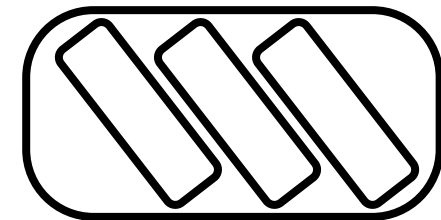
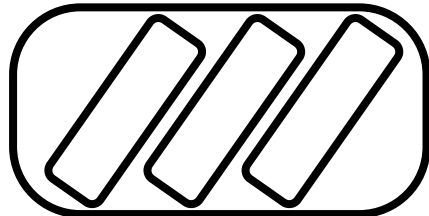


*Mecanum Wheeled Robot Modeling
and Path-Following Simulation*

2015012688 김준환

2015012742 박준태

2015012842 이준석

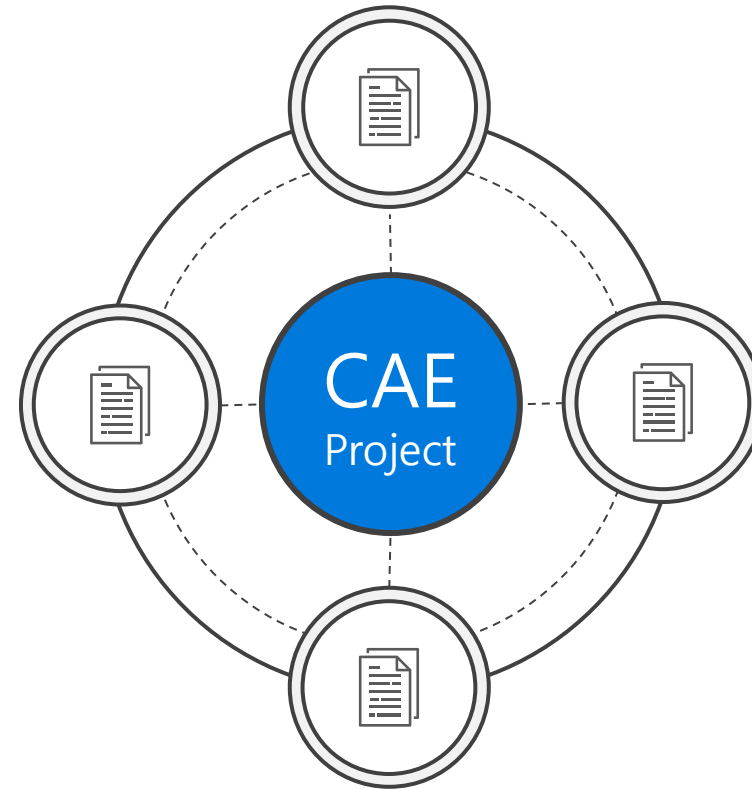


Team - Initial M

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1. Introduction

2. Modeling

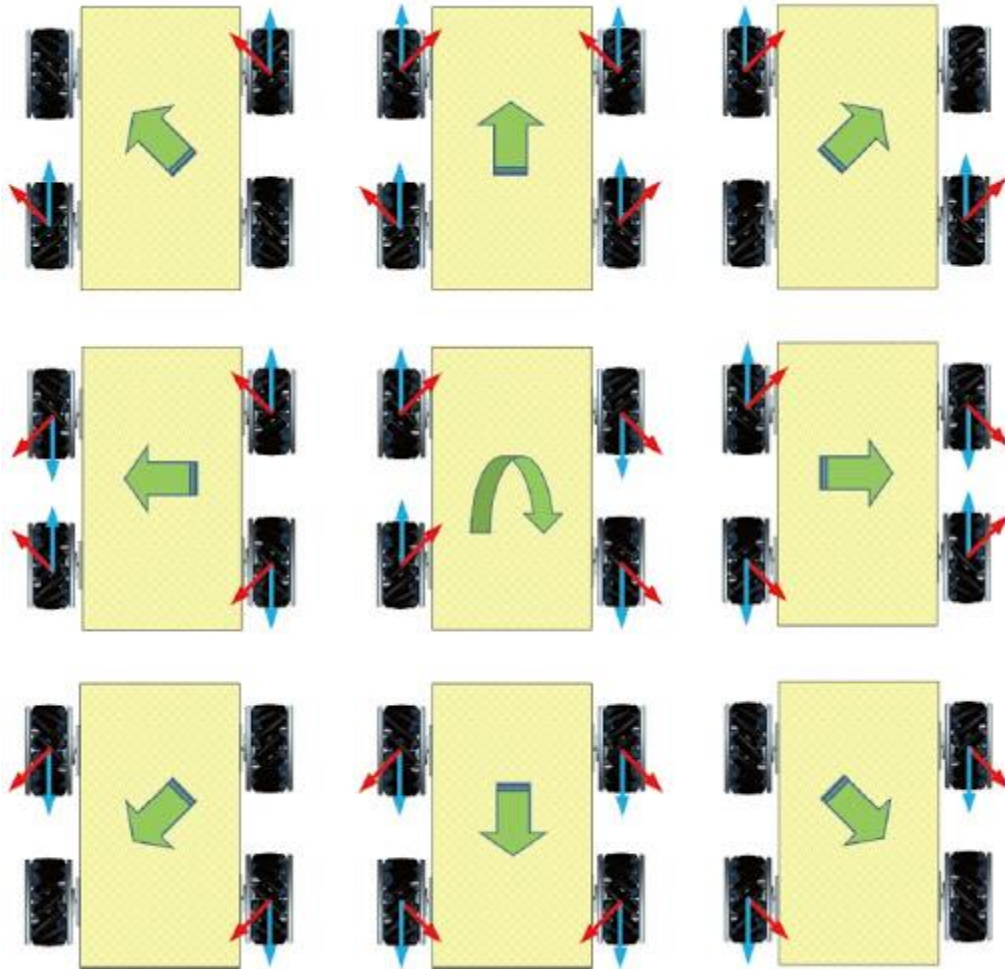


3. Simulink Simulation

4. Q&A

1. Introduction

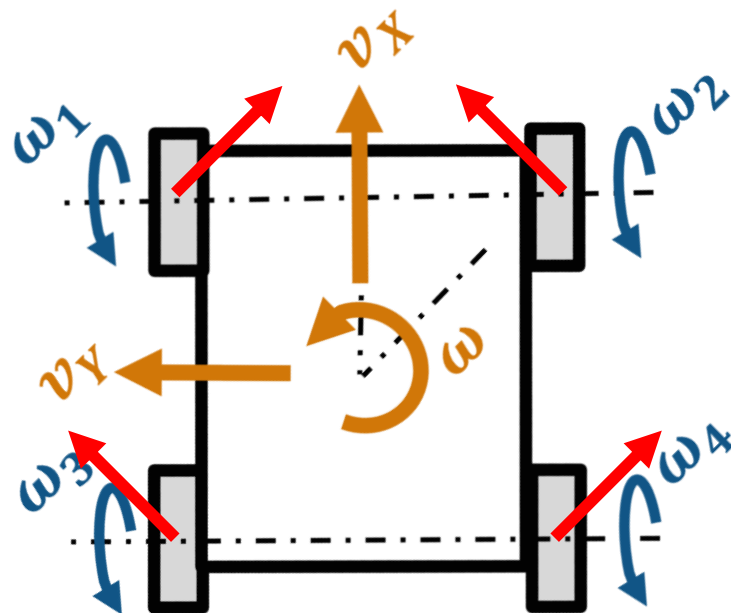
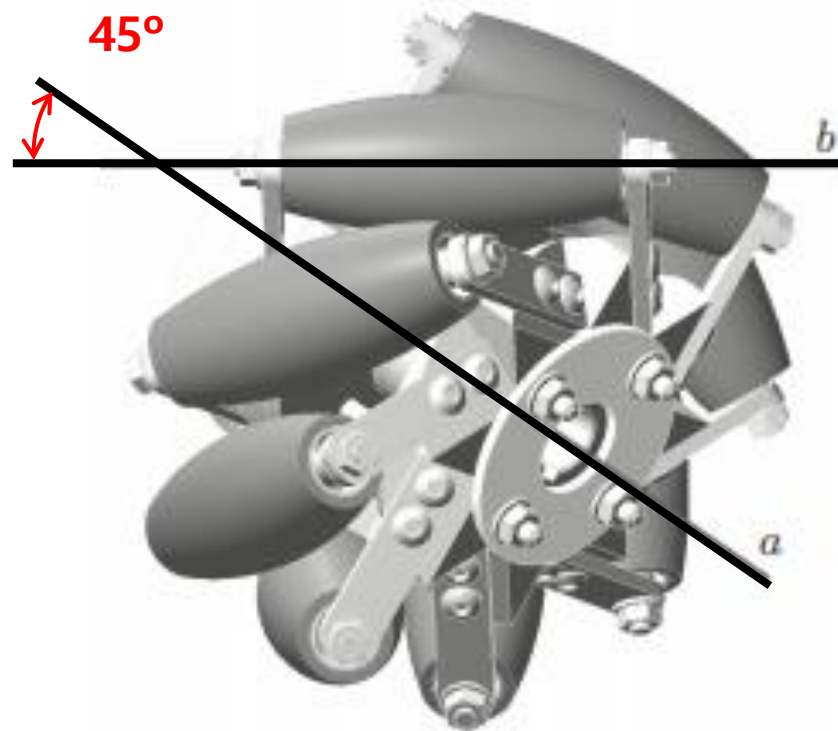
- 주제 선정 배경



