

PROJECT DAY PRESENTATION



# The Autonomous Vehicle : GNSS Technology Tracking Using PID Controller

Department of Control System and Instrumentation Engineering Faculty of Engineering

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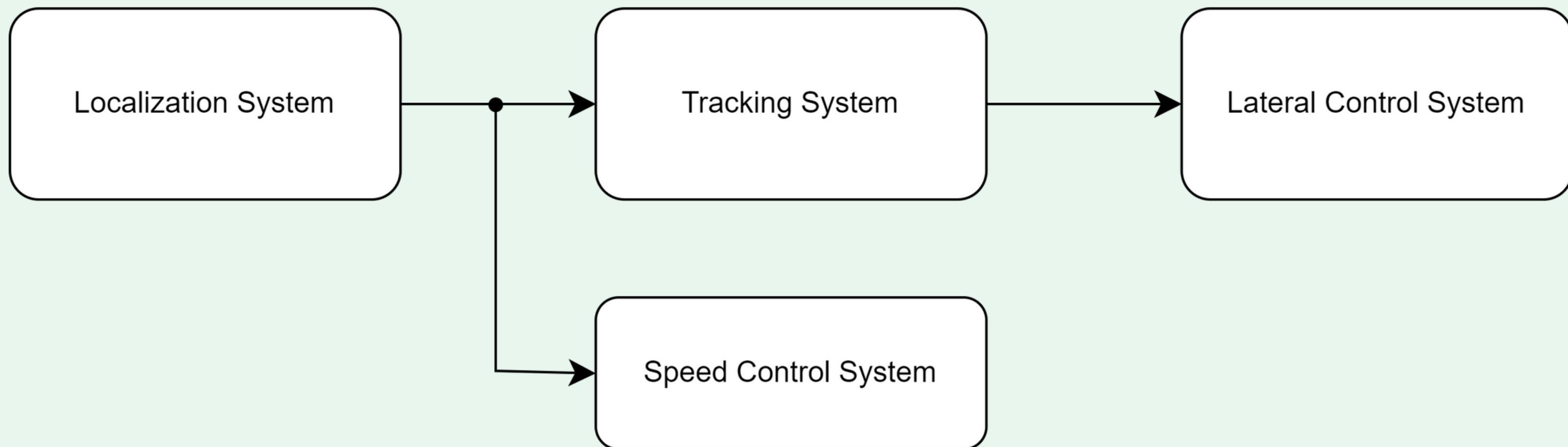


# Introduction

- Speed Control
- Navigation and Tracking Control
- Steering Control

# System Overview

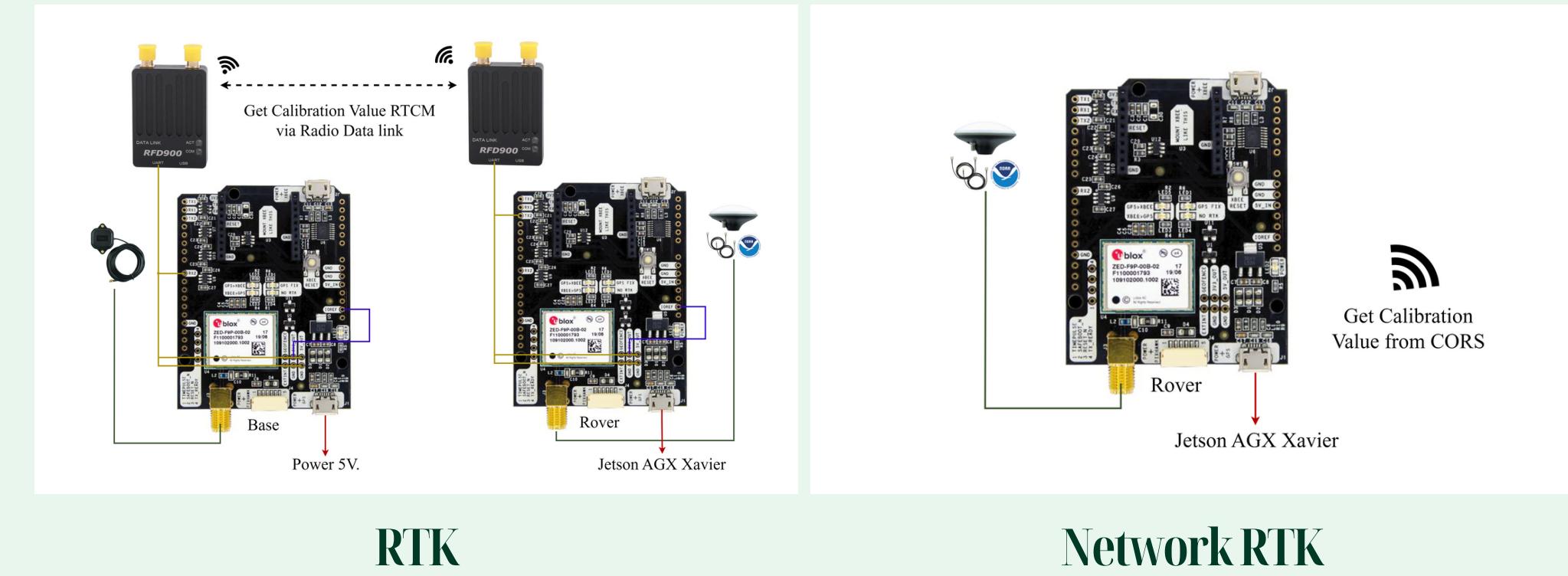
There are localization systems, Tracking systems, speed control systems, and Lateral Control systems in the autonomous vehicle.



