Product Knowledge Document

Antilock Braking System

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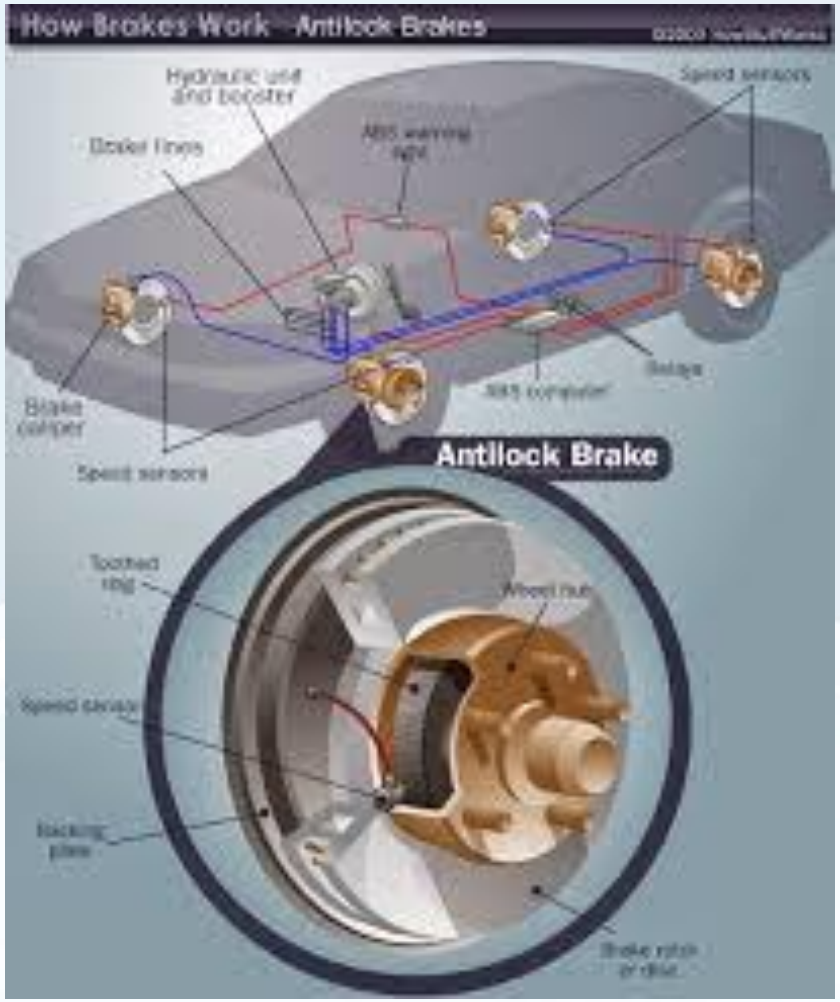
INTRODUCTION

Anti-lock braking system (ABS) is an automobile safety system prevent the wheels of a vehicle locking as brake pedal pressure is applied often suddenly in an emergency or short stopping distance. This enables the driver to have steering control, preventing skidding and loss of traction.



ABS generally offers improved vehicle control and decreases stopping distances on dry and slippery surfaces.

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.

With ABS system, the driver can brake hard, take the evasive action and still be in control of the vehicle in any road condition at any speed and under any load.

INTRODUCTION

HISTORY

- **1929 :-** ABS was first developed for aircraft by the French automobile and aircraft pioneer Gabriel Voisin, as threshold braking on airplanes is nearly impossible.
- **1936:** German company Bosch is awarded a patent an “Apparatus for preventing lock-braking of wheels in a motor vehicle”.
- **1936-:** Bosch and Mercedes-Benz partner - R&D into ABS.
- **1972:** WABCO partners with Mercedes-Benz developing first ABS for trucks.
- **1978:** First production-line installation of ABS into Mercedes and BMW vehicles.
- **1981:** 100,000 Bosch ABS installed.
- **1985:** First ABS installed on US vehicles

INTRODUCTION

HISTORY

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- **1986:** 1M Bosch ABS installed.
- **1987:** Traction control - in conjunction with ABS – used on passenger vehicles.
- **1989:** ABS hydraulic unit combined with standard hydraulic brake unit
- **1992:** 10M Bosch ABS installed.
- **1995:** Electronic Stability - in conjunction with ABS and TCS - for passenger cars.
- **1999:** 50M Bosch ABS installed.
- **2000:** 6 of 10 new cars on the road are ABS equipped.
- **2003:** 100M Bosch ABS installed.

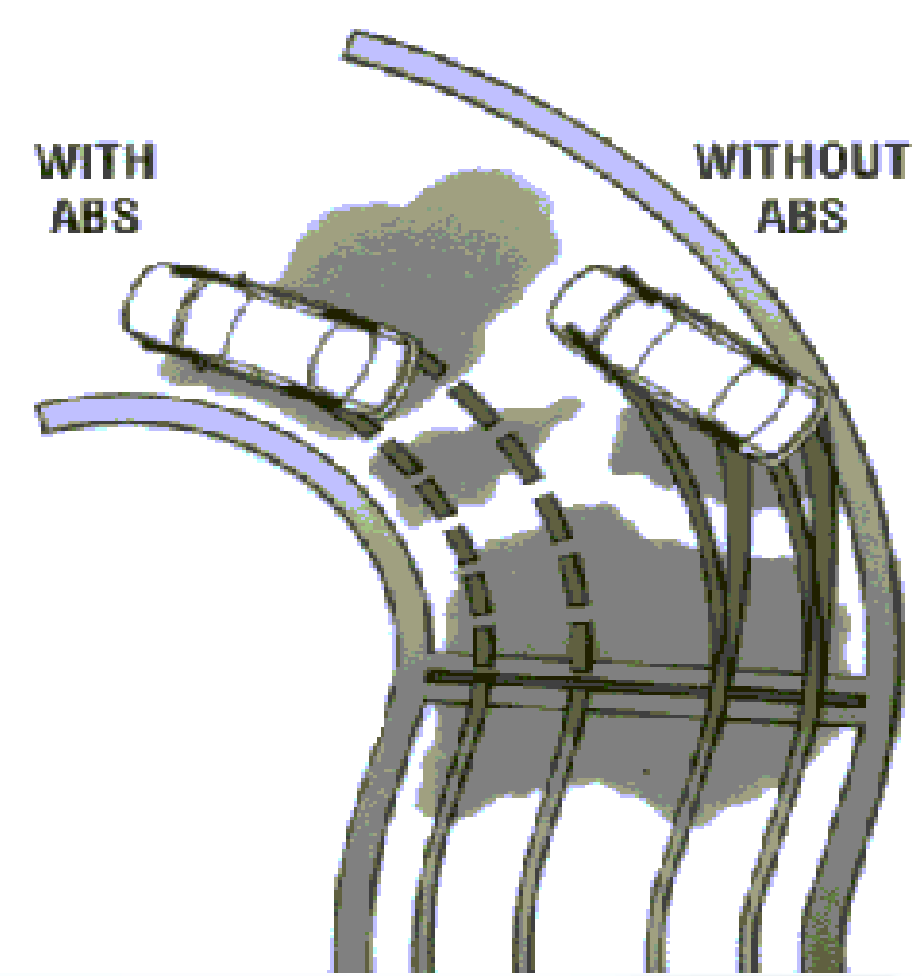
Concept of ABS

CONCEPT

A **skidding wheel** (where the tire contact patch is sliding relative to the road) has less **traction** than a non-skidding wheel

By keeping the wheels from skidding while you slow down, anti-lock brakes benefit you in two ways:

You'll stop faster, and you'll be able to steer while you stop



Objectives of ABS

OBJECTIVES

❖ To reduce stopping distance

1. The road surface type and conditions can be inferred from the vehicle's braking pressure, wheel slip measurements, and deceleration rate comparisons.

2. The wheel slip is regulated so that the road adhesion coefficient is maximized. By keeping all of the wheels of a vehicle near the maximum friction coefficient, an antilock system can attain maximum fictional force

3. In turn, this strategy leads to the minimization of the vehicle stopping distance.

❖ Stability

1. A locked-up wheel generates a reduced braking force, smaller than the peak value of the available adhesion between tires and road. A locked-up wheel will also lose its capability to sustain any lateral force. This may result in the loss of vehicle stability.

2. The basic purpose of a conventional ABS system is thus to prevent any wheel from locking and to keep the longitudinal slip in an operational range by cycling the braking pressure.

OBJECTIVES

❖ Steer ability

1. Good peak frictional force control is necessary in order to achieve satisfactory lateral forces and, therefore, satisfactory steer-ability.

