TIRE MODELLING FOR ANTI-LOCK BRAKING SYSTEM

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WHAT IS AN ABS ?

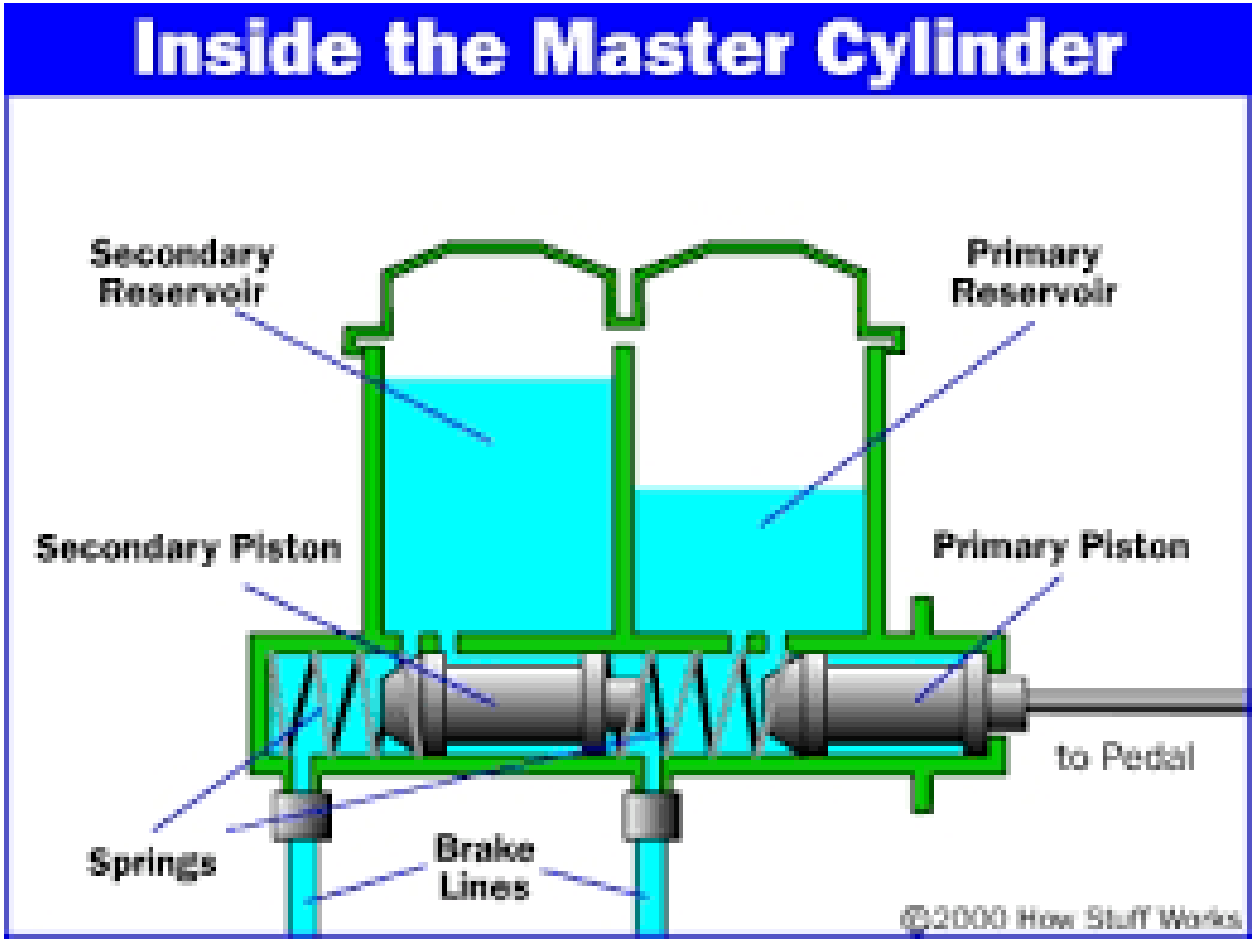
- It is an electronic system which monitors and controls the skidding of the vehicle during braking action and prevents the wheels from locking.
- It was first developed in for the aircrafts in 1929.
- ABS allows the driver to maintain the steering control while braking and it shortens the braking distances on slippery surfaces.
- ABS is an additional monitoring and control function superimposed on the existing vehicle braking system.
- ABS has the ability to handle all the possible worst events in given time constraint.

BRAKING SYSTEM IN AUTOMOBILES

- Generally, the brakes are actuated by the hydraulic pressure.
- In a simple braking system, the applied force by the driver onto the brake pedal transmits to the wheel through an incompressible fluid.
- But, the brake force applied by the driver is difficult to stop transport vehicles carrying heavy loads.
- To apply the brake force multiple times, hydraulic systems are used.
- The hydraulic system contains cylinders fitted with oil and connected with oil filled pipe.

BRAKING SYSTEM CONTD…

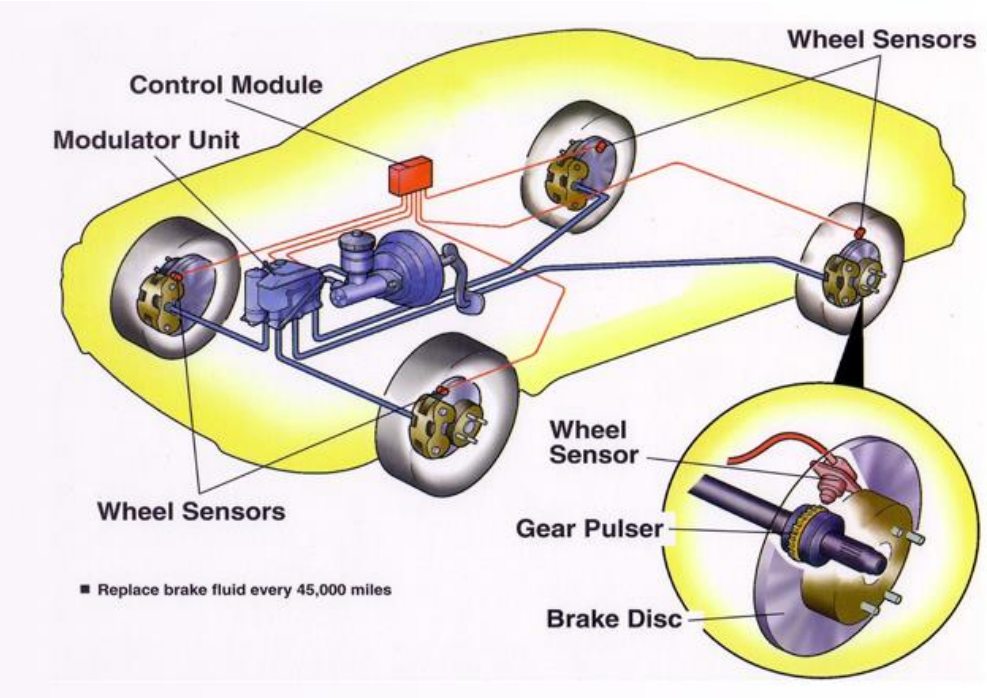
- If the downward force is applied to one piston, then the force is transmitted to another piston in the pipe through the incompressible oil.
- The Hydraulic system makes the force multiplication by changing the size of one cylinder and piston relative to the other one.


