Design & Simulate SolarPanel Tracking System

Prepared By:

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About Project

The solar tracking system will be Single axis in my project.

The solar tracking system includes 2 main subsystem. One is Panel and second is Motor. Here I will design the Simulink model using few equations regarding Motor and Panel motion. Then simulate and check the output of panel's angular position.

To make my system precise here I would apply the PID controller to minimize the error which will occurred as result of difference between actual sun's position and panel's position.

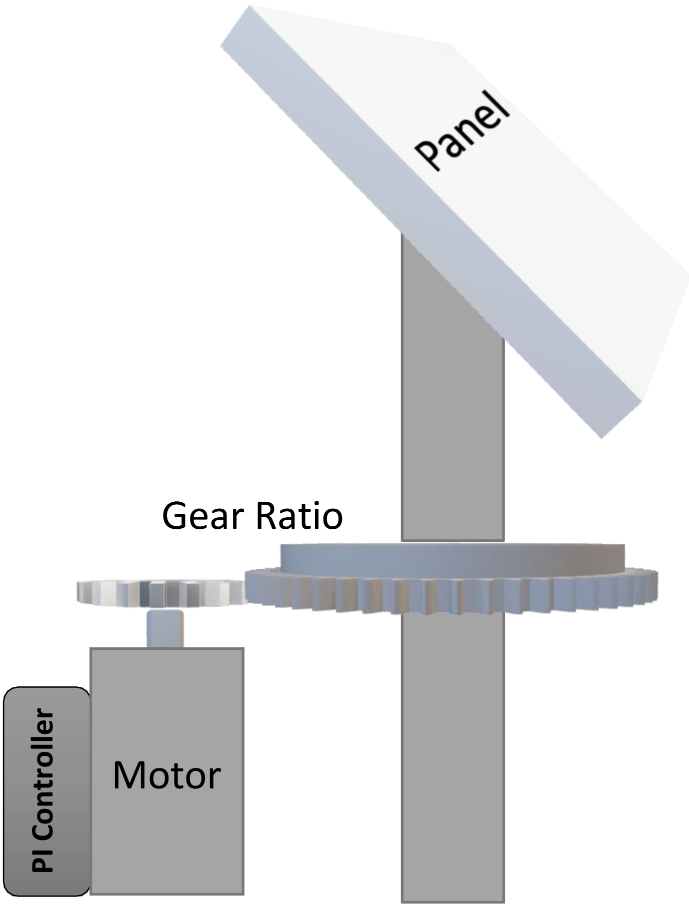
At the end, I compare the reference input so called Sun's different position during the whole day with my designed panel's position.

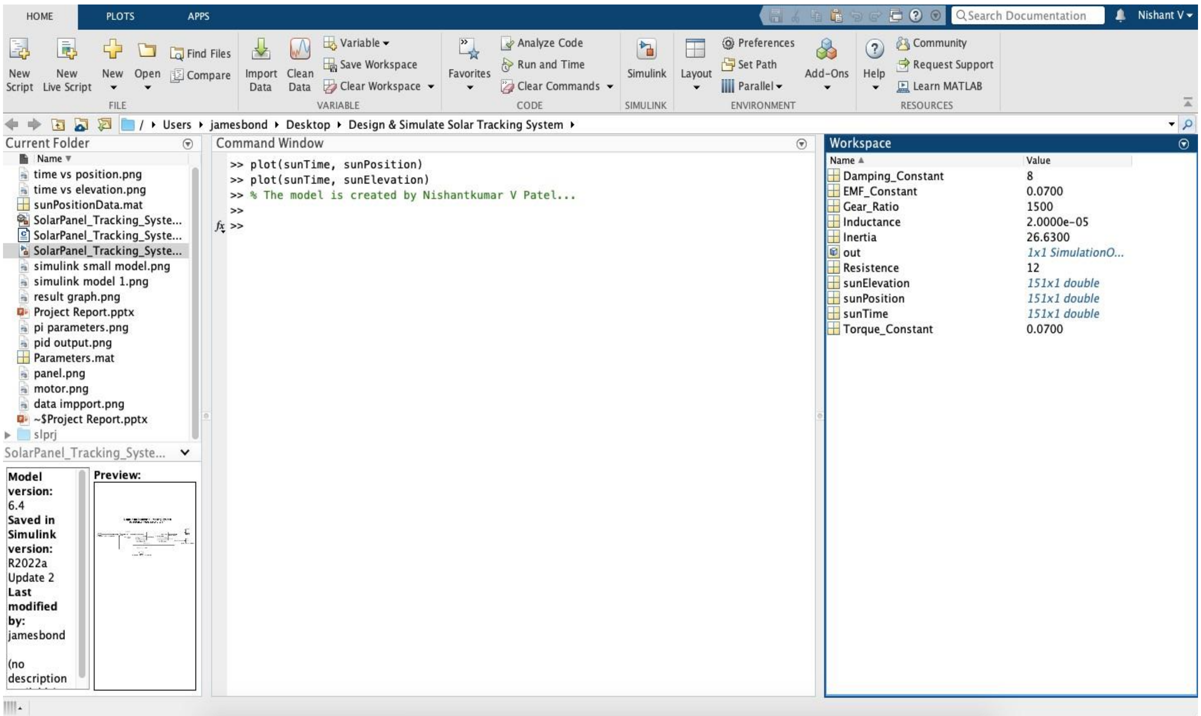
To ensure that whether the panel correctly tracks the sun over the period of time or not.

So, lets get Started…

Assumptions:

- I have taken the case of vertically rotating solar tracker.
- The dc motor I have taken into account with common dc motor specifications.
- I have taken the Solar panel's dimesions and weight hypothetically.
- The above picture gives you the idea about how my tracking system will working.