2. If an obstacle appears without warning, emergency braking may not be sufficient. When the wheels are locked, car no longer respond to the driver's steering intention.

3. With ABS car remains steerable even during emergency braking, and thus the obstacle can be safely avoided.

Principle of ABS

PRINCIPLES FOR OPERATION

- The skidding and lack of control was caused by the locking of wheels.

- The release and reapply of the brake pedal will avoid the locking of the wheels which in turn avoid the skidding.

- This is exactly what an antilock braking system does.

Pressure Modulation :

1. When the brake pedal is pumped or pulsed the pressure is quickly applied and released at the wheels. This is called **pressure modulation**. Pressure modulation works to prevent the wheel locking.

2. ABS can modulate the pressure to the brake as often as 15 times per seconds.

3. ABS precisely controls the slip rate of the wheels to ensure maximum grip force from the tire and it there by ensures maneuverability and stability of the vehicle

PRINCIPLES FOR OPERATION

Slip Ratio :

When the brake pedal is depressed during driving, the wheel speed decreases and the vehicle speed does as well. The decrease in the vehicle speed, however, is not always proportional to the decrease in the wheel speed.

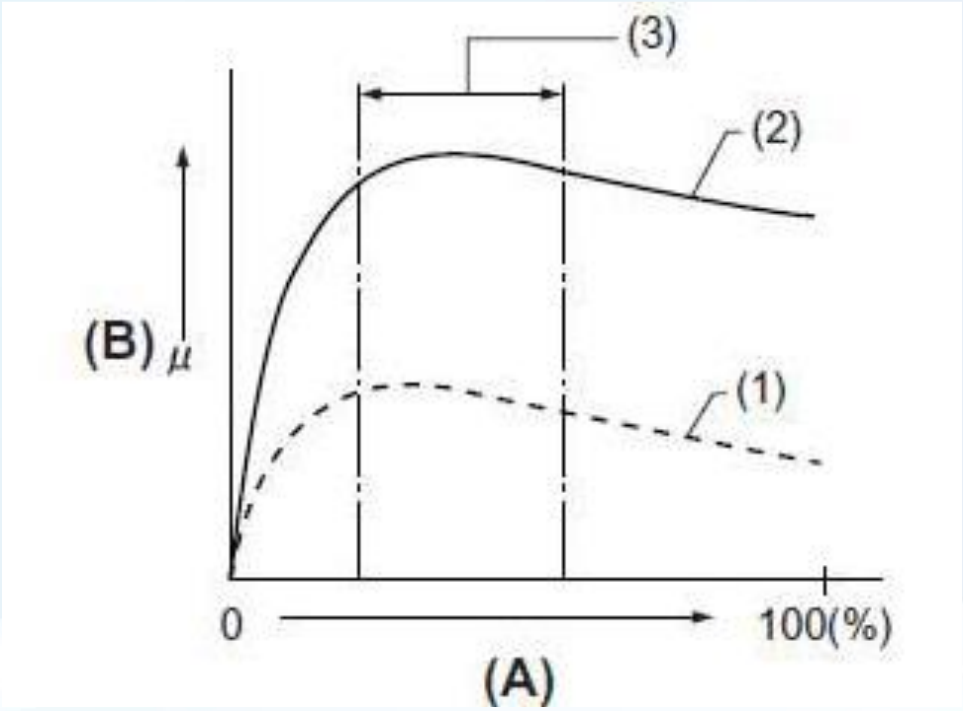
The non-correspondence between the wheel speed and vehicle speed is called “slip” and the magnitude of the slip is expressed by the “slip ratio” which is defined as follows:

$$\text{Slip ratio} = \frac{(\text{Vehicle speed} - \text{Wheel speed})}{\text{Vehicle speed}} \times 100\%$$

When the slip ratio is 0%, the vehicle speed corresponds exactly to the wheel speed. When it is 100%, the wheels are completely locking (rotating at a zero speed) while the vehicle is moving.

PRINCIPLES FOR OPERATION

- The best braking action occurs at between 10-20%.
- If vehicle speed and wheel speed is the same wheel slippage is 0%.
- A lock-up wheel will have a wheel slippage of 100%.
- A slip rate of 25 % means the velocity of a wheel is 25 % less than that of a freely rolling wheel at the same vehicle speed



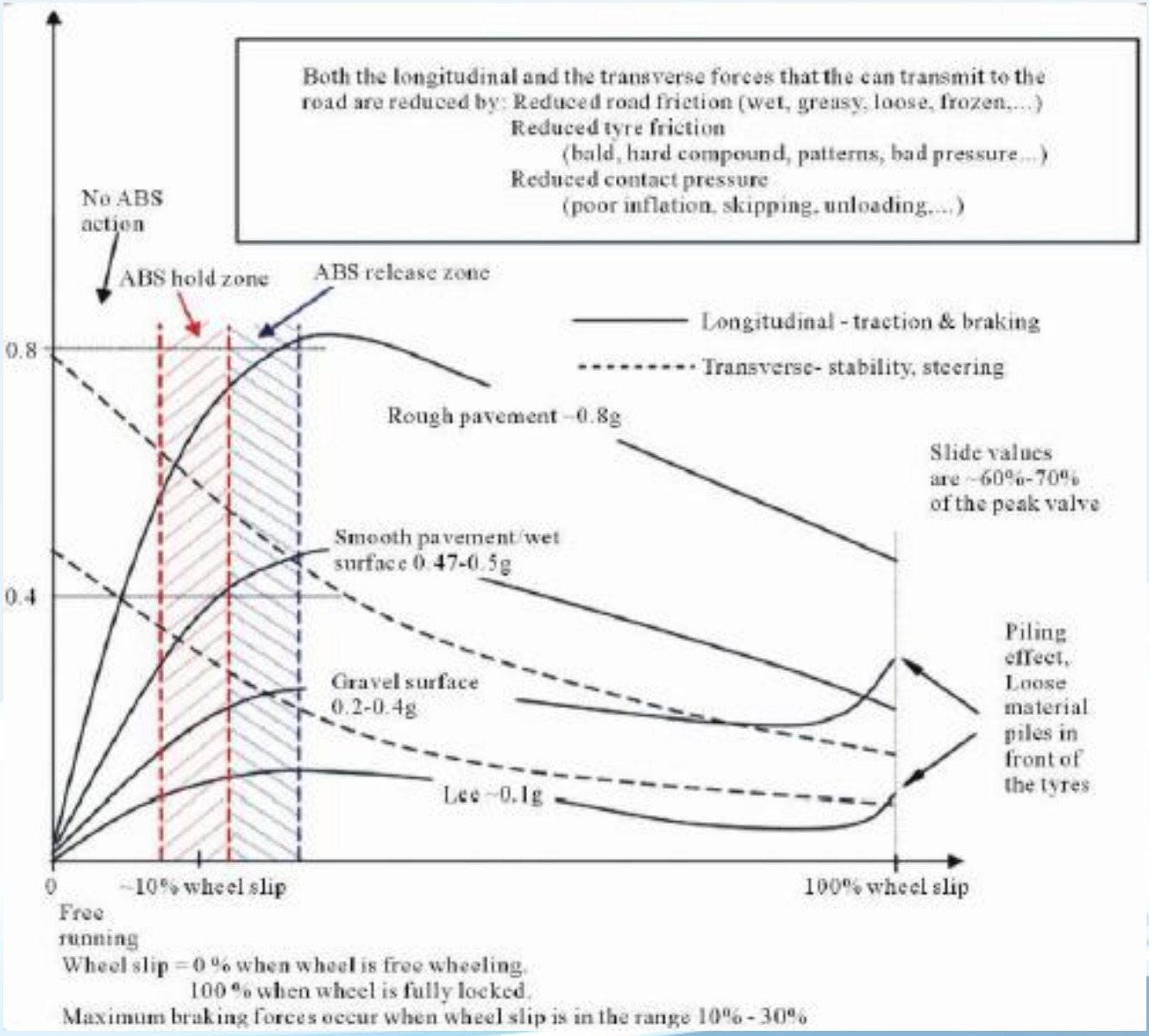
- **Where ;**
  - **A – Slip ratio**
  - **B - Coefficient of friction between tire and road surface**
  - **1 – Icy road**
  - **2 – Asphalt paved road**
  - **3 – Control range by ABS**

PRINCIPLES FOR OPERATION

Figure shows the relationship between braking co-efficient and wheel slip.