Inside the Master Cylinder
Secondary Reservoir
Primary Reservoir
Secondary Piston
Primary Piston
to Pedal
Springs
Brake Lines
©2000 How Stuff Works

ABS ARCHITECTURE

- Electronic Control Unit
- Speed sensors
- Hydraulic control unit
- ABS control valves
- Control Algorithm

- *Four channel ABS*
- *Three Channel ABS*

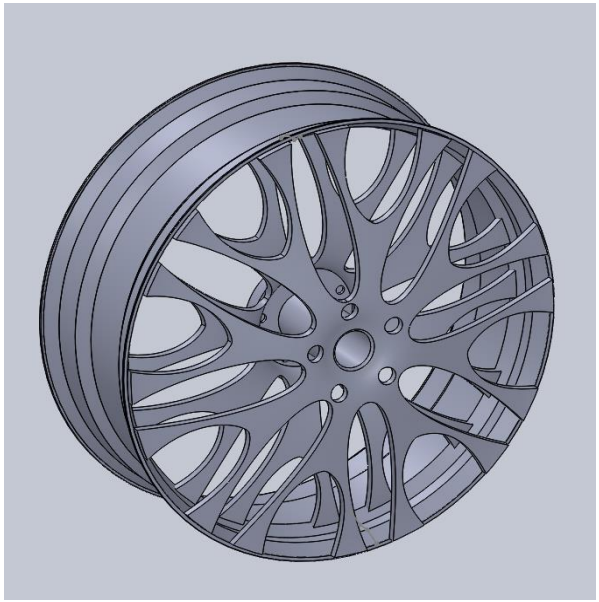


ABS CONTD…

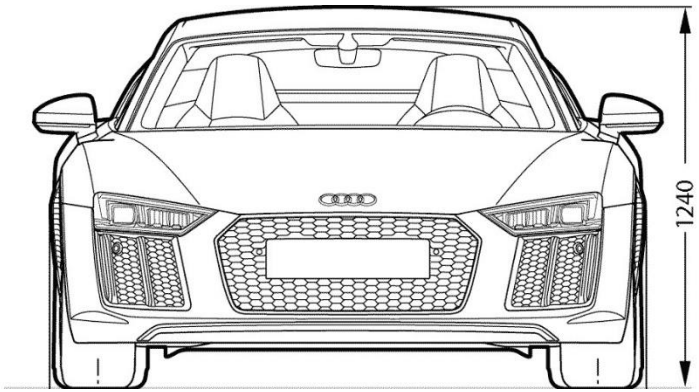
- Four channel ABS controls the brake force on each wheel individually.
- Three channel ABS controls the braking pressure on both the front wheels individually but rear wheels are controlled together, as a single unit.
- ***Wheel Speed Sensors:*** Constantly monitors the wheel performance and transmits the information to the ECU after particular interval of time.
- ***ECU*** receives the wheel performance data from each wheel sensor. When a wheel is about to lock, the ECU delivers a command to the hydraulic valve to control the brake pressure.

OPERATION OF ABS

- When the controller senses that the wheel is locking under the action of brakes, it first activates a solenoid valve to close the affected wheel's brake line which prevents the pressure from increasing further.
- If the locked wheel continues to lose speed, the controller activates a second solenoid valve which removes the pressure off the affected brake line, in effect to release the brake for that wheel regardless of whether the driver is still pushing on the brake pedal.
- As soon as the wheel regains traction, the solenoid valves de-activate and normal braking system resumes.




Axis1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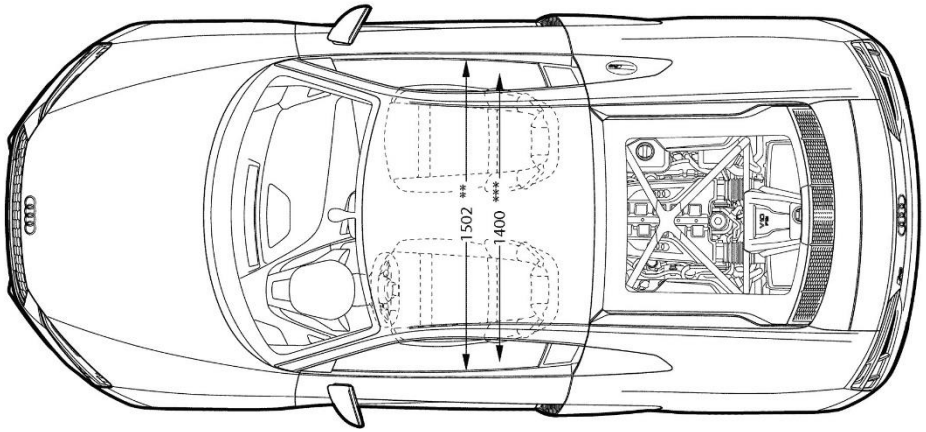
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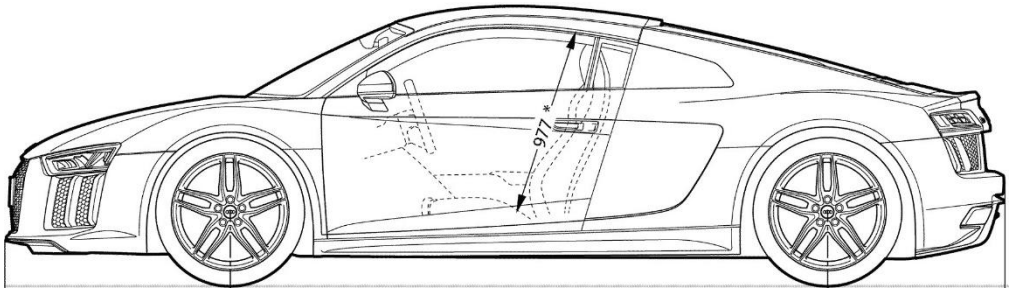
1400 ***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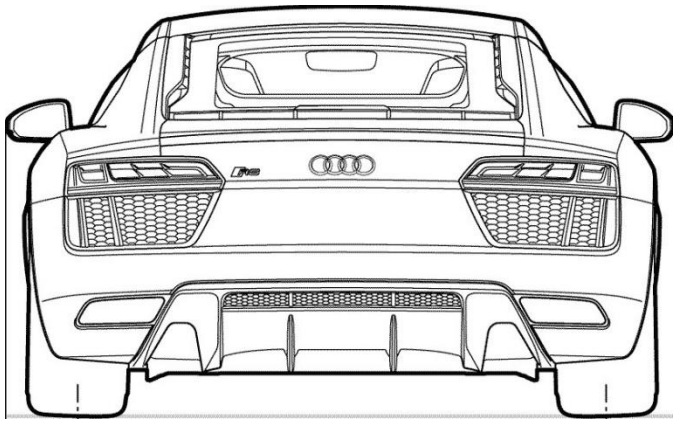

