

Topic:

TRACTION CONTROL
ON EBIKE

Presenter : Anh Tuan Mai

Outline

- TCS Overview
- System overview
- Control Algorithm Simulation
- Experimental Setup
- Results & Conclusion

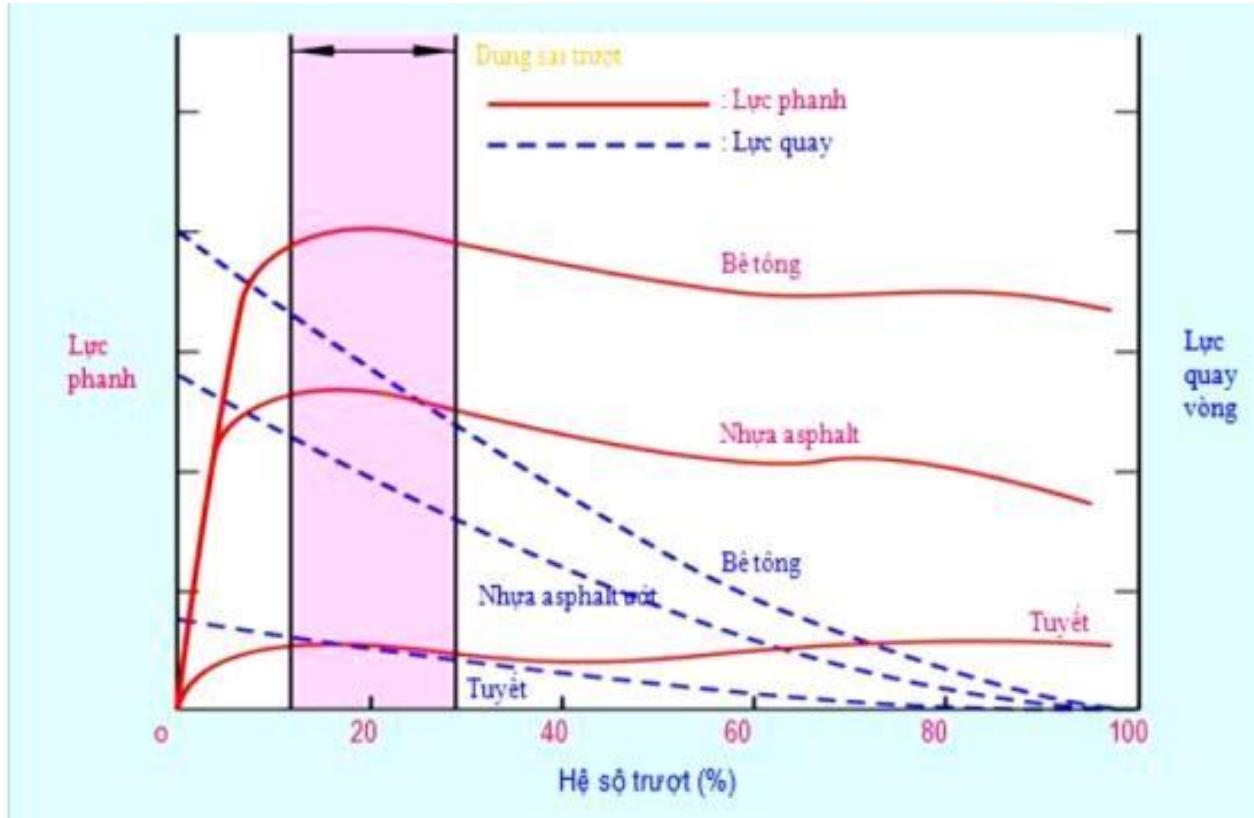
TCS OVERVIEW

TCS Overview

- A **traction control system (TCS)**, is typically (but not necessarily) a secondary function of the electronic stability control (ESC) on production motor vehicles, designed to prevent loss of traction (i.e., wheelspin) of the driven road wheels.
- TCS is activated when throttle input and engine power and torque transfer are mismatched to the road surface conditions
- The intervention consists of one or more of the following:
 - Closing the throttle, if the vehicle is fitted with drive by wire throttle.
 - Brake force applied to one or more wheels.

TCS Overview

- Slip Ratio $\delta_k = \frac{v_0 - v}{v_0} = 1 - \frac{V}{v_0} = -\frac{v_\delta}{v_0} = 1 - \frac{r_l}{r_b}$



Relationship between brake force and slip ratio

v_δ – slipping velocity (m/s)

v – actual velocity (m/s)

v_0 – theory velocity (m/s)

r_b – calculated radius (m)

r_l – rotation radius (m)



TCS Overview

- Purpose of this project:

Design controller for TCS on Simulation Environment

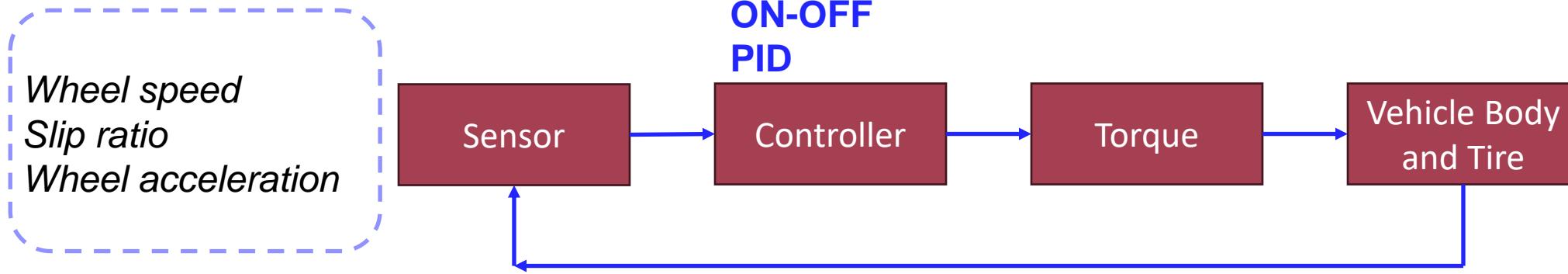
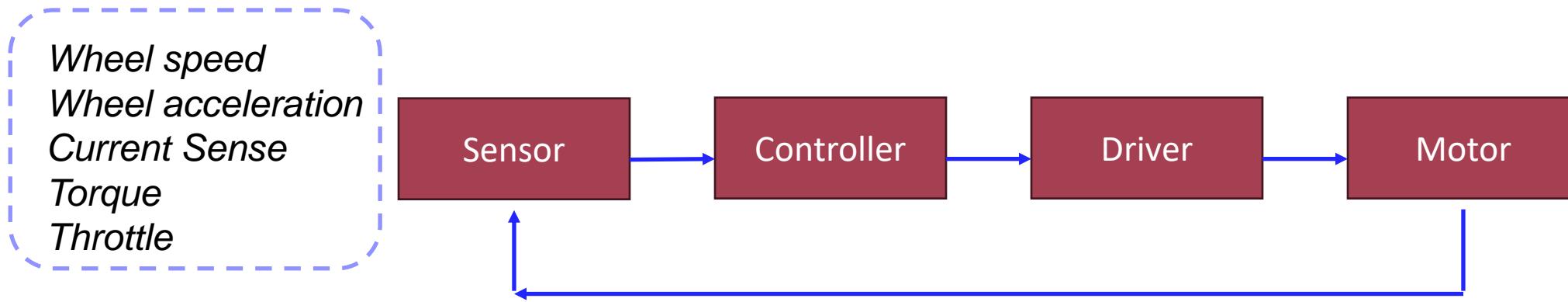
Have a basic grasp of electrical circuit on E-Bike

Design mechanical balance bar for testing experience

Do experience (collect data and tuning)

SYSTEM OVERVIEW

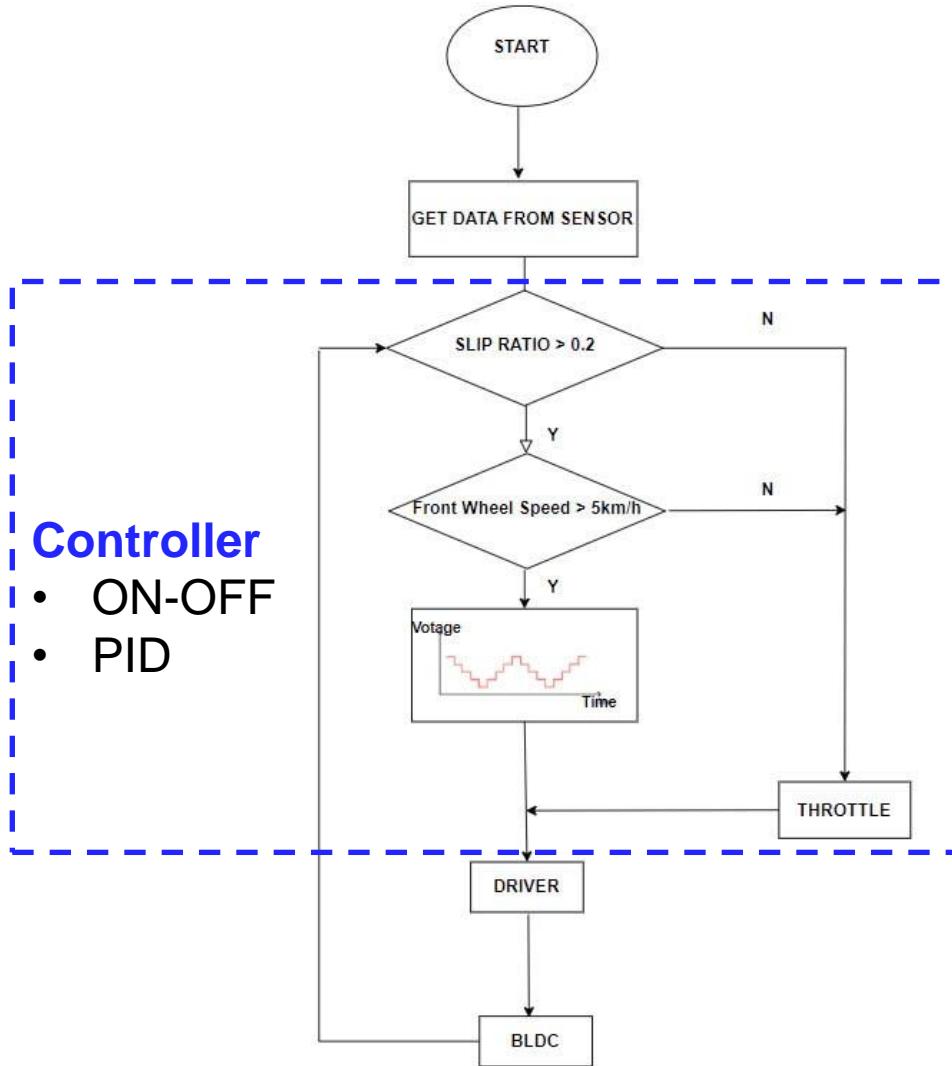
System Overview



System overview

Control method:

