Automotive Mechatronics Laboratory

Topic:

E-Bike simulation

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2024-11-08

aml.edu.vn

INTRODUCTION

Overview of research situation

- Domestic:
  - Vu, M. N., & Ta, M. C. (2015). A sliding mode algorithm for antilock braking /traction control of EVs. VNUHCM Journal of Science and Technology Development, 18(3), 174-182.
  - Phan, T. T., Ngo, H. T., & Huynh, B. T. (2022). Application of pid method to control traction on the vehicles through controlling the brake moment at the two driving wheels. Tra vinh university journal of science.
- International
  - Vecchio, C., Tanelli, M., Corno, M., Ferrara, A., & Savaresi, S. M. (2009, June). Second order sliding mode for traction control in ride-by-wire sport motorcycles. In 2009 American Control Conference.
  - Cabrera, J. A., Castillo, J. J., Carabias, E., & Ortiz, A. (2014). Evolutionary optimization of a motorcycle traction control system based on fuzzy logic. IEEE Transactions on Fuzzy Systems
  - Yuniarto, M. N., Wiratno, S. E., Nugraha, Y. U., Sidharta, I., & Nasruddin, A. (2022). Modeling, Simulation, and Validation of An Electric Scooter Energy Consumption Model: A Case Study of Indonesian Electric Scooter

BASIC THEORY

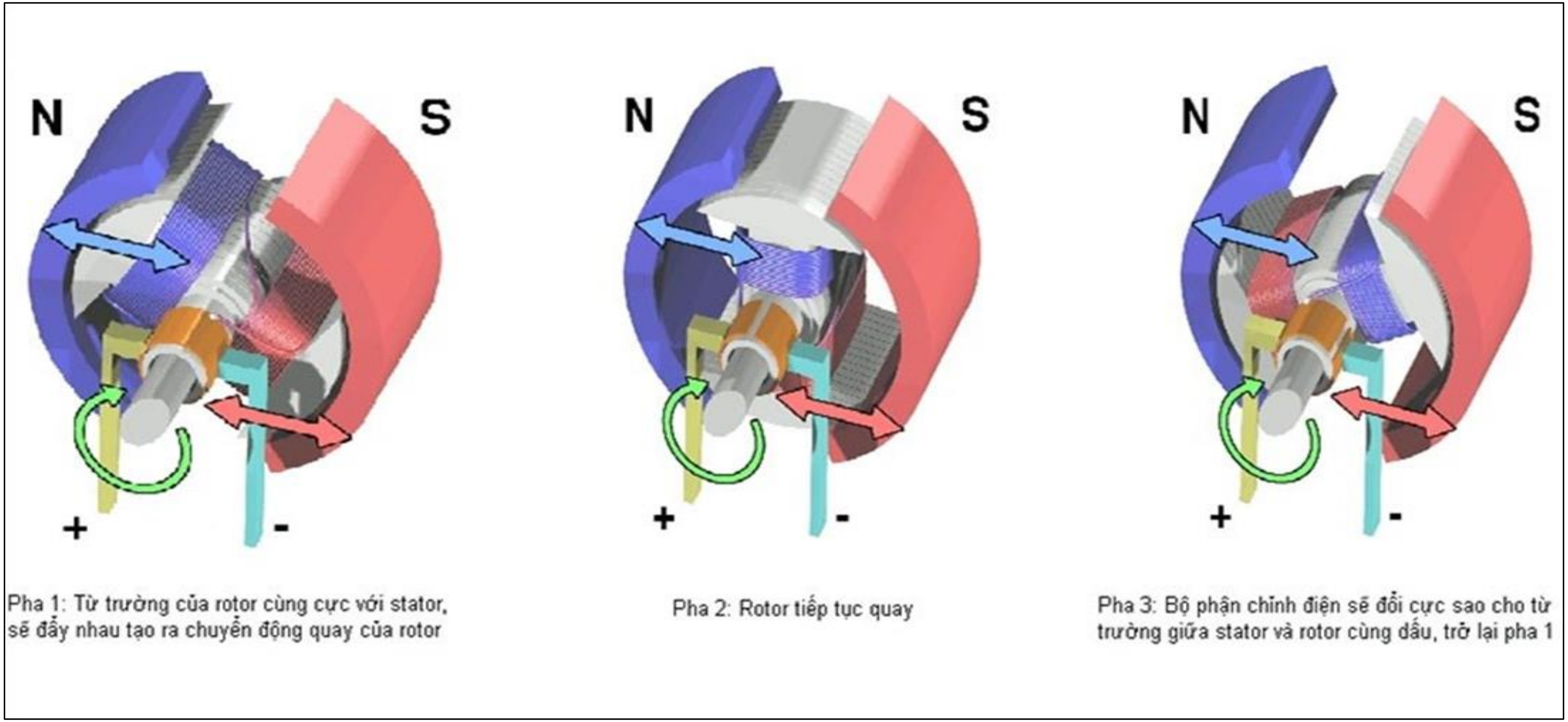
Types of electric motors

- Five main types of electric motors:
  - DC electric motor with DC carbon brush
  - Induction motor
  - Permanent magnet synchronous motor (PMSM)
  - Switched reluctance motor
  - Brushless DC motor (BLDC)
- BLDC motors and permanent magnet motors are more suitable, thanks to their advantages of low pollution and fuel consumption. Less and the power-to-mass ratio is higher.

DC Motor

- DC Motor (1-way electric motor with carbon brush):
  - DC motors (Direct Current Motors) are motors controlled by current with a specific direction. The output of this motor usually consists of two wires.
  - The no-load speed of a DC motor without deceleration can reach from 1000 RPM to 40 000 RPM.

DC Motor

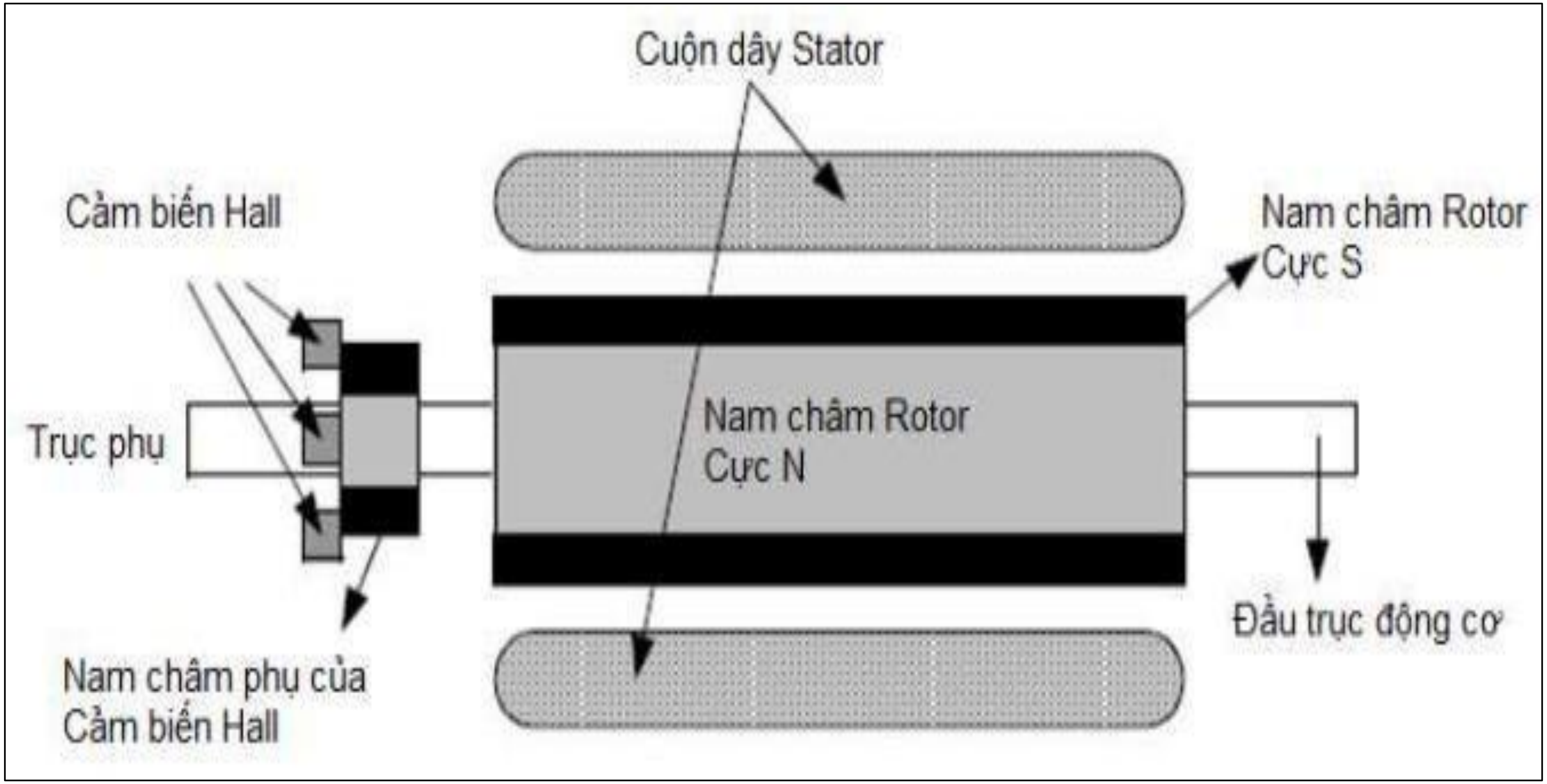


DC motor operating principle

BLDC Motor

- BLDC Motor (brushless motor):
  - BLDC motors are similar to DC motors but the functions of the rotor and stator are reversed.
  - The rotor is made up of a set of permanent magnets.
  - The stator is a controlled electromagnet.
  - Vary the change by controlling the current into the different coil wires to keep the rotor spinning.
- The reversal of the current through the winding wires is carried out by power transistor control according to the position of the rotor through sensors (Hall).

BLDC Motor

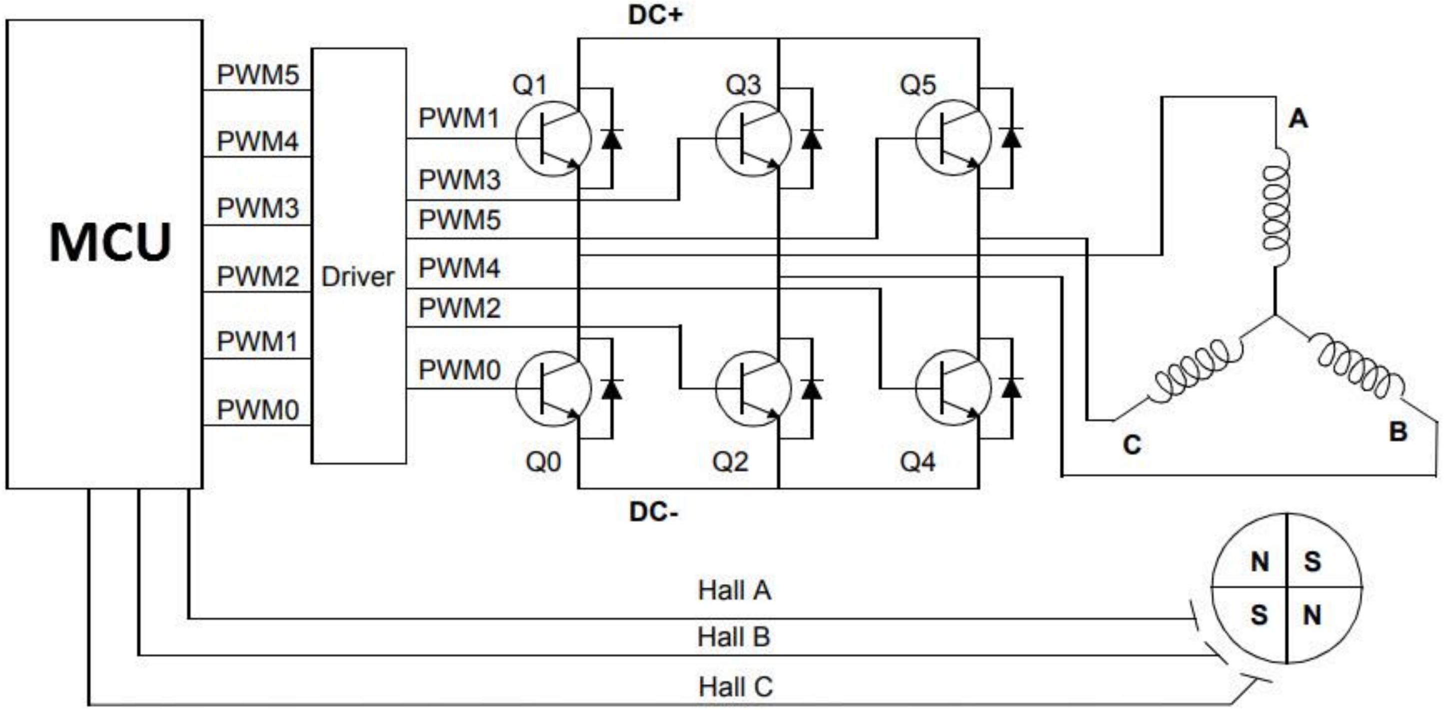


DC motor operating principle

BLDC Motor

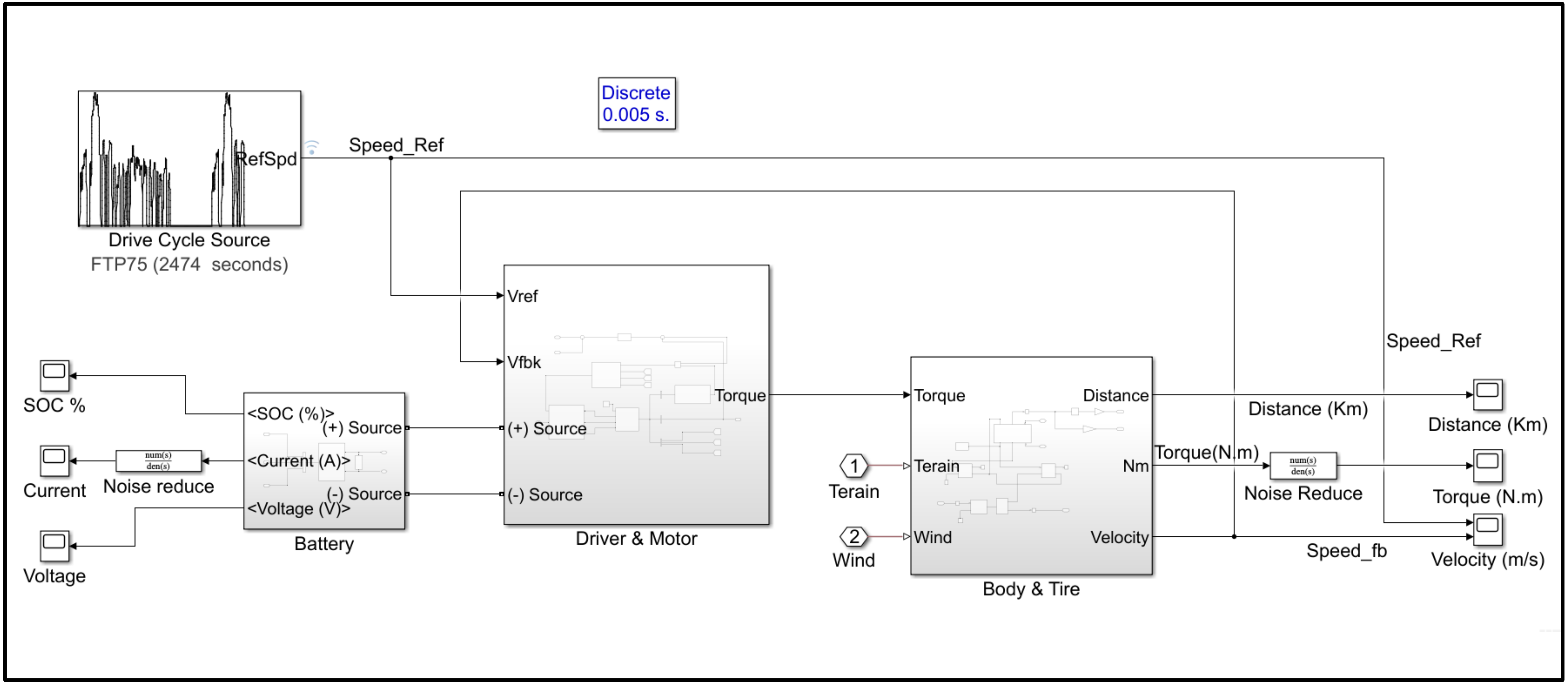
- Base on position of the rotor, the control system switches on and off the transistors. Each state:
  - 1 coil that is energized positively,
  - 1 coil that is energized negatively,
  - 1 coil that is de-energized.

- Torque is generated by the interaction between the magnetic field created by the stator coils and the permanent magnet.



