German Jordanian University

School of Applied Technical Sciences

Department of Mechatronics Engineering

ME551 – Robotics

Palletizing robot “IRB 460”

Prepared By

Tala Haddadin 20181102009
Celine Alarmouti 20189102005
Amro Habboush 20181102011

Supervised By

Dr. Mutaz Ryalat

Second Semester, 2022

1 Preliminary Matter

1. Abstract

The ABB IRB 460 is a four-axis compact industrial robot designed specifically for factory palletizing operations. Common industrial robots have six axes, which gives them more flexibility than four-axis robots. The benefits of a four-axis architecture, on the other hand, are numerous. Palletizing is a good example of this. When compared to similarly priced 6-axis robots, the IRB 460 can save you money. Because of its basic design, it can keep its price at a low level. Taking advantage of its cheaper cost. The arm weighs 925 kg and has a maximum payload of 110 kg. The robot's range of motion is 2400mm, while the repeatability is 0.2mm. It can only be mounted to the floor. Its base takes about 1007mm x 720mm of space.

2. Table of Contents

3. List of figures

4. List of Tables

1.2 Text Chapters

a) Chapter 1: Introduction

1.1 What Is Palletizing?

In logistics supply chains, palletizing or palletization refers to the act of placing things on a pallet for shipment or storage. Products should be piled in a way that optimizes the amount of product in the load by weight and volume while being stable enough to prevent shifting, falling, or crushing. Palletizing was formerly done by hand, but automated methods are progressively taking over the work. Robotic palletizers have progressed to the point where they can palletize many goods on a single pallet.

1.2 Palletizing robot “IRB 460”

In our project we are going to describe the IRB 460 robot, which is a 4-axis robot that is the fastest palletizing robot in the world with a reach of 2.4 meters and 110-kilogram capacity, this compact robot’s small footprint makes it ideal for integration into existing packing lines.

b) Chapter 2: Background/Literature Review

2.1 Overview of the robotic arm and its construction

The rigid elements that connect the joints are known as links. The movable components of the robot that cause relative motion between neighboring connections are called joints (sometimes called axes).

2.1.1 Joints

In the IRB 460 robot, screw joints are used.

ABB recommends UNBRAKO as a particular type of screw for certain screw joints. It has a Gleitmo* unique surface treatment that reduces friction while tightening the screw joint and is

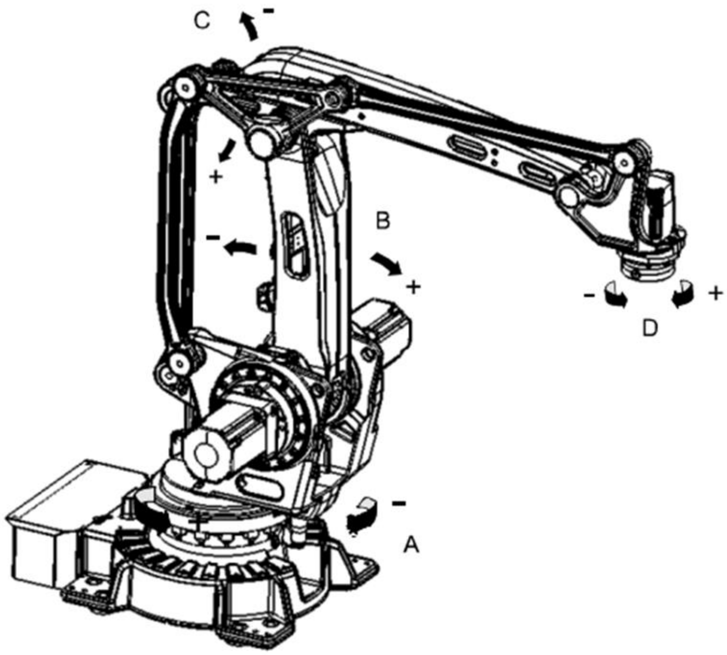

Figure 1: The IRB 460 manipulator has 4 axes(joints) as shown

extremely fatigue resistant. This is indicated in the instructions whenever it is used, and no other sort of replacement screw is authorized in such cases. Using other types of screws could result in serious injury or damage. Molycote 1000-lubricated screws can only be used if the repair, maintenance, or installation method instructions specify it.

