German University in Cairo (GUC)
Faculty of Engineering & Materials Science (EMS)
Mechatronics Department (MCTR)

Robotics (EDPT1009)

5/1/2022

Project Milestone: MS5

Team Number: 20

Left Robotic Leg Design and Implementation

Michel Magdy, Amr Abdrabo, Paula Amir, Mina Saeed, Sherif Richard

The Project's main goal is to design the left leg of the Poppy Humanoid on solid works to calculate the exact values needed to buy the suitable motors and to 3D print the parts. After finalizing the design, the robot motion is tested using Simscape. Last but not least an electrical wiring map is done to make sure the correctness of the whole system together. The results showed that the design was suitable and we don't really need to buy huge motors with huge torques as the weight of the robotic leg is not big.

Fig. 1: Poppy Humanoid Robot

Our task is to design and assemble the left leg (Fig.2) of the robot a part of the lower limb (Fig.3), which will described detailed throughout the milestones.

I. INTRODUCTION

The goal of the project is to design and control a robotic leg which contains of4 joints which corresponds of course to 4 servo motors to control the angel of rotation of each joint. Each team will work on a different part of the robot, either leg or arm, left or right and at the end the goal is to assemble the different parts together to come up with one complete robot (Fig.1).

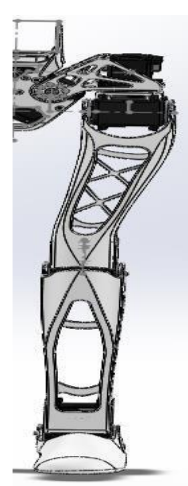

Fig. 2: Left Leg

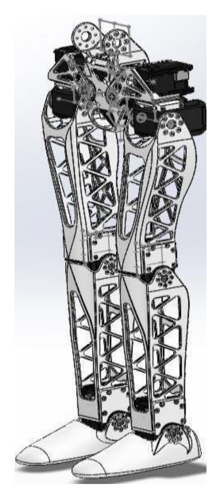

Fig. 3: Lower Limb

II. Methodology

At the beginning in section II the Hardware Components of the robotic leg will be demonstrated in the table (1) below, the table (2) for the design specifications. Followed by the electrical design circuit which is created using Proteus. To test cooperation of the components with each other we simulated the whole process using MATLAB, SOLIDWORKS and SIMSCAPE which will give us the results shown in section III

Item 1	3D printed parts
Item 2	4 servo motors
Item 3	Arduino Uno
Item 4	Power supply
Item 5	Jumper wire

Table (1) Hardware components

Length	46 cm
Width	5.3 cm
Depth	4.8 cm
Thickness	0.3 cm
Material	Esun Pla+

Table (2) Design specifications

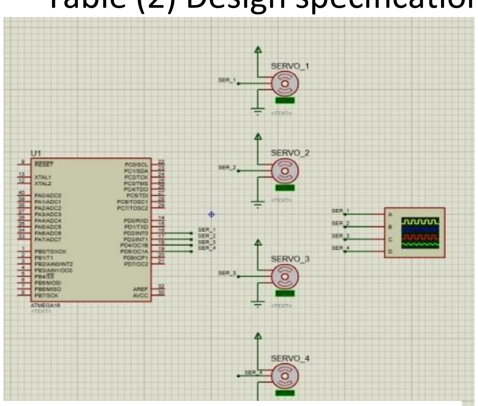

Fig. (4) Proteus Electrical Circuit

Now we can assign the different frames as shown in figure (5) on the left leg to able to construct the DH convention table as shown in figure (6) to be able to know the position of theend effector.

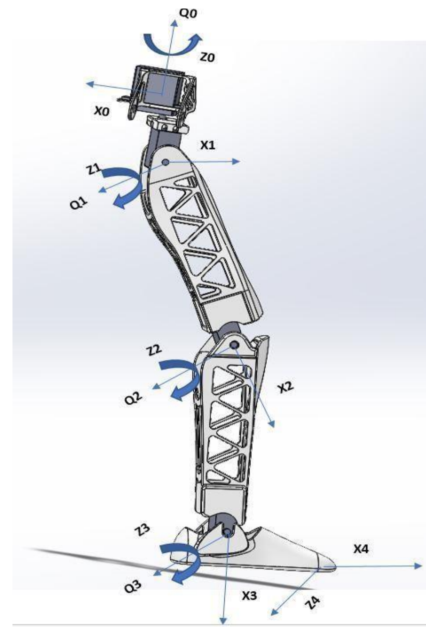

Fig. (5) different frame assignment

Old to new frame	theta	d	a	alpha
0 to 1	Q0	-L1	0	90
1 to 2	Q1	L2	L3	0
2 to 3	Q2	0	L4	0
3 to 4	Q3	0	L5	0

Links	length
L1	4.5 cm
L2	2.3 cm
L3	19 cm
L4	18 cm
L5	10 cm

Number of joints	Number of links
4	5

Fig. (6) DH convention table links value.