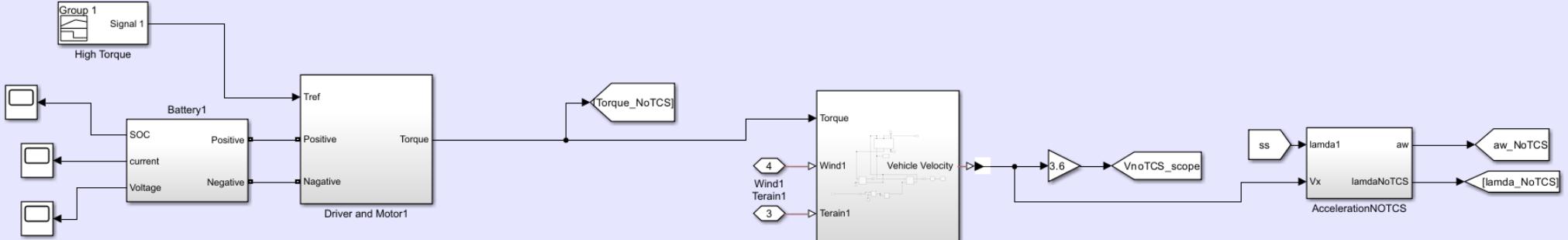
- Slip Ratio
- Wheel Acceleration



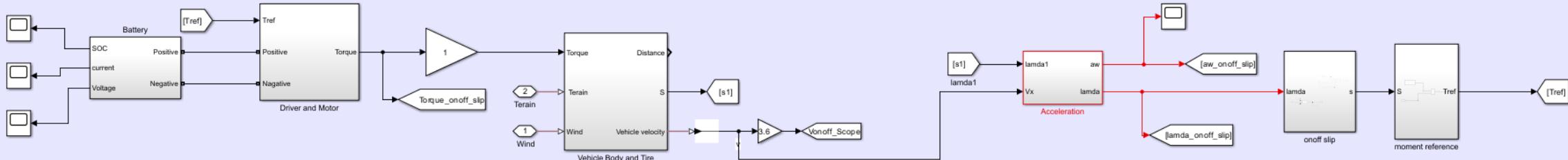
CONTROL ALGORITHM SIMULATION

Control algorithm simulation

NoTCS

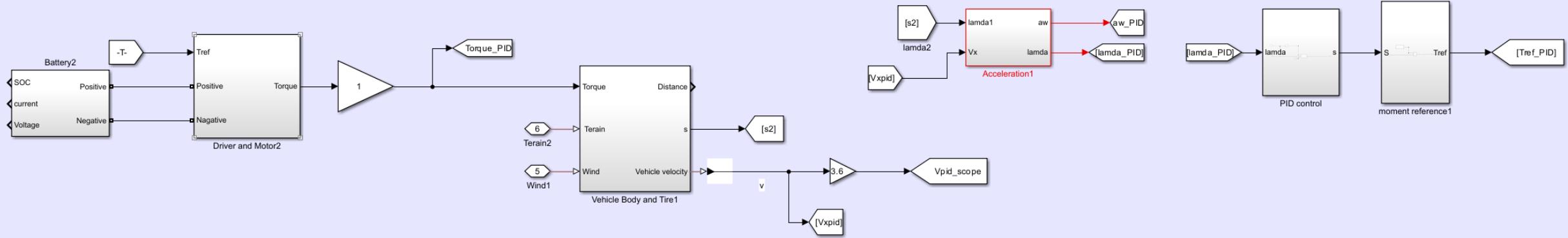


Slip_Control_ONOFF

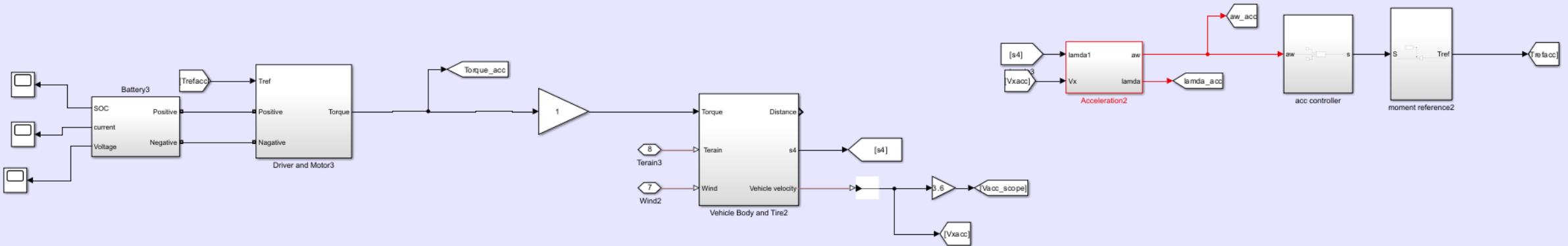


Control algorithm simulation

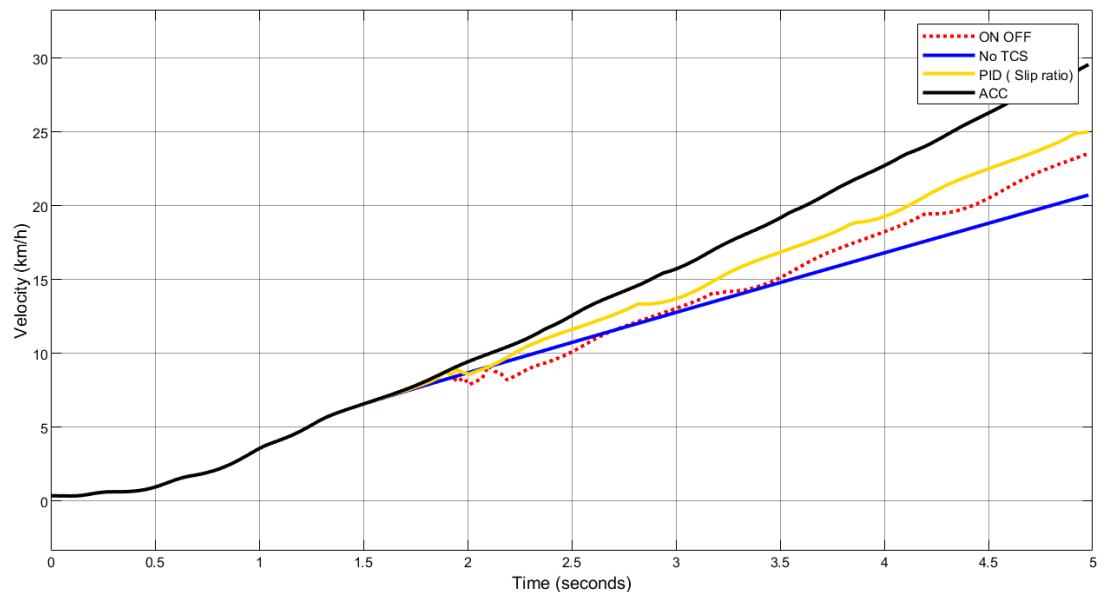
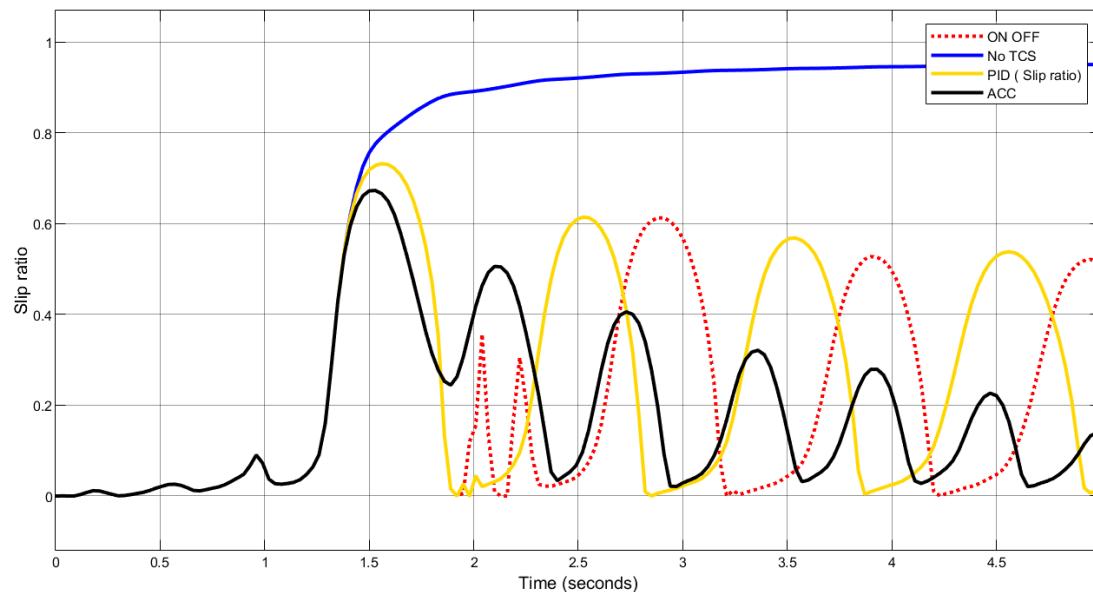
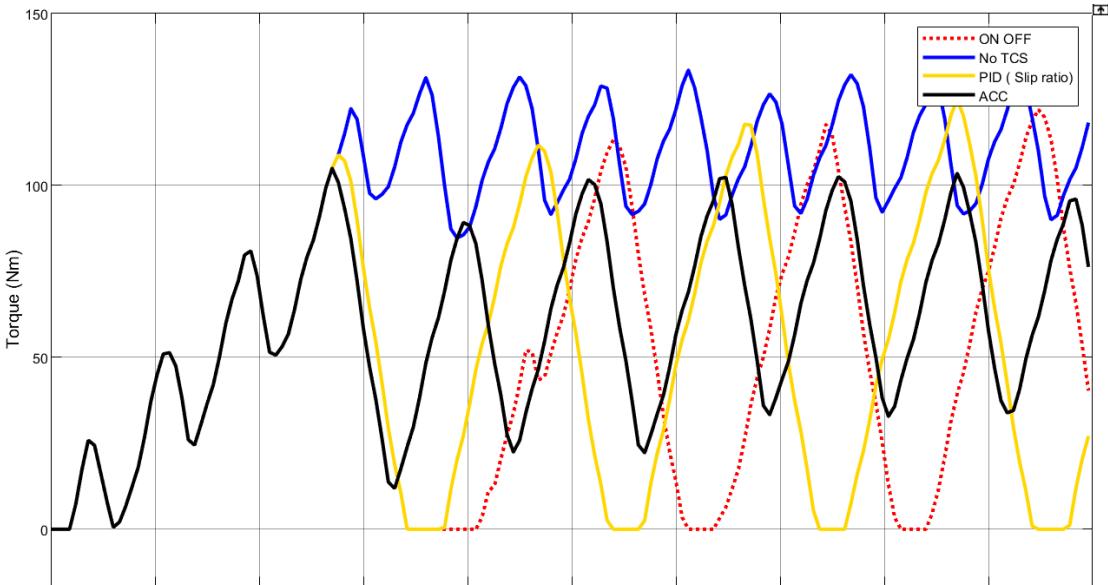
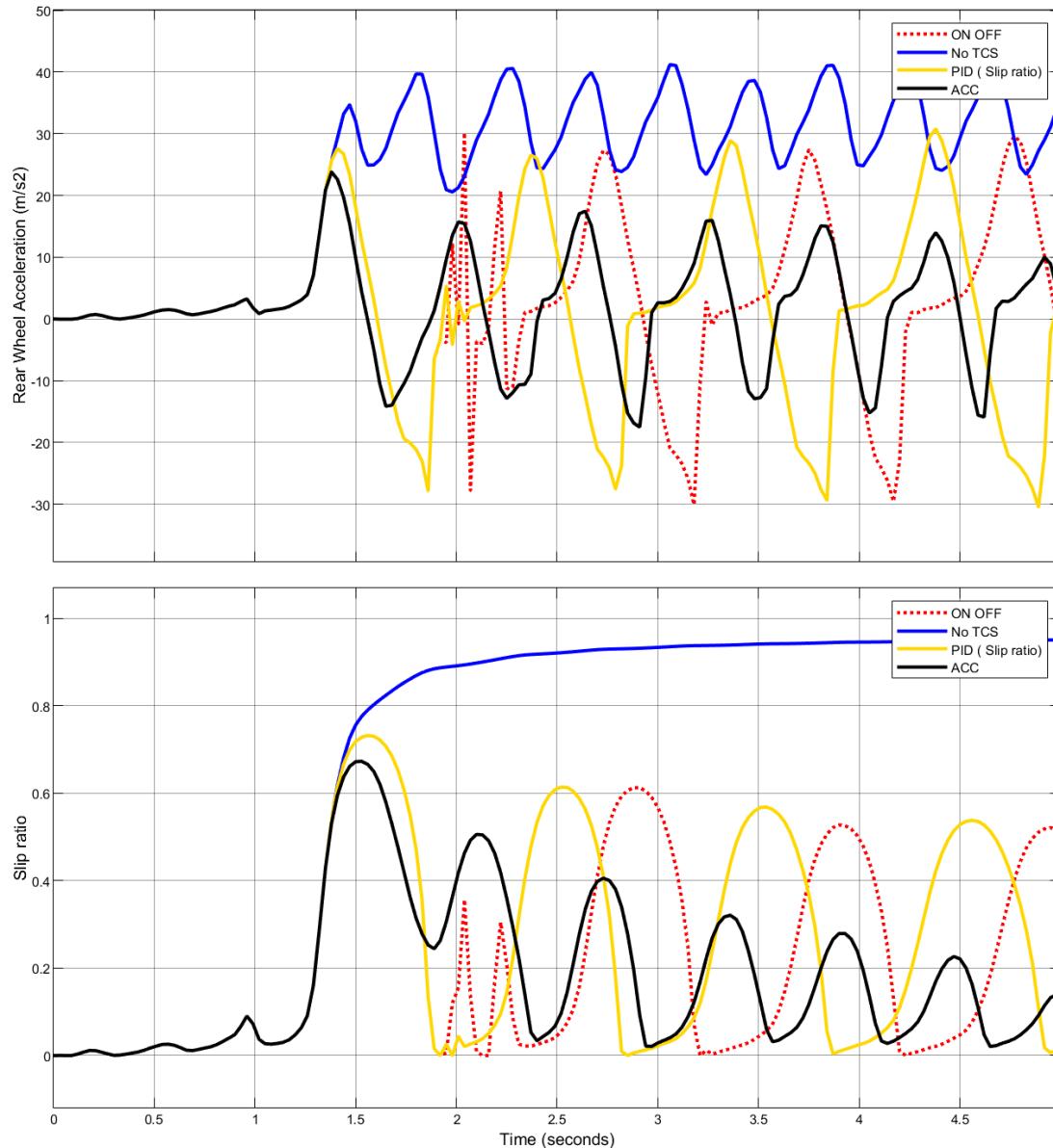
Slip_Control_PID



ACC_Control



Control algorithm simulation



EXPERIMENTAL SETUP

Hardware Setup



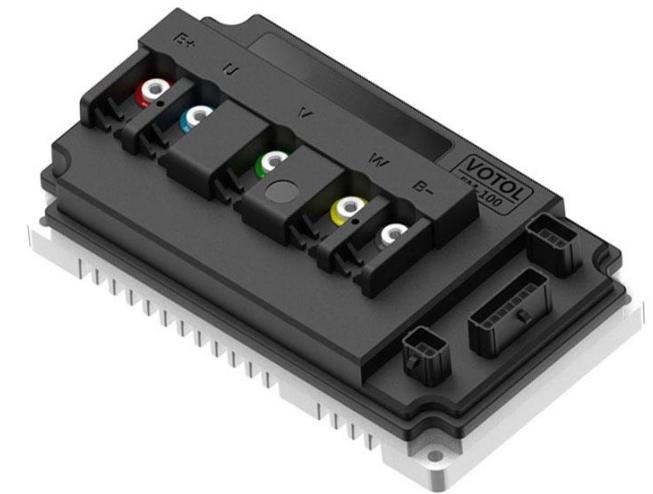
Vinfast Impes

- Power motor: 1200W
- Battery: 22Ah



QS 260 V4 3000

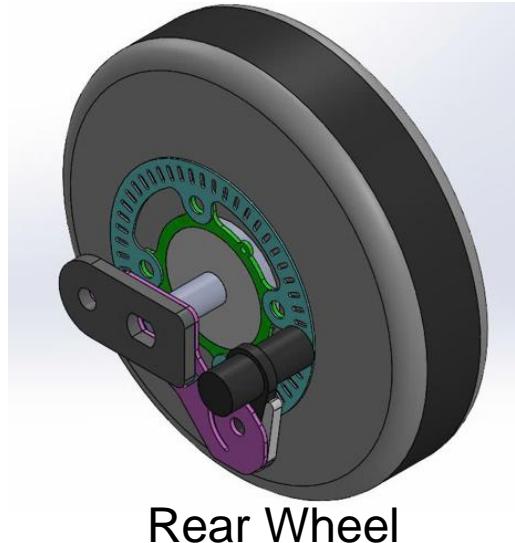
- Operating voltage: 48 -72V
- Power: 3000W
- Torque: 190N.m
- Max Speed: 100km/h
- Max rpm: 1280



Votol EM100

- Operating voltage: 48 -72V (max 90)
- Power: 2000W
- Max Current: 330A
- Continuous Current: 100A
- Hall Sensor Support

Hardware Setup



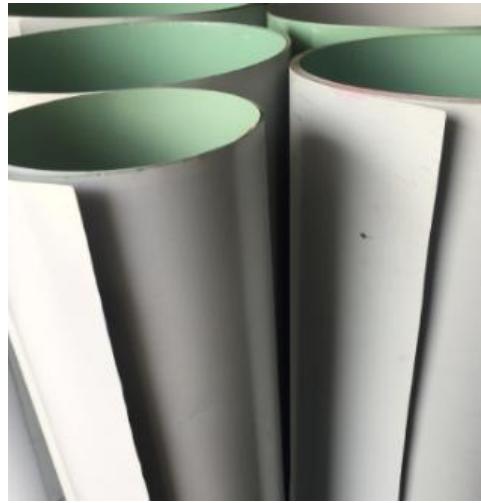
Rear Wheel



Front Wheel



Balance bar



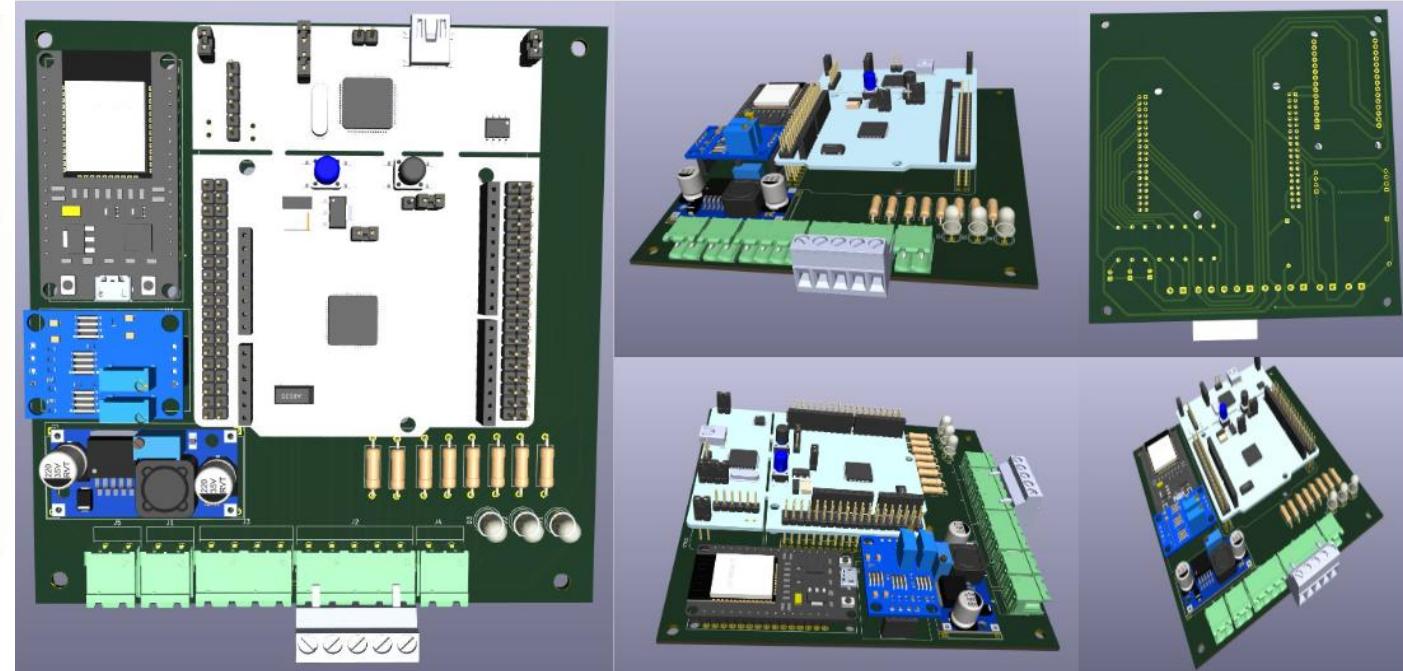
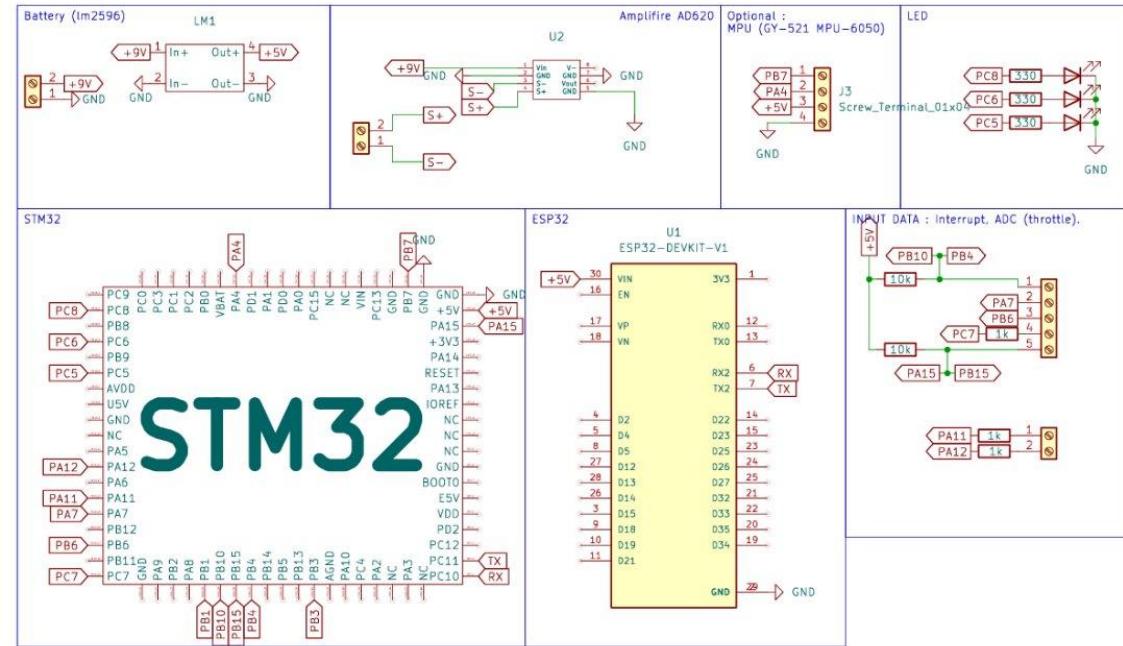
Slipping road



