JSS MAHAVIDYAPEETHA

JSS SCIENCE AND TECHNOLOGY UNIVERSITY

Subject: Hybrid Vehicles (EC825)Event – 4

Implementation report on,

"ANTI-LOCK BREAKING SYSTEM (ABS) SIMULATION IN SIMULINK"

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ABSTRACT

ABS assists driver to keep the steering control during hard braking. In the absence of ABS, it is difficult to stop the car from spinning because of wheel lockup in hard braking conditions, particularly on slippery surfaces. Mostly ABS are used with conventional brakes e.g. hydraulic or pneumatic pressure brakes. Antilock Braking System (ABS) is used in advanced automobiles to prevent slip and locking of wheels after brakes are applied. It is an automobile safety system; the controller is provided to control the necessary torque to maintain optimum slip ratio. The slip ratio denotes in terms of vehicle speed and wheel rotation. It's an automated system that runs on principles of threshold braking and cadence braking which were practised by skilful drivers with previous generation braking systems. Its response time is very fast so that makes easy steering for the driver. The model was developed in MATLAB Simulink. Wheel speed and Vehicle speed were plotted to interpret the results. Simulation results show that the ABS provides better result in slip regulation and reduction in the stopping distance of the vehicle.

TABLE OF CONTENTS

CHAPTER -1

1. INTRODUCTION

Human safety on the road not only requires a stringent car design but also involves sound braking being used, the ABS is an effective braking system technology as it saves the life due to sudden application of braking without slippage and it allows the driver to steer in heavy braking condition. ABS prevents locking of wheels during braking. During severe braking or on slippery surfaces, wheels approach lockup. At that time, ABS takes over. ABS modulates 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.

Engineers were determined to reduce driving accidents and improve the safety of vehicles. It is obvious that efficient design of braking systems is to reduce accidents. Vehicle experts have developed this field through the invention of the first mechanical antilock braking system (ABS) system which was designed and produced in the aerospace industry in 1930. In 1945, the first set of ABS brakes were put on a Boeing B-47 to prevent spin outs and tires from blowing and later in the 1950s, ABS brakes were commonly installed in airplanes. Soon after, in the 1960s, high end automobiles were fitted with rear-only ABS, and with the rapid progress of microcomputers and electronics technologies, the trend exploded in the 1980s. Today, all-wheel ABS can be found on the majority of late model vehicles and even on select motorcycles. ABS is recognized as an important contribution to road safety as it is designed to keep a vehicle steerable and stable during heavy braking moments by preventing wheel lock. It is well known that wheels will slip and lockup during severe braking or when braking on a slippery (wet, icy, etc.) road surface. This usually causes a long stopping distance and sometimes the vehicle will lose steering stability. The objective of ABS is to manipulate the wheel slip so that a maximum friction is obtained and the steering stability (also known as the lateral stability) is maintained. That is, to make the vehicle stop in the shortest distance possible while maintaining directional control. The ideal goal for the control design is to regulate the wheel velocity. The technologies of ABS are also applied in traction control systems (TCS) and vehicle dynamic stability control (VDSC). Typical ABS components include: vehicle’s physical brakes, wheel speed sensors (up to 4), an electronic control unit (ECU), brake master cylinder, a hydraulic modulator unit with pump and valves.

CHAPTER – 2

MOTIVATION

Though the Anti-lock Braking System has already been implemented in sophisticated cars, the technology is still considered cutting edge. As far as the automotive industry is concerned ABS technology is the most recent development in enhancing passenger safety and accident avoidance. A 2004 Australian study by Monash University Accident Research Centre found that ABS reduced the risk of multiple vehicle crashes by 18 percent, and it reduced the risk of run-off-road crashes by 35 percent. That is why we felt it is important to understand the working of the Antilock Braking System (ABS). Hence, we made an attempt to model the system in Simulink.

CHAPTER- 3

OBJECTIVES

The objectives of our ABS model are,

1. To reduce stopping distances: The distance to stop is a function of the mass of the vehicle, the initial velocity, and the braking force. By maximizing the braking force the stopping distance will be minimized if all other factors remain constant. However, on all types of surfaces, to a greater or lesser extent, there exists a peak in fiction coefficient. It follows that by keeping all of the wheels of a vehicle near the peak, an antilock system can attain maximum fictional force and, therefore, minimum stopping distance.