# Localization System

Global Navigation Satellite System

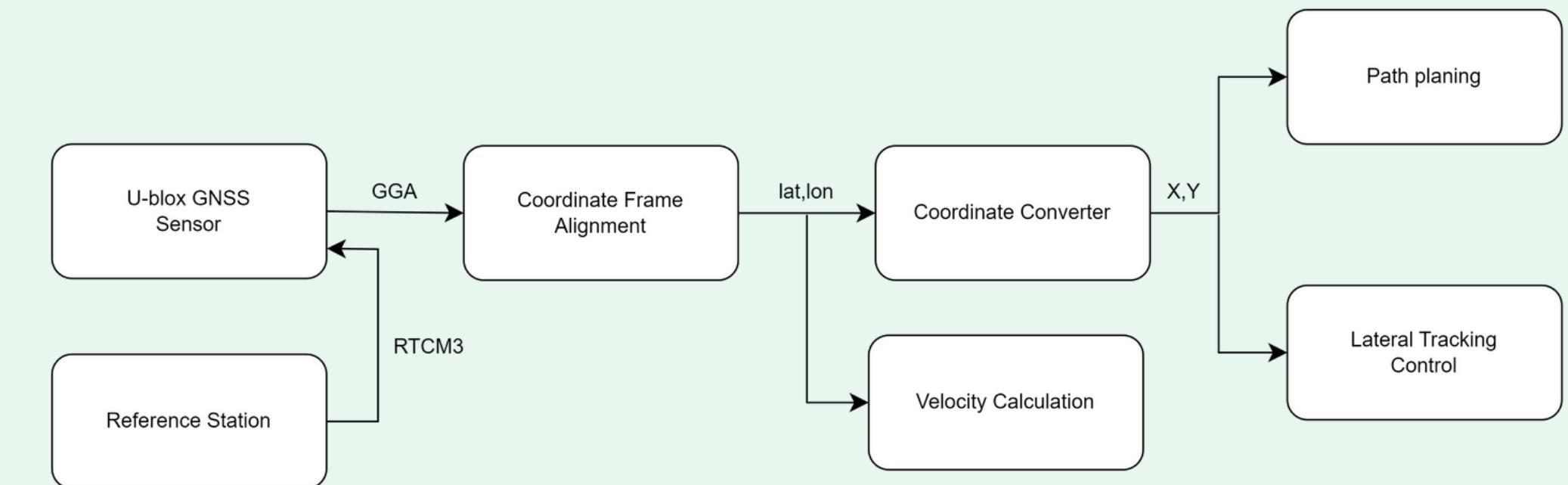
## REAL TIME KINEMATIC



RTK

Network RTK

## FRAMEWORK



# Reference Path

Around KMUTT Soccer field

01 Straight Path 1: South to North

02 Curve Path 1: North to West

03 Straight Path 2 : East to West

04 Curve Path 2: West to South

05 Straight Path 3: North to South

06 Curve Path 3: South to East

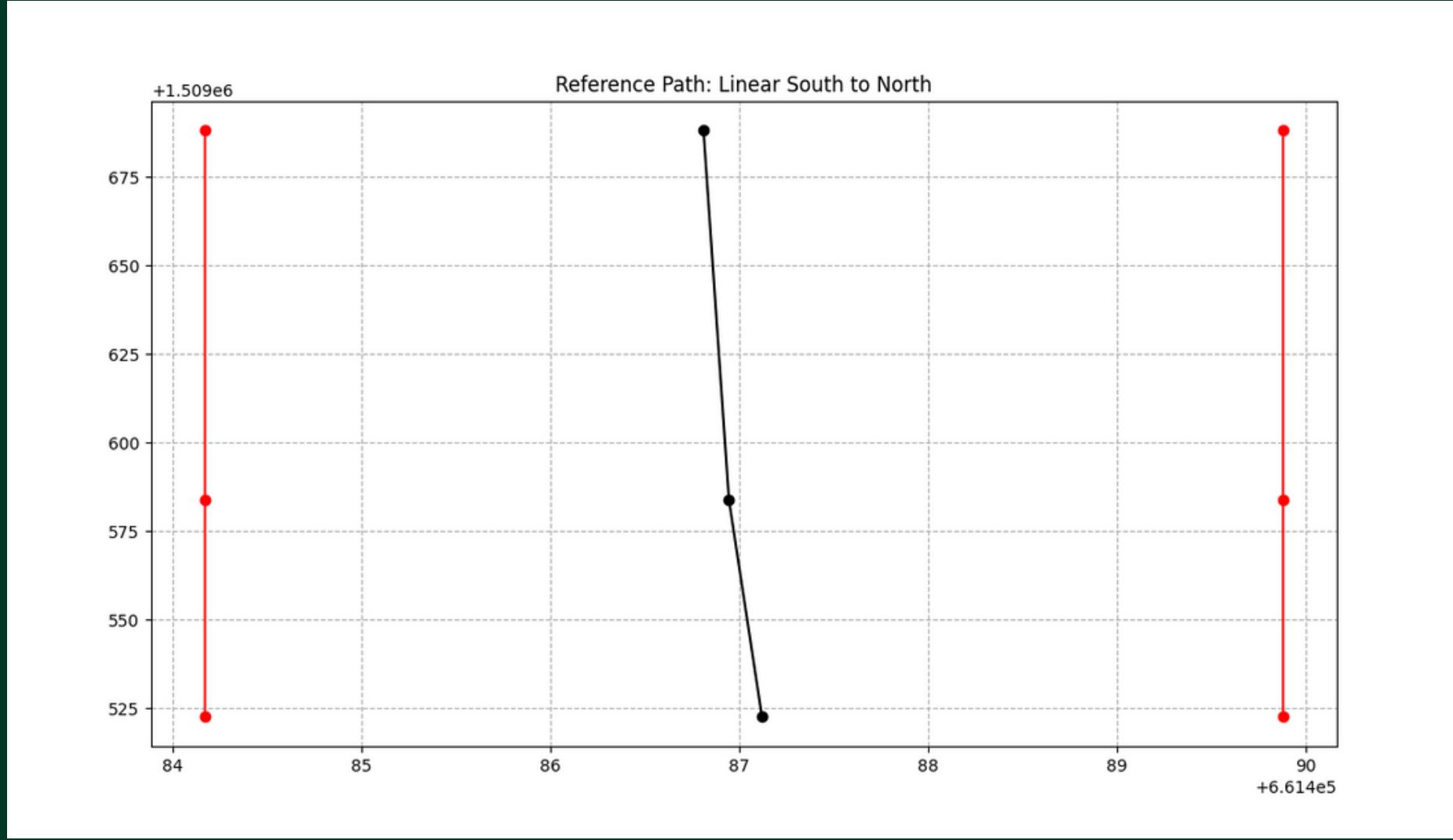
07 Straight Path 4: West to East

08 Curve Path 4: East to North



# Reference Path

## 01 Straight Path 1: South to North

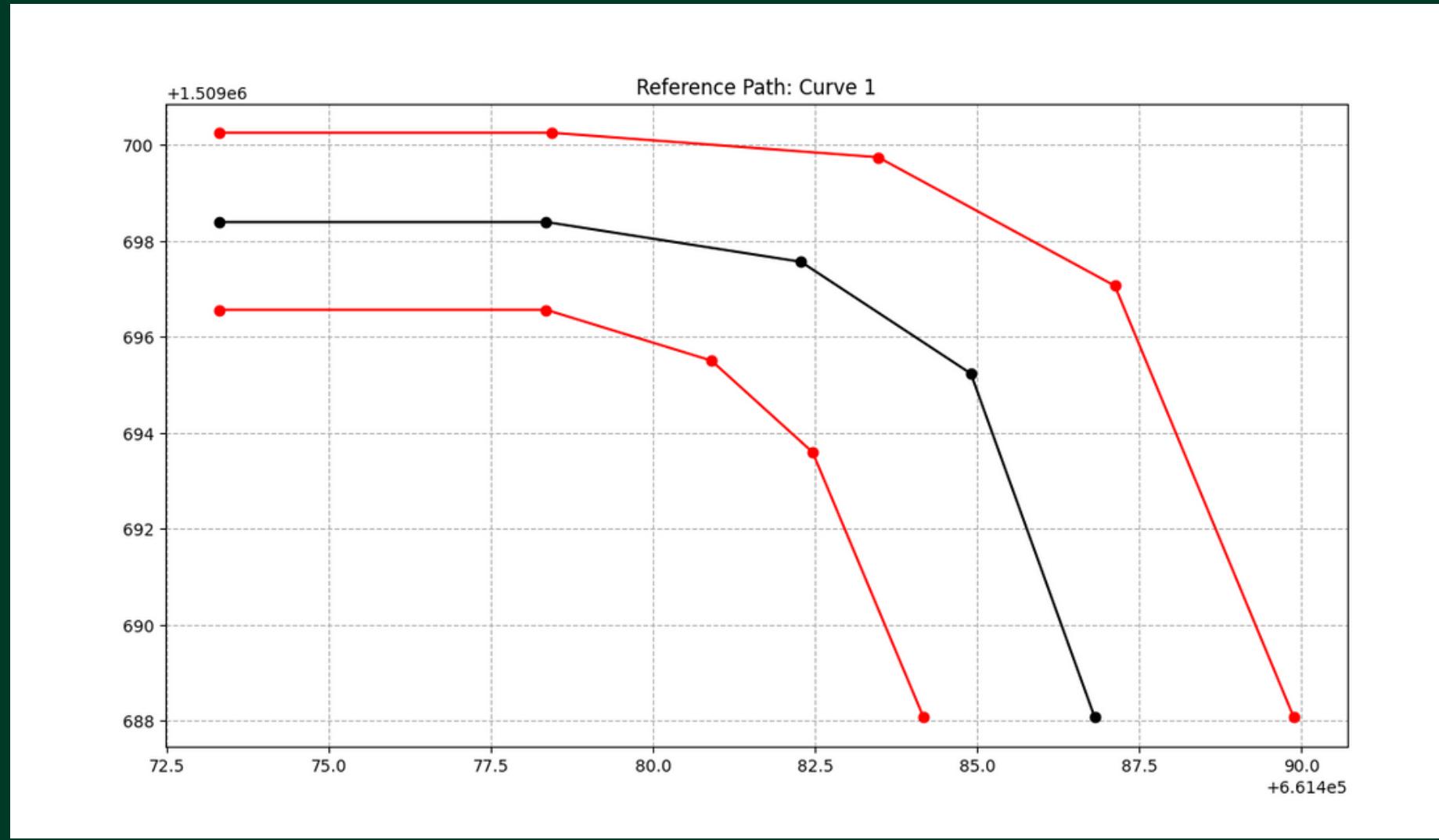


UTM XY Coordinate

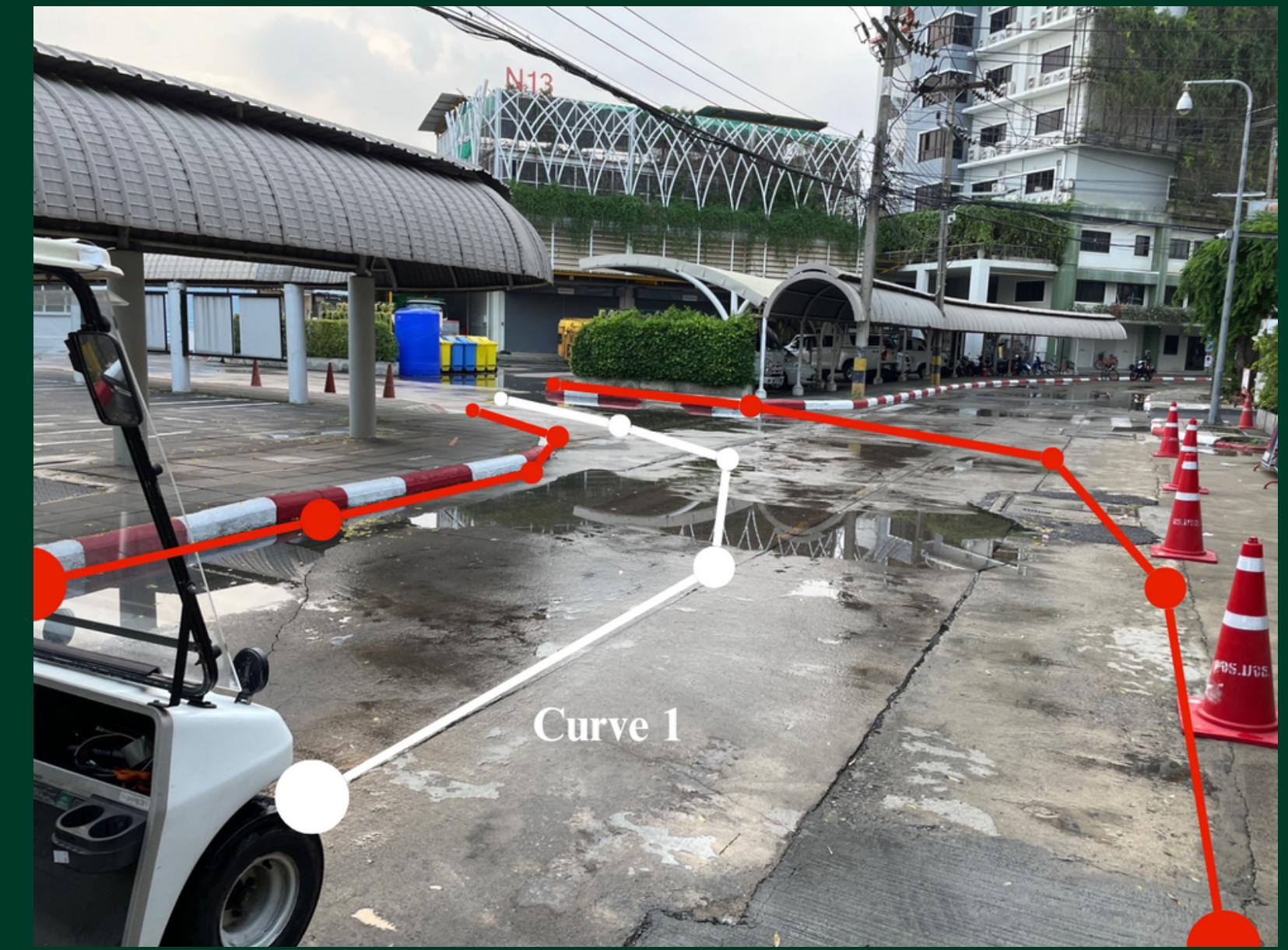


# Reference Path

## 02 Curve Path 1: North to West

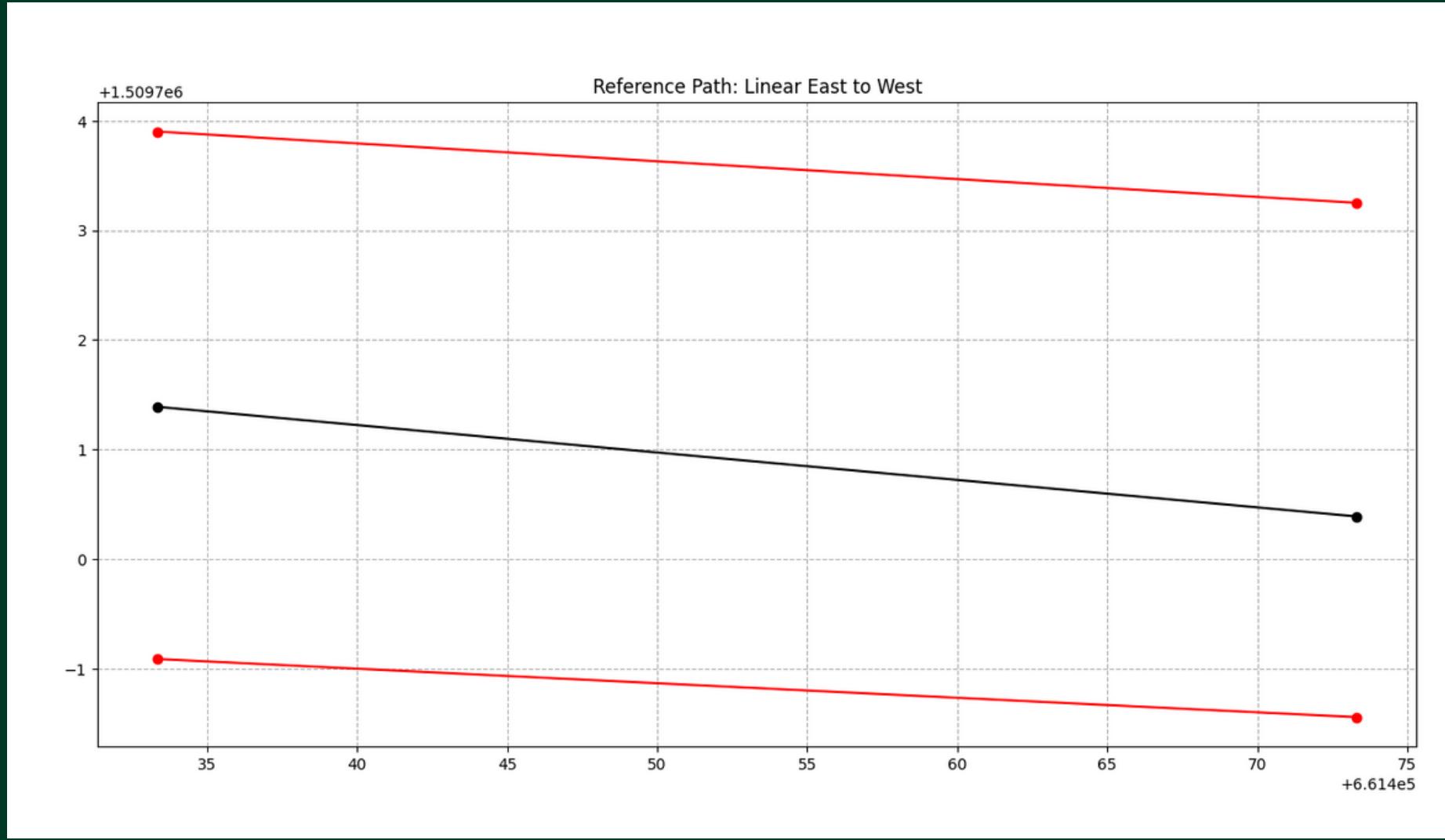


UTM XY Coordinate