2.1.2 Links

Our robot consists of 5 links as shown in Figure 2.

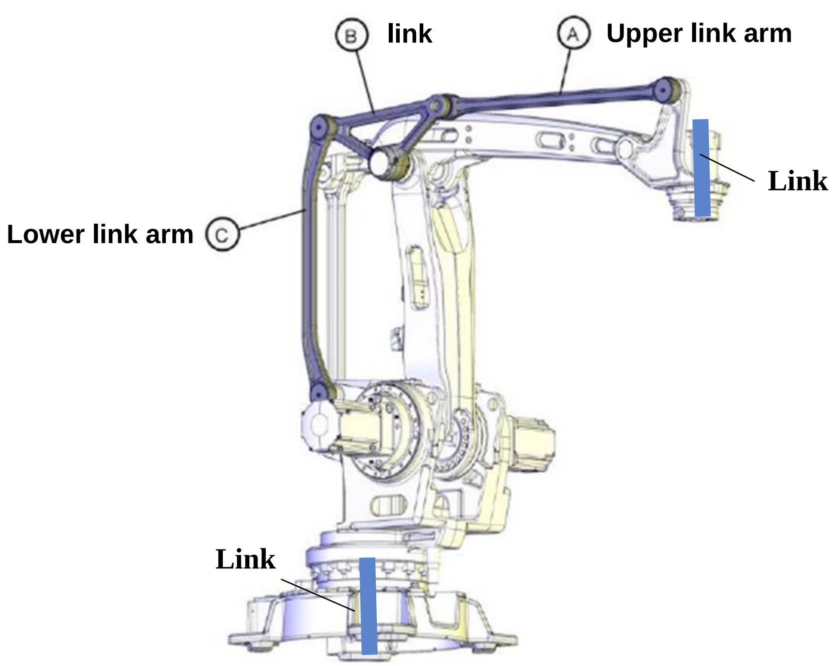

Figure 2:Links of the IRB 460 robot

2.1.3 Gripper

A gripper is a tool that allows you to hold and manipulate an object. Consider the human hand while describing a gripper, it allows you tighten, handle, and release an object.to hold, In IRB460, it is advised to use two types of grippers, Claw gripper and Clamp gripper, which are shown in the figures below:

Figure 3: Claw Gripper

Figure 4: Clamp Grippe

2.1.4 Mechanical mounting interfaces

Figure 5: mechanical mounting

2.2 Main features

1. Fastest palletizing robot in the world
2. Compact design
3. Integrated process cabling
4. Fully supported by ABB palletizing software
5. 4-axis design optimized for palletizing:

    a. shorter cycle times

    b. Lower weight of robot arm Higher payload (110 kg)

    c. Lower complexity

2.3 Focus Applications

1. High speed and robust – designed for high speed bag palletizing
2. Compact - designed for end of line palletizing

Palletizing, depalletizing, and material handling are the most common applications.