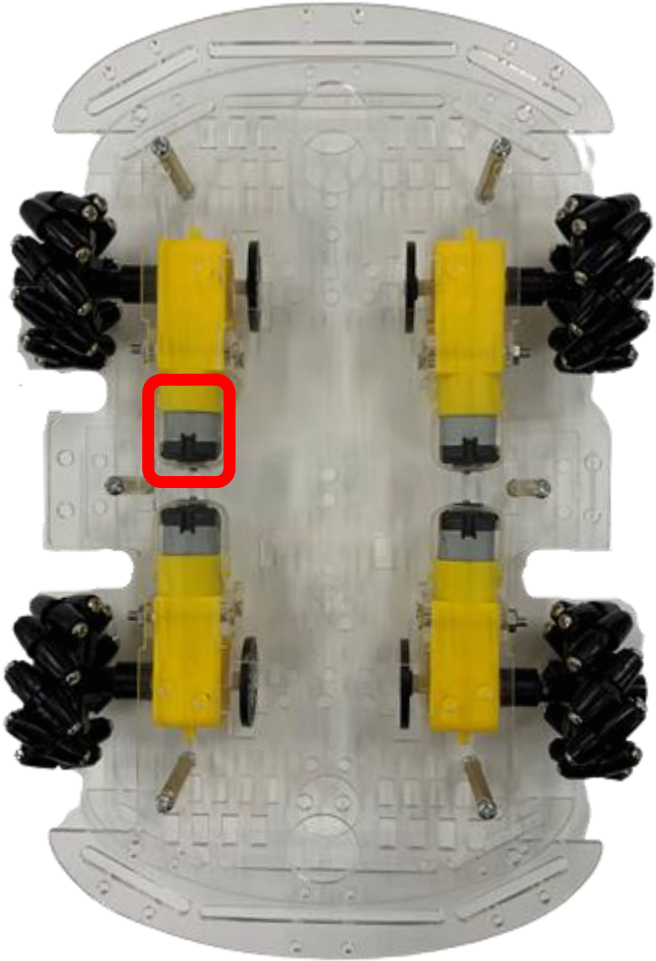
Team - Initial M

1. Introduction

- Mecanum Wheel



2. Modeling



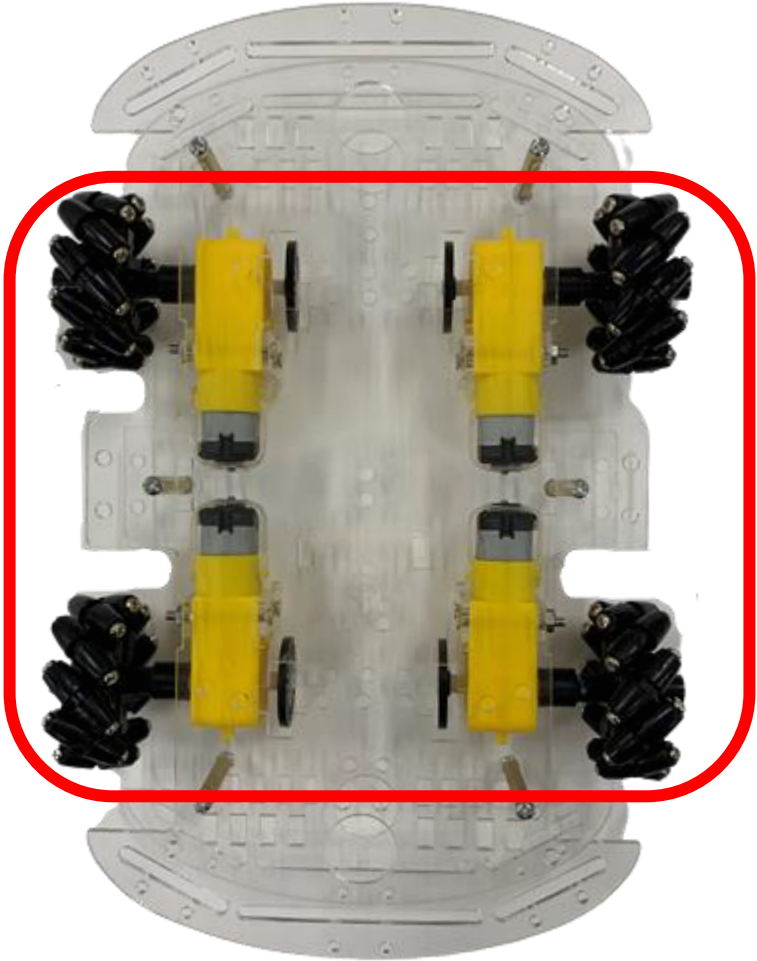
(1) PMDC motor with controller

(2) Powertrain model

(3) Kinematic model

(4) Pure pursuit algorithm

2. Modeling



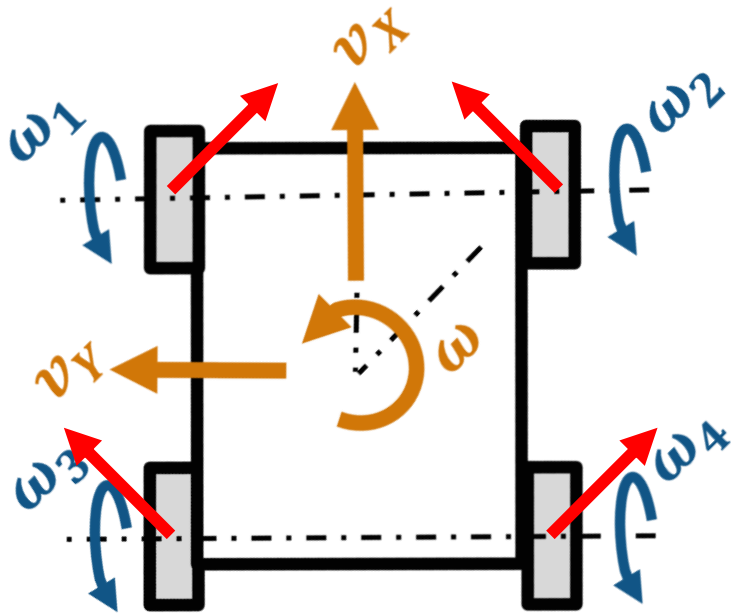
(1) PMDC motor with controller

(2) Powertrain model

(3) Kinematic model

(4) Pure pursuit algorithm

2. Modeling



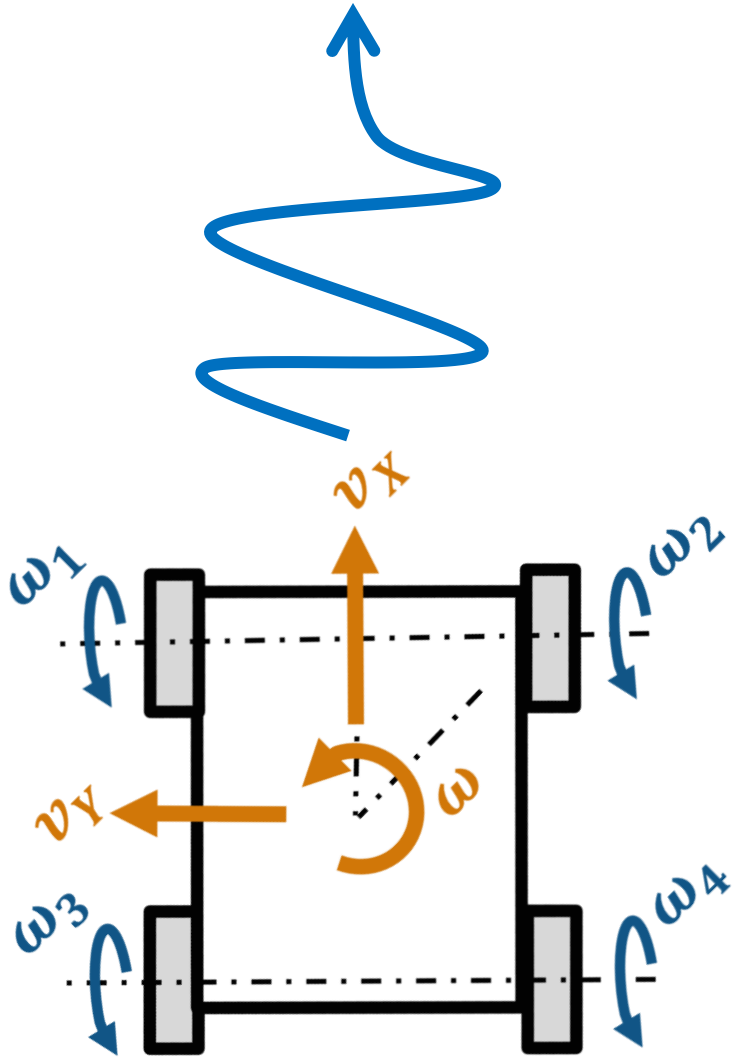
(1) PMDC motor with controller

(2) Powertrain model

(3) Kinematic model

(4) Pure pursuit algorithm

2. Modeling



(1) PMDC motor with controller

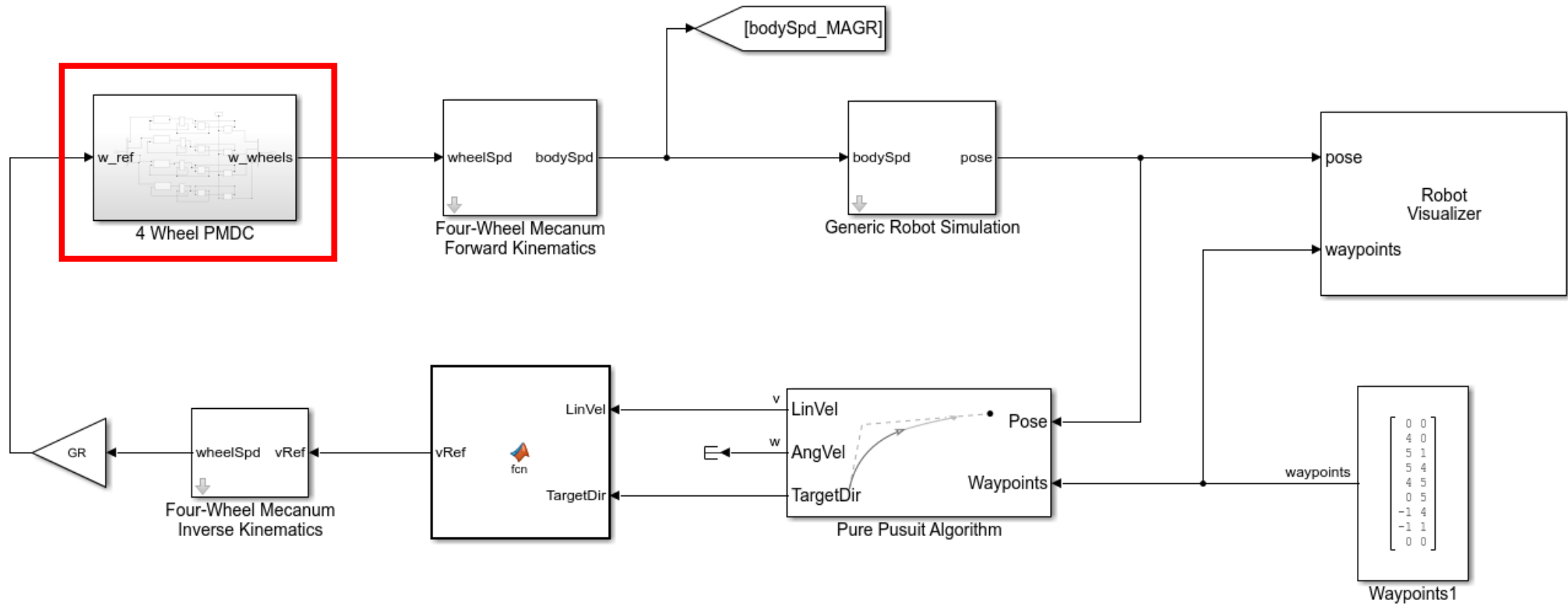
(2) Powertrain model

(3) Kinematic model

(4) Pure pursuit algorithm

2. Modeling

– PMDC Motor with Controller Modeling



2. Modeling

- PMDC Motor with Controller Modeling

DC-max 16 S Ø16mm, 메탈 브러시 CLL, 볼 베어링