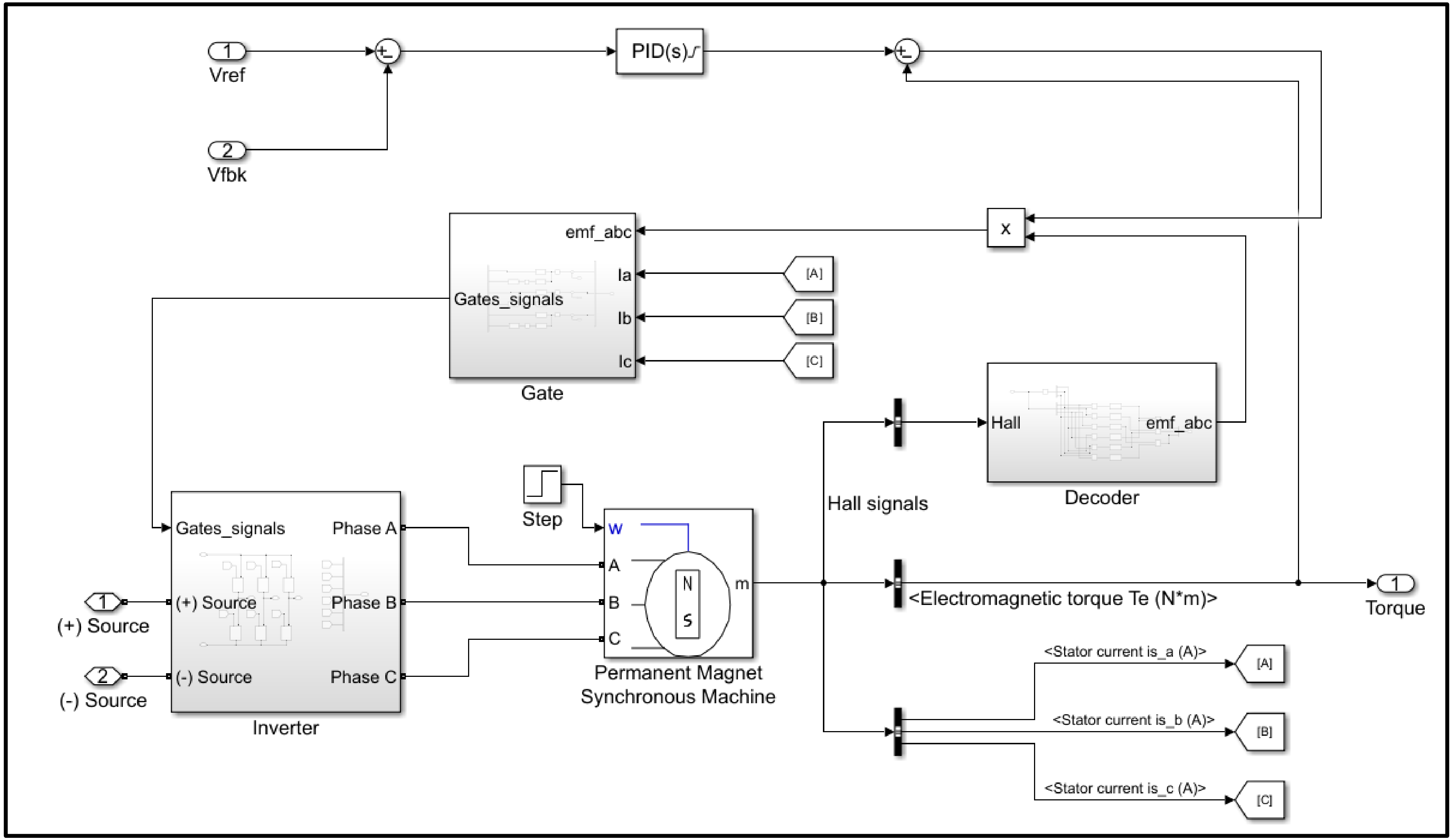
E-BIKE MODELING

General

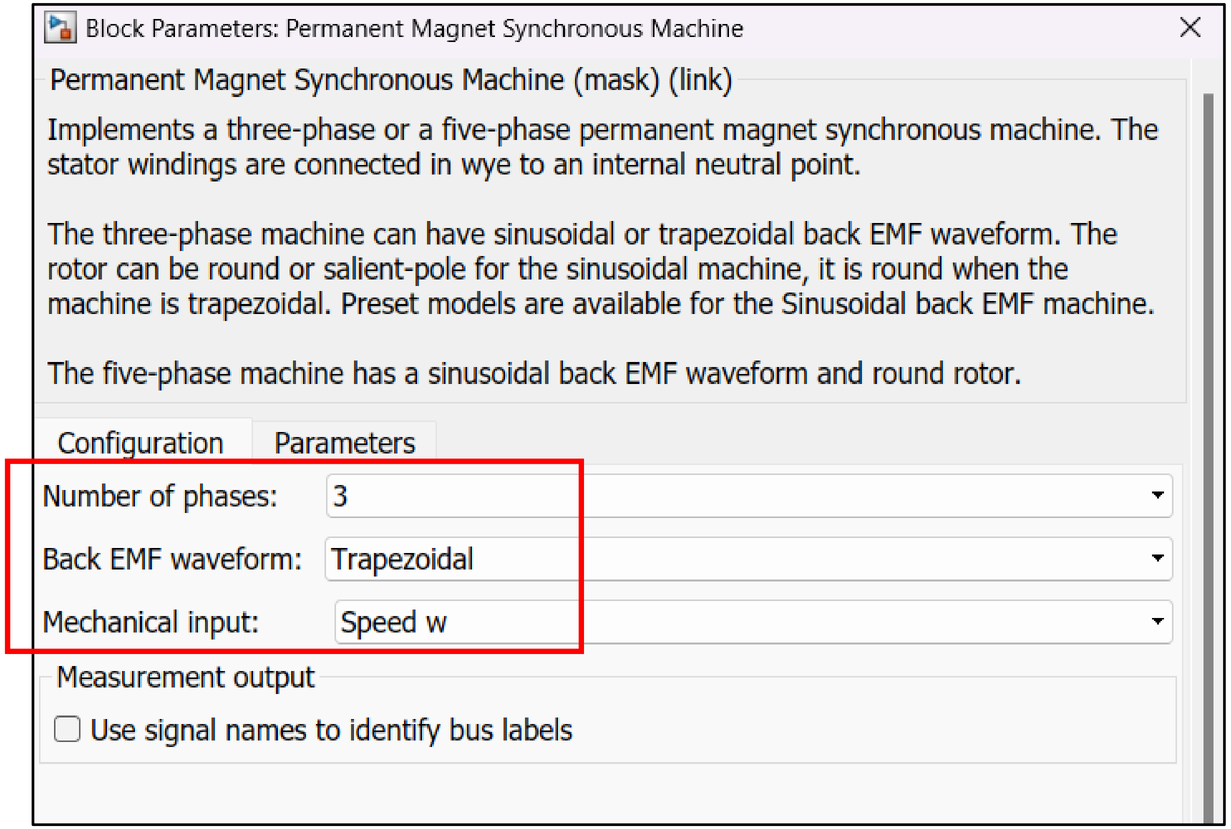


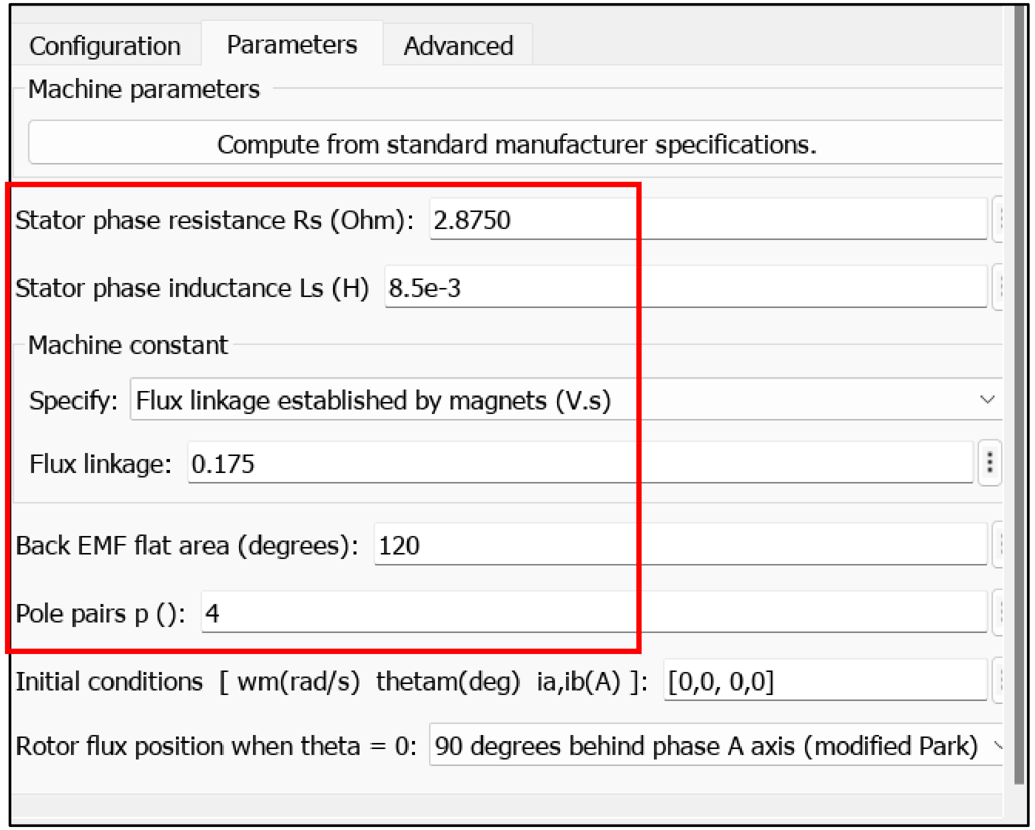
Discrete
0.005 s.
RefSpd
Speed_Ref
Drive Cycle Source
FTP75 (2474 seconds)
Vref
Vfbk
(+) Source
(-) Source
Torque
Driver & Motor
SOC %
Current
Noise reduce
Voltage
<SOC (%)>
<Current (A)>
<Voltage (V)>
(+) Source
(-) Source
Battery
Speed_Ref
Torque
Terain
Wind
Distance
Nm
Velocity
Body & Tire
1
Terain
2
Wind
Distance (Km)
Torque(N.m)
Noise Reduce
Speed_fb
Distance (Km)
Torque (N.m)
Velocity (m/s)

Driver & Motor



Motor configuration

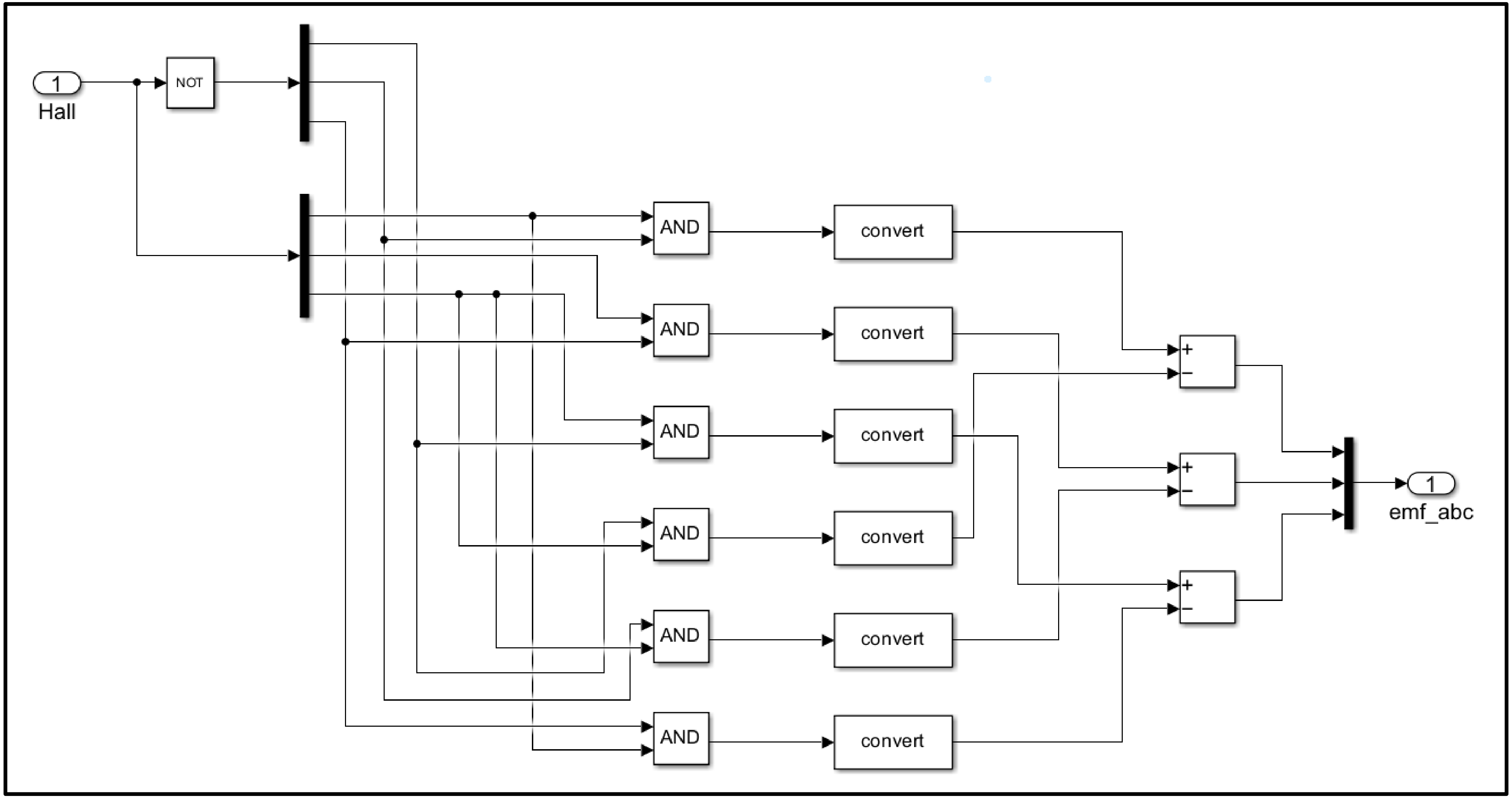




Hall signal solving

ha	hb	hc	$EMFa$	$EMFb$	$EMFc$
0	0	0	0	0	0
0	0	1	0	-1	+1
0	1	0	-1	+1	0
0	1	1	-1	0	+1
1	0	0	+1	0	-1
1	0	1	+1	-1	0
1	1	0	0	+1	-1
1	1	1	0	0	0