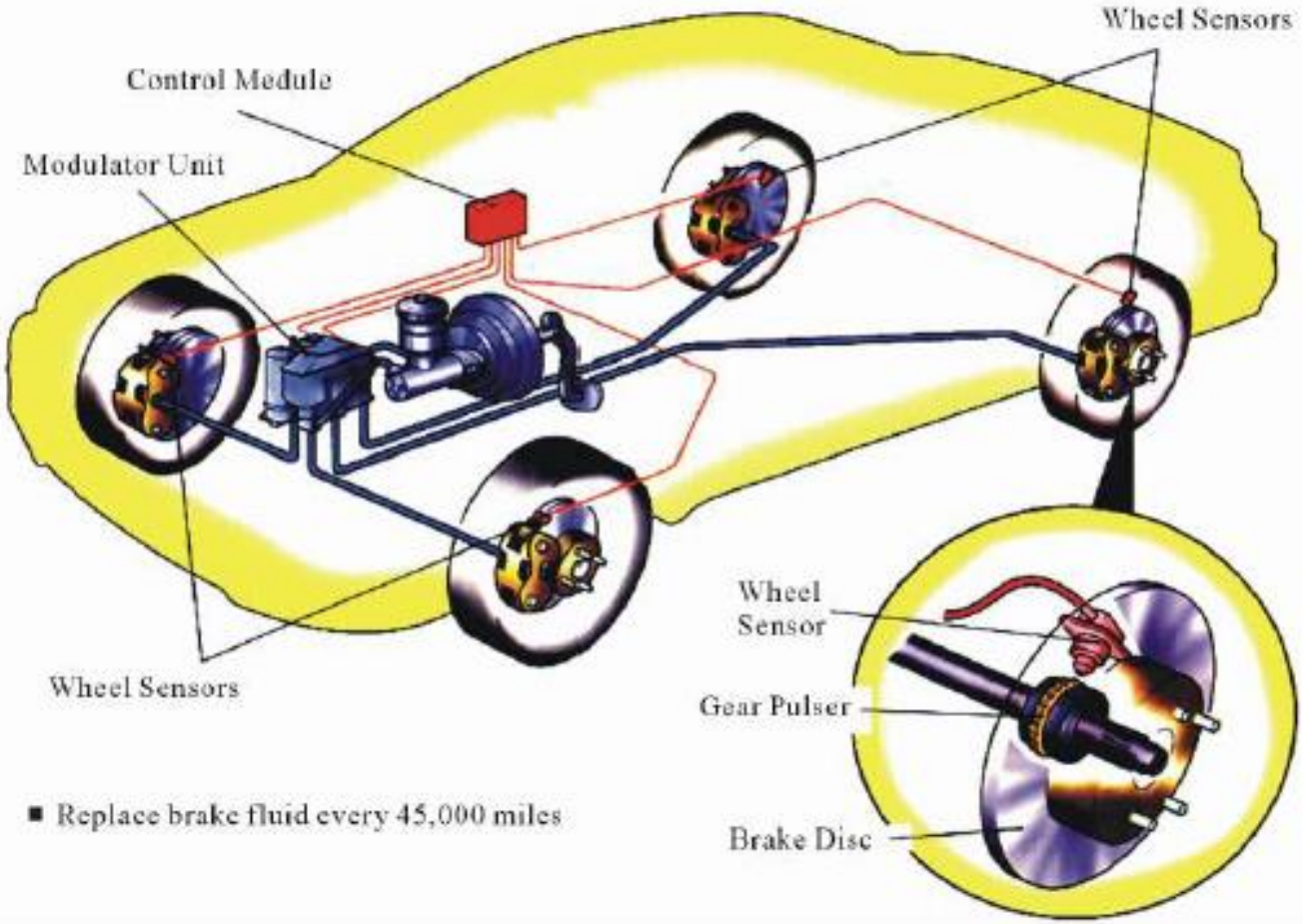
It is shown that the slide values for stopping/traction force are proportionately higher than the slide values for cornering/steering force.

A locked-up wheel provides low road handling force and minimal steering force.



Components of ABS

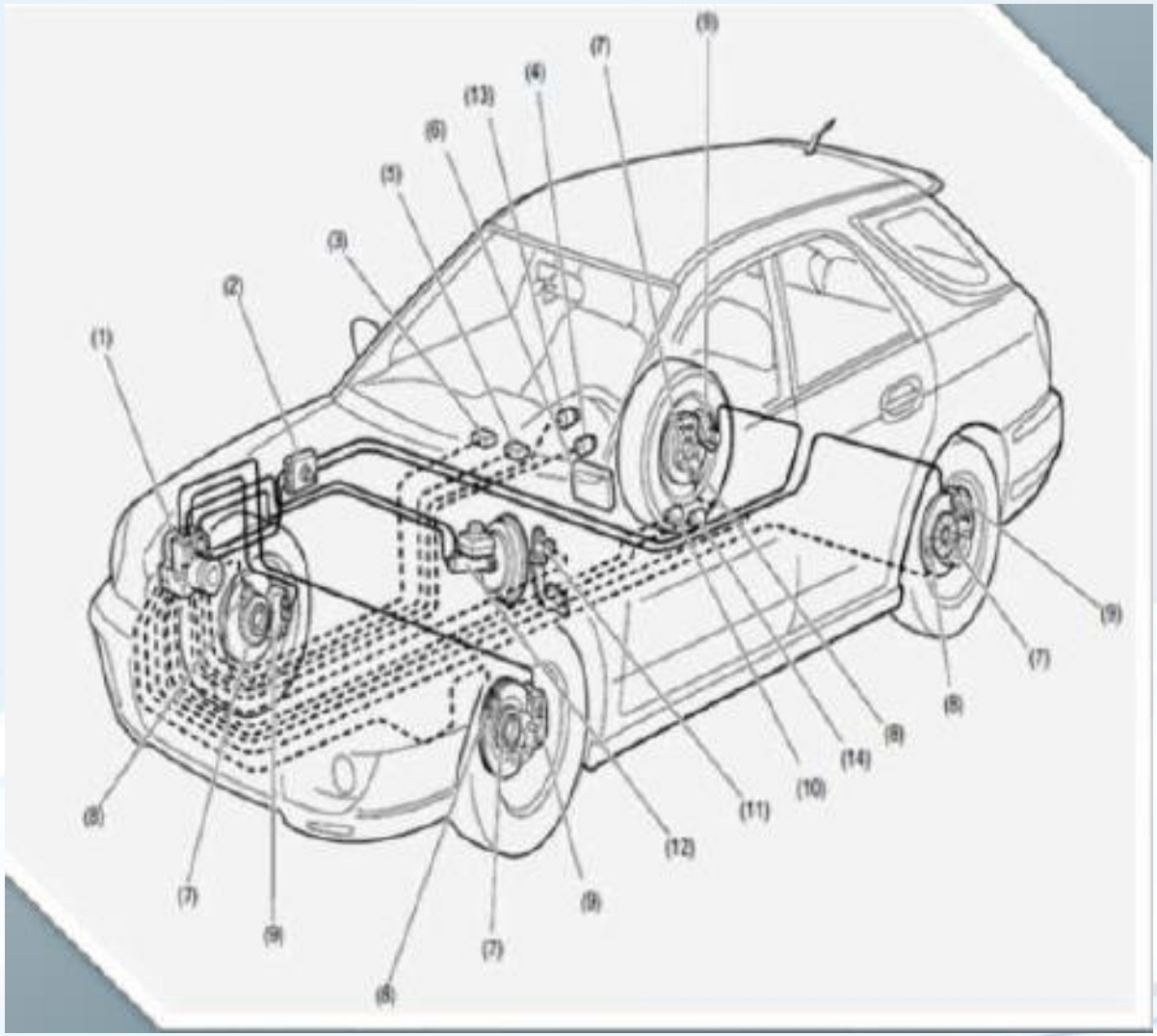
ABS COMPONENTS OVERVIEW



- Hydraulic unit
- Electronic brake control module (EBCM).
- Two system fuses.
- Four wheel speed sensors.
- Interconnecting wiring
- The ABS indicator
- The rear drum brake.

ABS COMPONENTS OVERVIEW

1. ABS control module and hydraulic control unit (ABSCM & H/U).
2. Two-way connector.
3. Diagnosis connector.
4. ABS warning light.
5. Data link connector (for SUBARU select monitor).
6. Transmission control module (AT models only).
7. Tone wheels.
8. ABS wheel speed sensor.
9. Wheel cylinder.
10. G sensor.
11. Stop light switch.
12. Master cylinder.
13. Brake & EBD warning light.
14. Lateral G sensor (STi).



ABS COMPONENTS OVERVIEW

ABS Brake System Are –

- **Integrated –**
  An integrated system has the master cylinder and control valve assembly made together.

- **Non Integrated –**
  A nonintegrated has the master cylinder and control valve assembly made separate.