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Import Data
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Save Workspace
Clear Workspace
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Favorites
Analyze Code
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Clear Commands
CODE
Simulink
SIMULINK
Layout
Preferences
Set Path
Parallel
Add-Ons
ENVIRONMENT
Help
Community
Request Support
Learn MATLAB
RESOURCES
/ Users jamesbond Desktop Design & Simulate Solar Tracking System
Current Folder
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time vs position.png
time vs elevation.png
sunPositionData.mat
SolarPanel_Tracking_Syste...
SolarPanel_Tracking_Syste...
SolarPanel_Tracking_Syste...
simulink small model.png
simulink model 1.png
result graph.png
Project Report.pptx
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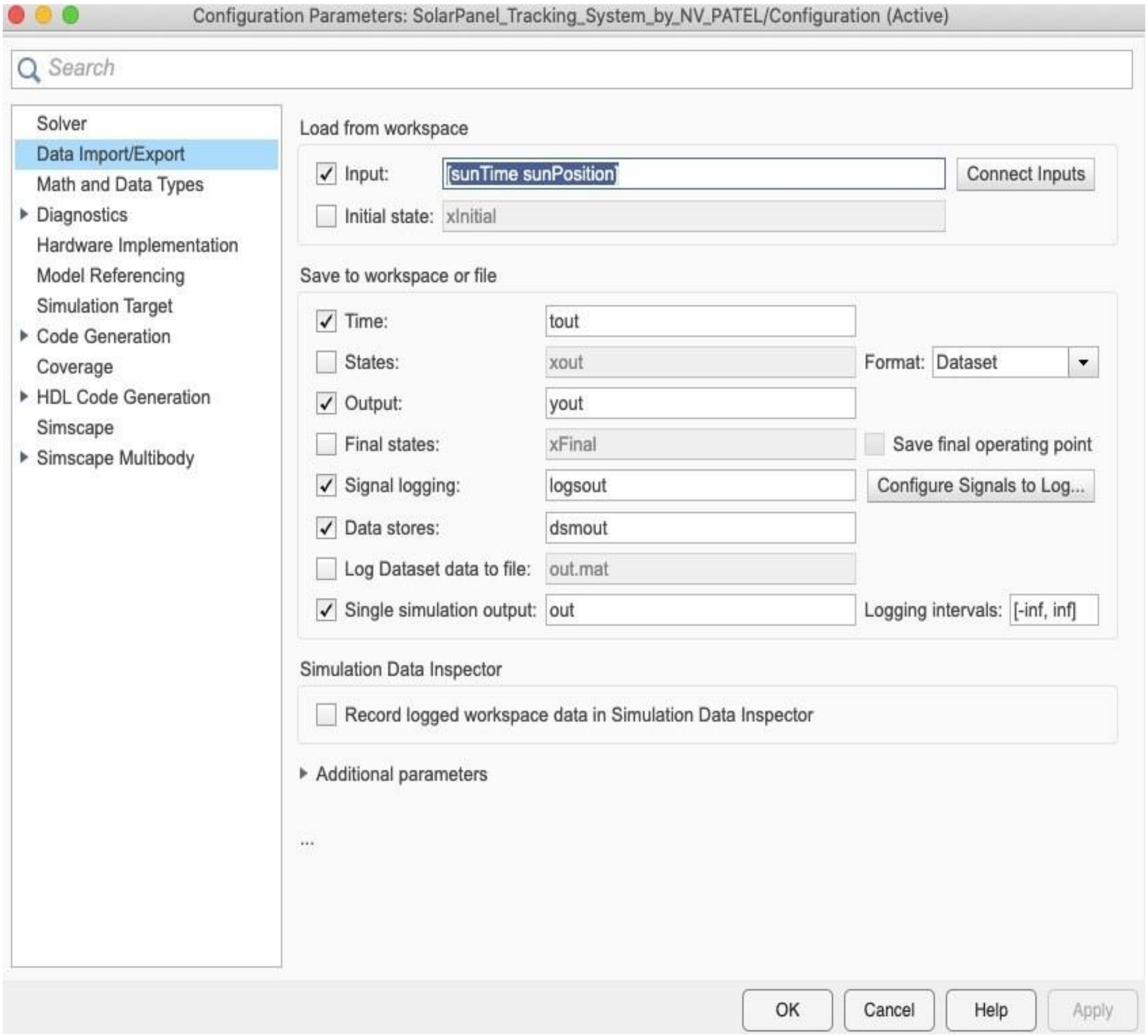
Parameters.mat
panel.png
motor.png
data impport.png
~$Project Report.pptx
slprj
SolarPanel_Tracking_Syste...
Model version: 6.4
Saved in Simulink version: R2022a Update 2
Last modified by: jamesbond
(no description
Preview:
Command Window
>> plot(sunTime, sunPosition)
>> plot(sunTime, sunElevation)
>> % The model is created by Nishantkumar V Patel...
>>
>>
Workspace
Name
Value
Damping_Constant 8
EMF_Constant 0.0700
Gear_Ratio 1500
Inductance 2.0000e-05
Inertia 26.6300
out 1x1 SimulationO...
Resistence 12
sunElevation 151x1 double
sunPosition 151x1 double
sunTime 151x1 double
Torque_Constant 0.0700



- To import the sun position and time data of .mat file I went to the 'model parameters/ configuration parameters' the by typing the '.mat file names' in the 'Load from workspace' section I did it so.
- It is important to note that always type in

[time_data other_data] format to import correctly.

The click on the 'connect inputs' button.