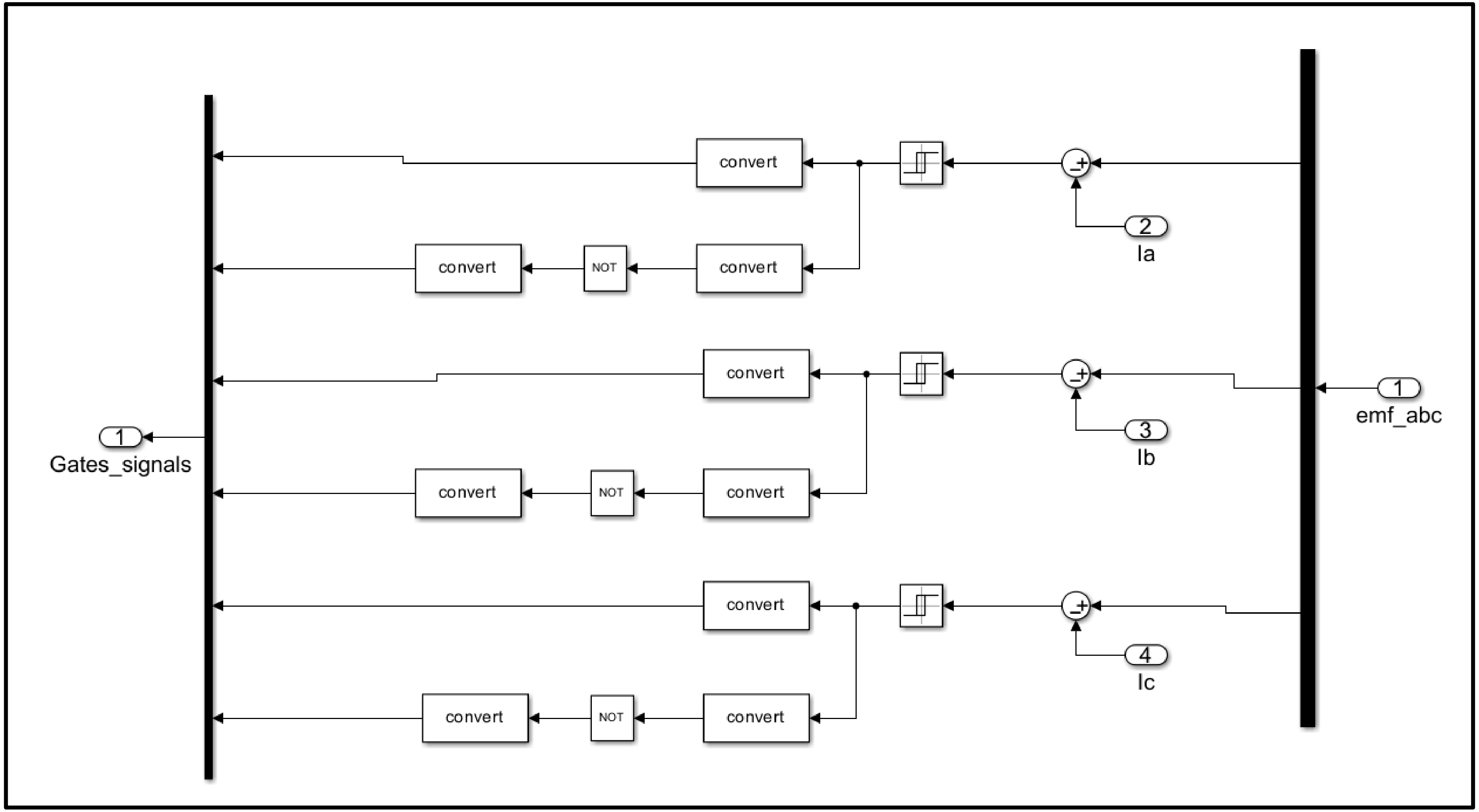
Hall decoder



Convert EMF into phase signal

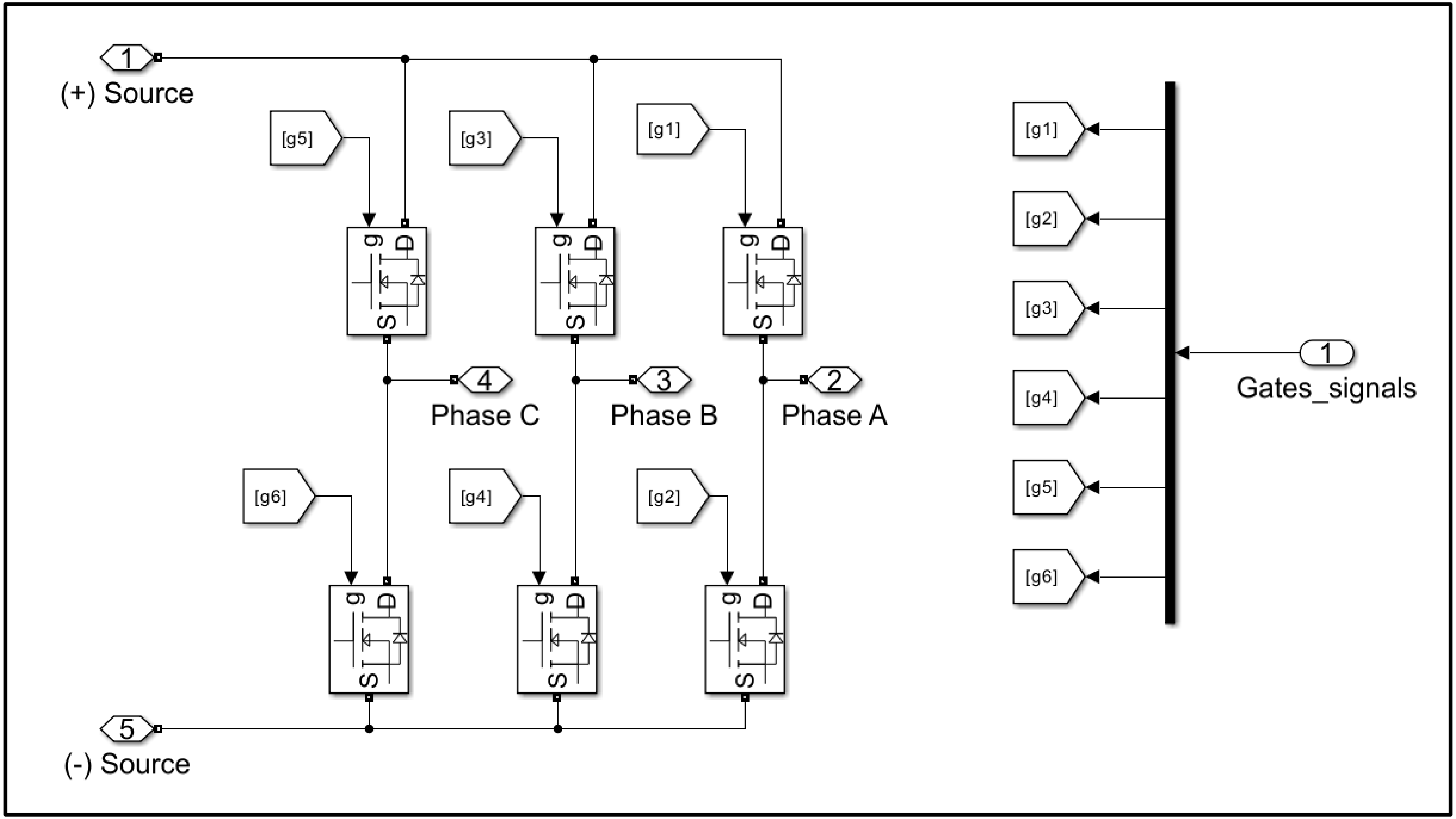
EMF_a	EMF_b	EMF_c		G_1	G_2	G_3	G_4	G_5	G_6
0	0	0		0	0	0	0	0	0
0	-1	+1		0	0	0	1	1	0
-1	+1	0		0	1	1	0	0	0
-1	0	+1		0	1	0	0	1	0
+1	0	-1		1	0	0	0	0	1
+1	-1	0		1	0	0	1	0	0
0	+1	-1		0	0	1	0	0	1
0	0	0		0	0	0	0	0	0

Gate signal



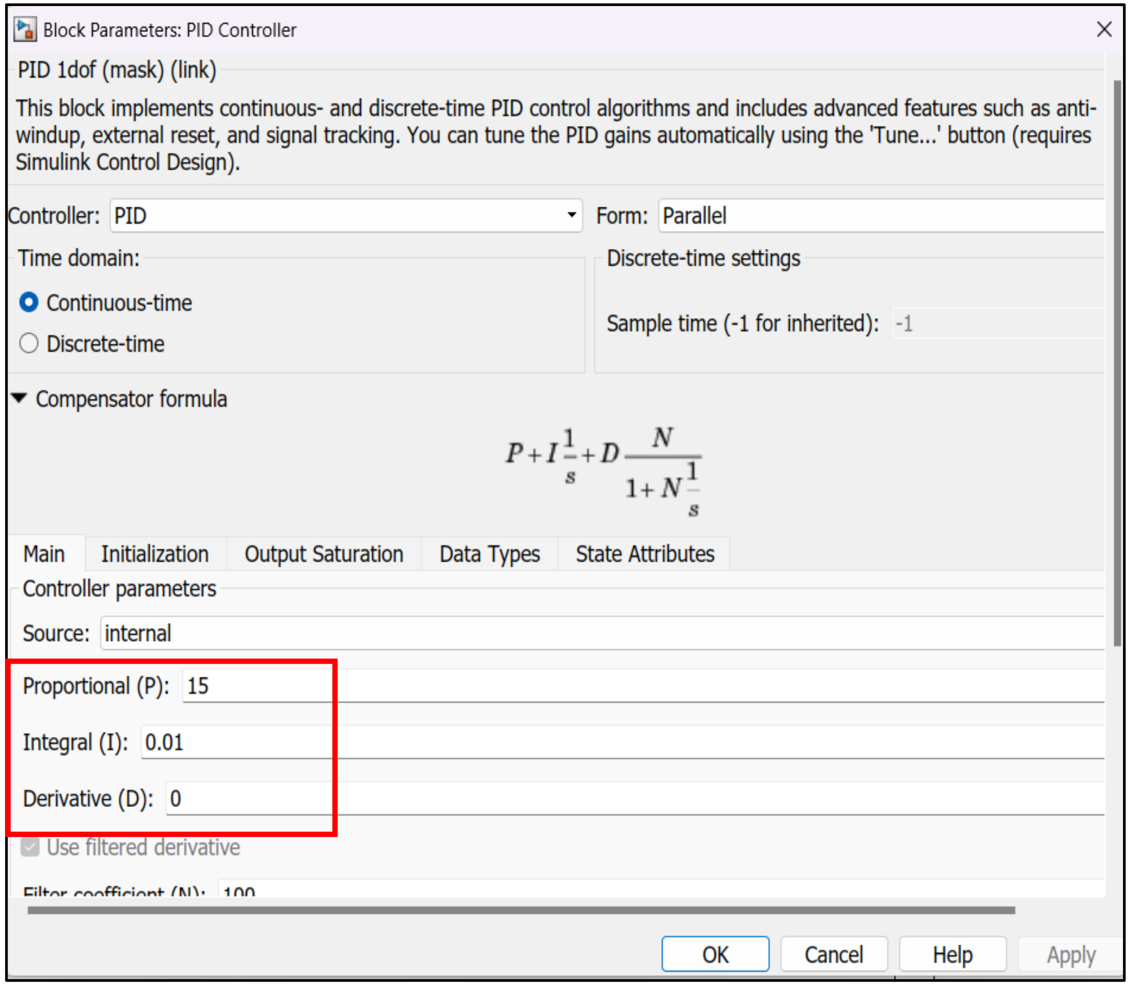
convert
convert
NOT
convert
convert
convert
NOT
convert
convert
convert
NOT
convert
2
Ia
3
Ib
4
Ic
1
emf_abc
1
Gates_signals

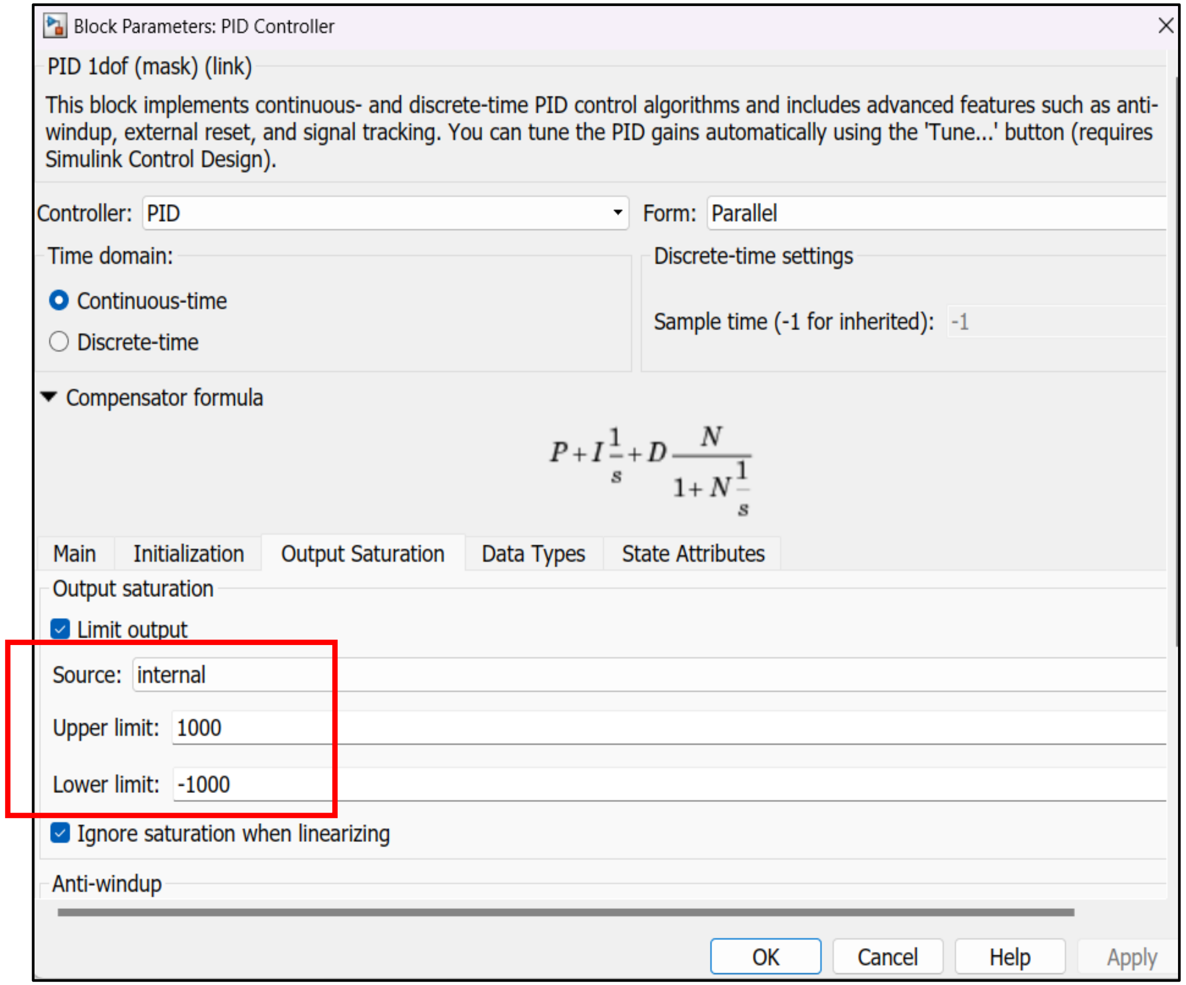
Inverter



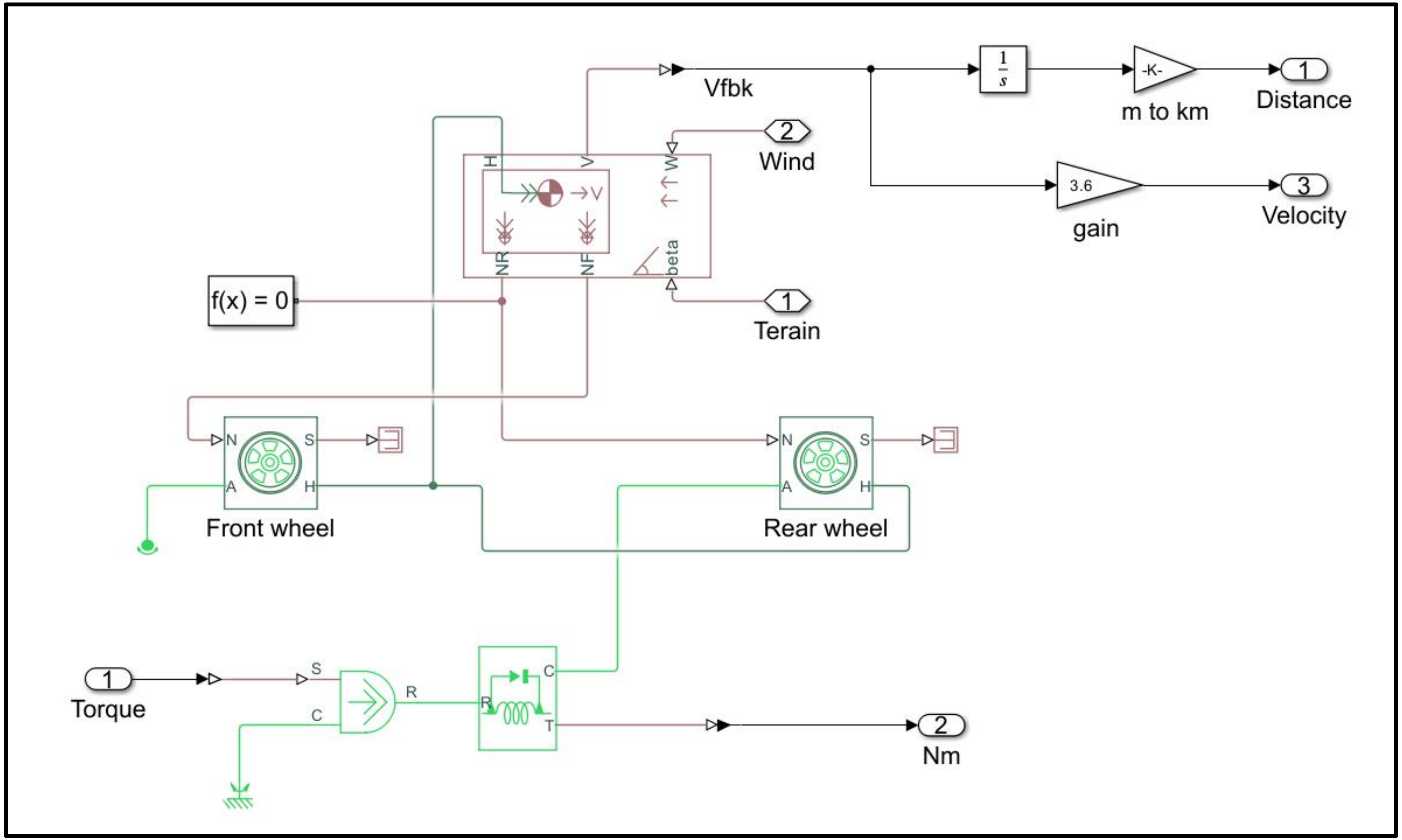
1
(+) Source
[g5]
[g3]
[g1]
g
D
S
4
Phase C
3
Phase B
2
Phase A
[g6]
[g4]
[g2]
5
(-) Source
[g1]
[g2]
[g3]
[g4]
[g5]
[g6]
1
Gates_signals

