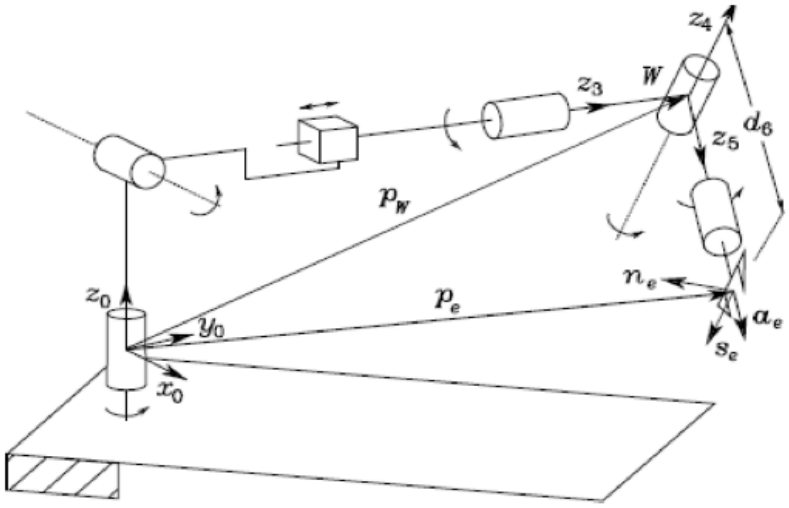
Report Milestone 3



Robotics Project

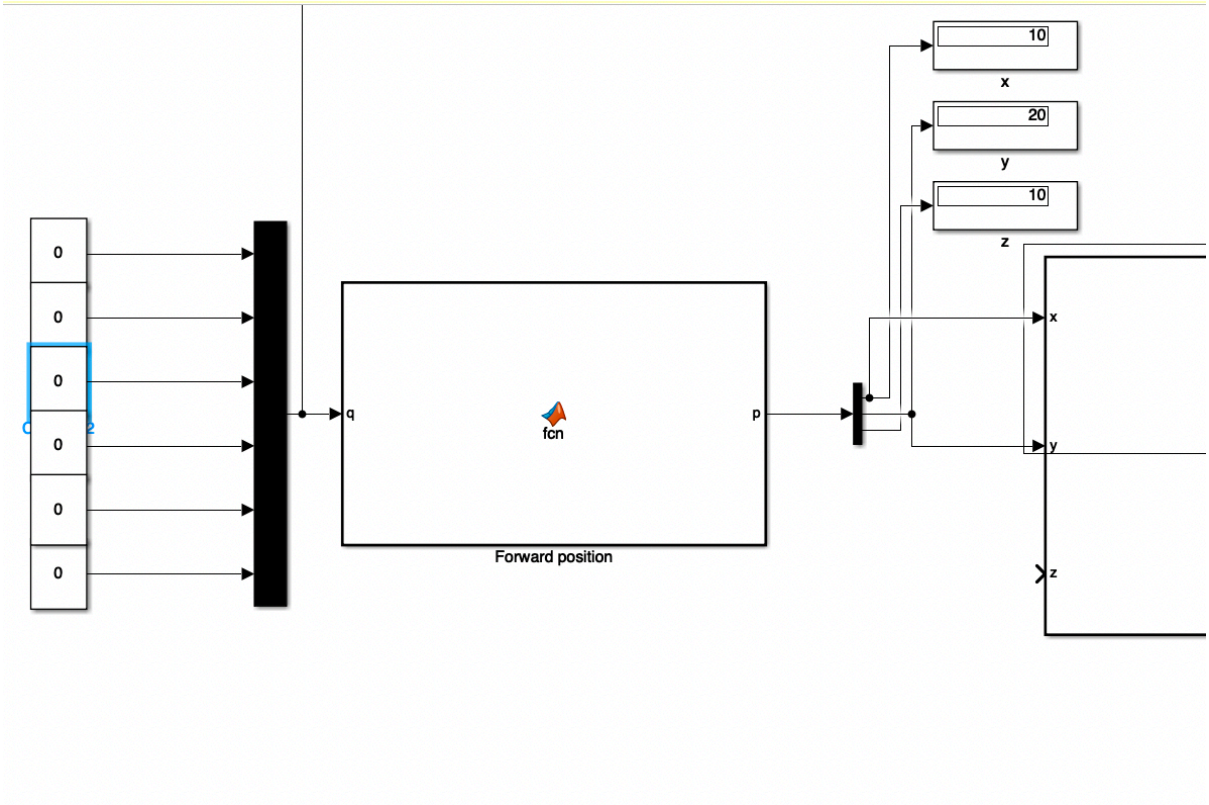
Names:

Gasser Mohammed El Azab 37-15647
Omar Salah El Hediny 37- 4362
Omar Wahsh 37-6138
Mariam Ali Abdelhazim 37-7153
Ahmed Kamel El salamony 37-7258

As we mentioned later in the position, our zero position is as follows **(after modifying the offset in the total homogenous transformation matrix)** :

The zero position (which all the q's are zeros):
Assuming all lengths = 10.

When all the q's are zeros:
Z = L1=10;
X= L4= 10;
Y= L2+q3+L3=20;



The results are as shown that the maximum positions are right!
From Milestone 2 we made sure that the forward and inverse position are working well.