.c) Chapter 3: Methodology

3.1 Measurements of the design

3.1.1 Key Dimensions

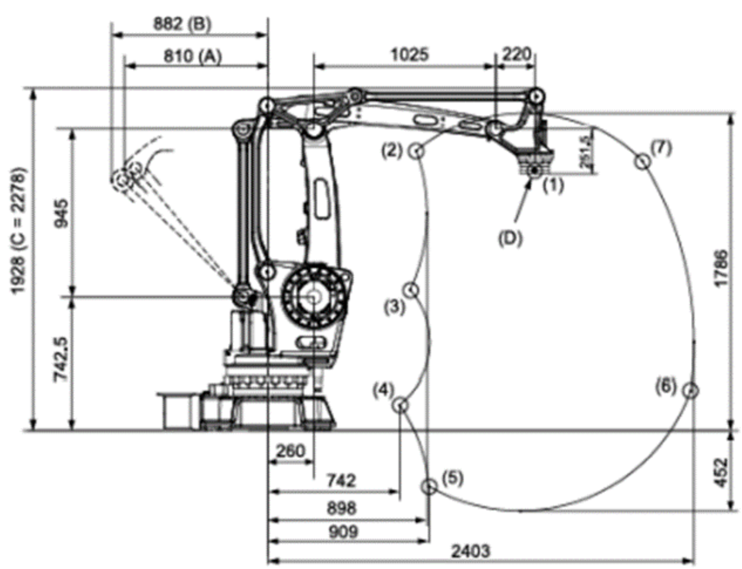

Figure 6: key dimensions

A Maximal working range, B Mechanical stop, C Maximal working range, D Tool flange center.

Table 1: key dimensions

Position	Position (mm)		Angles (degrees)	
	X	Z	Axis 2	Axis 3
1	1505	1437	0	0
2	836	1565	-40	-20
3	802	782	-40	25
4	742	145	55	120
5	909	-314	85	120
6	2385	223	85	20
7	2111	1510	45	-20

3.1.2 Axis work range and speed

The table below specifies the types and ranges of the robot motion in every axis

Table 2: axis work range and speed

Axis movement	Working range	Axis max speed
Axis A (rotation motion)	-165° to +165°	145°/s
Axis B (arm motion)	-40° to +85°	110°/s
Axis C arm	-20° to +120°	120°/s
Axis D turn	-300° to +300°	400°/s

d) Chapter 4: Results and Discussions

4.1 DH Convention

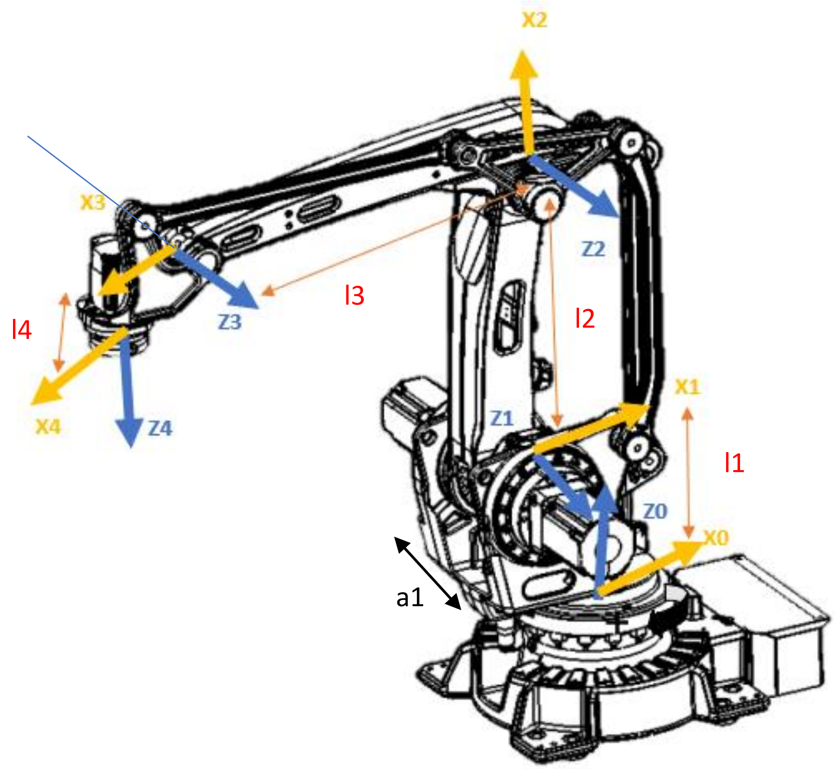

Figure 7: DH Convention frames

Table 3: DH convention symbols

Frame (i)	**a_i**	**α_i**	**d_i**	**θ_i**
1	-a1	0	l1	90^o
2	l2	$90^o + q_{12}$	0	0
3	l3	$-90^o + q_{23}$	0	0
4	0	0	l4	90^o
	Translation about x-axis	**Rotation about z-axis**	**Translation about z-axis**	**Rotation about x-axis**