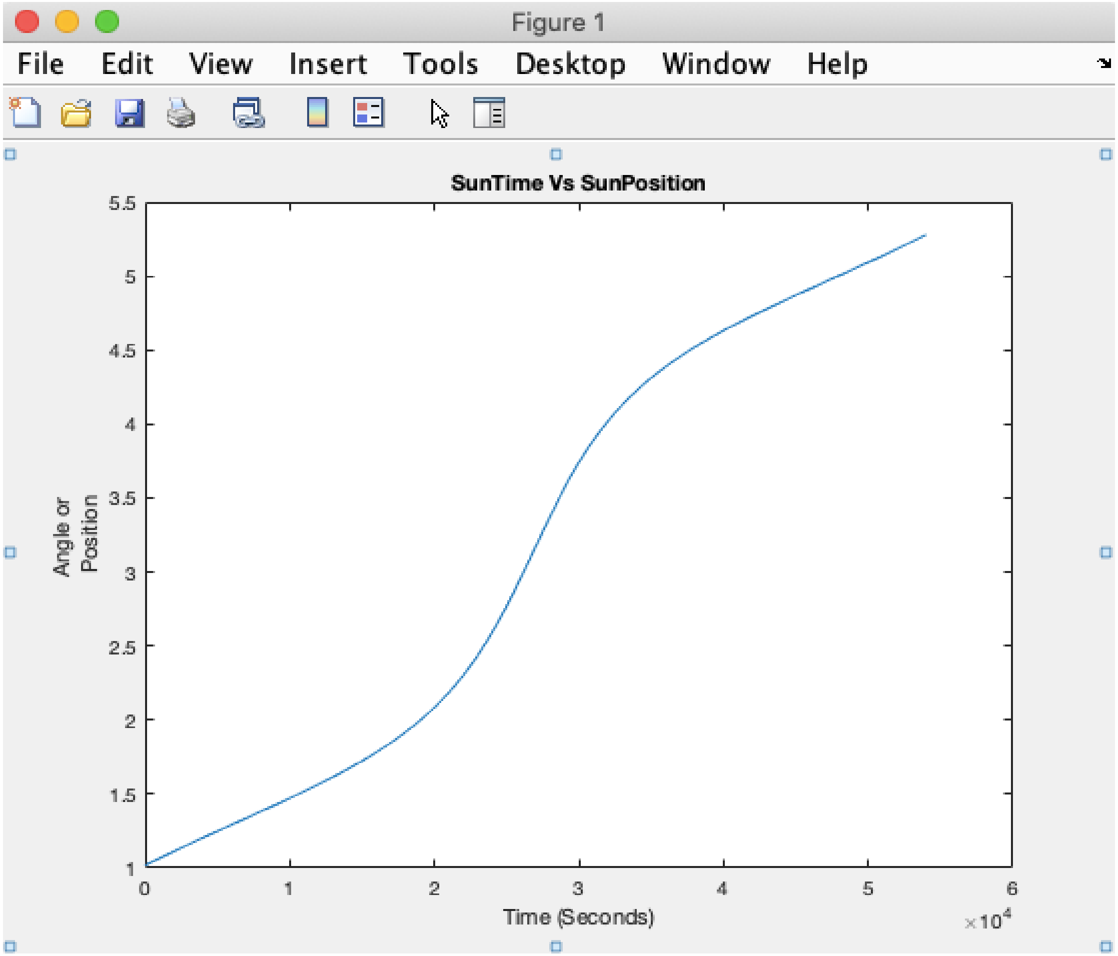


Figure 1
File Edit View Insert Tools Desktop Window Help
SunTime Vs SunPosition
Angle or Position
Time (Seconds)
×10^4
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
0
1
2
3
4
5
6