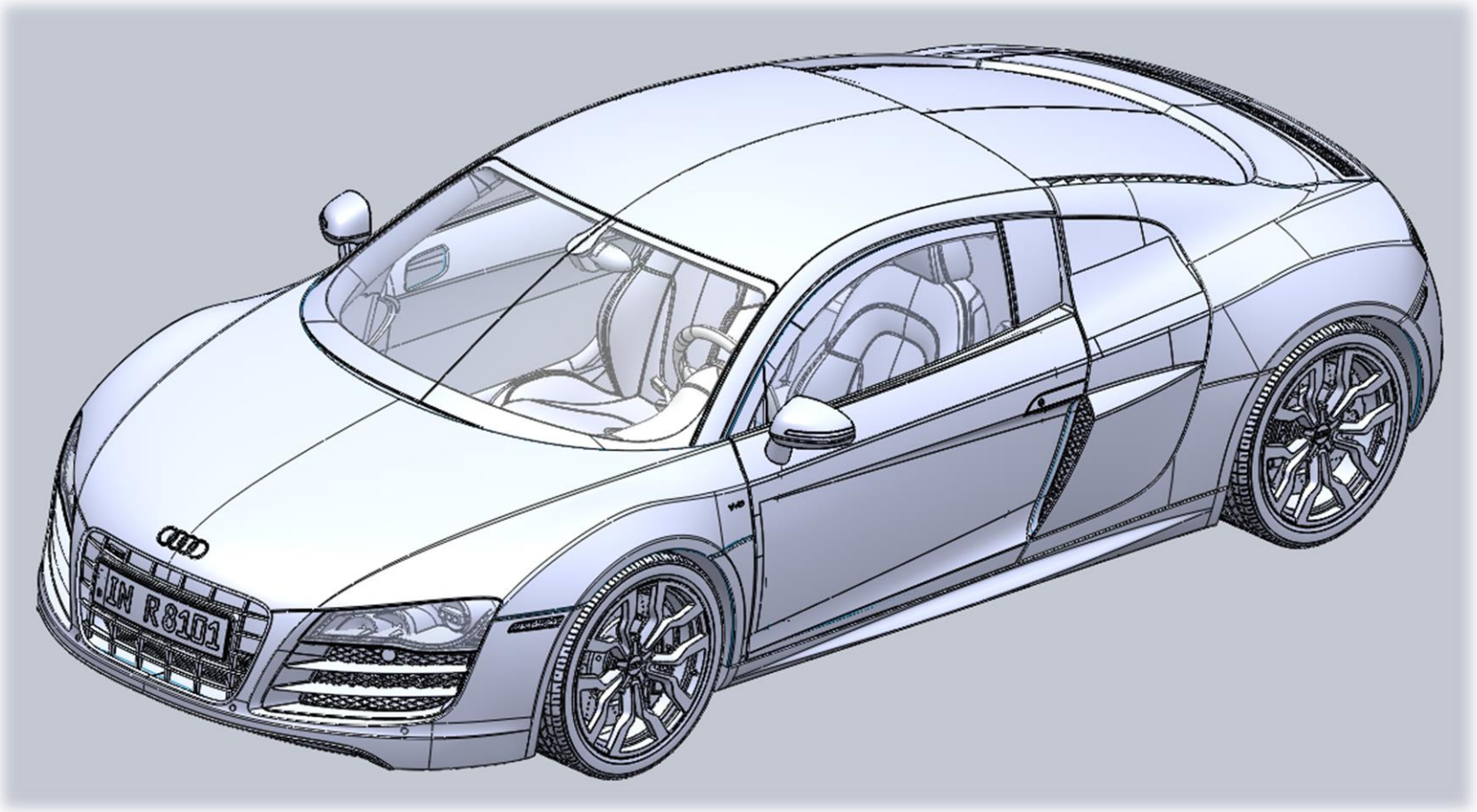
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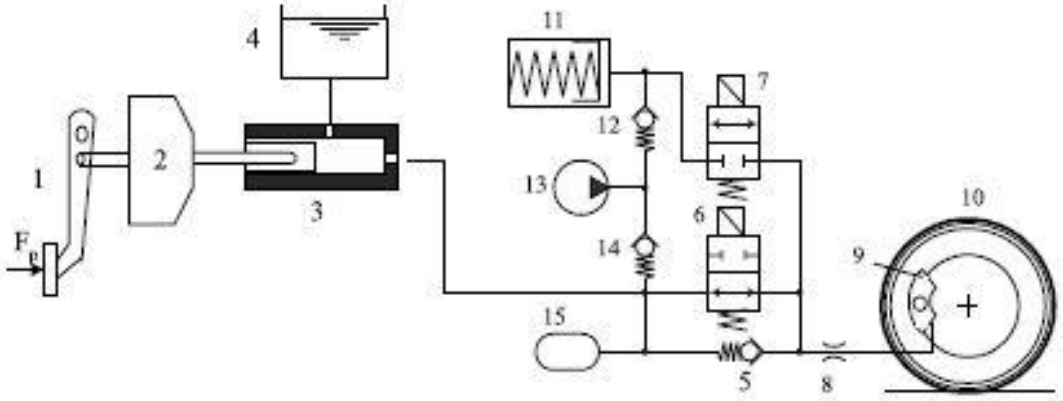


1.brake padel
2.power brake assembly
3.master cylinder
4.oil tank
5.check valve
6.inlet valve
7.outlet valve
8.throttle
9.caliper
10.wheel assembly
11.low-pressure oil tank
12.check valve
13.oil pump
14.check valve
15.damper chamber

Fig. 4. Anti-lock braking system.

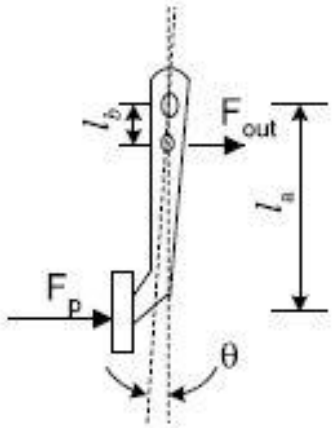


Fig. 5. Free body diagram of a brake pedal.

INITIAL KE

$$E_{k_0} = mv_0^2 / 2 ,$$

$$Q_1 = \int_0^t (v_v - \omega R)\mu_0 mg dt \ ,$$

$$Q_2 = \int_0^t pS\mu_m \omega R dt \ ,$$

FROM THE LAW OF CONSERVATION OF ENERGY

$$E_{k_0} - Q_1 - Q_2 = mv_v^2 / 2$$

$$mv_0^2 / 2 - \int_0^t (v_v - \omega R)\mu_0 mg dt - \int_0^t pS\mu_m \omega r dt$$
$$= mv_v^2 / 2$$

