ANTI - LOCK BREAKING SYSTEM (ABS)

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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 uses electronics to detect and prevent wheel lock up. This helps a driver maintain control of a vehicle when braking in low grip situations, because a car's steering will still work when ABS is engaged.

The main advantages of using ABS system in vehicle is that it provides better control over the vehicle and decreases stopping distance on dry and slippery surfaces. If ABS installed vehicle the chance of skidding is very less and hence it provides a better steering control during braking.

2.Working

- ABS is part of an overall stability system, commonly known as electronic stability control, which monitors wheels under heavy braking. Each wheel has a sensor attached to it. If the intelligent sensors detect that a wheel is about to lock up and stop moving, the system will release the brake. The release is only for a moment.

- In a vehicle, wheel speed sensors are located on the wheels that monitor the speed of each wheel. The electronic control unit (ECU) reads the signal from each sensor. After the speed sensors detect that the speed of any of the wheel(s) is reducing drastically compared to others, the ECU sends the signal to the valves of the respective wheel(s) to reduce the brake pressure, and the valves get closed.
- After this, the wheels start to accelerate again, and the signal is sent to the ECU one more time, which in turn sends the signal to open the valve and increase the brake pressure, and hence, brakes are applied.
- The cycle repeats itself until the application of brakes becomes normal.

3.Modelling of Anti-Lock Braking System

The wheel rotates with an initial angular speed that corresponds to the vehicle speed before the brakes are applied. We used separate integrators to compute wheel angular speed and vehicle speed. We use two speeds to calculate slip, which is determined by Equation 1. Note that we introduce vehicle speed expressed as an angular velocity (see below).

$$\omega_v = \frac{V}{R} \text{ (equals the wheel angular speed if there is no slip)}$$

Equation 1

$$\omega_v = \frac{V_v}{R_r}$$

$$slip = 1 - \frac{\omega_w}{\omega_v}$$

$\omega_v =$ vehicle speed divided by wheel radius

$V_v =$ vehicle linear velocity

$R_r =$ wheel radius

$\omega_w =$ wheel angular velocity

From these expressions, we see that slip is zero when wheel speed and vehicle speed are equal, and slip equals one when the wheel is locked. A desirable slip value is 0.2, which means that the number of wheel revolutions equals 0.8 times the number of revolutions under non-braking conditions with the same vehicle velocity. This maximizes the adhesion between the tire and road and minimizes the stopping distance with the available friction.

