Report

1. Anti-Lock Braking System :

ABS works by detecting individual wheel-lock and momentarily releasing the brakes on that wheel, by decreasing the amount of brake fluid supplied to the wheel to allow the wheel to regain traction. ABS prevents wheel lock-up and consequent sliding under heavy braking or on slippery road surfaces.

Wheel lock-up causes loss of steering and vehicle control, so ABS allows the driver to steer away from hazards, even on slippery surfaces, while applying maximum braking force.

1.1 Equation

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

Wv = Vv / Rr

where,

Wv = Vehicle speed divided by Radius of the wheel
Vs = Vehicle Linear velocity
Rr = Wheel radius
Slip = 1 – (Ww/Wv)
Ww = Wheel angular velocity

1.2 Callbacks

PreLoadFcn callback is used (shown in fig.(a)), to initialize the default data for the model before it loads. To clear the workspace variables when closing the model, the CloseFcn callback is utilized (shown in fig.(b)) as it clears the initialized data in the workspace to prevent it from being cluttered.

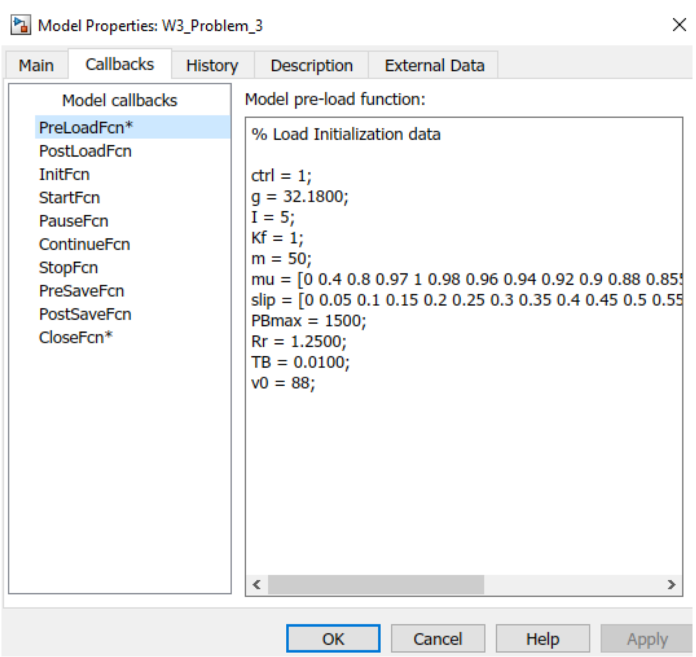


Fig.(a)

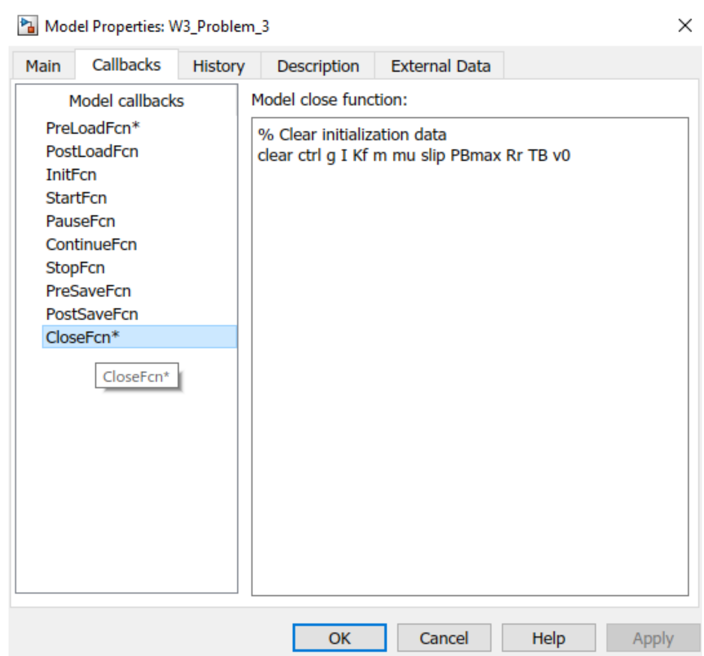


Fig.(b)

1.3 Data Inspector

From the equations, we see that slip is zero when wheel speed and vehicle speed are equal, and slip equals one when the wheel is locked.