정격 전압에서의 값	
정격 전압	6 V
무부하 속도	7890 rpm
무부하 전류	14.8 mA
정격 속도	4840 rpm
정격 토크 (최대 연속 토크)	4.04 mNm
정격 전류 (최대 연속 전류)	0.575 A
정지 토크	10.5 mNm
정지 전류	1.46 A
최대 효율	81 %
특성	
단자 저항	4.1 Ω
단자 인덕턴스	0.14 mH
토크 상수	7.19 mNm/A
속도 상수	1330 rpm/V
속도/토크 기울기	758 rpm/mNm
기계적 시상수	8.87 ms
로터 관성	1.12 gcm ²

[PMDC Motor Specs]

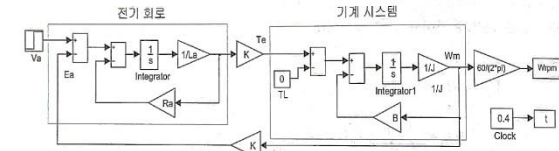


그림 2.56 전자기 모델과 부하 시스템 모델의 결합

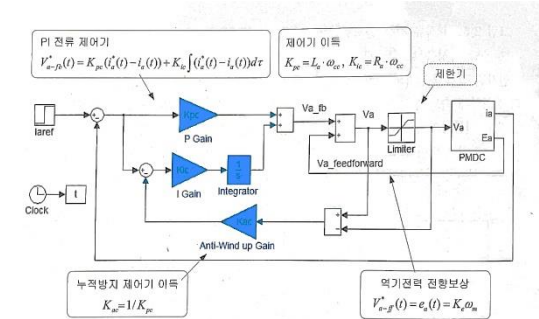


그림 2.59 비례적분 전류 제어기가 포함된 전체 구동시스템의 모델

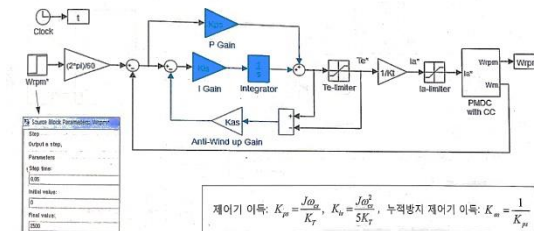
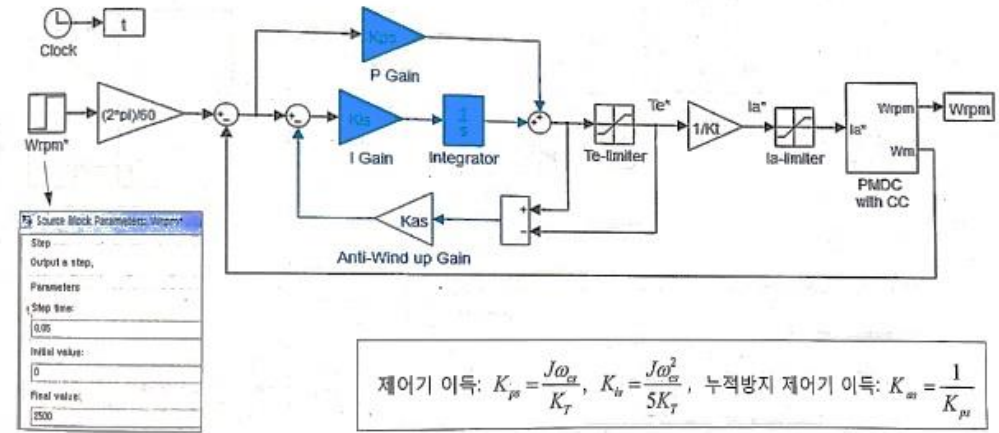
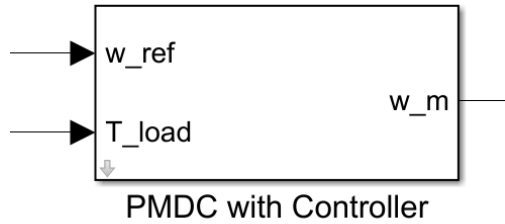


그림 2.61 비례적분 속도 제어기의 모델링

[PMDC Motor 제어기]

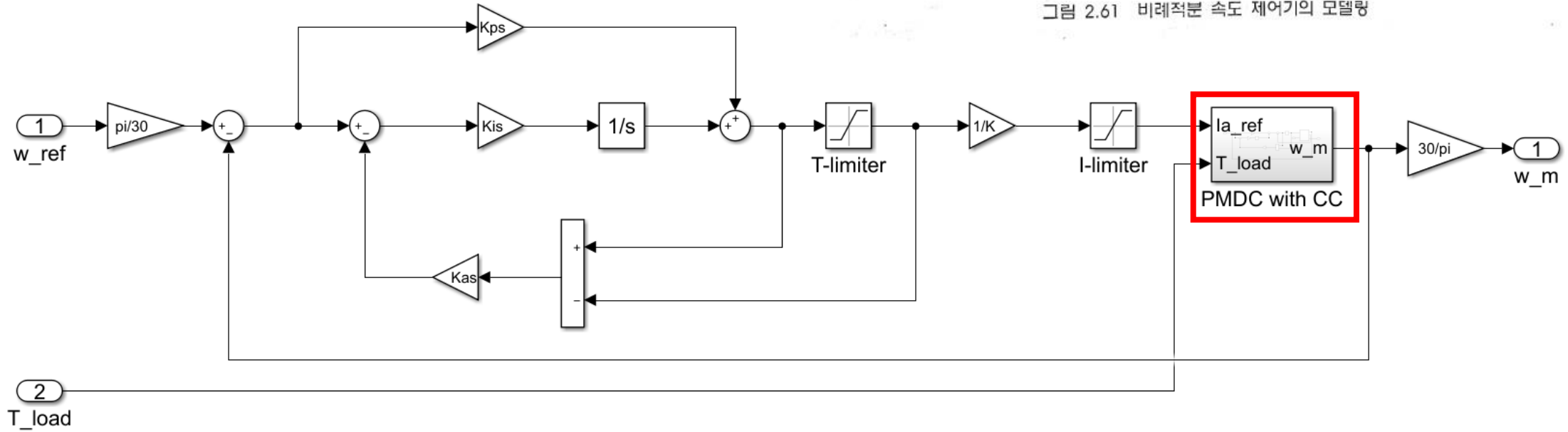
2. Modeling

- PMDC Motor with Controller Modeling



제어기 이득: $K_{ps} = \frac{J\omega_{cr}}{K_T}$, $K_{is} = \frac{J\omega_{cr}^2}{5K_T}$, 누적방지 제어기 이득: $K_{as} = \frac{1}{K_{ps}}$

