Report 04 – (a)

Forward and Inverse Kinematics for RP Robot

MCT 621

Motion Control and Servo Systems

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Submitted By/

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Introduction

In this Report, 2 blocks are introduced regarding the RP robot ARM studied in the lectures for MCT621-Fall 2021, the Two blocks are:

1. Forward acceleration Kinematics
2. Inverse acceleration Kinematics

These Blocks are described in detail with the aid of mathematical equations behind them. Then simulation is done on each of them to get the desired output to test. And final the two blocks are tested among each other, so that the input is given to Forward Kinematics Block then gets out of it to the Inverse kinematics Block, and if the output is the identical to the input so that the two blocks are correct.

All simulations are done using MATLAB/Simulink, and the blocks are written as a MATLAB functions.

Previous Study

In Report 3, Forward and invers Blocks and their test cases for Position and velocity were introduced. So, in this report only the acceleration is introduced

L1 is the joint length which is fixed as L1 = 0.5 m.

Acceleration Kinematics

Acceleration Kinematics means to calculate the End-Effector Accelerations in X and Y components from known actuators accelerations, velocities, and positions for forward kinematics. Or having the actuators accelerations using the X , Y acceleration components of end effector.

1. Forward Acceleration Kinematics

From calculations the following 2 equations describes the Forward position kinematics for the RP robot.

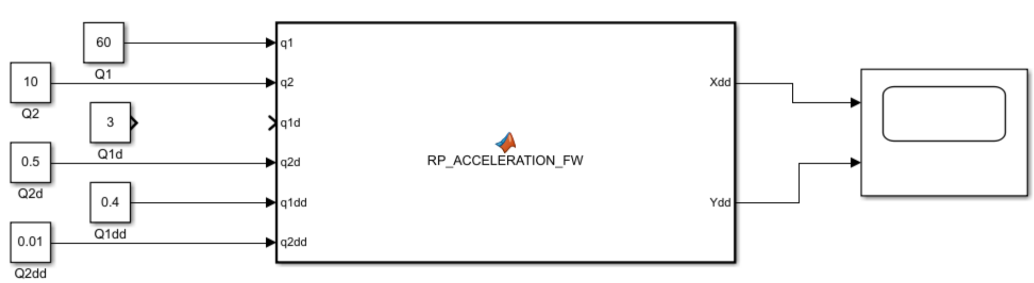
$$\ddot{X} = J * \dot{q}$$

MATLAB Function code.

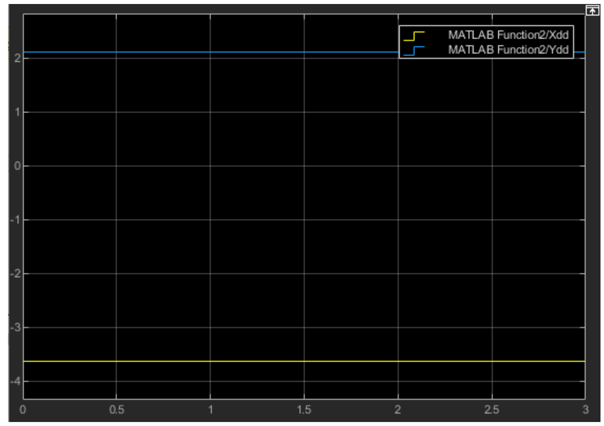
```
function [Xdd,Ydd] = RP_ACCELERATION_FW(q1,q2,q1d,q2d,q1dd,q2dd)
L1=0.5;

J = [-(L1+q2)*sind(q1),cosd(q1);
      (L1+q2)*cosd(q1),sind(q1)];
Jd = [(-(L1+q2)*cosd(q1)*q1d - sind(q1) * q2d) , -sind(q1) * q1d;
      ( (L1+q2)*sind(q1)*q1d + cosd(q1) * q2d) ,  cosd(q1) *
q1d];

  Xdd = Jd(1,1)*q1d + Jd(1,2)*q2d + J(1,1)*q1dd + J(1,2)*q2dd;
  Ydd = Jd(2,1)*q1d + Jd(2,2)*q2d + J(2,1)*q1dd + J(2,2)*q2dd;

end
```

Simulink Testing Block Diagram.