# Reference Path

## 03 Straight Path 2: East to West



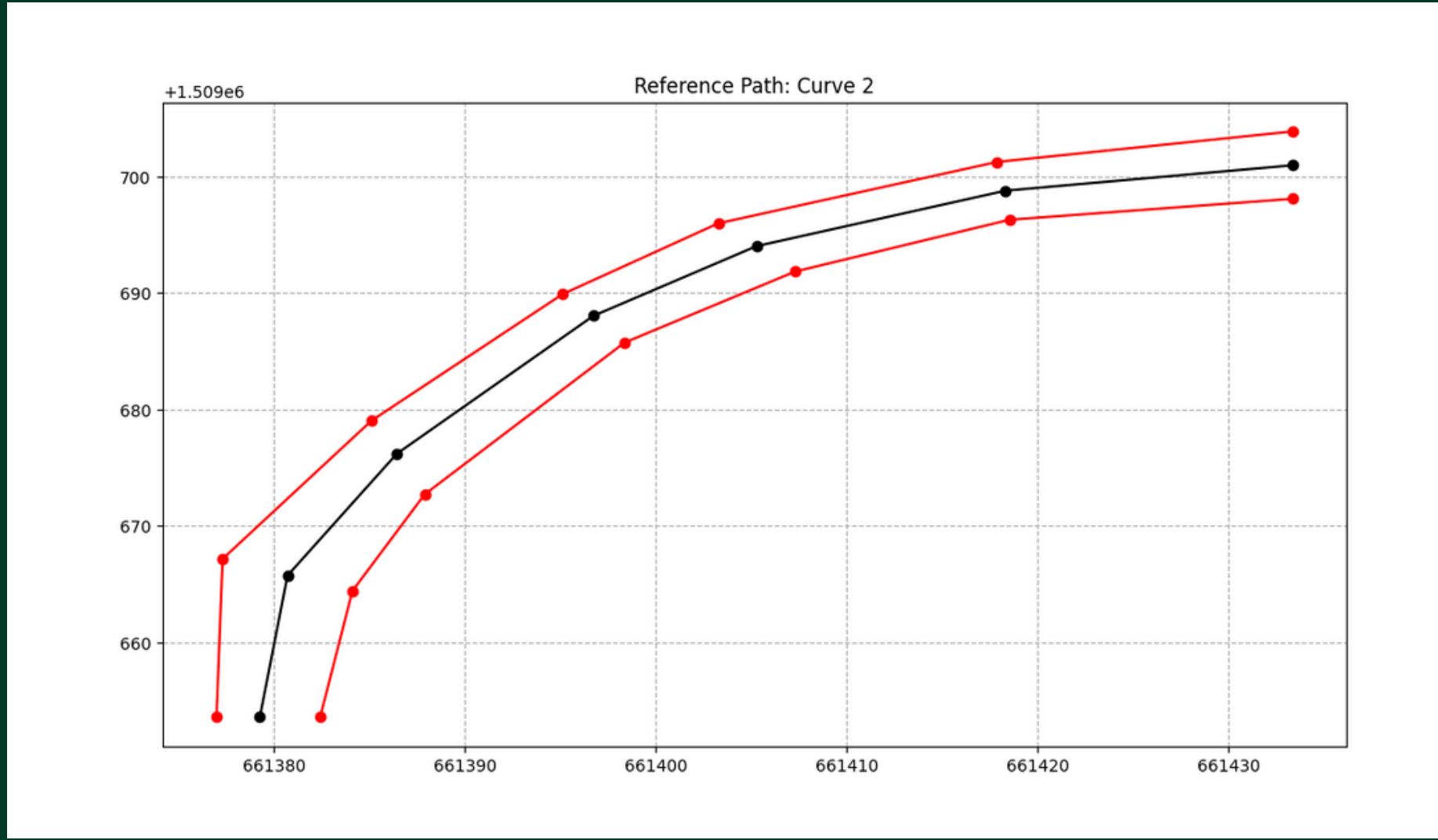
UTM XY Coordinate



Straight E-W

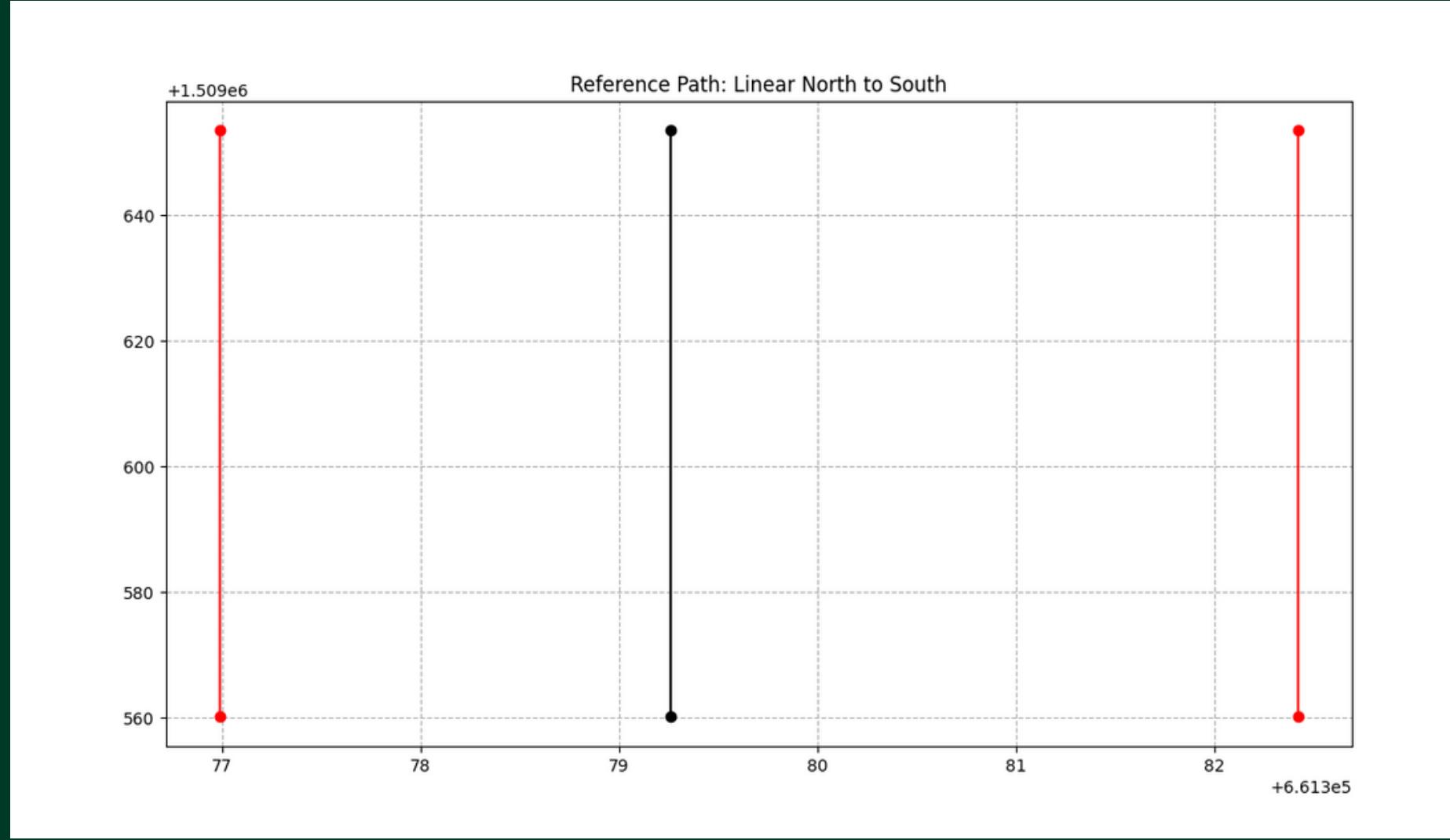
# Reference Path

## 04 Curve Path 2: West to South



# Reference Path

## 05 Straight Path 3: North to South

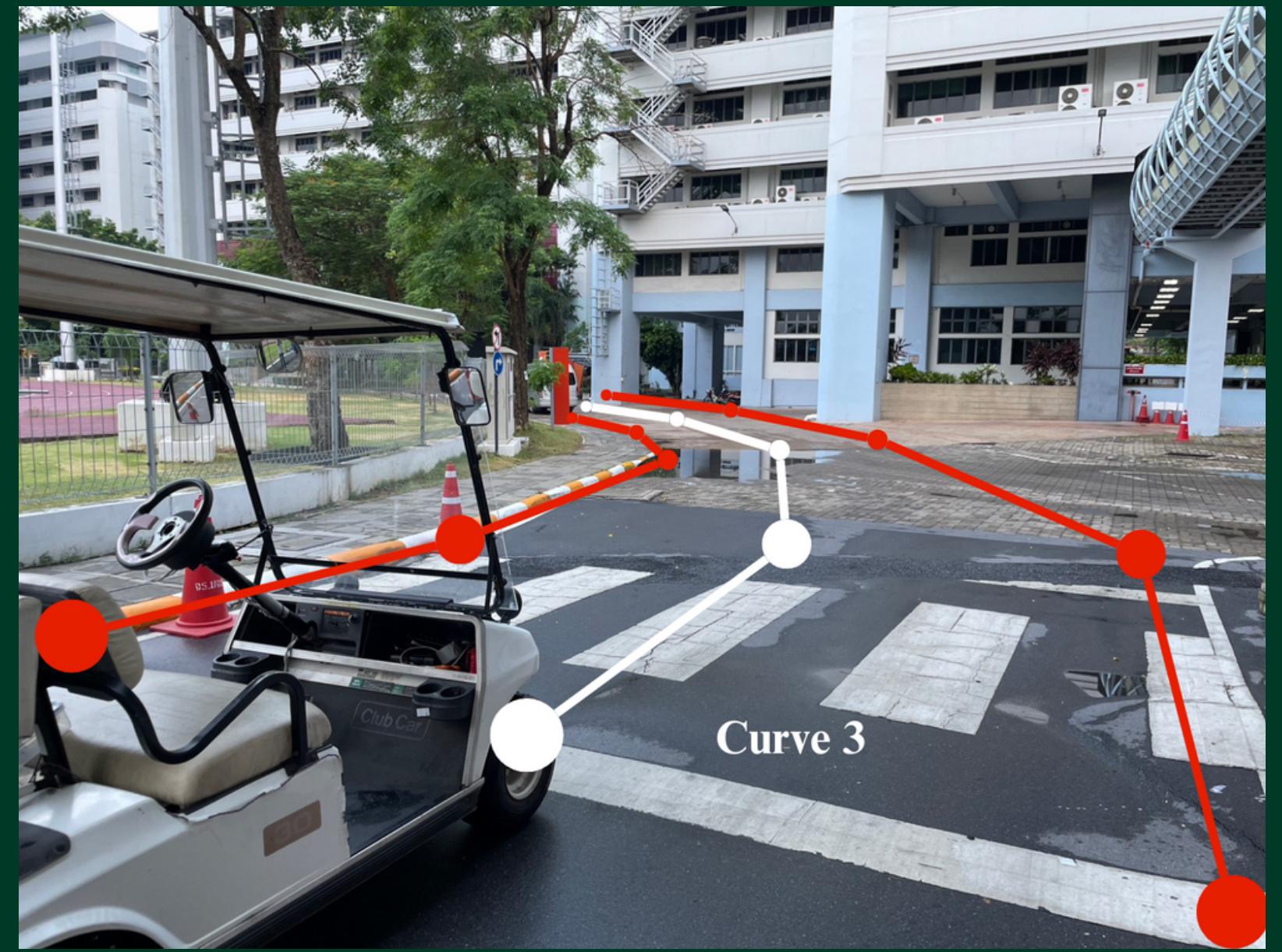
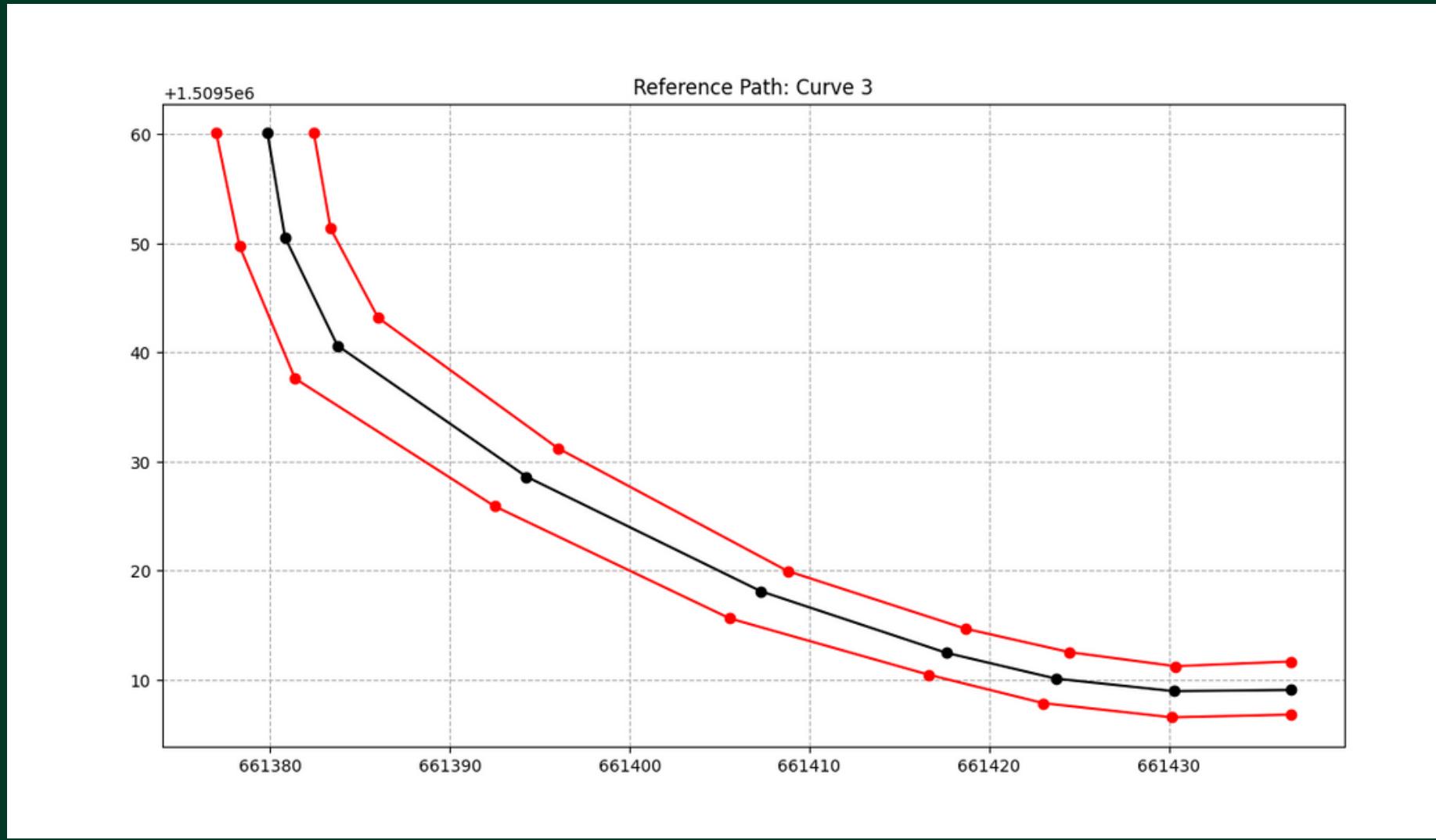


UTM XY Coordinate



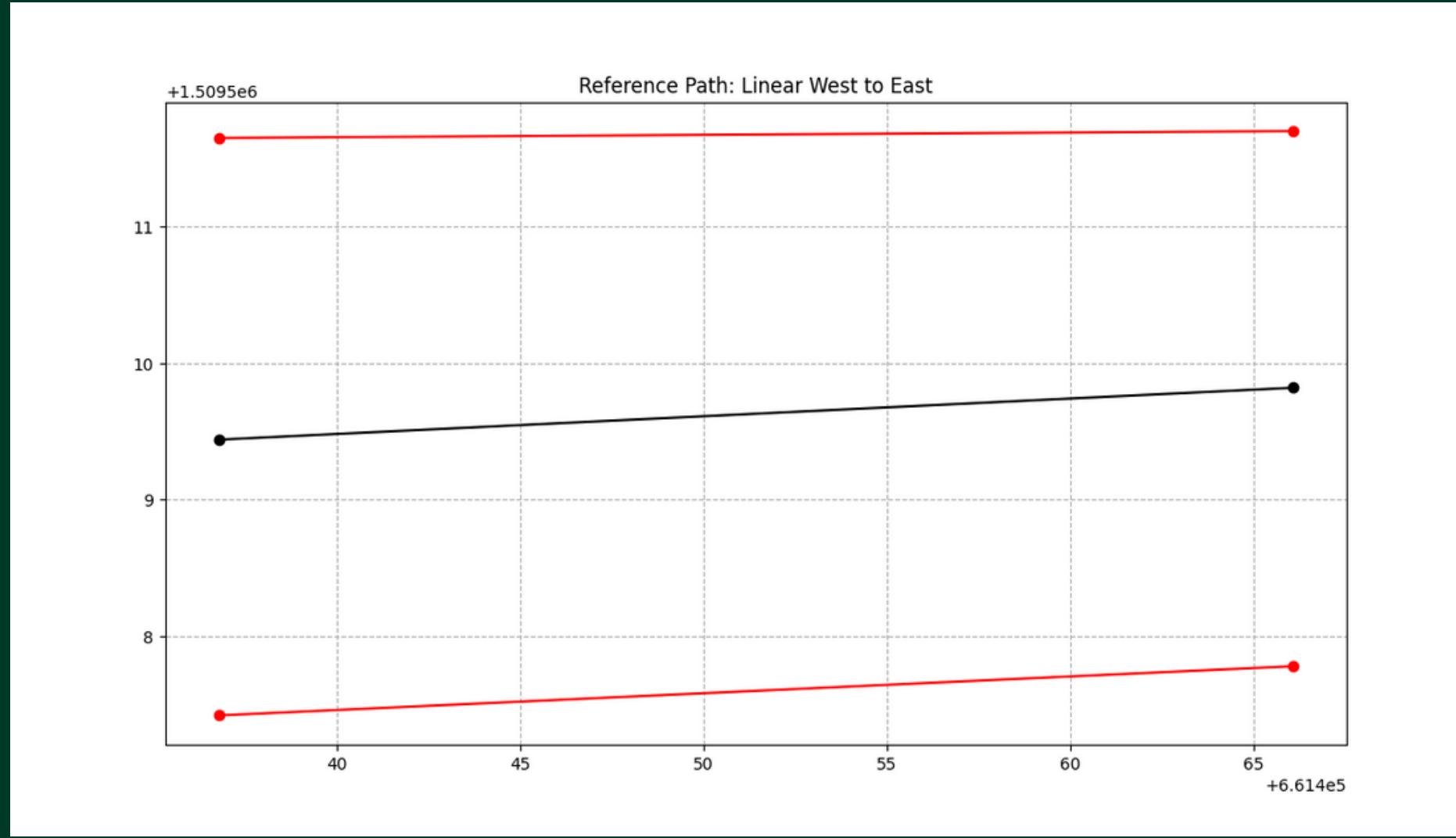
# Reference Path

## 06 Curve Path 3: South to East



# Reference Path

07 Straight Path 4: West to East

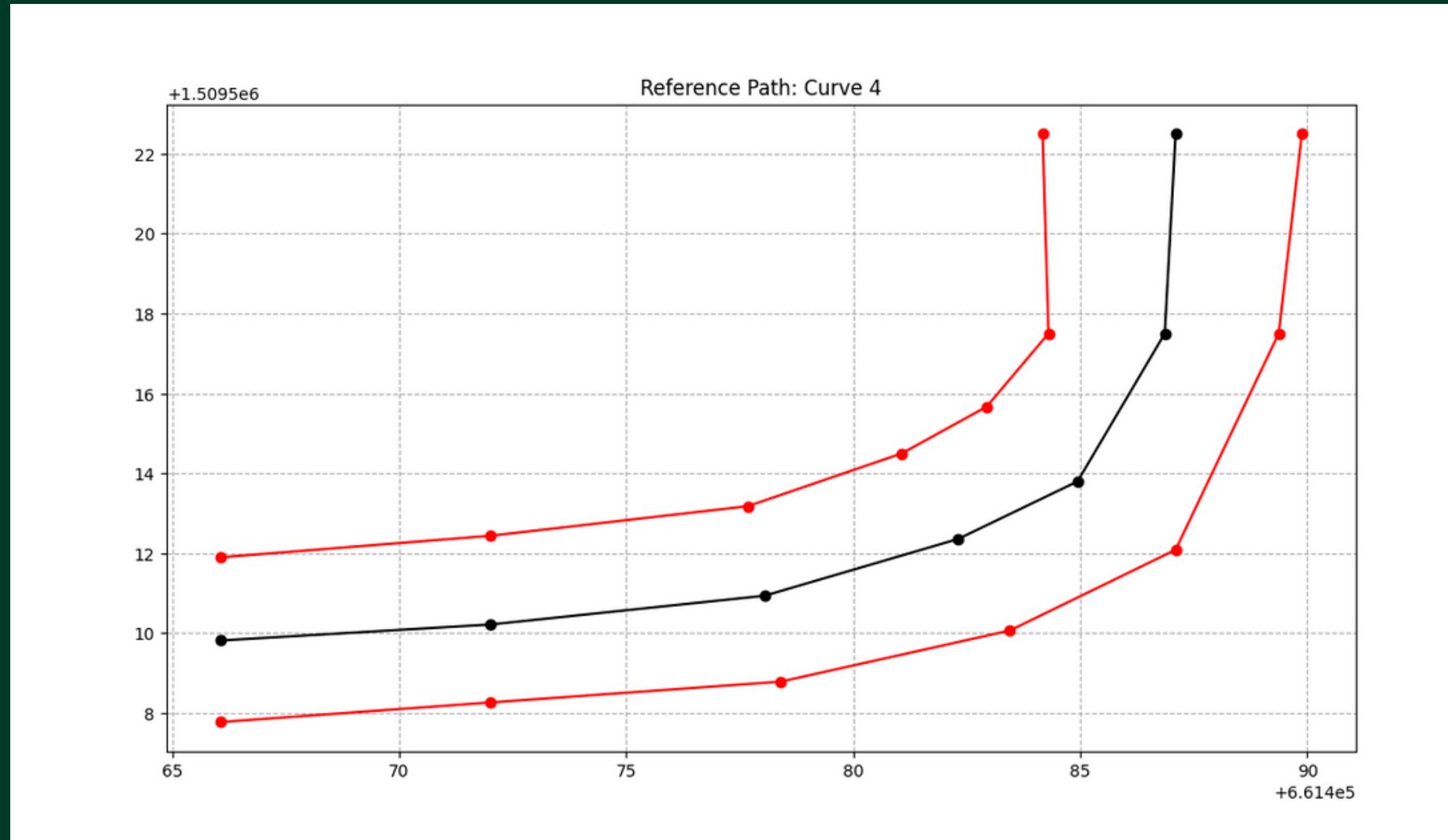


UTM XY Coordinate



# Reference Path

08 Curve Path 4: East to North

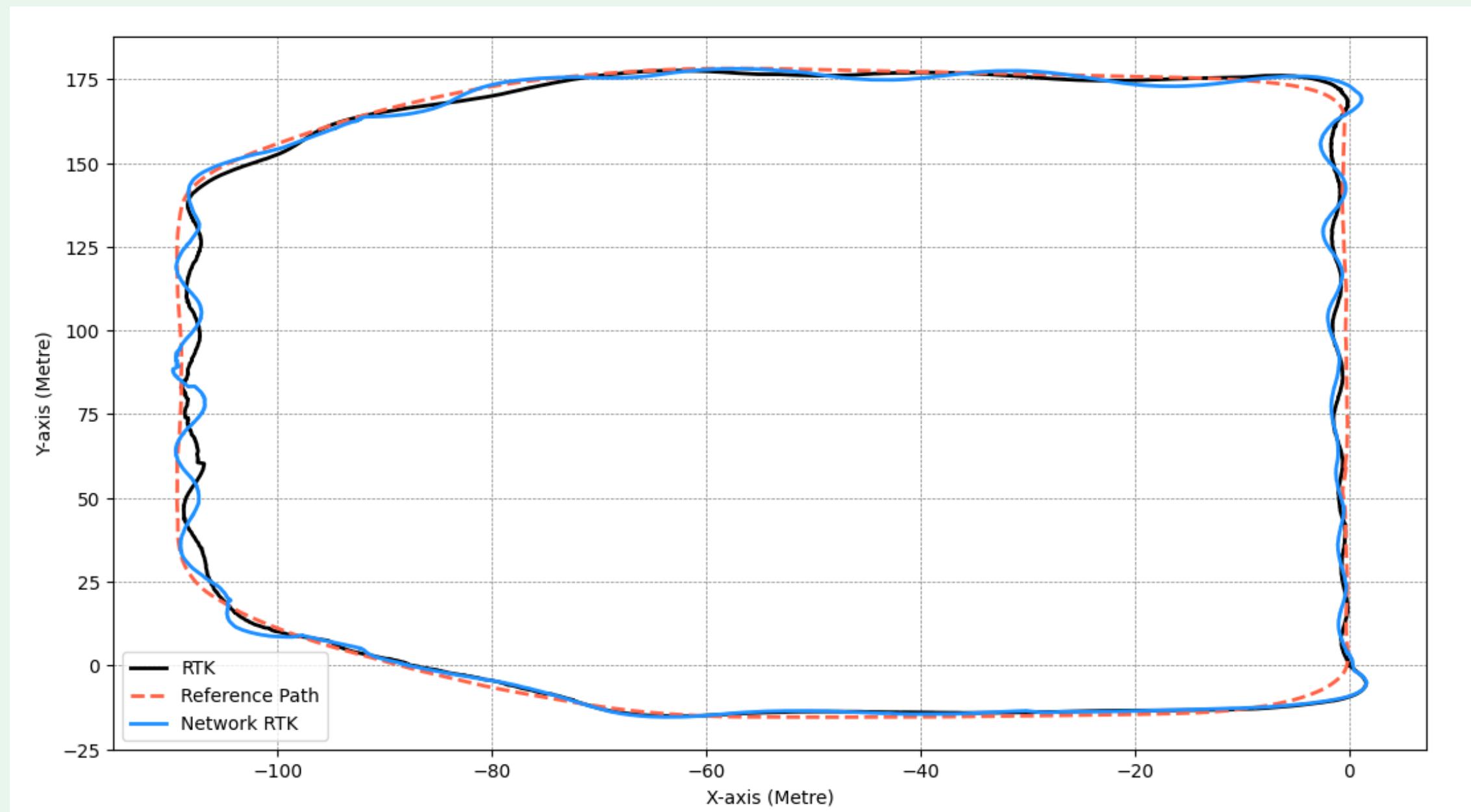


UTM XY Coordinate



# Coordinate Around KMUTT Soccer Field.

Between RTK (2 boards) and Network RTK (1 board)