2. Stability: Although, decelerating and stopping vehicles constitutes a fundamental purpose of braking systems, maximum friction force may not be desirable in all cases. For example, not if the vehicle is on a so-called p-split surface, such that significantly more braking force is obtainable on one side of the vehicle than on the other side. Applying maximum braking force on both sides will result in a yaw moment that will tend to pull the vehicle to the high friction side and contribute to vehicle instability, and forces the operator to make excessive steering corrections to counteract the yaw moment. If an antilock system can maintain the slip of both rear wheels at the level where the lower of the two friction coefficients peaks, then lateral force is reasonably high, though not maximized. This contributes to stability of automobile.

3. Steerability: Good peak frictional force control is necessary in order to achieve satisfactory lateral forces and, therefore, satisfactory steerability. Steerability while braking is important not only for minor course corrections but also for the possibility of steering around an obstacle. Tire characteristics play an important role in the braking and steering response of a vehicle. For ABS-equipped vehicles the tire performance is of critical significance. All braking and steering forces must be generated within the small tire contact patch between the vehicle and the road. Tire traction forces as well as side forces can only be produced when a difference exists between the speed of the tire circumference and the speed of the vehicle relative to the road surface.

CHAPTER – 4

WORKING OF ANTI-LOCK BREAKING SYSTEM (ABS)

4.1 Components of ABS

ABS consists of:

• Wheel speed sensors

• Controller unit

• Hydraulic modulator Unit

• Braking device

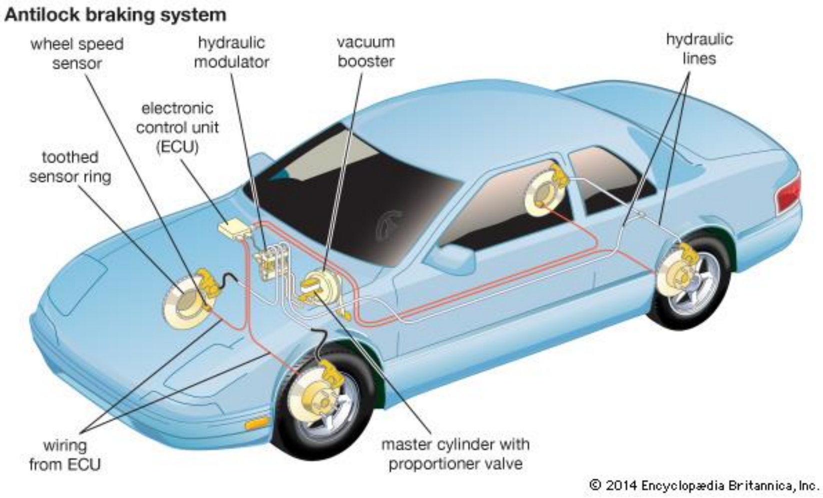

Figure 4.1 ABS system in an automobile

Figure 4.1 Depicts the subsystem for construction of the ABS system in a typical four wheeled automobile.

1. **Wheel Speed Sensors:** Electro-magnetic or Hall-effect pulse pickups with toothed wheels mounted directly on the rotating components of the drivetrain or wheel hubs. As the wheel turns the toothed wheel (pulse ring) generates an AC voltage at the wheel-speed sensor. The voltage frequency is directly proportional to the wheel's rotational speed.
2. **Electronic Controller Unit:** The electronic control unit receives, amplifies and filtersthe sensor signals for calculating the wheel rotational speed and acceleration. ABSis usually implemented here. ECU assists the vehicle operator to prevent wheel

lockup by regulating the wheel slip.

3. **Hydraulic Unit:** The hydraulic pressure modulator is an electro-hydraulic device for reducing, holding, and restoring the pressure of the wheel brakes by manipulating the solenoid valves in the hydraulic brake system. • Hydraulic unit actuates the brakes by increasing the hydraulic pressure or bypassing the pedal force to reduce the braking power. Depending on the design, this device may include a pump, motor assembly, accumulator and reservoir

4.2 Operation

When a wheel lockup is detected or eminent, ECU commands HCU to release the brake pressure to allow the wheel velocity to increase and the wheel slip to decrease. Once the wheel velocity spins up, ECU re-applies the brake pressure to confine the wheel slip to a predetermined value or interval. HCU Controls hydraulic brake pressure to each disc brake calliper or wheel cylinder based on input from the system sensors, thereby controlling wheel speed. It is assumed the exerted weight is distributed equally among all four wheels of the vehicle and all wheels bear equal amounts of vehicle braking force. Moreover, it is also supposed that other factors for this quarter-vehicle model such as road roughness and other forces which are related are negligible. The vehicle speed depends on the rotation of wheels which rotate with initial angular speed (1) until the brakes are applied. Integrators are used for the calculation of vehicle speed and the angular speed of the wheel. Two speed calculators are used for calculating the slip (2) is used for the determination of slip. We have introduced the vehicle speed which shown as angular velocity.

