KPIT

MBD PROJECT

Anti-Lock Braking System

KPIT Technologies Ltd.

Sr. No	Name	Employee ID	Approved By
1	Indrajit Marathe	214846	Mr. Pawankumar Fakatkr

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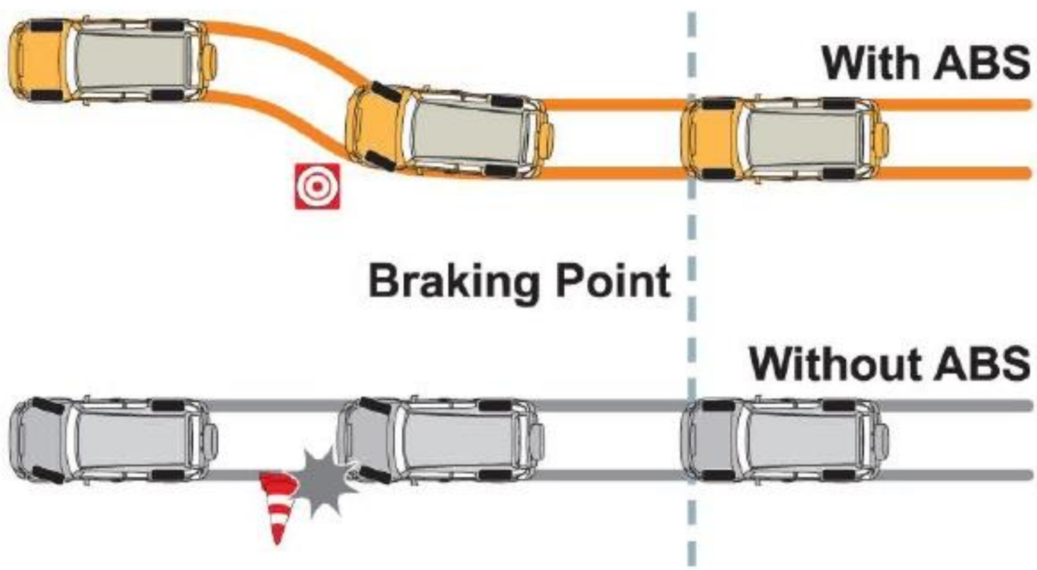
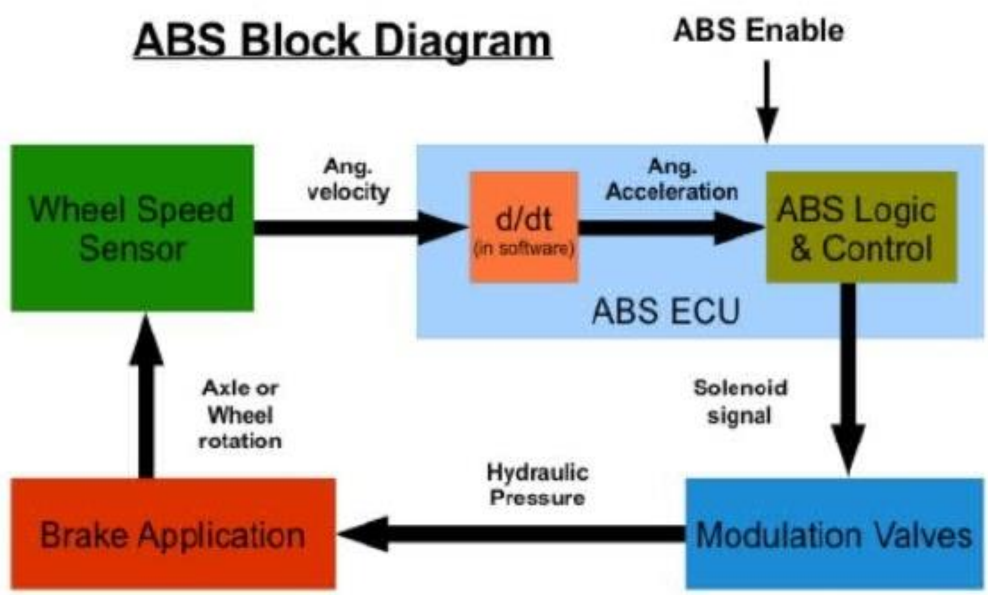
1.INTRODUCTION

- An anti-lock braking system (ABS) is a safety anti-skid braking system used on aircraft and on land vehicles, such as cars, motorcycles, trucks, and buses.
- ABS operates by preventing the wheels from locking up during braking, thereby maintaining tractive contact with the road surface and allowing the driver to maintain more control over the vehicle.
- ABS is an automated system that uses the principles of threshold braking and cadence braking, techniques which were once practiced by skillful drivers before ABS was widespread.
- ABS operates at a much faster rate and more effectively than most drivers could manage.
- ABS generally offer improved vehicle control and decreases stopping distances on dry and slippery surfaces.
- ABS modulate the brake line pressure independent of the pedal force, to bring the wheel speed back to the slip level range that is necessary for optimal braking performance.

2.BLOCK DIAGRAM





3.COMPONENT OF ABS SYSTEM

The primary components of the ABS braking system are:

- Electronic control unit (ECU)

  1.It receives signals from the sensors in the circuit and controls the brake pressure at the road wheels according to the data analyzed by the Unit.
  2.ECU assists the vehicle operator to prevent wheel lockup by regulating the wheel slip.