그림 2.61 비례적분 속도 제어기의 모델링



2. Modeling

- PMDC Motor with Controller Modeling

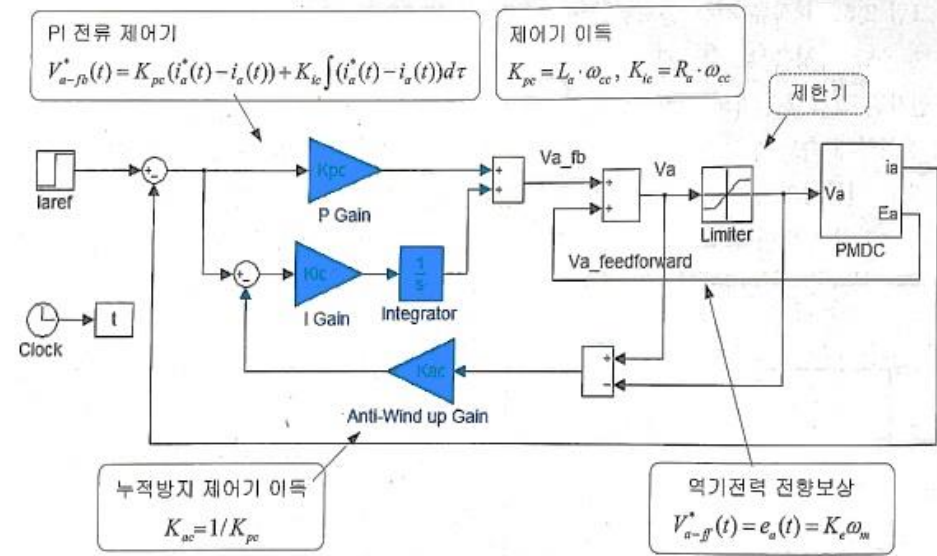
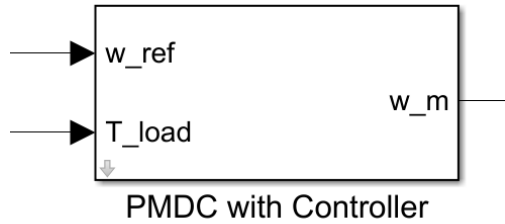
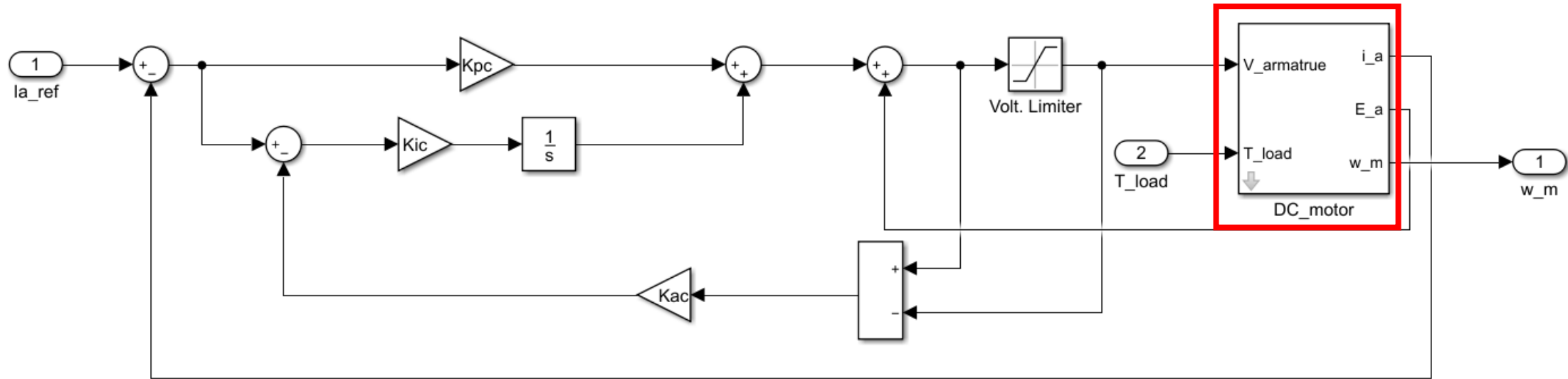
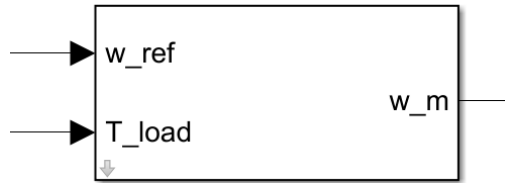


그림 2.59 비례적분 전류 제어가 포함된 전체 구동시스템의 모델



2. Modeling

- PMDC Motor with Controller Modeling



PMDC with Controller

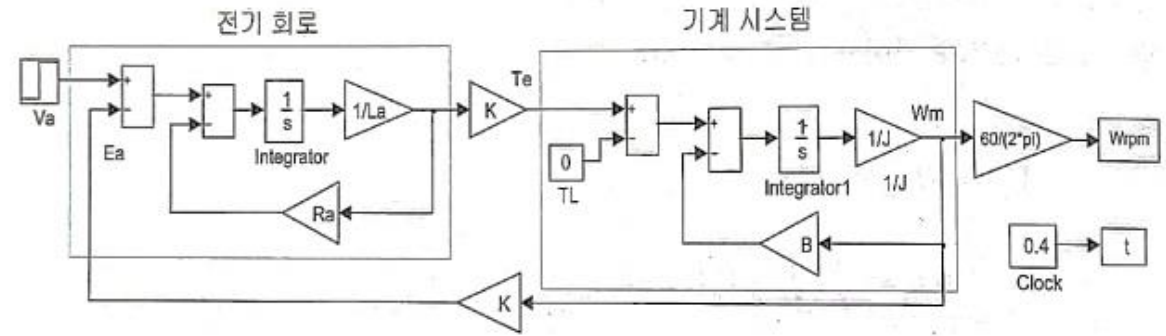
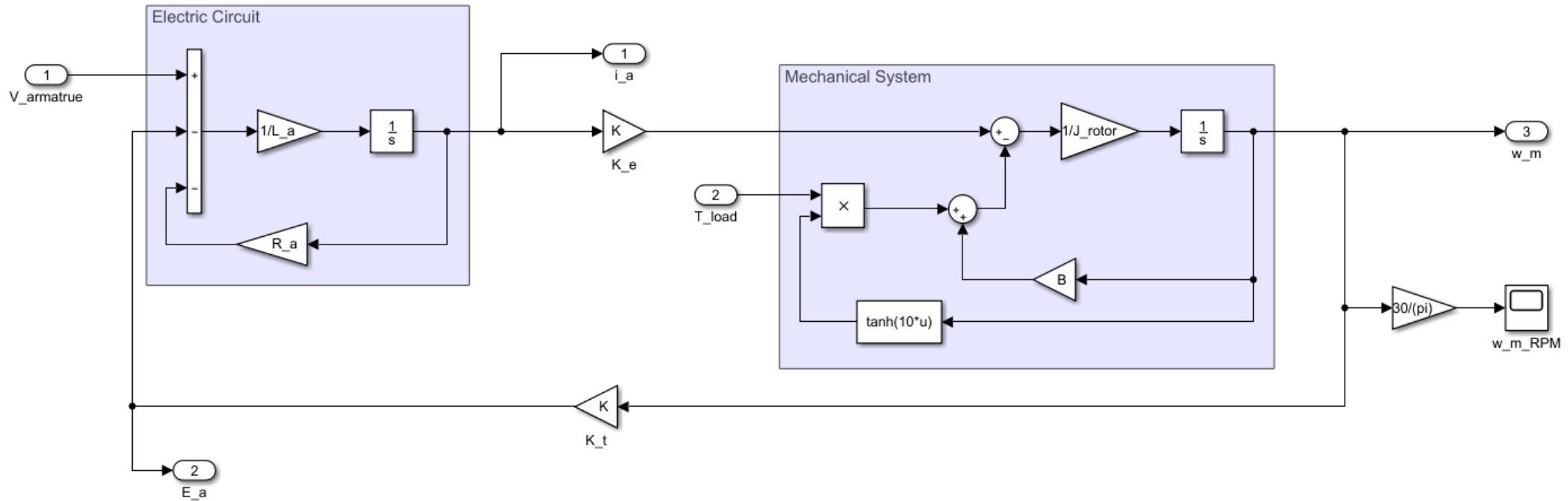
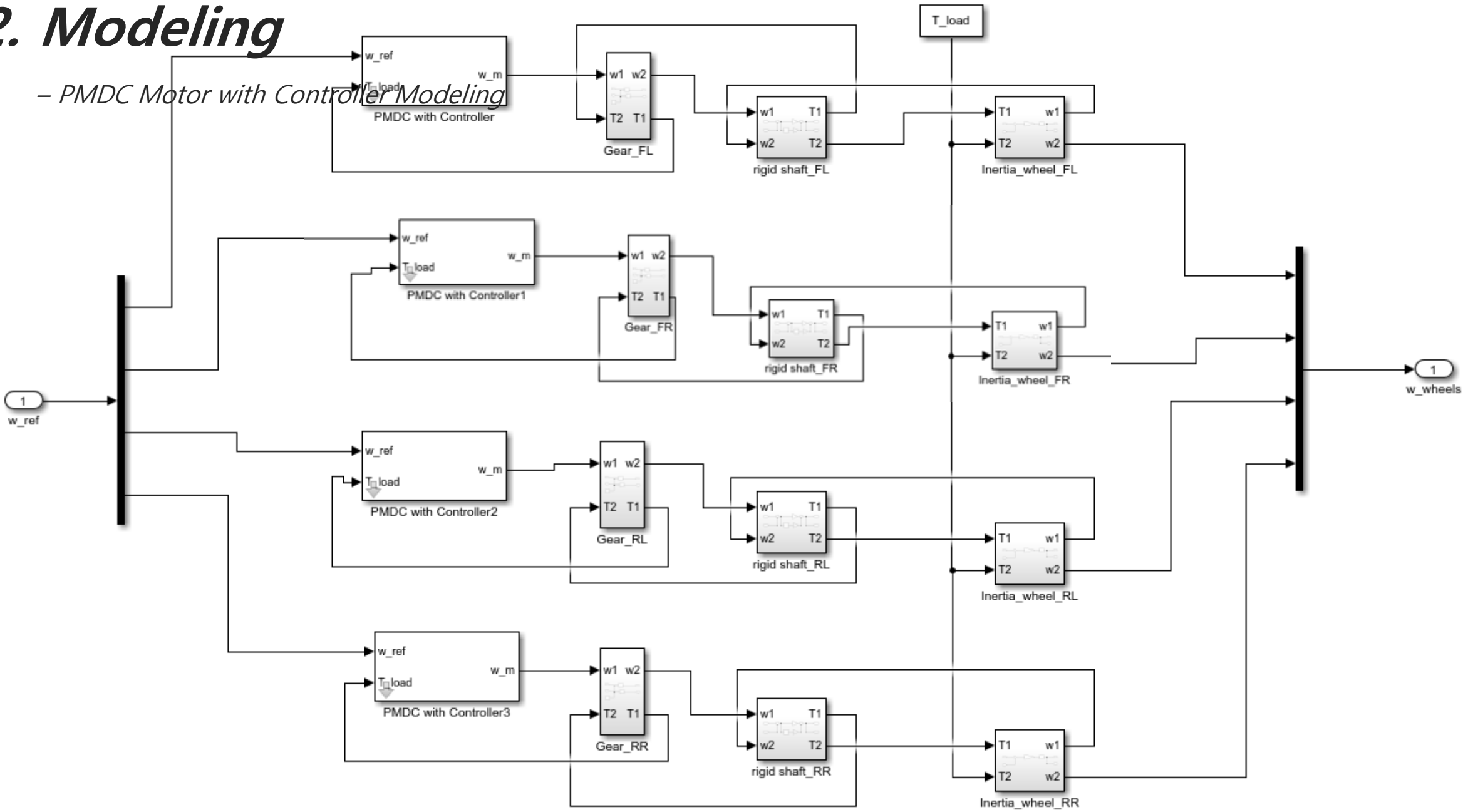