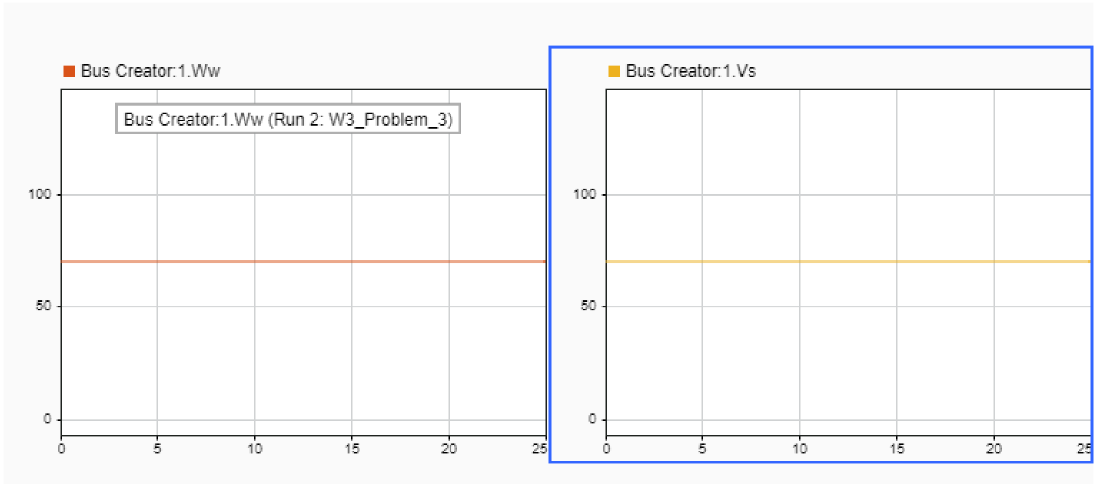


Fig.(c) Slip = 0; Vs = Vehicle Speed & Ww = Wheel Speed

Without the Anti-Lock Braking System, (ctrl is set to ‘0’ in the model), the wheel locks up at 9 secs as shown in the first plot of Fig. (d) and skids for a while.