- Hydraulic control unit or modulator

  1.It receives operating signals from the ECU to apply or release the brakes under ABS conditions.
  2.It executes the commands using three solenoid valves connected in series with the master cylinder and the brake circuits- one valve for each front wheel hydraulic circuit, and one for both of the rear wheels. Thus, brakes can be actuated by controlling hydraulic pressure.

- Power booster and master cylinder assembly

  1.It is activated when the driver pushes down on the brake pedal. The master cylinder transforms the applied pedal force into hydraulic pressure which is transmitted simultaneously to all four wheels.
  2.It provides the power assistance required during braking.

- Wheel sensor unit

1.Speed sensors are comprised of a magnet wrapped in a coil and a toothed sensor ring. An electrical field given off by the contact between the magnet and the toothed ring creates a AC voltage.
2.The voltage frequency is directly proportional to the wheel's rotational speed.
3.It monitors the rotational speed of the wheel and transmits this data to the ABS control module.

4.WORKING OF ABS

- If a wheel-speed sensor signals a lock up - the ECU sends a current to the hydraulic unit. This energizes the solenoid valve. The action of the valve isolates the brake circuit from the master cylinder. This stops the braking pressure at that wheel from rising, and keeps it constant. It allows wheel velocity to increase and slip to decrease.

- When the velocity increases, ECU re-applies the brake pressure to restrict the wheel slip to a particular value.

- Hydraulic control unit controls the brake pressure in each wheel cylinder based on the inputs from the system sensor. This in result controls the wheel speed.

5.MATHAMATICAL MODEL

- Wheel slip:

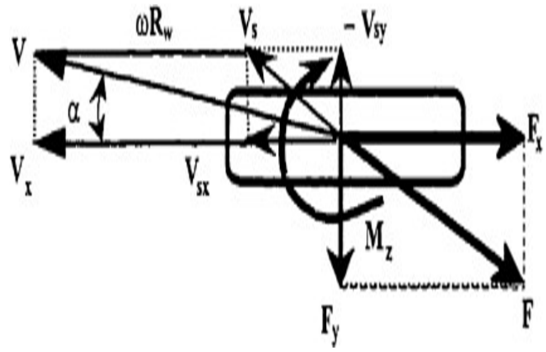
  When the braking action is initiated, a slippage between the tire and the contacted road surface will occur, which make the speed of the vehicle to be different from that of the tire.

- The longitudinal slip is defined as

$$S = \frac{V\cos\alpha - \omega R_w}{V\cos\alpha}$$

The side slip angle is

$$\alpha = \tan^{-1}\frac{V_{sy}}{V_x}$$



Force and velocity components on tire

➢ Vehicle dynamics

According to Newton's second law, the equation of motion of the simplified vehicle can be expressed by,

$$m_t V = -F_t - F_a$$

The road friction force is given by Coulomb law

$$F_t = \mu N$$

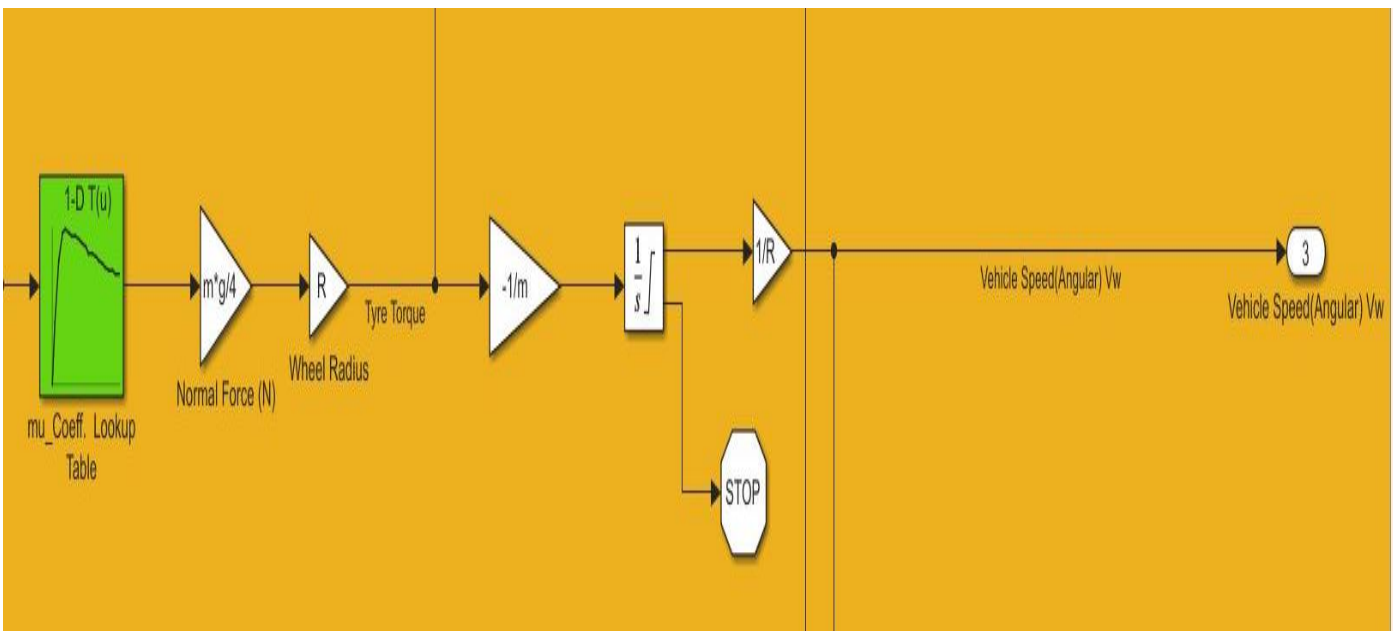
The total mass of the quarter vehicle can be written as