그림 2.56 전동기 모델과 부하 시스템 모델의 결합



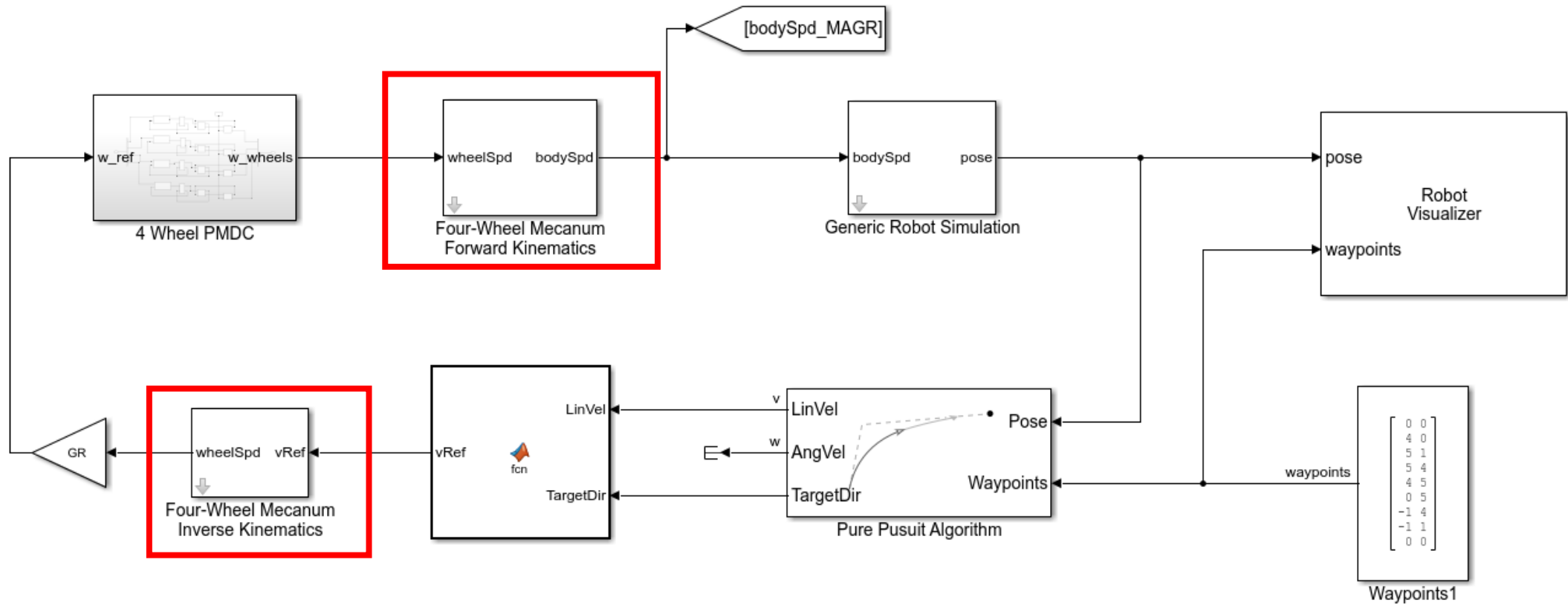
2. Modeling

- PMDC Motor with Controller Modeling



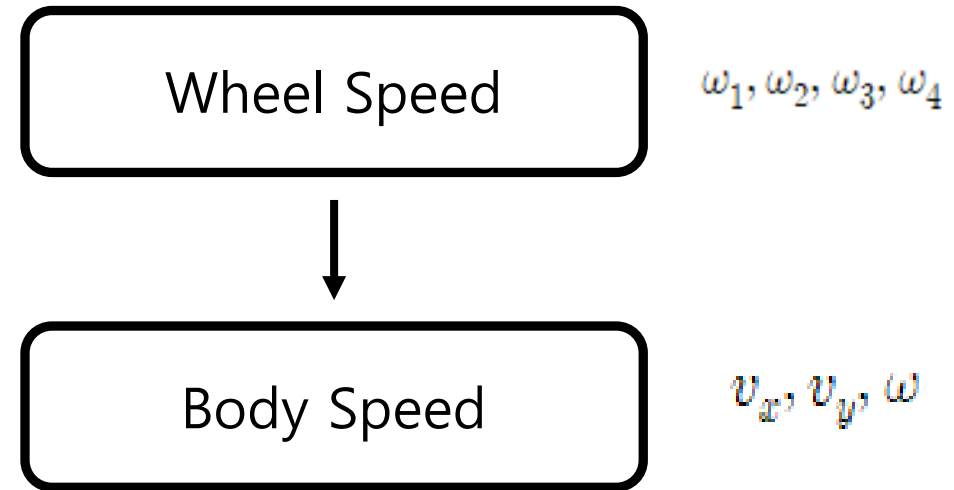
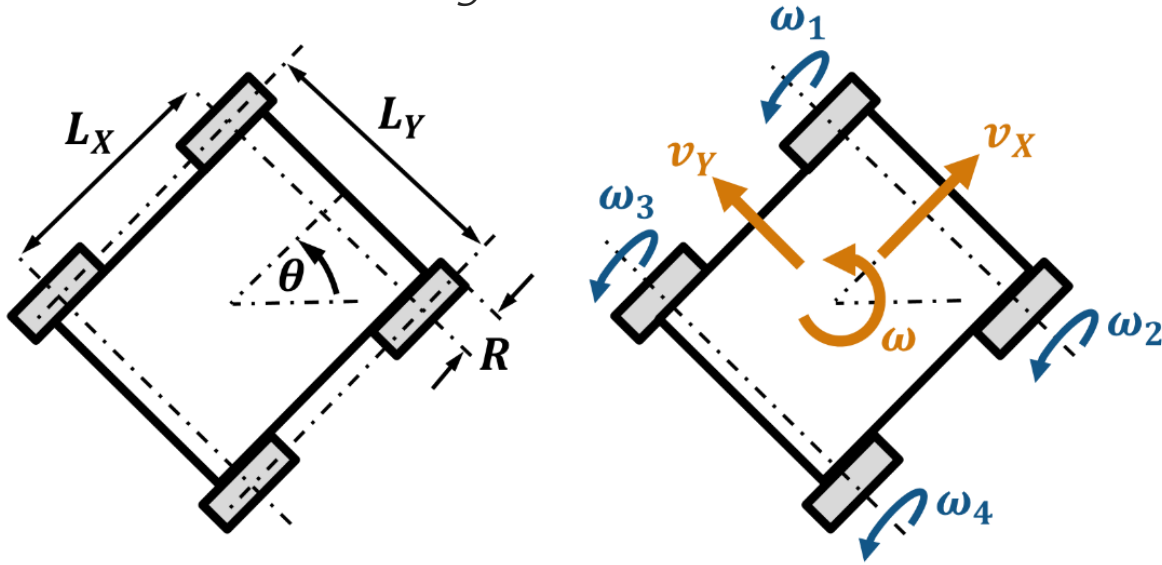
2. Modeling