ABS consists of 4 primary components :

1. ABS controller
2. ABS speed sensors
3. ABS modulator / valves
4. ABS pumps

ABS COMPONENTS OVERVIEW

ABS Components:

1. ABS Controller –

- The brains of the system. ABS Controllers are a computer that reads the inputs and then controls the system to keep the wheels from locking up and skidding.
- It receives signals from the sensors in the circuit and controls the brake pressure at the road wheels according to the data analysed by the Unit.

2 . ABS Speed Sensors –

- There are generally one on each wheel (sometimes they are located on the differential). It detects a change in acceleration in the longitudinal direction of the vehicle and outputs it to the ABSCM as a voltage signal.

ABS COMPONENTS OVERVIEW

ABS Components:

3. ABS Modulator / Valves –

- Some system have separate valves for each wheel with a modulator to control them. Other systems they are combined. In either case they work with the controller and the pump to add or release pressure from the individual wheels brakes to control the braking.

4 . ABS Speed Sensors –

- There are generally one on each wheel (sometimes they are located on the differential). It detects a change in acceleration in the longitudinal direction of the vehicle and outputs it to the ABSCM as a voltage signal.

- It receives operating signals from the ECU to apply or release the brakes under ABS conditions.
- 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.

Working of ABS

WORKING

- 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.
- Wheel slip:

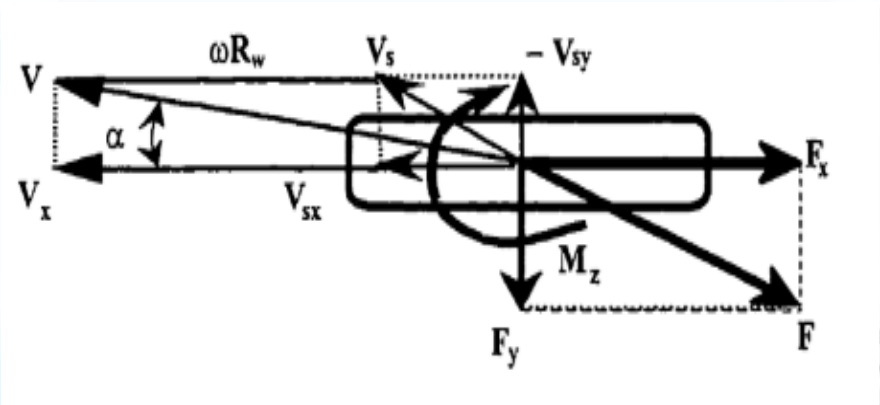
When the braking action is initiated, a slippage between the tire and the contacted road surface will occur, which make the speed of the vehicle to be different from that of the tire.

The longitudinal slip is defined as

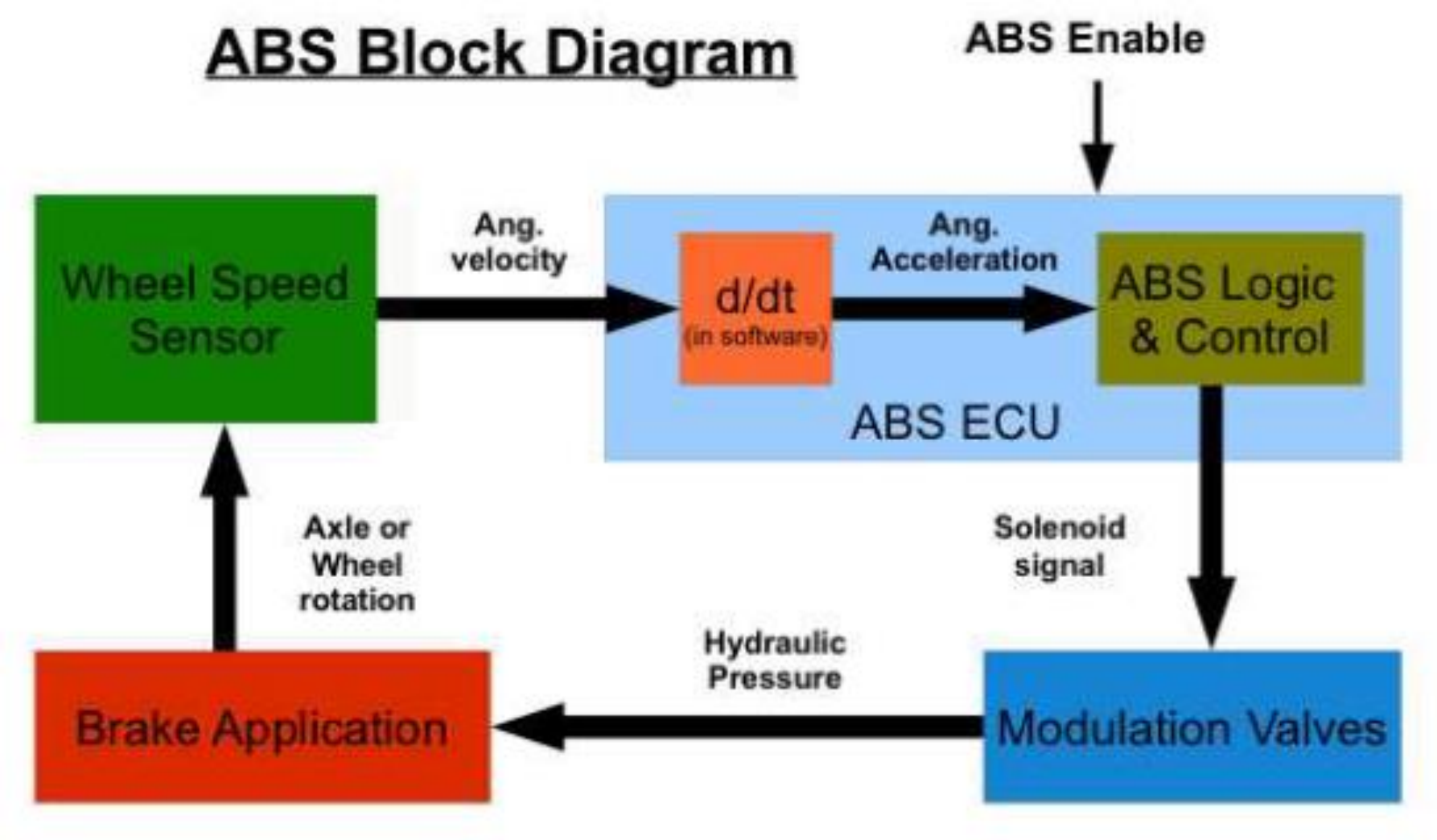
$$S = \frac{V\cos\alpha - \omega R_w}{V\cos\alpha}$$

The side slip angle is

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



SYSTEM DIAGRAM



Solenoid Valve Assembly

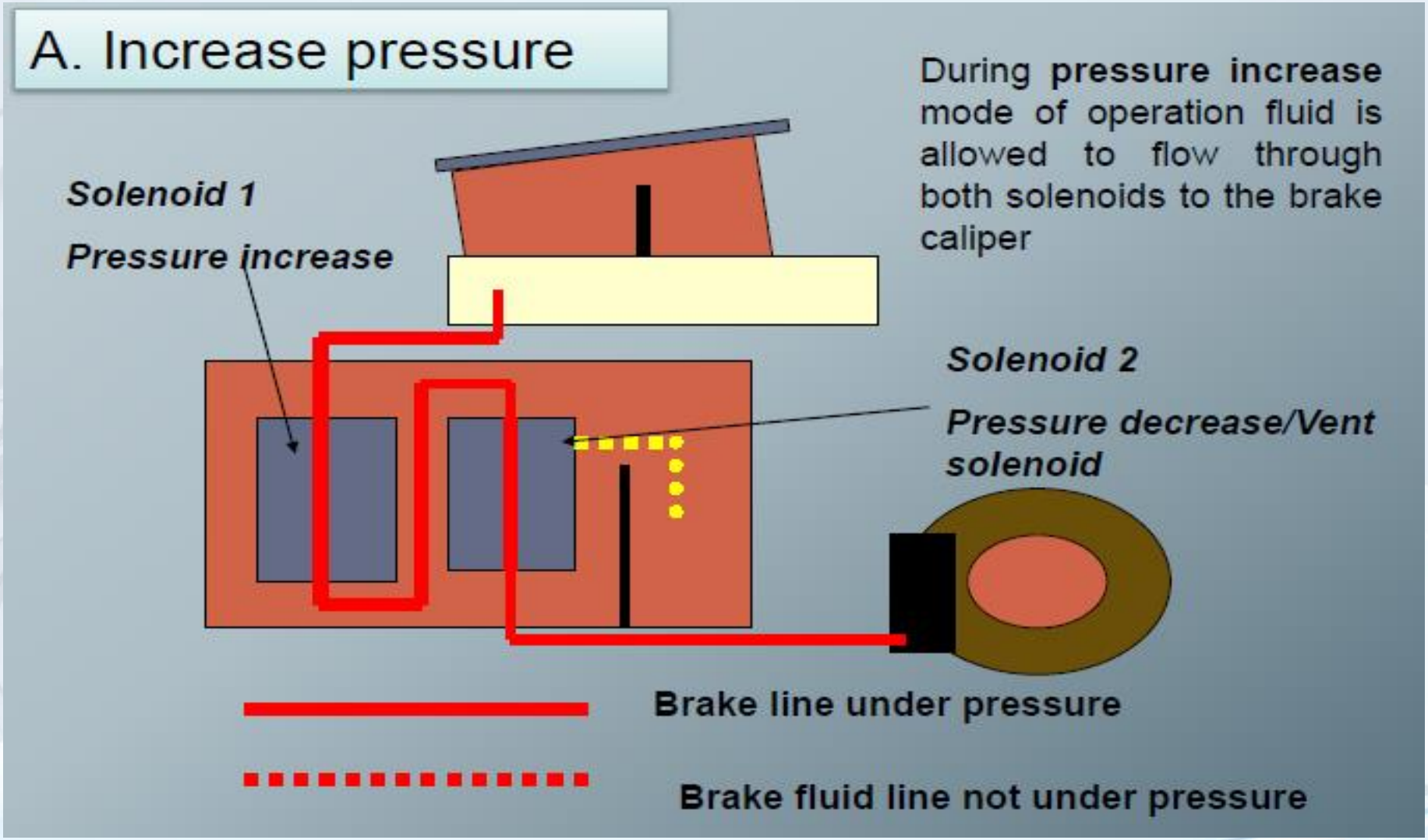
Pair of valves that can :