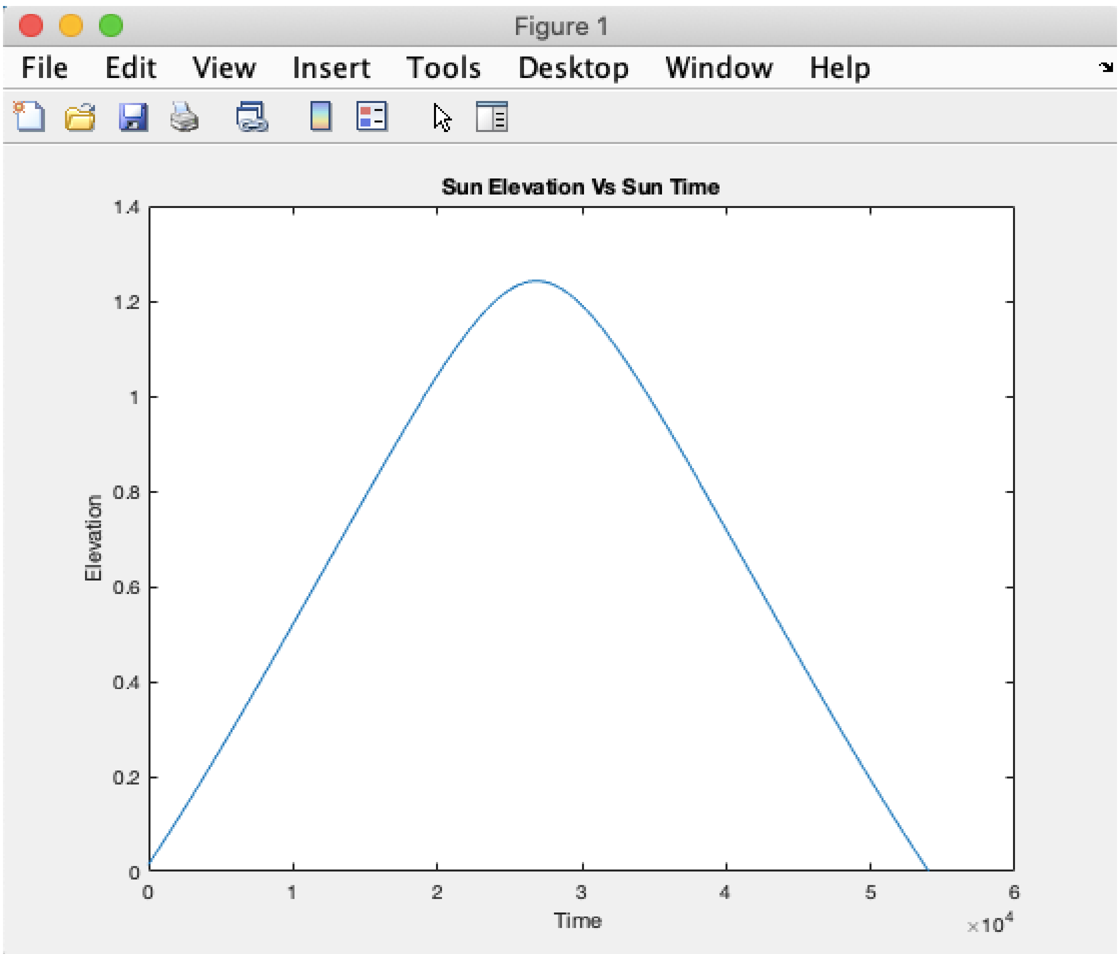


Figure 1
File Edit View Insert Tools Desktop Window Help
Sun Elevation Vs Sun Time
Elevation
Time
×10^4
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1
2
3
4
5
6

Panel Subsystem

The Solar panel size and its diemsions are important factors to be considered because from which one can derived the Inertia of the rectangle shaped panel.

<u>Panel Parameters:</u>

Mass (m)= 75 kg

Width (w)= 1.5 m

Length (l)= 2 m

Depth (d)= 0.15 m

Elevation Angle (a)= 45^0 (ideal angle for solar panel as 45 is the most effective angle for parabolic motions)

Damping Constant (Kd)= 8

θ.

The Inertia formula for rectangular shape,

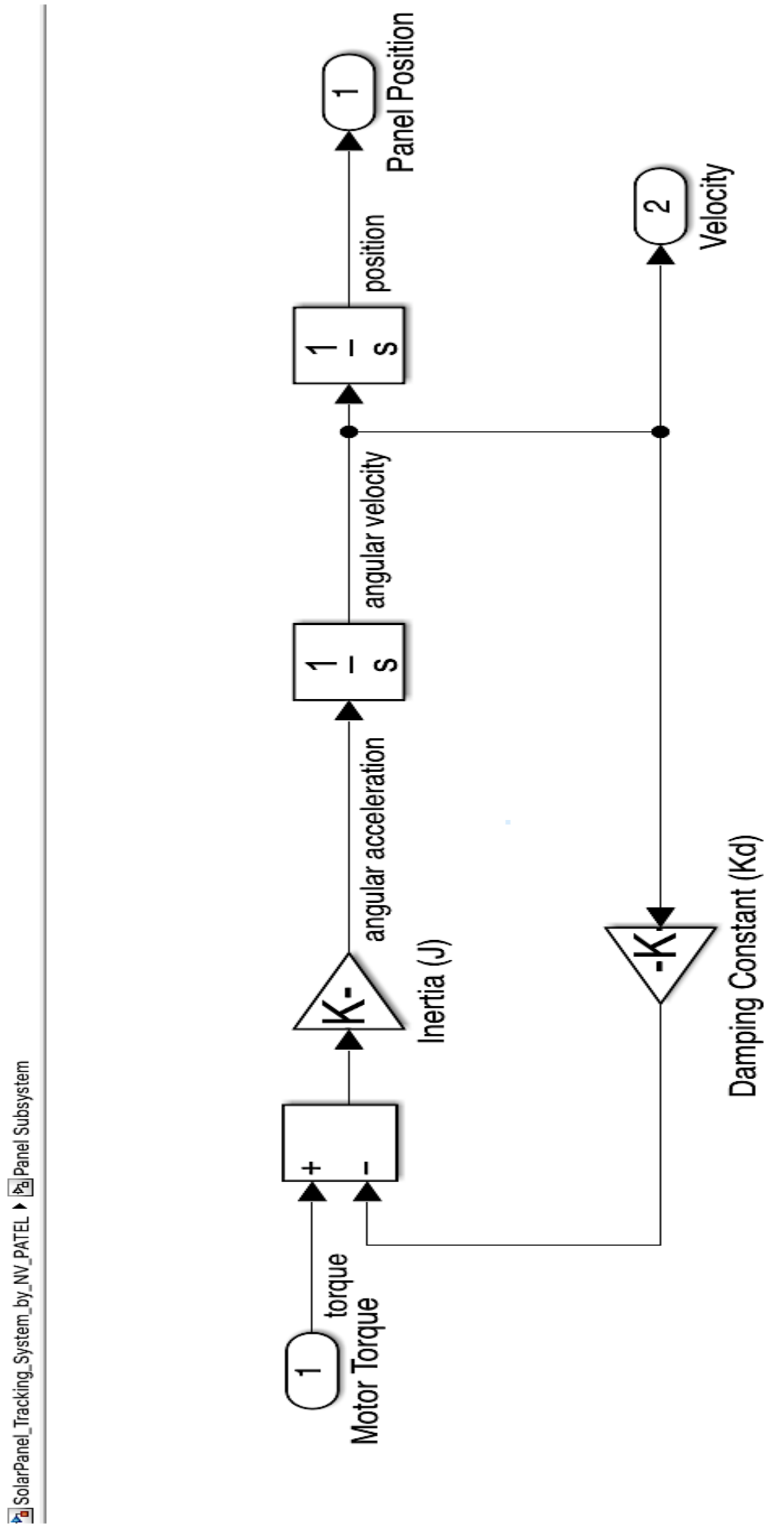
J= m/12*[l^2*cosa^2 + d^2*cosa^2 + w^2]

J= 26.63 kg*m^2

This is the solar panel motion equation,

$$\therefore d^2\theta/dt^2 = 1/J * [T - (Kd * d\theta/dt)]$$

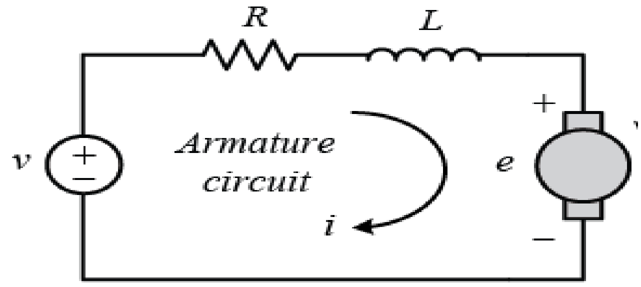
$$\therefore \frac{d^2\theta}{dt^2} = 1/J * [T - (Kd * d\theta/dt)]$$



This equation is mathematically modelled and I have made the panel subsystem using different blocks like Subtract, Gain, Integrator. There is one Inport and Outport available in Panel subsystem which will taking input data and delivering the output data respectively.