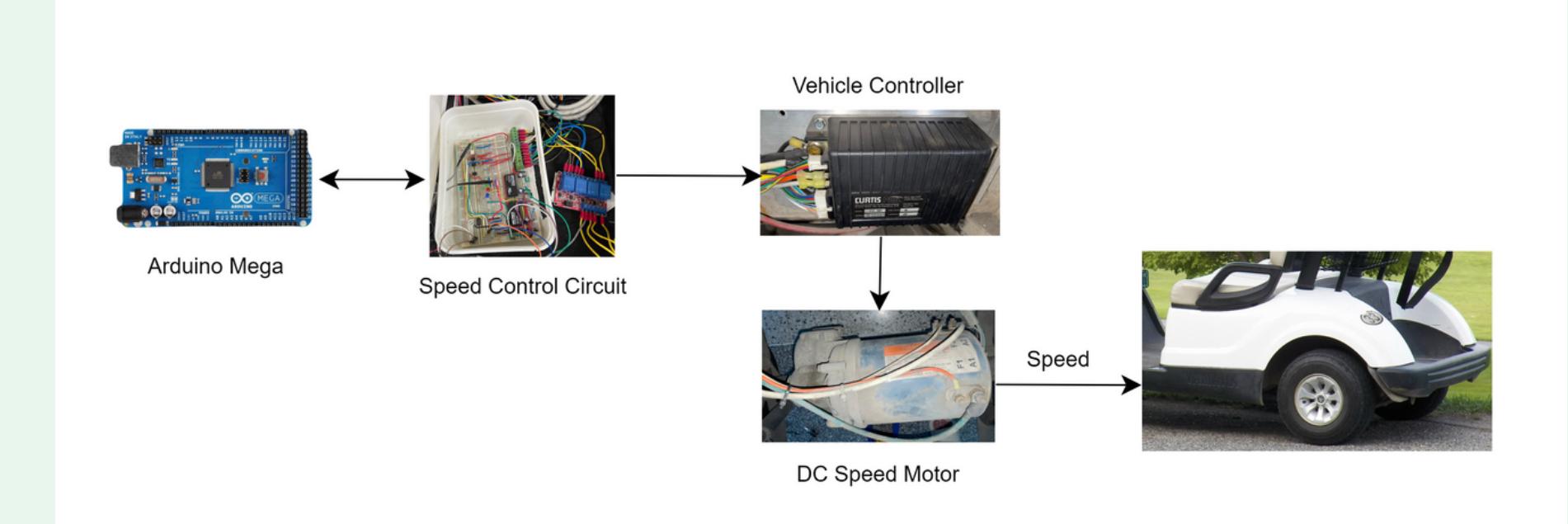


UTM XY Coordinate

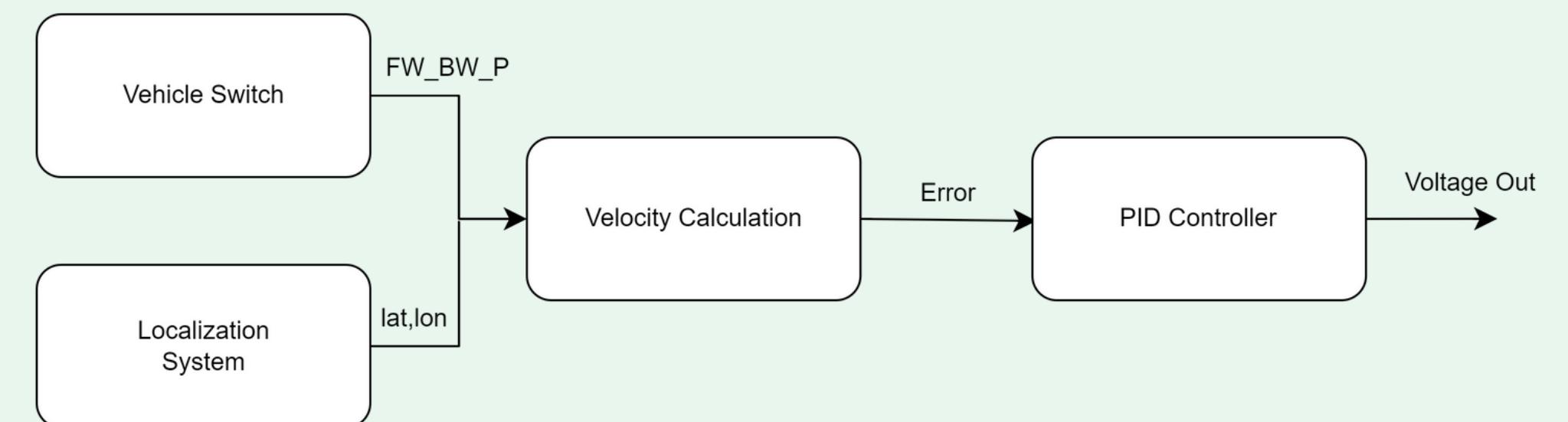
# Speed Control System

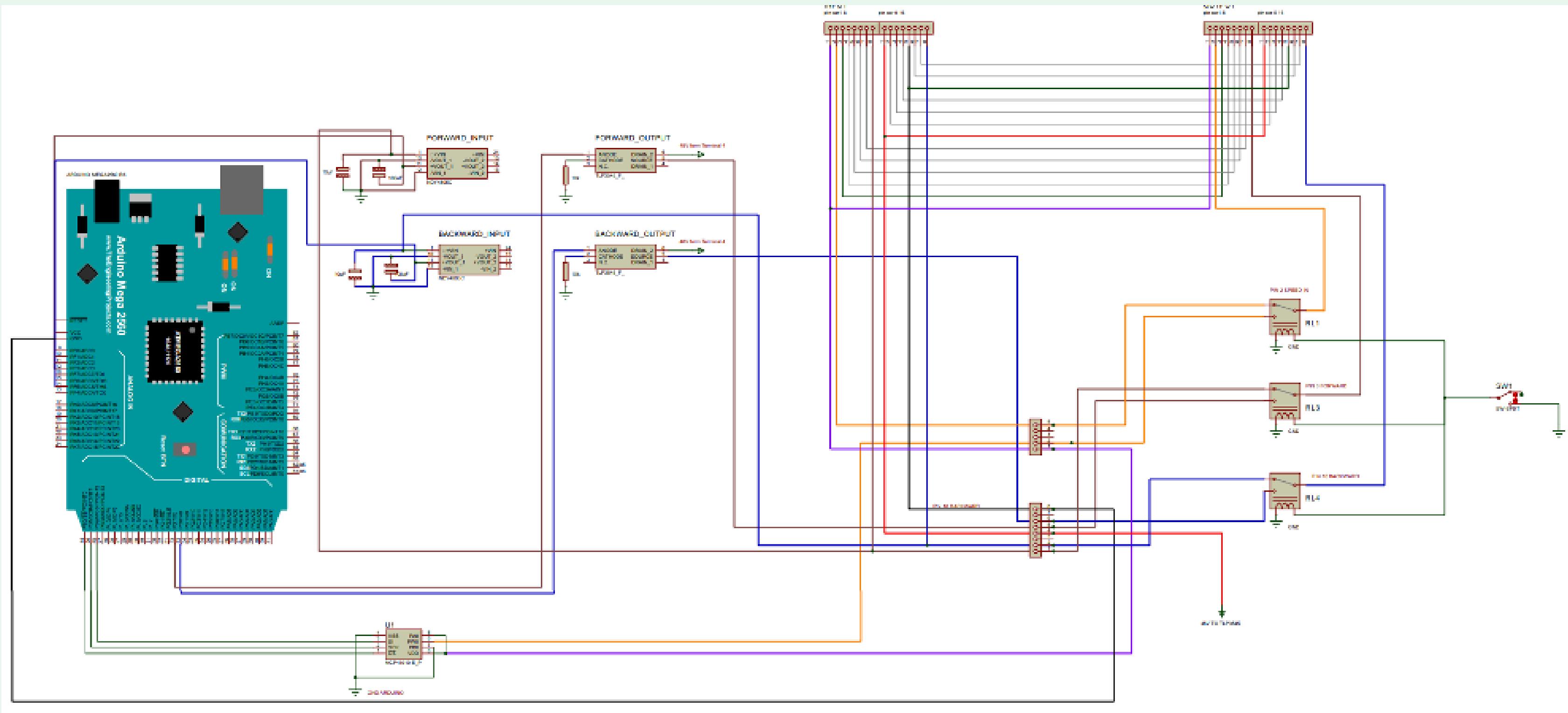
DC Motor Speed Control by PID Controller

## CONTROL VOLTAGE FOR CONTROL SPEED



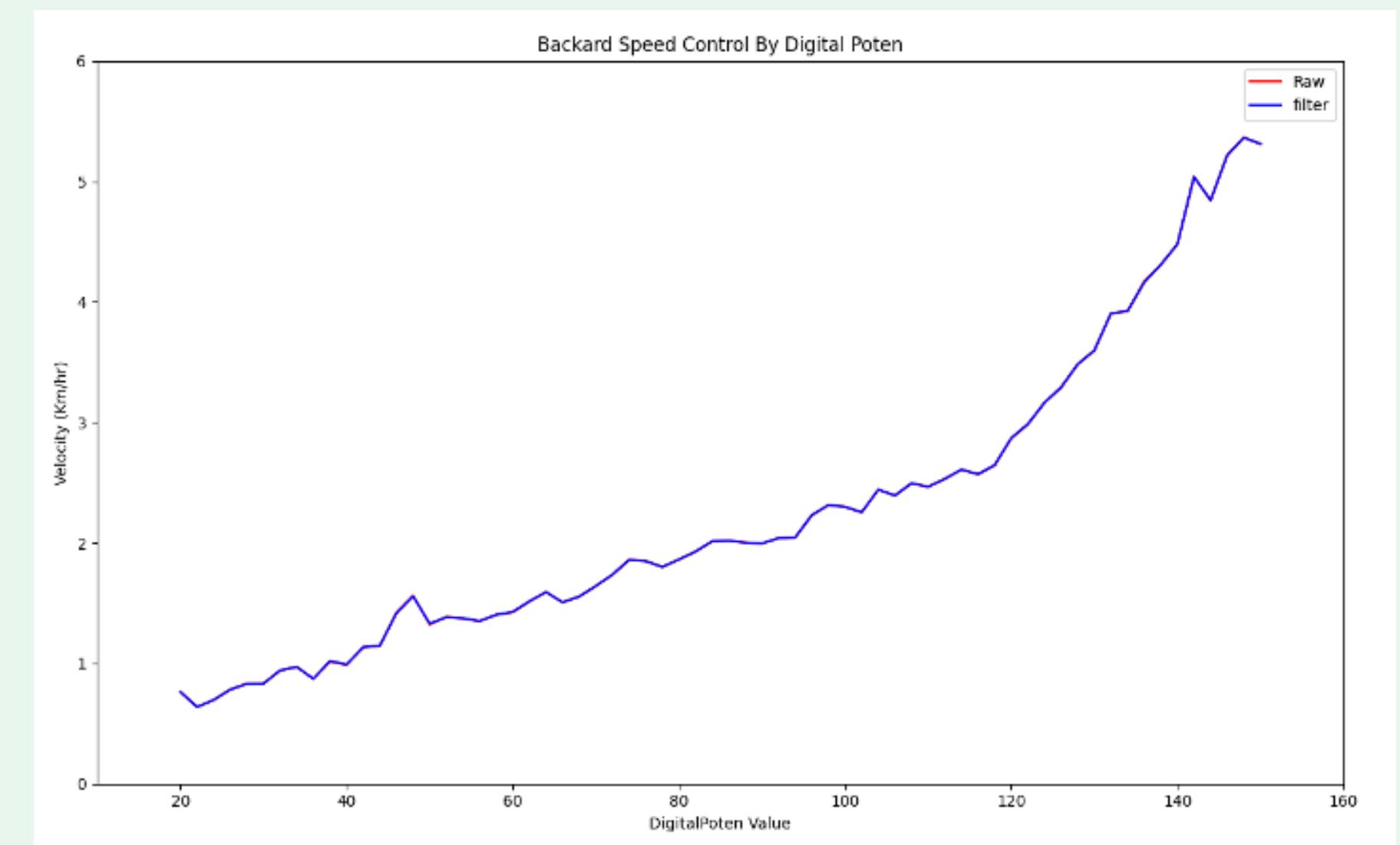
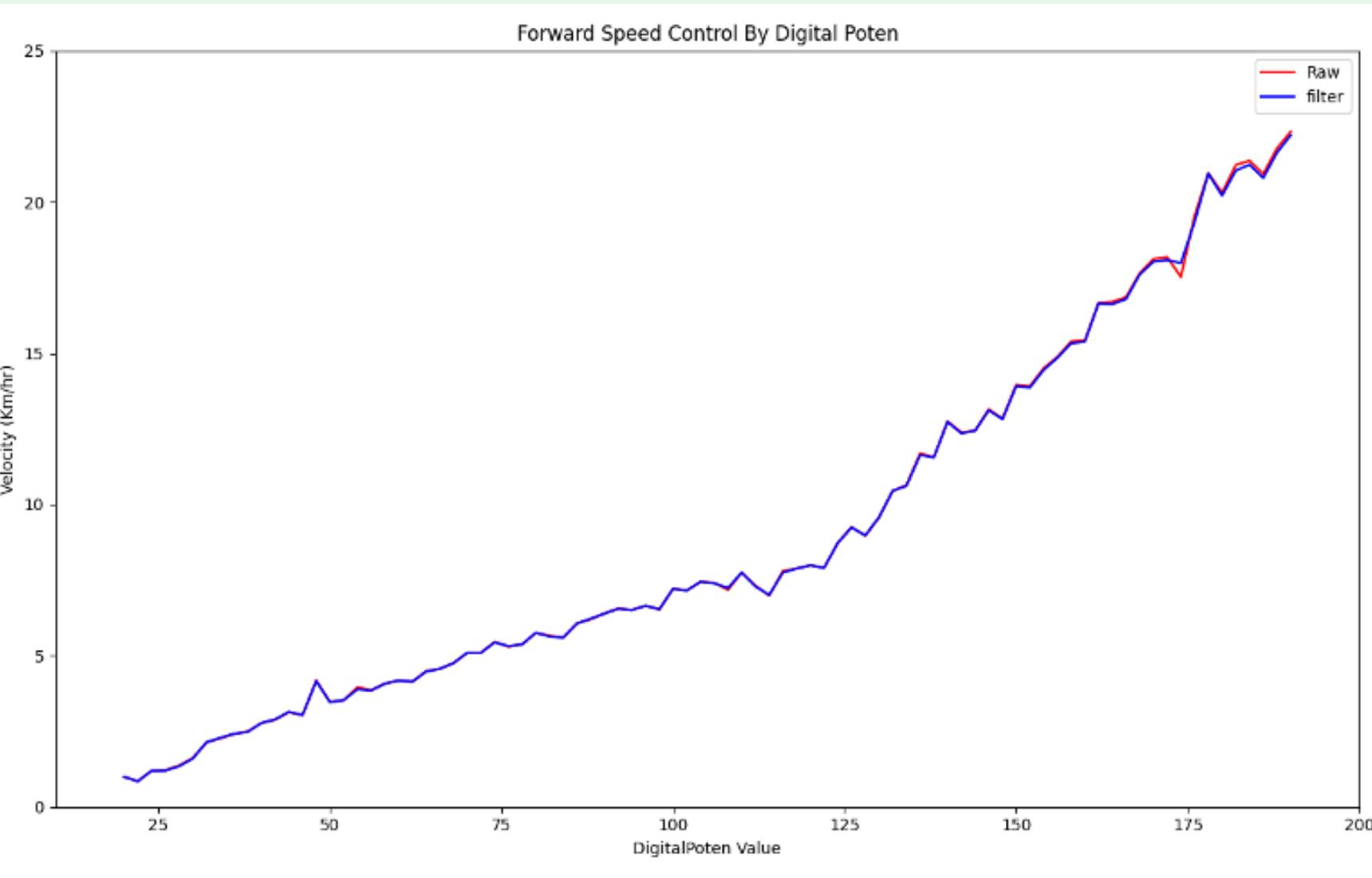
## FRAMEWORK