The block is tested with the following inputs



Shown in the opposite figure the outputs of the Block, accelerations in X & Y.



2. Inverse Acceleration Kinematics

From calculations using the Jacobian matrices, results in acceleration kinematics for the RP robot.

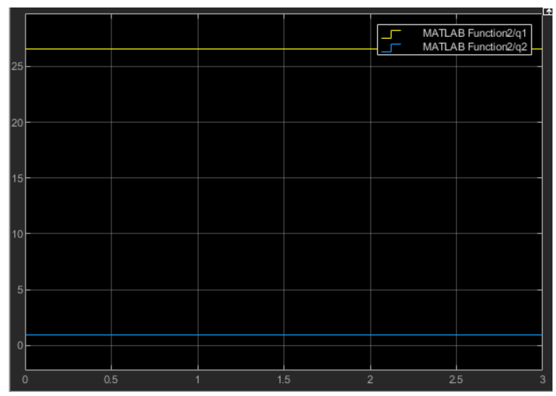
$$\ddot{q} = J^{-1}(\ddot{X} - \dot{J}\dot{q})$$

MATLAB Function code.

```
function [q1dd,q2dd] = RP_ACCELERATION_INV(q1,q2,q1d,q2d,Xdd,Ydd)
L1=0.5;
J = [-(L1+q2)*sind(q1),cosd(q1);
      (L1+q2)*cosd(q1),sind(q1)];
Jd = [(-(L1+q2)*cosd(q1)*q1d - sind(q1) * q2d) , -sind(q1) * q1d;
      ( (L1+q2)*sind(q1)*q1d + cosd(q1) * q2d) ,  cosd(q1) *
q1d];

  Xdd = Jd(1,1)*q1d + Jd(1,2)*q2d + J(1,1)* q1dd + J(1,2) * q2dd
;
  Ydd = Jd(2,1)*q1d + Jd(2,2)*q2d + J(2,1)* q1dd + J(2,2) * q2dd
;

  Joint_ACC = (J^(-1)) * ( [Xdd ; Ydd] - (Jd * [q1d ; q2d] ) );

  q1dd = Joint_ACC(1);
  q2dd = Joint_ACC(2);
end
```

Simulink Testing Block Diagram.

As seen in the opposite figure the End Effector has the output of the previous inputs

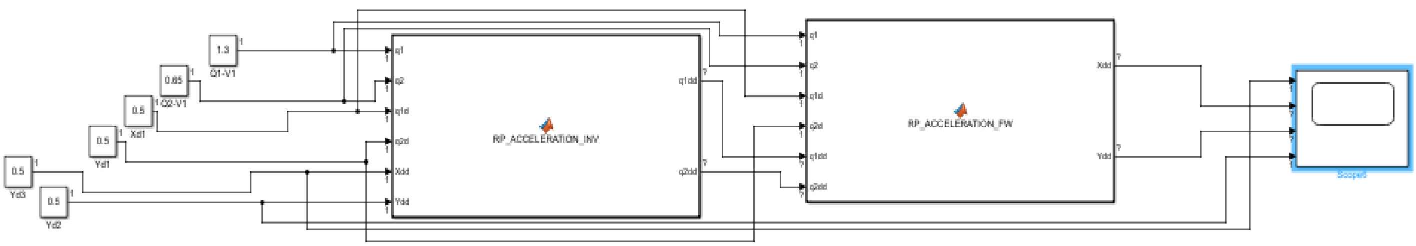


3. Forward & Inverse Acceleration Kinematics

In the following part the 2 blocks are put back-to-back to test if they are correct or not.

Simulink Testing Block Diagram.

The block is tested with the inputs as follows



As shown in the opposite figure the input is identical to the output, so that the two blocks are correct.