III. RESULTS

After finalizing the design and analyzing the results we had to simulate the whole process first before implementing it, to test weather everything will work as planned. To make this simulation we designed the process using MATLAB and Simscape (Fig.7).

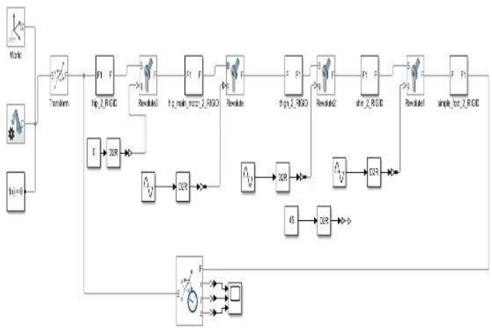

Fig.7: Simscape Simulation Design

We combined the solid works design with Simscape so that we could put input torques on each joint to test capability of the motors the rotate the whole system as shown in the below figure (Fig.8)

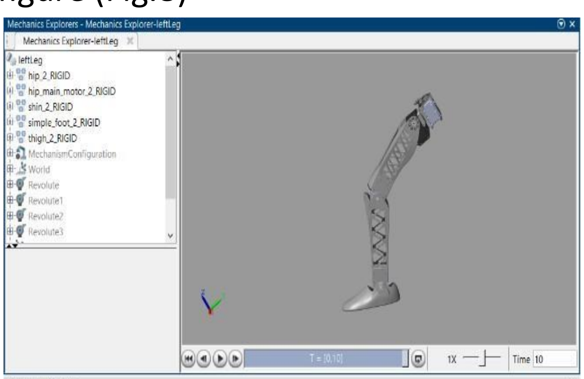

Fig.8: Simscape Simulation

First Results, we had to write the code On MATLAB to calculate all the values we need for simulating the whole process on Simscape as shown in the figure (9) below. These results of the different angles calculated will be used as input for Simscape and for the Arduino code to move the robotic leg using desired values and here in figure (10) the shape of the robotic leg from Simscape where the angles are zero

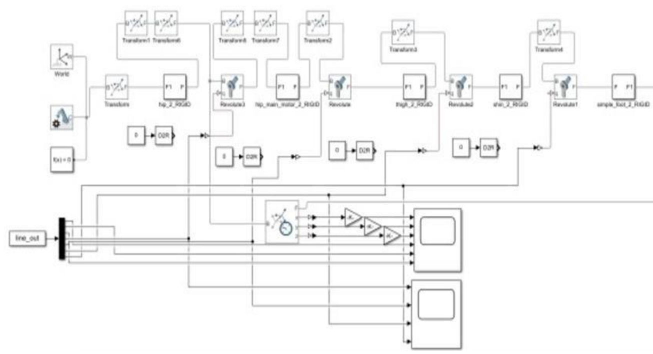

Fig.9 Final Simscape

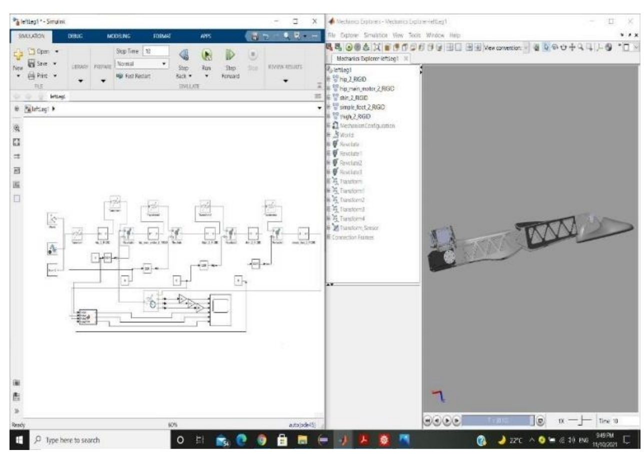

Fig.10.Zero position of the robot

Before taking the Angles obtained from MATLAB to be taken as input to the Arduino code we had taken into consideration the limitation of the angles using trial and error in the real system to know the limit of each motor, second limitation is the frame that we use to fix the Robot on it we take also the limits of the robot angles in order to not to break the Robot we will find the first two motors will range from 0 to 180 degree while the third motor will range from 0 to 90 degree, The last motor range from 0 t0 60 degree

Second results here we will see the comparison between X, Y, Z obtained from the Task Space trajectory Planning and the X, Y, Z obtained from the Simscape as shown in the next figure (11)