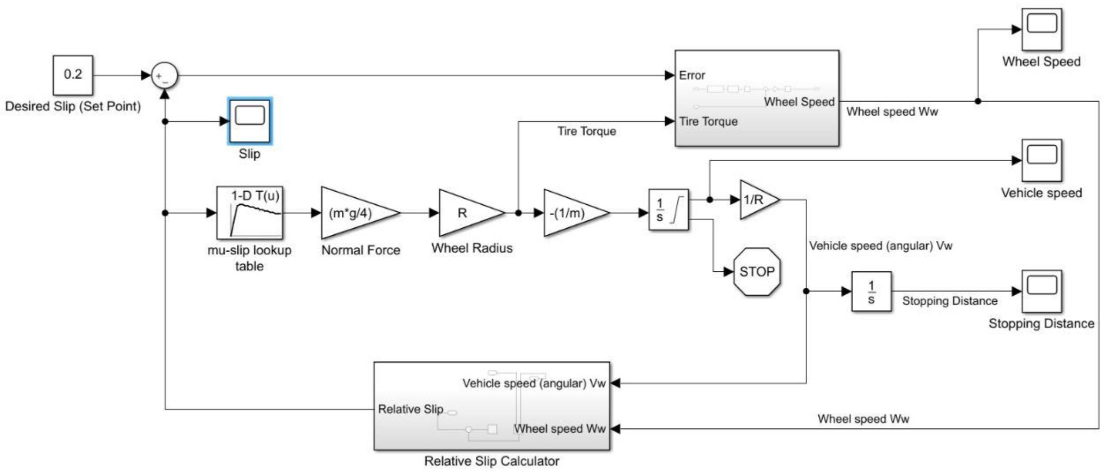

Figure 4.2: Simulink model of ABS

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.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.
The friction coefficient between the tire and the road surface is a function of slip, known as the mu-slip curve. We created slip curves by passing MATLAB variables into the block diagram using a Simulink lookup table. The model multiplies the friction coefficient by the weight on the wheel, W, to yield the frictional force, Ff, acting on the circumference of the tire. Ff is divided by the vehicle mass to produce the vehicle deceleration, which the model integrates to obtain vehicle velocity.

In this model, we used an ideal anti-lock braking controller that uses 'bang-bang' control based upon the error between actual slip and desired slip. We set the desired slip to the value of slip at which the slip curve reaches a peak value, this being the optimum value for minimum braking distance.

To control the rate of change of brake pressure, the model subtracts actual slip from the desired slip and feeds this signal into a bang-bang control (+1 or -1, depending on the sign of the error). This on/off rate passes through a first-order lag that represents the delay associated with the hydraulic lines of the brake system. The model then integrates the filtered rate to yield the actual brake pressure. The resulting signal, multiplied by the piston area and radius with respect to the wheel (Kf), is the brake torque applied to the wheel.
The model multiplies the frictional force on the wheel by the wheel radius (Rr) to give the accelerating torque of the road surface on the wheel. The brake torque is subtracted to give the net torque on the wheel. Dividing the net torque by the wheel rotational inertia, I, yields the wheel acceleration, which is then integrated to provide wheel velocity. In order to keep the wheel speed and vehicle speed positive, limited integrators are used in this model.

CHAPTER –5

RESULTS AND CONCLUSION

This model shows the simulation of a braking system under the action of an ABS controller. The controller in this example is idealized, but any proposed control algorithm can be used in its place to evaluate the system's performance. C code is generated and compiled for the controller hardware to test the concept in a vehicle. This significantly reduces the time needed to prove new ideas by enabling actual testing early in the development cycle.