PID controller configuration for motor



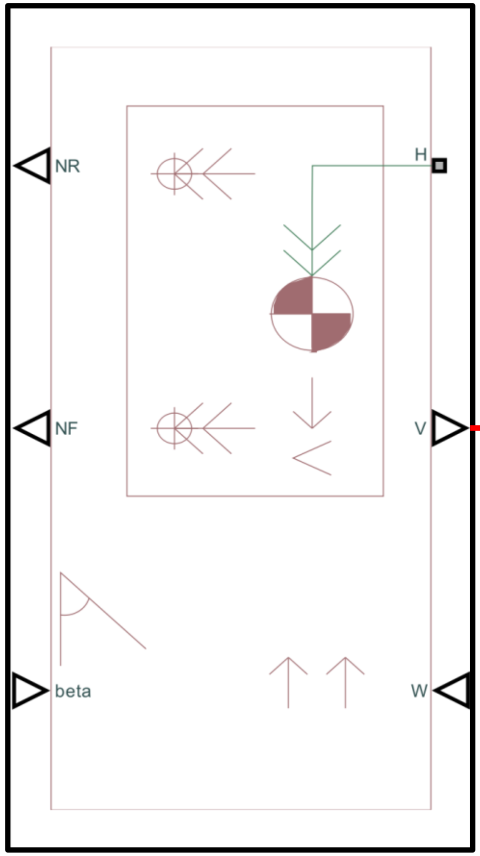


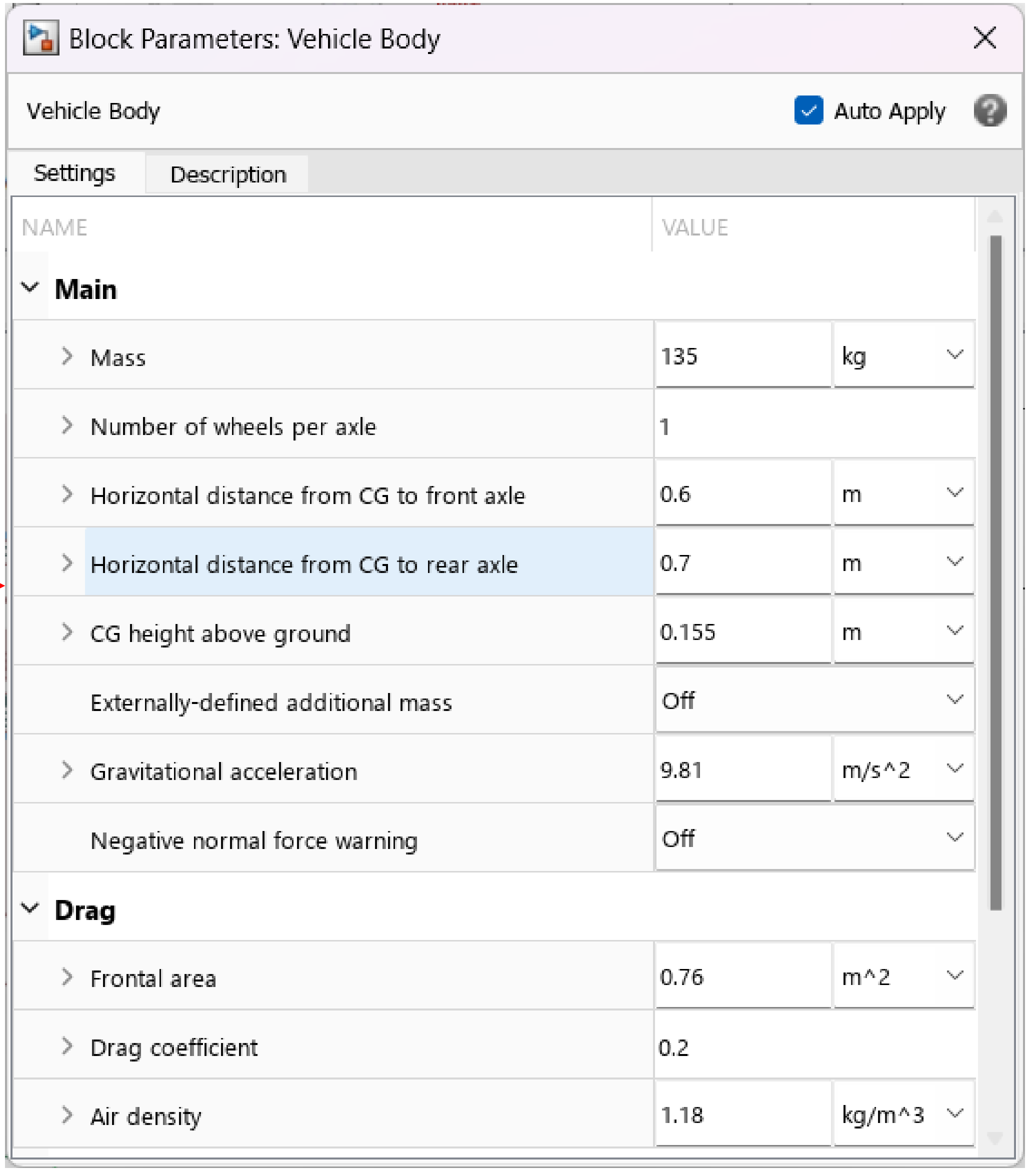
Body & Tire



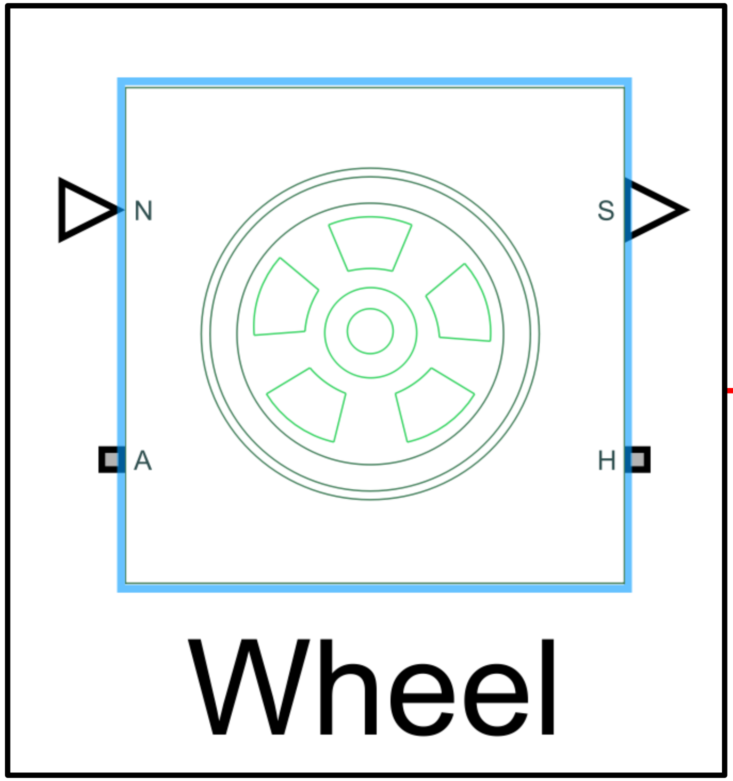
Vfbk
1/s
-K-
m to km
1
Distance
2
Wind
3.6
gain
3
Velocity
H
V
W
NR
NF
beta
f(x) = 0
1
Terain
N
S
A
H
Front wheel
N
S
A
H
Rear wheel
1
Torque
S
C
R
R
C
T
2
Nm

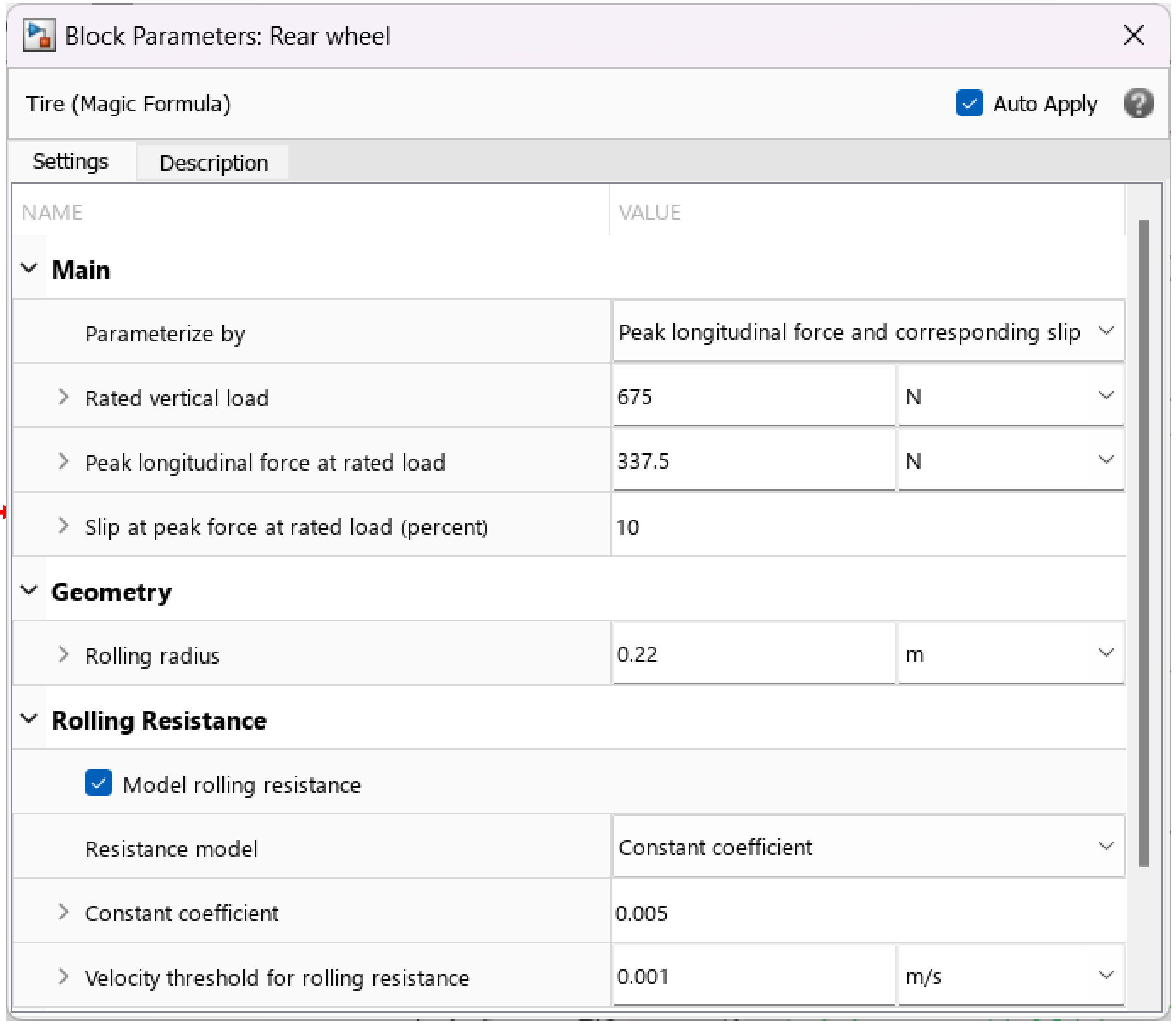
Body configuration



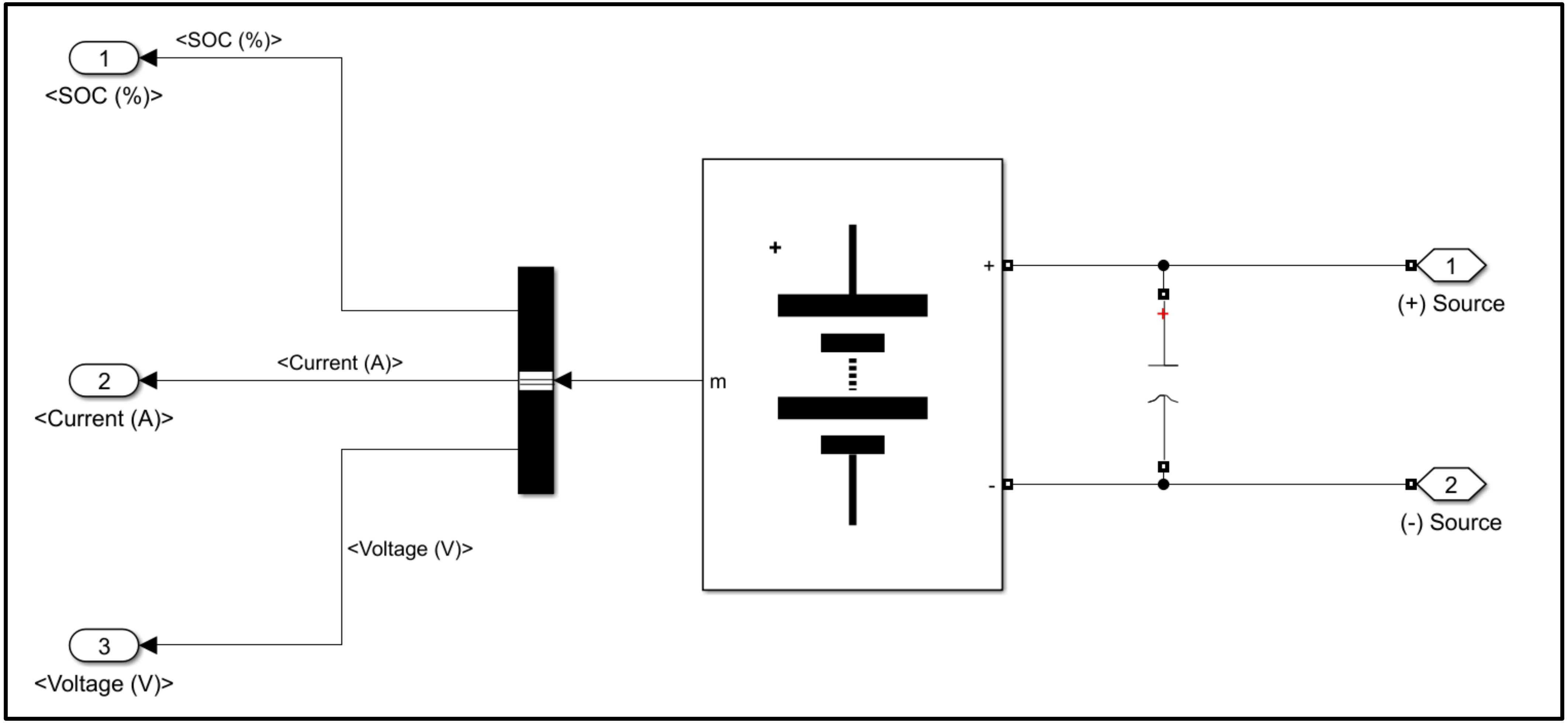


Wheel configuration



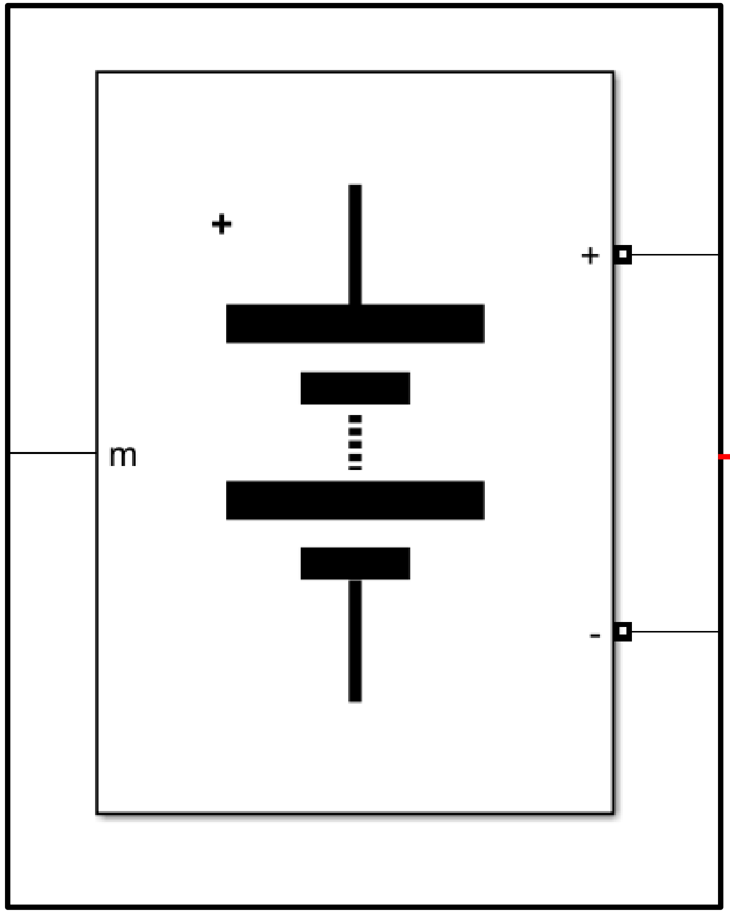


Battery

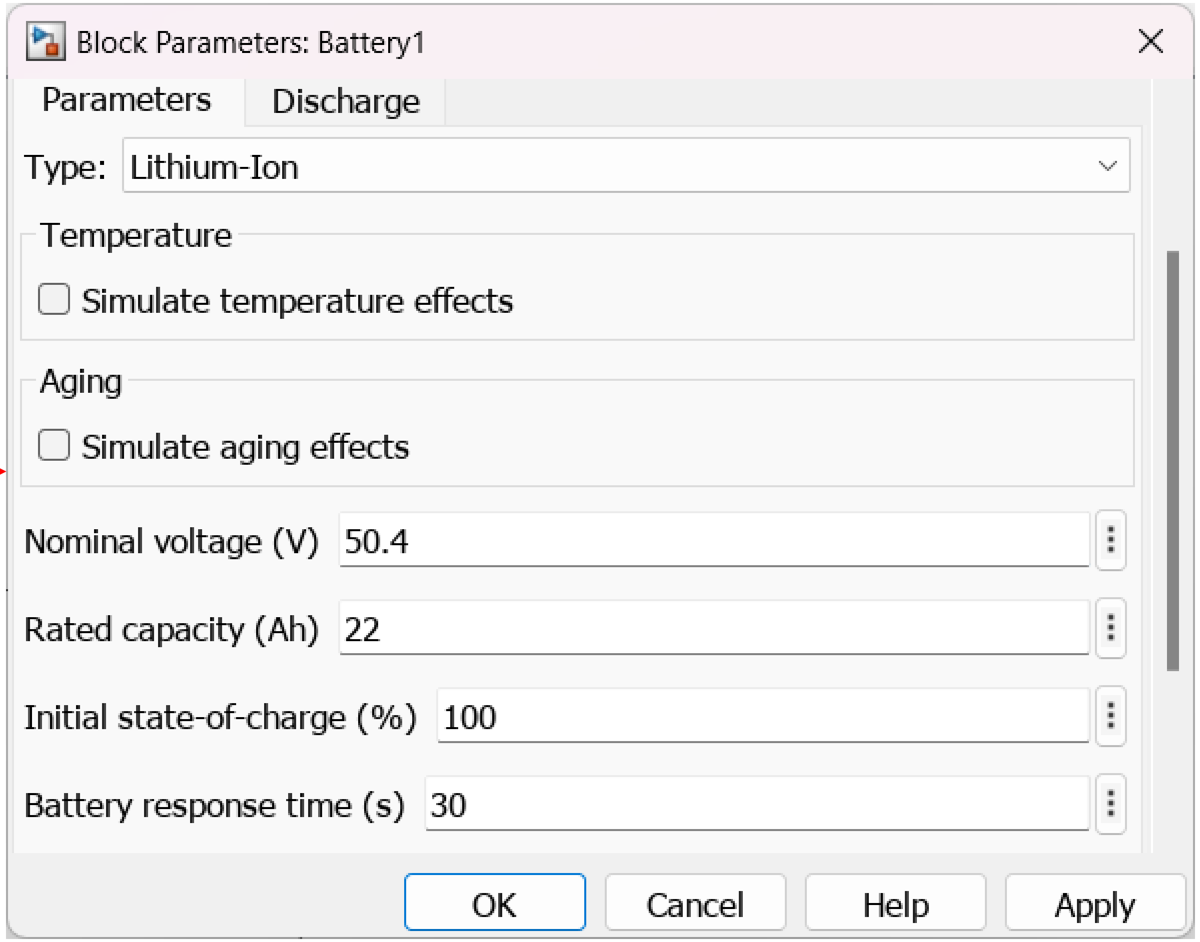


<SOC (%)>
1
<SOC (%)>
<Current (A)>
2
<Current (A)>
<Voltage (V)>
3
<Voltage (V)>
+
m
+
-
1
(+) Source
2
(-) Source