Starting by the forward velocity analysis:

By finding Jv and Jw of each joint, we have conducted the Jacobian matrix of the velocity as implemented in the matlab code:

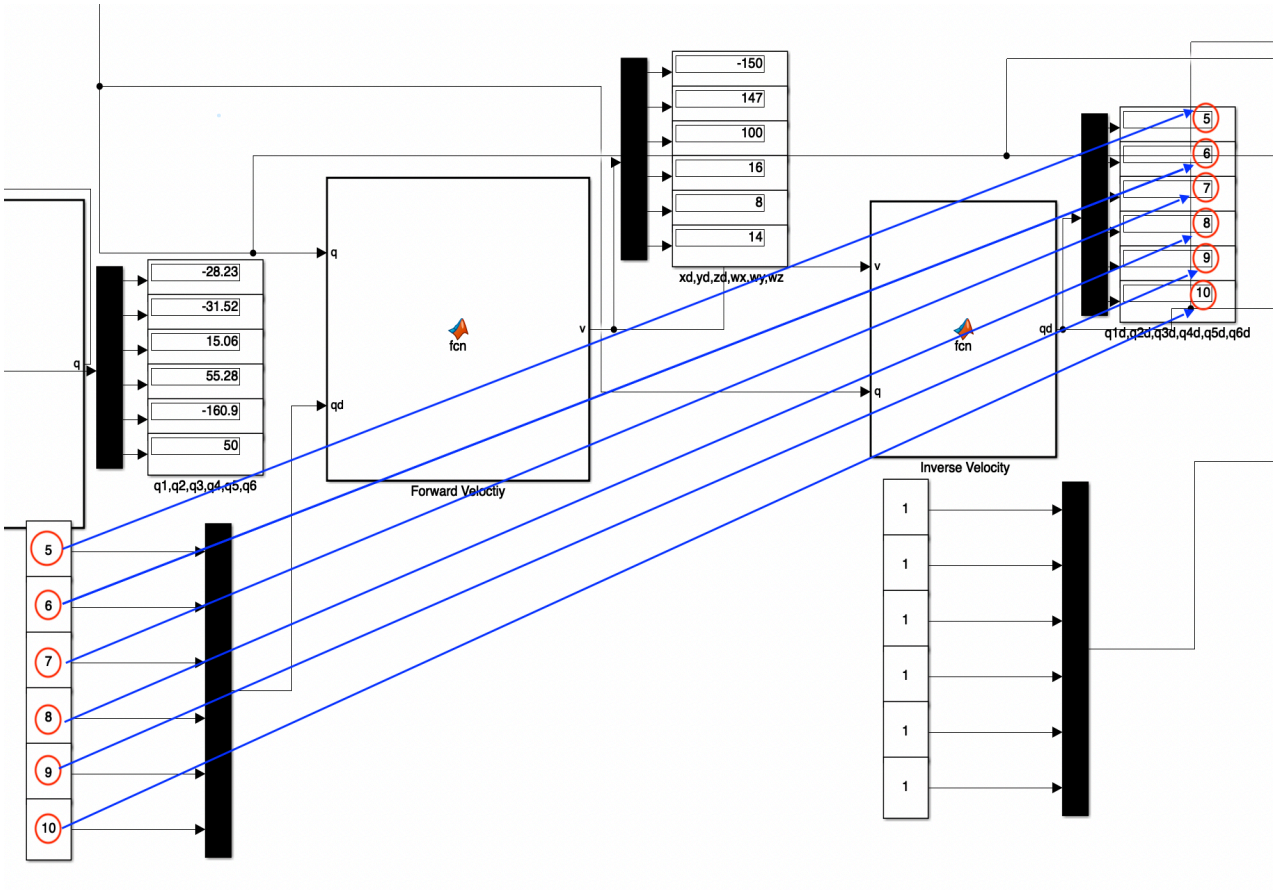
```
Jv1= cross([0;0;1], A0T6(:,4)-[0;0;0]);
Jv2= cross(A0T1(:,3),(A0T6(:,4)-A0T1(:,4)));
Jv3= A0T3(:,3);
Jv4= cross(A0T3(:,3),(A0T6(:,4)-A0T3(:,4)));
Jv5= cross(A0T4(:,3),(A0T6(:,4)-A0T4(:,4)));
Jv6= cross(A0T5(:,3),(A0T6(:,4)-A0T5(:,4)));

Jw1=[0;0;1];
Jw2= A0T1(:,3);
```

```
Jw3=[0;0;0];
Jw4= A0T3(:,3);
Jw5= A0T4(:,3);
Jw6= A0T5(:,3);
v= [Jv1 Jv2 Jv3 Jv4 Jv5 Jv6; Jw1 Jw2 Jw3 Jw4 Jw5
Jw6]*[q1d;q2d;q3d;q4d;q5d;q6d];
```

where cross is the cross product, and T is the transformation matrices.

1: Simulink model for Forward Velocity, Inverse Velocity, Forward acceleration, and Inverse Acceleration:

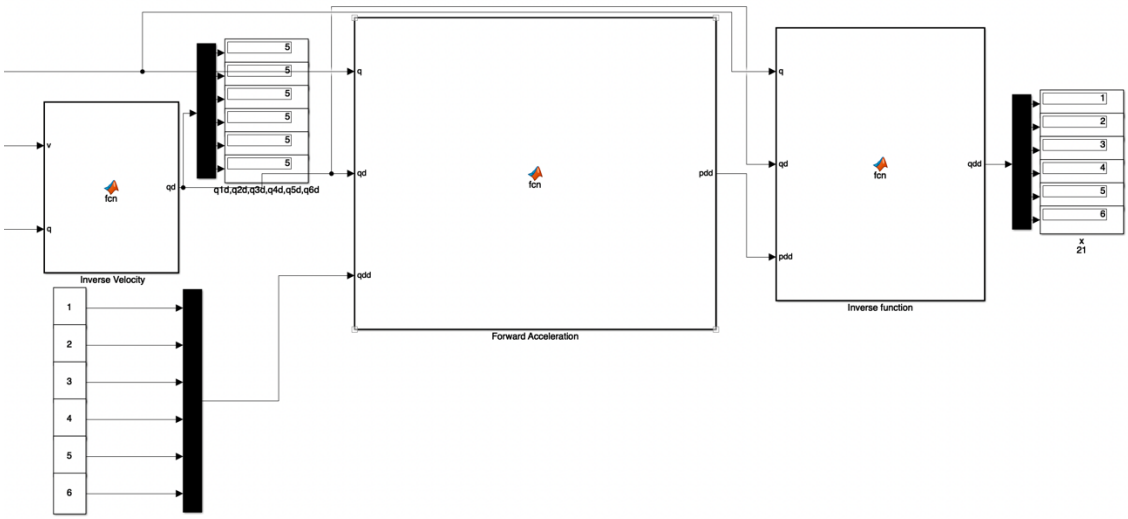
A) Velocity:



It's obvious that the input to the forward velocity is the same as the output of the Inverse, which indicates that it is correct!

The input is q1d,q2d,q3d,q4d,q5d,q6d respectively.

B) Acceleration:



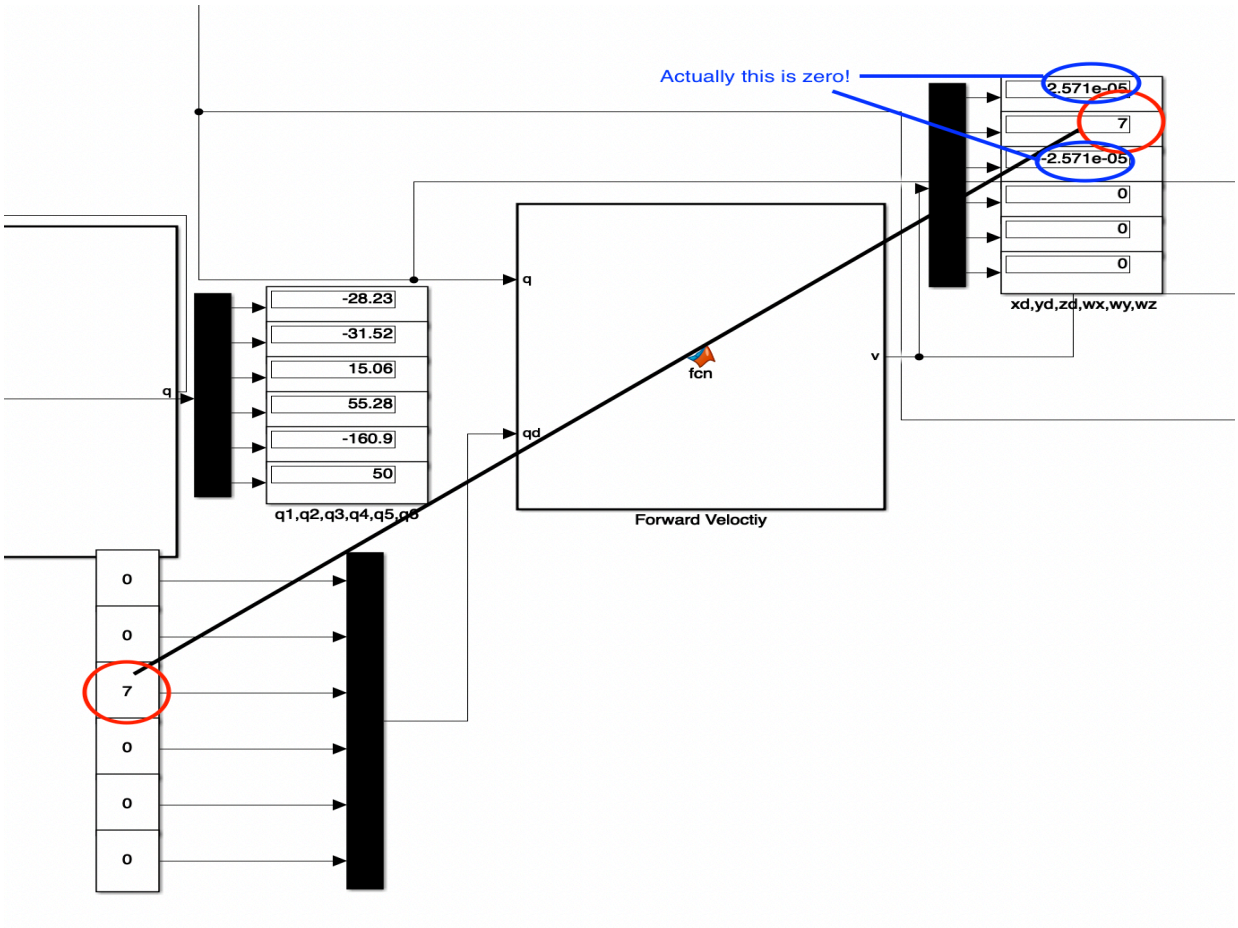
It's obvious that the input to the forward acceleration is the same as the output of the Inverse, which indicates that it is correct!

The input is q1dd,q2dd,q3dd,q4dd,q5dd,q6dd respectively.