$$\lambda = \frac{v_v - \omega R}{v_v}$$

SLIP RATE

$$\omega_0 + \int_0^t [2T / m_w R^2]dt = \omega$$

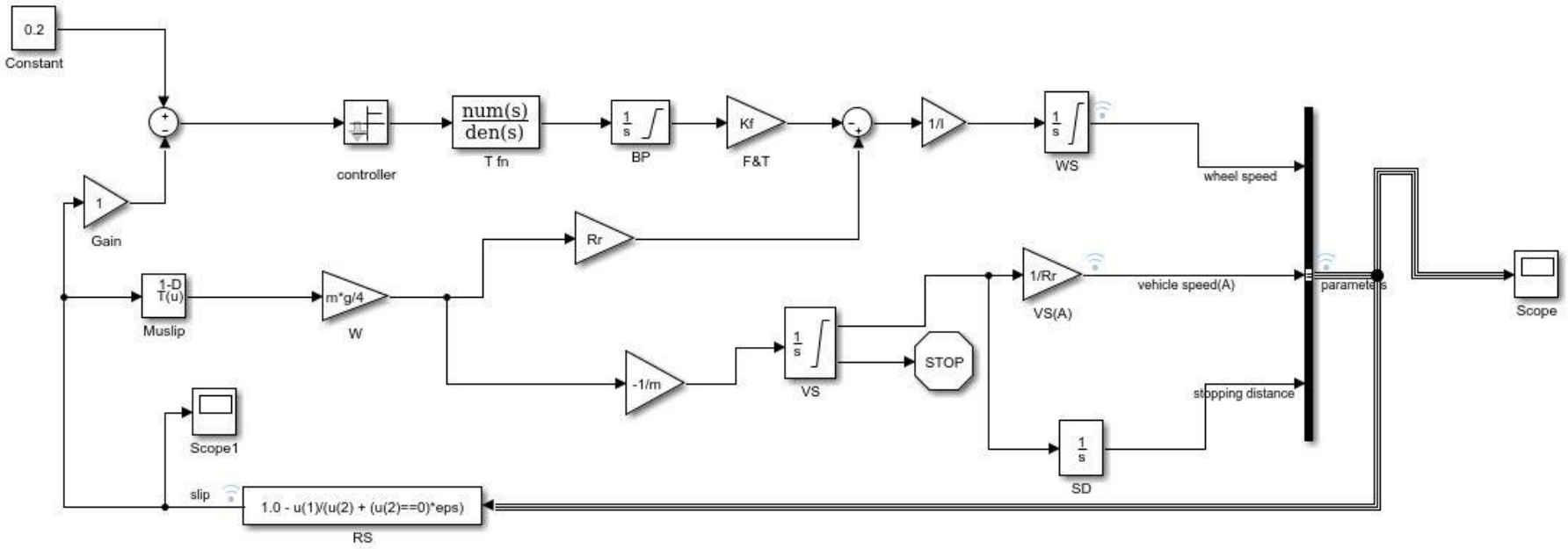
RESULTANT MOMENT ON THE WHEELS

$$T = \begin{cases} R\mu_0 mg - pS\mu_m r(\omega > 0, v_v > 0) \\ R\mu_0 mg - pS\mu_m r(\omega = 0, v_v > 0, R\mu_0 mg > pS\mu_m r) \\ 0(\omega = 0, v_v > 0, Ru_0 mg \le pS\mu_m r) \end{cases}$$