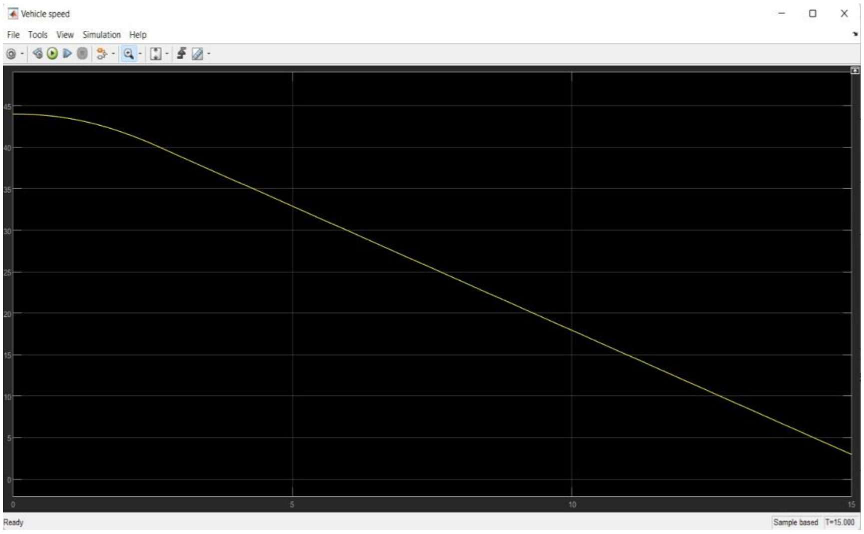

Figure 5.1: Graph of Vehicle Speed

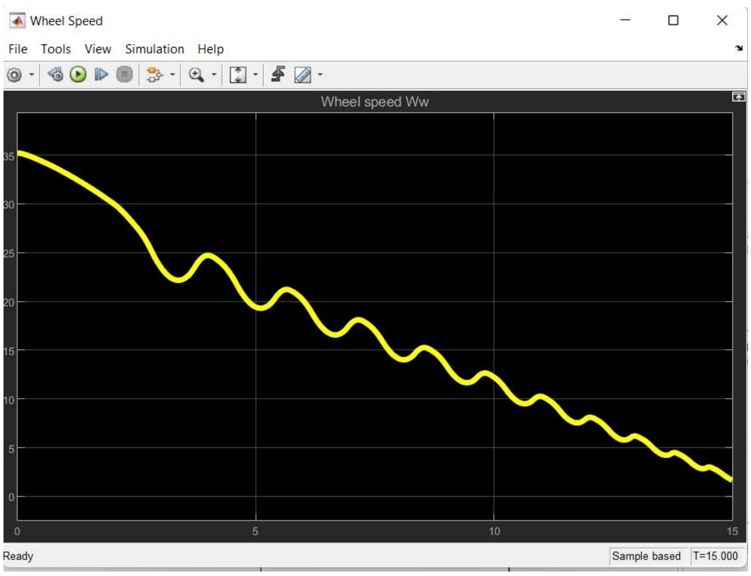

Figure 5.2: Graph of Vehicle's Wheel Speed

Figures 5.1 and 5.2, represent the Graphs of Vehicle's speed and Vehicle's wheel speed. These represent the Vehicle's speed and wheel speed in a normal ABS system in automobiles. The vehicle's wheel speed sensor takes in the input from all the 4 wheels of the vehicle, whereas the Vehicle speed shows the overall speed of the vehicle.

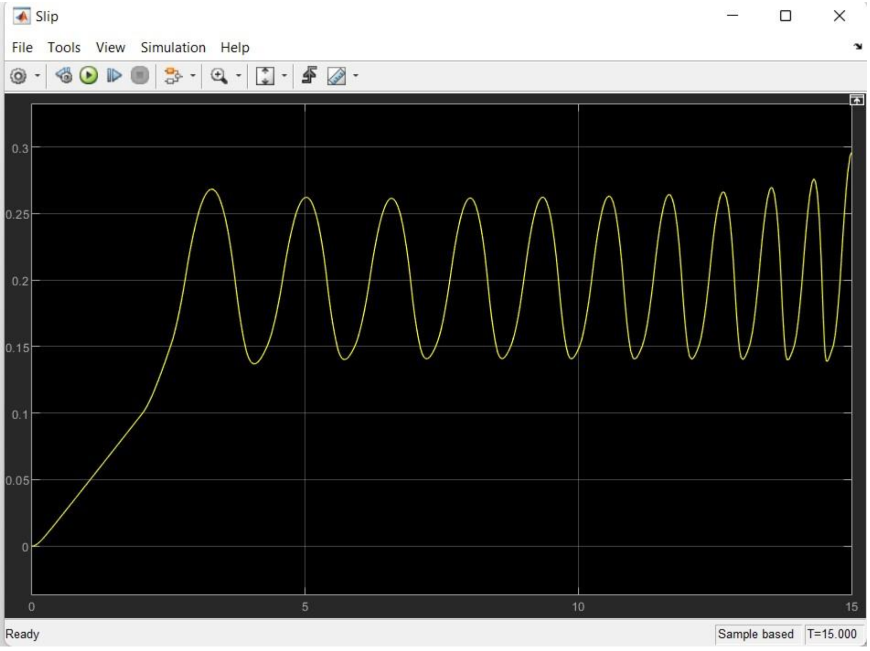

Figure 5.3: Graph of Vehicle Slip

Figure 5.3 shows the graph of Vehicle slip. Vehicle slip is the relative motion between a tire and the road surface where it is going. Due to the rotational speed going greater or lesser than the free-rolling speed, or by the tire's plane of rotation being at an angle to it's direction of motion.