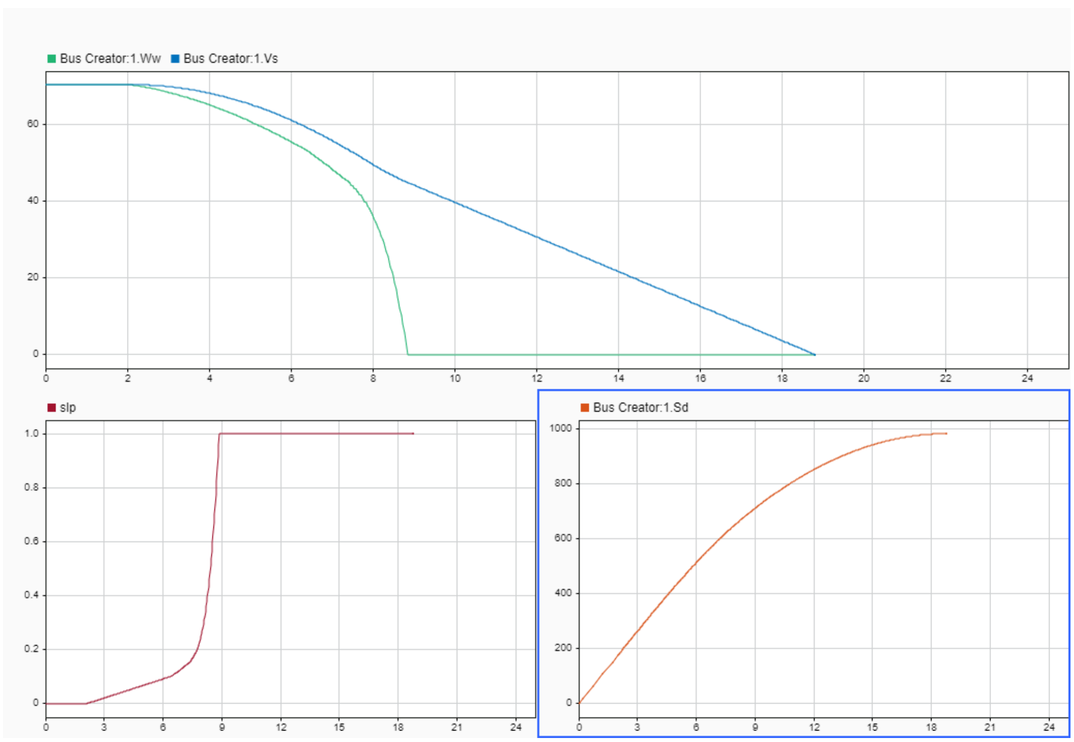


Fig.(d) Without ABS

After employing the ABS, (ctrl is set to ‘1’), the wheel is prevented from being locked up as shown in the first plot of fig.(e)