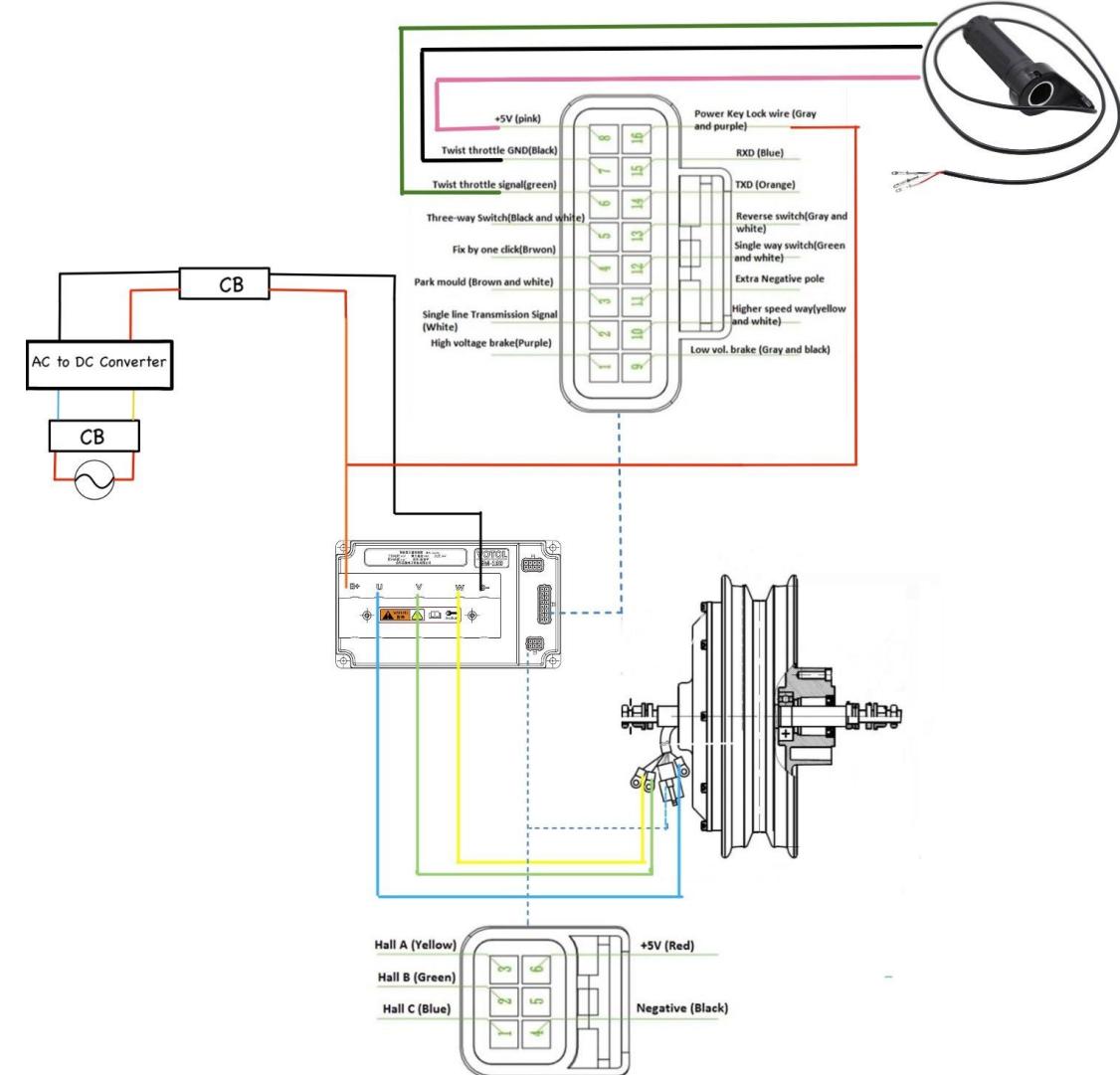
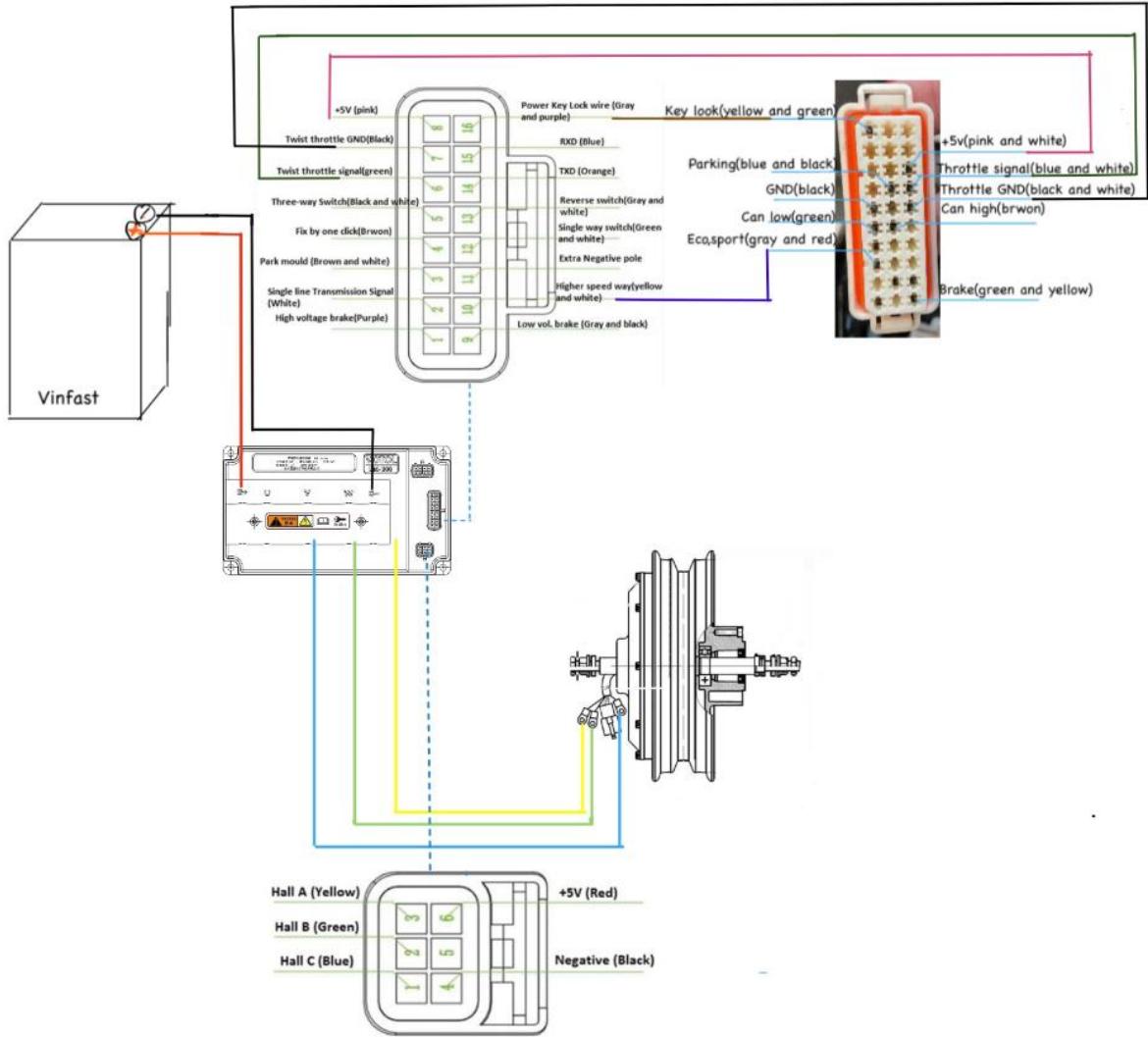
Hall Sensor