1. ***Testing different input joint velocities and accelerations:***

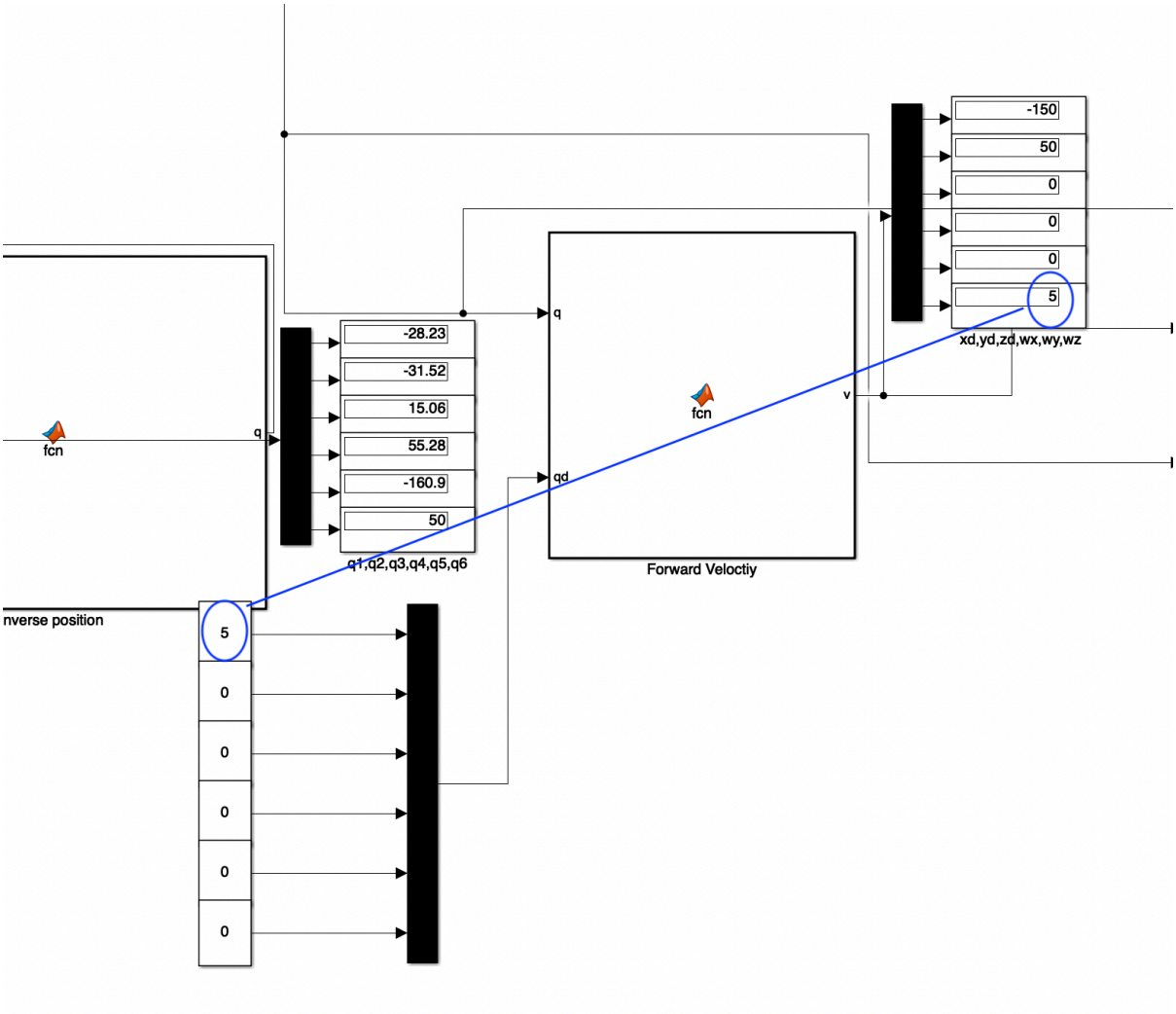
A) Velocity

In our robot, q3 is the only prismatic joint. So, If we make an input velocity to q3 with a certain value and assume that the other velocities q's are equal to zero, with fixing our robot in its initial position, it should result **only** linear velocity in y direction.



This result of the simulation is as we expected!

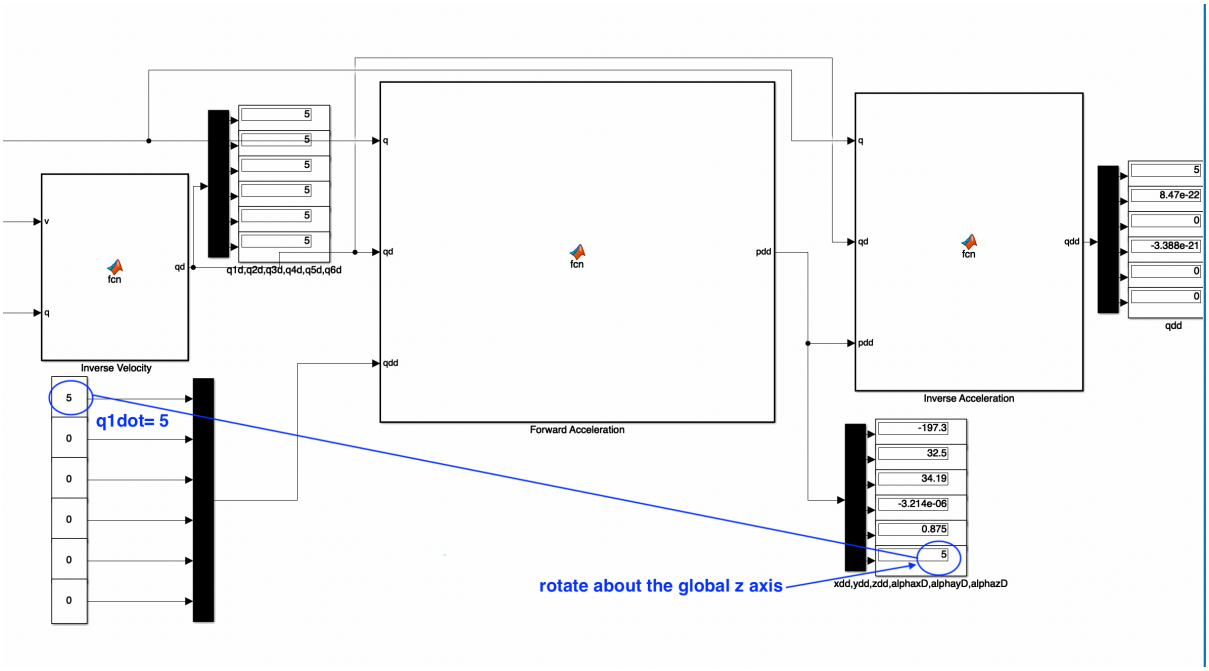
As q1 is rotation about the global Z so it is very easy to be deduced from the output angular velocity, as an example if joint(q1)'s velocity has a certain value, it should result **only** velocity in x and y directions and angular velocity about global z.