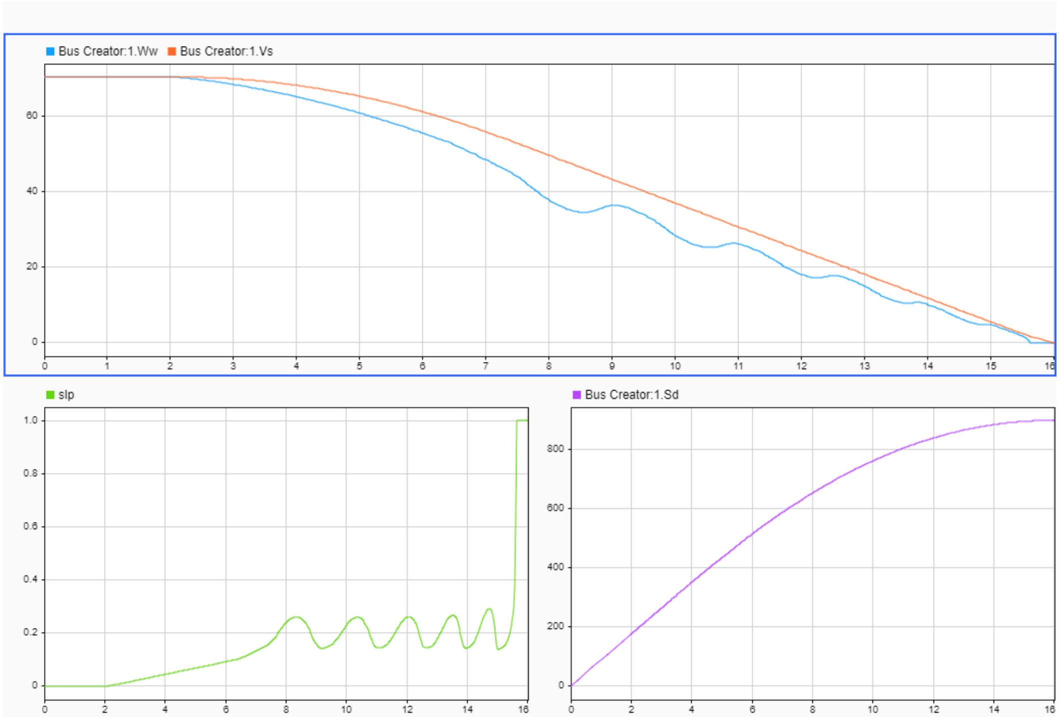


Fig.(e) With ABS

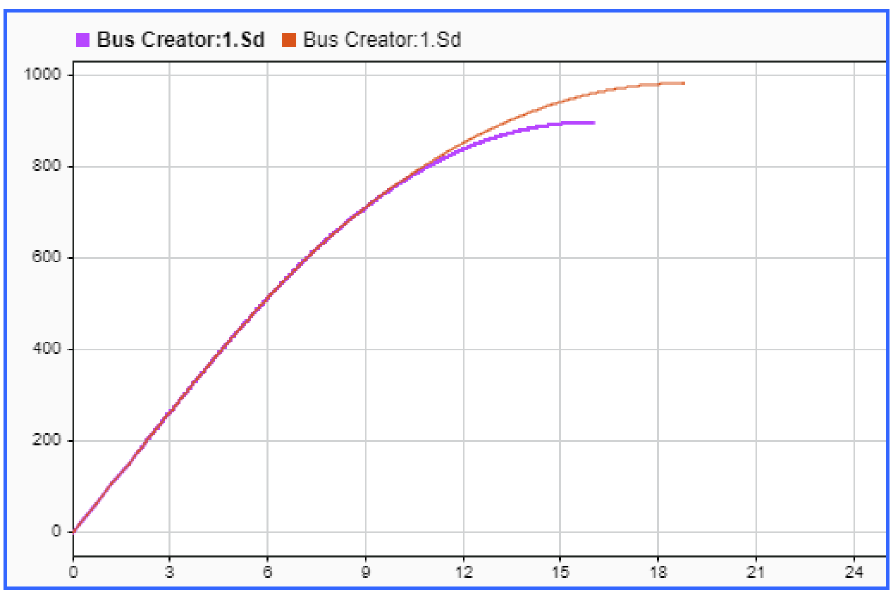
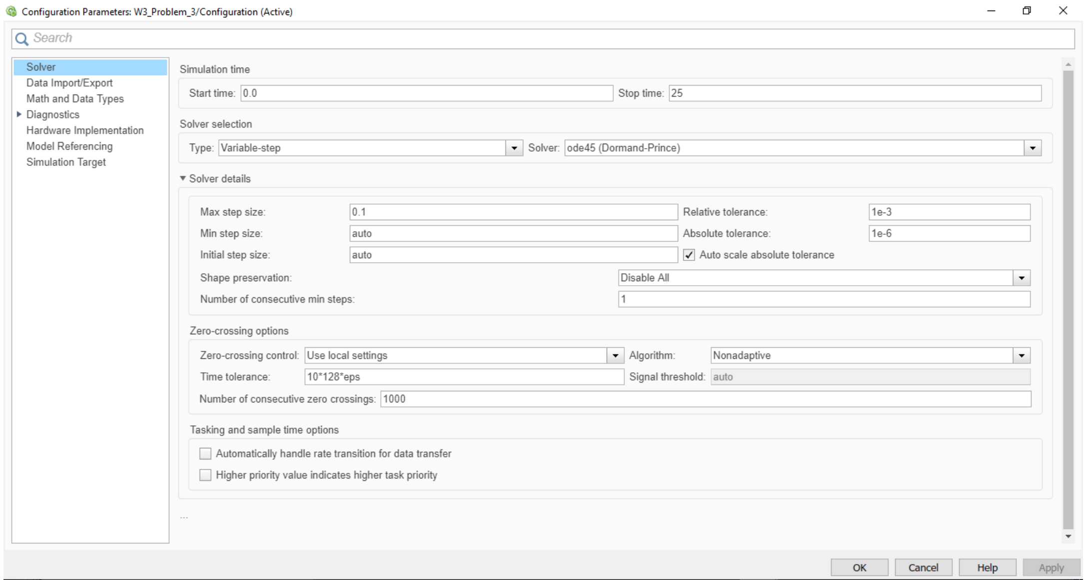


Fig.(f) With ABS (Purple) vs Without ABS (Orange)

When compared to each other (as shown in fig. (f)), it is observed that the distance travelled by the vehicle after applying hard-brake is more as compared to the one using ABS, i.e., the vehicle's tires without the Anti-Lock Braking System skids more and takes longer time to come to a halt.

1.4 Solver selection strategy

Variable step solver is taken as the system is dynamic and ODE-45 was selected as the problem was non-stiff and the required accuracy for was not very high. The default RelTol (relative tolerance) of 1e-3 is chosen and the AbsTol (absolute tolerance) of 1e-6 is selected such that the value of the solution component is ignored when it falls below the given threshold.



Fig,(g) Solver Settings

1.5 *MATLAB function block*

Inside the function block, the equation for relative slip is measured from the input (u) received from the bus. The output (y) is then fed to the system as a feedback and its equation is as follows :

$$y = 1 - u(1) / u(2) + (u(2) = = 0) *eps;$$

where, u(1) = Ww and u(2) = Vs.