– Kinematic Modeling



2. Modeling

– Kinematic Modeling

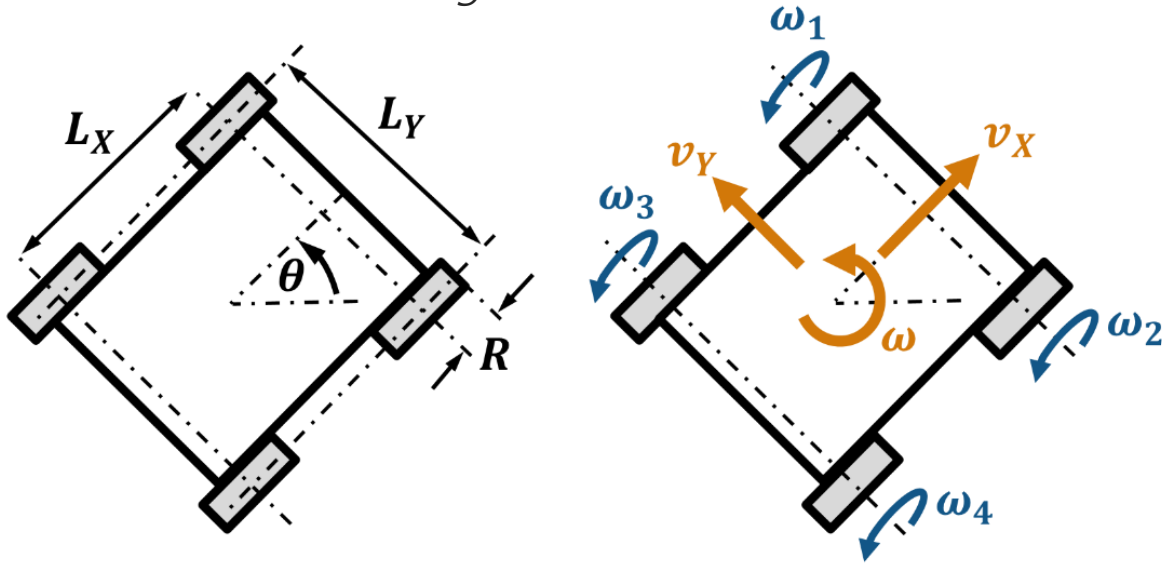


Forward Kinematics Matrix

$$\begin{bmatrix} v_x \\ v_y \\ \omega \end{bmatrix} = \frac{R}{4} \begin{bmatrix} 1 & 1 & 1 & 1 \\ -1 & 1 & 1 & -1 \\ -2 & 2 & -2 & 2 \end{bmatrix} \begin{bmatrix} \omega_1 \\ \omega_2 \\ \omega_3 \\ \omega_4 \end{bmatrix} \quad (1)$$

2. Modeling

– Kinematic Modeling



v_x, v_y, ω



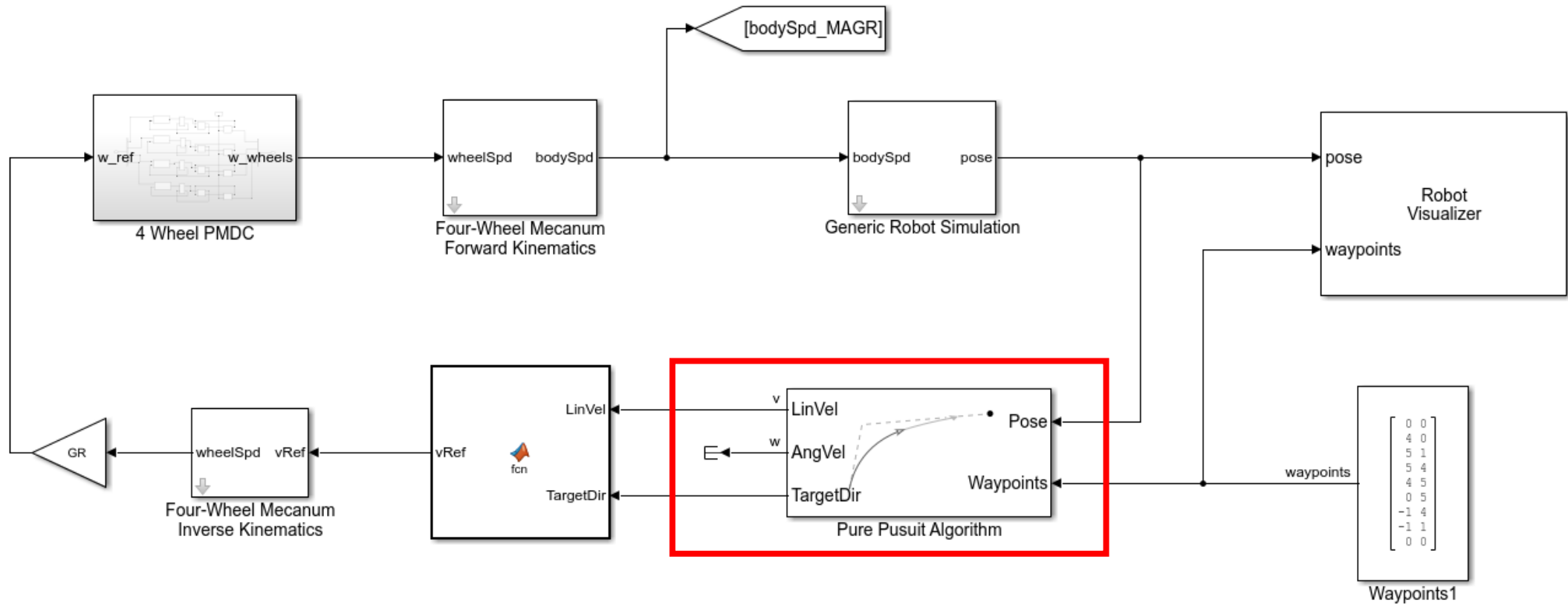
$\omega_1, \omega_2, \omega_3, \omega_4$

Inverse Kinematics Matrix

$$\begin{bmatrix} \omega_1 \\ \omega_2 \\ \omega_3 \\ \omega_4 \end{bmatrix} = \frac{1}{R} \begin{bmatrix} 1 & -1 & -(L_x + L_y)/2 \\ 1 & 1 & (L_x + L_y)/2 \\ 1 & 1 & -(L_x + L_y)/2 \\ 1 & -1 & (L_x + L_y)/2 \end{bmatrix} \begin{bmatrix} v_x \\ v_y \\ \omega \end{bmatrix}$$

2. Modeling

– Pure Pursuit Algorithm



2. Modeling

– Pure Pursuit Algorithm

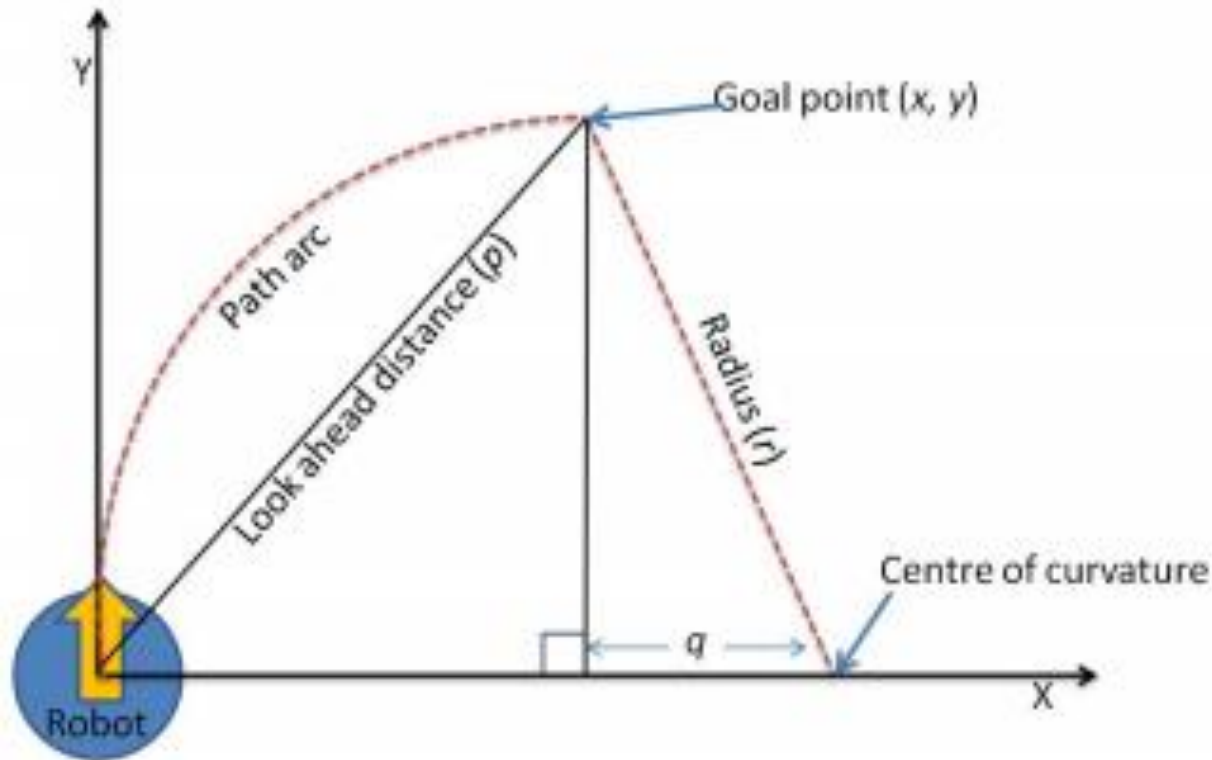


Figure 1: Geometry of the pure pursuit algorithm.

