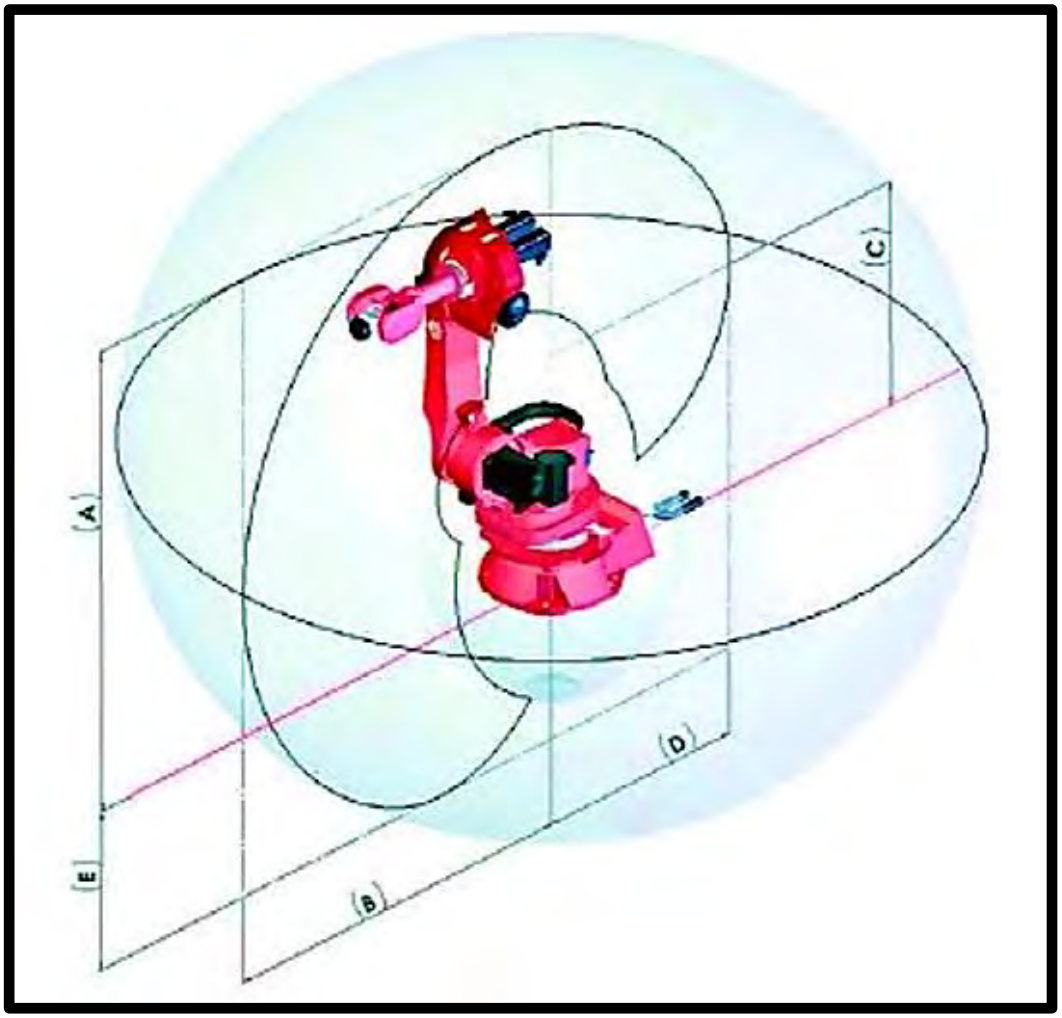

Figure 2.4 : SMART NS 16-1.65 working envelope (COMAU Robot Manual, 2005)

2.2.3 Operating Areas and Robot Overall Dimensions

Figure 2.5 and Figure 2.6 shows the operating areas and overall dimension of SMART NS 16-1.65 from the top view, front view and side view.