# SPEED CONTROL SYSTEM

## TEST SPEED UNDER HAVE LOAD



FORWARD

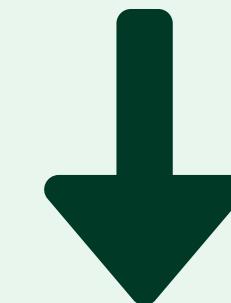
BACKWARD

## SPEED CONTROL SYSTEM

### EQUATION OF PID

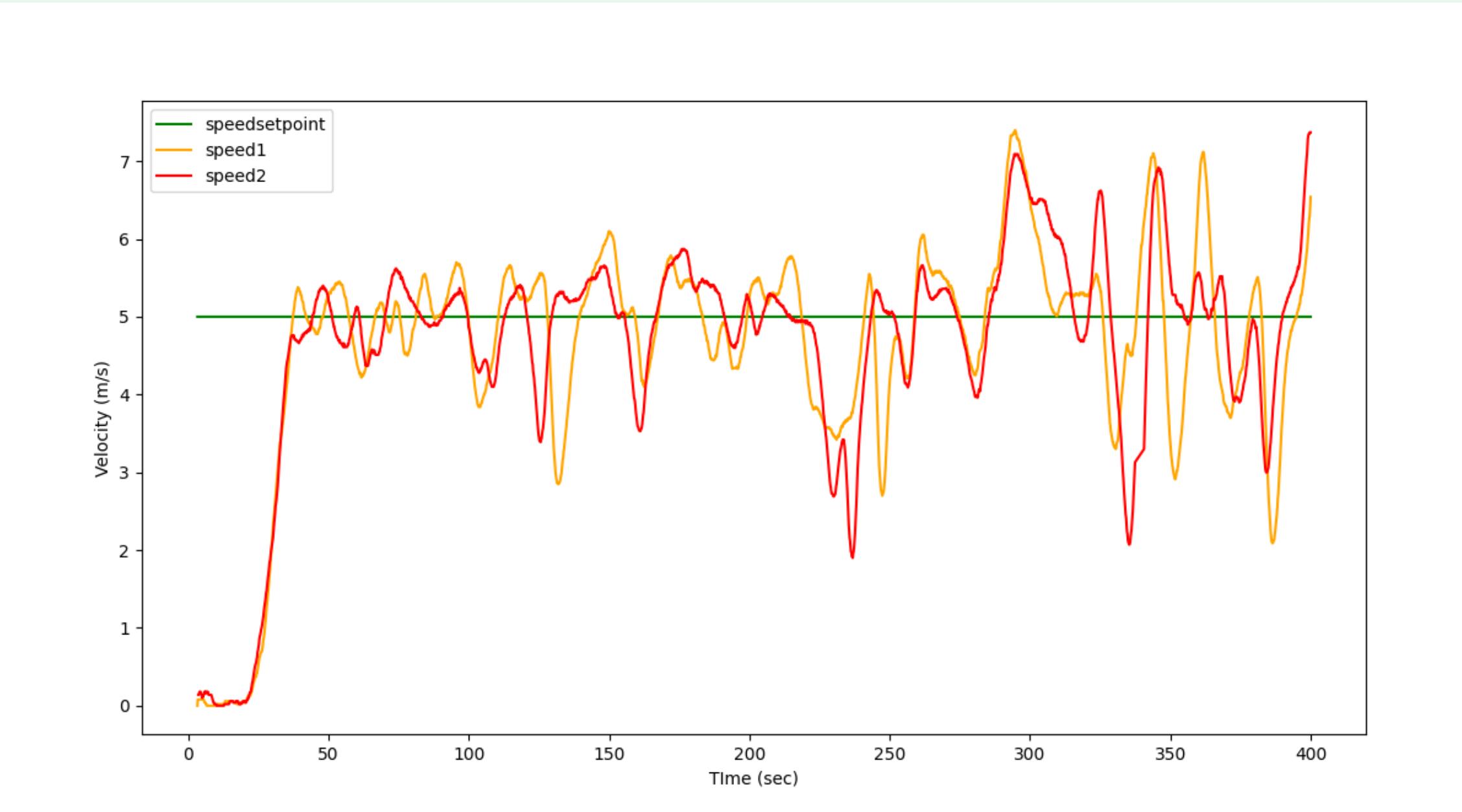
$$u(k) = k_p e(k) + k_i \sum_{i=1}^k e(i) + k_d \Delta e(k)$$

(error\*kp)+(ki\*sigmaerror)+(kd\*((error-preerror)/dt))



MAPPING DATA AND SENT TO CONTROL OUTPUT

# Tuning PID and Result



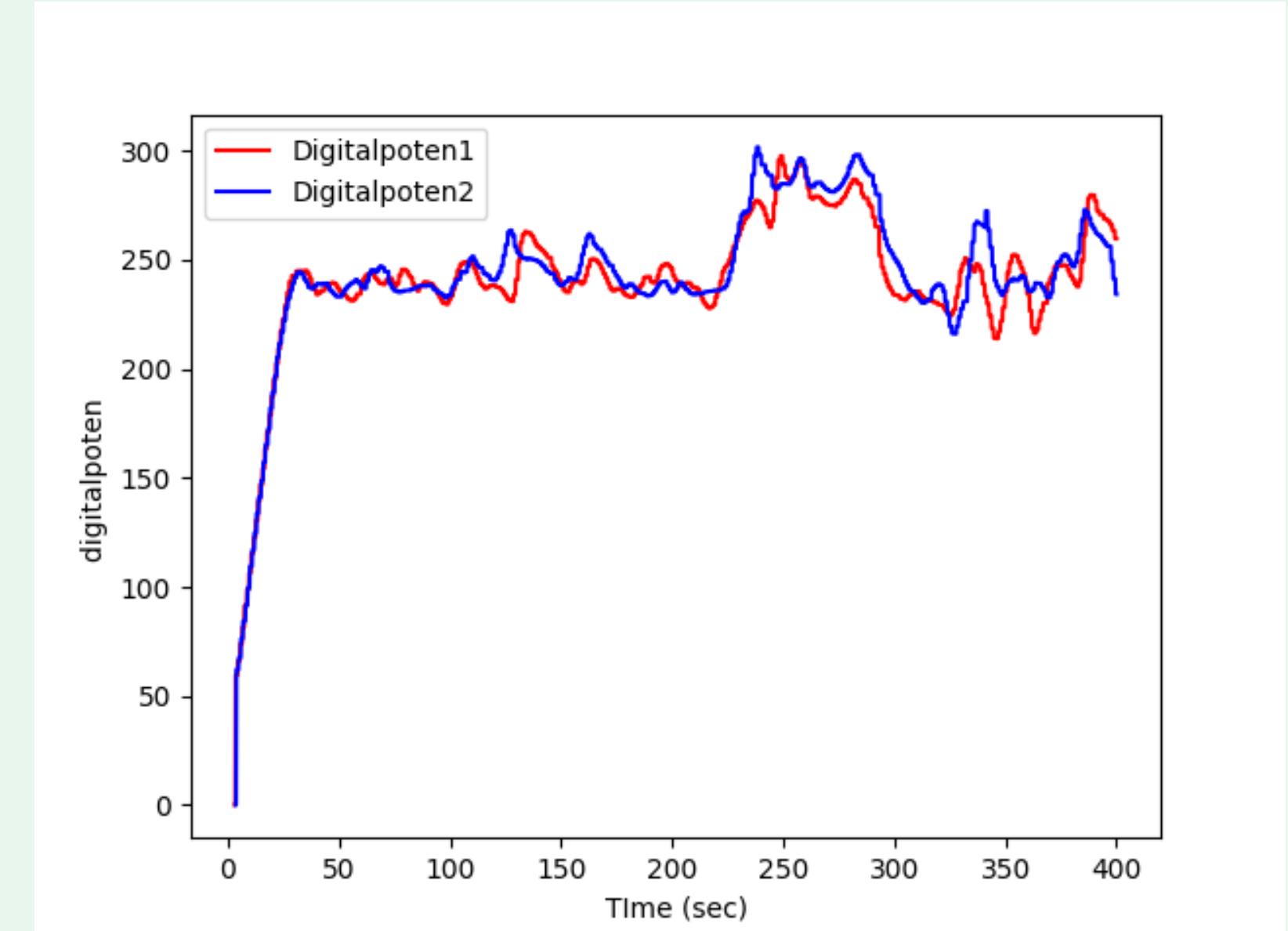
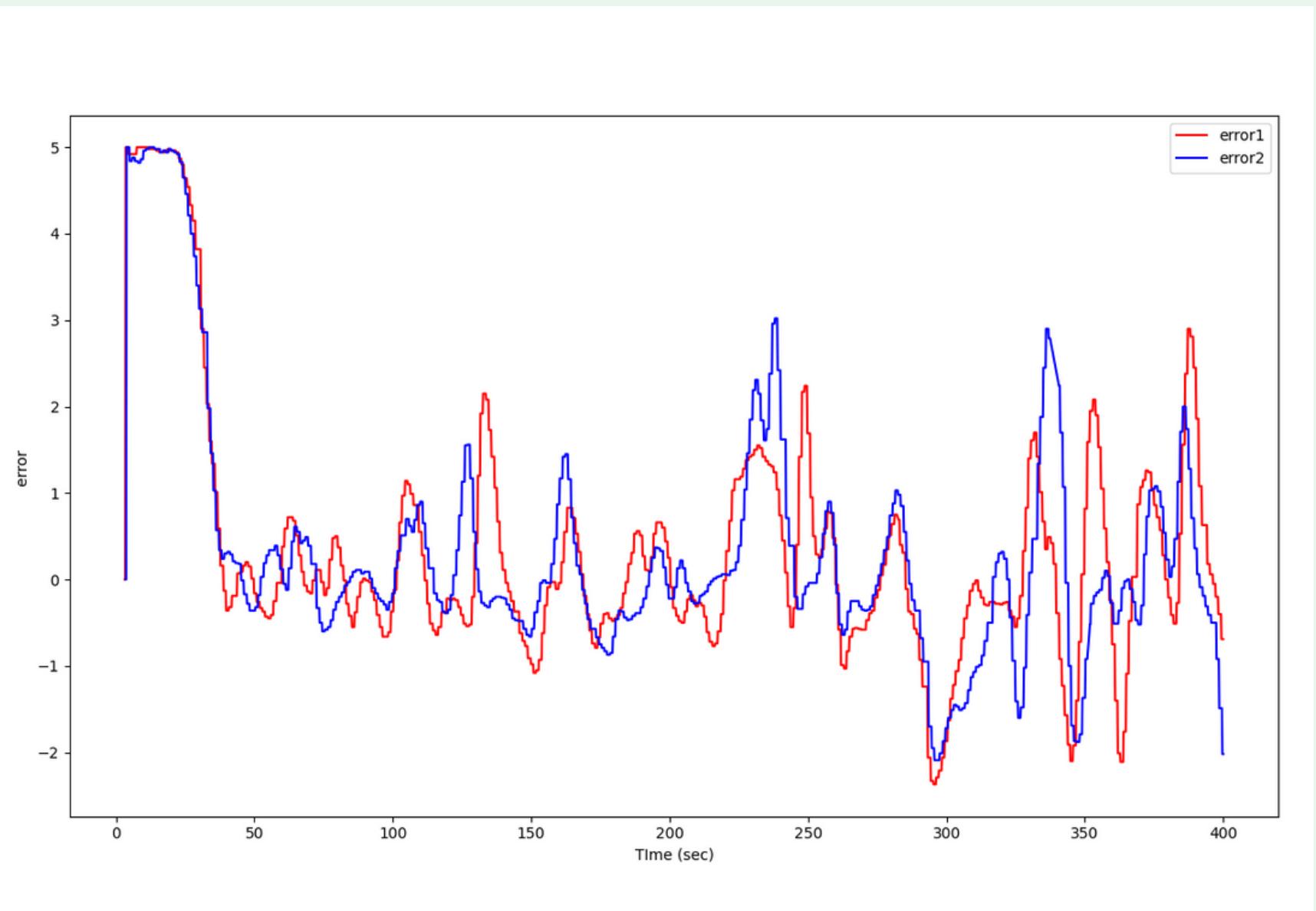
# Experiment & Result

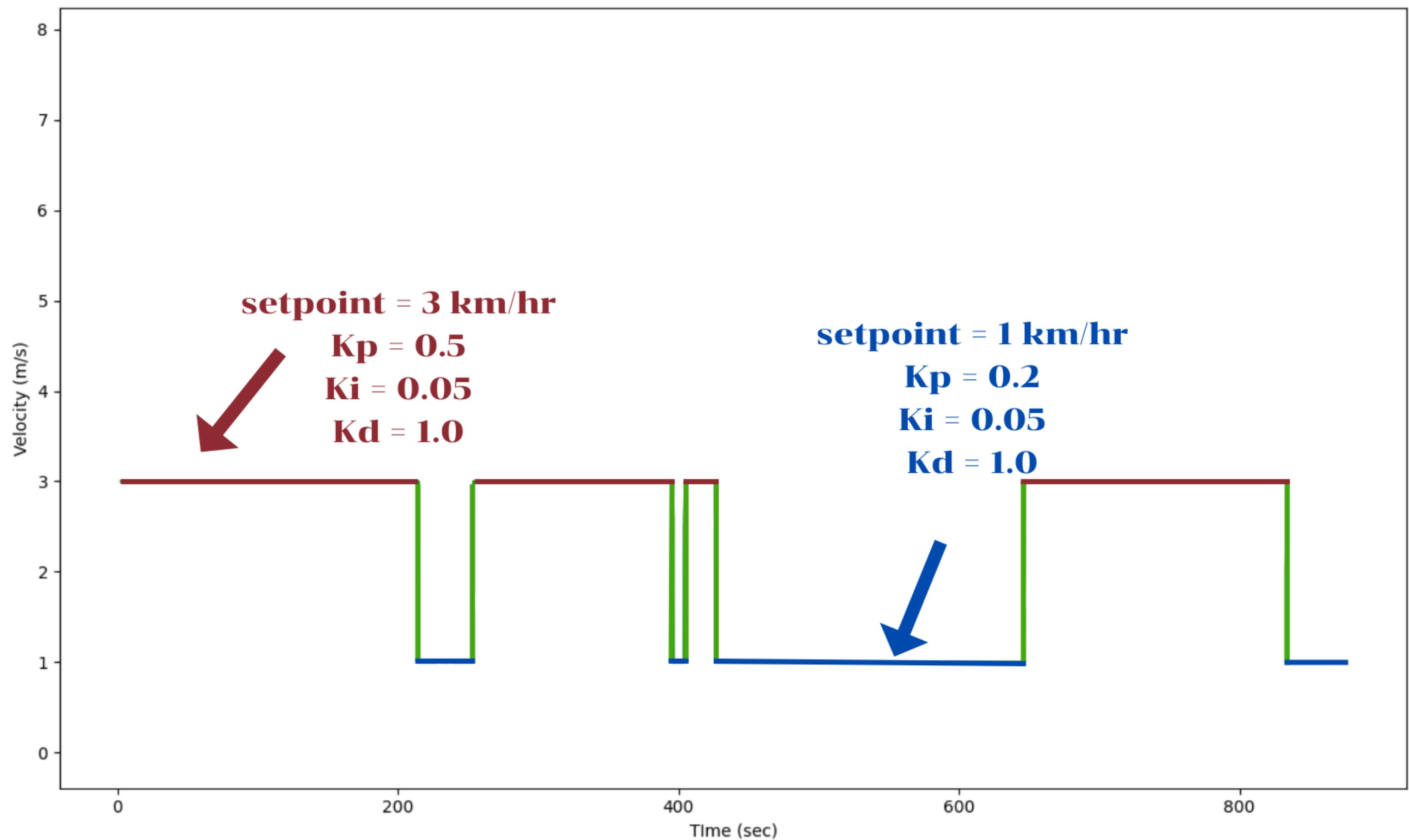
Velocity 5 Km/hr Around KMUTT Soccer field