A. Increase pressure

B. Hold pressure steady

C. Decrease pressure

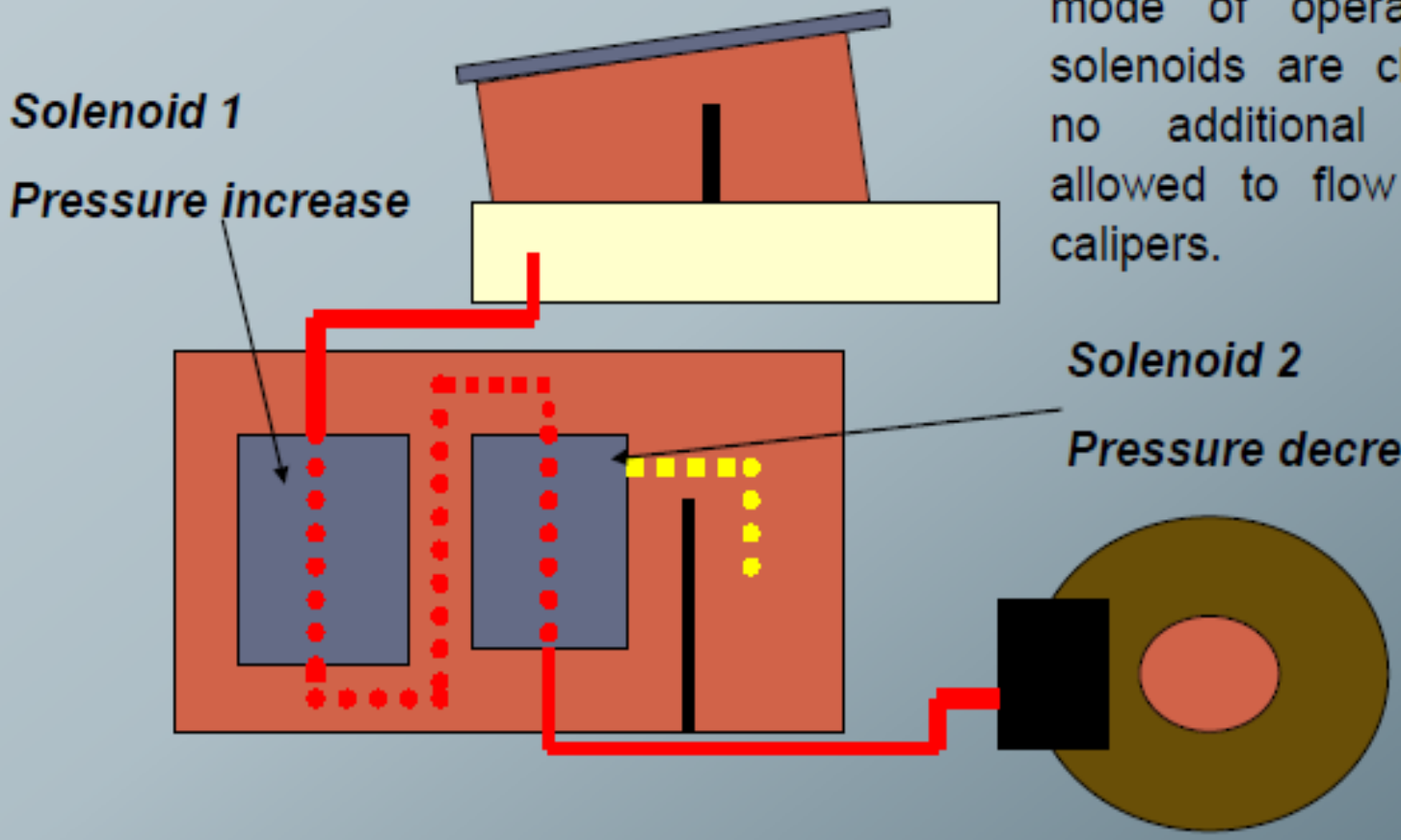
WORKING



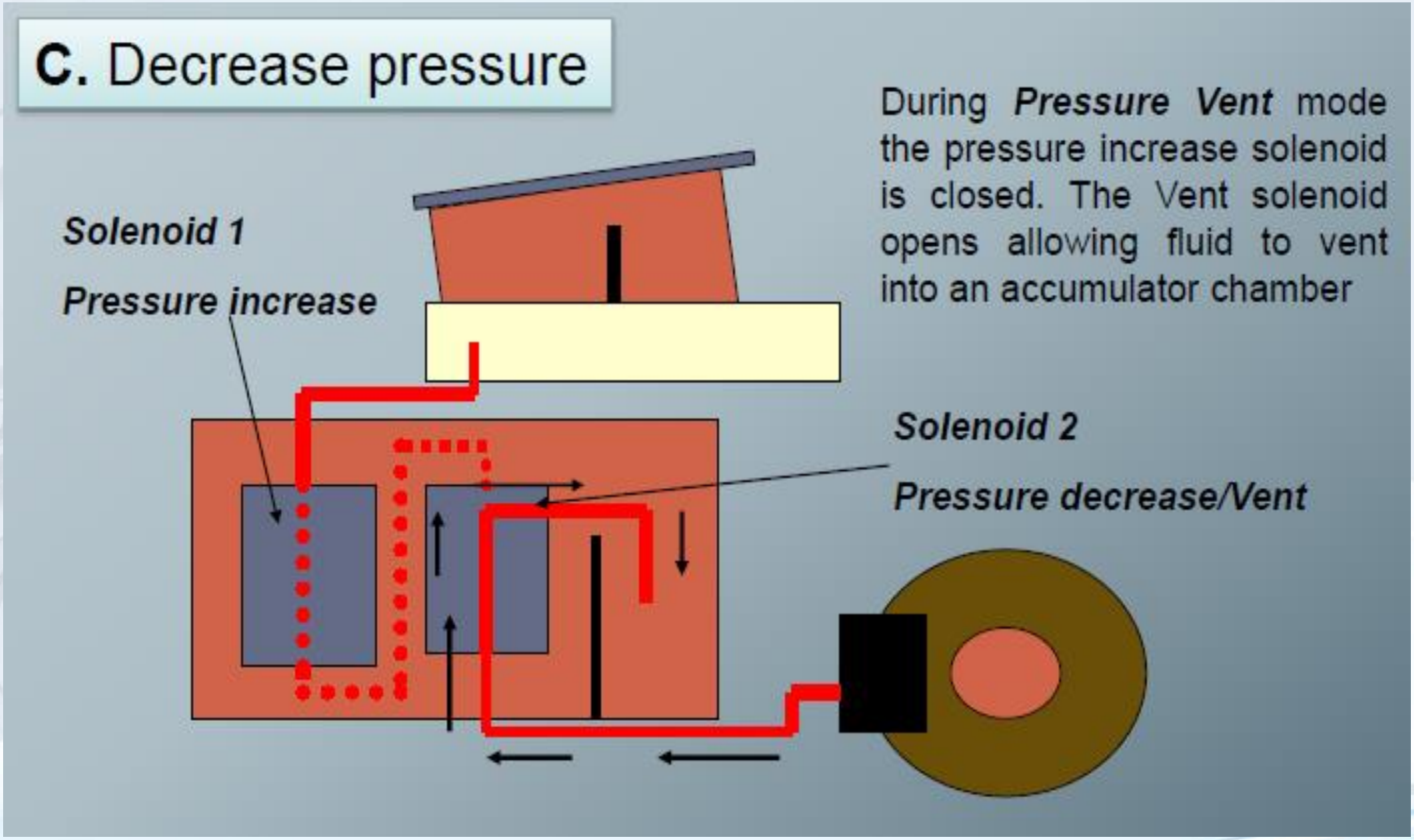
WORKING

B. Hold pressure steady

During *Pressure Hold* mode of operation both solenoids are closed and no additional fluid is allowed to flow to brake calipers.