Hardware Setup

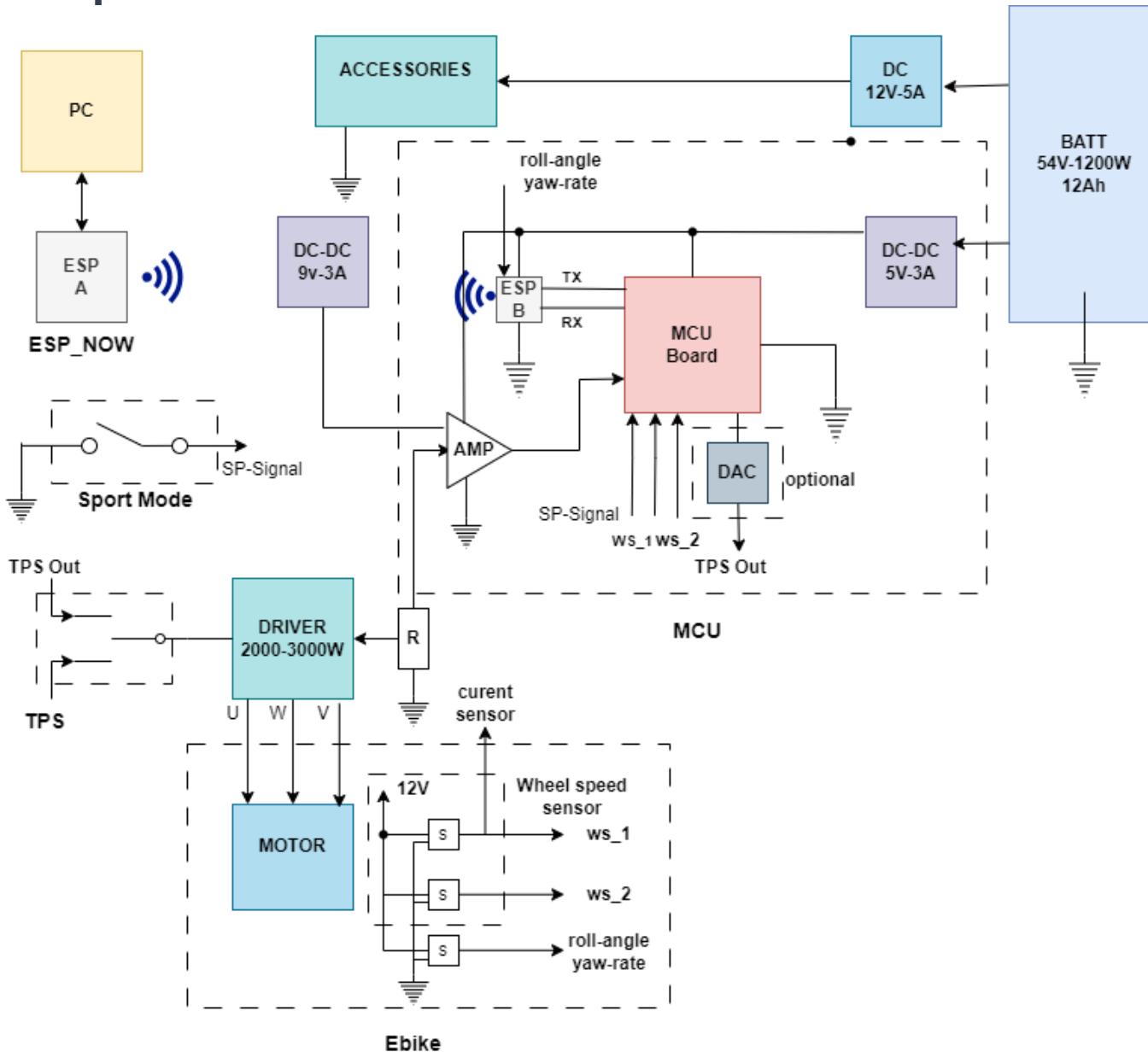
3D Placement for controller board



Hardware Setup

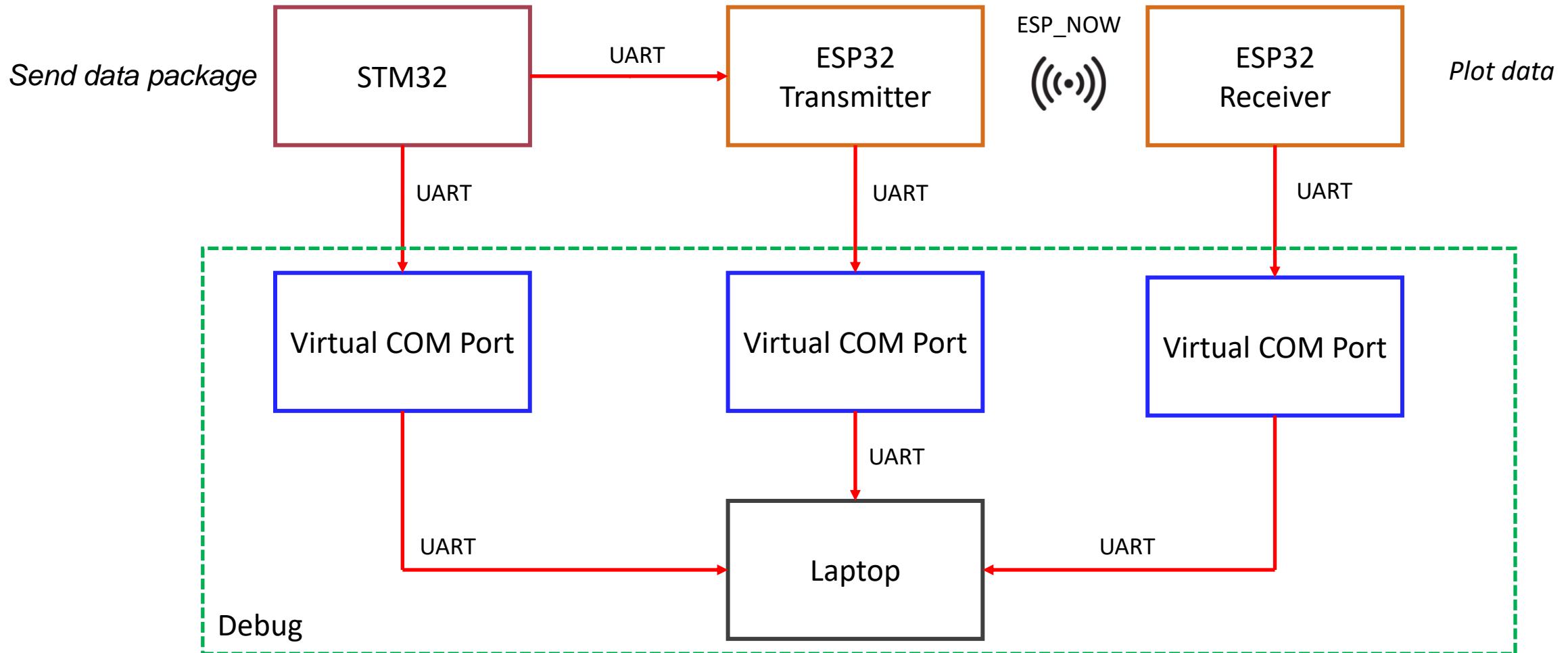


Hardware Setup

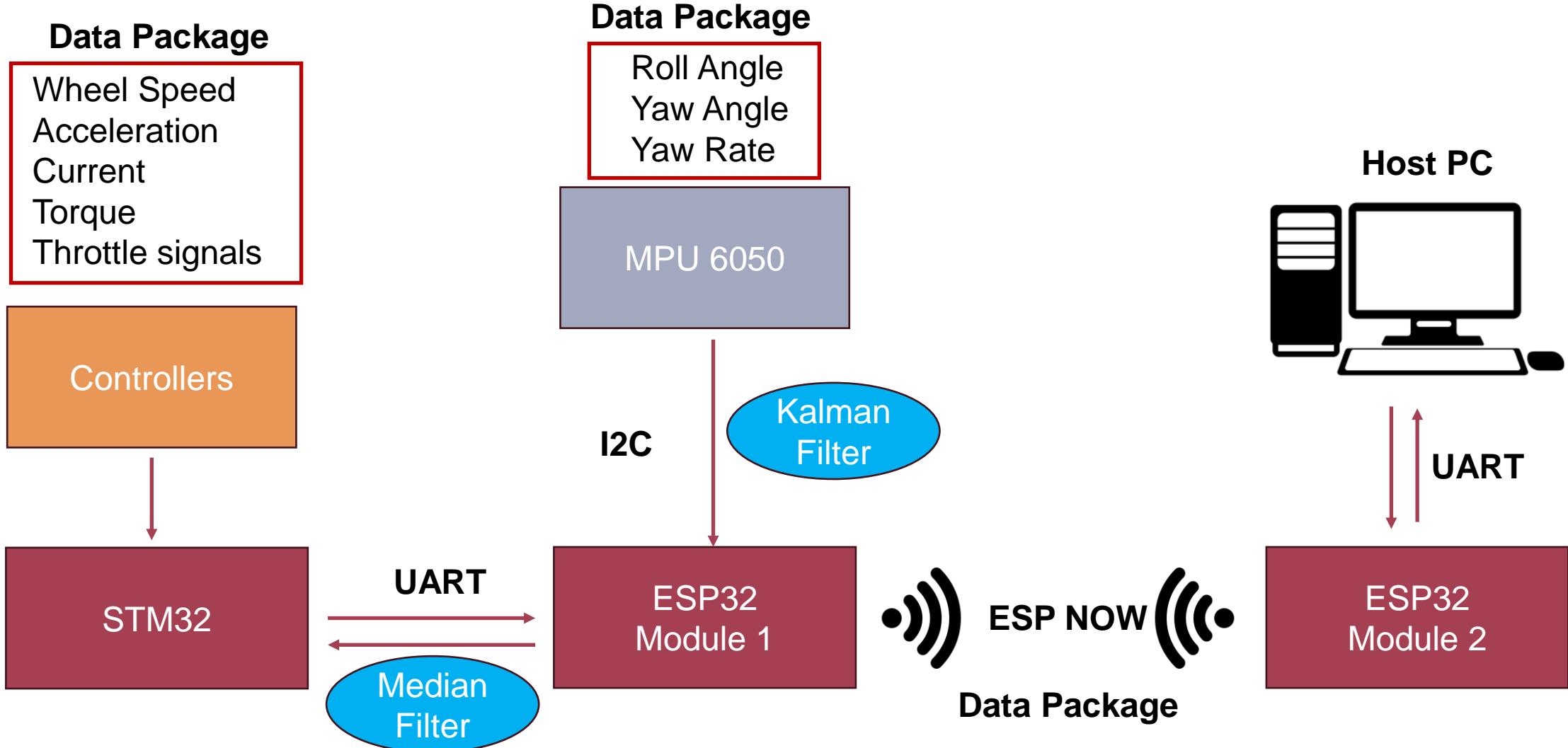


Software Setup

ESP NOW Protocol

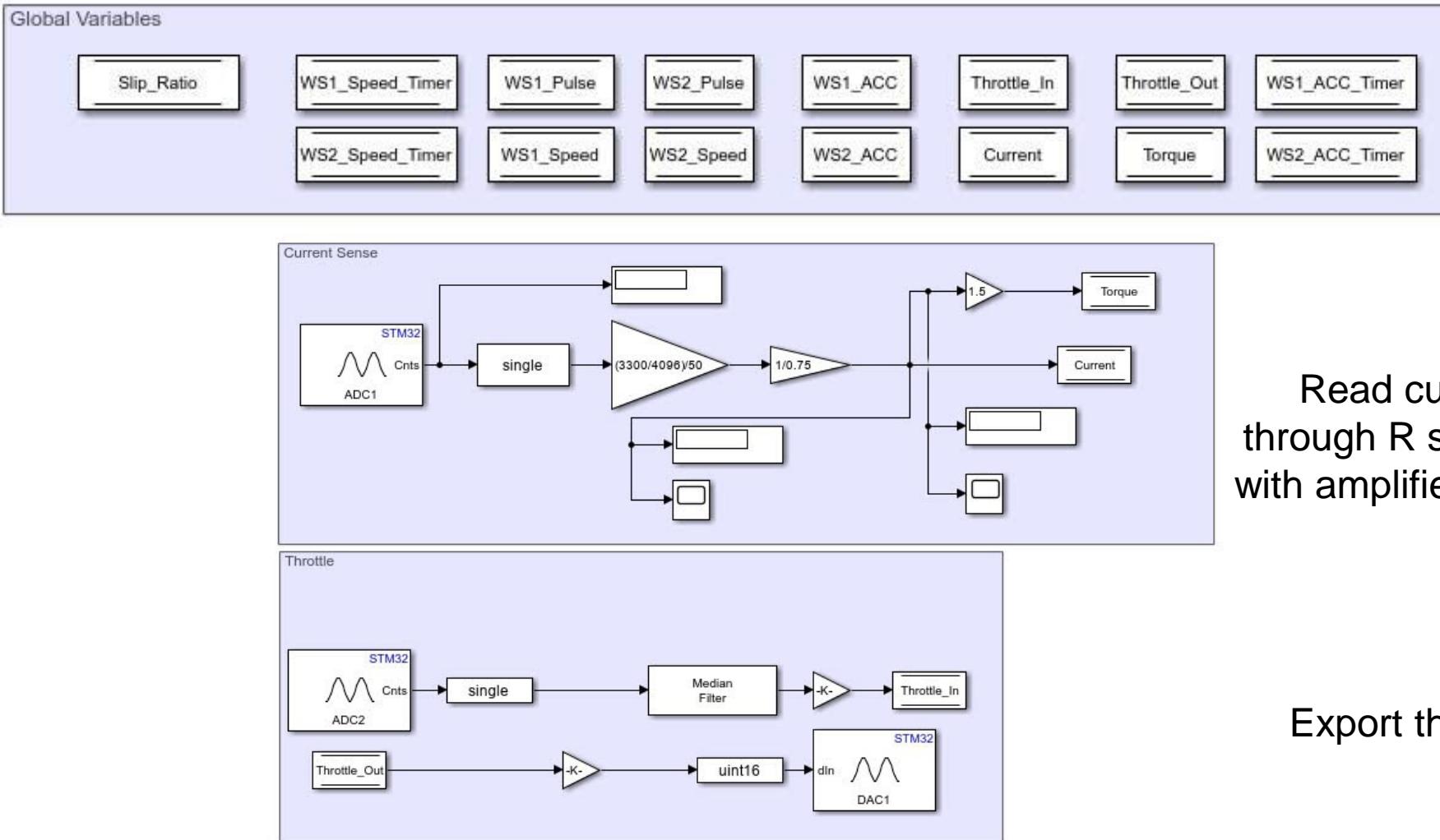


Software Setup



Software Setup for testing data collection

Initialize global variables

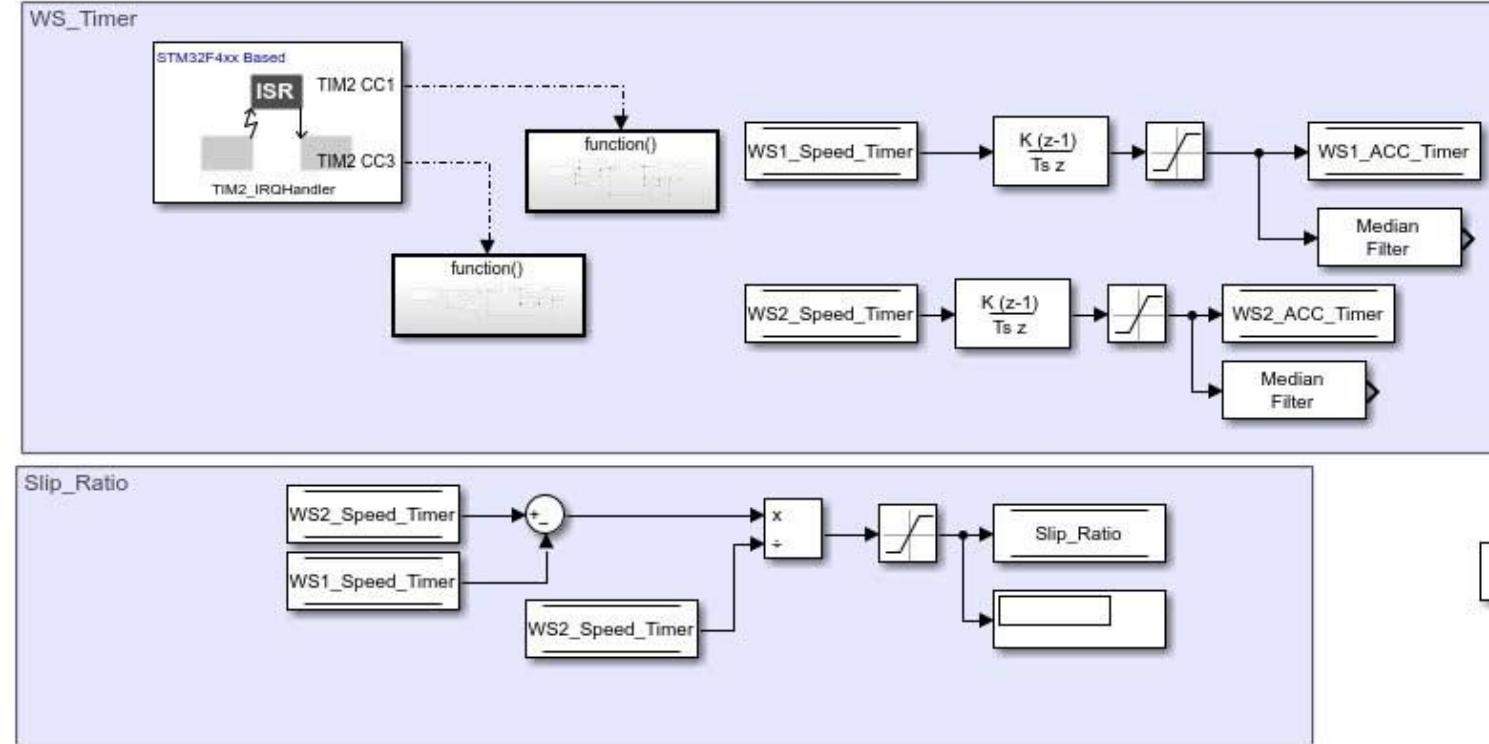


Read current values
through R sunt 0,75mOhm
with amplifier multiplying 40

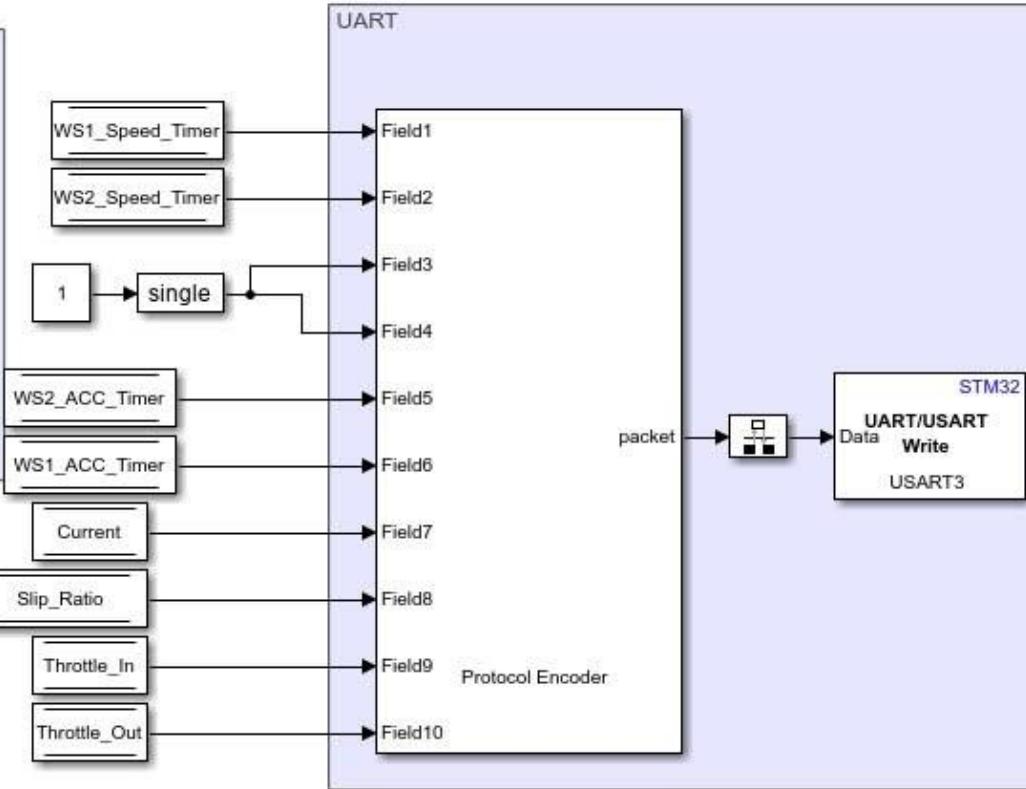
Export throttle values

Software Setup for testing data collection

Block read wheel speed and calculate slip ratio index



Block send data package via UART

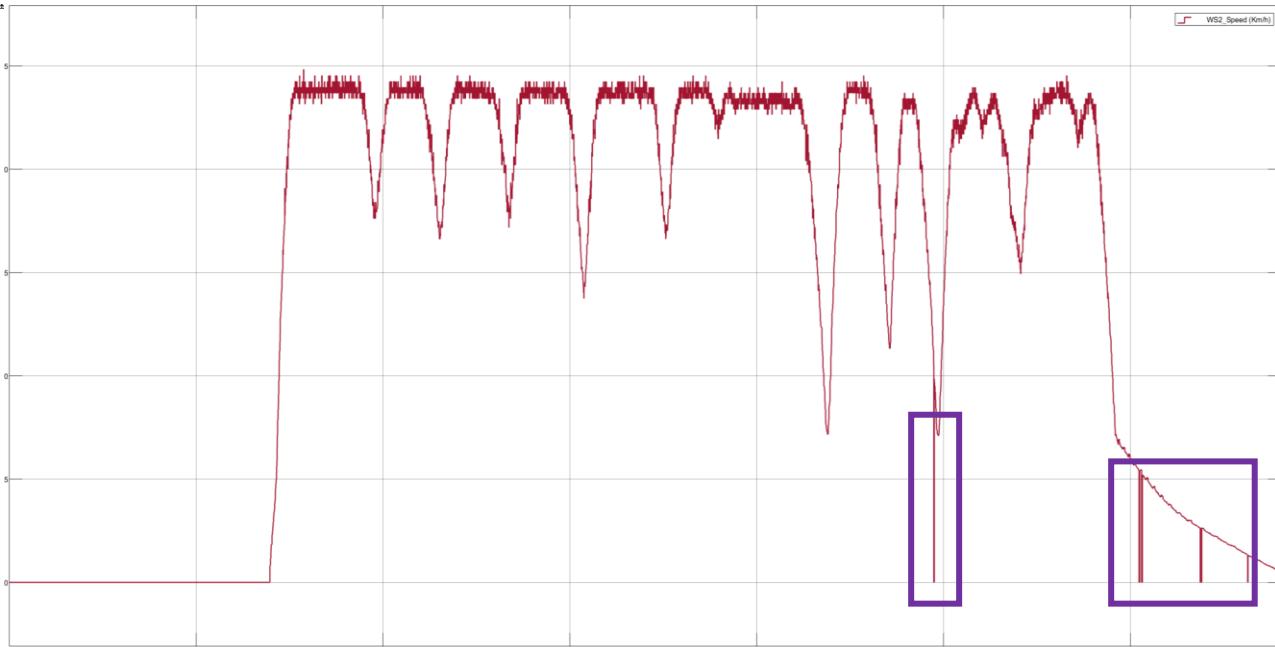
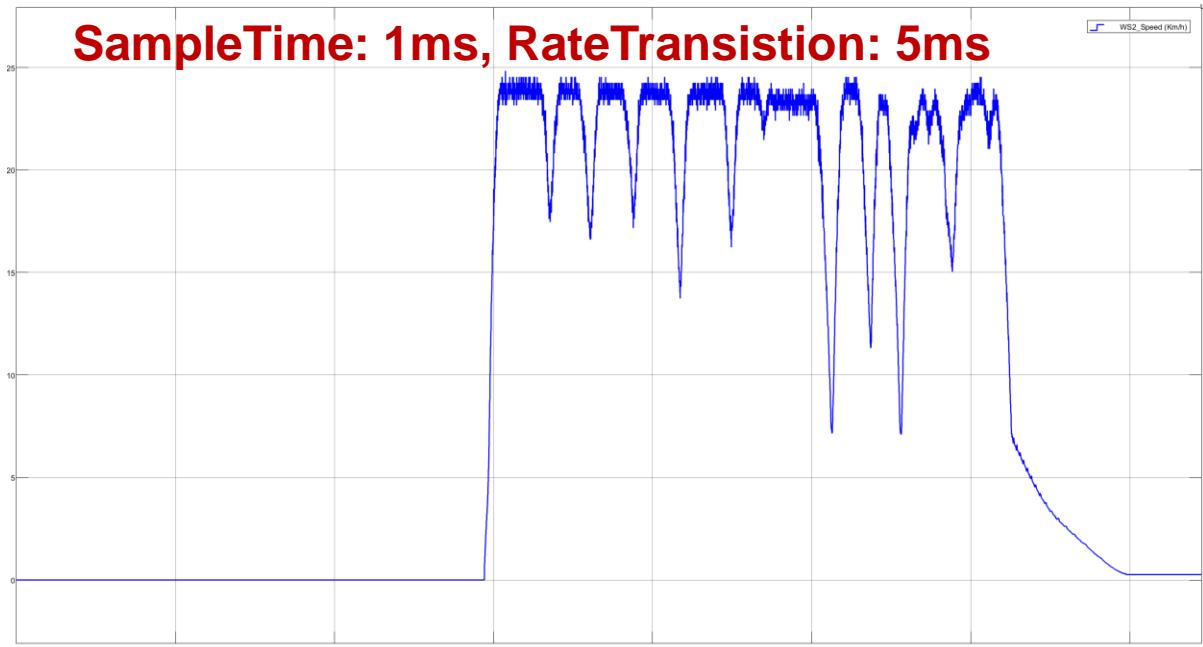


Block **Rate Transition** send whole data package with a period **5ms**

Software Setup for testing data collection

E-Bike didn't operate

SampleTime: 1ms, RateTransiston: 5ms



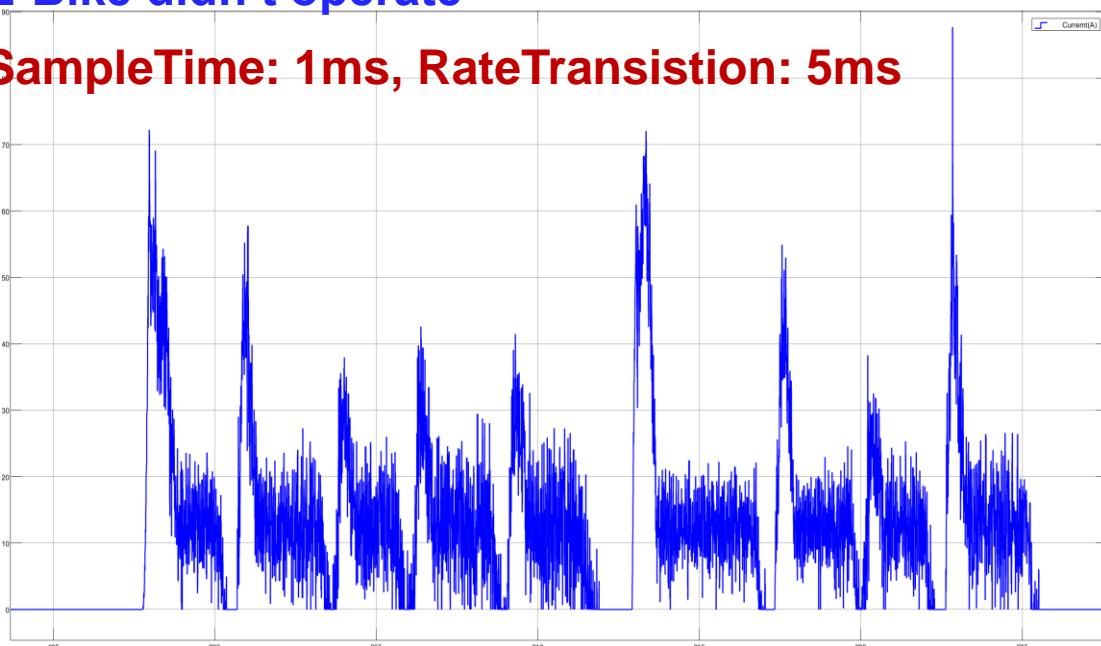
External Mode and Host Serial run parallelly

Nhận xét: Xuất hiện 1 vài chỗ giá trị nhận được trên máy tính giảm về 0 -> **xãy ra nhiễu** trong lúc truyền nhận các giá vận tốc

Software Setup for testing data collection

E-Bike didn't operate

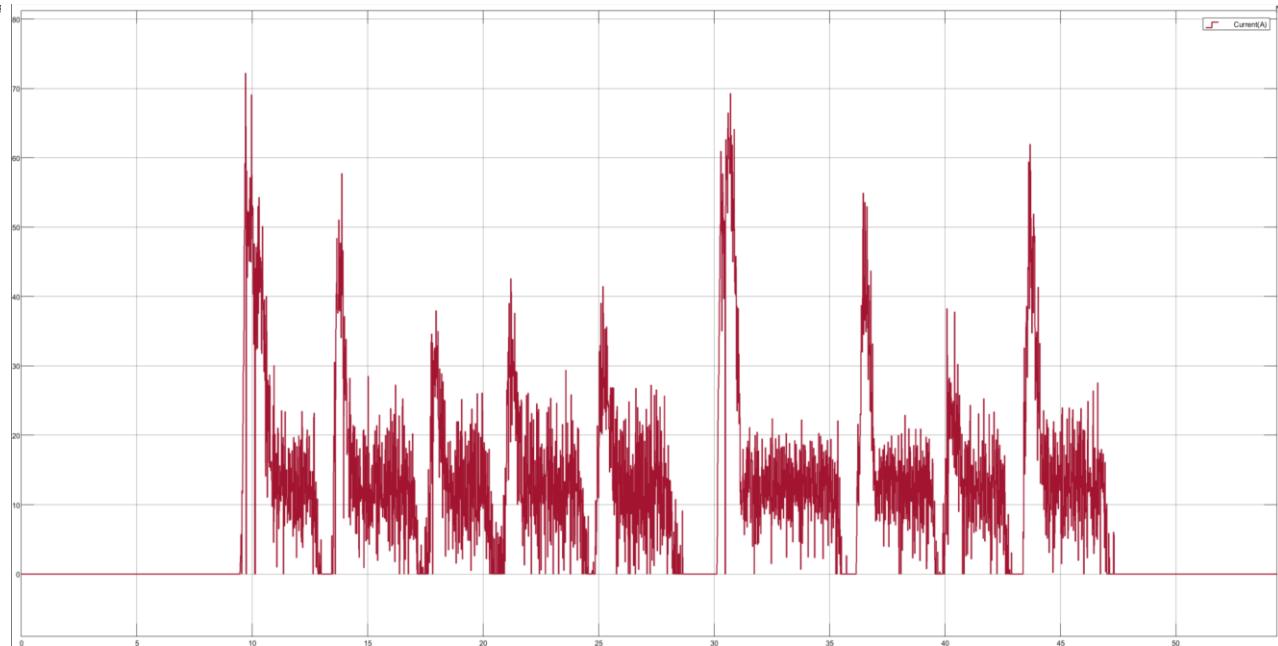
SampleTime: 1ms, RateTransistion: 5ms



Current values on STM32
External Mode

External Mode and Host Serial run parallelly

Nhận xét: Không có sự khác nhau giữa các đồ thị -> Các giá trị thu được trên máy tính đúng với các giá trị thực tế trên STM (ở khoảng cách gần ~2m). Có thể kết luận thuật toán nhận truyền dữ liệu (wireless) hoạt động tốt ở trường hợp này.