Motor Subsystem

DC Motor Calculation:



<u>Motor Parameters:</u>

Emf constant (Kf)= 0.07 v/(rad/s)

Torque Constant (Kt)= 0.07 Nm/A

Inductance (L)= $2*10^{-5}$ H

Resistence (R)= 12 Ohms

Gear Ratio (Kg)= 1500

- As you can see this is the simple diagram for the DC motor.
- v is represents the applied voltage, e is emf (electro motive force) induced inside the motor.
- Applied voltage (v) is directly proportional to rotational velocity of the motor. Whereas, applied(i) current is proportional to torque of the motor.
- Thus, ultimately by regulating or fluctuating the voltage we can change the motor speed and consecutively the wheel velocity or vehicle speed.
- According to kirchoff law applied in this circuit,

$$\therefore di/dt = \int 1/L * [v - Kg * Kf * (d\theta/dt) - i(t)R]$$

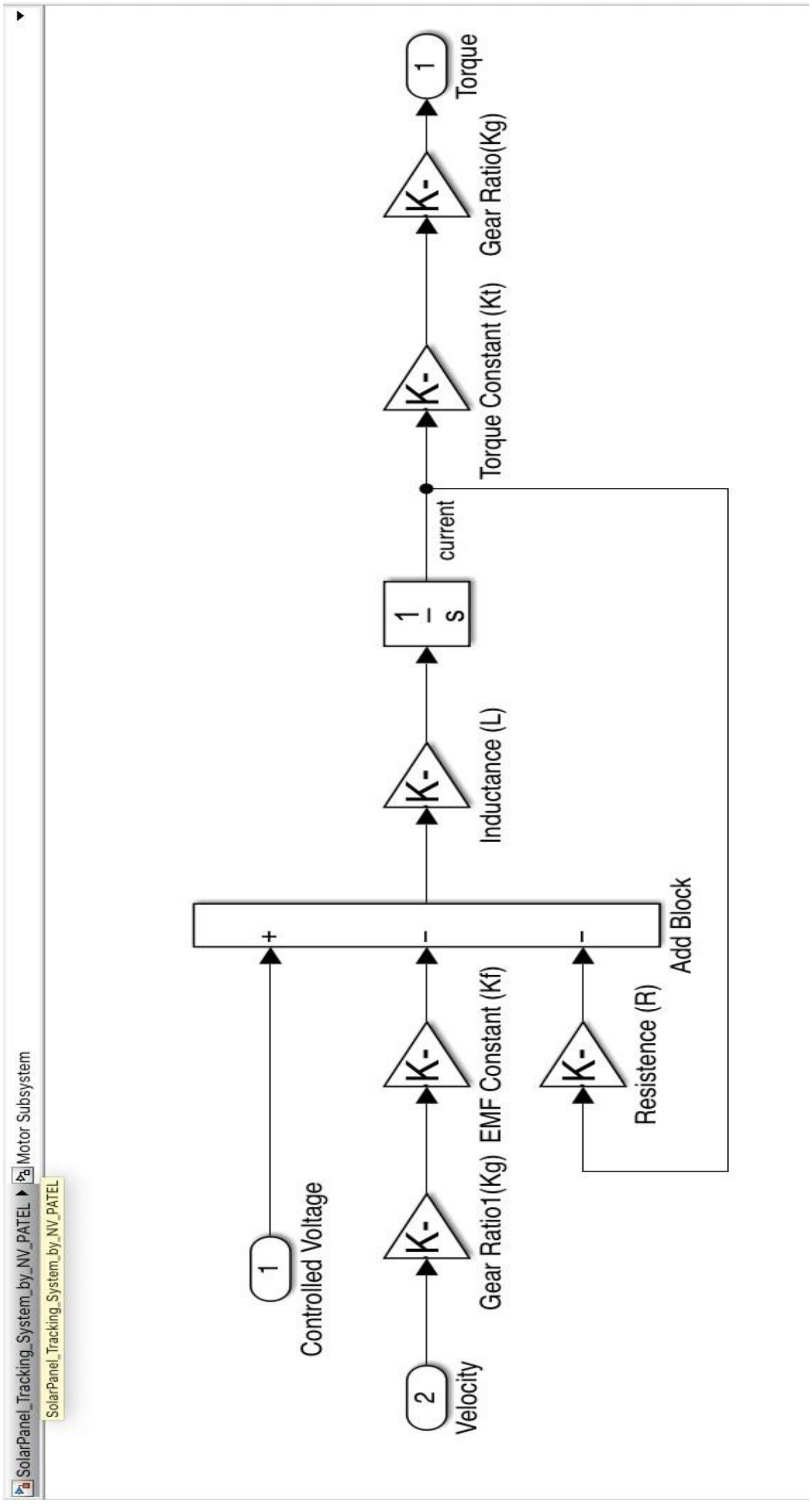
- As the current is directly proportional to motor torque,

$$\therefore T = Kg*Kt*i(t)$$

Based on these two equations I have modelled the subsystem in simulink.