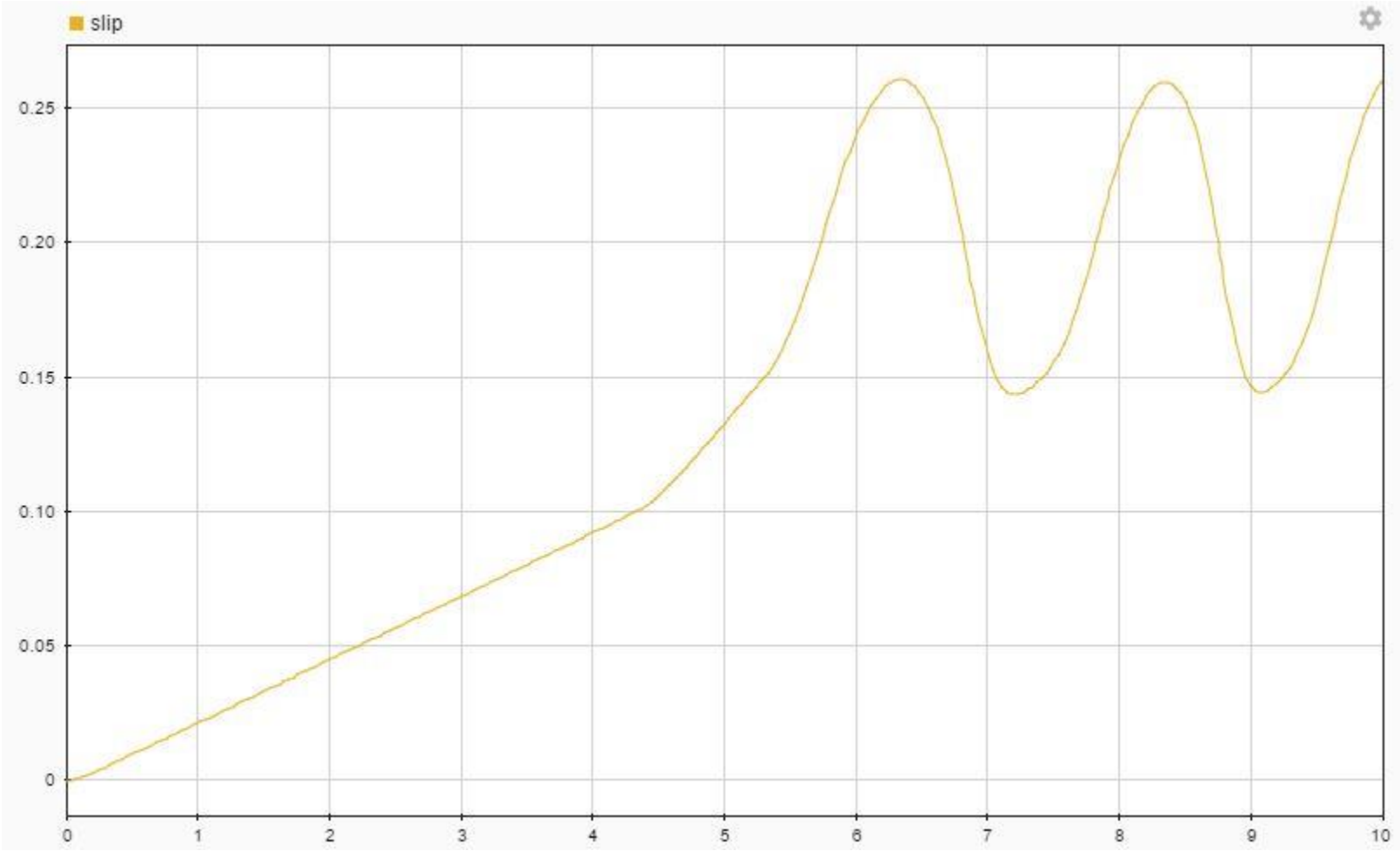
FLUID BRAKING MODEL

$$p_l + C_p \frac{dp_l}{dt} = p_z$$

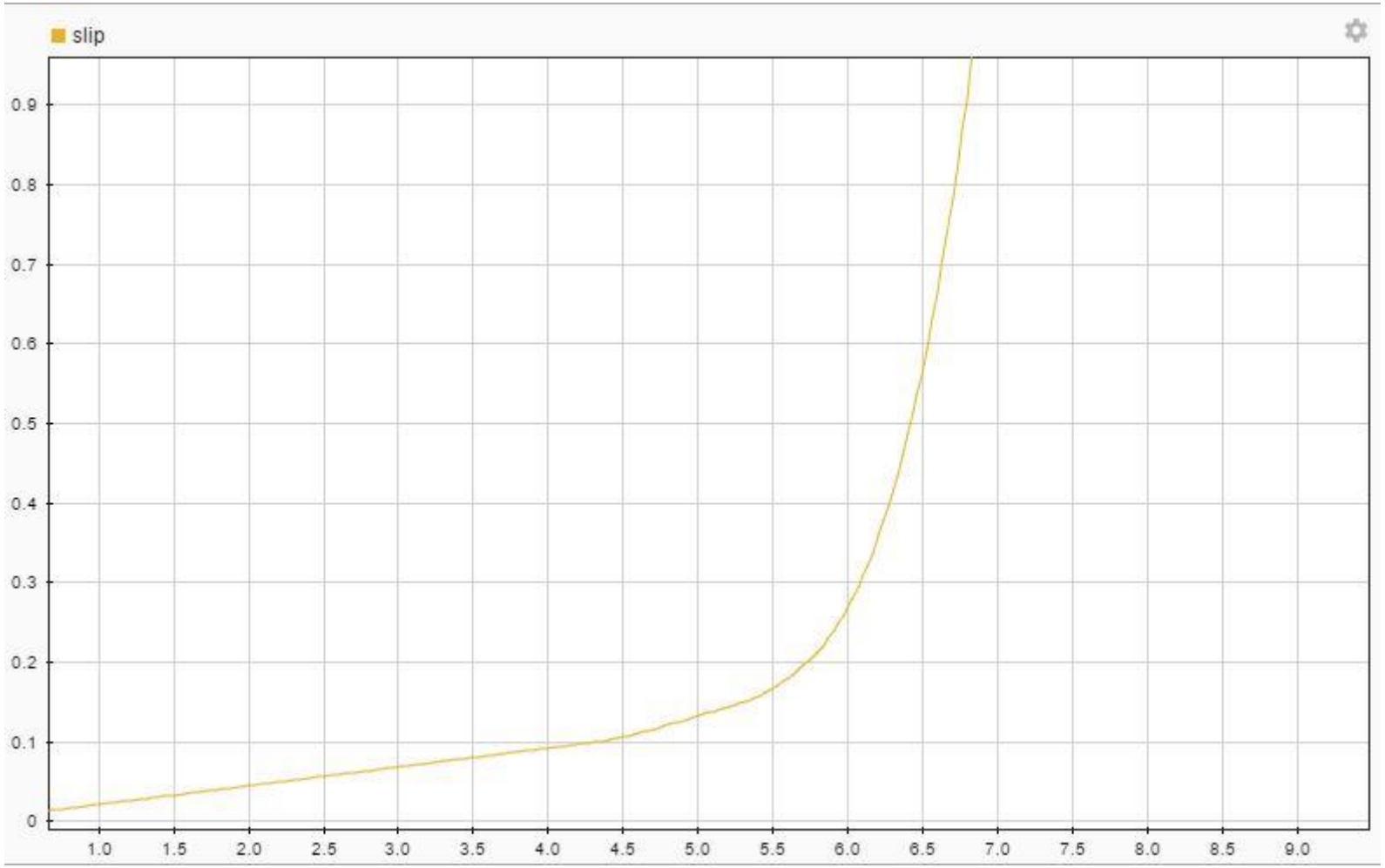
SIMULINK MODEL



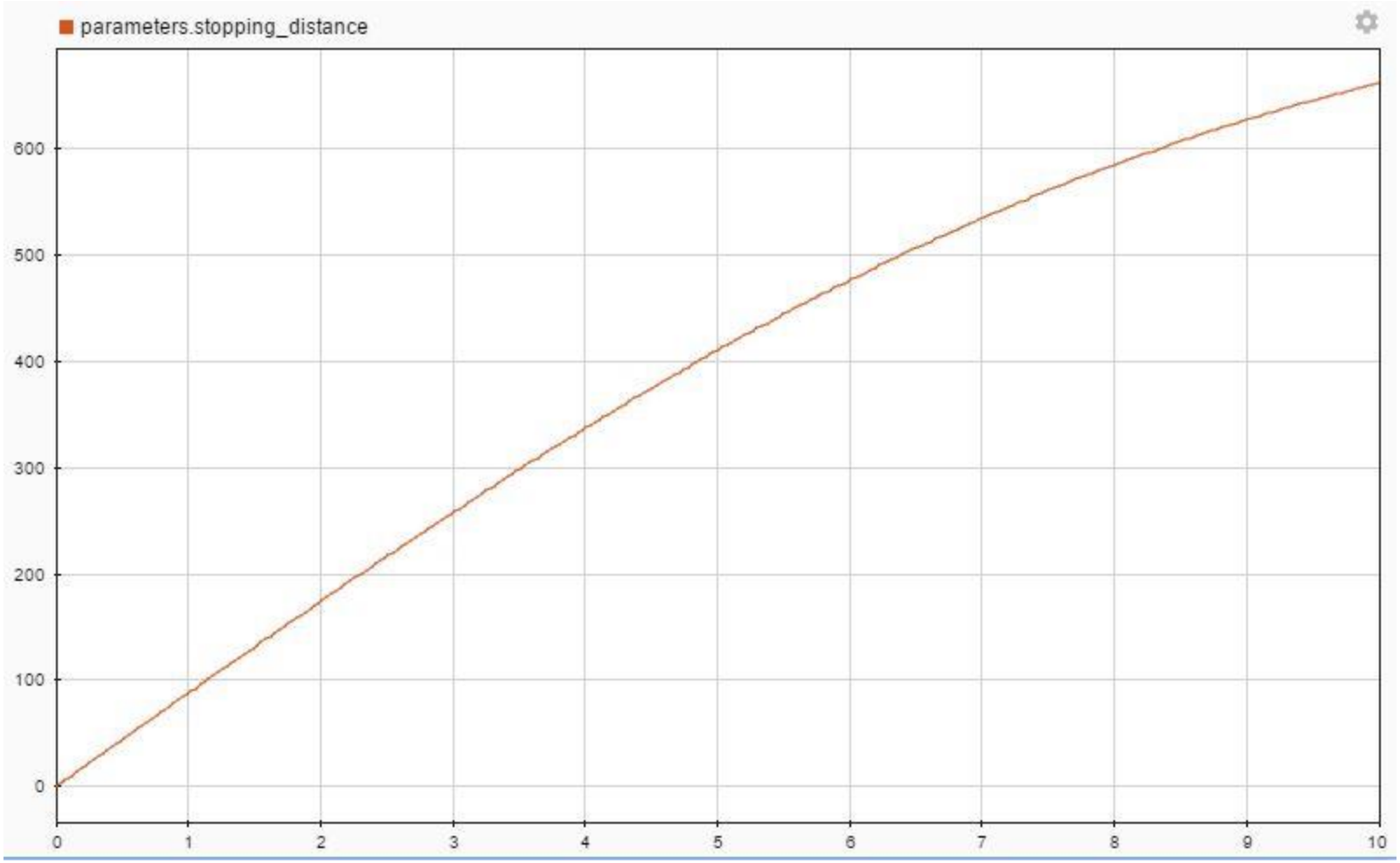
VARIATION OF SLIP WITH ABS