$$K_p = 7.9$$

$$K_i = 1.5$$

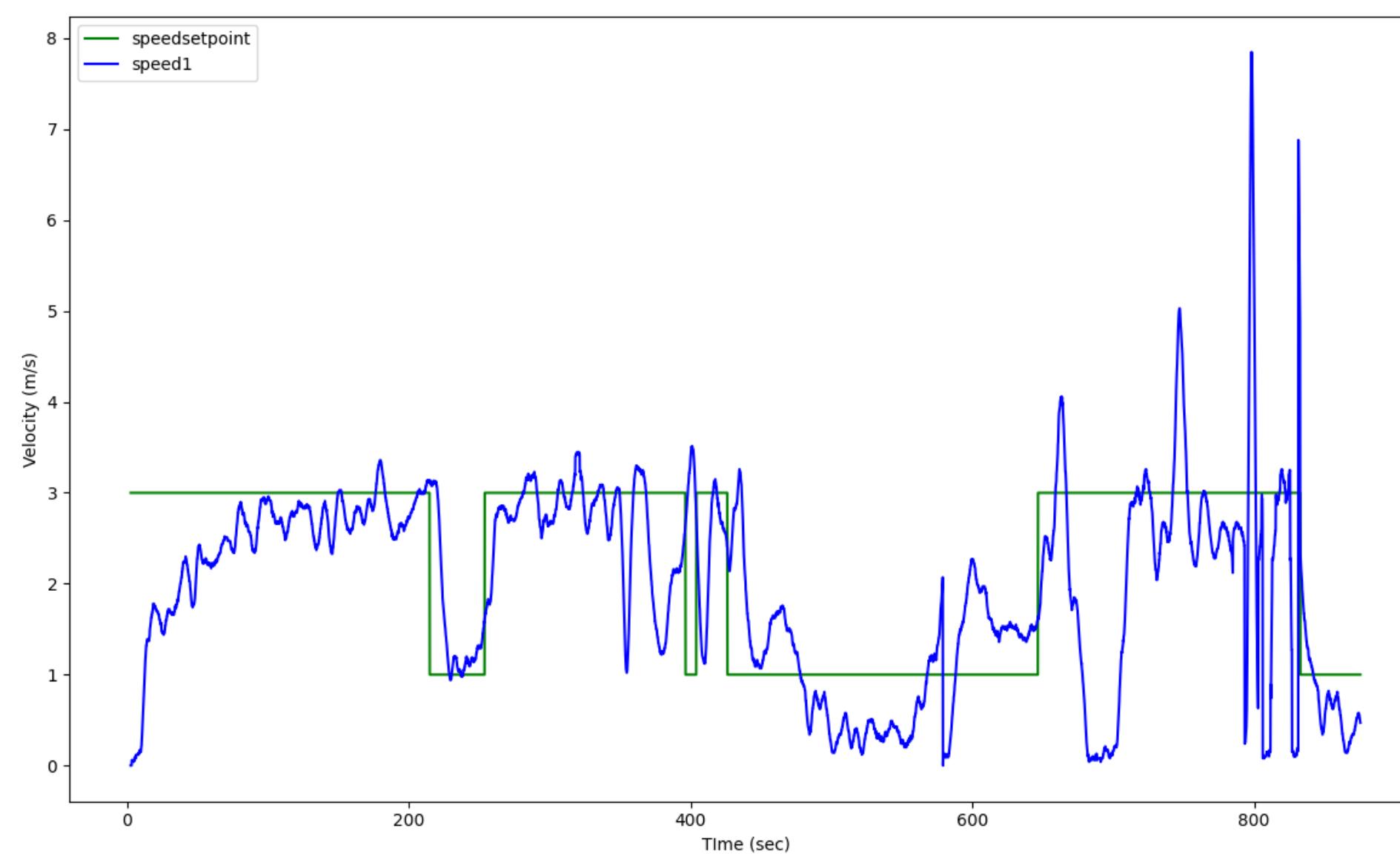
$$K_d = 3.8$$

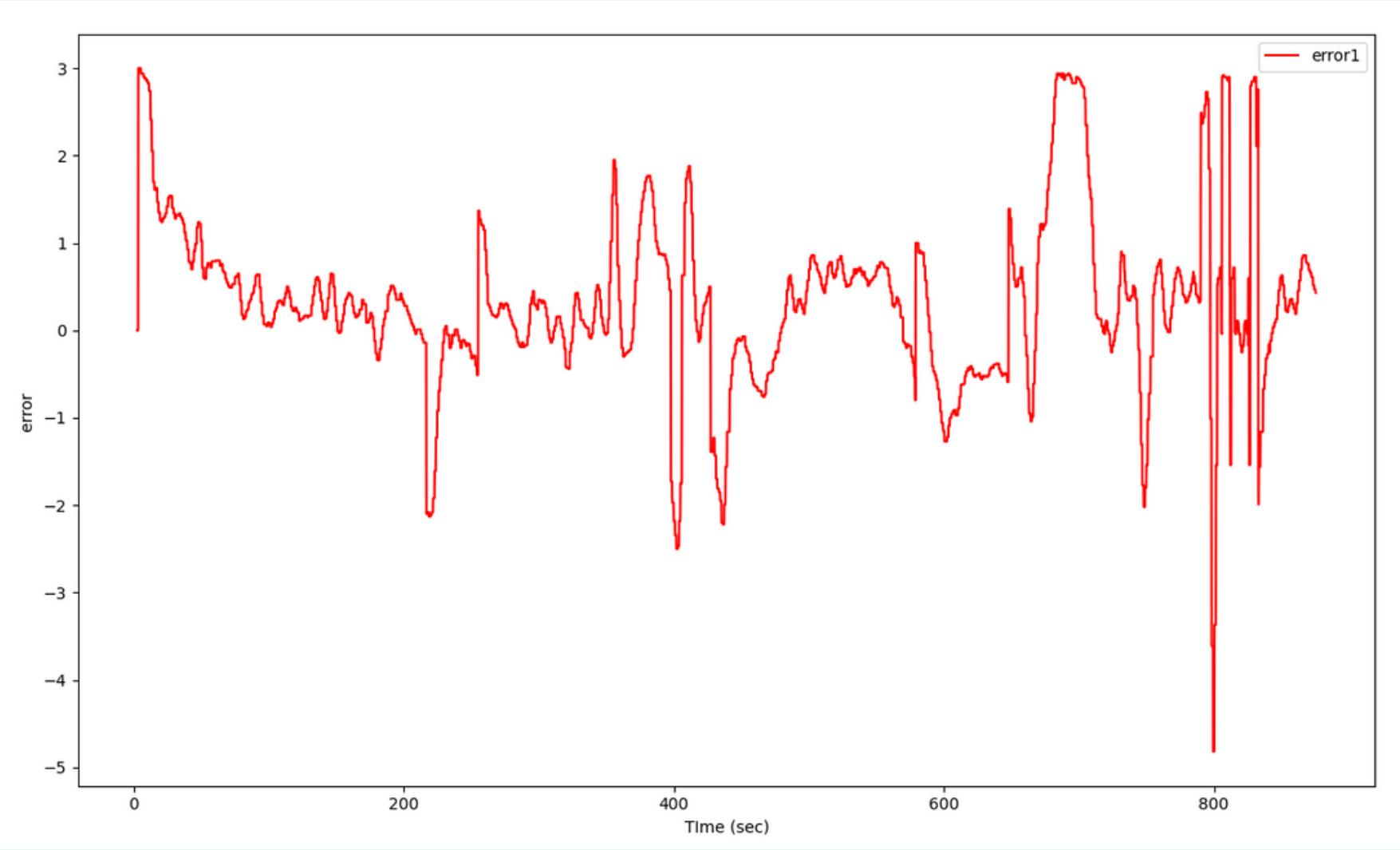




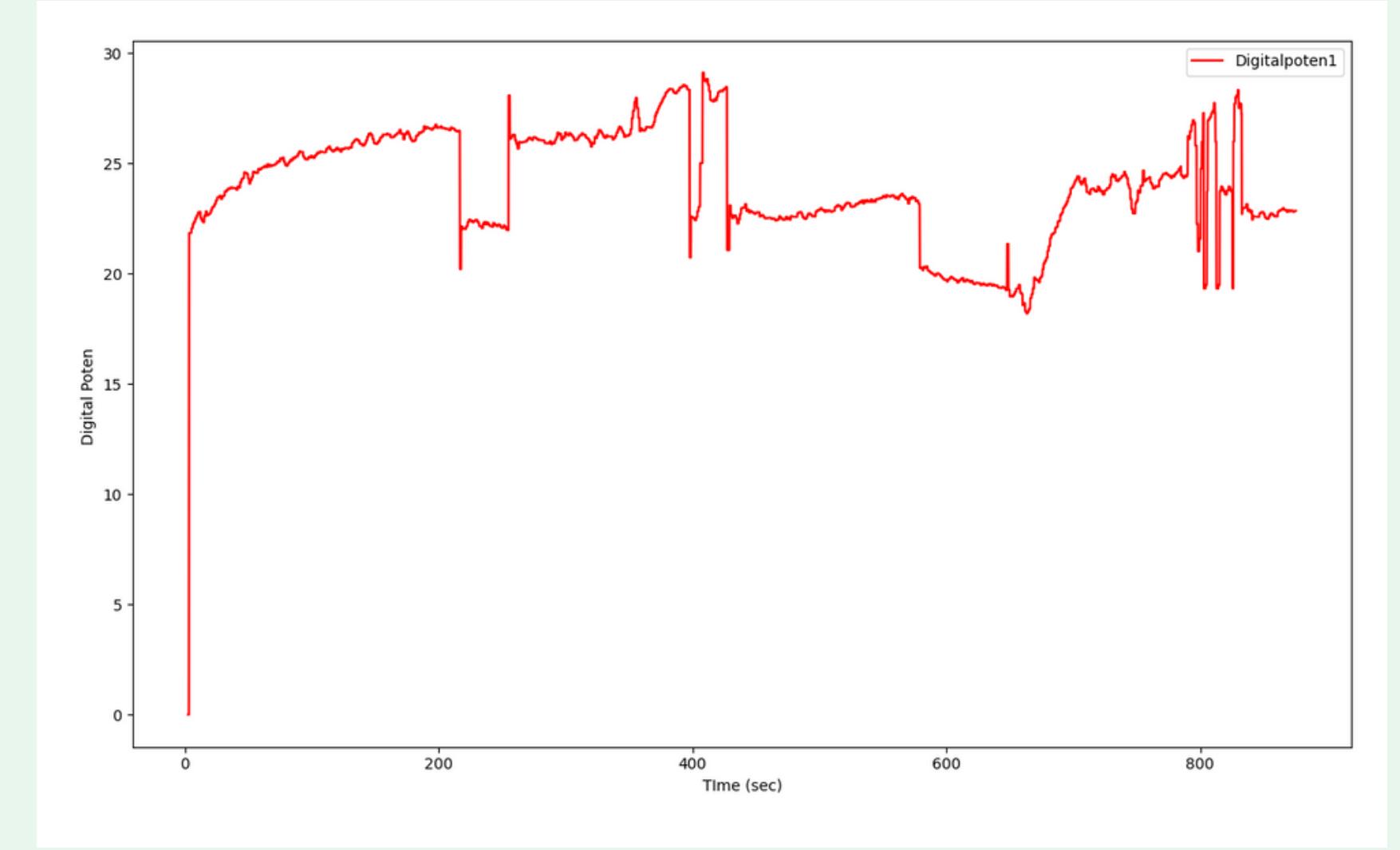
# Experiment & Result

Velocity Around KMUTT Soccer field  
3 Km/hr and 1 Km/hr





**ERROR**

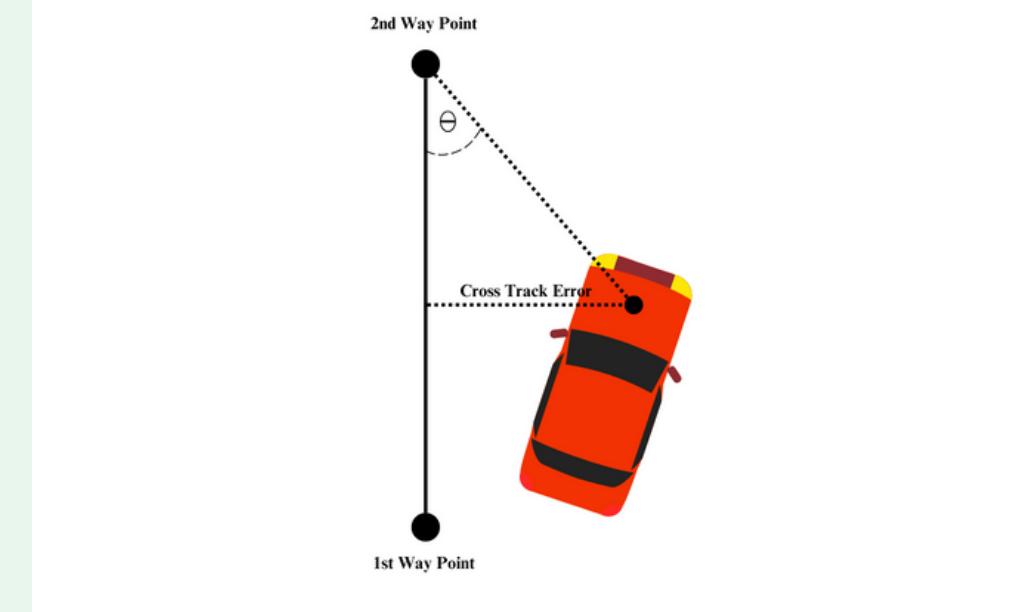


**DIGITAL POTEN**

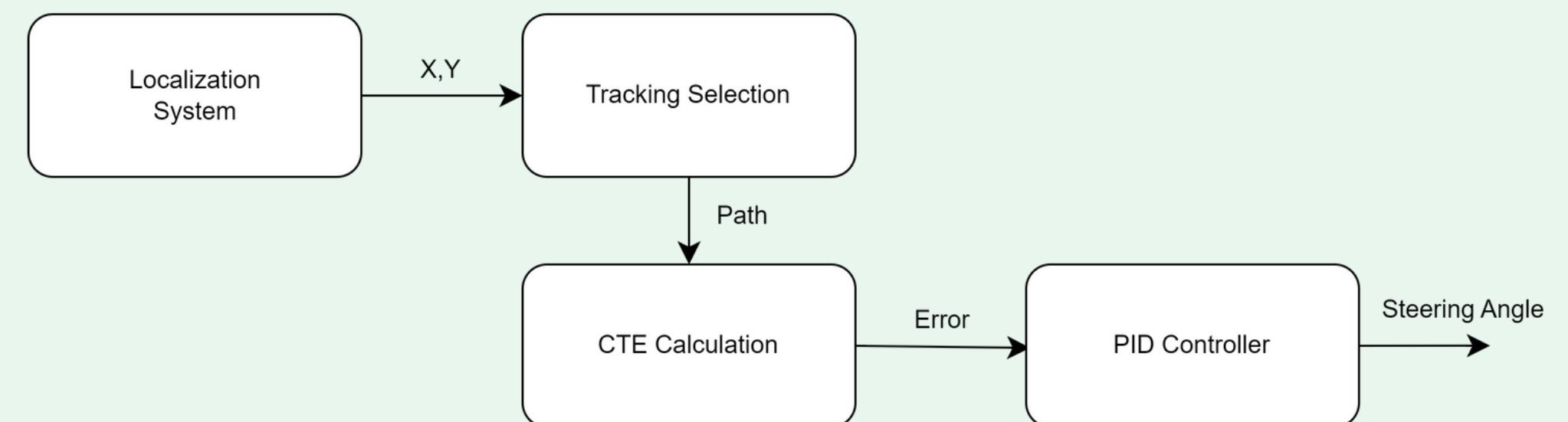
# Tracking & Lateral Control System

Cross Track Error & DC Motor Position Control by PID Controller

## STEERING MOTOR CALCULATION



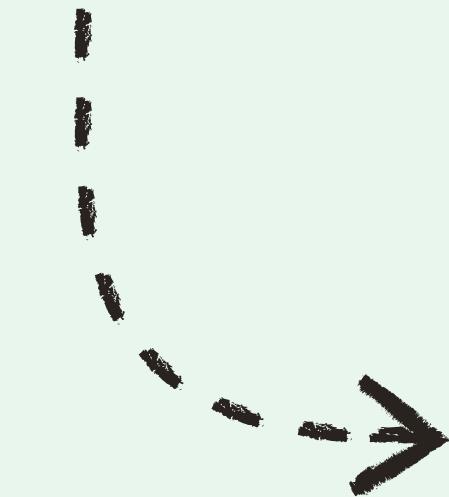
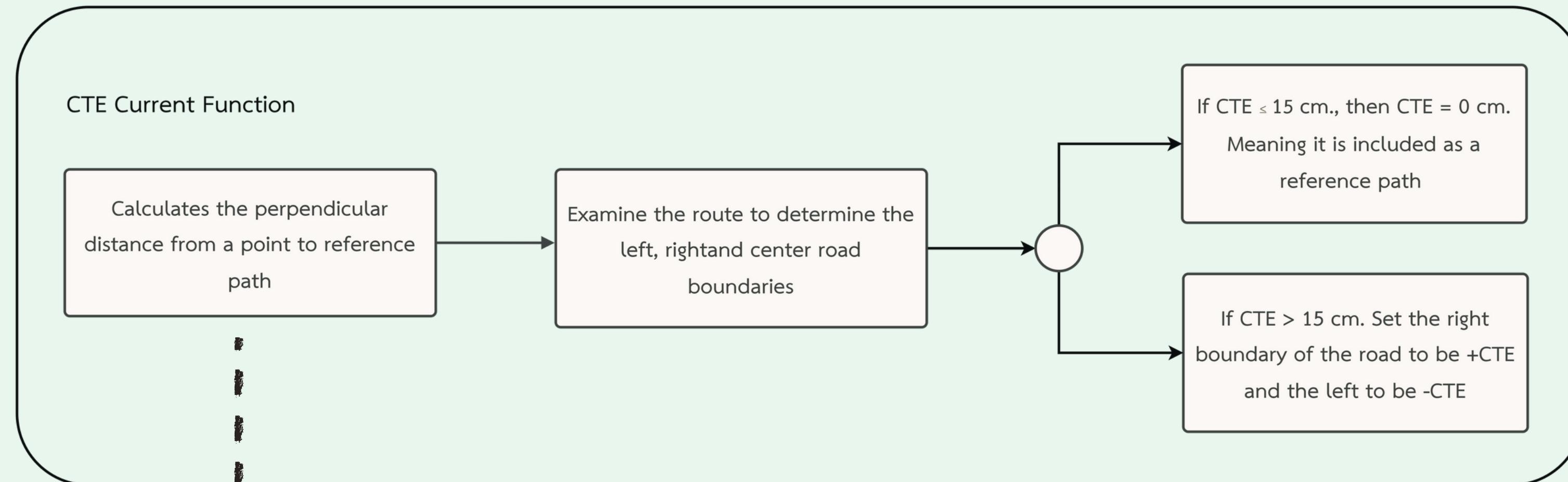
## FRAMEWORK



# Cross Track Error (CTE) Calculation

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To find the perpendicular distance from the vehicle to the reference path



$$\text{Cross Track Error (CTE)} = \frac{|Ax+By+C|}{\sqrt{A^2+B^2}}$$

# PID Controller

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For Steering Angle Control