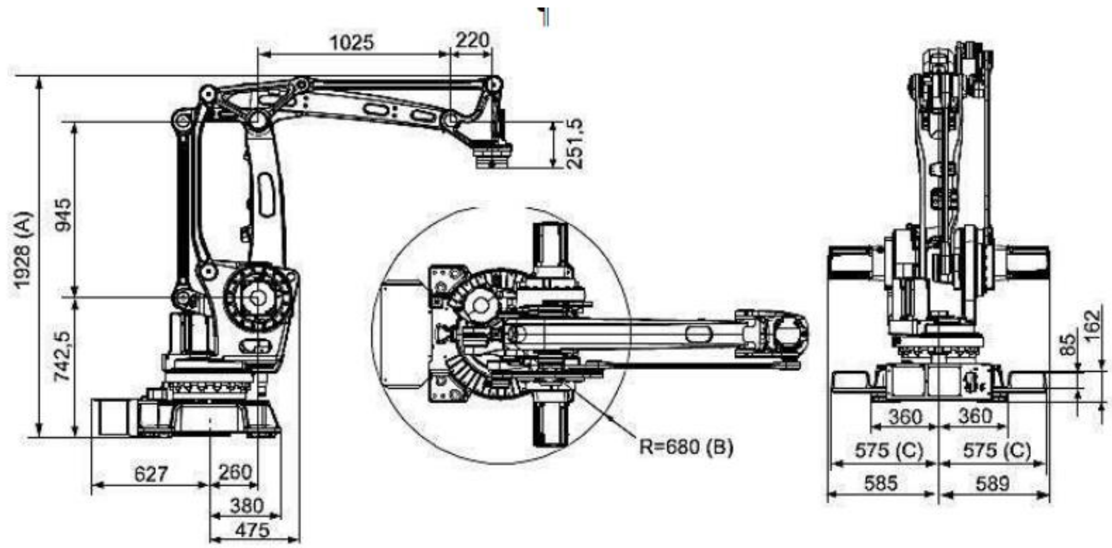

Figure 8: size of links

Table 4: DH convention values

Frame (i)	a_i	α_i	d_i	θ_i
1	-627	0	742.5	90°
2	945	175	0	0
3	1024	-130	0	0
4	0	0	492	90°

l1 = 742.5, l2 = 945, l3 = 1024, l4 = (1928 – (742.5+ 945)) +251.5 = 492

$q_{12} = 85^o$ from table 2 axis B, $q_{23} = -40^o$ from table 2 axis C

4.2 Forward Kinematics

```
%forward kinematics (home position)

a = [pi/2 0 0 pi/2];
IRB460.fkine(a)
IRB460.plot(a)

%Forward Kinematics (desired Position)
q = [pi 0.2706*pi -0.127*pi 0];
IRB460.fkine(q)
%visualization
IRB460.plot(q), 'workspace';
```

Figure 9: Forward Kinematics code

```
a =

    1.5708         0         0    1.5708



ans =
   -0.5253         0    0.8509     418.6
         0        -1         0      1342
    0.8509         0    0.5253      1001
         0         0         0         1


ans =
   -0.7828    0.5018   -0.3680    -979.2
   -0.5389   -0.2508    0.8041    -866.2
    0.3112    0.8278    0.4668      1291
         0         0         0         1

ans =

    'workspace'
```