$$m_t = m_{tire} + \frac{m_c}{4}$$

Thus, the total normal load cm be expressed by

$$N = m_t g - F_l$$

F_l is the longitudinal weight transfer load due to braking

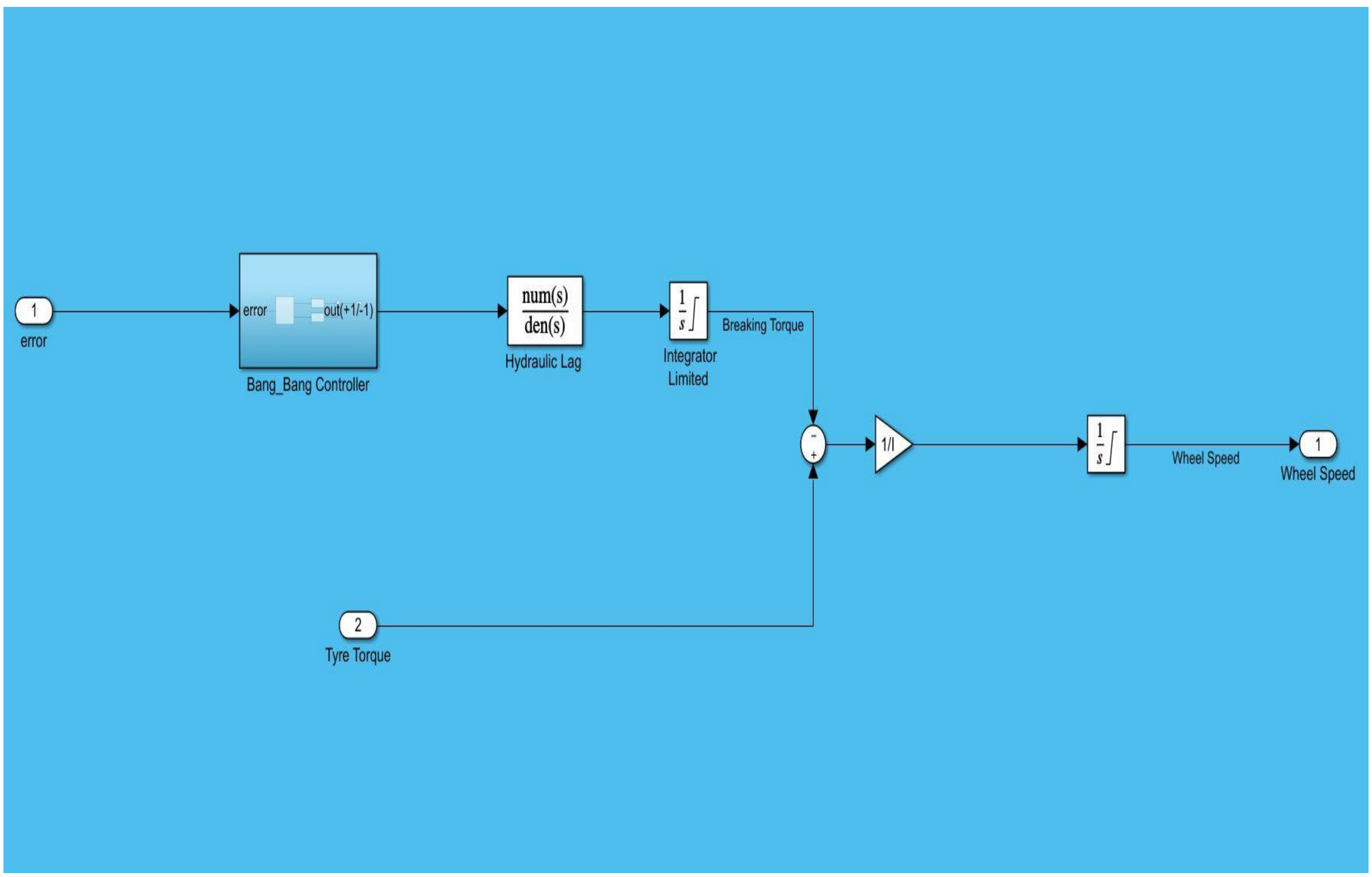