So, The result is as expected, the output is only velocity in x,y and angular velocity about Z.

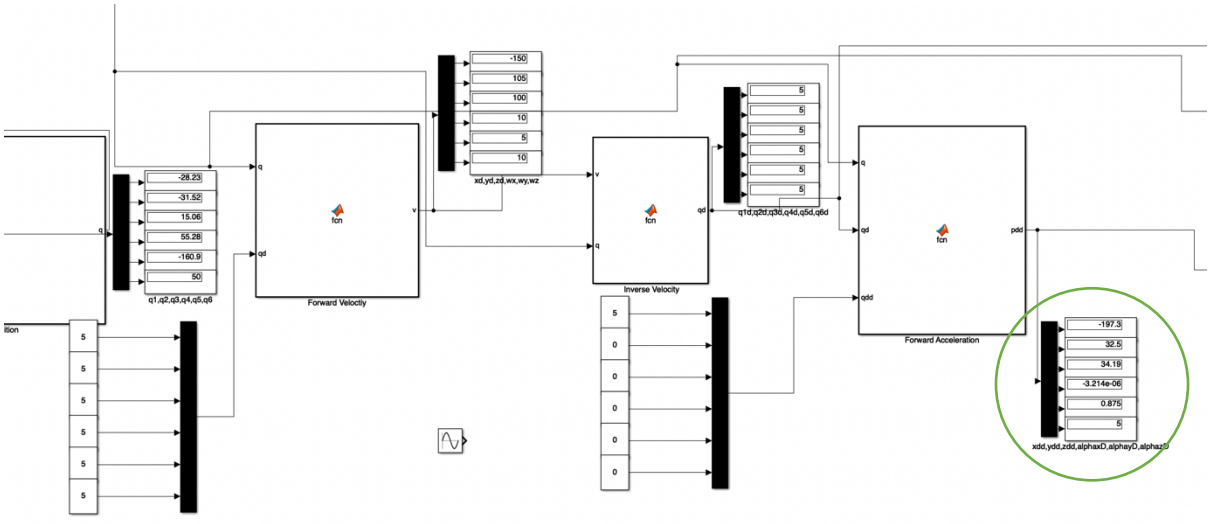
B) Acceleration

With the same concept we used in the velocity analysis, As q1 is rotation about the global z so it is very easy to be deduced from the output acceleration around z, with keeping the velocity of 5 5 rad/sec in every joint, so q1 double dot = certain value, with keeping the other other joint accelerations= 0, this certain value should be the same output in the angular acceleration about z.

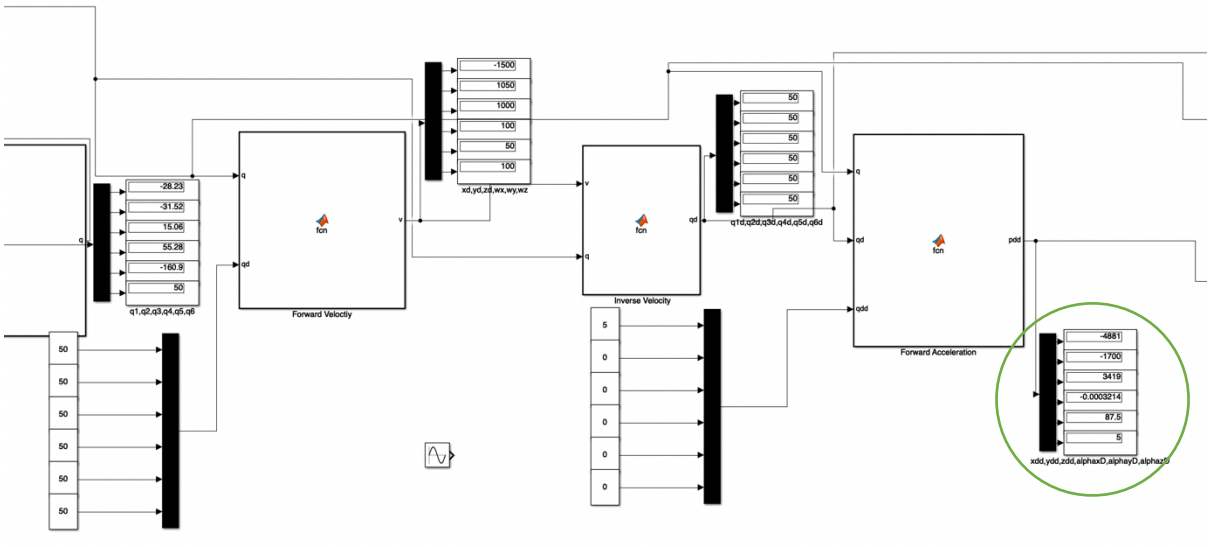


To test the effect of changing the speed only on the acceleration, by increasing the velocity of the q's the output angular acceleration should increase as well as, by keepings the acceleration's input to the joints to zero:

The angular velocities to the joints are all of 5 rad/sec:



The angular velocities to the joints are all of 50 rad/sec:

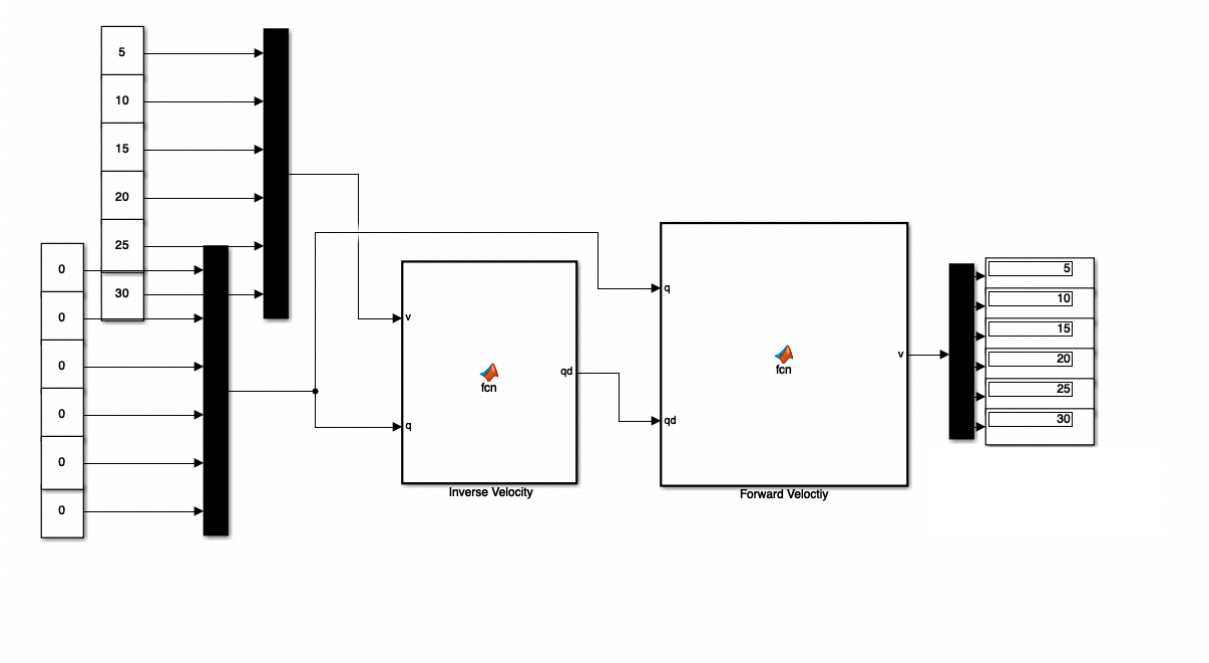


It is pretty obvious the effect of increasing the input angular velocities to the joints on the angular acceleration of the end effector.

2. *Testing different input angular velocities and accelerations to the end effector:*

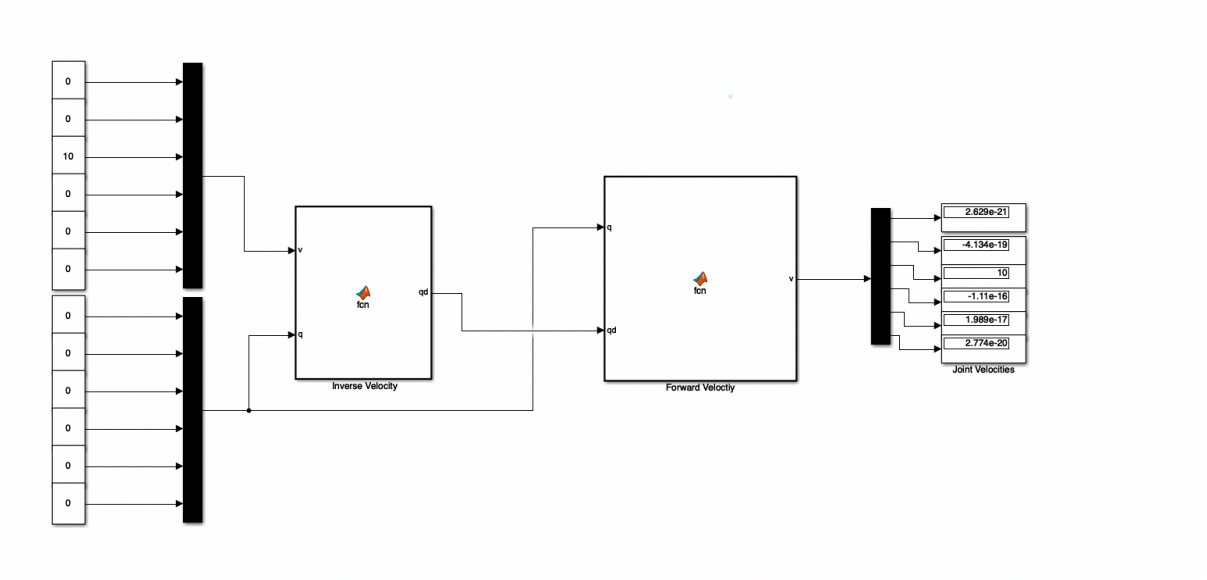
A) *Velocity*

Validating the input angular velocities to end effector (by passing it to the forward once again) :