Battery



+
+
m
-

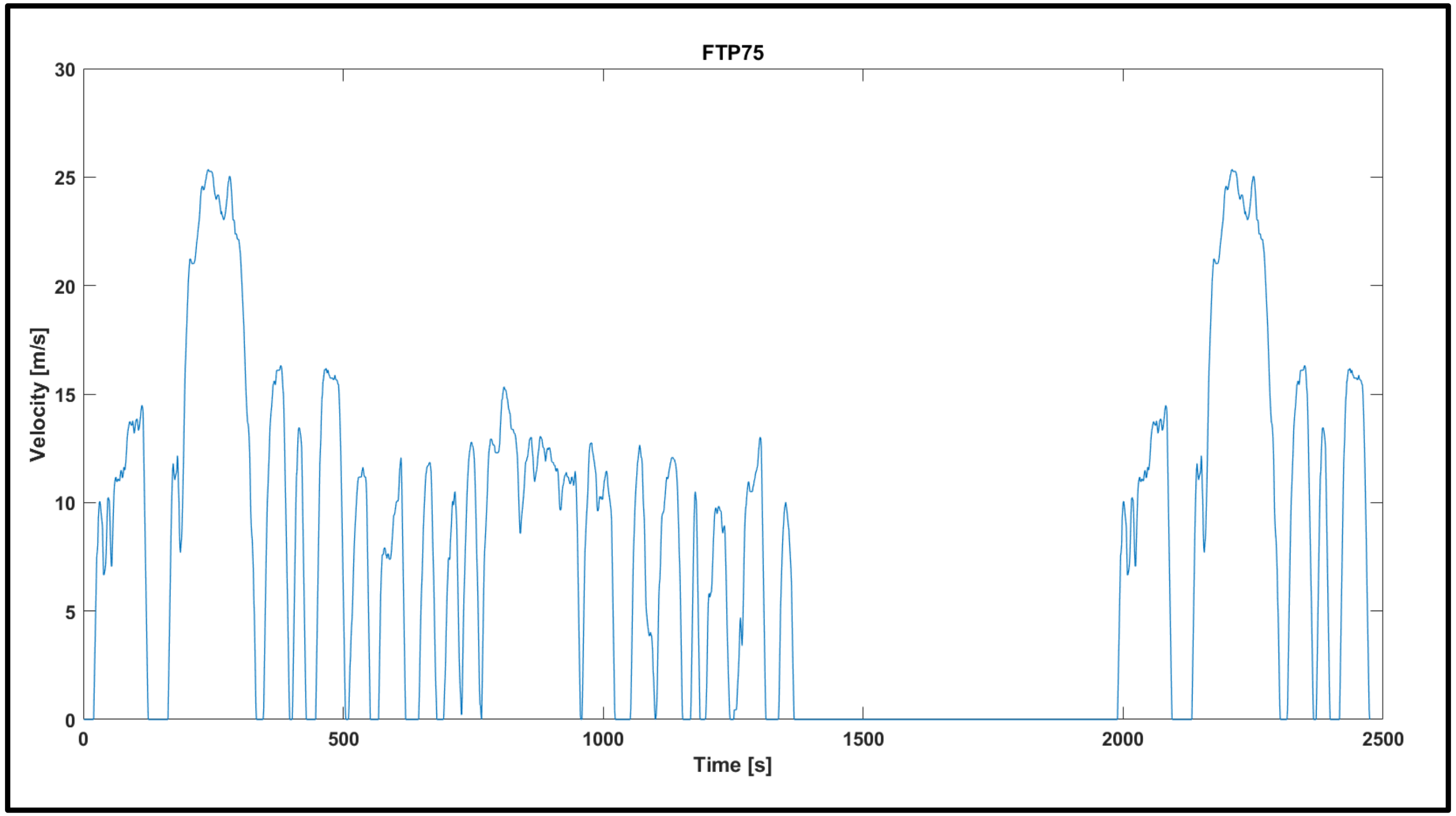


Block Parameters: Battery1
Parameters
Discharge
Type: Lithium-Ion
Temperature
Simulate temperature effects
Aging
Simulate aging effects
Nominal voltage (V) 50.4
Rated capacity (Ah) 22
Initial state-of-charge (%) 100
Battery response time (s) 30
OK
Cancel
Help
Apply

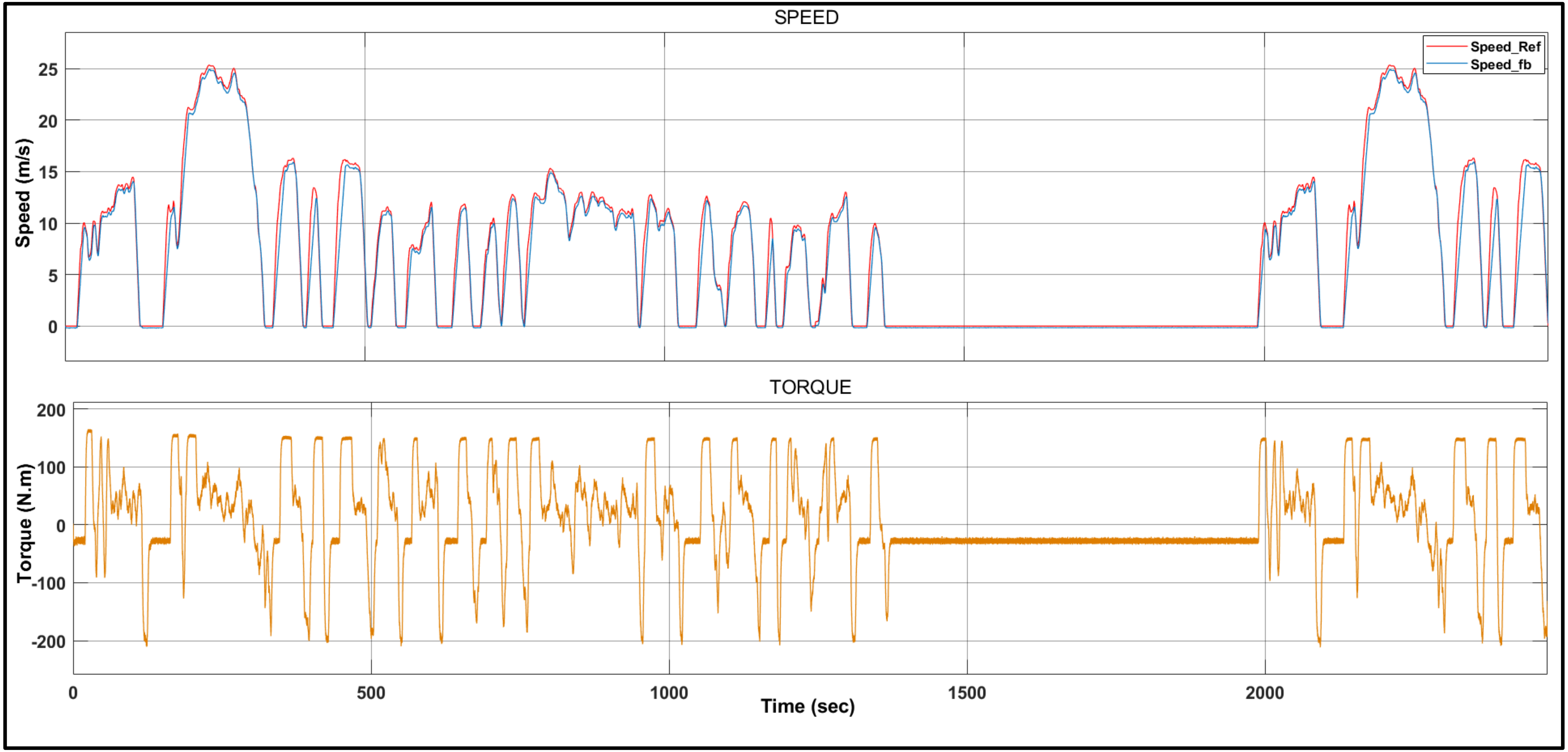
SIMULATION

FTP-75 Cycle

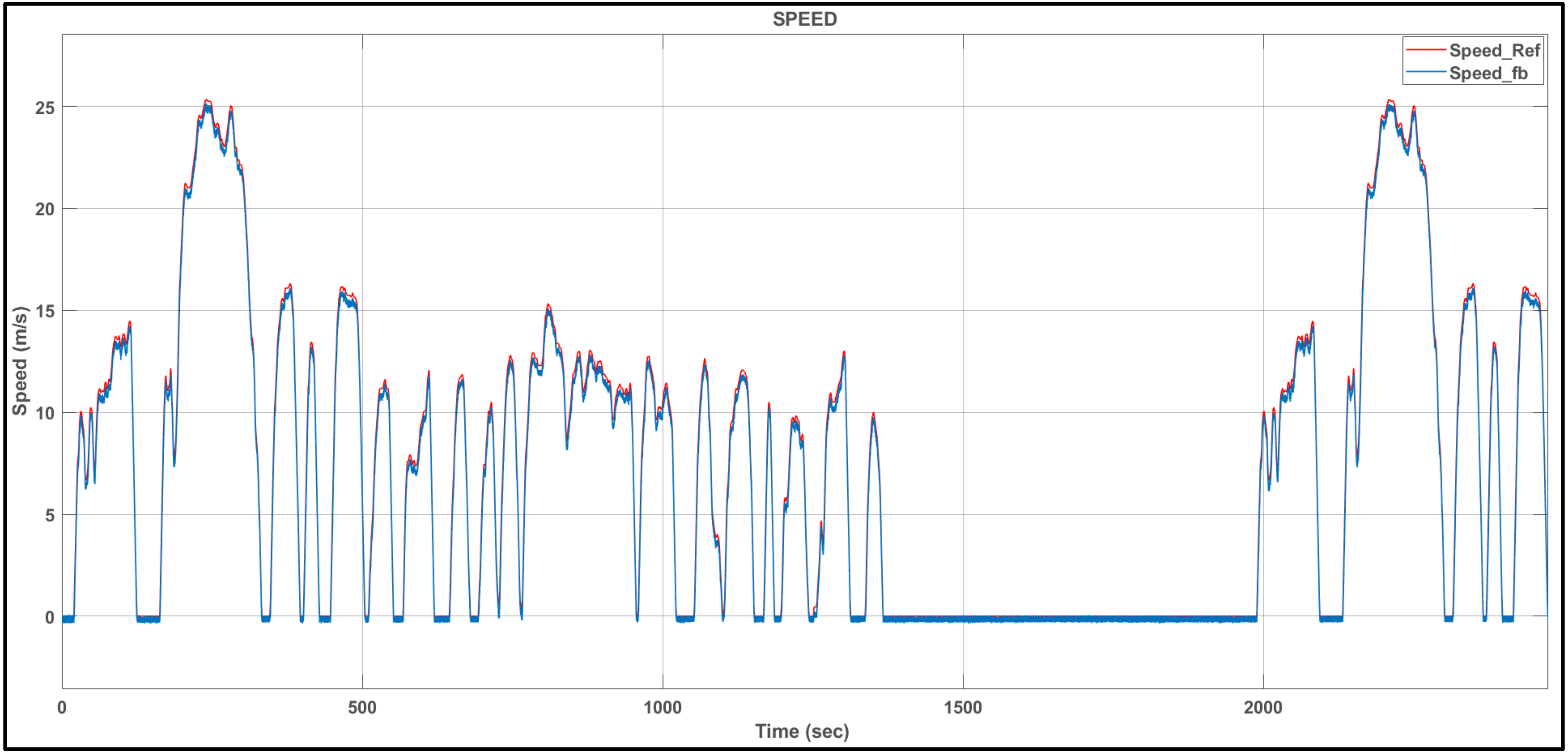
- FTP-75 cycle is a standard for testing fuel economy and emissions used by the USA Environmental Protection Agency (EPA). This cycle simulates low-speed city driving conditions in 31 mins, 12km, average speed at 32km/h.



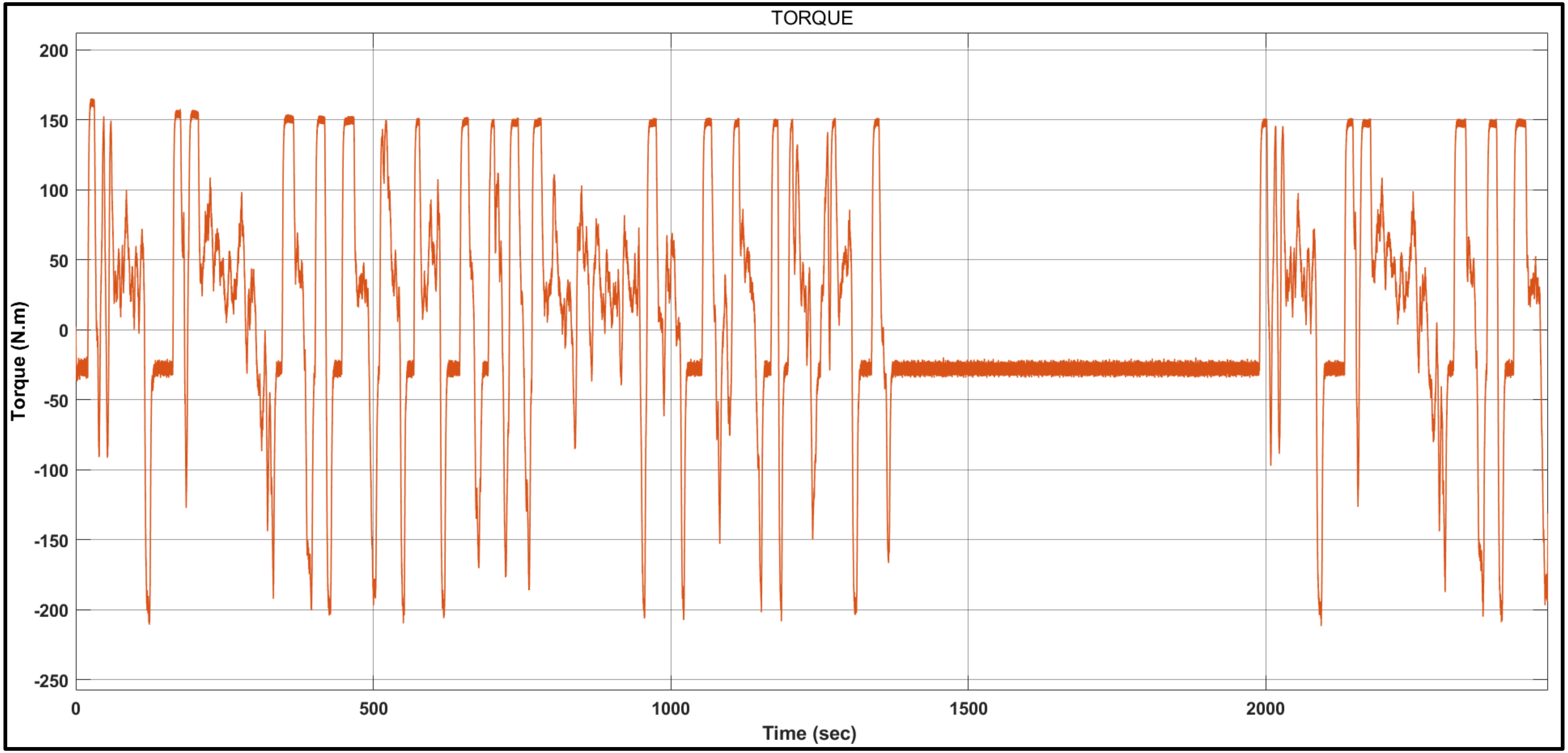
Testing result (FTP-75)



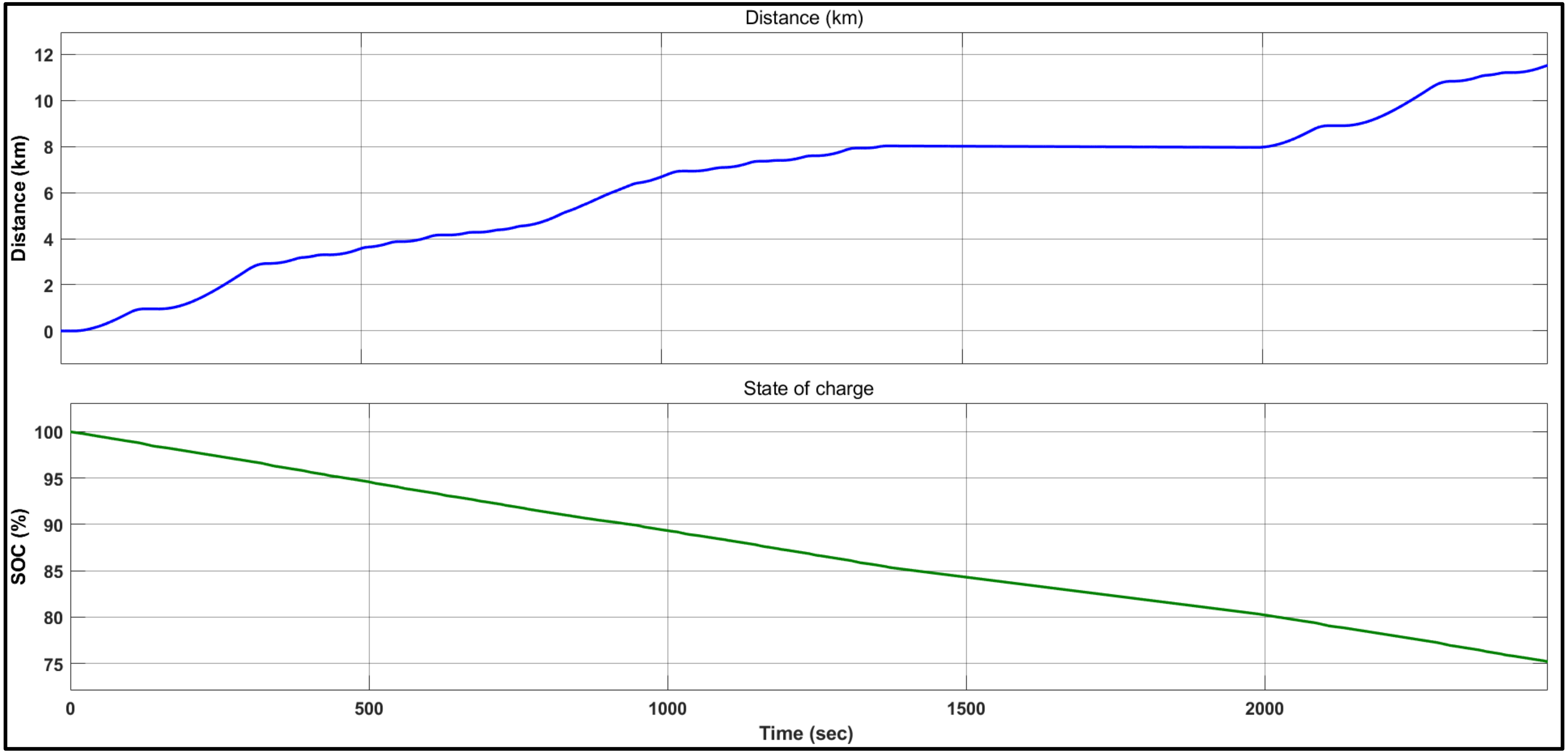
Speed result (FTP-75)