Simulink model for Vehicle Dynamics

➢ Wheel dynamics

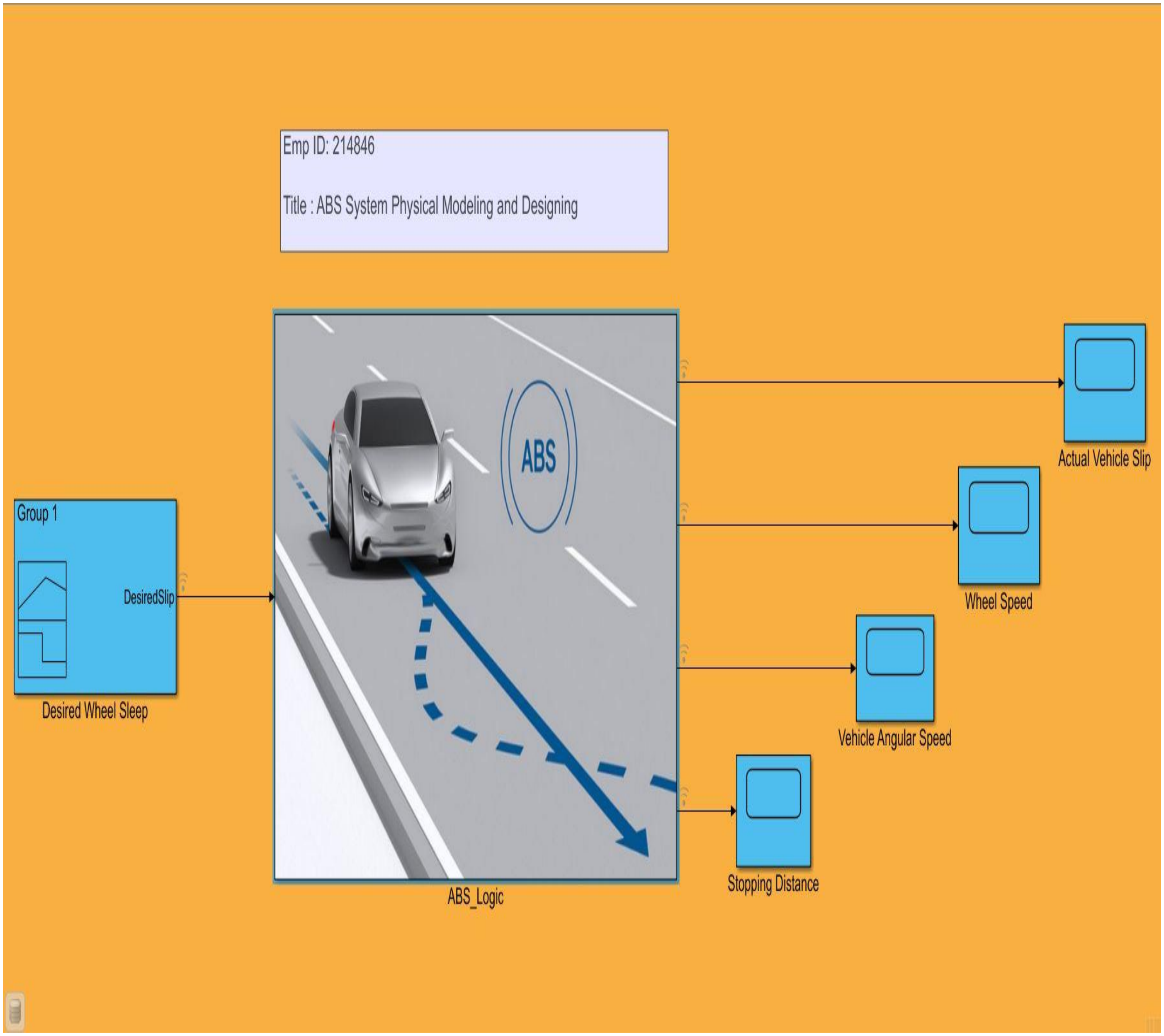
According to Newton's second law, the equation of motion at wheel level for the rotational DOF is given by,