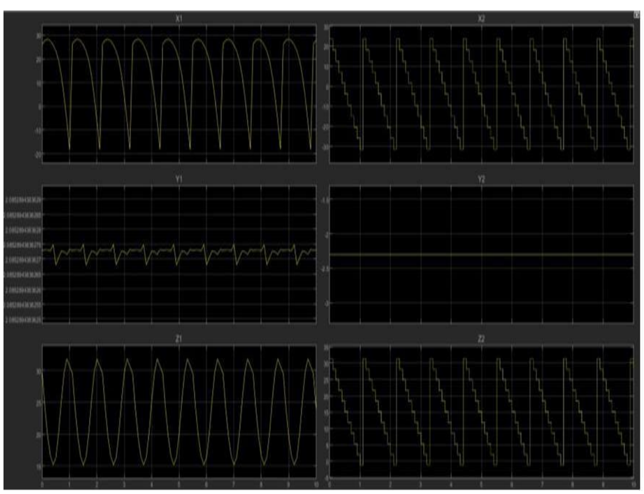

Fig.11 X, Y, Z comparison

Third results The angles obtained from the task Space trajectory to be given to the motor to move in line Space trajectory as shown in the figure (12) Below and here we will have the results of the two trajectories in figure (13,14)

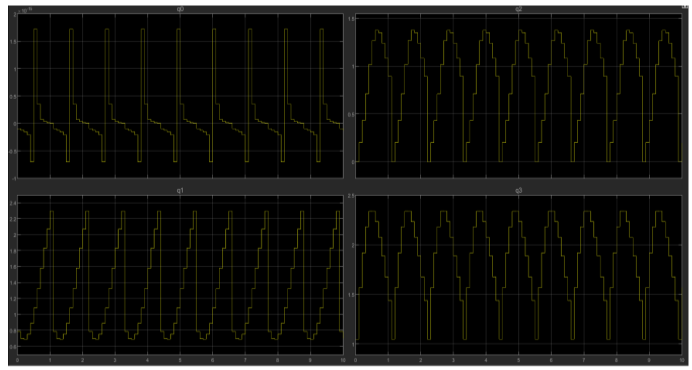

Fig.12 Angles of Line space Trajectory

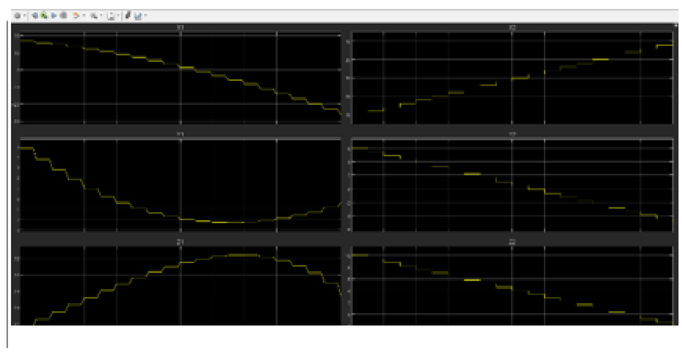

Fig.13 result Line space Trajectory

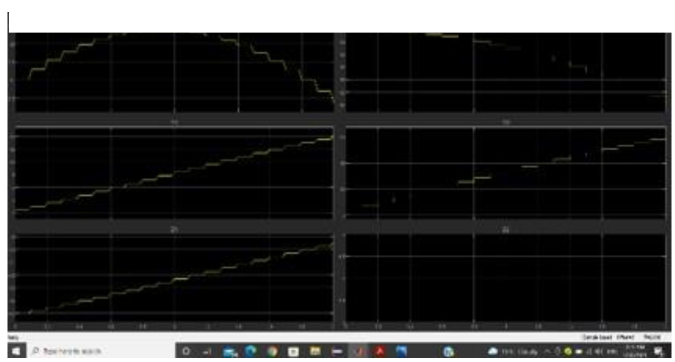

Fig. (14) result of the Circular space trajectory

IV. Conclusions

To sum it all up, to start manufacturing the above- mentioned robot our first step was to finalize the SOLIDWORKS design to move on to the next step which is designing the electrical circuit. After finishing those two steps we were able to figure out the exact dimensions and specs of the servo motors we need to rotate this robot by knowing the weight and other dimensions from the design. Before we purchased the materials, we first had to test whether this combination of components will work or not, so we used Simscape to simulate the whole process which worked well. Last but not least. we purchased the components and started 3D printing. After finalizing the manufacturing of the parts, we connected the 4 servomotors to test the rotation of each joint by giving it input from the Arduino. We also combined the final design with Simscape through MATLAB To test the position of the end-effector when giving the system different angles.

We also developed the DH-Convention of the limb and sensed the Position of the end effector andwas the same as that obtained by kinematic equations with simple tolerance. Then throughout the inverse position kinematics,forward position kinematics and Task space Trajectory we were able to specify the Trajectory in which the robot will follow. At theend, the main goal of the project is to be able to move the left leg with specific Trajectories. And also, to make sure that these trajectories on the real life is the same trajectories that had been done in Simscape and here is the Final Shape of the left leg in the below figure (15)

Fig. (15): Final Design

Here the video for the two trajectories!
Scan the QR code and watch