1.6 *Look-up table*

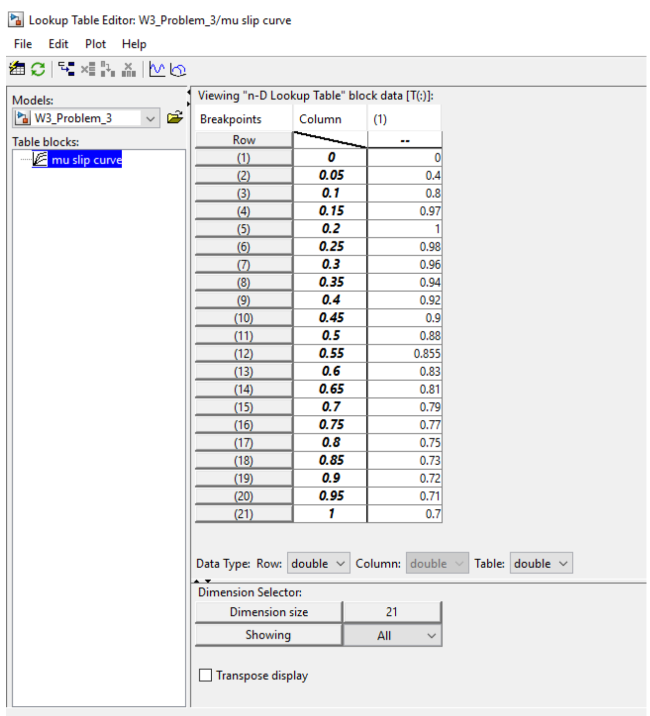


Fig.(h) Look-up table values

The Look-up table data was obtained from mu-slip curve for default values and data was interpolated during the simulation from it.

1.7 Signal builder

Generated three signals for obtaining the desired relative slip. As for slip = 0, it indicates that the speed of the vehicle is equal to the wheel speed whereas for slip = 1, it indicates that the wheel is locked. For suitable slip value, 0.2 is chosen and the signals are as shown below.

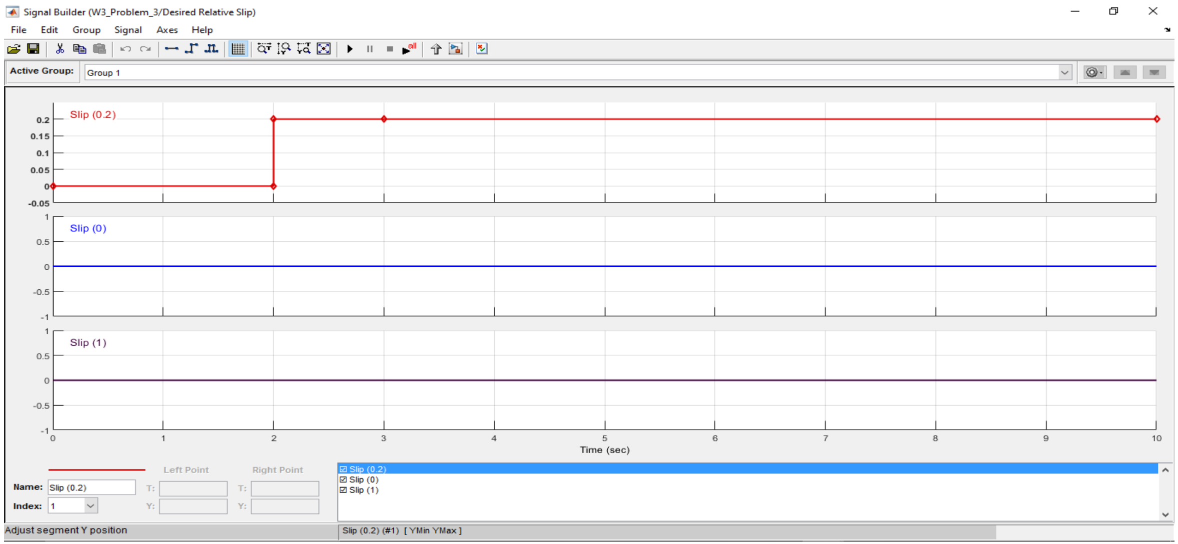


Fig.(i) Signal builder