Torque result (FTP-75)

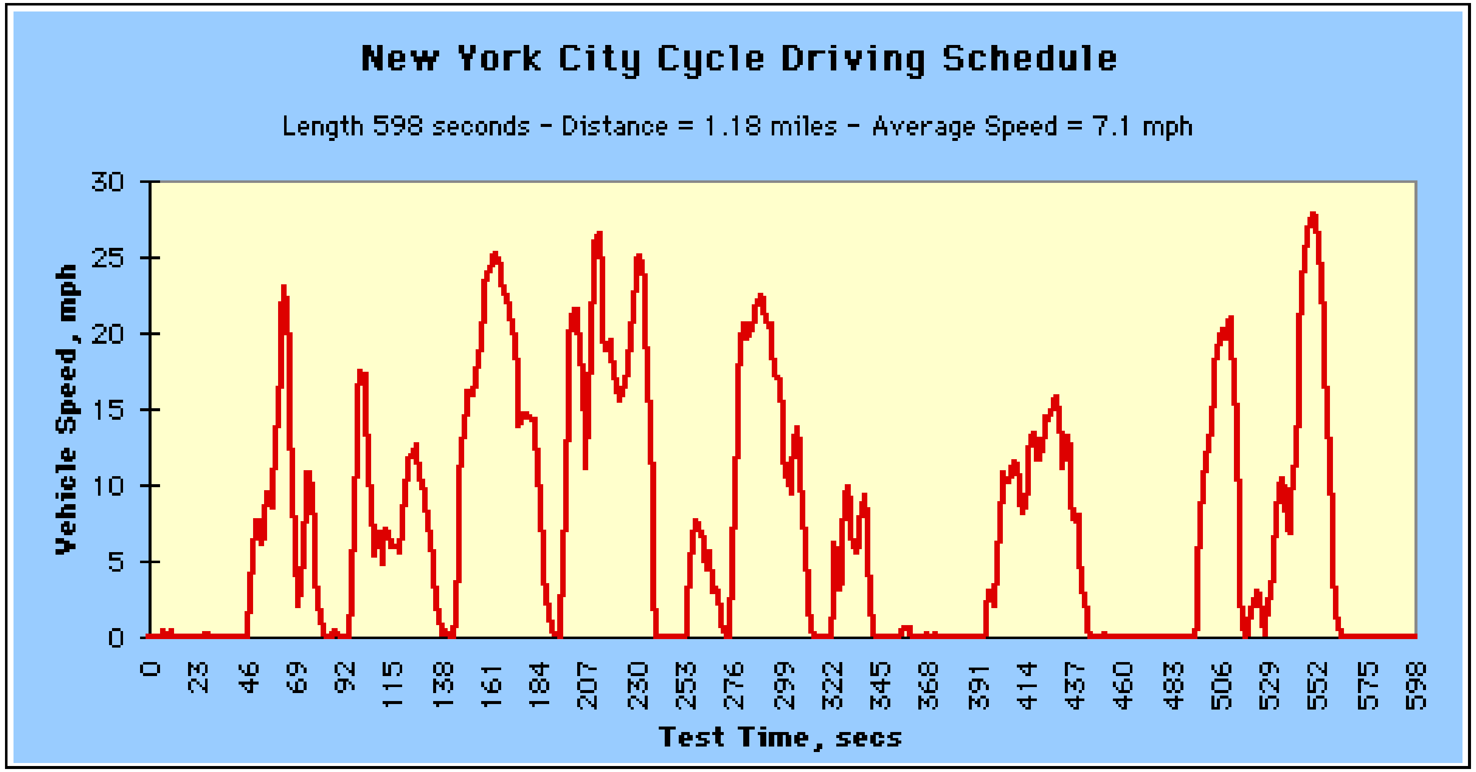


Distance and SOC (FTP-75)

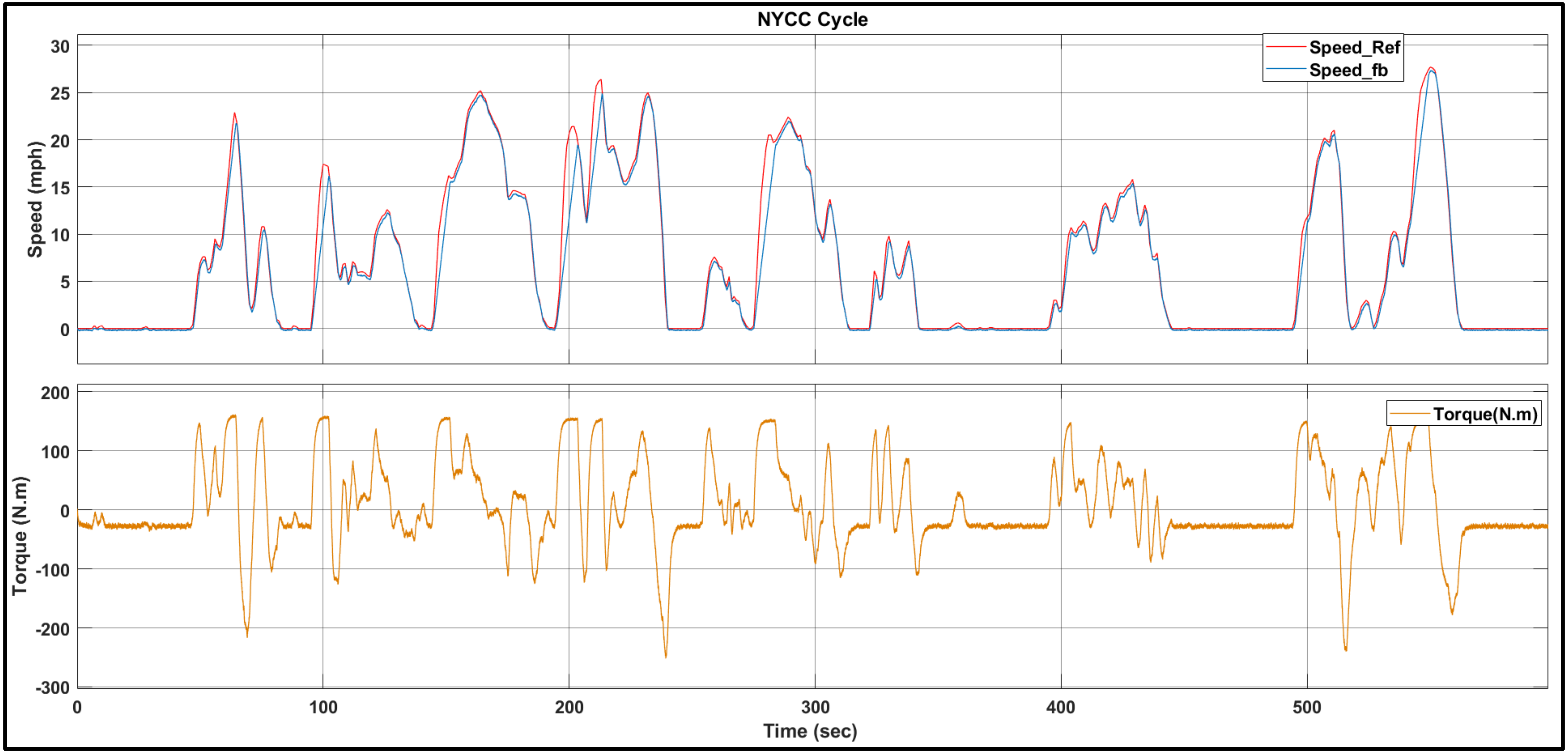


The New York City Cycle (NYCC)

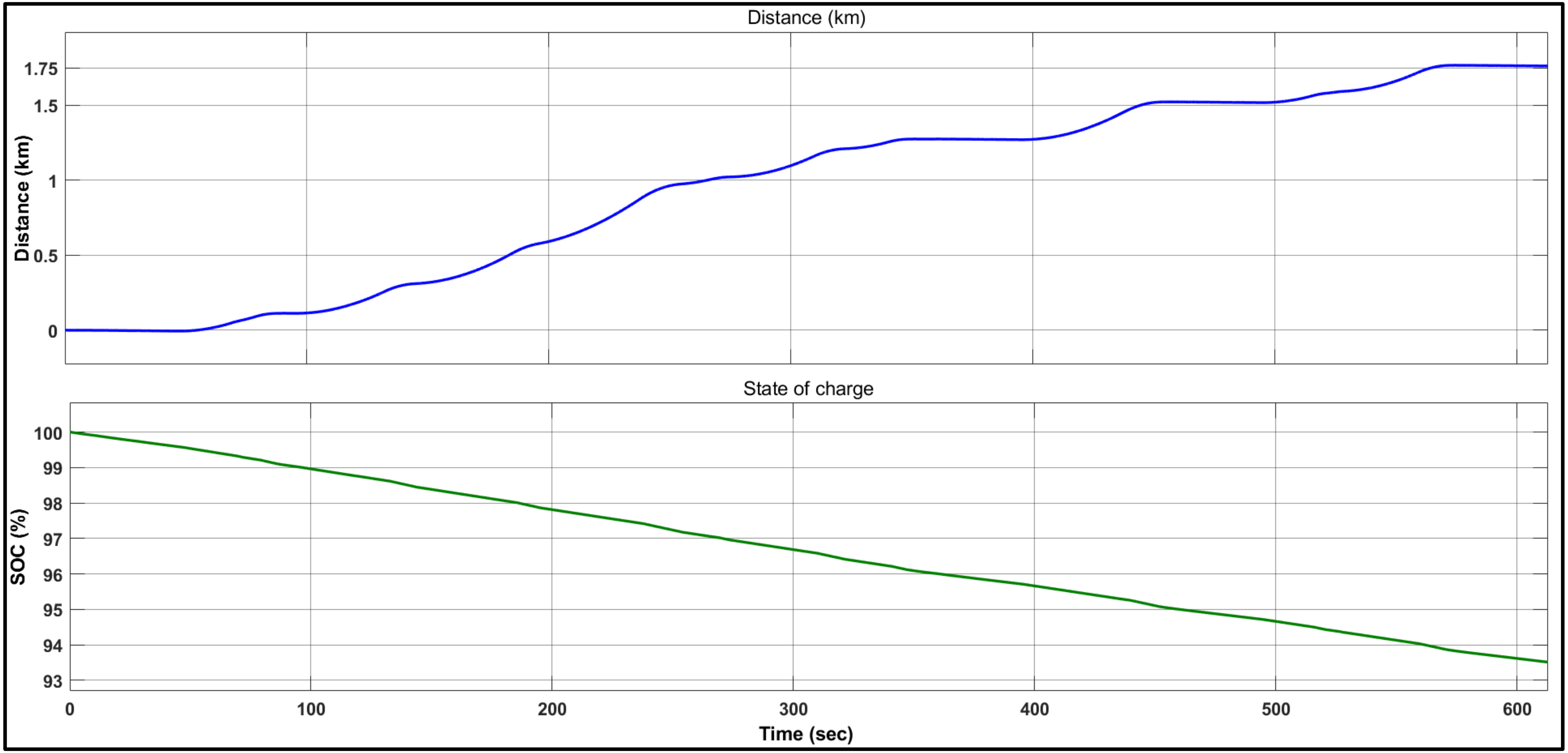
- NYCC cycle is designed to simulate typical stop-and-go traffic conditions in a densely populated urban environment. This cycle simulates low-speed conditions, lasts 10mins, 1.9km, average speed at 11km/h.



Testing result (NYCC)

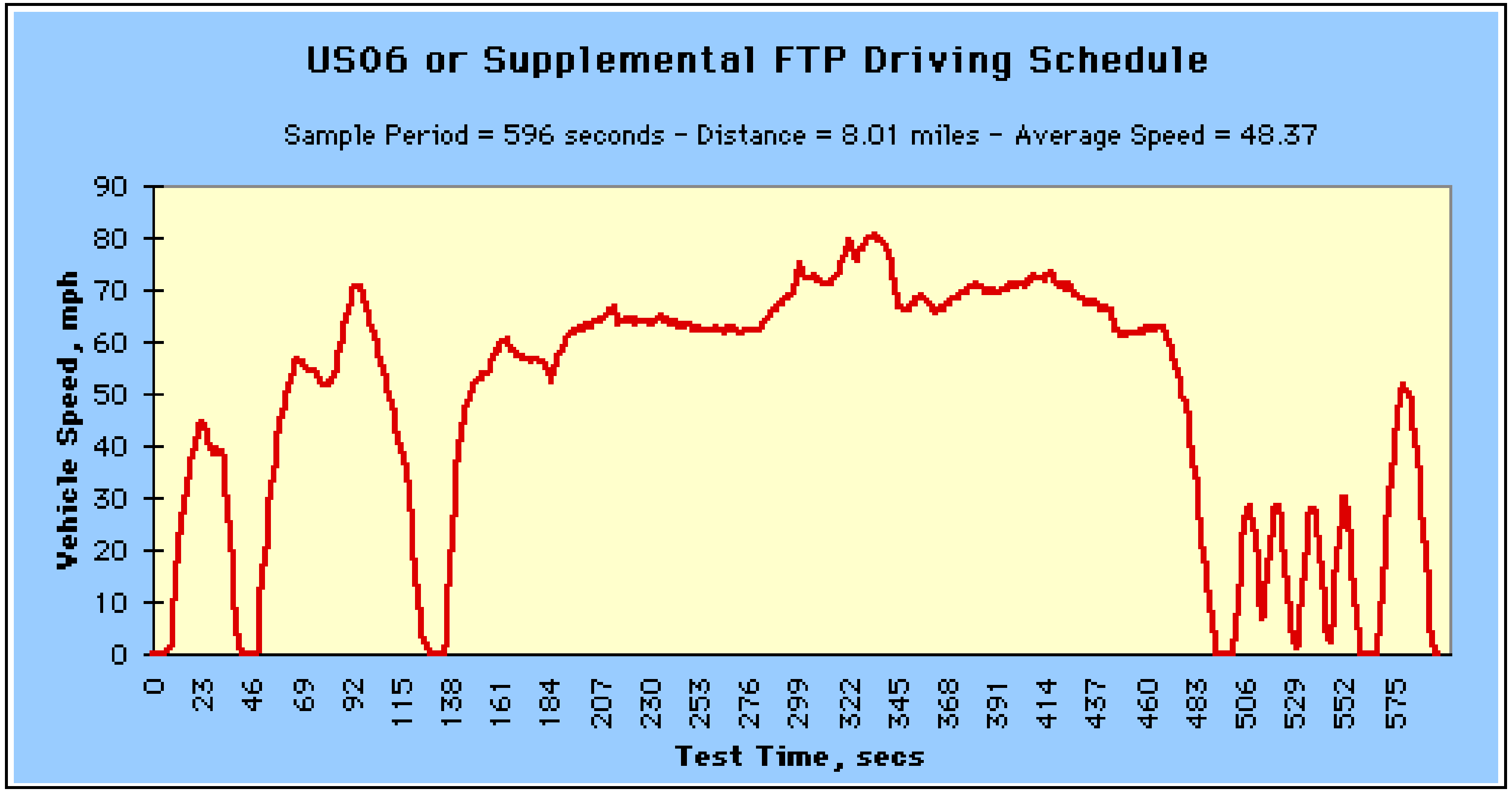


Distance and SOC (NYCC)