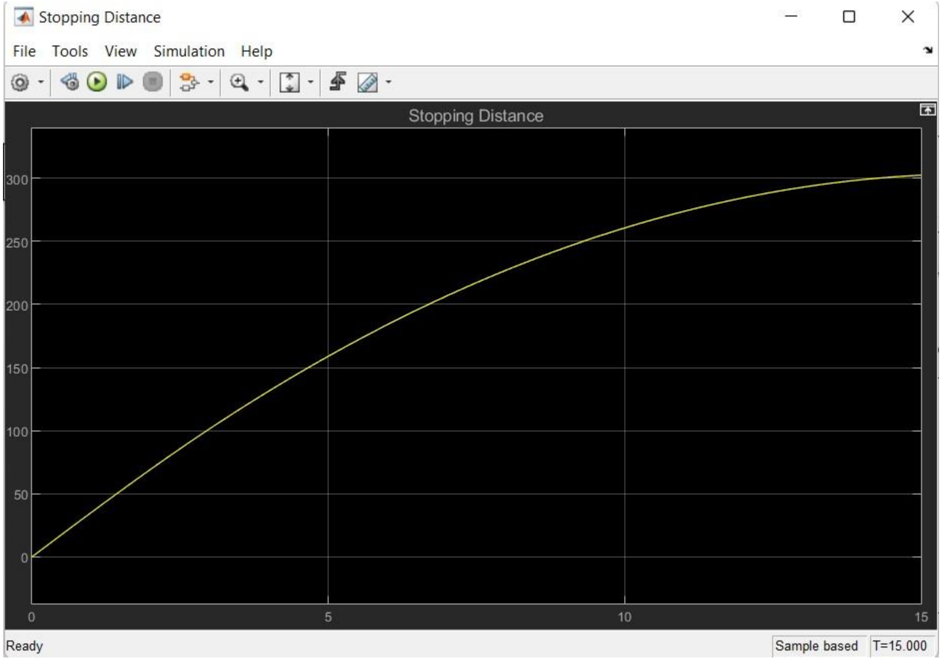

Figure 5.4: Graph of Stopping Distance (in Metres)

It is evident from the graph plotted in Simulink that, when ABS is applied as time (X-Axis) is increased both wheel and vehicle speed decreases. The brake pads apply and remove braking force to the wheels. Hence the wheel speed curve is not speed. While vehicle speed decreases regularly. Finally, vehicle comes to halt after certain time.

CHAPTER-6

ADVANTAGES AND DISADVANTAGES

6.1 Advantages of ABS

- **Stopping on ice.** As mentioned above, an ABS prevents lock-ups and skidding, even in slippery conditions. Anti-lock brakes have been proven to save lives in some situations by helping drivers keep control of a vehicle.
- **Lower insurance costs.** Because it is a thoroughly tested safety device with a track record of effectiveness, insurers often give customers specific discounts for having an ABS system on their vehicle.
- **Higher resale value.** As a feature on a car or truck, an ABS raises the market value of the vehicle. Nowadays, where ABS technology has become standard on many vehicles, not having it could result in a lower price for resale.
- **Traction control.** ABS shares some of the infrastructure of a traction control system, where new technology helps ensure that each wheel has traction on the road. That makes it easy for manufacturers to install both of these features at the factory

6.2 Disadvantages of ABS

- **Inconsistent stop times.** Anti-lock brakes are made to provide for surer braking in slippery conditions. However, some drivers report that they find stopping distances for regular conditions are lengthened by their ABS, either because there may be errors in the system, or because the clunking or noise of the ABS may contribute to the driver not braking at the same rate.
- **Expense.** ABS can be expensive to maintain. Expensive sensors on each wheel can cost hundreds of dollars to fix if they get out of calibration or develop other problems. For some, this is a big reason to decline ABS in a vehicle.
- **Delicate systems.** It's easy to cause a problem in ABS by messing around with the brakes. Problems include disorientation of the ABS, where a compensating brake sensor causes the vehicle to shudder, make loud noise or generally brake worse.

CHAPTER – 7

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