Start Point



Goal Point

$$x^2 + y^2 = p^2$$

$$x + q = r$$

$$q = r - x$$

$$q^2 + y^2 = p^2$$

$$(r - x)^2 + y^2 = r^2$$

$$r^2 - 2rx + x^2 + y^2 = r^2$$

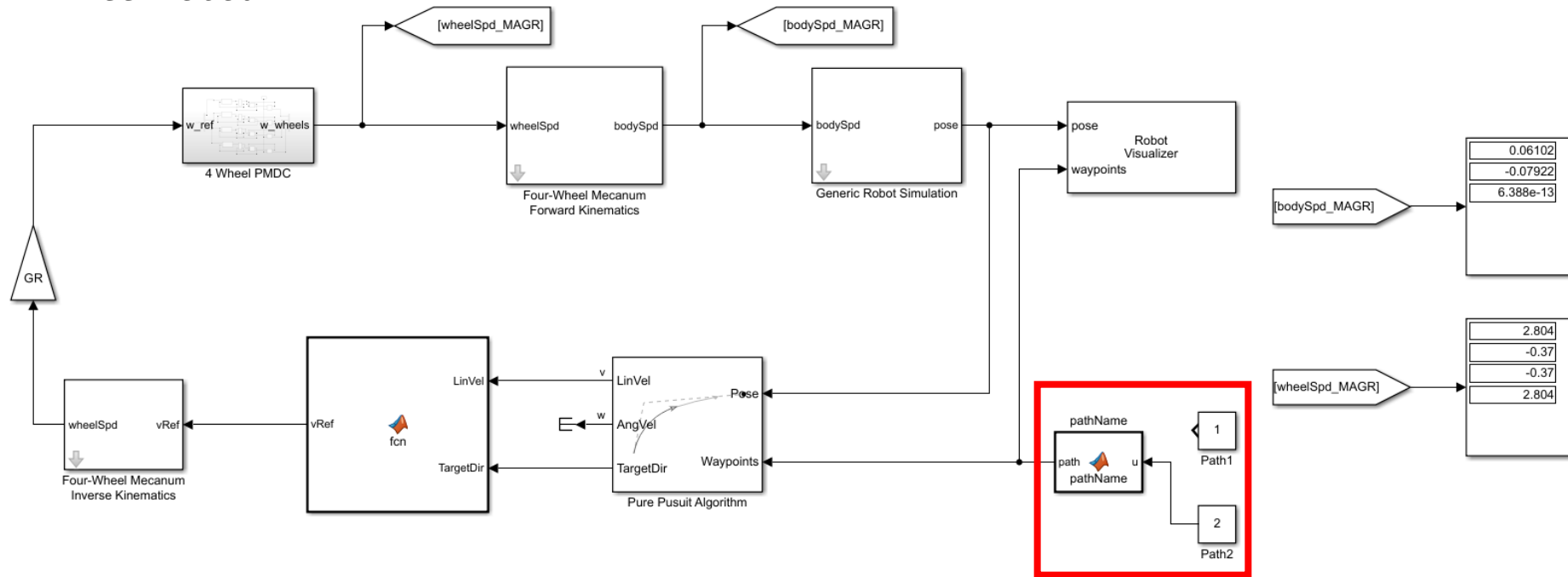
$$2rx = p^2$$

$$\rho = \frac{1}{r} = \frac{2x}{p^2}$$

Team - Initial M

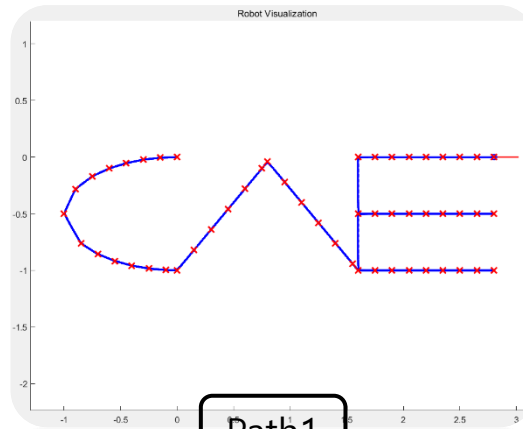
3. Simulation

– Mecanum Wheel Robot



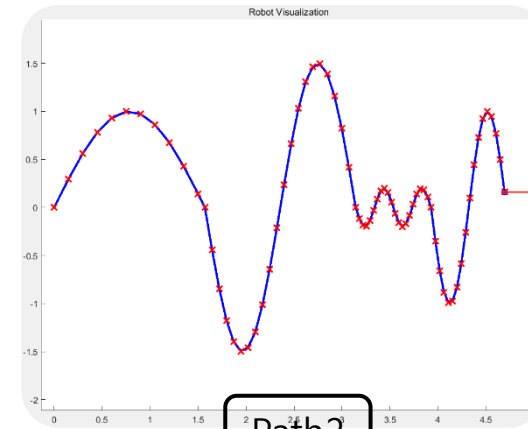
0	0
4	0
5	1
5	3
4	4
0	4
-1	3
-1	1
0	0

Waypoints1



Path1

OR

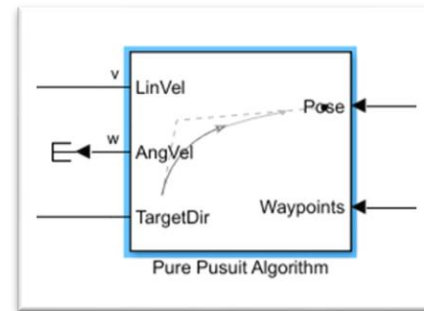
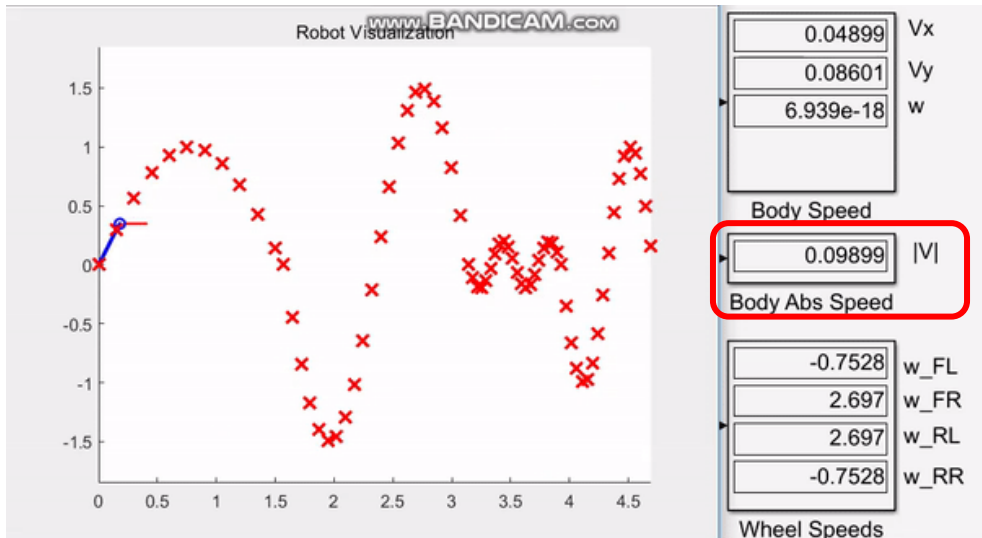
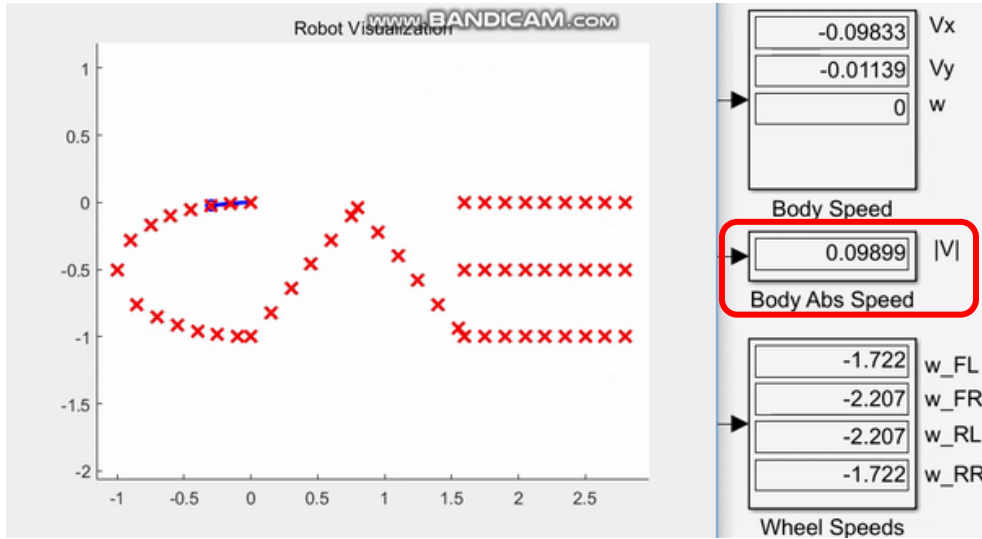


Path2

Team - Initial M

3. Simulation

– Mecanum Wheel Robot



Block Parameters: Pure Pursuit Algorithm

Pure Pursuit

Compute linear and angular velocity control commands for following a path using a set of waypoints and current pose of a differential drive robot.