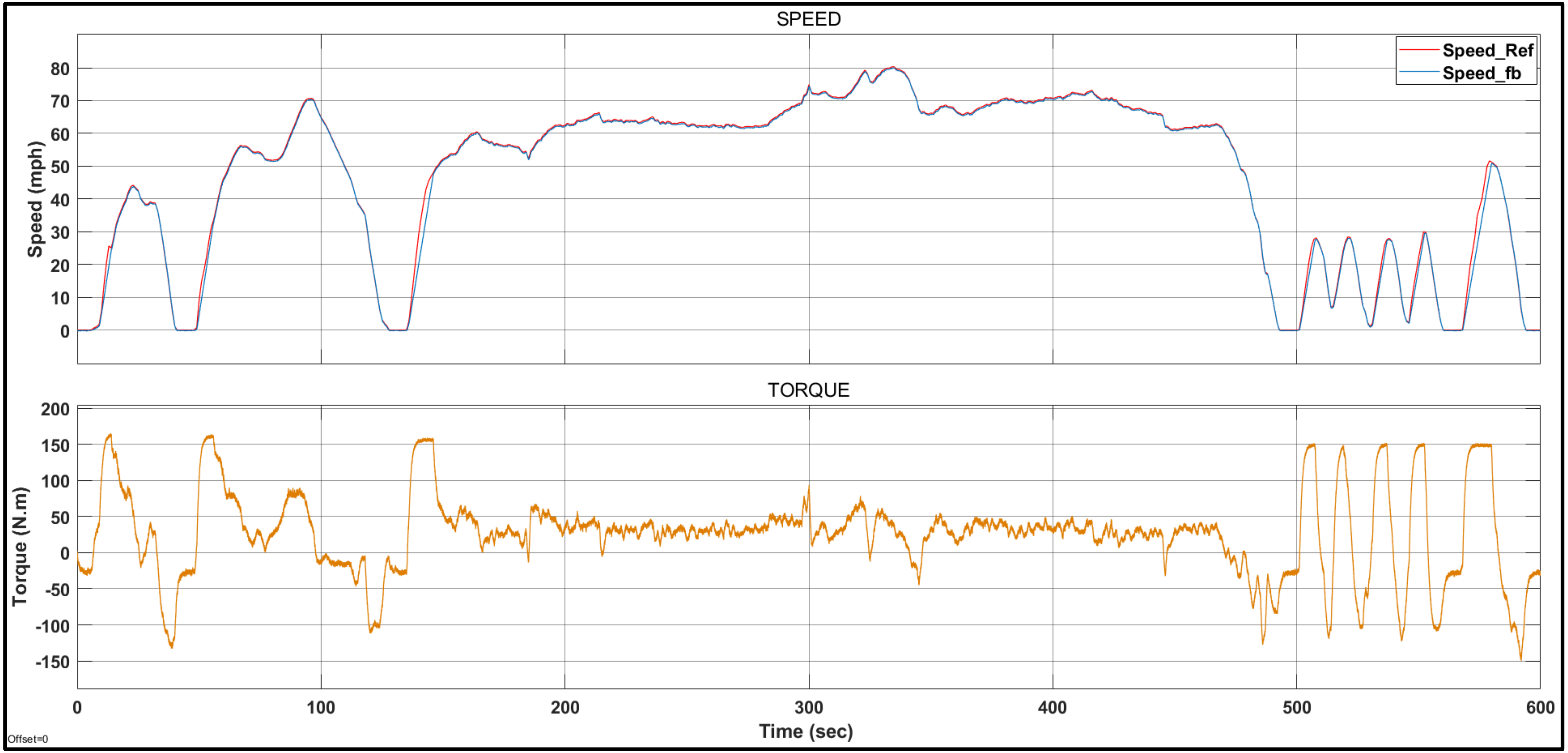


US06 - Supplemental FTP

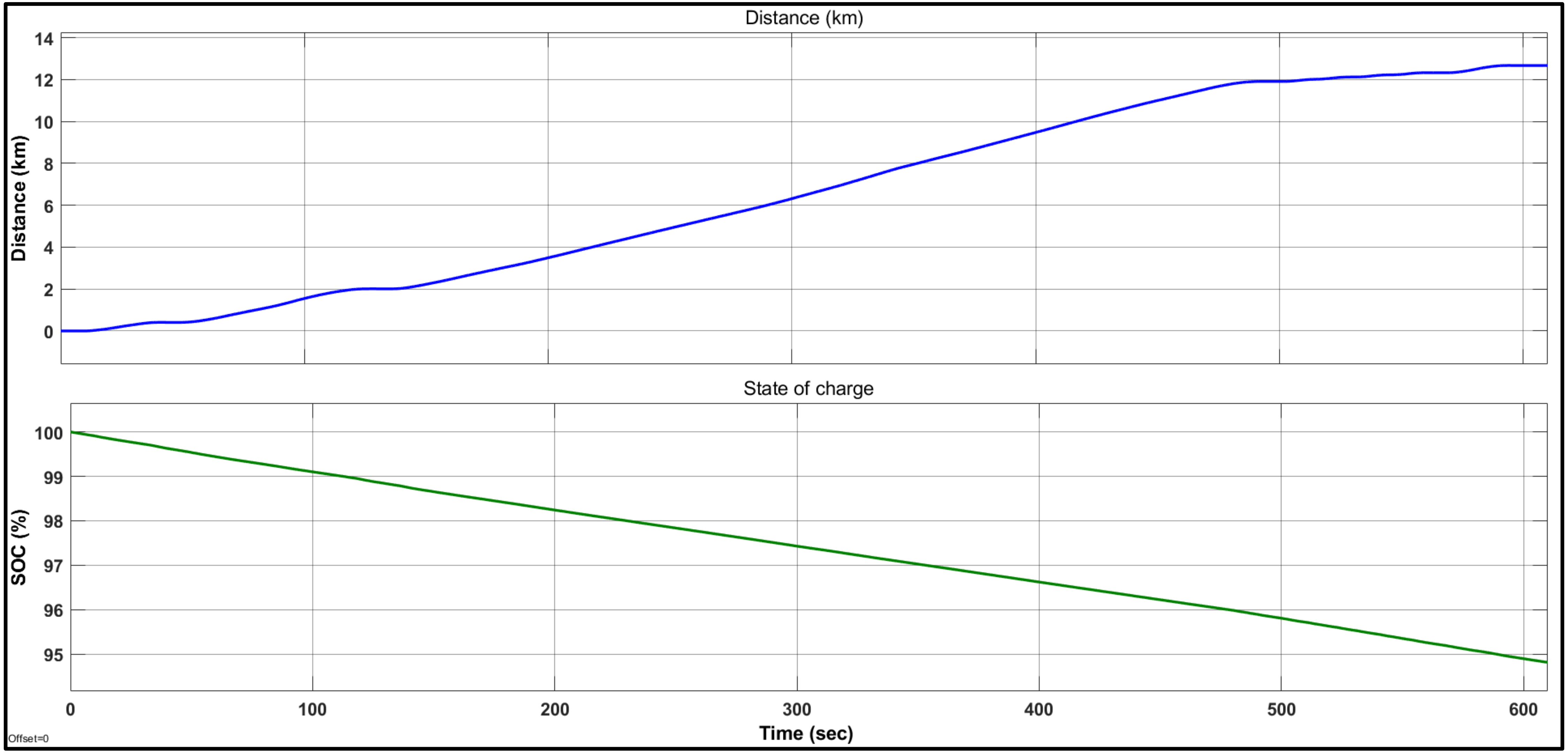
- US06 cycle is designed to represent aggressive driving conditions. This cycle simulates higher speeds and acceleration rates conditions, lasts 10mins, 12.8km, average speed at 48km/h, peak speed 128km/h.



Testing result (US06)

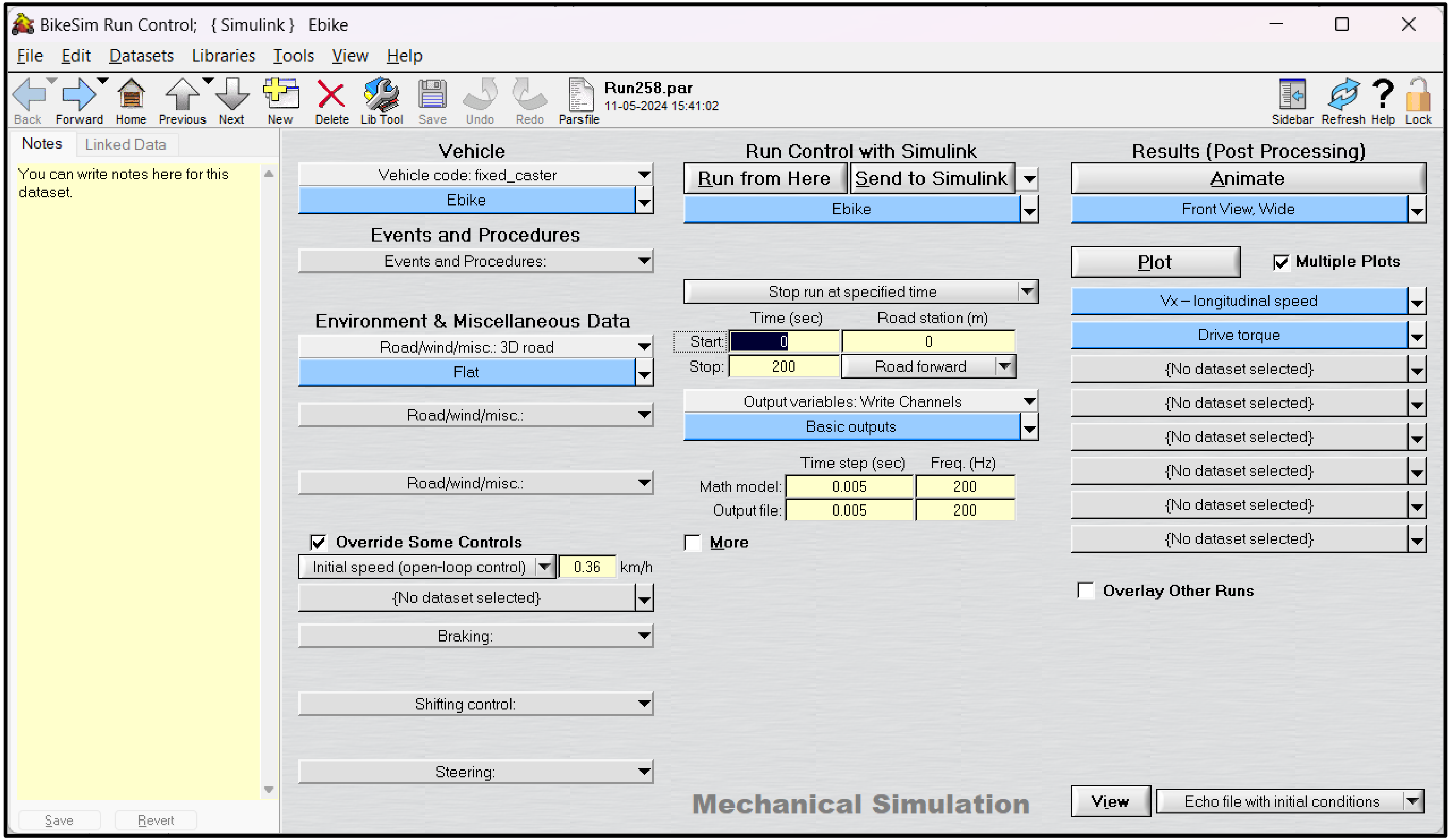


Distance and SOC (US06)



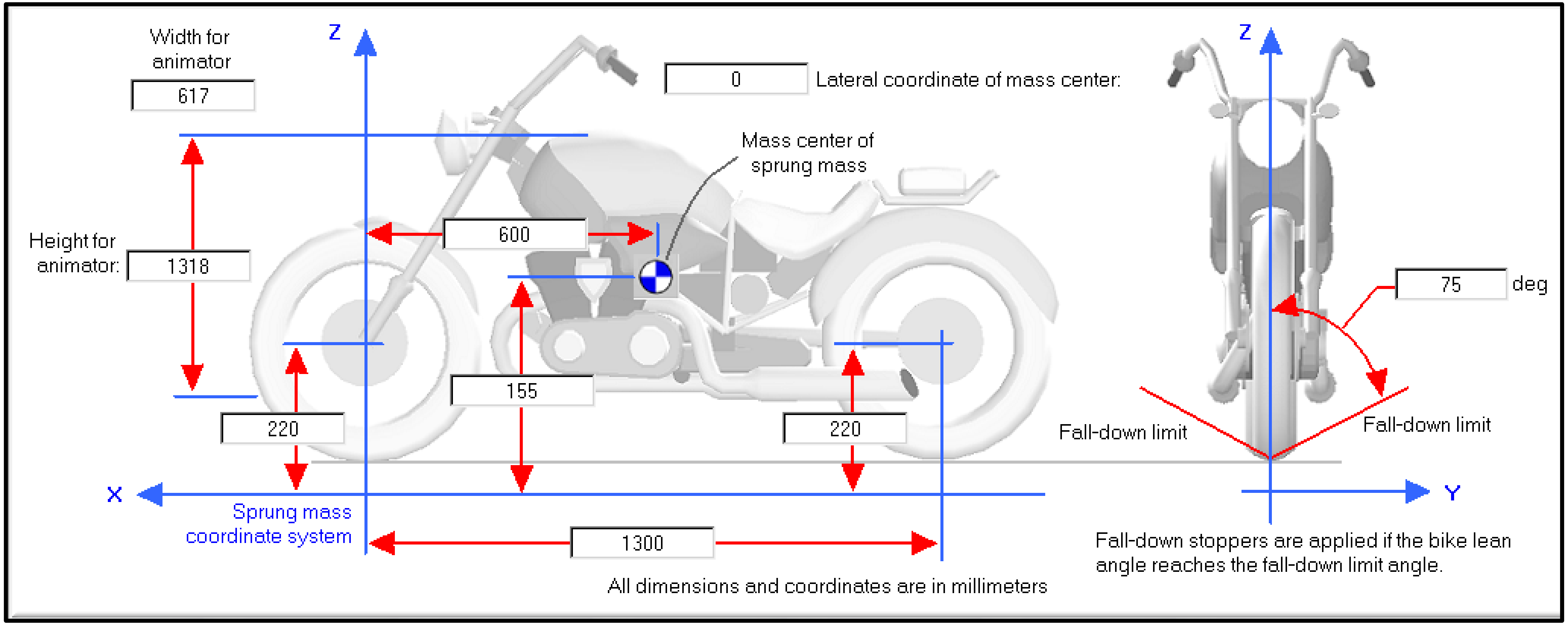
BIKESIM MODEL

General

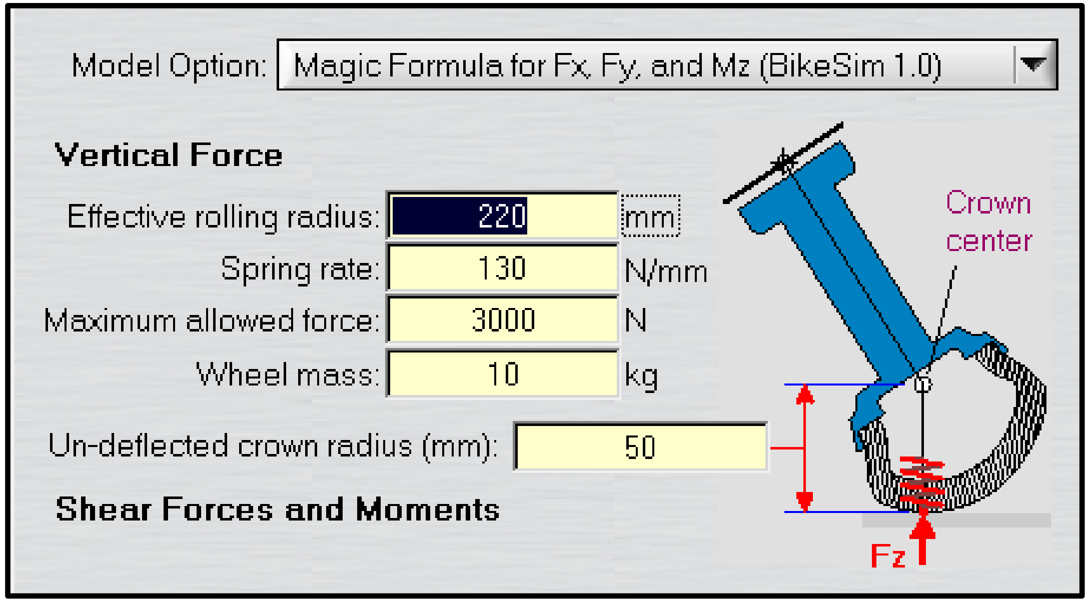


BikeSim Run Control; { Simulink } Ebike
File Edit Datasets Libraries Tools View Help
Back Forward Home Previous Next New Delete Lib Tool Save Undo Redo Parsfile
Run258.par
11-05-2024 15:41:02
Sidebar Refresh Help Lock
Notes Linked Data
You can write notes here for this dataset.
Save Revert
Vehicle
Vehicle code: fixed_caster
Ebike
Events and Procedures
Events and Procedures:
Environment & Miscellaneous Data
Road/wind/misc.: 3D road
Flat
Road/wind/misc.:
Road/wind/misc.:
Override Some Controls
Initial speed (open-loop control) 0.36 km/h
{No dataset selected}
Braking:
Shifting control:
Steering:
Run Control with Simulink
Run from Here
Send to Simulink
Ebike
Stop run at specified time
Time (sec) Road station (m)
Start: 0 0
Stop: 200 Road forward
Output variables: Write Channels
Basic outputs
Time step (sec) Freq. (Hz)
Math model: 0.005 200
Output file: 0.005 200
More
Mechanical Simulation
Results (Post Processing)
Animate
Front View, Wide
Plot
Multiple Plots
Vx – longitudinal speed
Drive torque
{No dataset selected}
{No dataset selected}
{No dataset selected}
{No dataset selected}
{No dataset selected}
{No dataset selected}
Overlay Other Runs
View
Echo file with initial conditions