Simulink Model

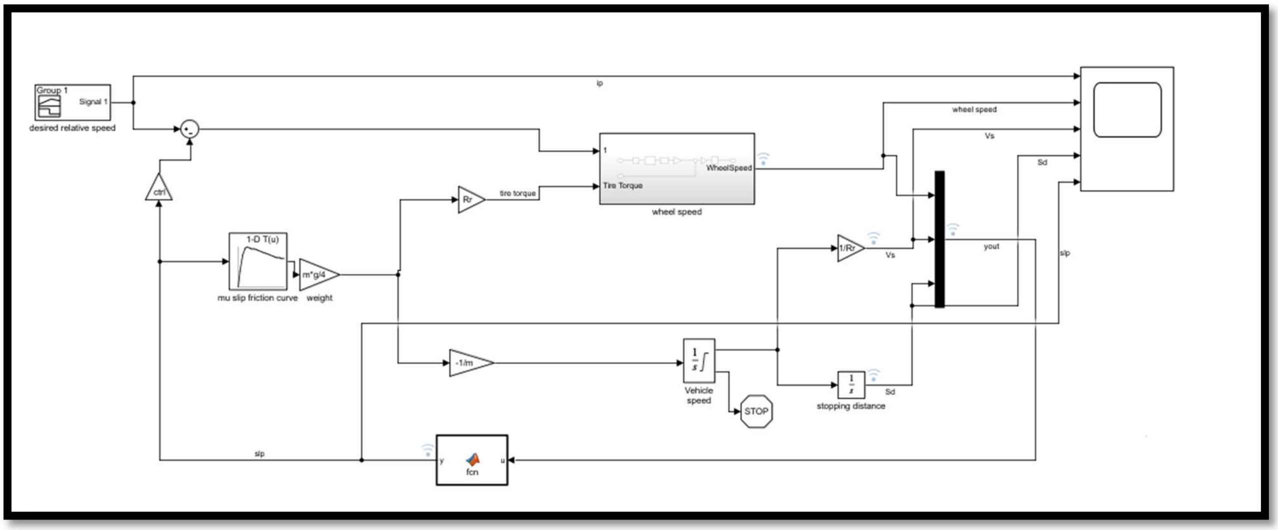


Figure 1 Abs model

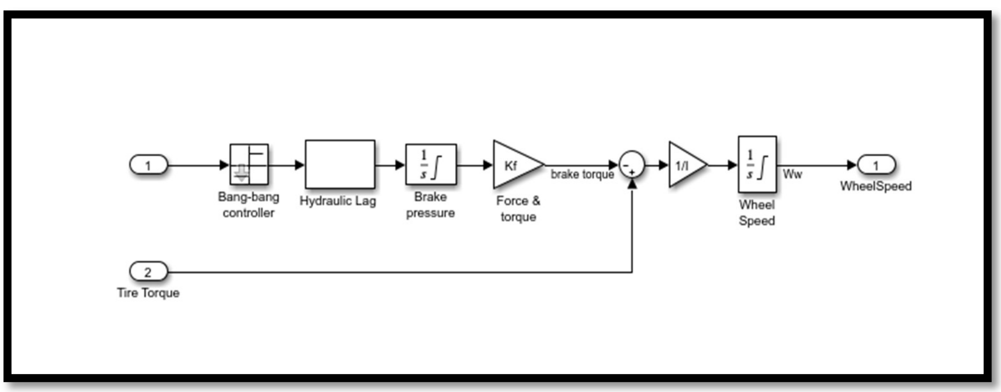


Figure 2 wheel speed subsystem

4.Skills Demonstrated

1. <u>Callbacks</u>

   A **callback** is a function that executes in response to some predefined user action. Associate a callback with a specific user action by assigning a function to the callback property for that user action.

Callback Function demonstrated for model:

1. **Initialization function (InitFcn)** is a type of callback that is executed or evaluated at the beginning of model compilation. It Initial Parameter used in the model . i.e. init

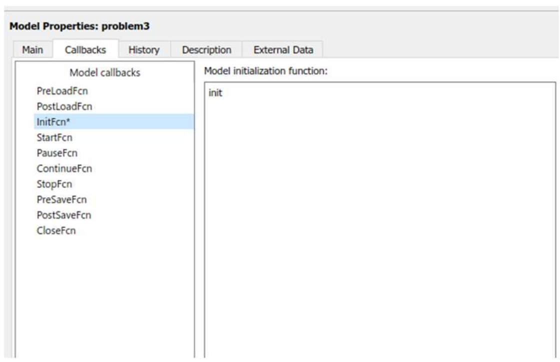
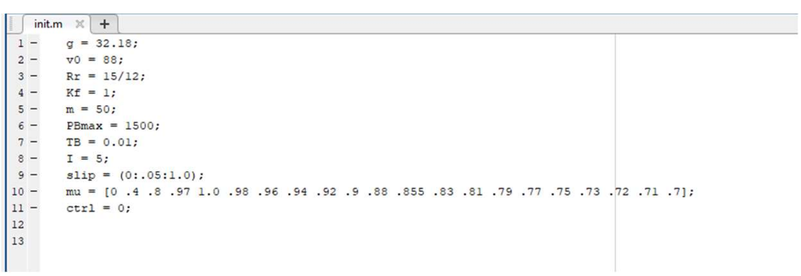


Figure 3 Model explorer - Call back functions



```
init.m
g = 32.18;
v0 = 88;
Rr = 15/12;
Kf = 1;
m = 50;
PBmax = 1500;
TB = 0.01;
I = 5;
slip = (0:.05:1.0);
mu = [0 .4 .8 .97 1.0 .98 .96 .94 .92 .9 .88 .855 .83 .81 .79 .77 .75 .73 .72 .71 .7];
ctrl = 0;
```

Figure 4 Initialization of variables

2. Data Inspector

The Simulation Data Inspector visualizes and compares multiple kinds of data.