$$J_w \omega = -T_b + F_t R_w$$

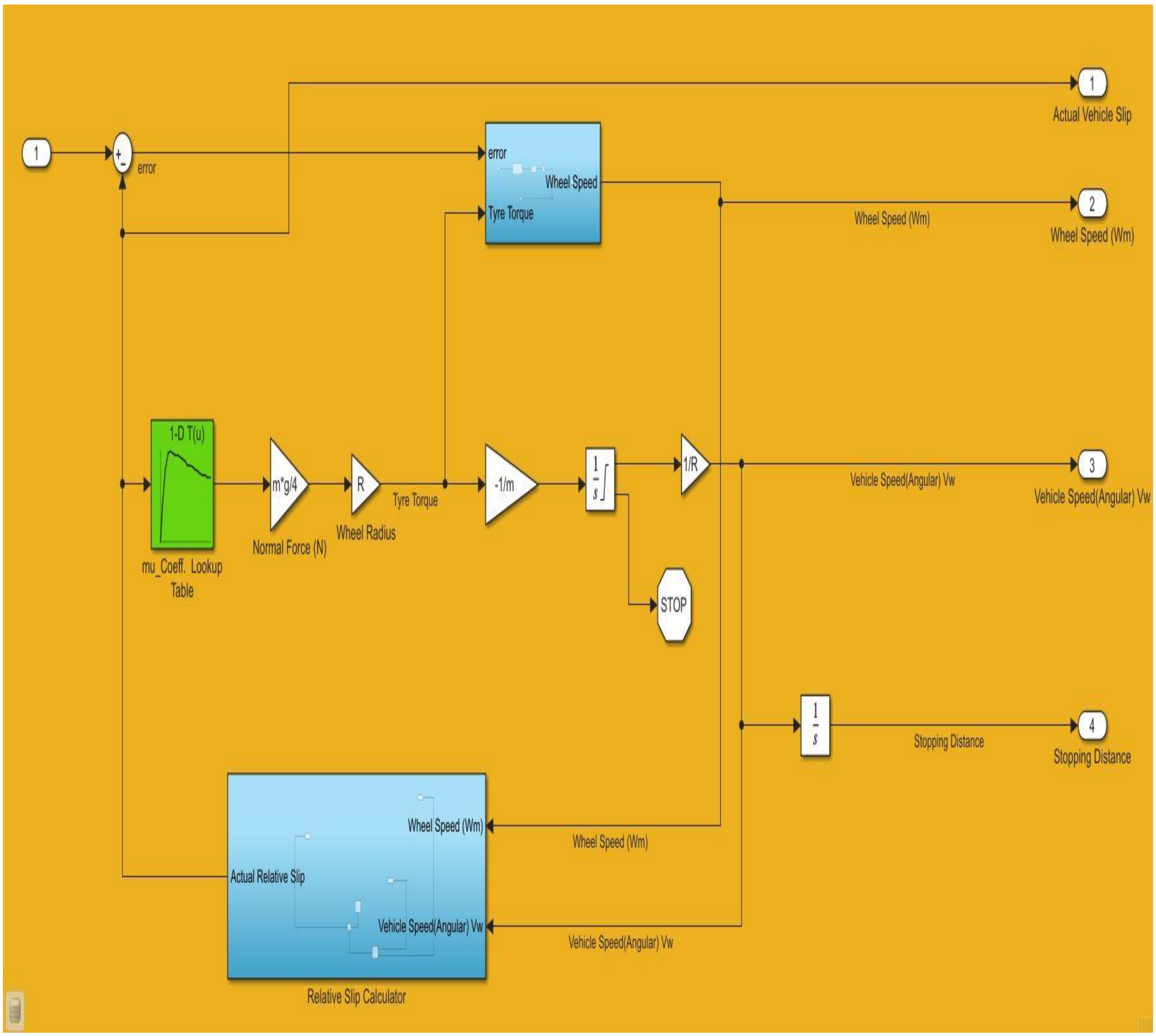


Simulink model for Wheel Dynamics

➢ ABS MODEL:



Emp ID: 214846
Title : ABS System Physical Modeling and Designing
Group 1
DesiredSlip
Desired Wheel Sleep
ABS
ABS_Logic
Actual Vehicle Slip
Wheel Speed
Vehicle Angular Speed
Stopping Distance


1
error
Wheel Speed
Tyre Torque
Actual Vehicle Slip
Wheel Speed (Wm)
2
1-D T(u)
mu_Coeff. Lookup Table
m*g/4
Normal Force (N)
R
Wheel Radius
Tyre Torque
-1/m
1/R
STOP
Vehicle Speed(Angular) Vw
3
Stopping Distance
4
Actual Relative Slip
Vehicle Speed(Angular) Vw
Relative Slip Calculator

6. INPUT PARAMETER FOR SIMULINK MODEL FOR ABS SYSTEM

1.Gravitational constant
g = 9.01 cm/s^2

2.Initial velocity of vehicle
v_0 = 88 cm/s

3.Wheel Radius
Rr = 1.25 cm

4.Mass of vehicle
m = 75kg.