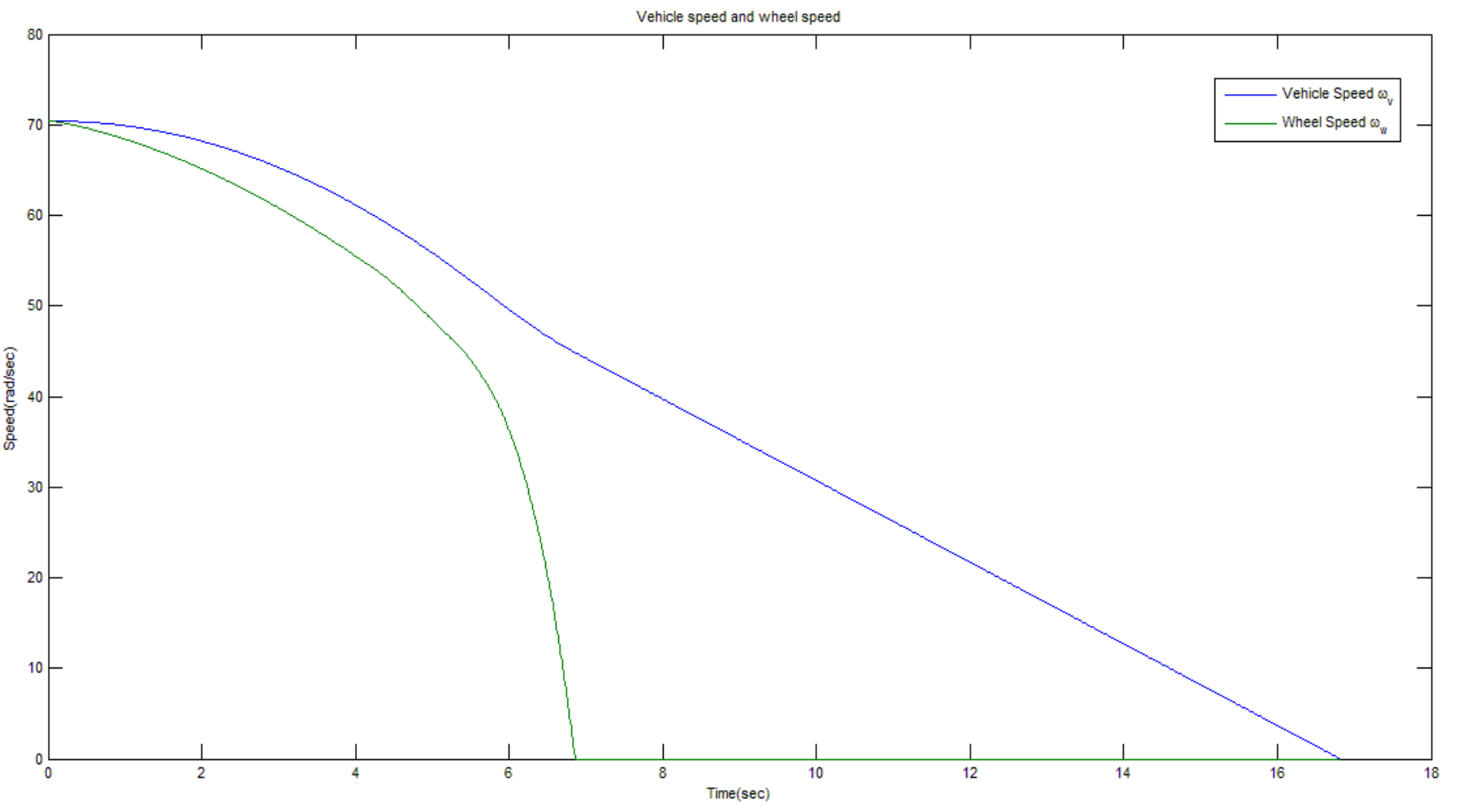


WORKING

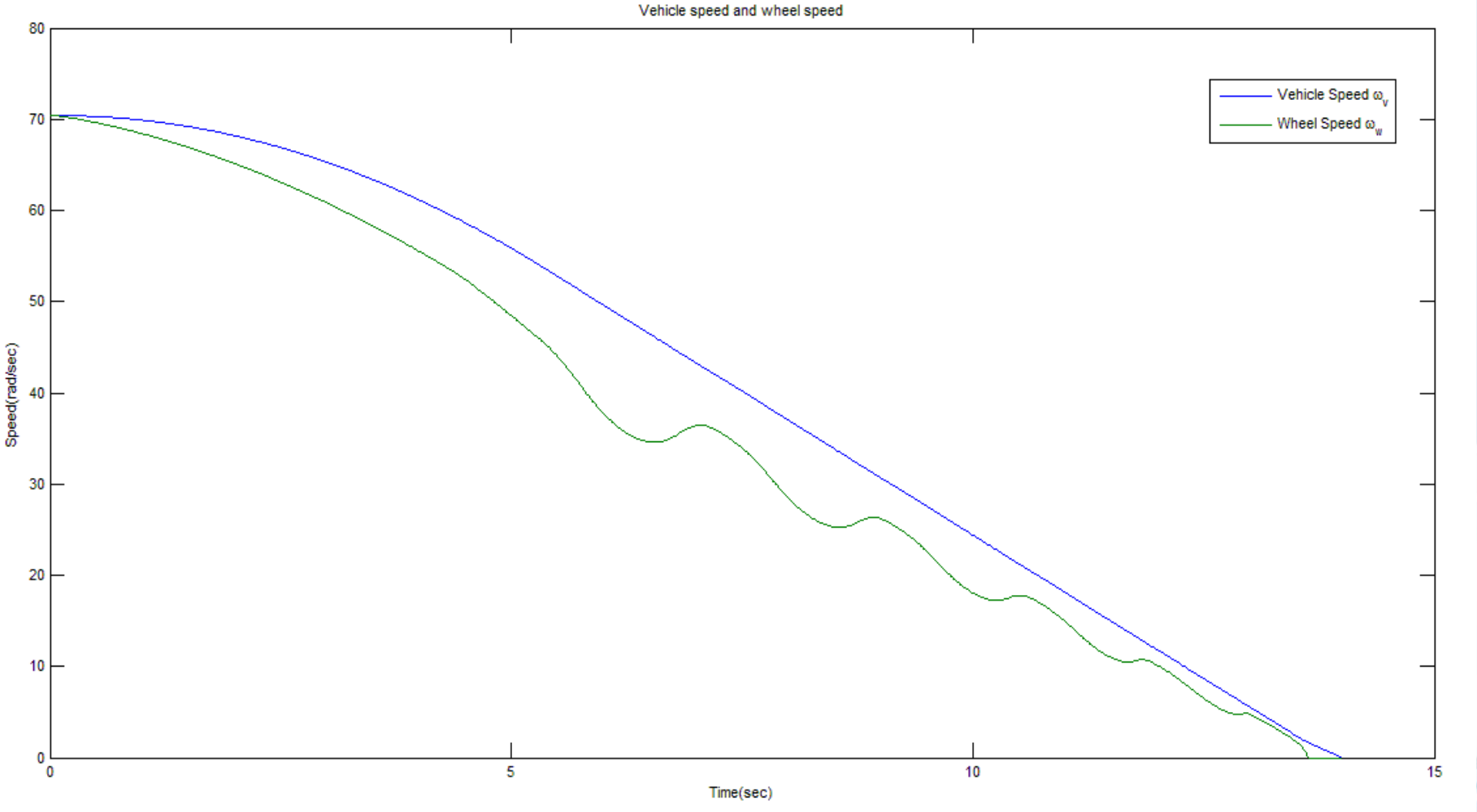


Result & Conclusion

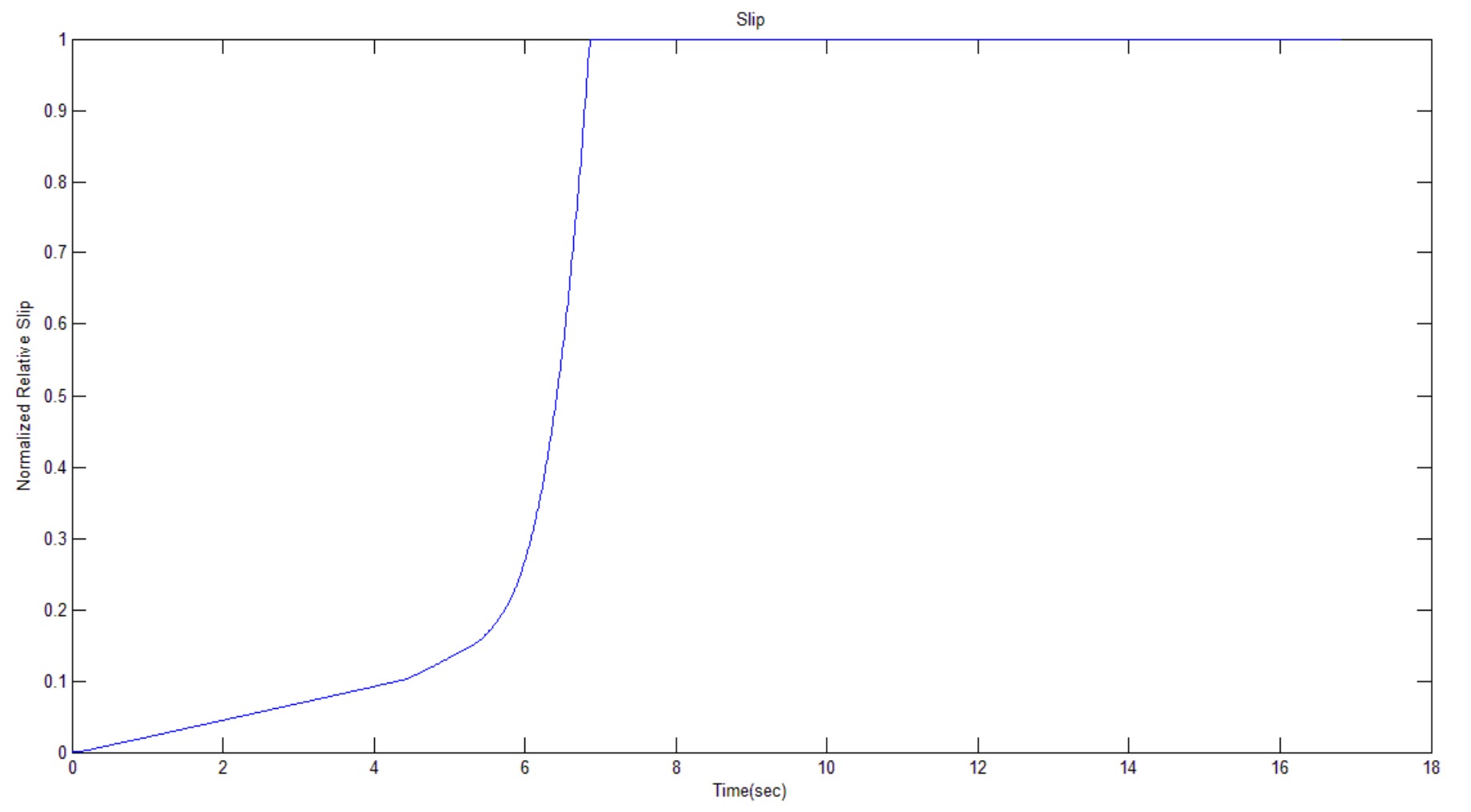