### PID Angle Function

Calculate angle (Yaw Expect)  
via PID equation

$$u(t) = P + I + D = K_p e(t) + K_i \int_0^t e(t) dt + K_d \frac{d}{dt} e(t)$$

**u(t)** is the output of Steering Angle  
or Yaw Expect

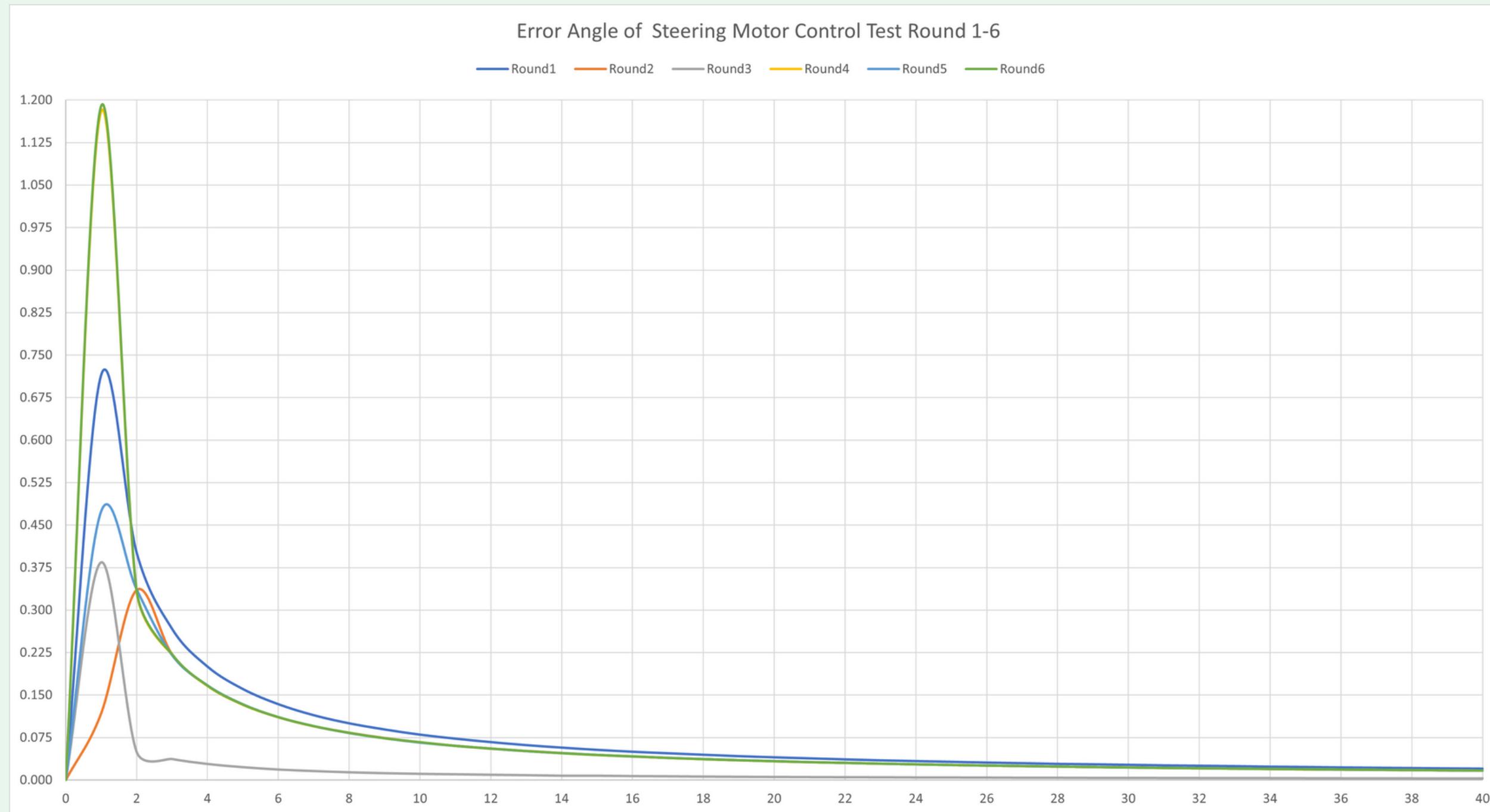
### Angle Control Motor Function

If CTE > 15 cm. (On the right side of  
the road) The motor control angle is  
positive or turn counter-clockwise

If CTE > -15 cm. (On the left side of  
the road) The motor control angle is  
negative or turn clockwise

If CTE = 0 Sets The motor control  
angle to 0

# Error Result of Send & Received data via CANbus Protocol

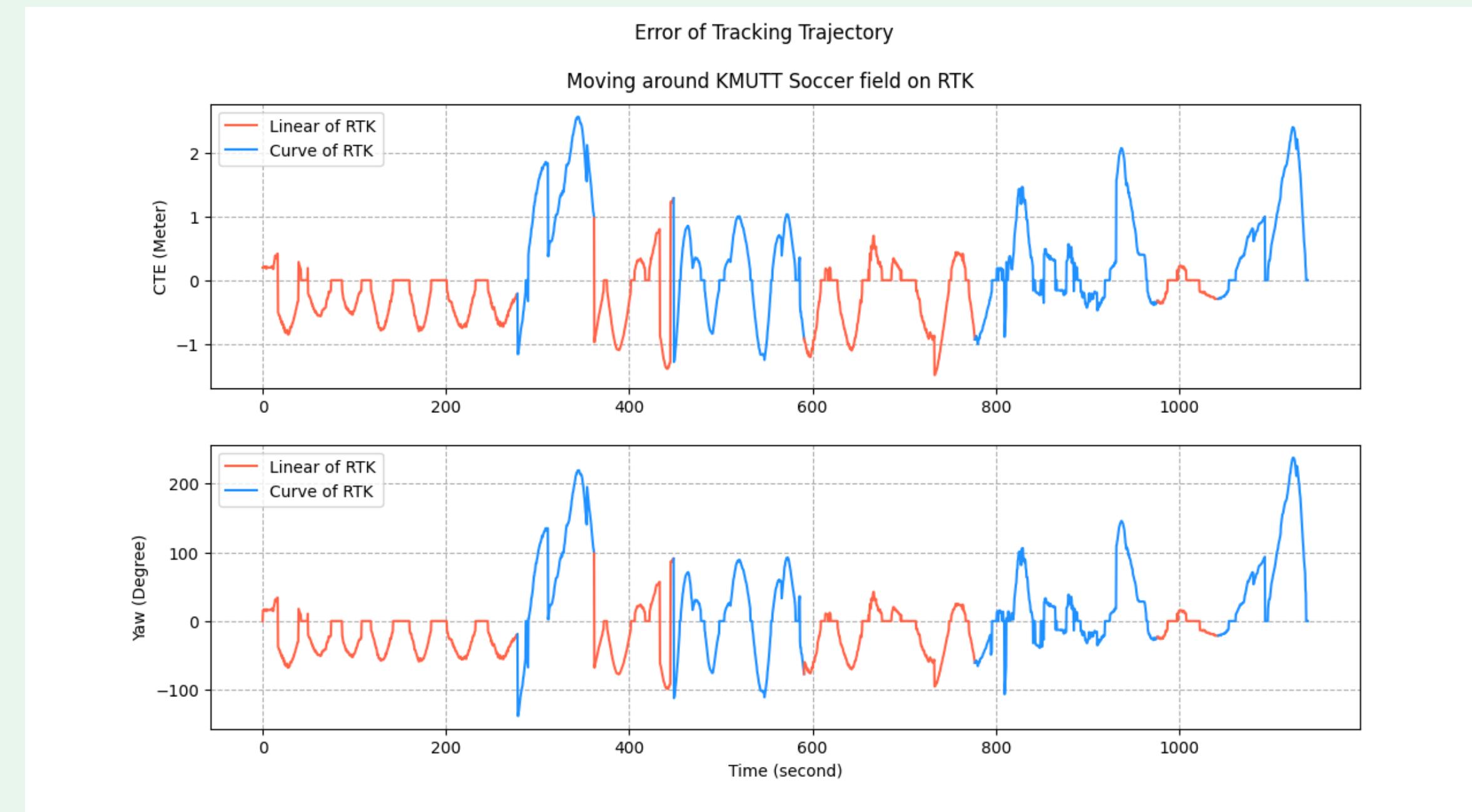


**Comparison of the Error from the motor control in send & Receive data of the motor for 6 cycles**

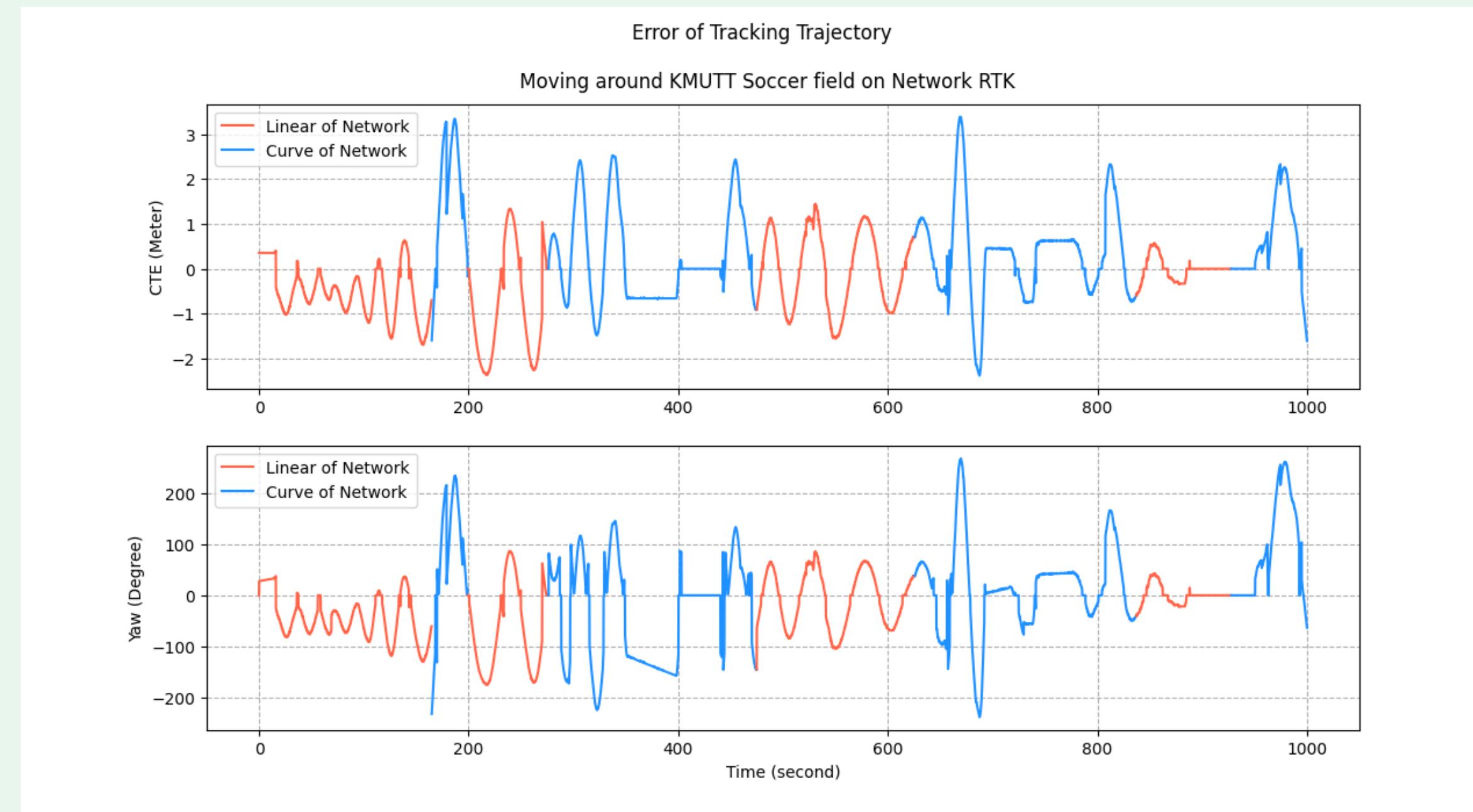
# Compare Error Result of Tracking Trajectory Around KMUTT Soccer field

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Between RTK and Network RTK Measurement