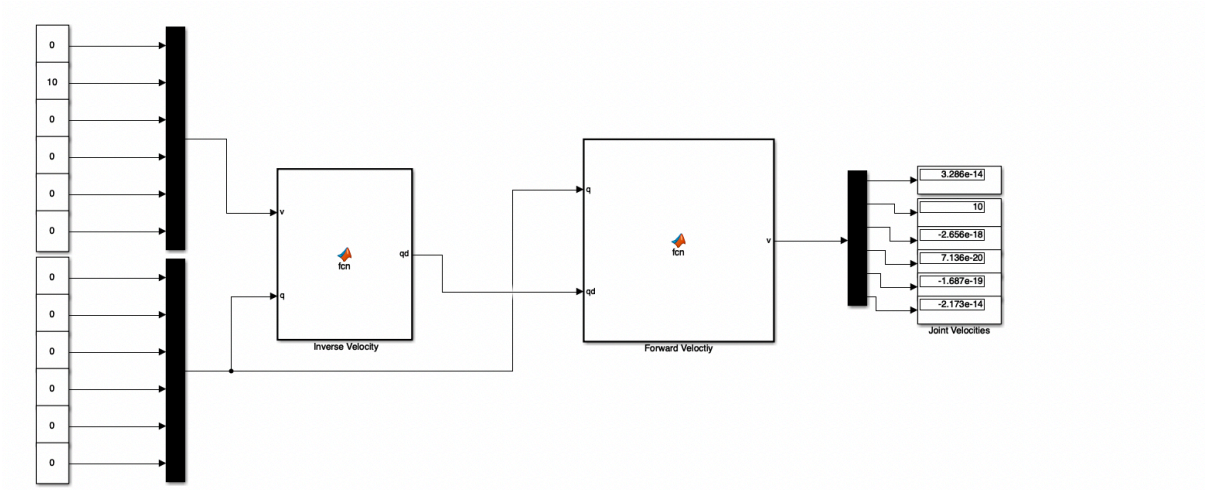


As shown, the input is the same as the output by passing by the inverse then the forward blocks.

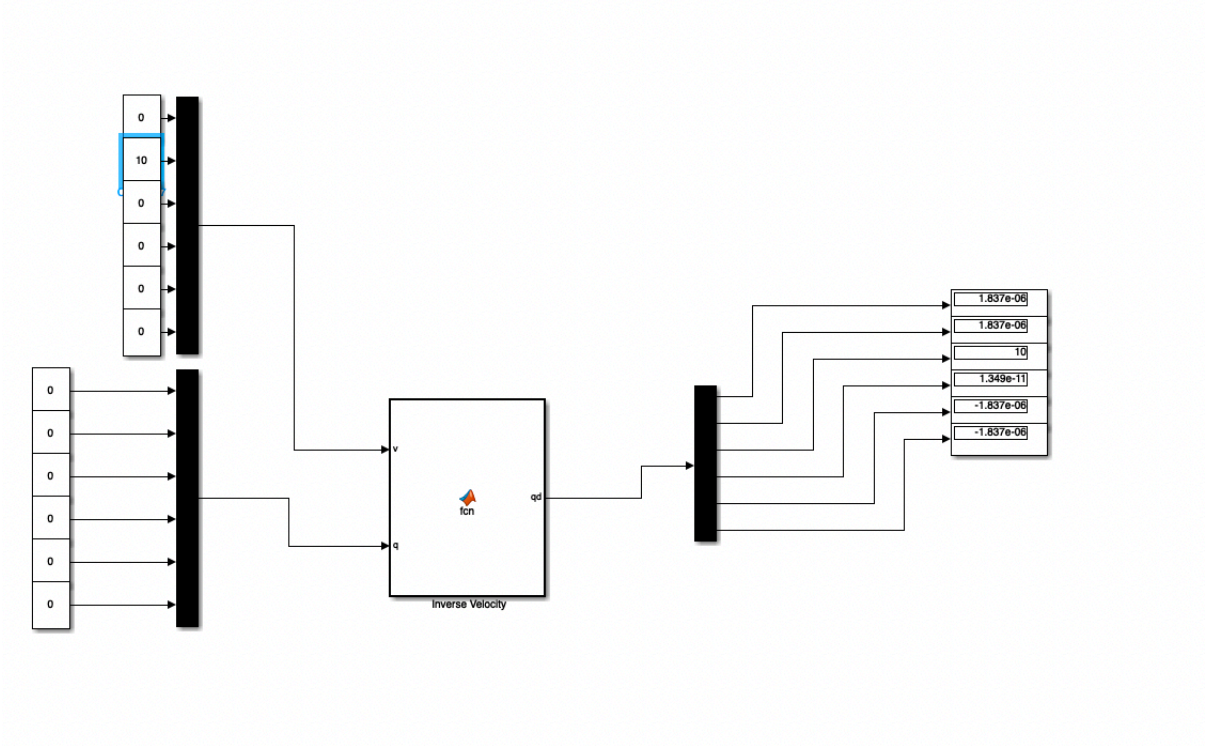
The output is also correct for the next two simulations:
(linear velocity in z direction = 10)