The input port Waypoints accepts an [Nx2] matrix as x-y coordinates. The TargetDir port outputs an angle with respect to robot's forward direction with positive angles measured counter-clockwise.

Set the Lookahead distance to tune how closely the robot follows the path. A smaller Lookahead distance improves path tracking, but it can lead to instability.

Parameters

Desired linear velocity (m/s): 0.1

Maximum angular velocity (rad/s): 1.5

Lookahead distance (m): 0.035

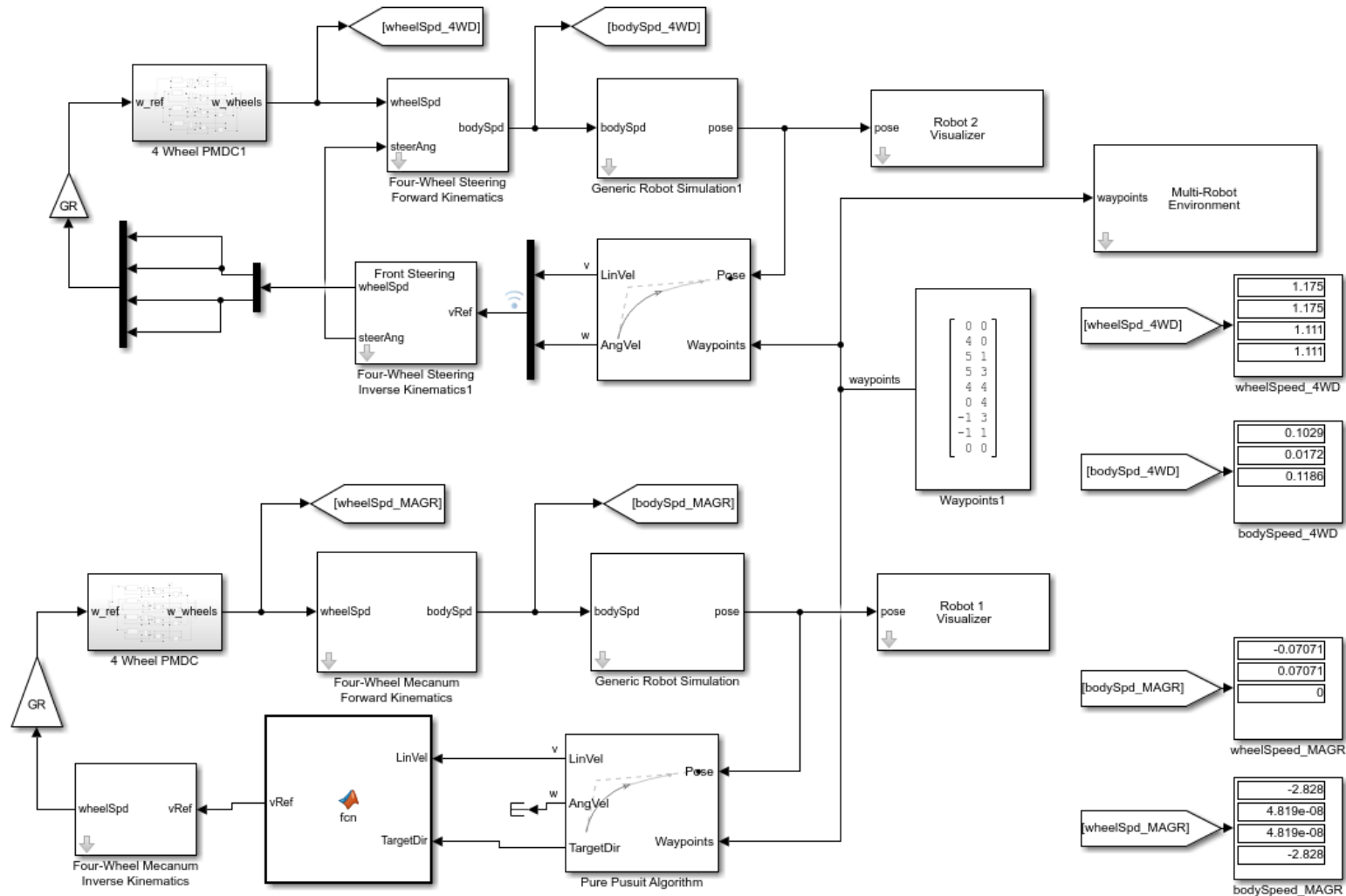
Show TargetDir output port

Simulate using: Interpreted execution

OK Cancel Help Apply

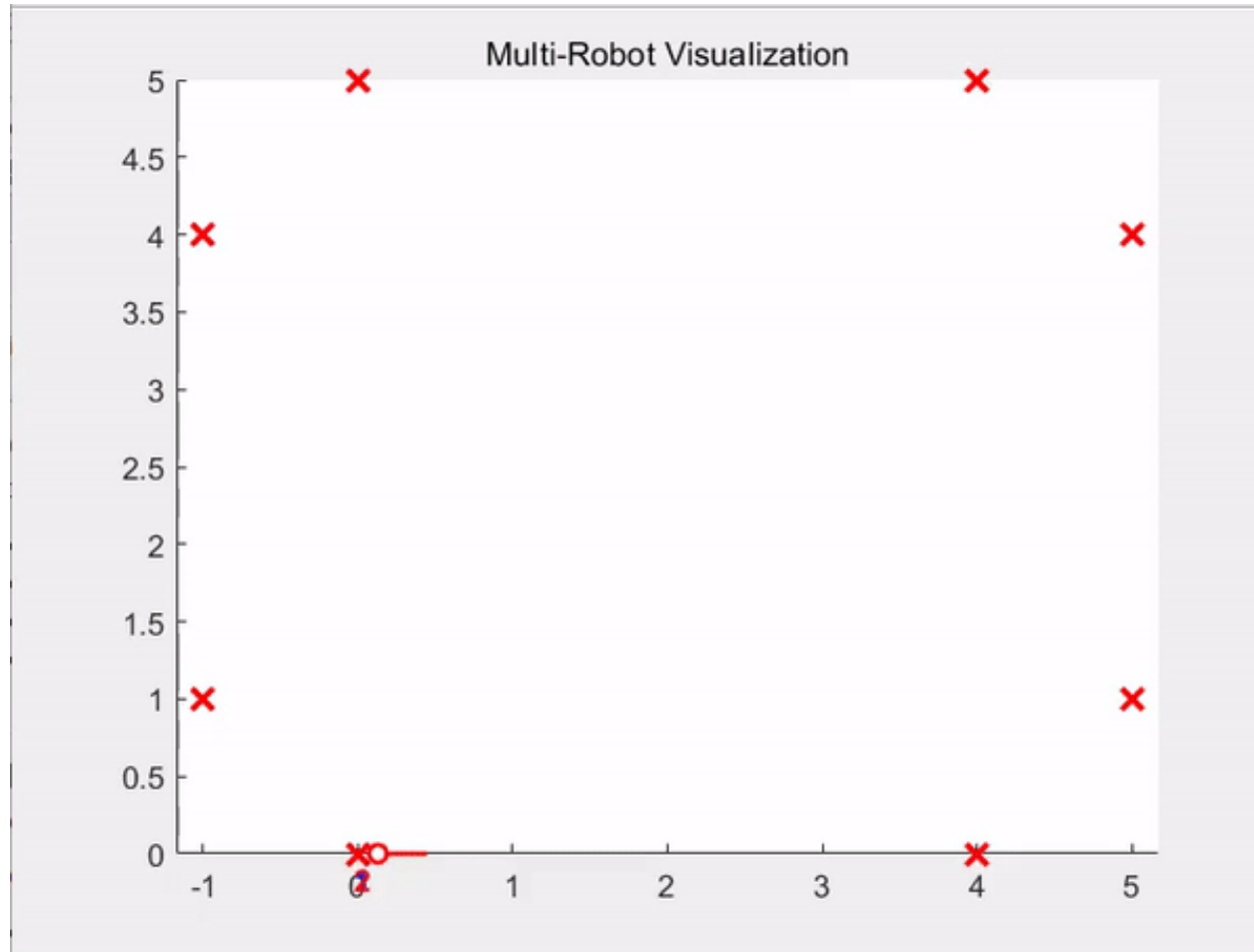
3. Simulation

– Mecanum Wheel Model vs Steering Model



3. Simulation

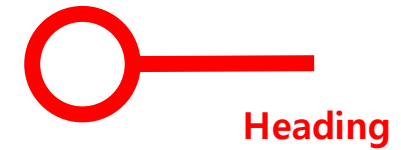
– Mecanum Wheel Model vs Steering Model



1. Mecanum Wheel Model



2. Steering Model



4. Q&A

Q & A

References

Coulter, R. C. (1992). *Implementation of the pure pursuit path tracking algorithm*. Carnegie-Mellon UNIV Pittsburgh PA Robotics INST.

Gfrerrer, A. (2008). Geometry and kinematics of the Mecanum wheel. *Computer Aided Geometric Design*, 25(9), 784-791.

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Patel, A. A. (2019) MATLAB modelling of Mecanum wheeled mobile robot platform with extended capabilities of forming Swarms.

김상훈, 모터제어, 제2판 (강원대학교) p. 104-109.