Figure 10: Forward Kinematics code output

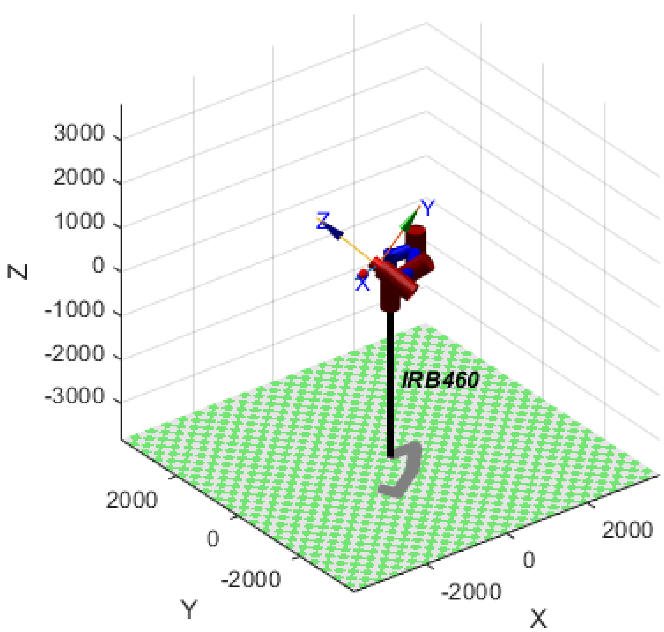

Figure 11: Workspace

4.3 Inverse Kinematics

```
%inverse kinematics
q = [pi 0.2706*pi -0.127*pi 0];
T = IRB460.fkine(q)

qi = IRB460.ikine(T,'mask',[1,1,1,1,0,0]);
%'Number of robot DOF must be >= the number of 1s in the mask matrix')
qi % result
```

Figure 12: Inverse Kinematics code

```
T =
   -0.7828    0.5018   -0.3680    -979.2
   -0.5389   -0.2508    0.8041    -866.2
    0.3112    0.8278    0.4668      1291
         0         0         0         1

qi =

    3.1416    0.8501   -0.3990         0
```

Figure 13: Inverse Kinematics code output

4.4 Jacobean Method

```
%Jacobian
qj = [pi 0.2706*pi -0.127*pi 0];
J = IRB460.jacobe(qj)
rank(J)
```

Figure 14 : Jacobean Method code

```
J =

   1.0e+03 *

   -0.1503    0.1876    0.4576         0
    0.6803    0.8376   -0.3761         0
   -1.1062   -1.6104   -0.9524         0
    0.0003    0.0003         0         0
    0.0008    0.0008    0.0009         0
    0.0005    0.0005   -0.0004    0.0010


ans =

     4
```