5.Maximum Braking Torque
$T_{b_{max}}$=1500 $lbf*ft$

6.Hydraulic Lag
TB =0.01 s

7.Moment of Inertia
I= J_w = 6 ft^4

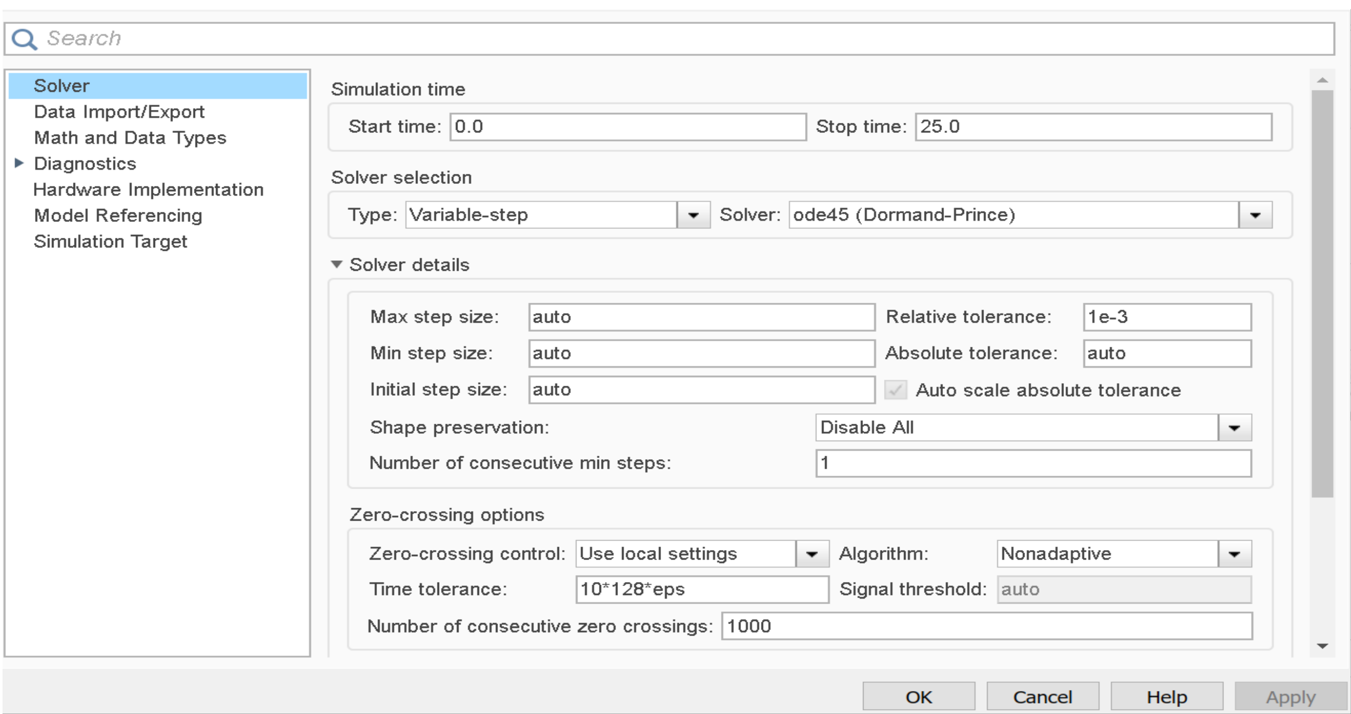
7.SOLVER SELECTION STRATEGY

ode45

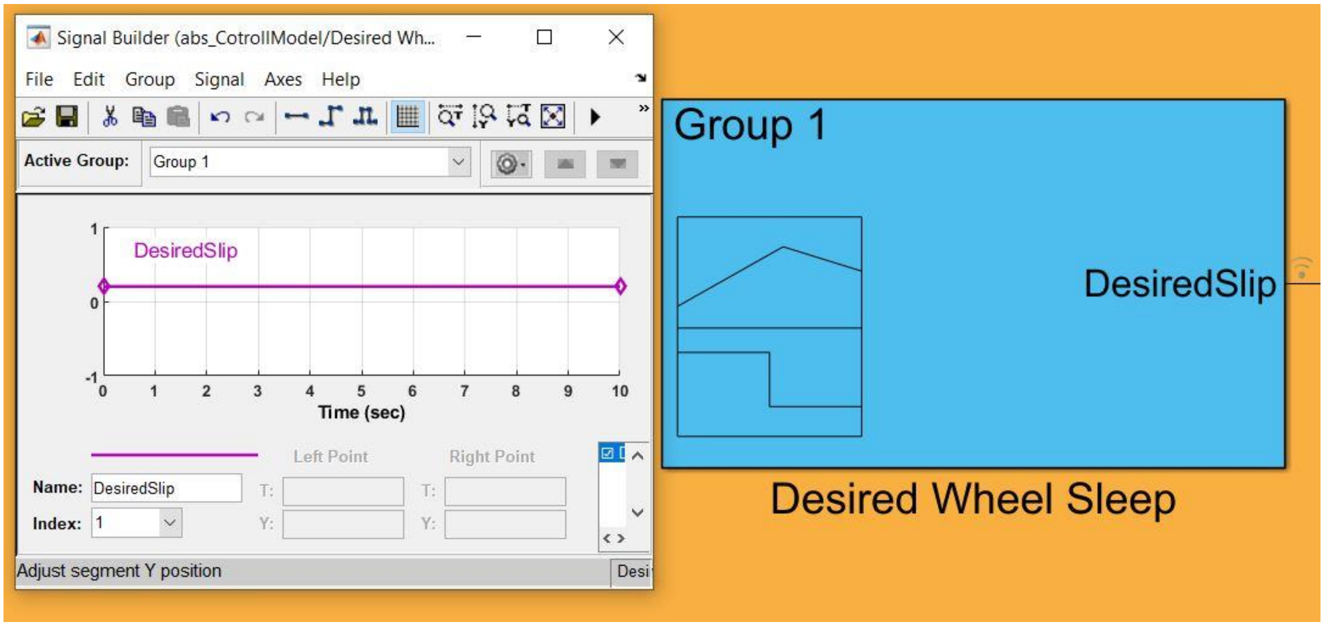
Solve differential equations — medium order method