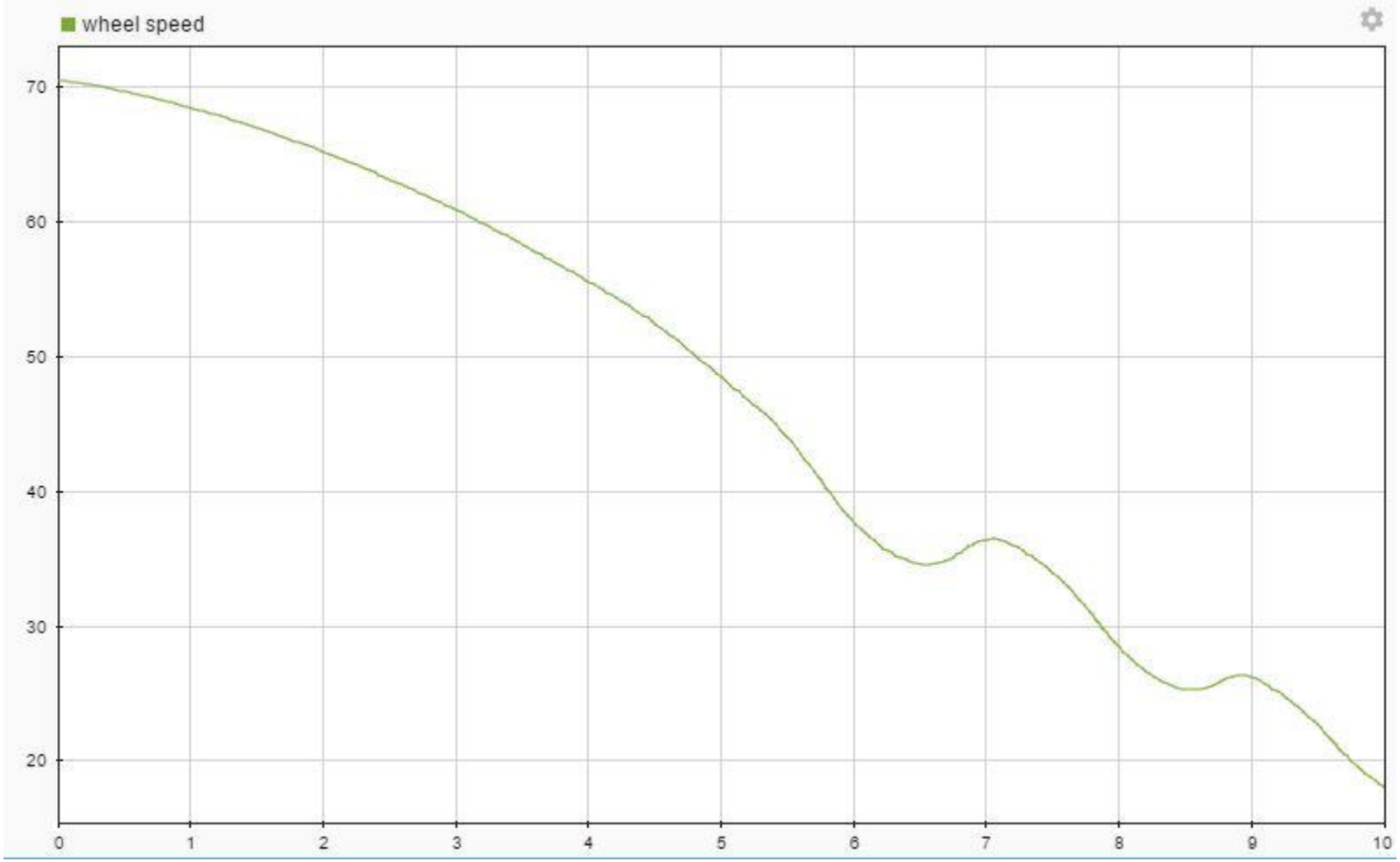
VARIATION OF SLIP WITHOUT ABS



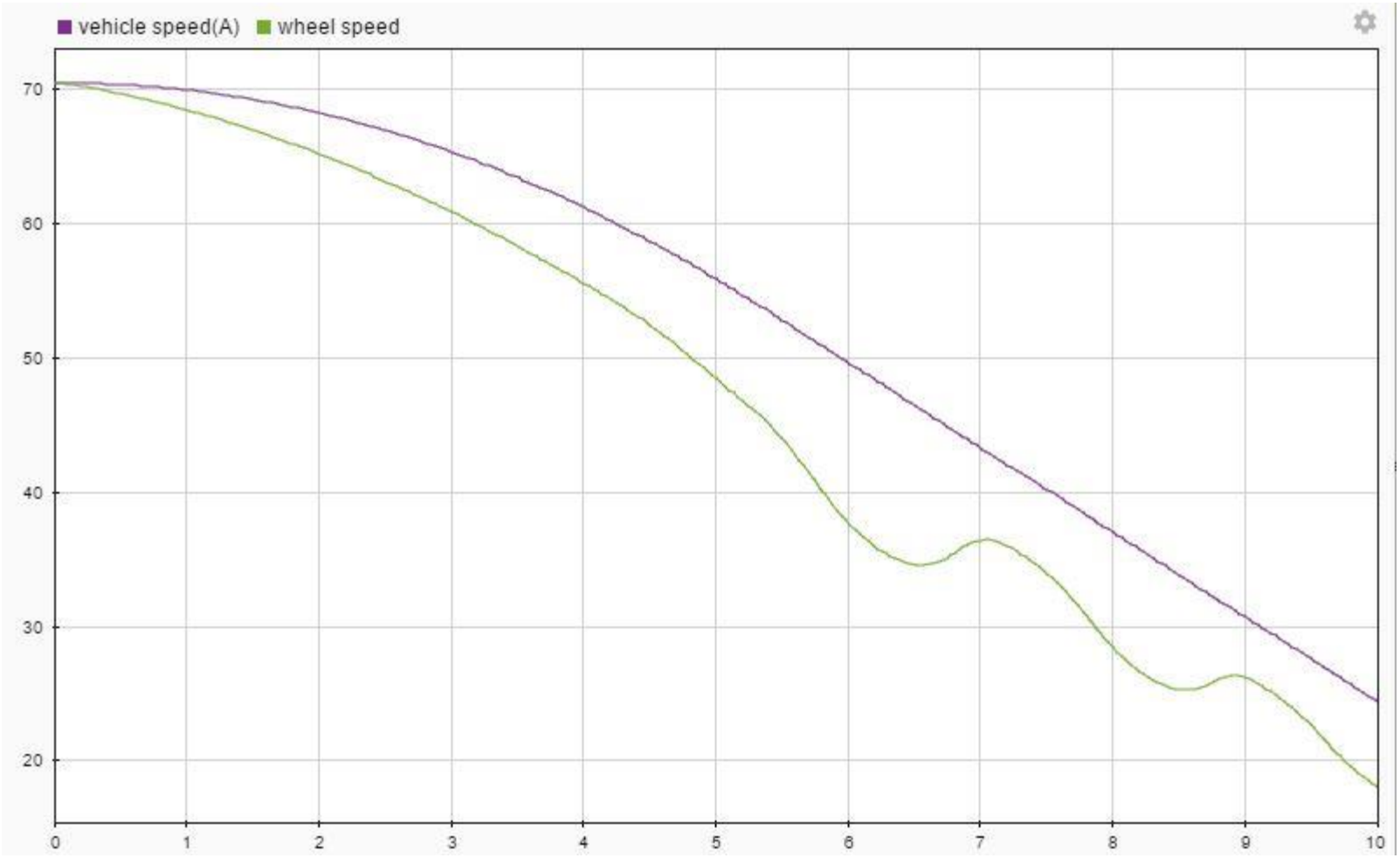
VARIATION OF STOPPING DISTANCE



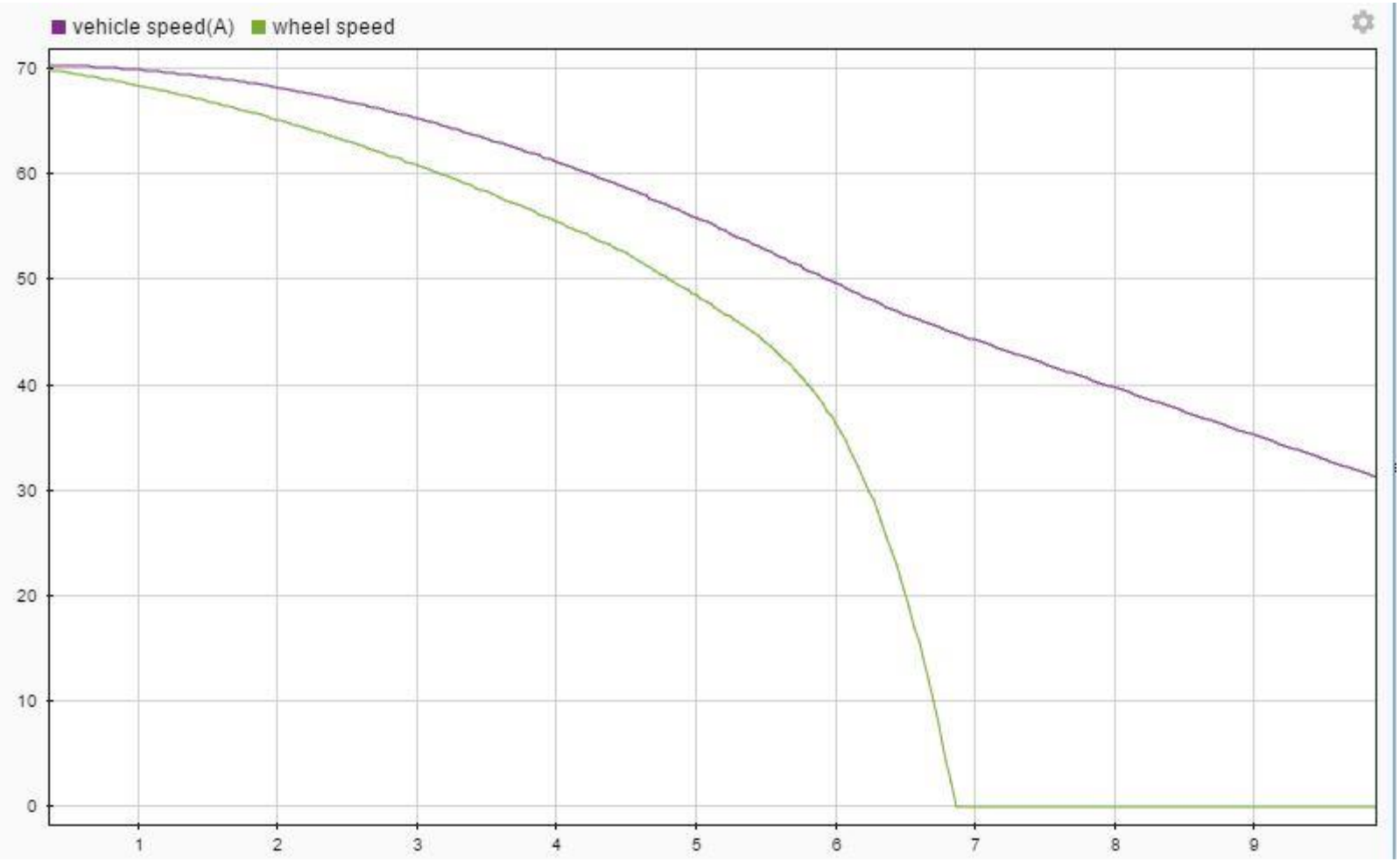
VARIATION OF WHEEL SPEED



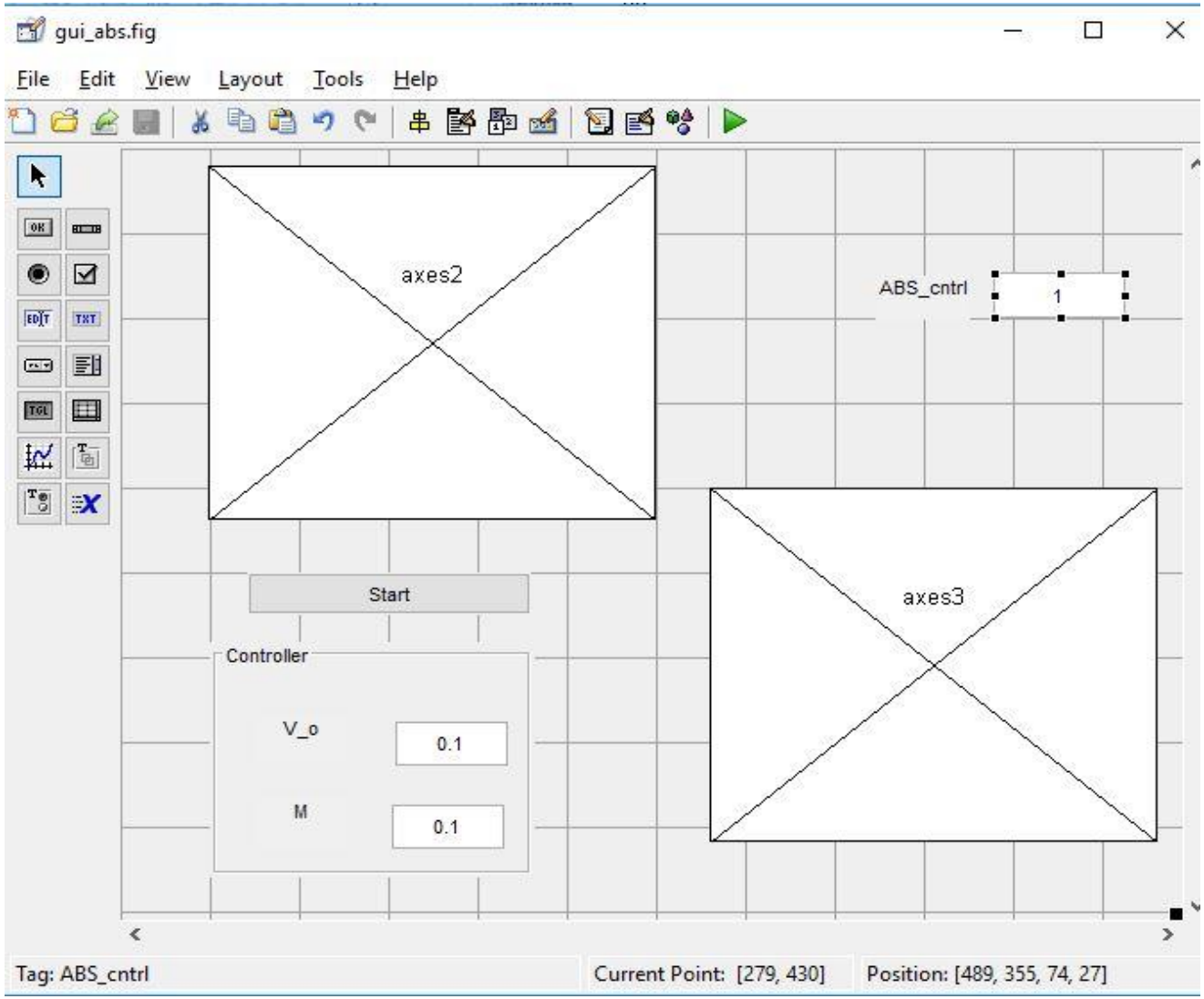