Figure 15: Jacobean Method code output

4.5 Animation of the system

```
%simulation and animation
IRB460.teach
```

Figure 16: animation code

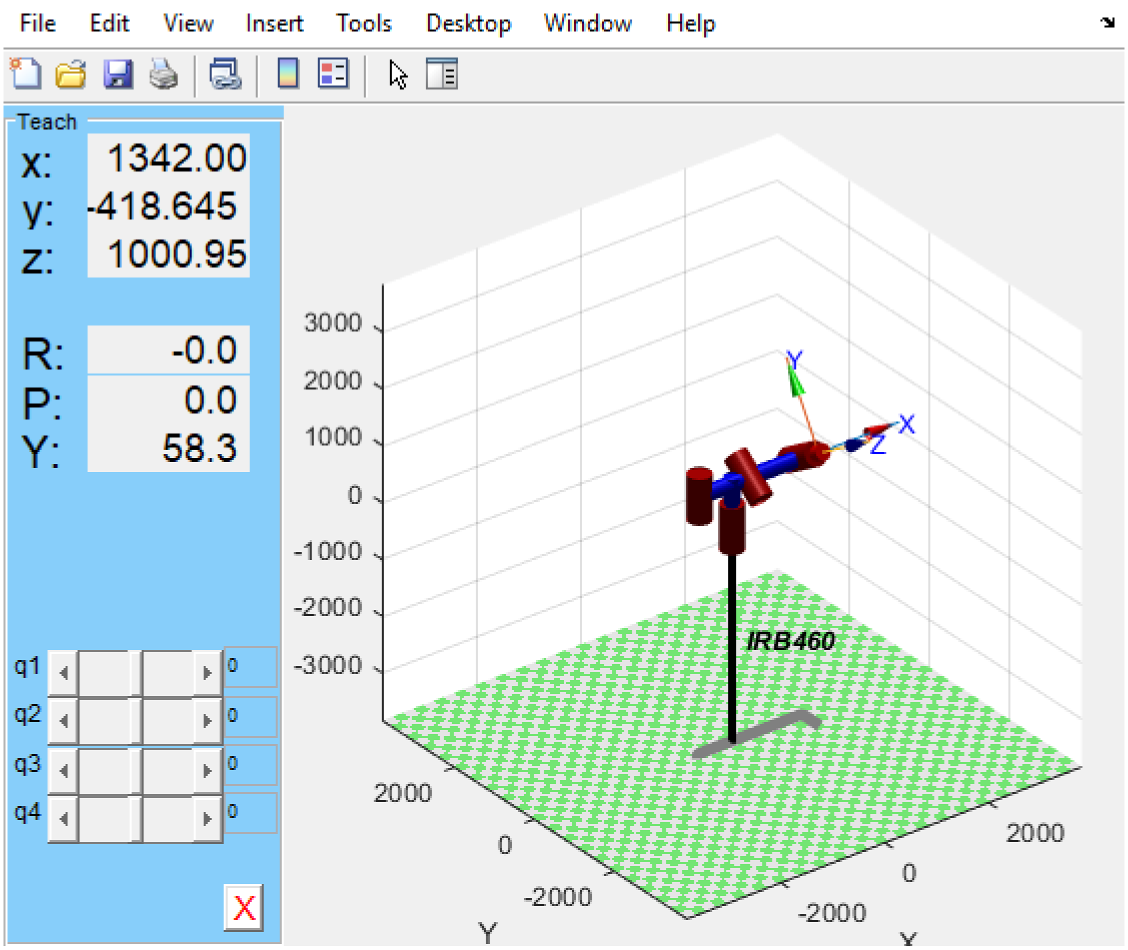

Figure 17: Animation of the system

e) Chapter 5: Conclusions and Recommendations

The design of the IRB-460 robot suits the real-life applications because of its high-complexity design, the IRB 460 can complete a regular cycle faster while producing more payload. IRB 460, according to ABB, is one of the fastest palletizing robots on the market, completing 2190 well-defined cycles in one hour with a load of 60 kg and 2040 similar cycles in one hour with a load of 110 kg According to the calculations, the robot's longest cycle time is only about 1.76 seconds, which is much faster than the rate at which the blocks are produced.

1.3 Back Matter

a) References

[1] "IRB 460 | ABB Robotics", Robotics, 2022. [Online]. Available: https://new.abb.com/products/robotics/industrial-robots/irb-460

[2] "PalletPack 460 data sheet", Search.abb.com, 2022. [Online]. Available: https://search.abb.com/library/Download.aspx?DocumentID=ROB0219EN_A_PalletPack460%20data%20sheet&LanguageCode=en&DocumentPartId=&Action=Launch

[3] "Product specification IRB 460", Library.e.abb.com, 2022. [Online]. Available: https://library.e.abb.com/public/a575fb0d4b0241beabc5eab5a9e86fa5/3HAC039611%20PS%20IRB%20460-en.pdf

[4] "IRB 460 High speed robotic palletizer", Library.e.abb.com, 2022. [Online]. Available: https://library.e.abb.com/public/60adc541544c45c0b11df356926f8082/IRB460-ROB0206EN-Rev.C.pdf

[5] "Product manual IRB 460", Library.e.abb.com, 2022. [Online]. Available: https://library.e.abb.com/public/9449f3270b9b4358b4d4cc2b41b17054/3HAC039842%20PM%20IRB%20460-en.pdf