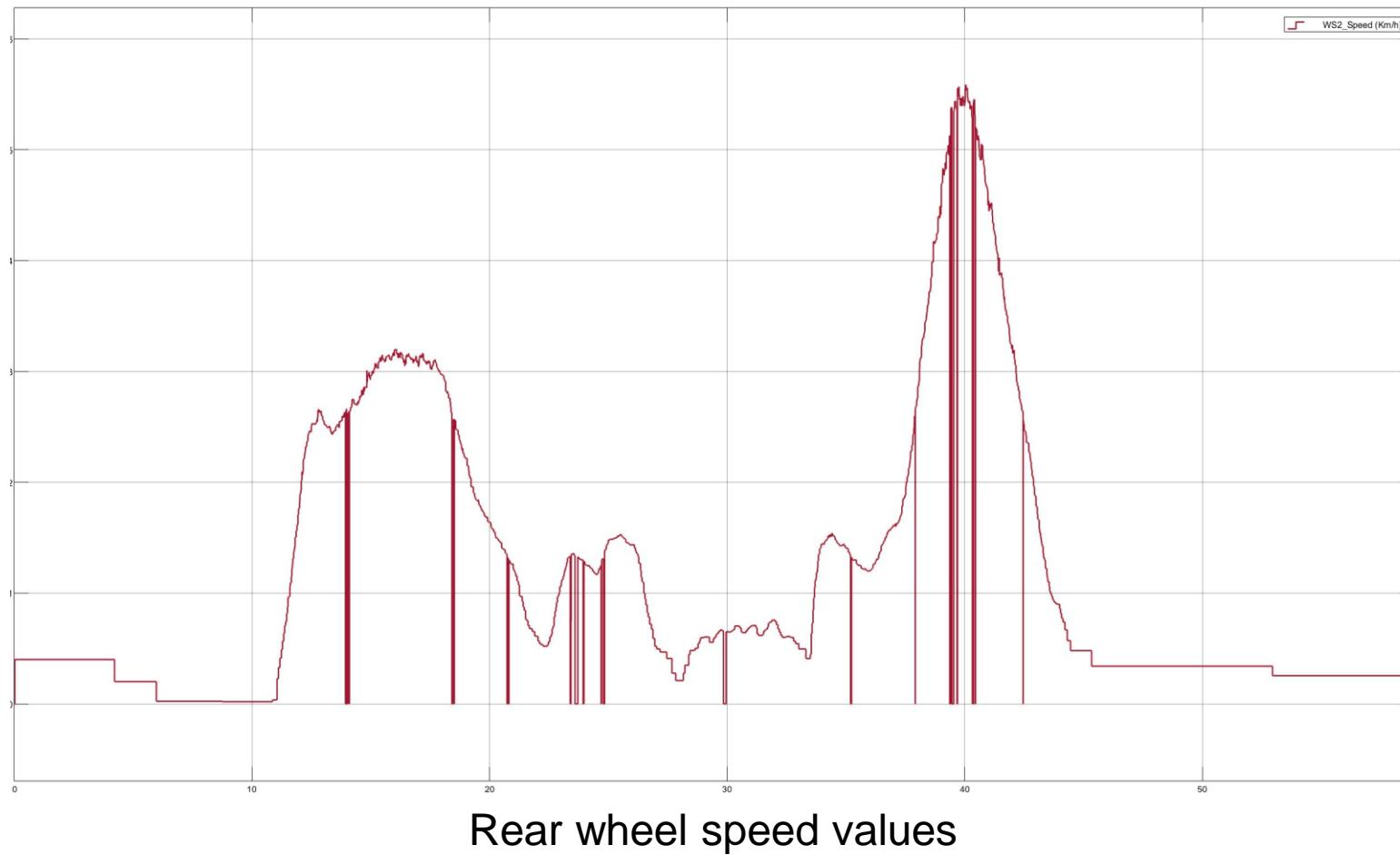
Current Values on ESP32
ESP Now

Software Setup for testing data collection

E-Bike operated

SampleTime: 1ms, RateTransistion: 5ms trên STM

SampleTime: 5ms trên Host PC

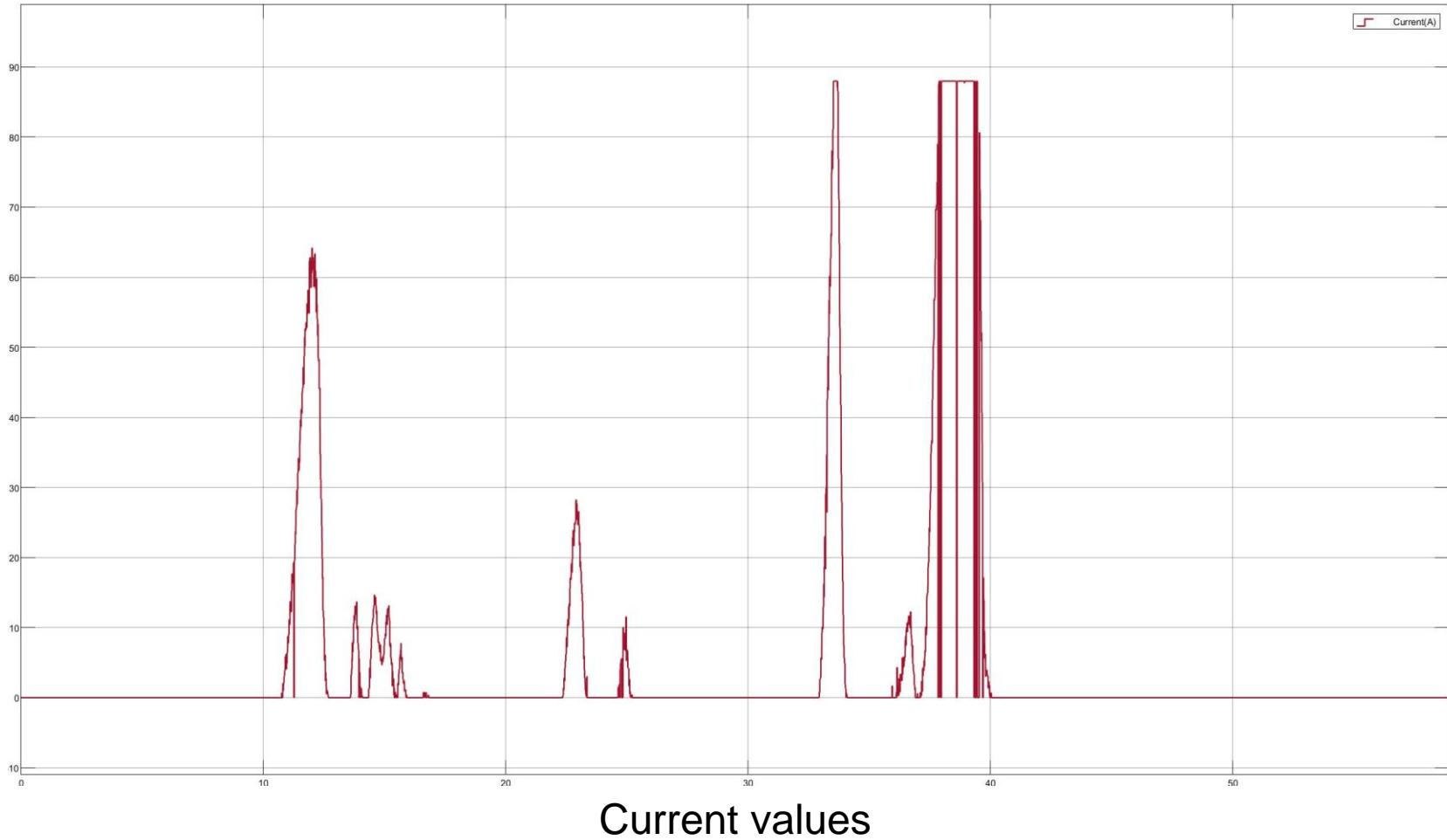


Software Setup for testing data collection

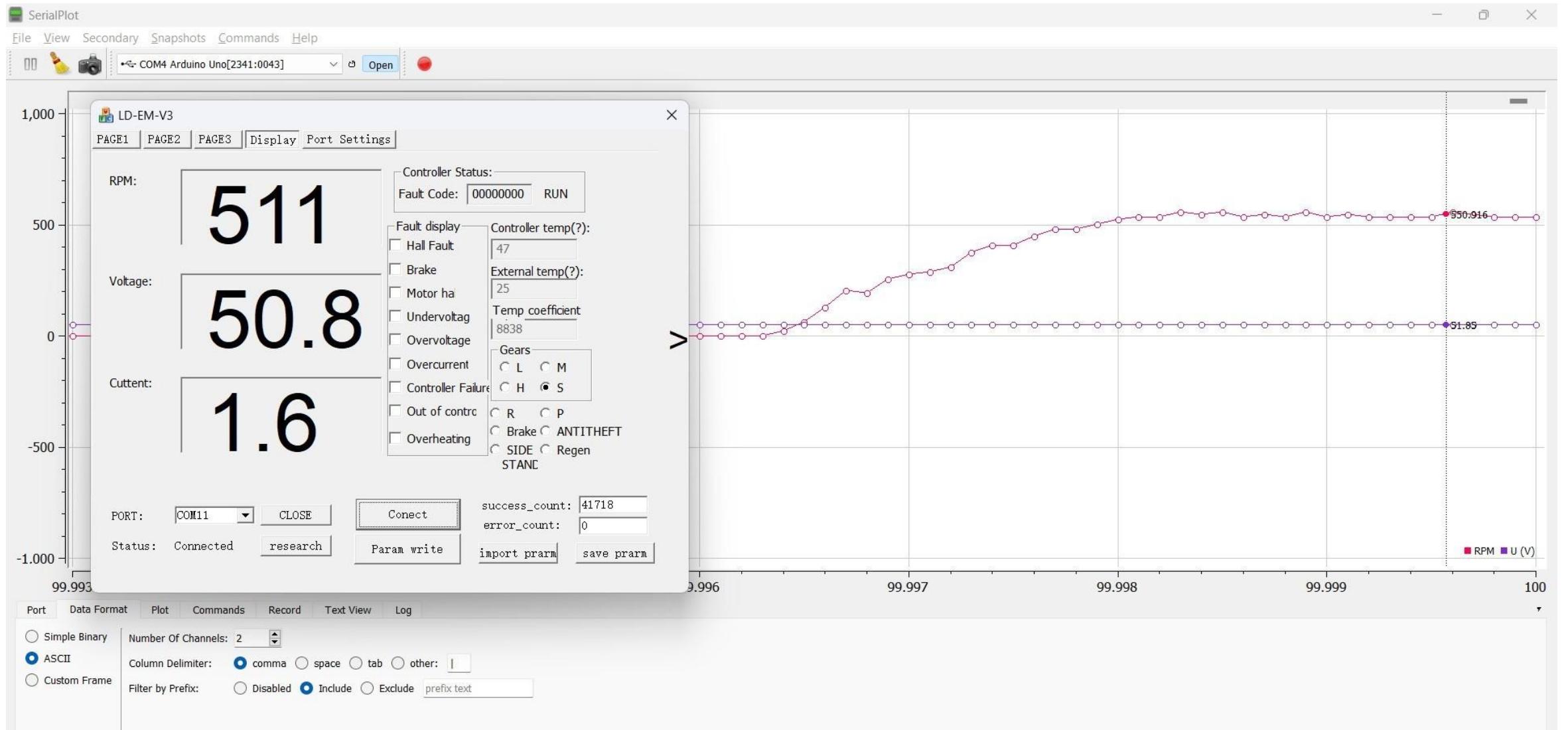
E-Bike operated

SampleTime: 1ms, RateTransistion: 5ms trên STM

SampleTime: 5ms trên Host PC



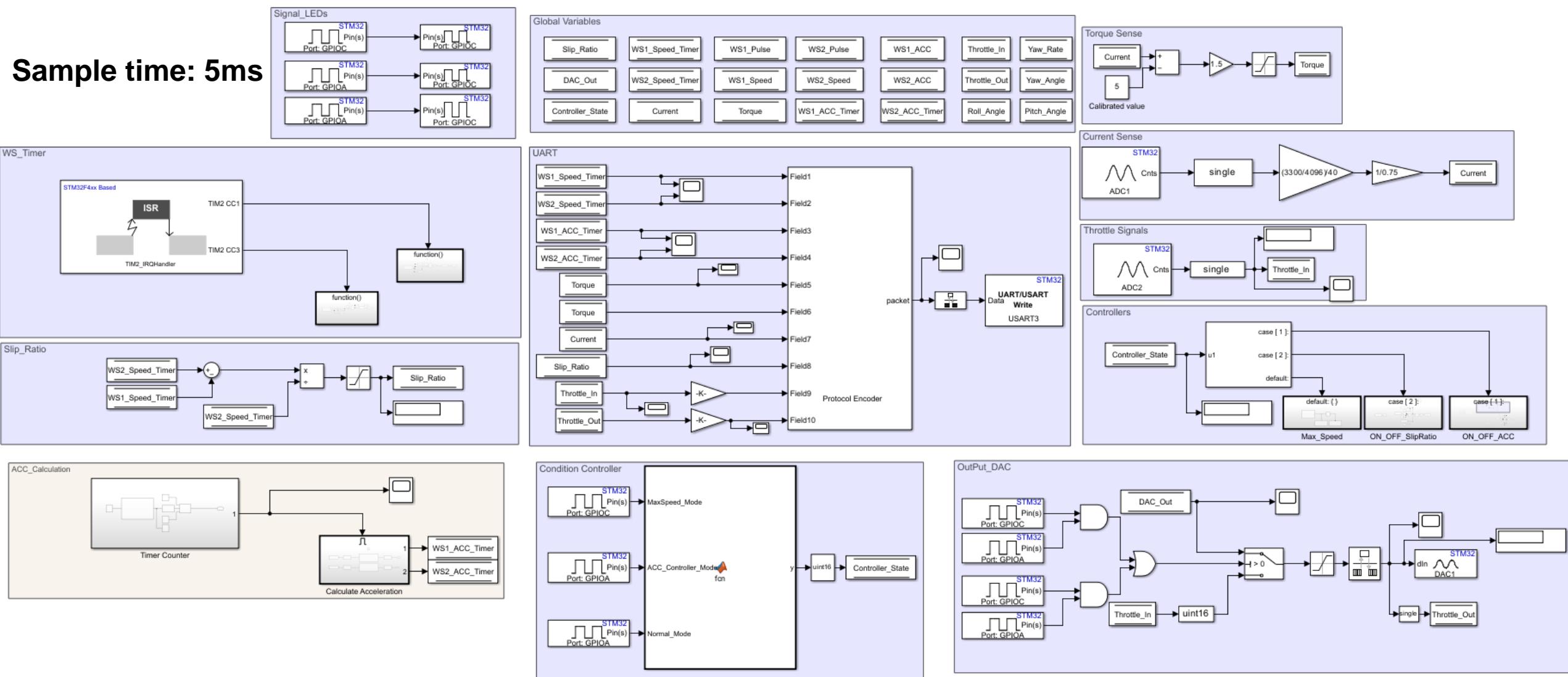
Software Setup for testing data collection