VARIATION OF WHEEL AND VEHICLE SPEEDS WITH ABS



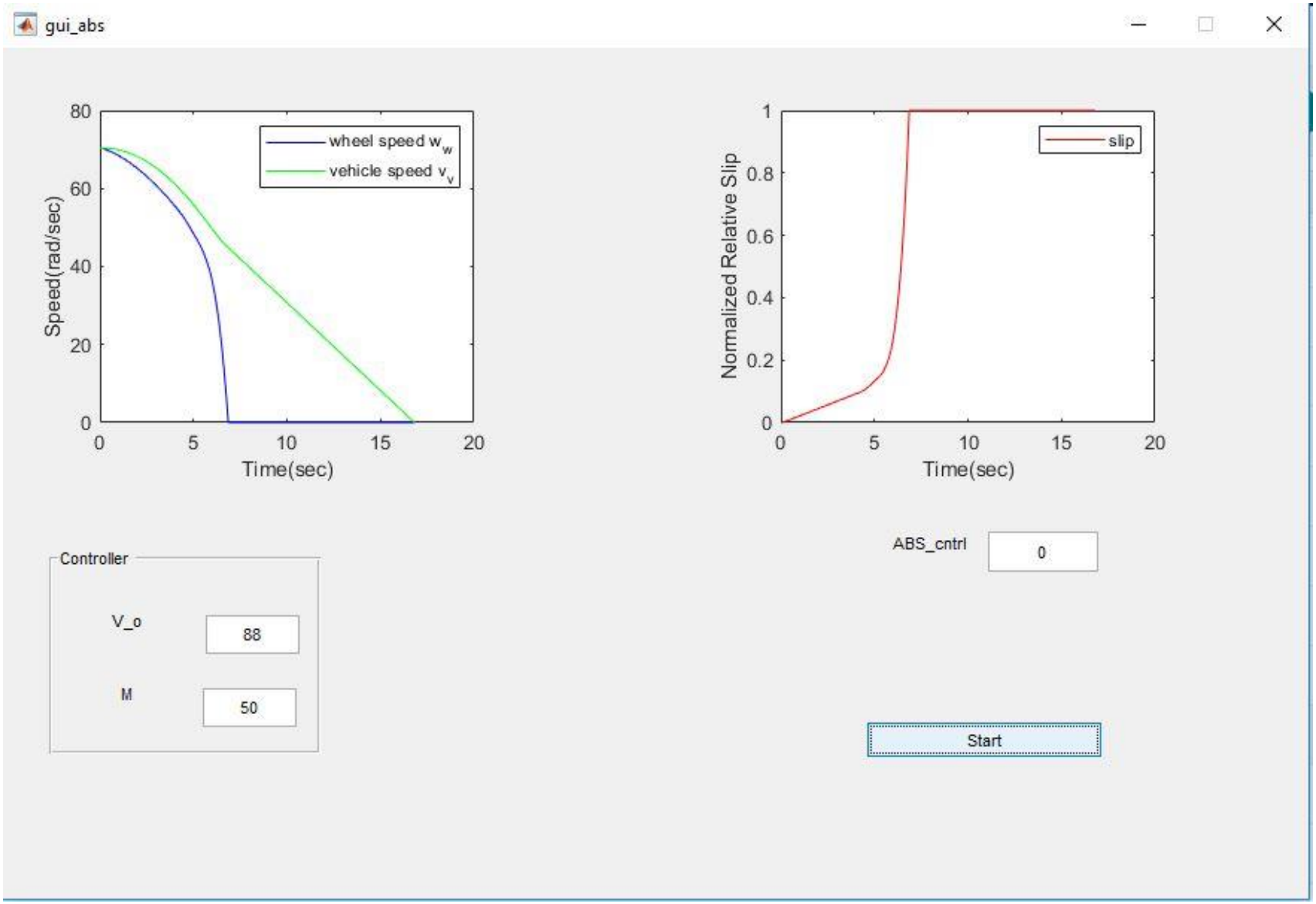
VARIATION OF WHEEL SPEED AND VEHICLE SPEED WITHOUT ABS



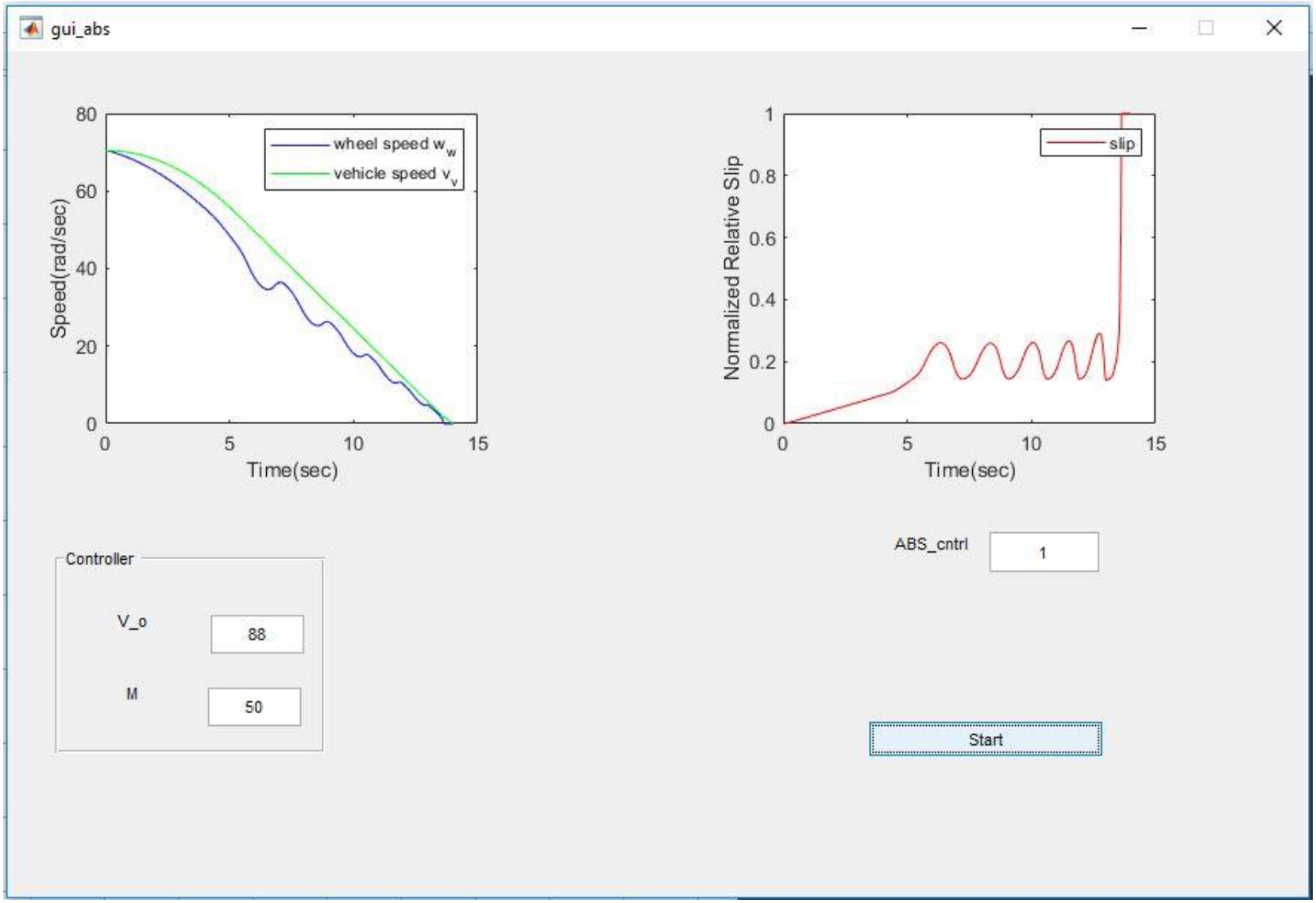
GRAPHICAL USER INTERFACE



GUI WITHOUT ABS



GUI WITH ABS


gui_abs
Speed(rad/sec)
Time(sec)
wheel speed w_w
vehicle speed v_v
Normalized Relative Slip
Time(sec)
slip
Controller
V_o
88
M
50
ABS_cntrl
1
Start

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THANK YOU