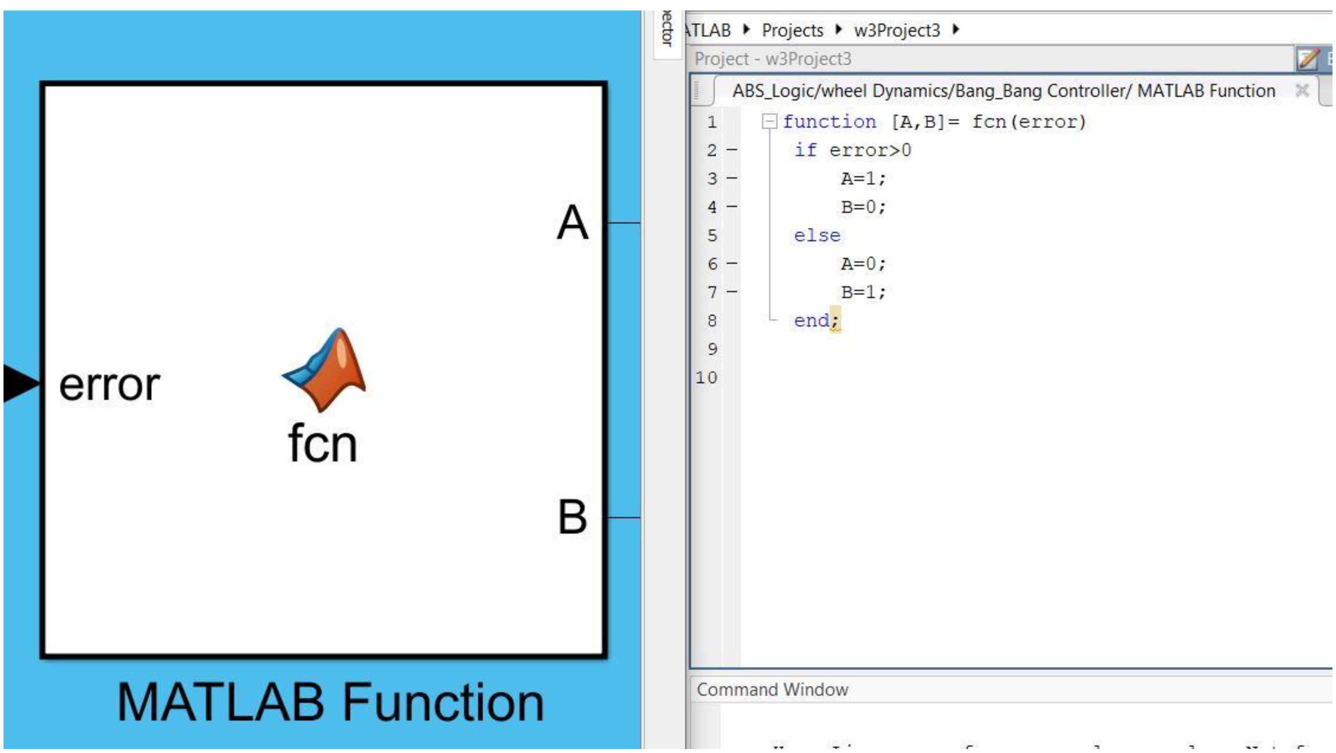
Syntax

```
[t,y] = ode45(odefun,tspan,y0)
[t,y] = ode45(odefun,tspan,y0,options)
[t,y,te,ye,ie] = ode45(odefun,tspan,y0,options)
sol = ode45(___)
```