Whole data double checked with Votol Software

Software Setup for slipping process

Sample time: 5ms

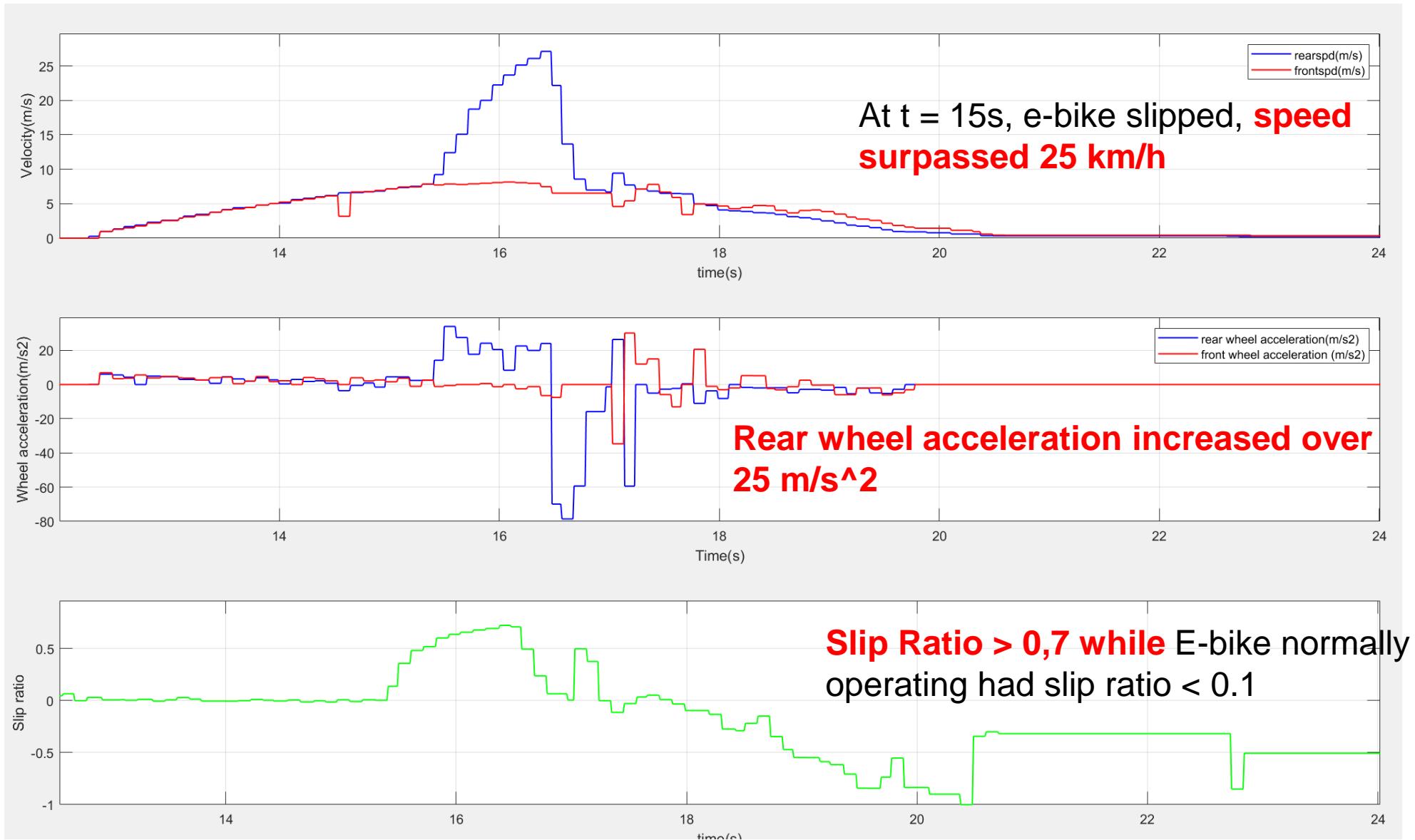


Software Setup for slipping process

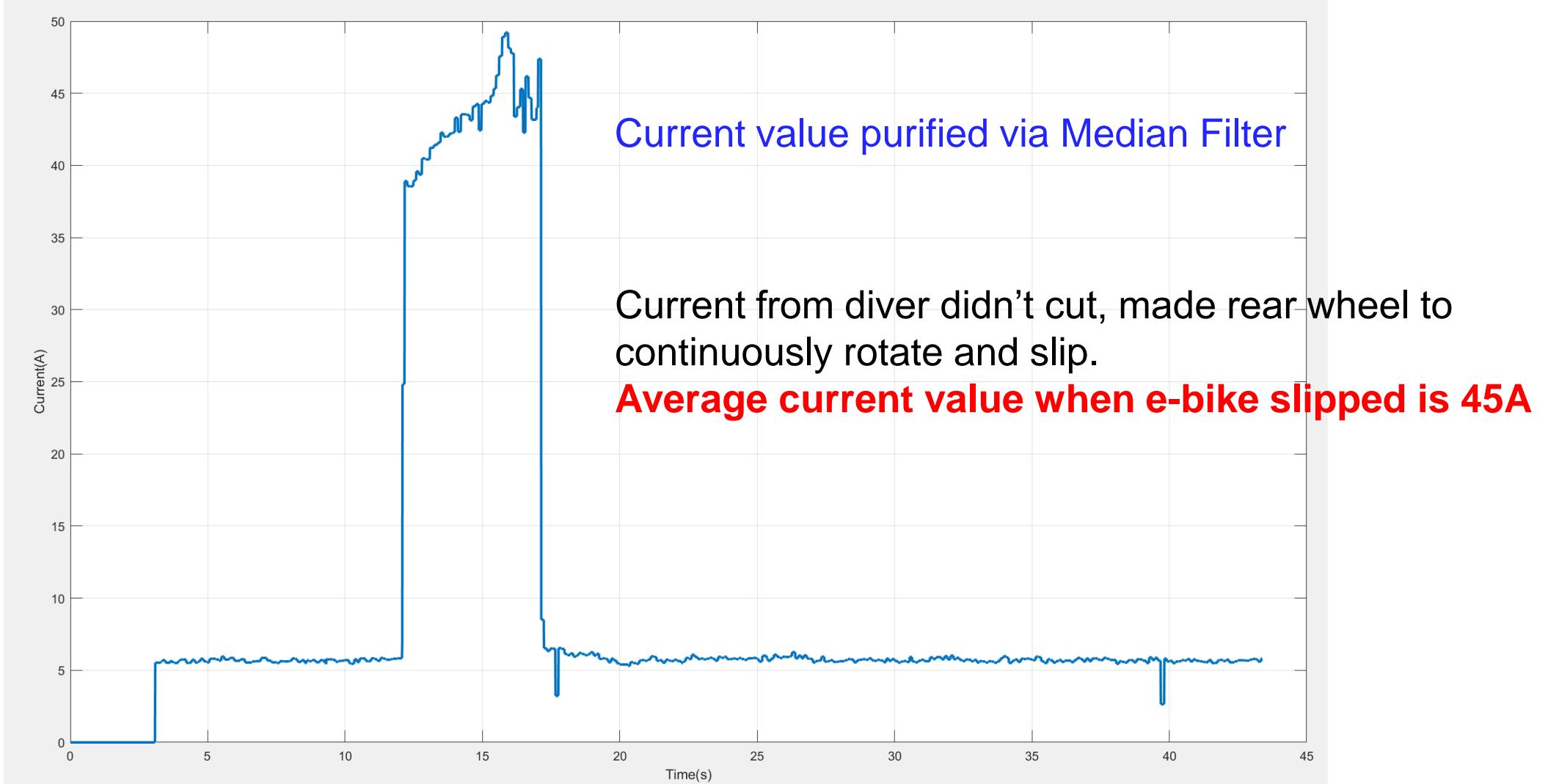


RESULTS AND CONCLUSION

No TCS



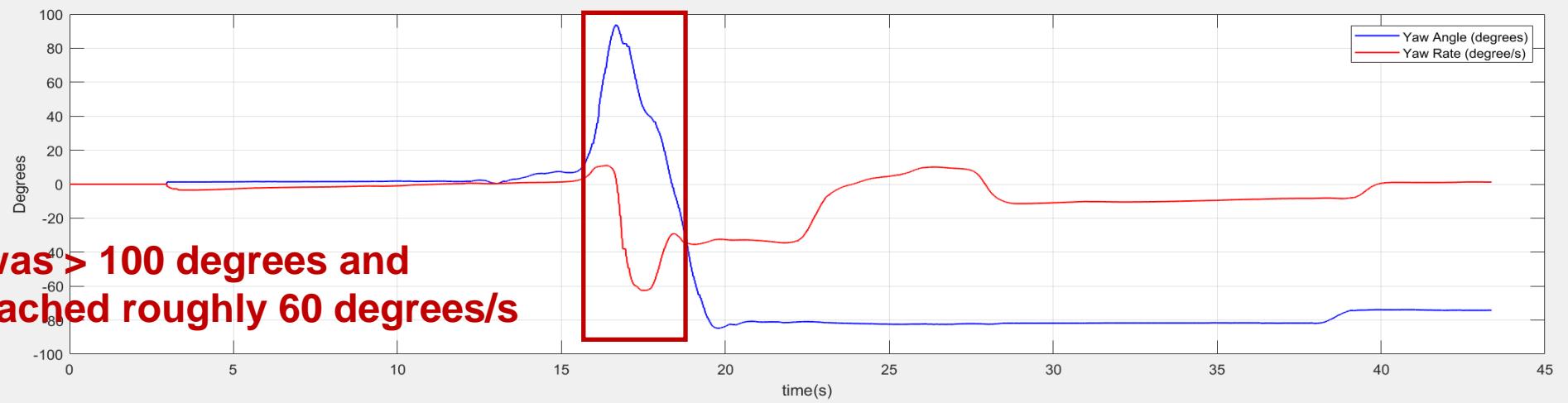
No TCS



No TCS

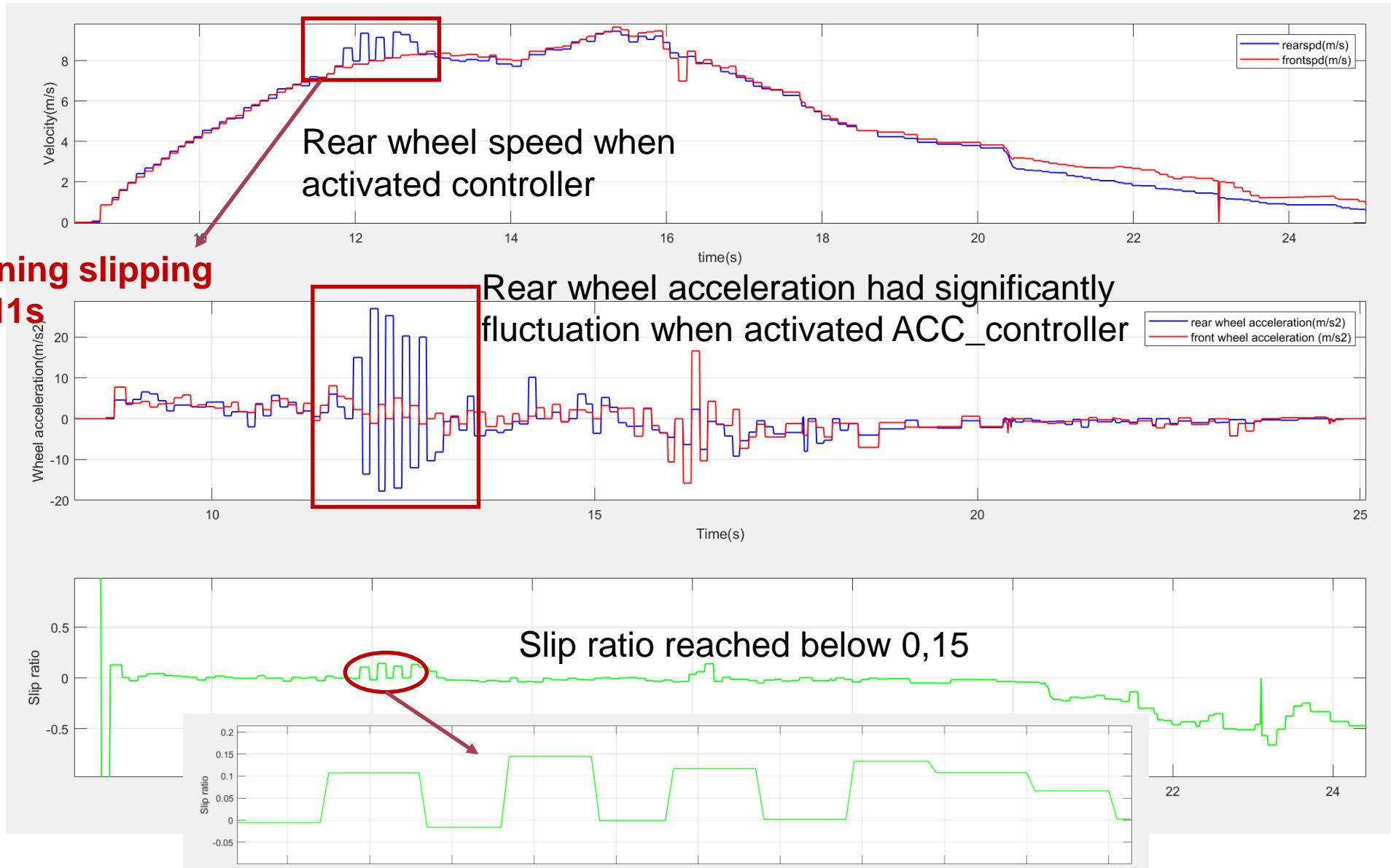


The graph showing characteristics of roll angle



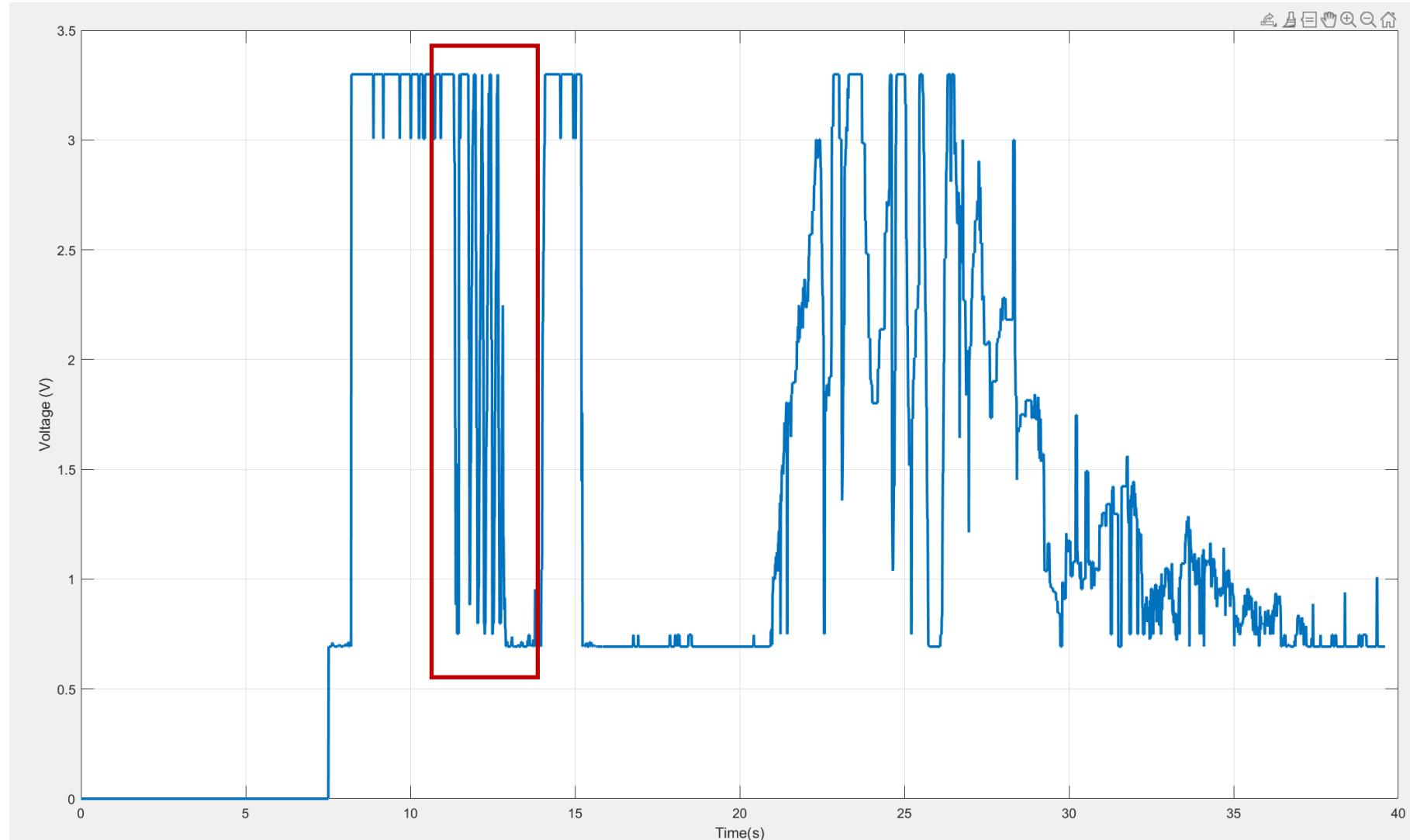
The graph showing characteristics of yaw angle and yaw rate

TCS ON OFF (Based on Wheel Acceleration)



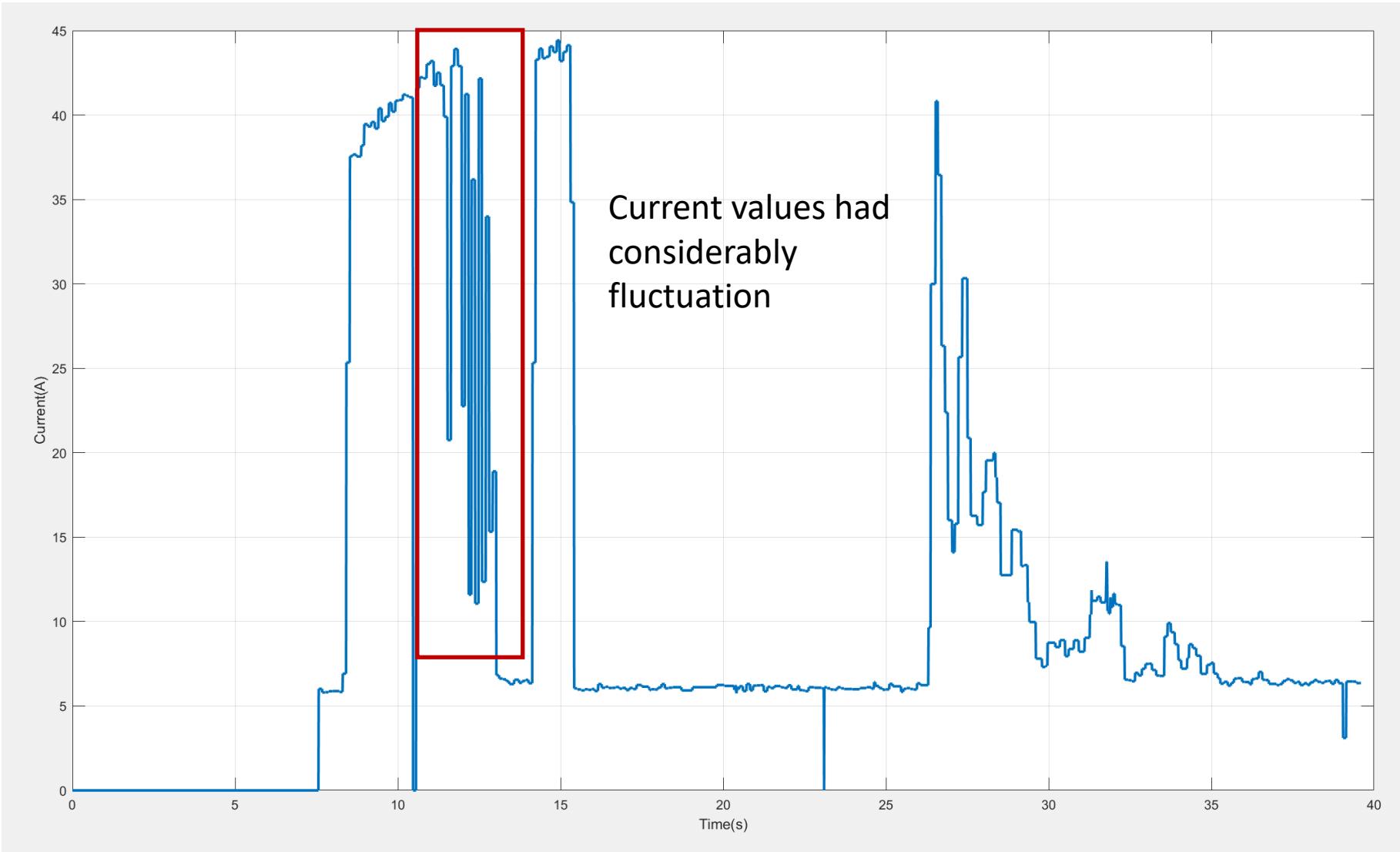


TCS ON OFF (Based on Wheel Acceleration)