The Simulation Data Inspector to visualize the data that we generate throughout the design process and data that we log in a Simulink model logs to the Simulation Data inspector.

In designed model **ABS,** signals logged are Vehicle speed, wheel speed, Stopping distance and slip , to visualize the results.

Figures of Results obtained with and without ABS are placed below:

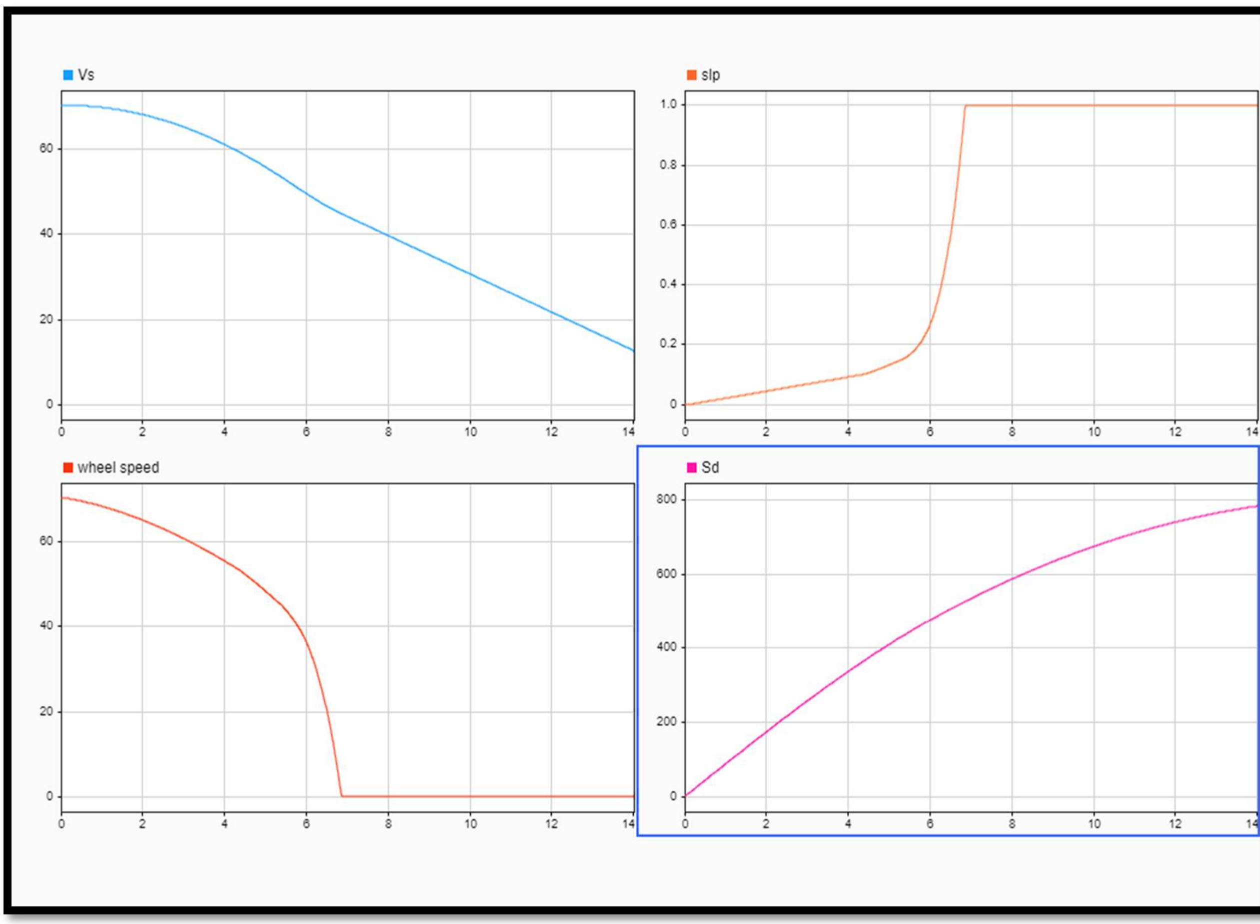


Figure 5 Data inspector : Results without ABS

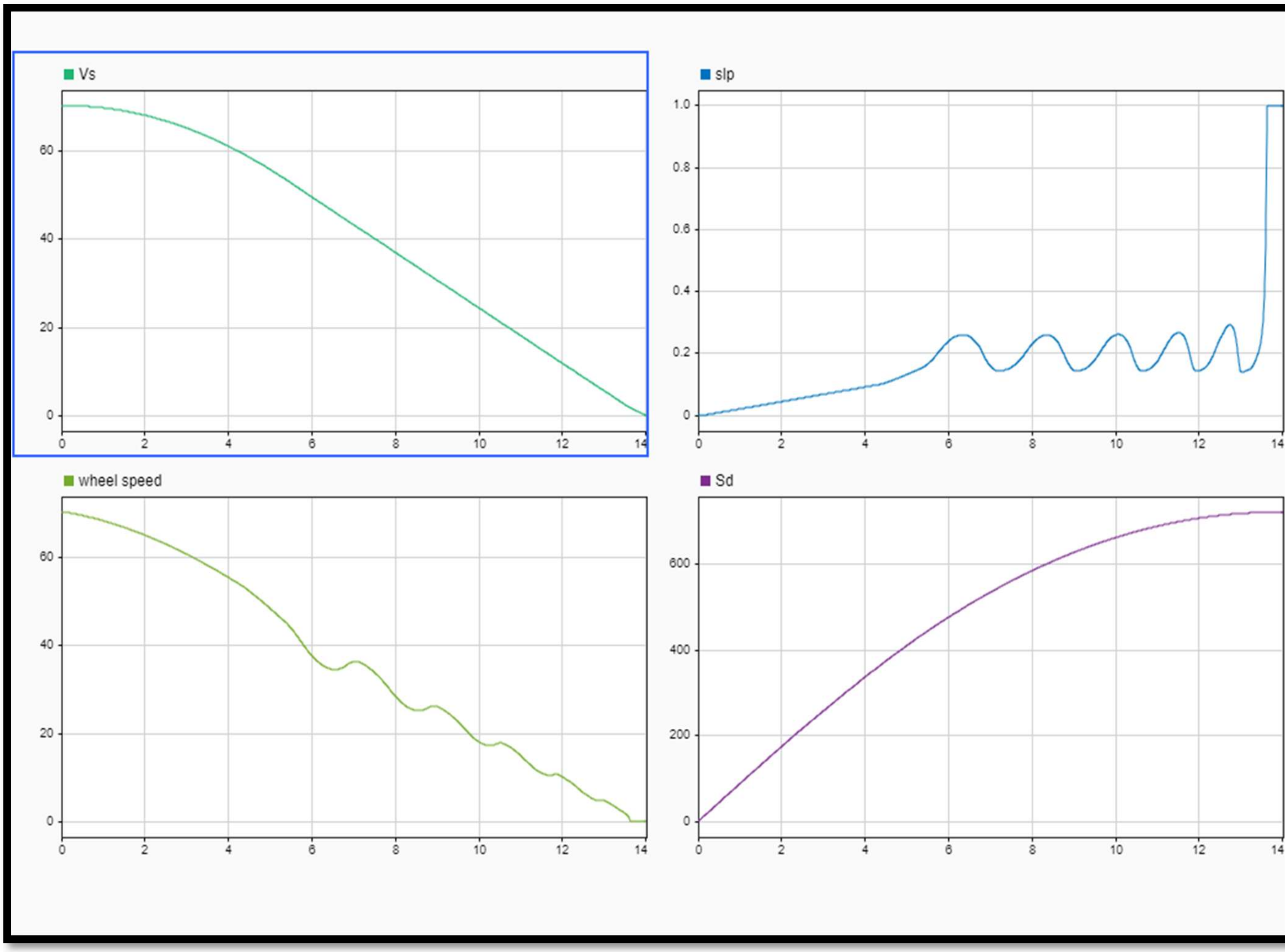


Figure 6 Data inspector : Results with ABS

3. <u>Solver</u>

In **ABS** model solver selection:

- Type: Variable –step.
- Solver: ode45(Dormand Prince).
- Problem type: Non stiff.
- Accuracy: Medium.
- This solver computes the model's state at the next step using an explicit Runge –Kutta (4,5) formula for numerical integration.
- Explicit takes care of absolute / Relative tolerance and finishes computation faster.
- The reason of choosing the ode45 solver is that it has more accuracy than ode23 and ode113 when it comes to a Non stiff problem type.
- ode45 does more work per step than ode23 and ode113.

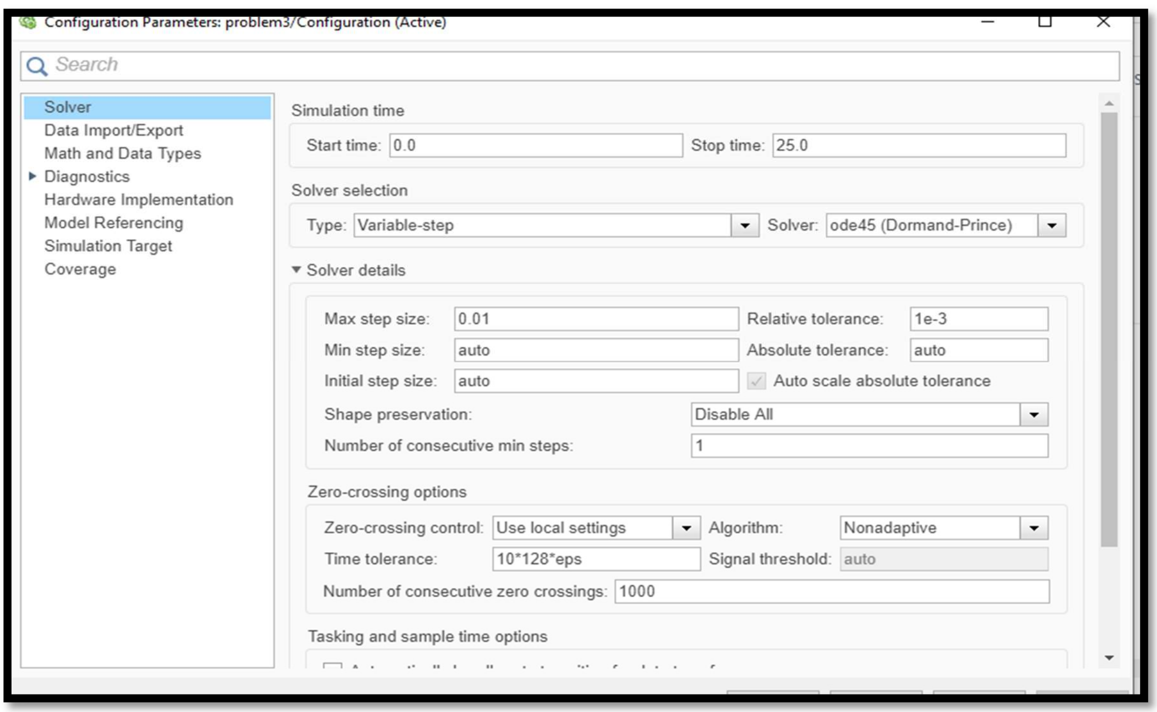


Figure 7 Model configuration :solver setting

4. MATLAB Function Block

MATLAB Function blocks enable you to define custom functionality in Simulink® models by using the MATLAB language.

In designed **ABS** model MATLAB Function block is used to calculate Relative Slip. It takes input from bus selector output and gives Slip as output.