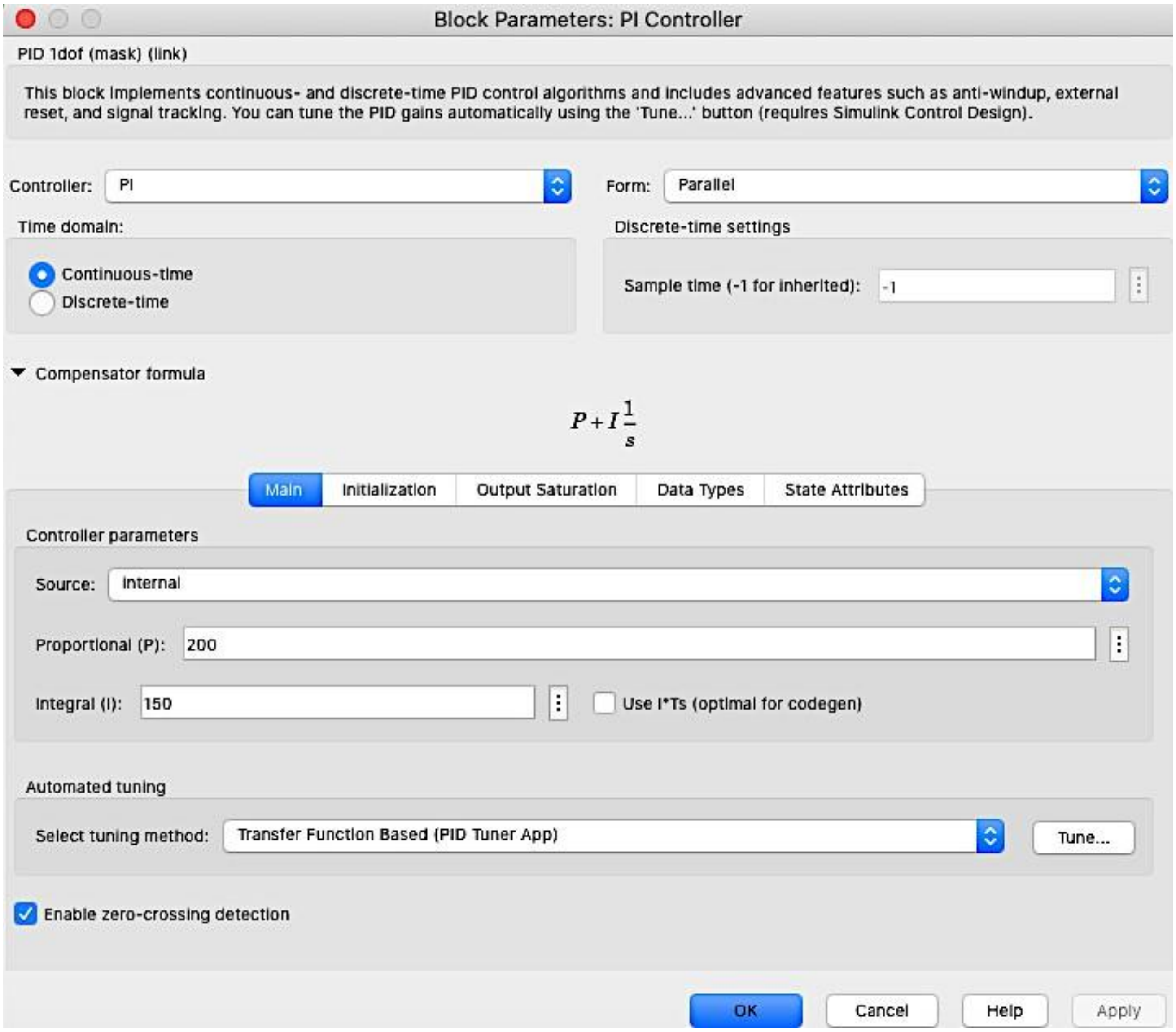
$$: T = Kg*Kt*i(t)$$

$$: di/dt = \int 1/L * [v - Kg*Kf*(d\theta/dt) - i(t)R]$$



The above two equations which are completely describe the motor is mathematically modelled in simulink with the help of diffent blocks like Gain, Add, Integrator. There are two Inports and one Outport present in motor subystem.