VEHICLE SPEED AND WHEEL SPEED (WITHOUT ABS)



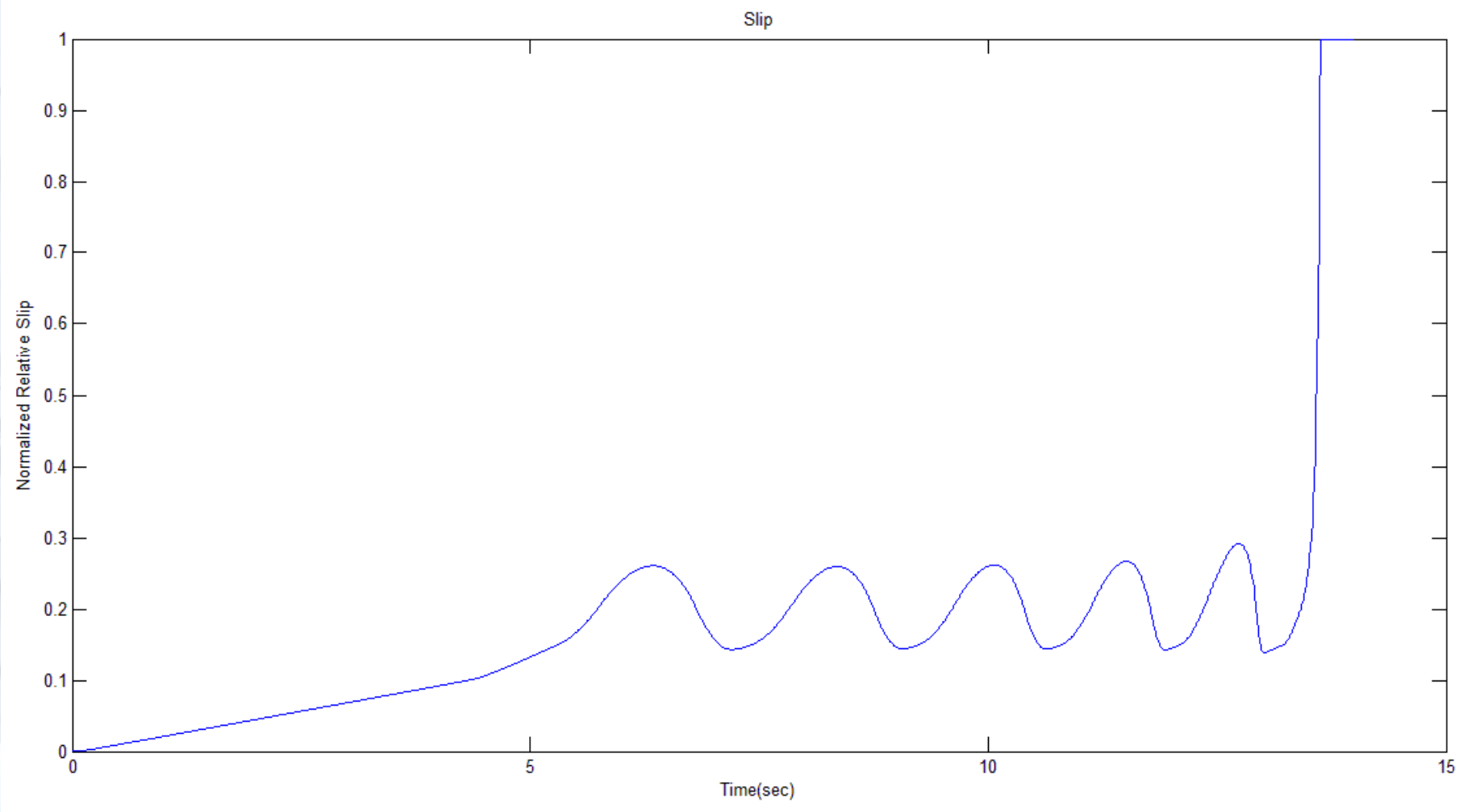
VEHICLE SPEED AND WHEEL SPEED (WITH ABS)