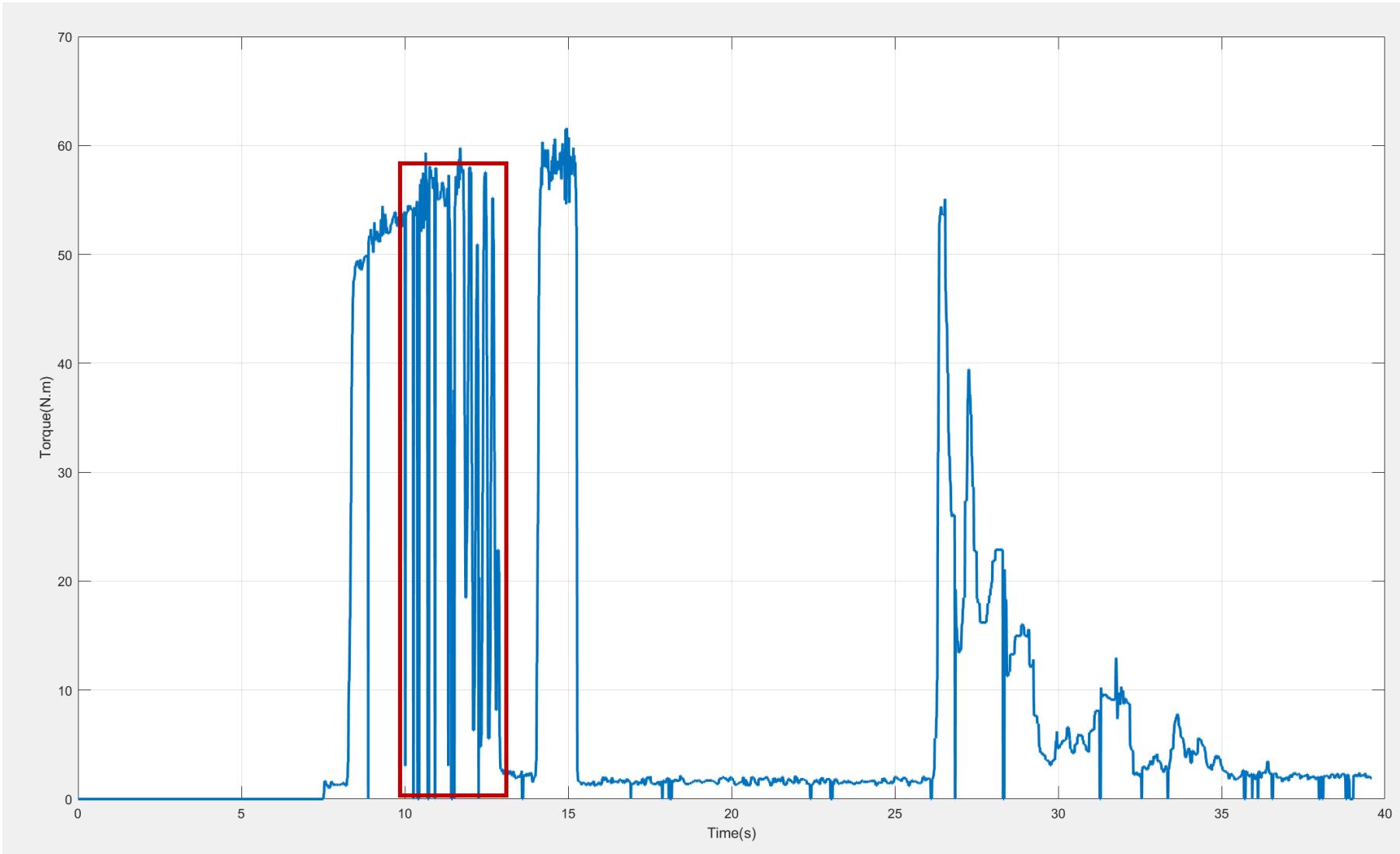
The graph showing characteristics of throttle

TCS ON OFF (Based on Wheel Acceleration)



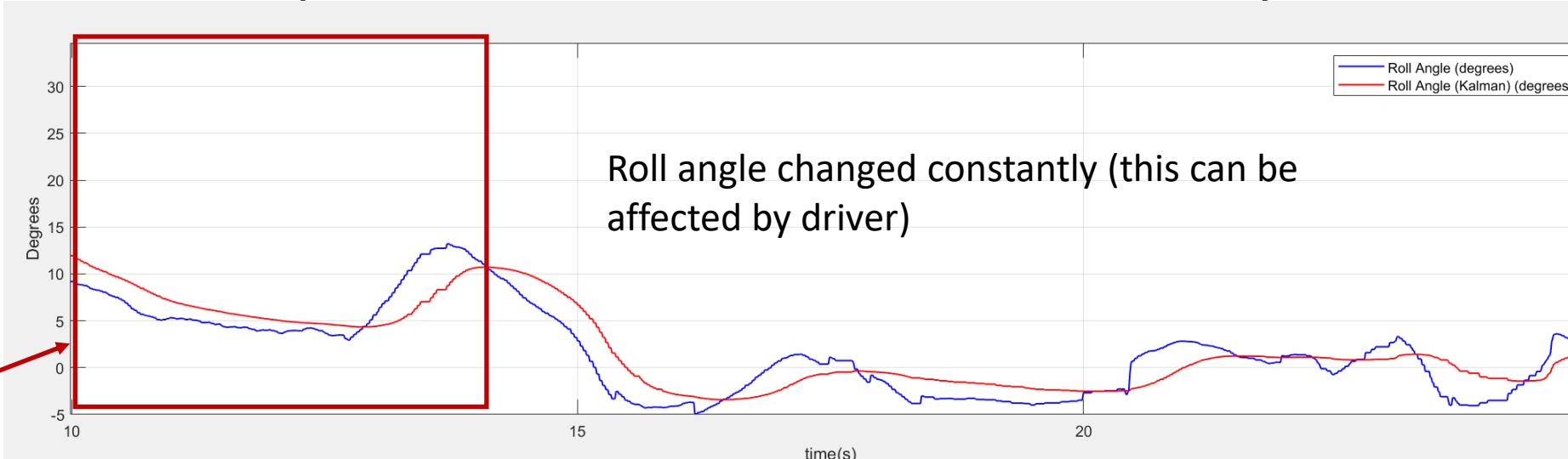
The graph showing characteristics of current

TCS ON OFF (Based on Wheel Acceleration)

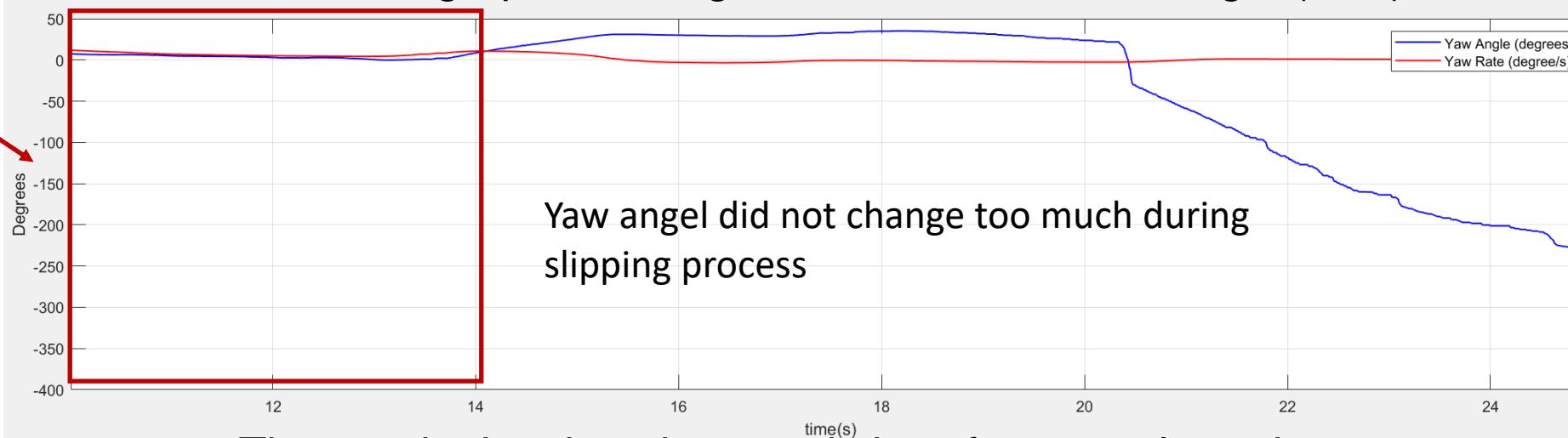


The graph showing characteristics of torque (N.m)

TCS ON OFF (Based on Wheel Acceleration)



The time frame for slipping process



The graph showing characteristics of yaw angle and yaw rate

TCS ON OFF (Based on SlipRatio)



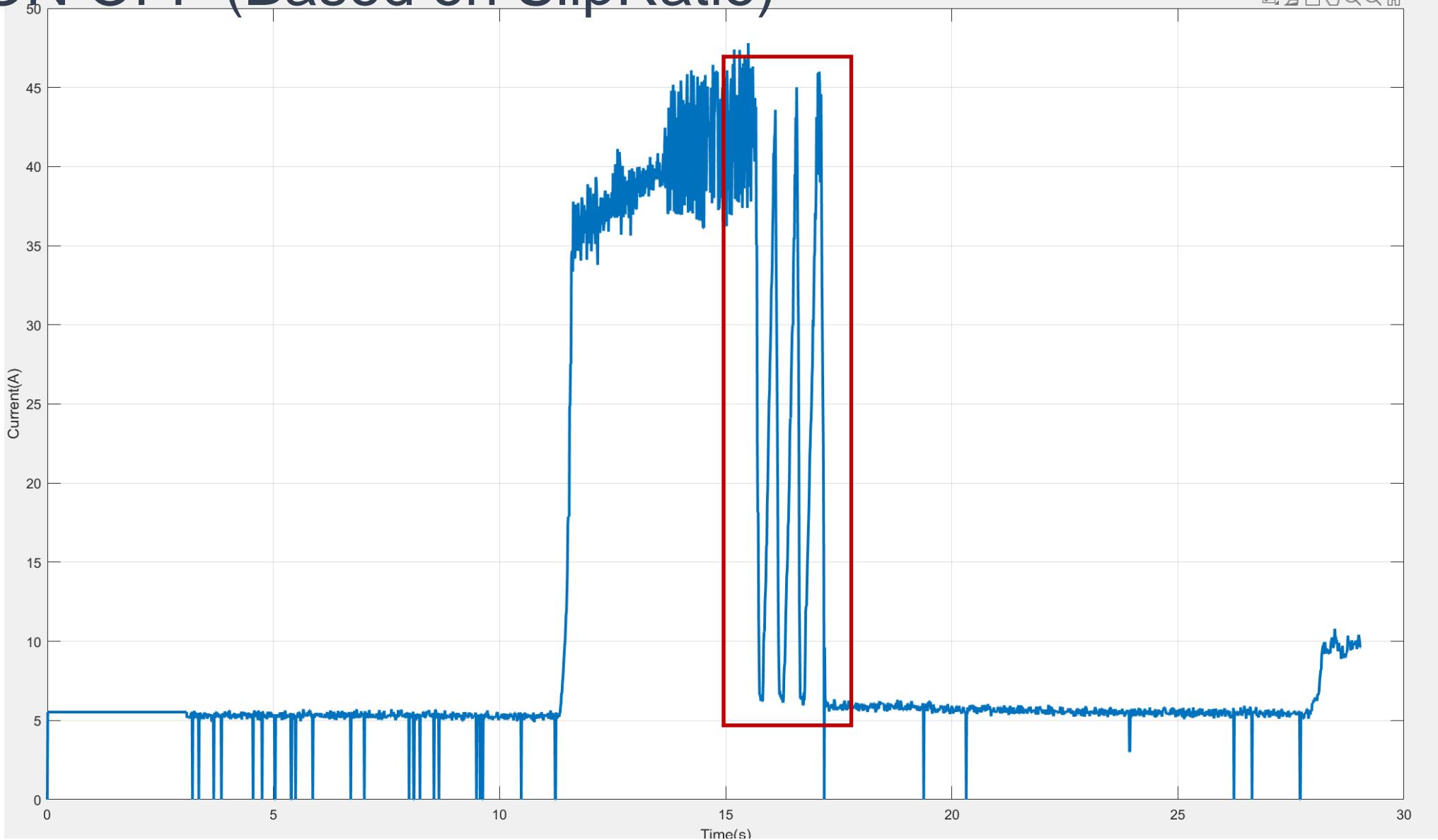
At the beginning slipping process $t = 15s$





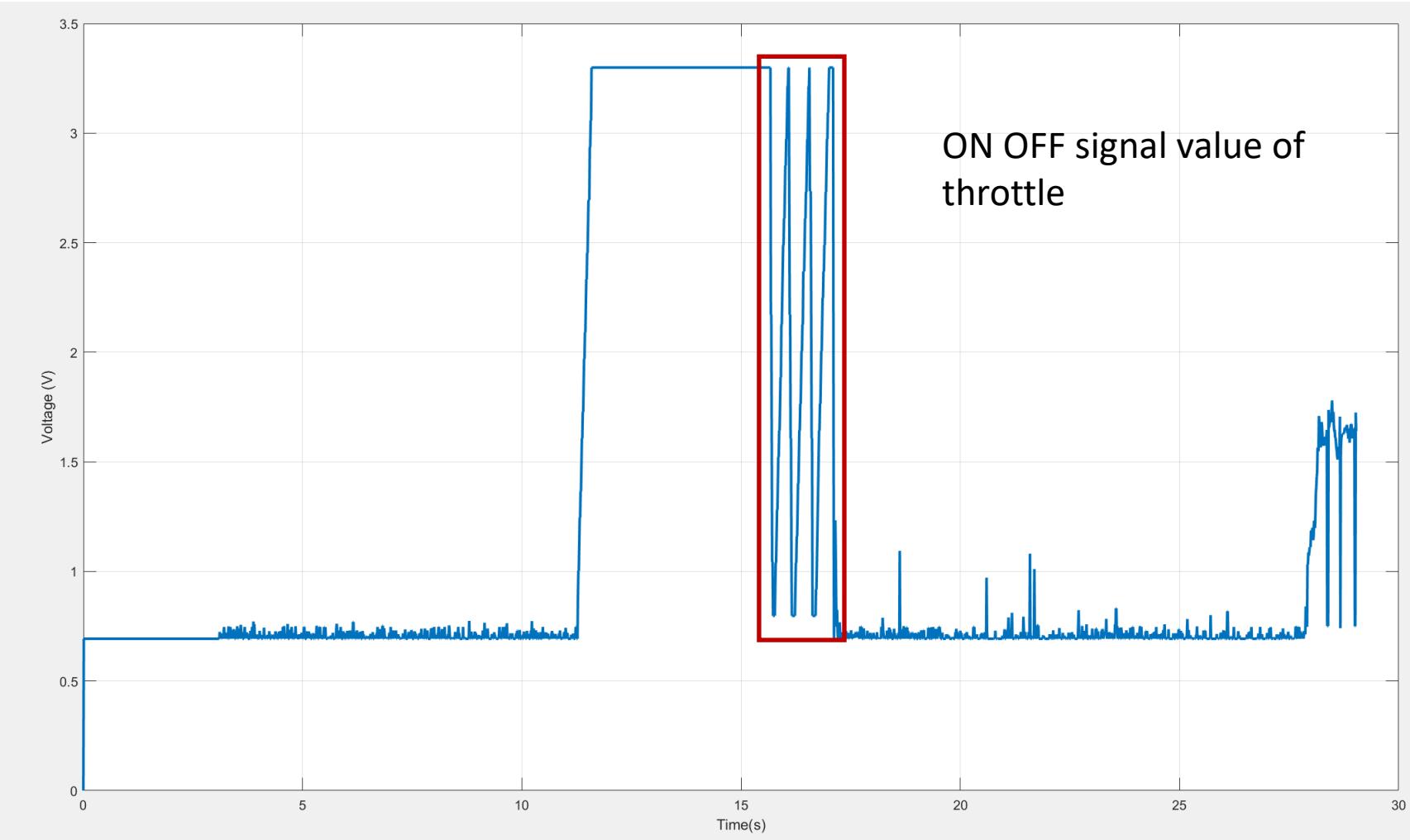
TCS ON OFF (Based on SlipRatio)

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The graph showing characteristics of current

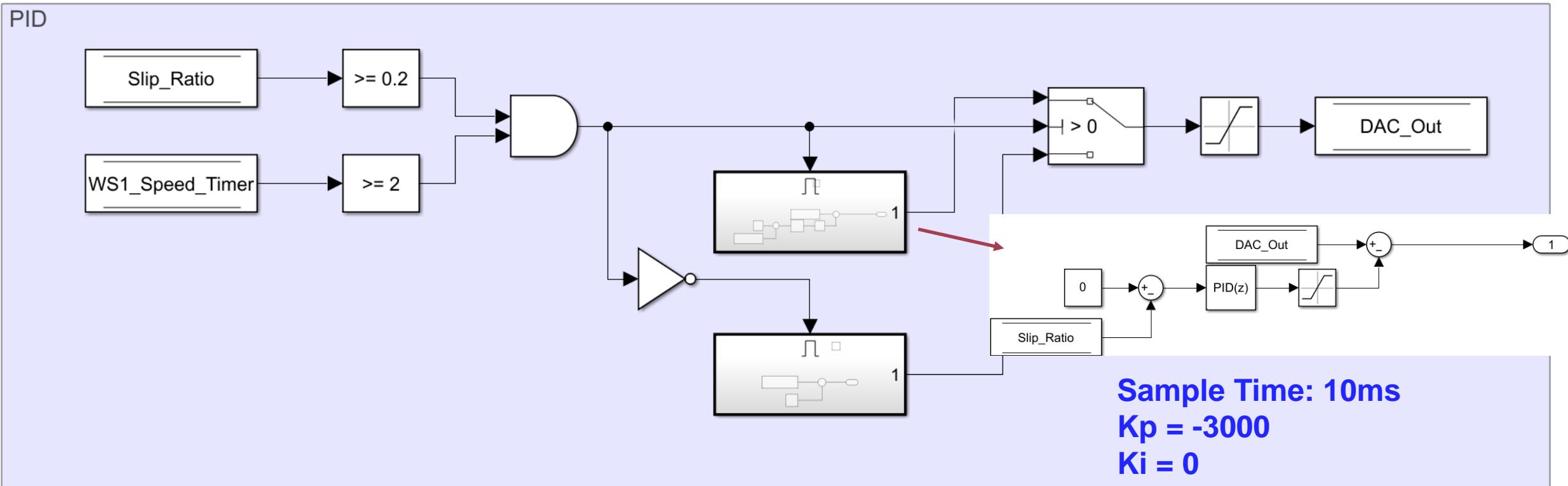
TCS ON OFF (Based on SlipRatio)