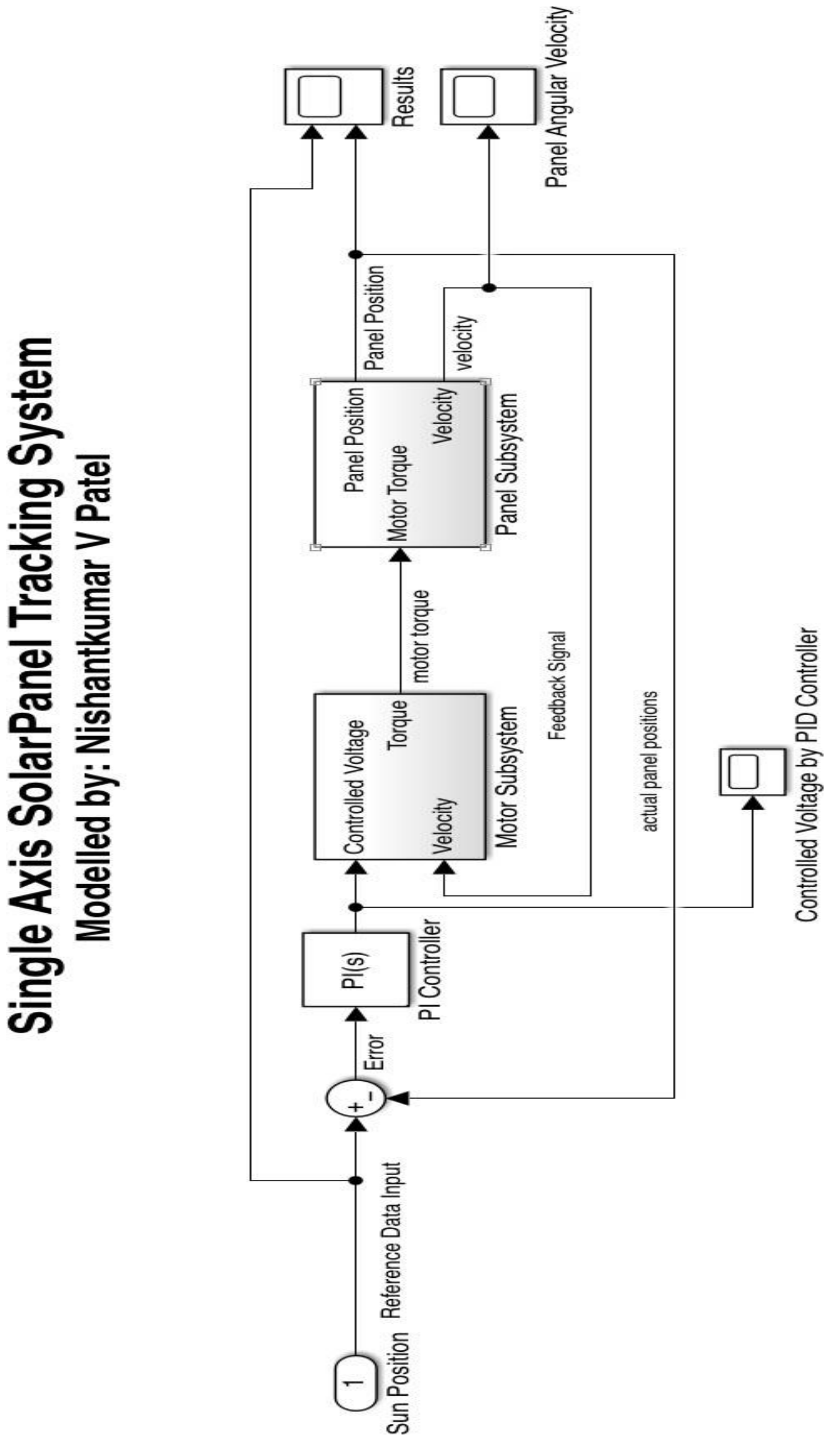
PI Controller

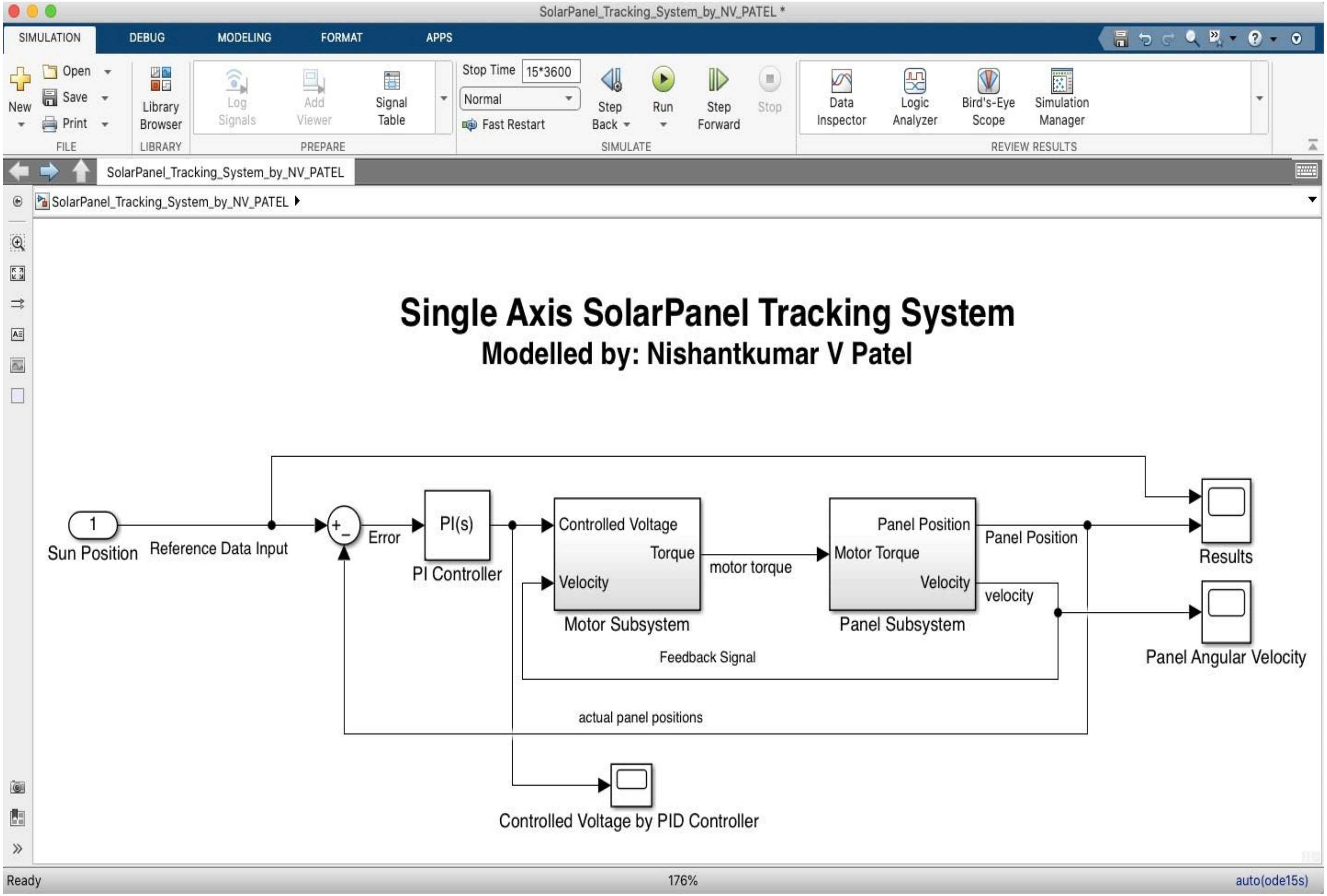


- I have take PI gain values and neglecting the derivative gain by keeping its value 0. The reason is sun is moving steadily over the period of time and not chaning its position so fast so there is not rate of change of error produced in the closed loop system.