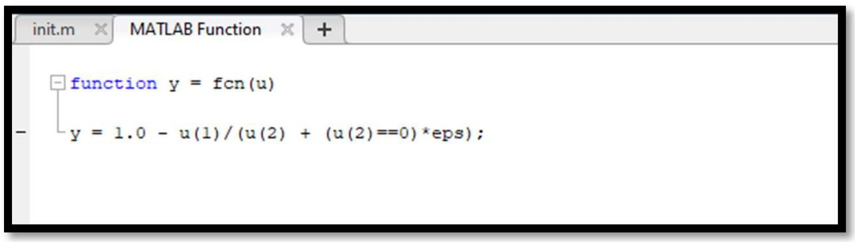


Figure 8 MATLAB Function Block

5. LOOK UP TABLE

Look up tables are used to model non linearity, it uses array of data to map input values to output values approximating mathematical functions.
In ABS model I have used 1-D look up table for generating mu slip friction curve.
mu and slip variables are initialized in init function.

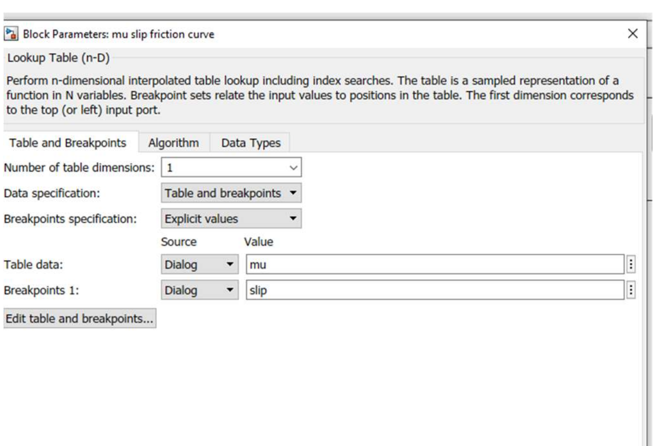


Figure 9 1-D look up Table

6. SIGNAL BUILDER

The Signal Builder block allows us to create interchangeable groups of piecewise linear signal sources and use them in a model.

In ABS model, signal builder is used to generate constant input signal which is Desired Relative speed , which is given input to the ABS model.

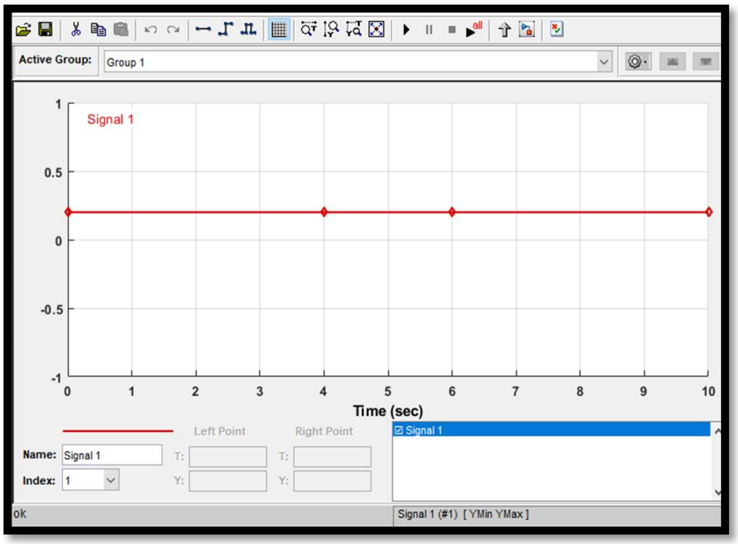


Figure 10 signal builder used to generate desired relative speed

7.References

https://in.mathworks.com/help/simulink/slref/modeling-an-anti-lock-braking-system.html

https://en.wikipedia.org/wiki/Anti-lock_braking_system

https://www.confused.com/on-the-road/gadgets-tech/what-is-abs

https://www.mathworks.com/help/