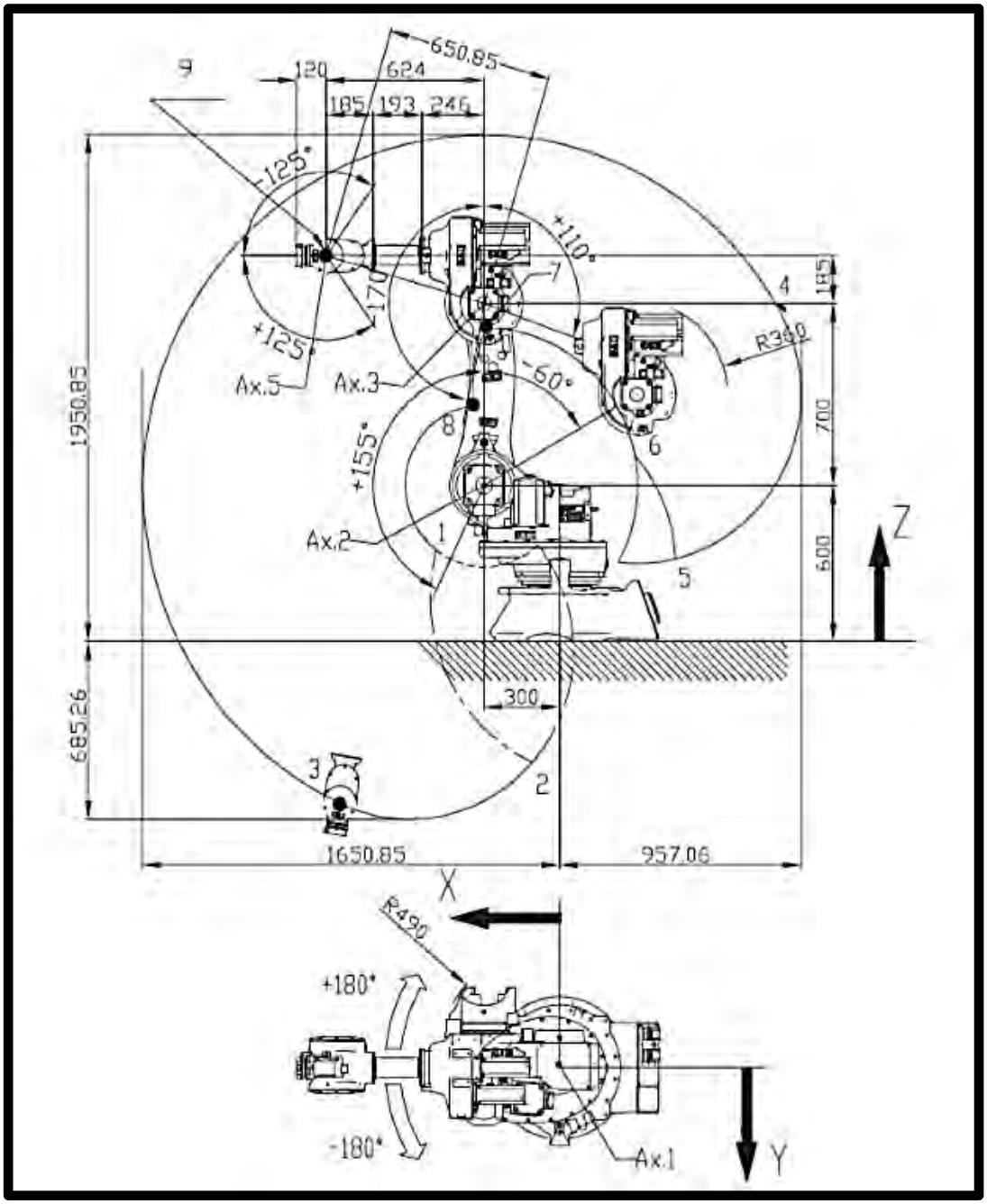

Figure 2.5 : Top and side view of operating areas and overall dimension of SMART NS 16-1.65 (COMAU Robot Manual, 2005)