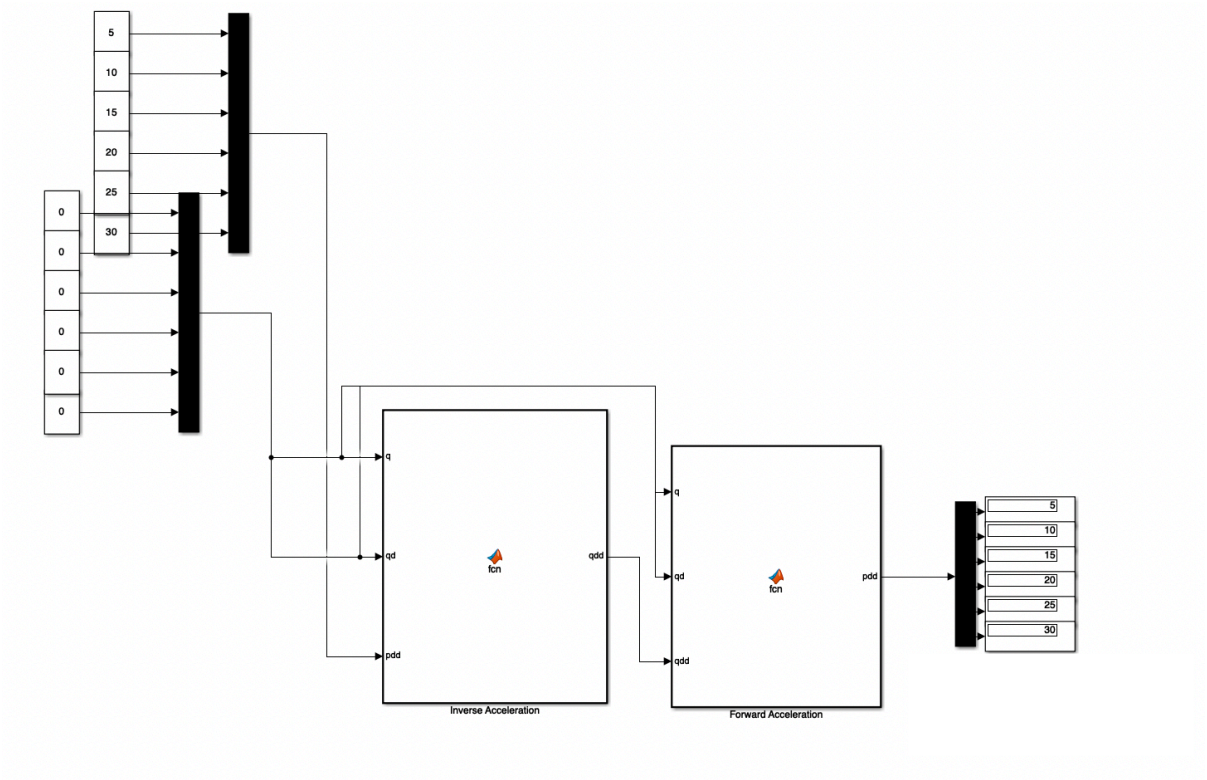
(linear velocity in y direction = 10)



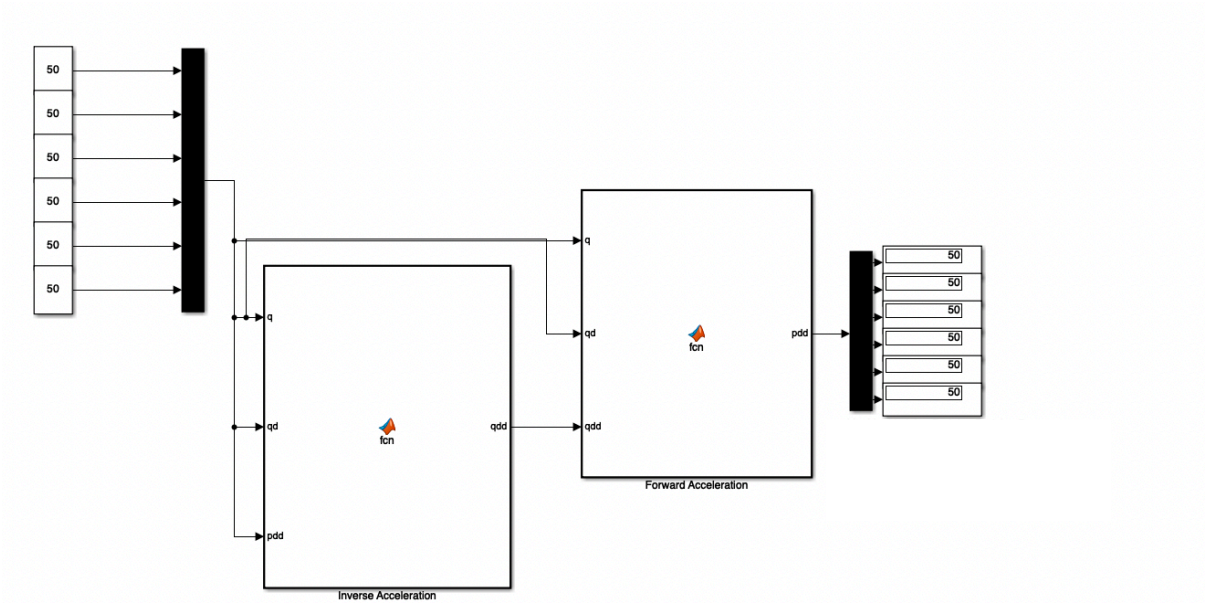
If we require a lienar velocity in the y direction by 10 unit/sec, so q3 will be equal to 10 unit/sec, which makes sense as it is the only prismatic joint we have.



B) Acceleration:



This also for another input:



For Input to end effector:
If our robot is moving with a constant velocities in the joints, and it is required to make the end effector to move by linear acceleration in y by 100 rad/sec^2, so the required acceleration required will be the largest at q3, which is the only prismatic joint in our robot. So, yes it is logical!