**ERROR OF TRACKING TRAJECTORY AROUND KMUTT SOCCER FIELD**

**The error from tracking the autonomous driving trajectory  
around the KMUTT Soccer field by RTK technique**

**ERROR OF TRACKING TRAJECTORY AROUND KMUTT SOCCER FIELD**

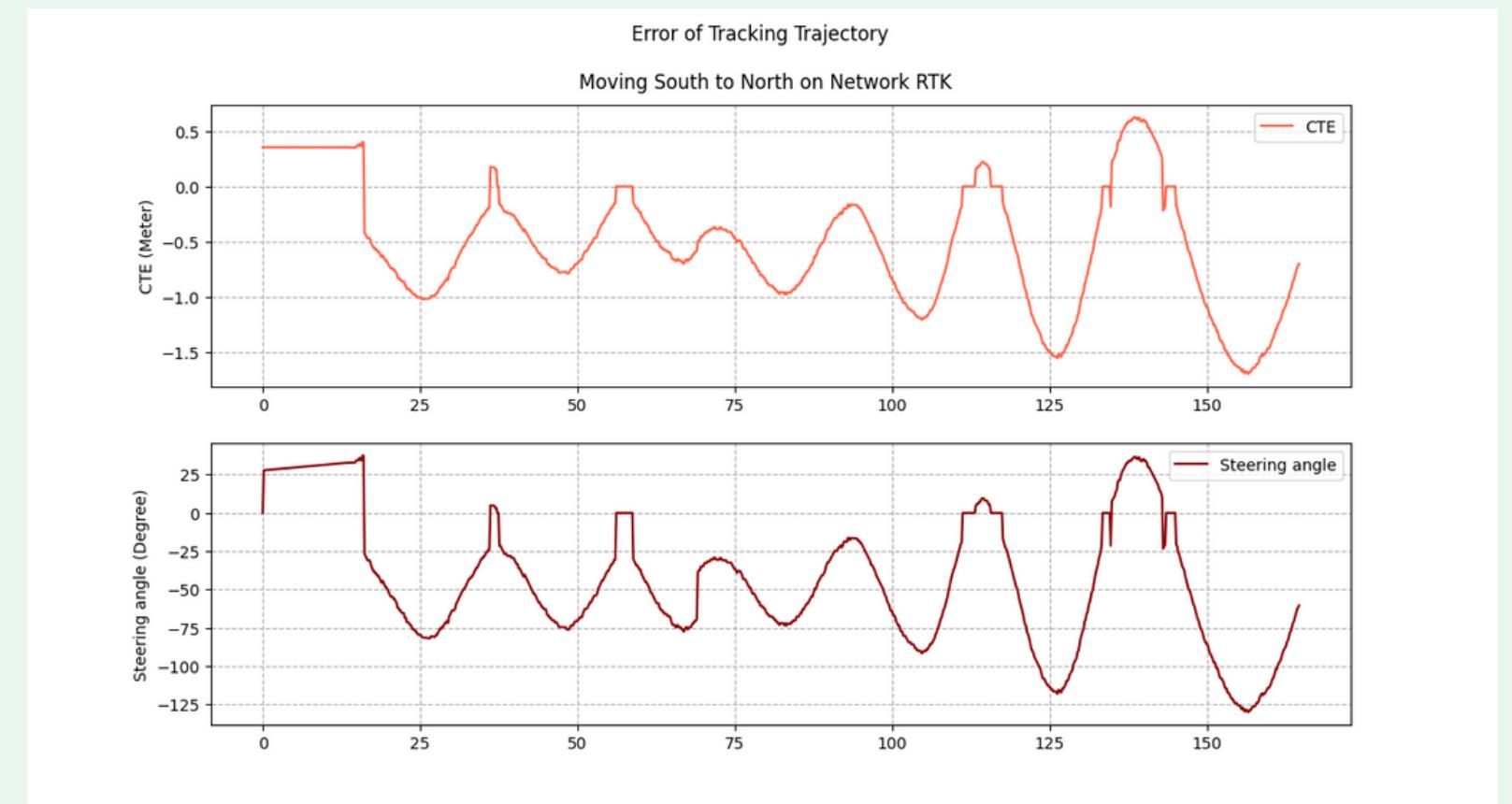
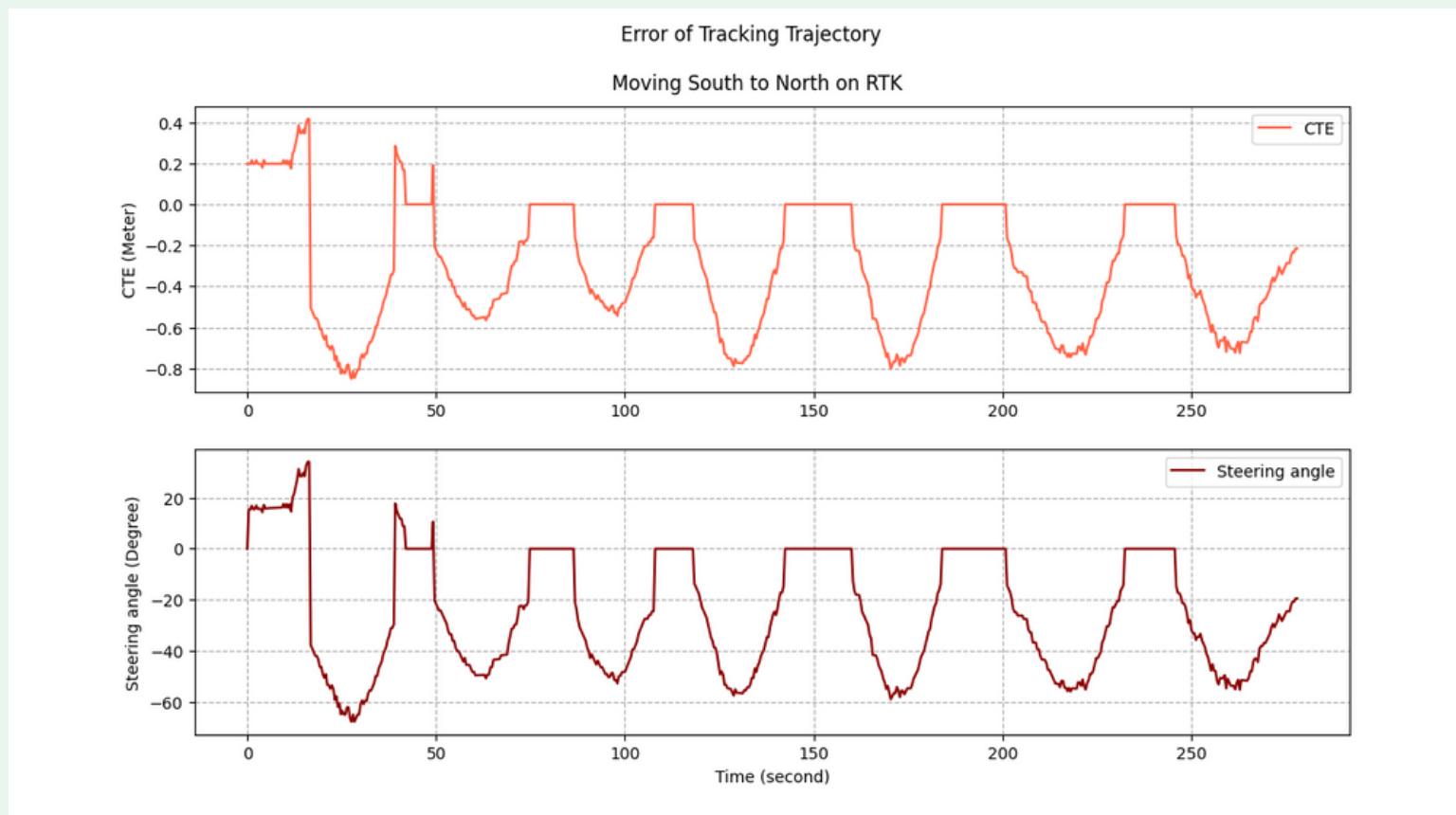
**The error from tracking the autonomous driving trajectory around the KMUTT Soccer field by Network RTK technique**

# Compare Error Result of Tracking Trajectory on Straight Path

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Between RTK and Network RTK Measurement Around KMUTT Soccer field

## ERROR OF TRACKING TRAJECTORY MOVING ON LINEAR SOUTH TO NORTH



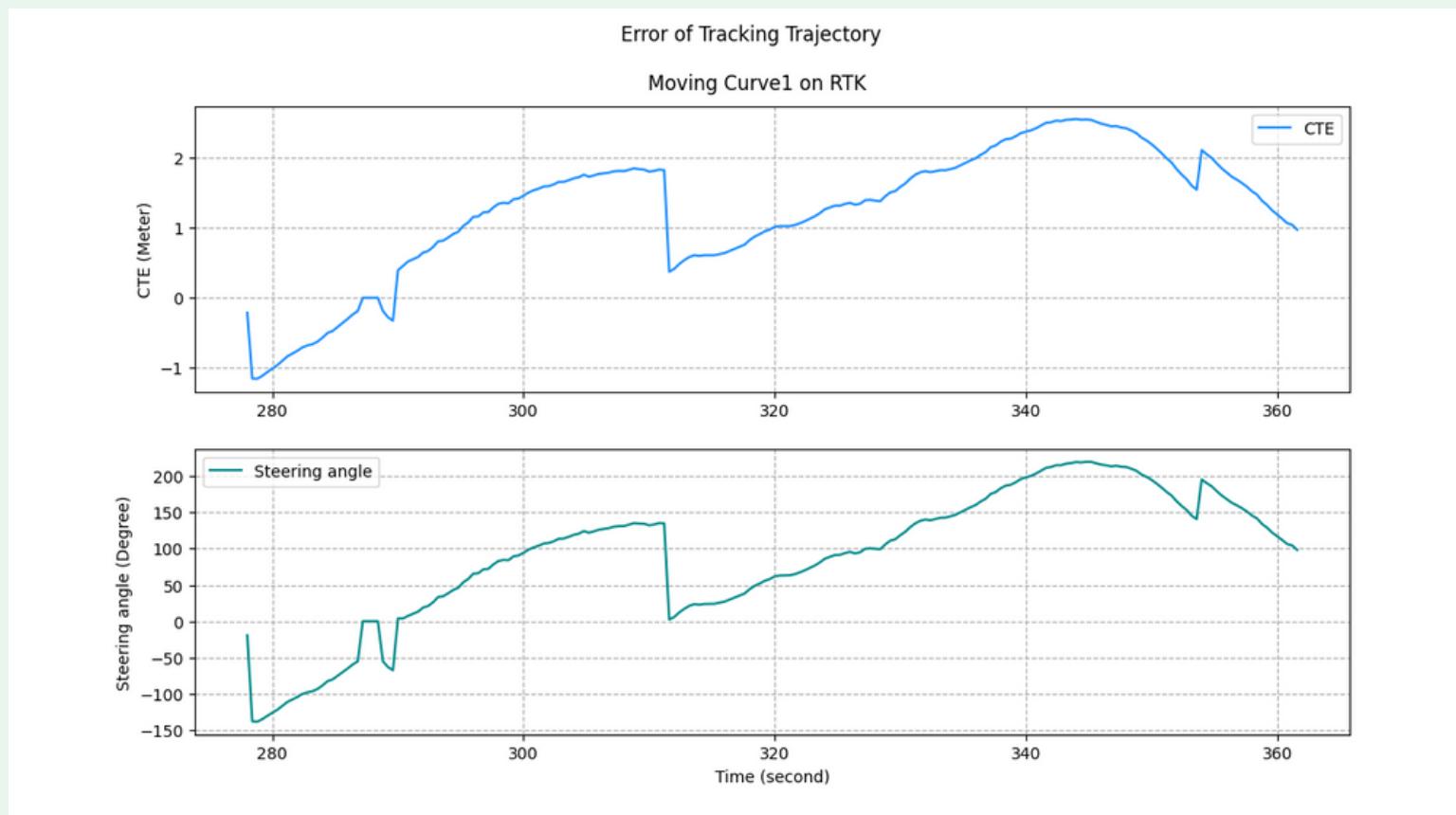
An example of Network RTK and RTK measurement techniques to show the Error of autonomous golf cart driving around the soccer field on a straighted path

# Compare Error Result of Tracking Trajectory on Curve Path

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Between RTK and Network RTK Measurement Around KMUTT Soccer field

## ERROR OF TRACKING TRAJECTORY MOVING ON CURVE1 (S-N & E-W)



An example of Network RTK and RTK measurement techniques to show the Error of autonomous golf cart driving around the soccer field on a Curved path



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# Thank you

# Summary Of Different and Improvement

## Last year

### Tracking and Navigation

- 2 Antenna/Receiver Board and 2 RF Data link to sent calibration value from base to rover

### Control System

#### Speed :

- Arduino Mega Board to control speed at 5km/hr

#### Steering :

- RS-232 Communication
- PID Controller and Bicycle Model

### Robot Operating System

- for coding steering control with joystick

## Current year

### Tracking and Navigation

- 1 Antenna/Receiver at rover and get calibration value from Internet

### Control System

#### Speed :

- Change The Speed Follow Track path.
- New Hardware Design

#### Steering :

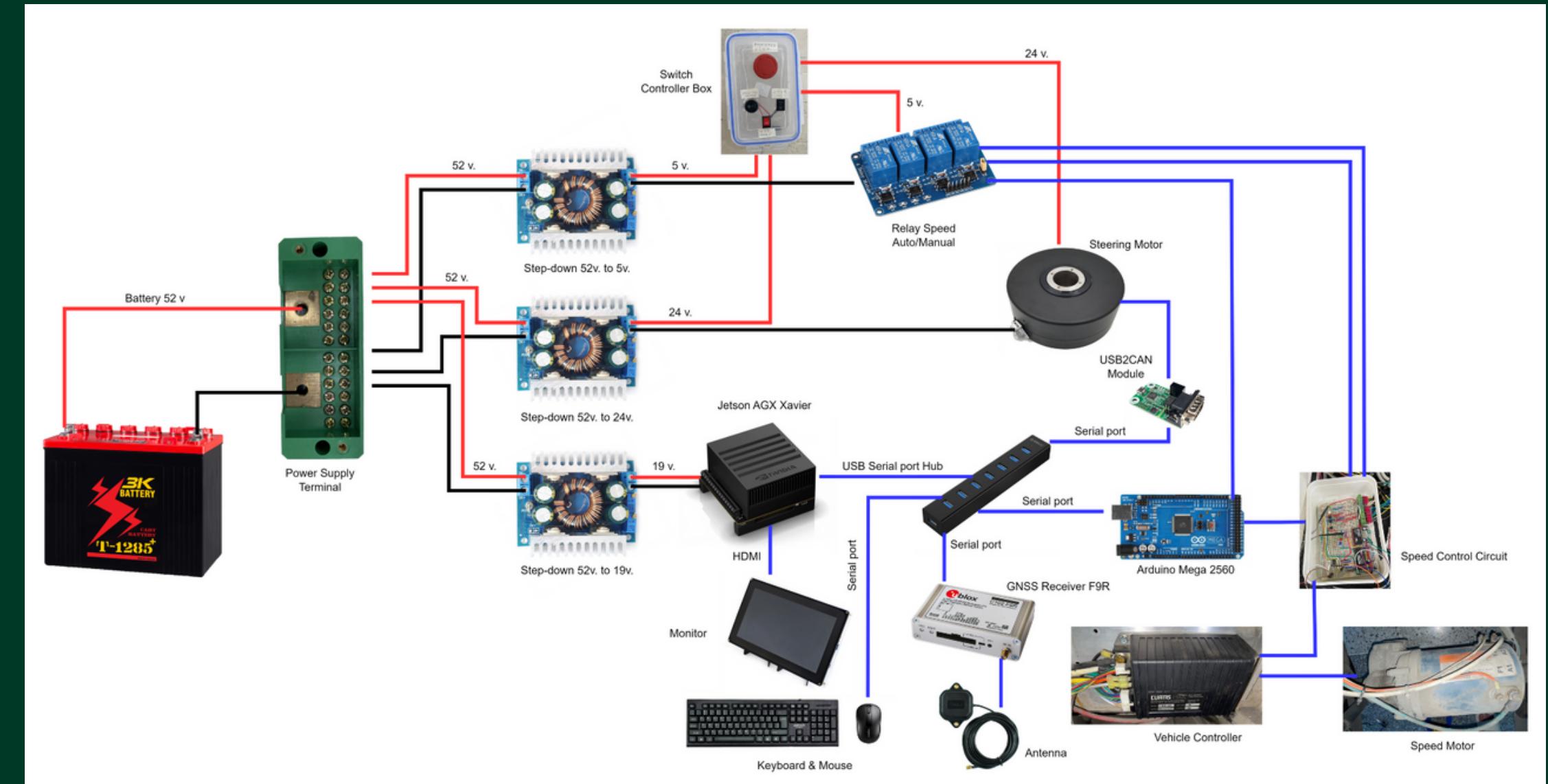
- Can bus Communication.
- Design new Steering Connector
- PID Controller tuning

### Robot Operating System

- Implement all systems to ROS Node

# Technical Information

## Hardware



# Technical Information

## Software