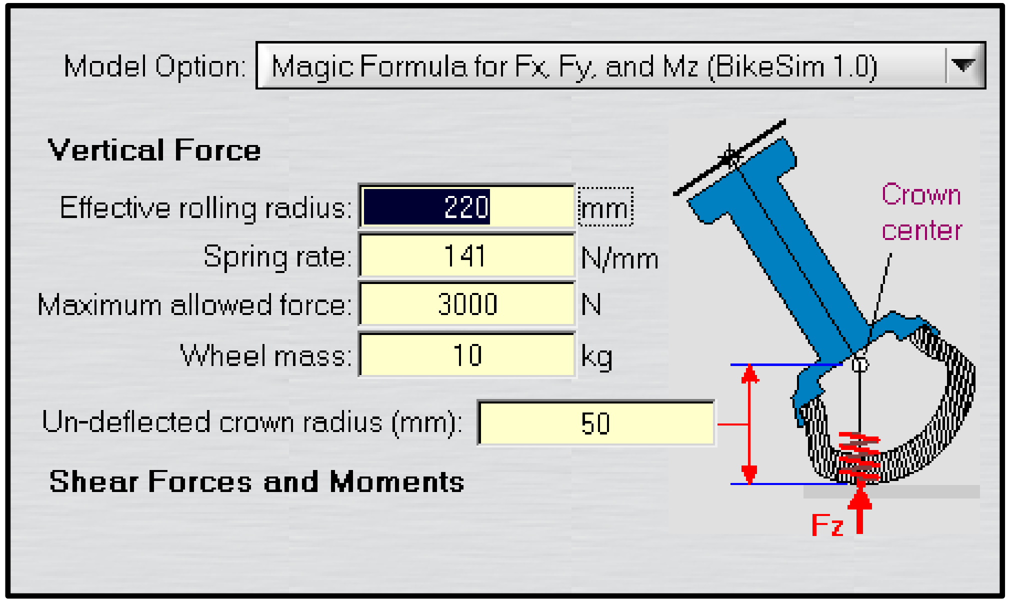
Vehicle sprung mass



Wheels

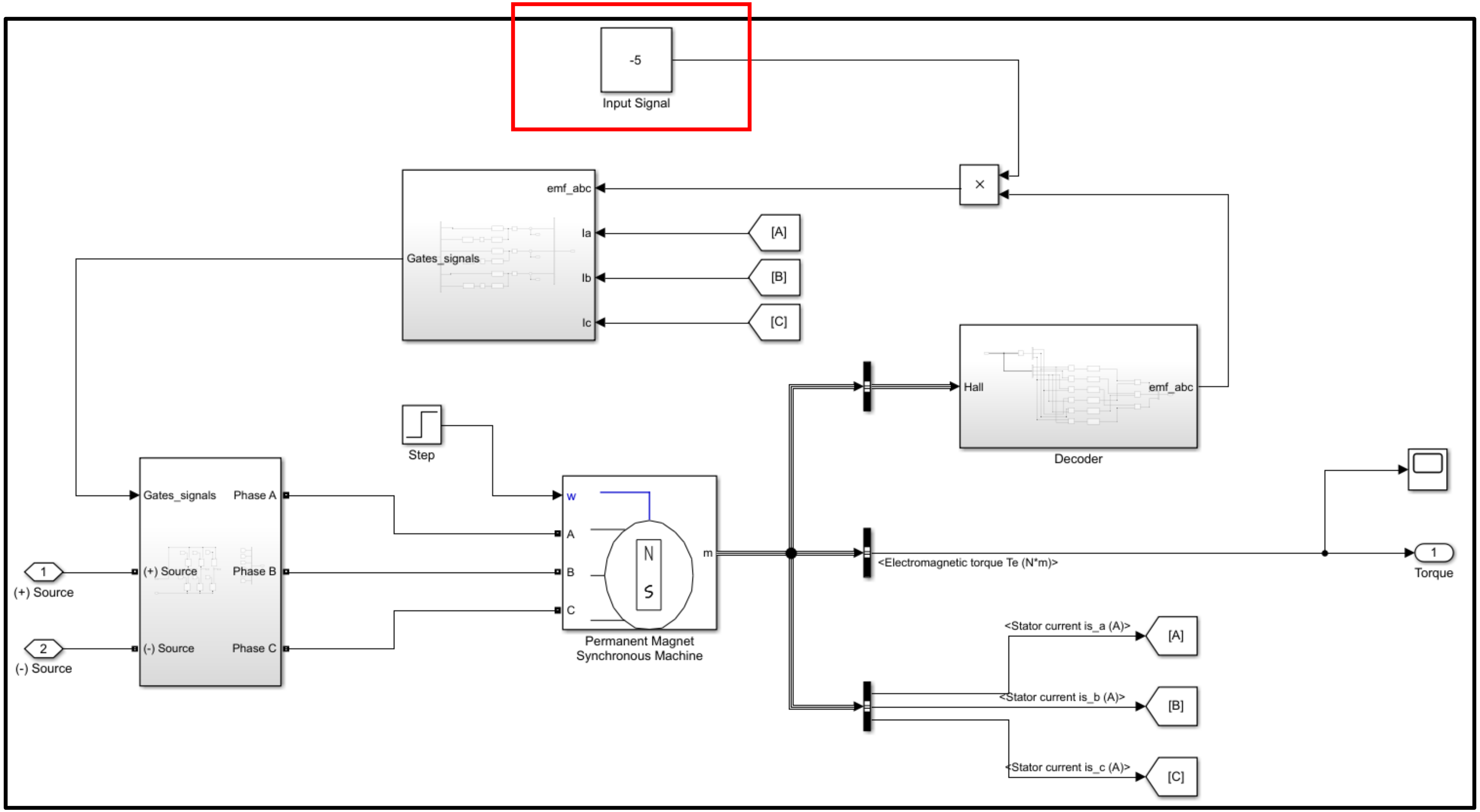


Front tire

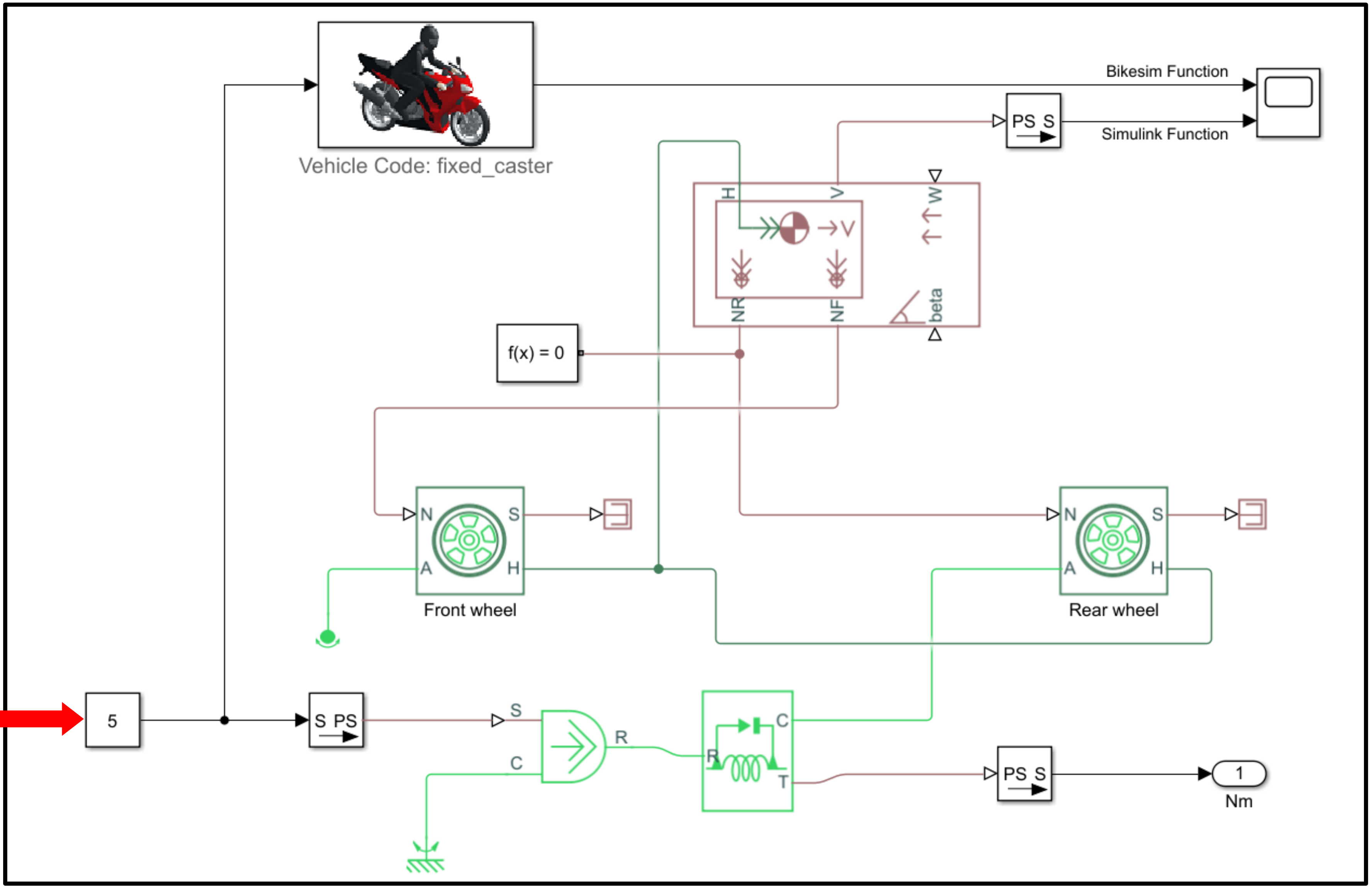


Rear tire

Driver & Motor testing block

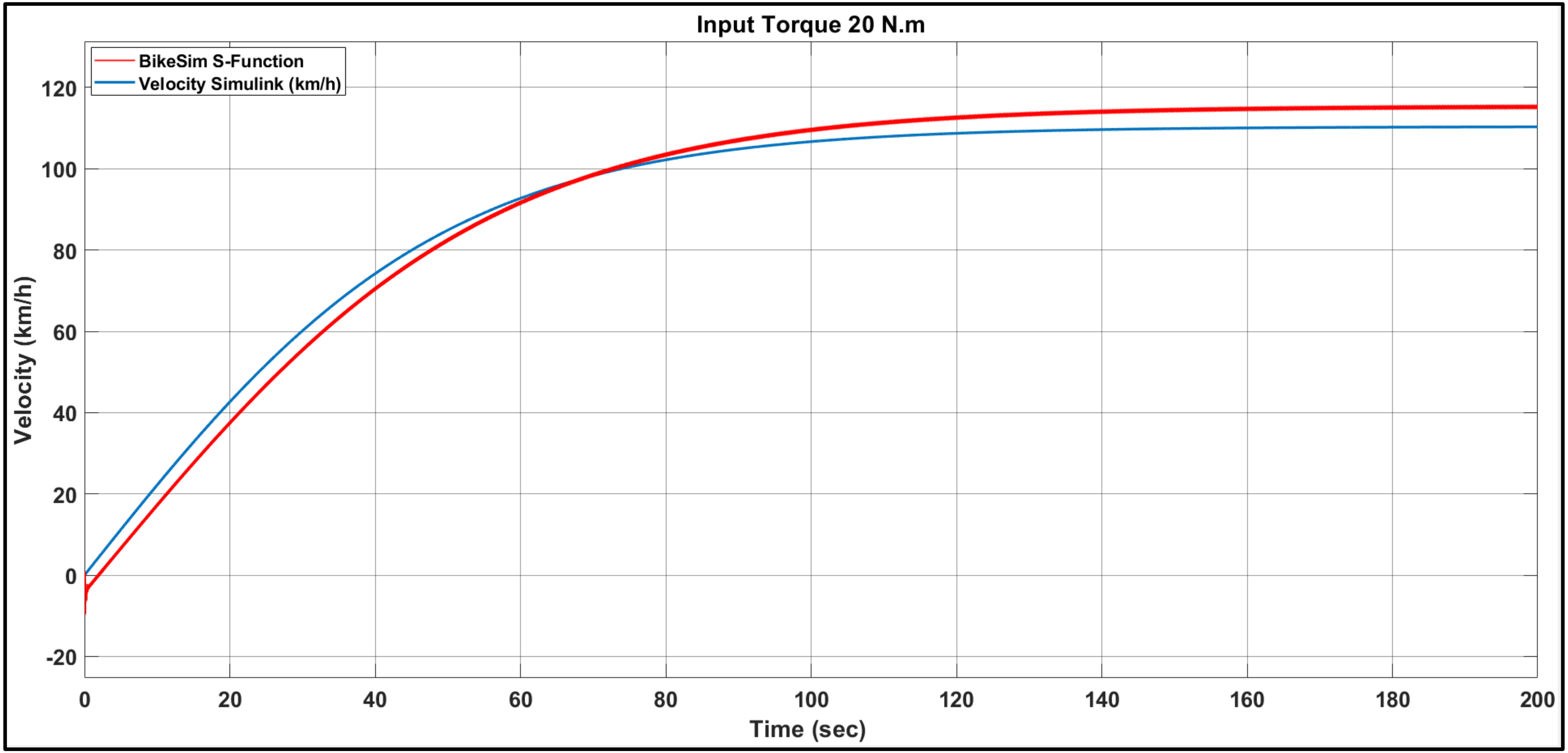


Simulink body vs Bikesim body

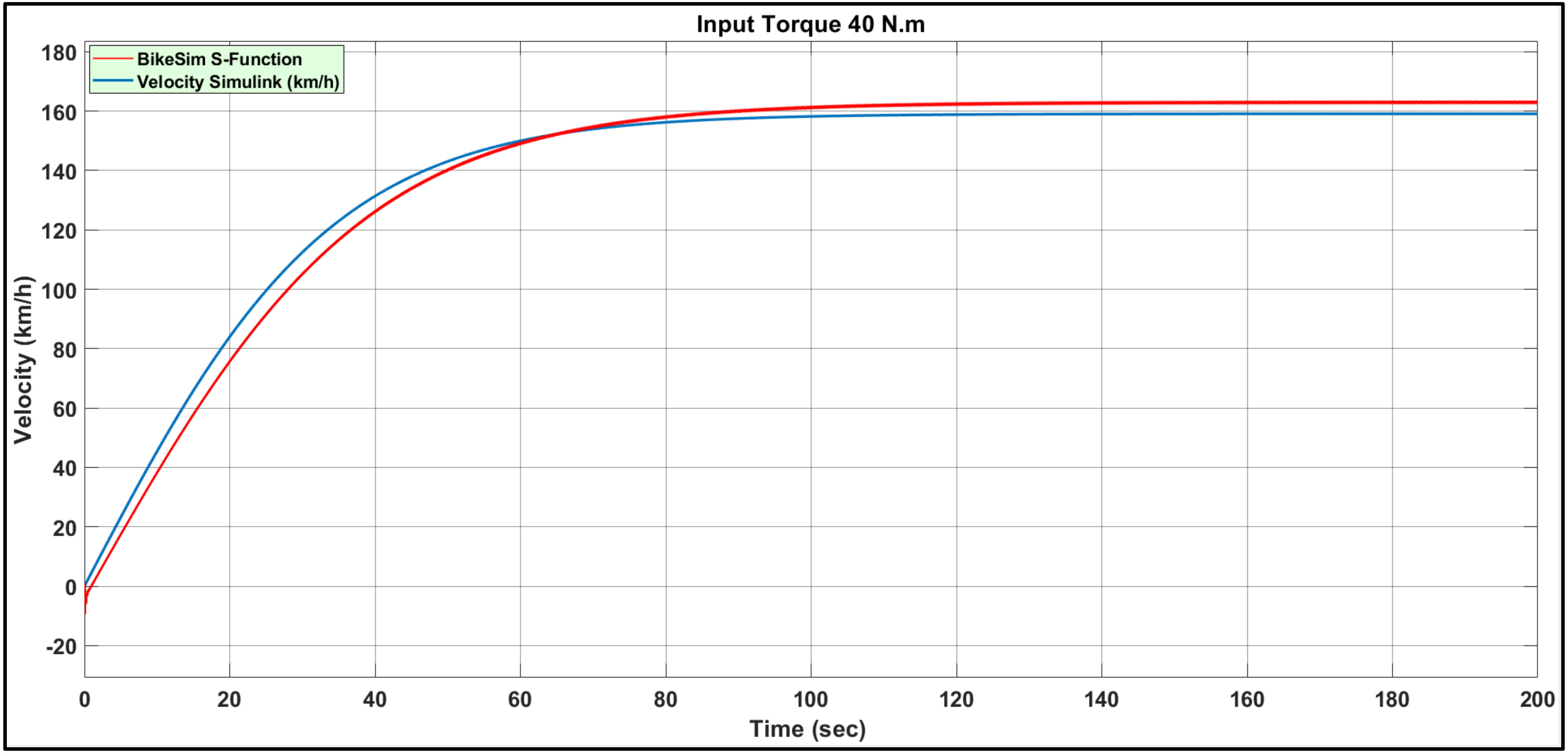


Input torque

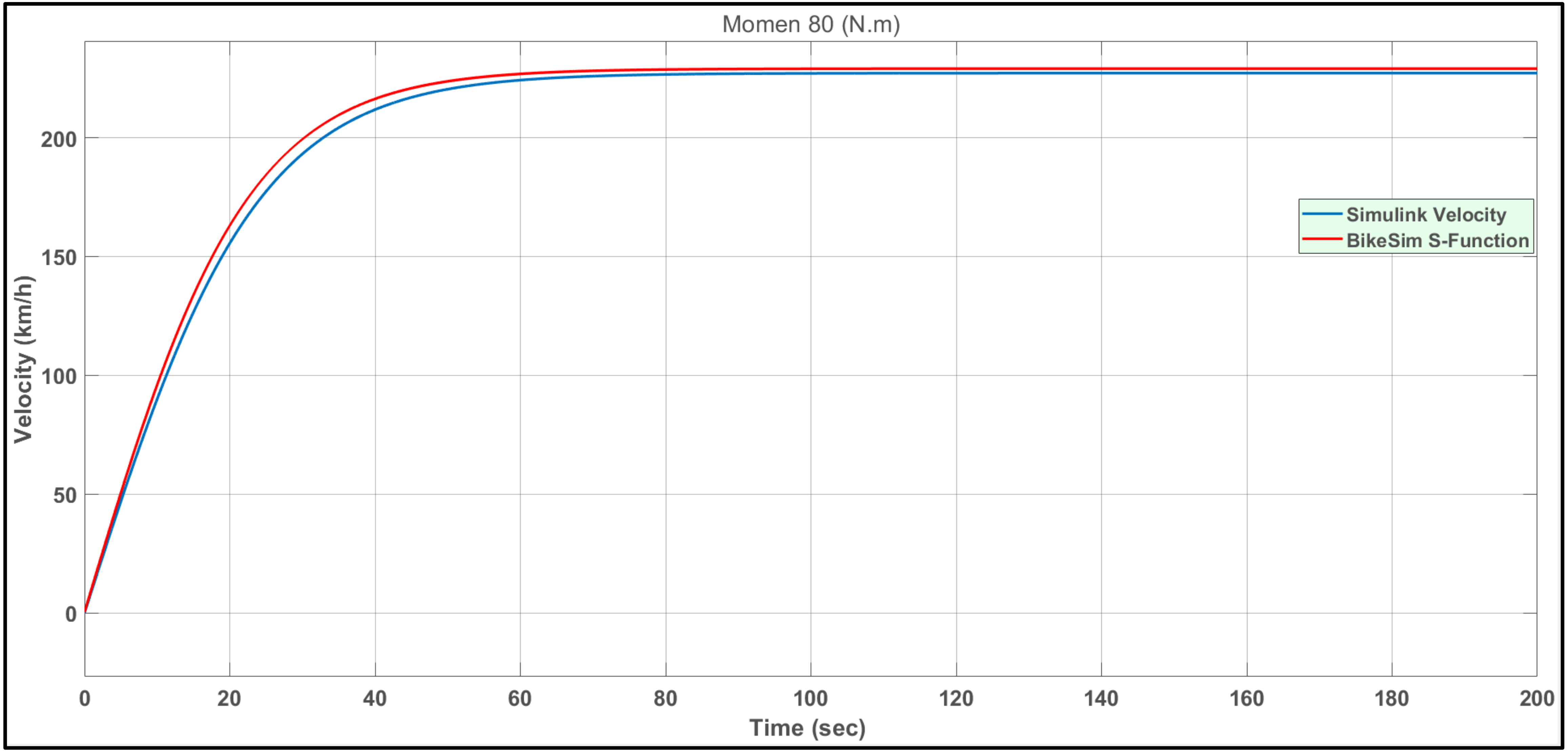
Input torque at 20 N.m



Input torque at 40 N.m



Input torque at 80 N.m



Thank you

For your attention

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