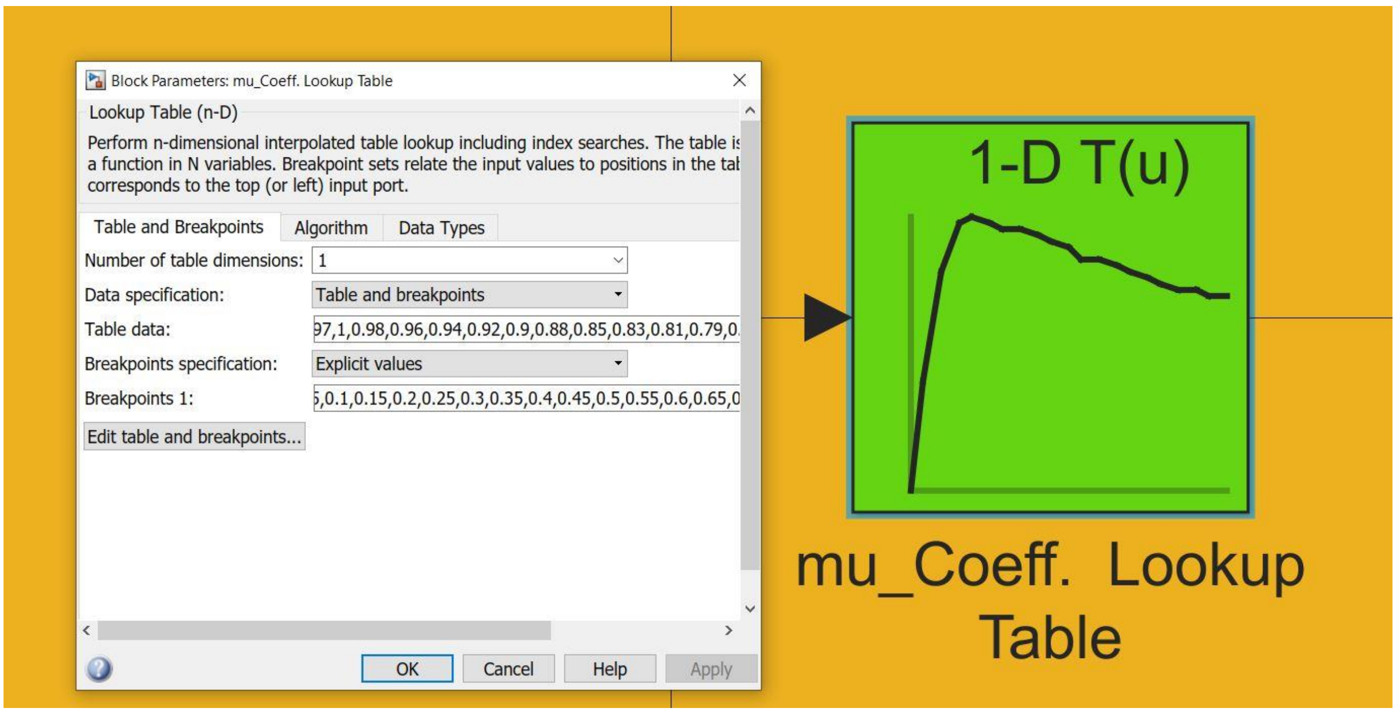


8. SIGNAL BUILDER AND MATALAB FUNCTION

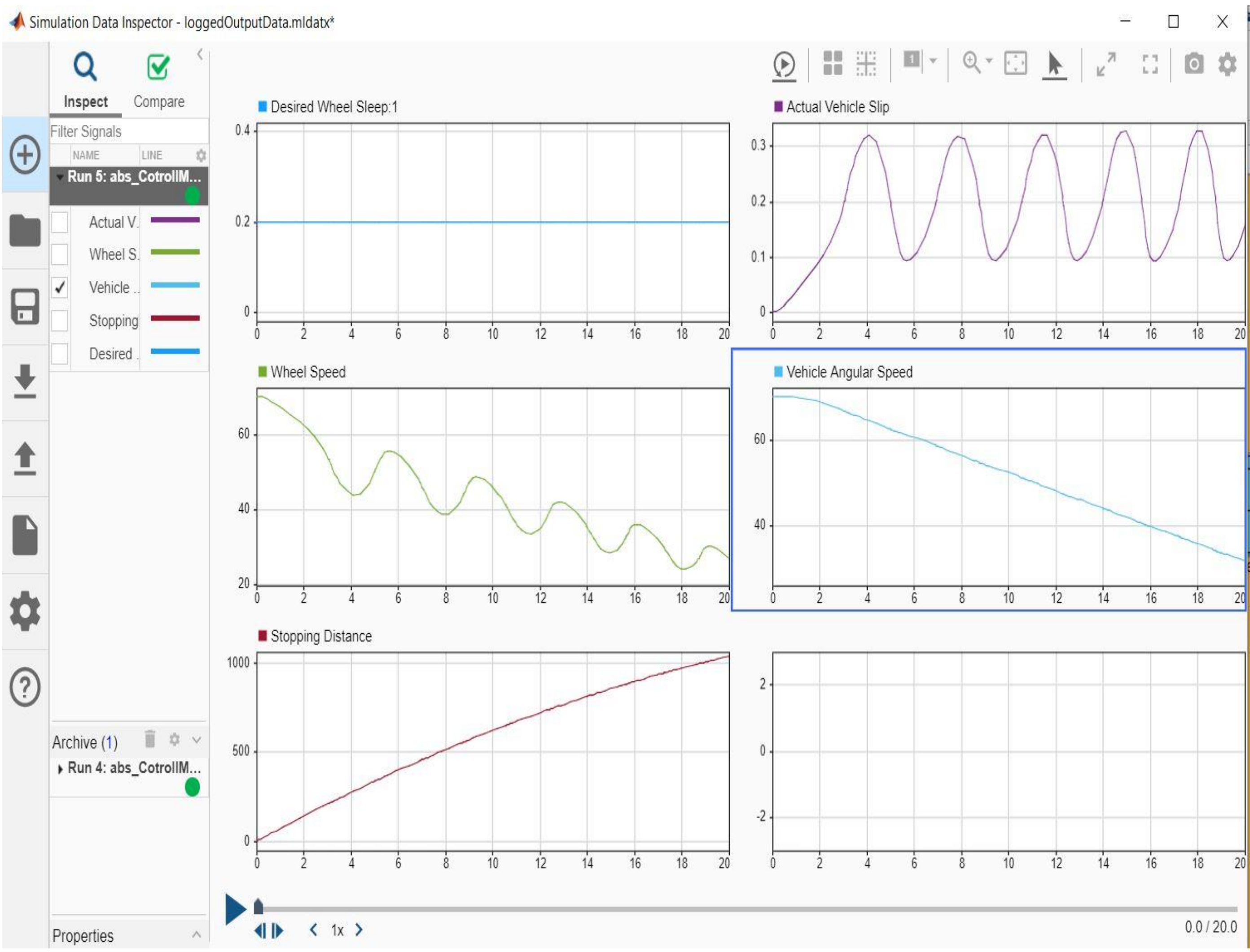




9. LOOK UP TABLE



9. DATA INSPECTOR



10.RESULT OF SIMULATION