Proportional Gain=200, Integral Gain=150

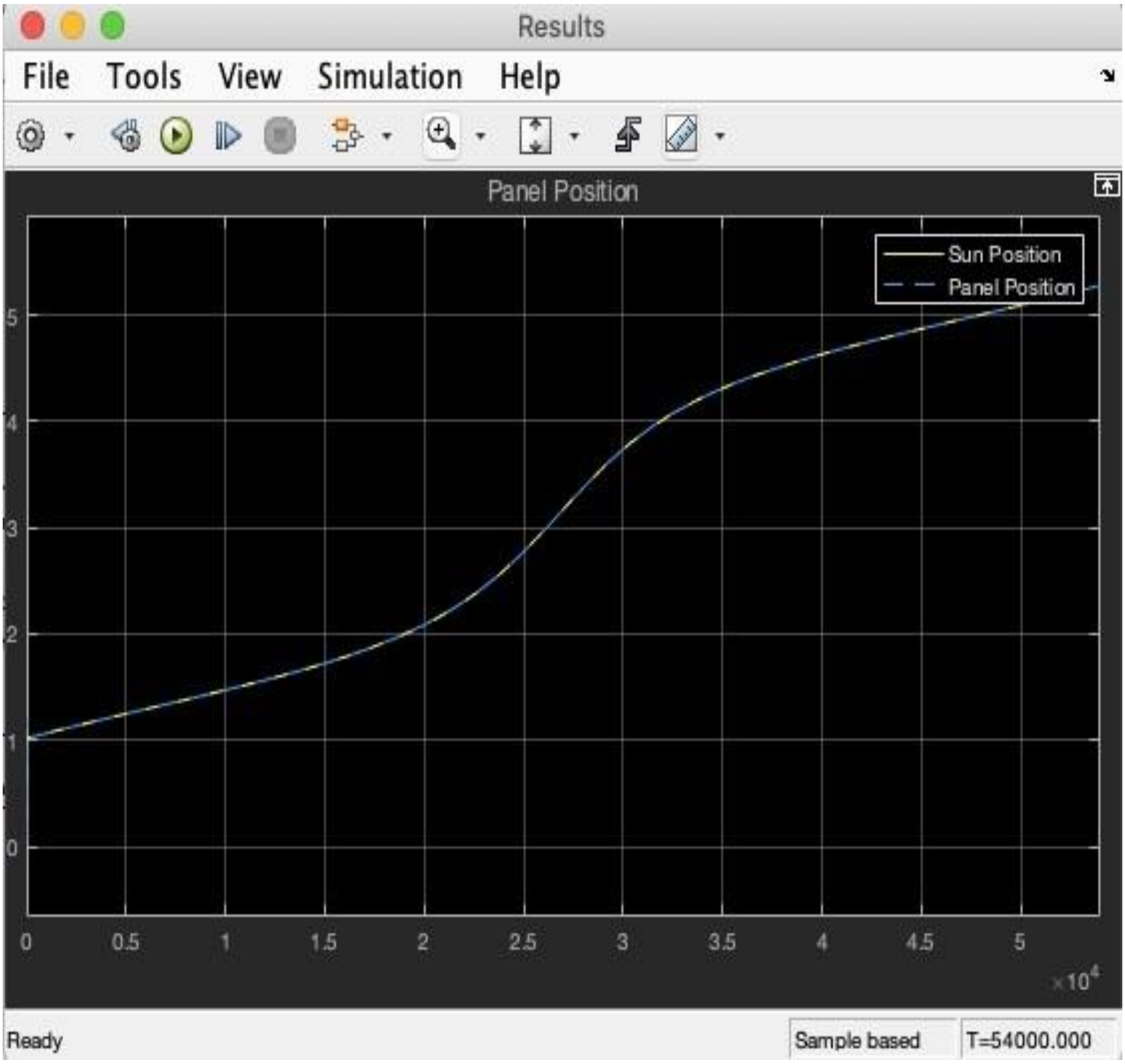
Simulink Model





SolarPanel_Tracking_System_by_NV_PATEL *
SIMULATION
DEBUG
MODELING
FORMAT
APPS
New
Open
Save
Print
FILE
Library Browser
LIBRARY
Log Signals
Add Viewer
Signal Table
PREPARE
Stop Time
15*3600
Normal
Fast Restart
Step Back
Run
Step Forward
Stop
SIMULATE
Data Inspector
Logic Analyzer
Bird's-Eye Scope
Simulation Manager
REVIEW RESULTS
SolarPanel_Tracking_System_by_NV_PATEL
Single Axis SolarPanel Tracking System
Modelled by: Nishantkumar V Patel
1
Sun Position
Reference Data Input
Error
PI(s)
PI Controller
Controlled Voltage
Torque
Velocity
Motor Subsystem
motor torque
Panel Position
Motor Torque
Velocity
Panel Subsystem
Panel Position
velocity
Results
Panel Angular Velocity
Feedback Signal
actual panel positions
Controlled Voltage by PID Controller
Ready
176%
auto(ode15s)

Testing the Model



- As You can see the the panel position constantly pointing with the sun position during the day. Here I took the simulation time as per the data of 15 hours means 54,000 seconds for the day.
- The X-axis is indicating simulation time 54,000 sec.
- The Y-axis is indicating the angle with the scale from 1 to 5.27 as per the sunPosition data.