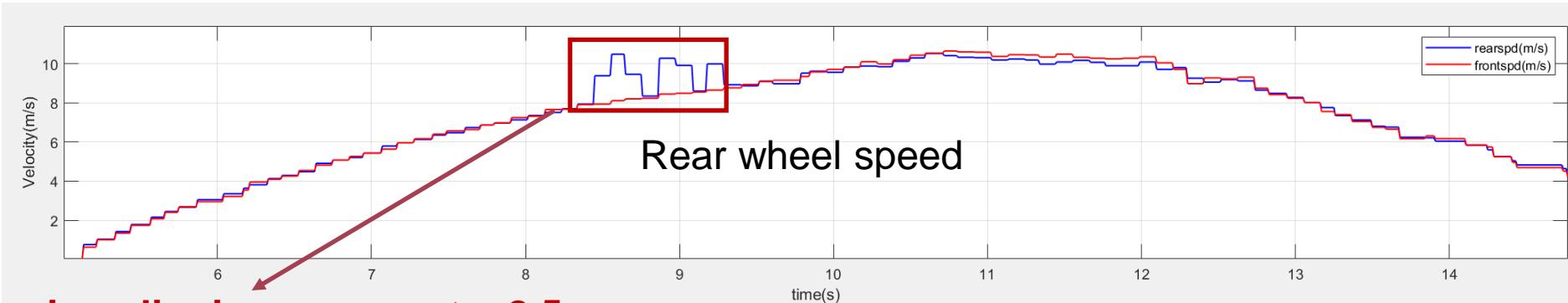
The graph showing characteristics of throttle

TCS PID (Based on SlipRatio)

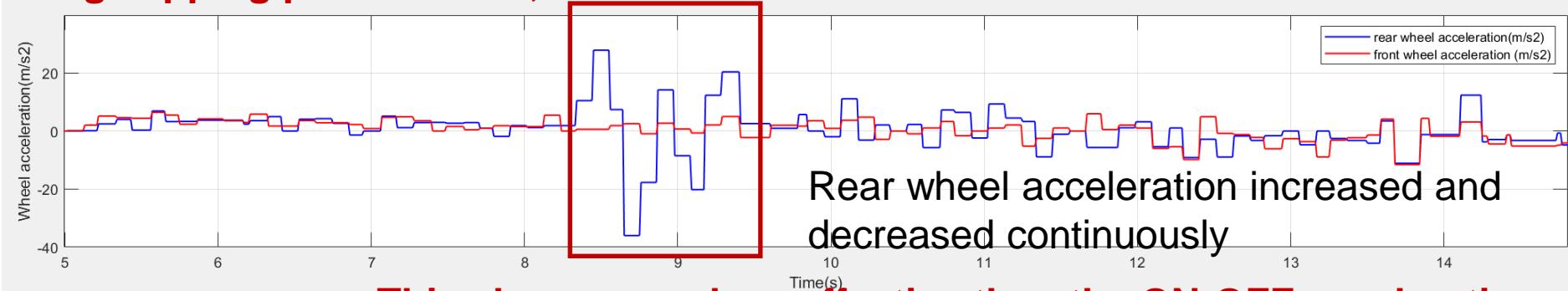
PID Controller setup



TCS PID (Based on SlipRatio)



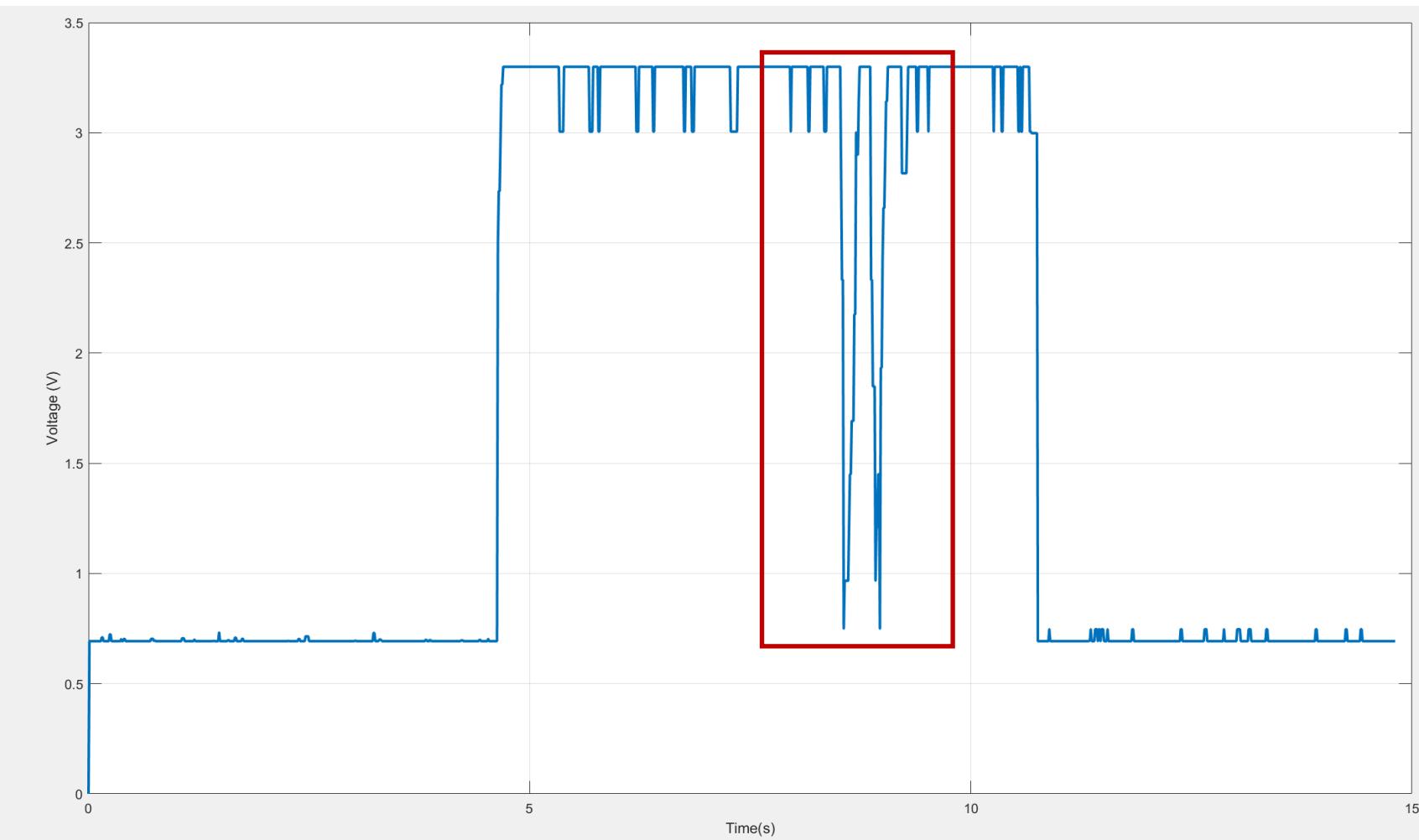
At the beginning slipping process $t = 8.5$ s



This change was less effective than the ON-OFF acceleration controller.



TCS PID (Based on SlipRatio)

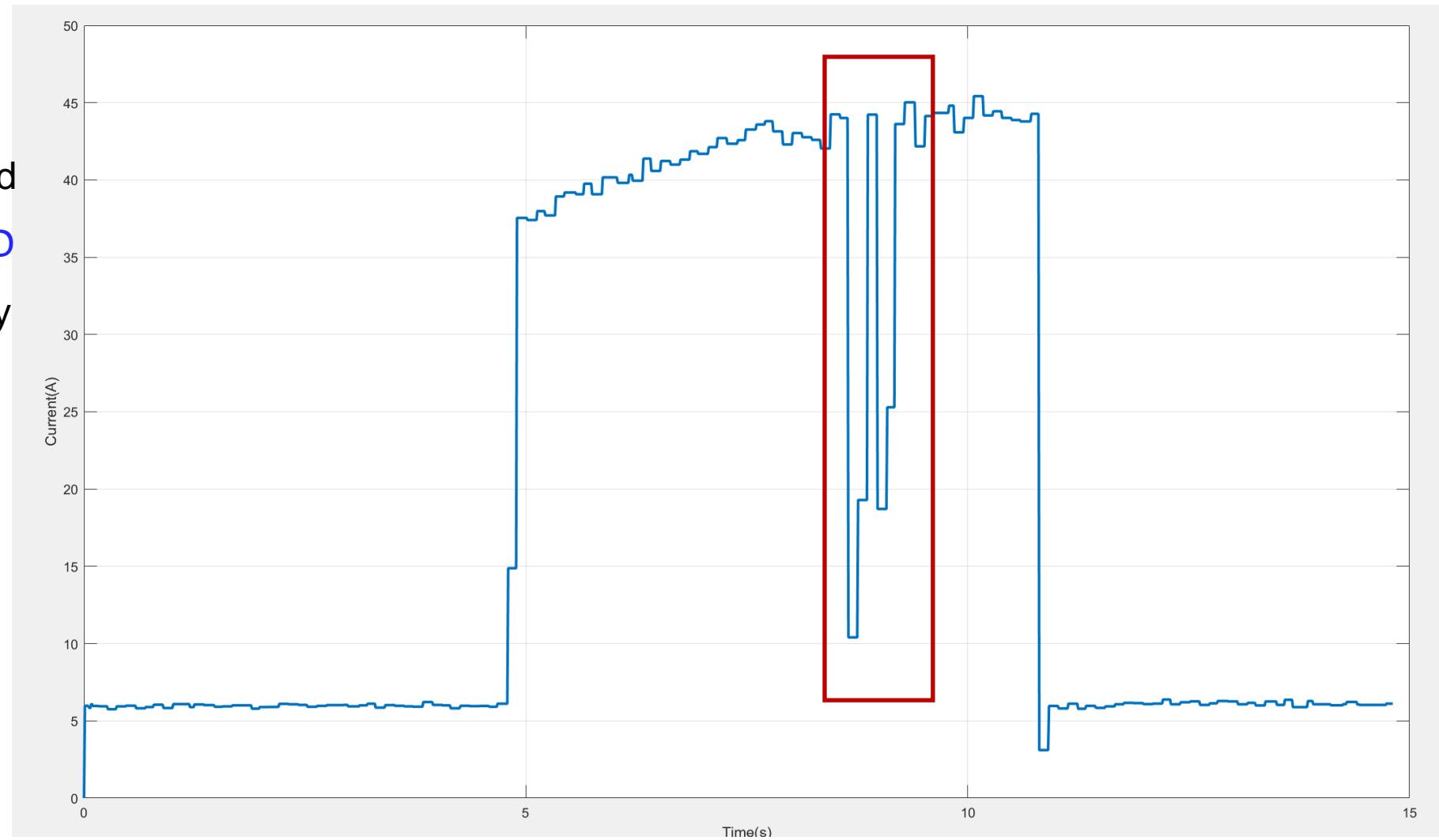


The graph showing characteristics of throttle

TCS PID (Based on SlipRatio)

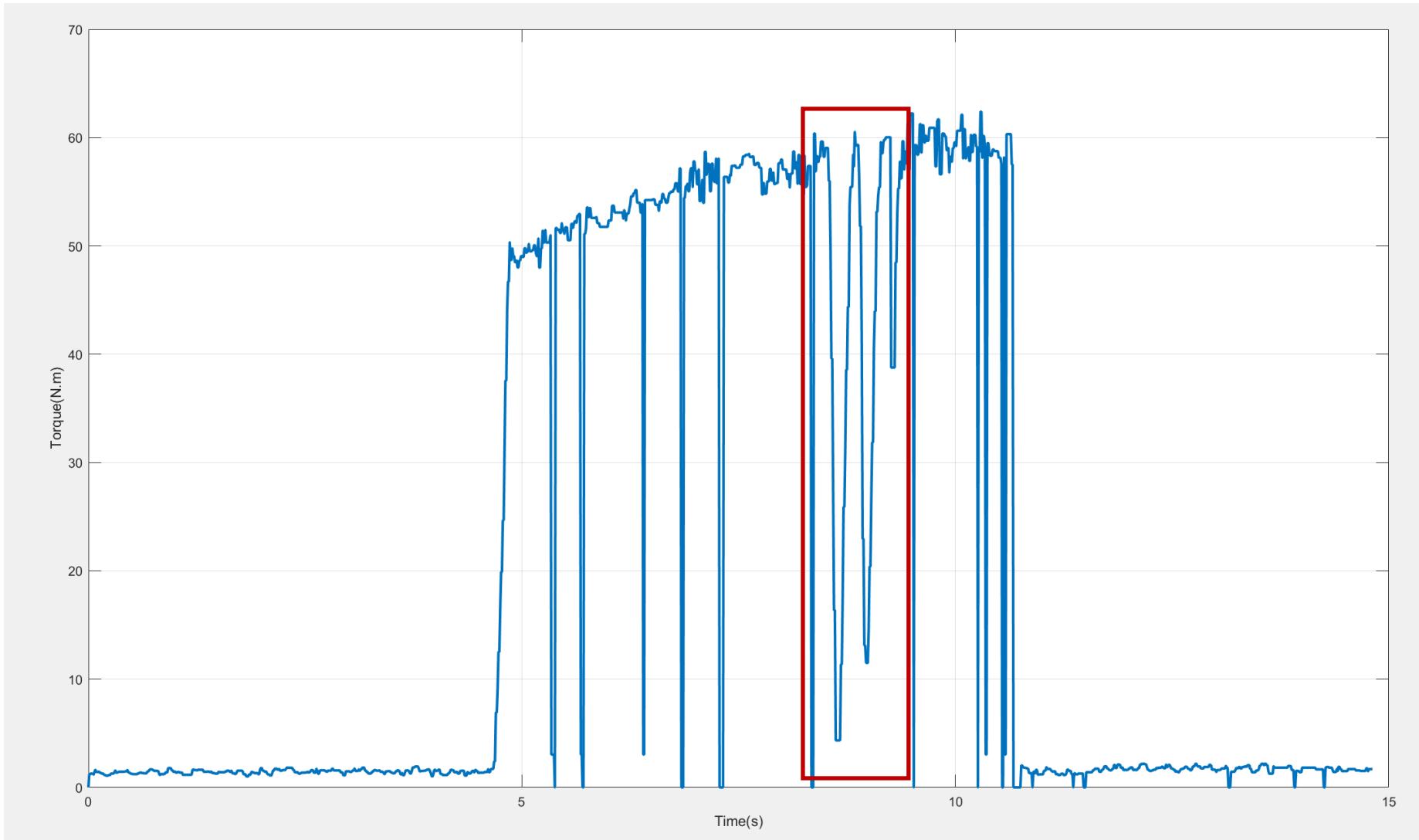
Comment and reviews:

- The phenomenon happened because sample time of PID controller is 10ms. That why we can see that fluctuation in this graph was less than ON-OFF controllers 5ms
- But we can adjust and tool again K_i, K_p, K_d with new sample time.*



The graph showing characteristics of current value

TCS PID (Based on SlipRatio)



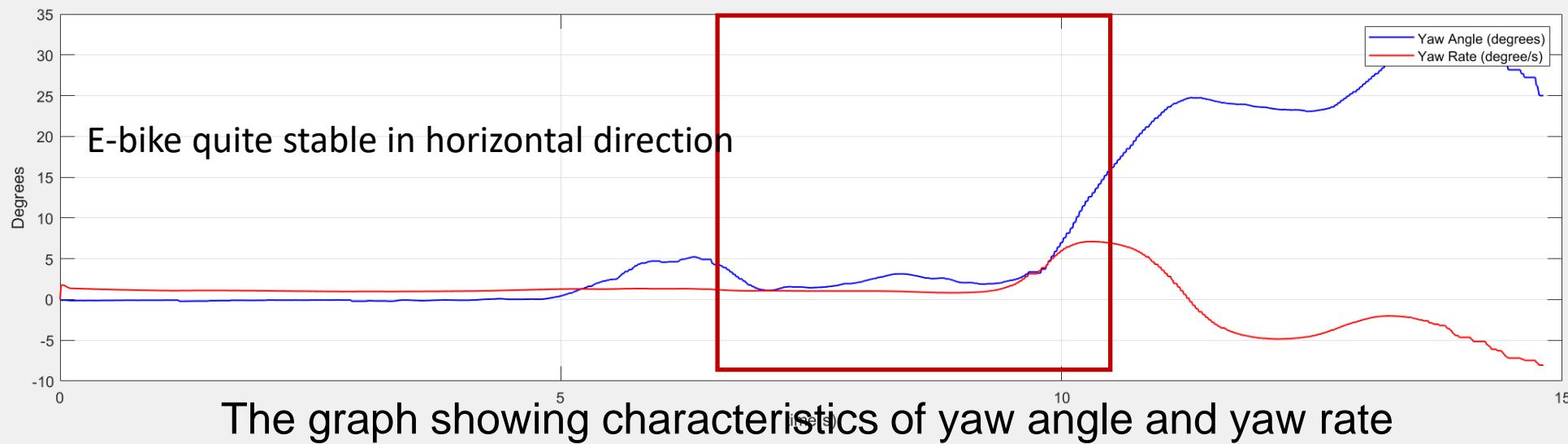
The graph showing characteristics of torque (N.m)

TCS PID (Based on Slip-Ratio)

Slipping process 8s – 10s



The graph showing characteristics of roll angle



The graph showing characteristics of yaw angle and yaw rate

Conclusion

- Controllers have been tested:
 1. ON – OFF (based slip ration)
 2. ON – OFF (rear wheel acceleration)
 3. PID (setpoint slip ratio = 0)
- An efficiency of controllers based on slip ratio: 2>3>1 is 0,15 ; 0,22 ; 0,3, respectively.
- Designed successfully traction control system for E-bike.
- This achievement can be used for educational purposes.
- A beginning stages for TCS which combines with ABS (equipped hydraulic brake system).
- Can communicate directly with Votol Driver to get necessary data in the future.

Thank you

For your attention



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WELCOME TO AML Automotive Mechatronics Lab