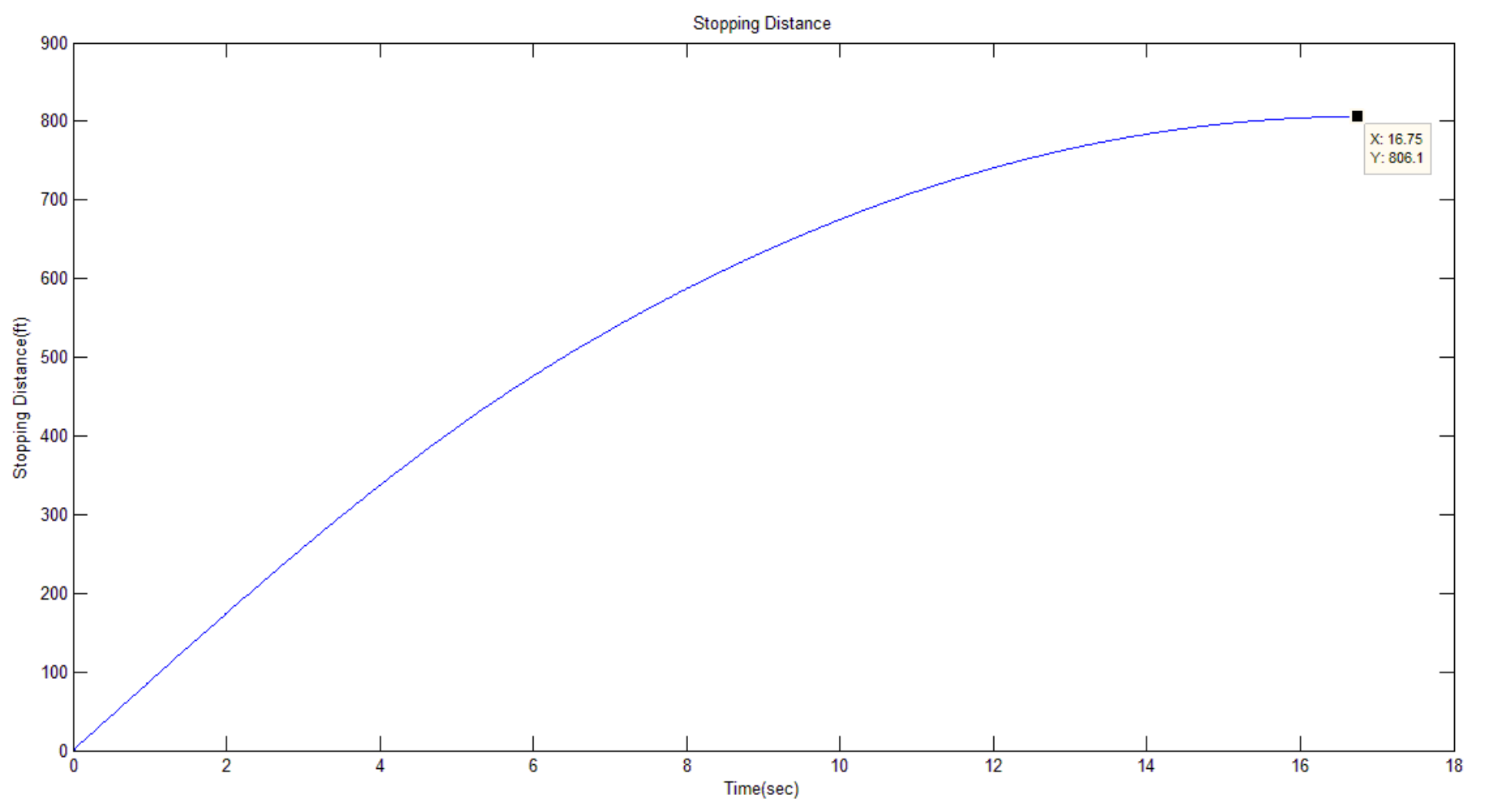
SLIP
(WITHOUT ABS)



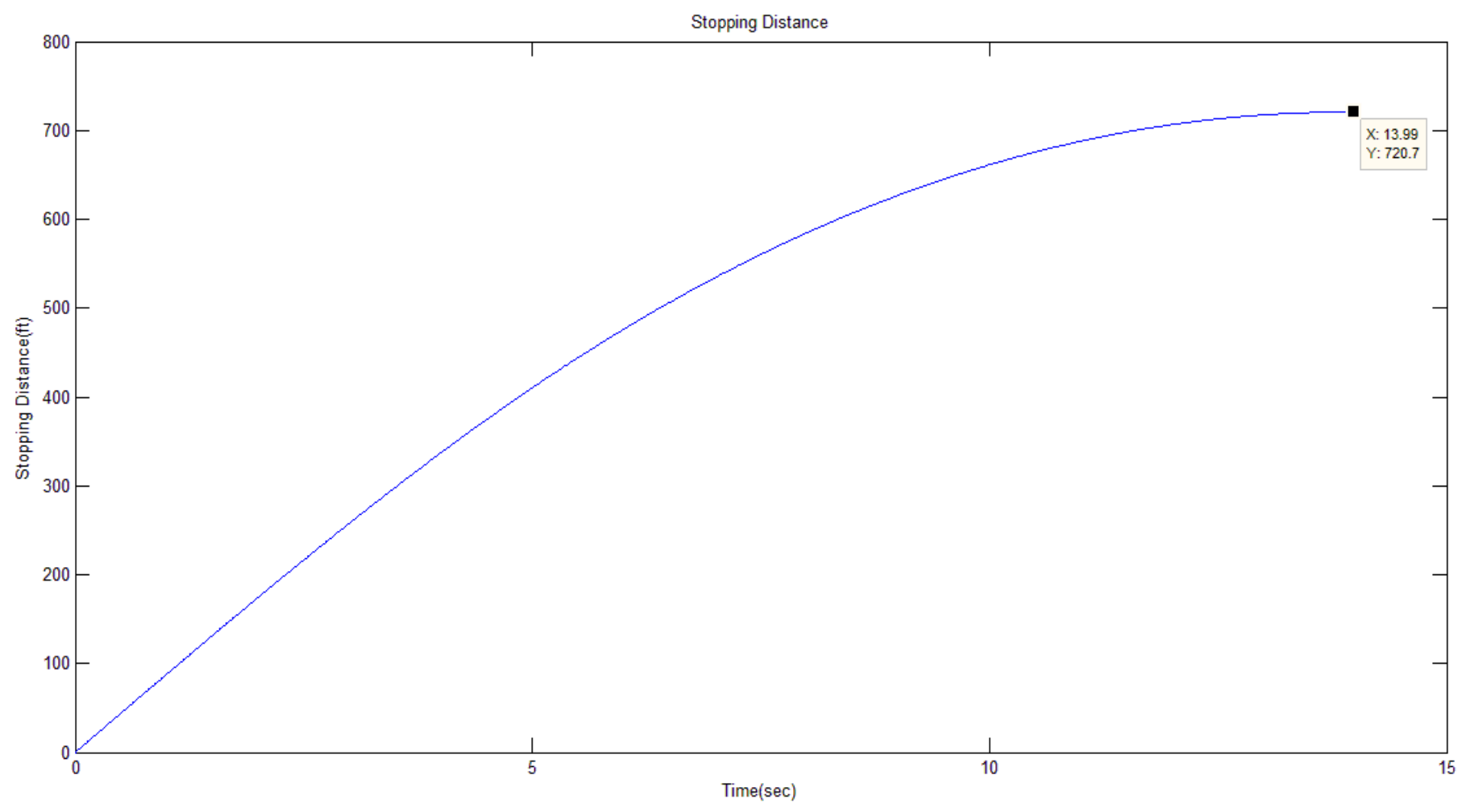
SLIP
(WITH ABS)



STOPPING DISTANCE (WITHOUT ABS)



STOPPING DISTANCE (WITH ABS)



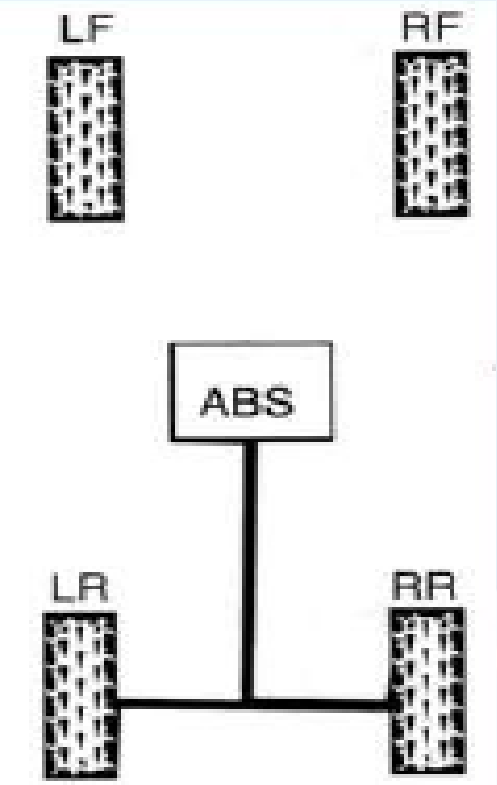
CONCLUSION

- It is inferred that ABS improves the braking performance.
- The stopping distance after using ABS system has considerably reduced.
- The error in slip and desired slip is used to manipulate brake pressure in brake cylinder.

ABS Types

One-channel, One-sensor ABS

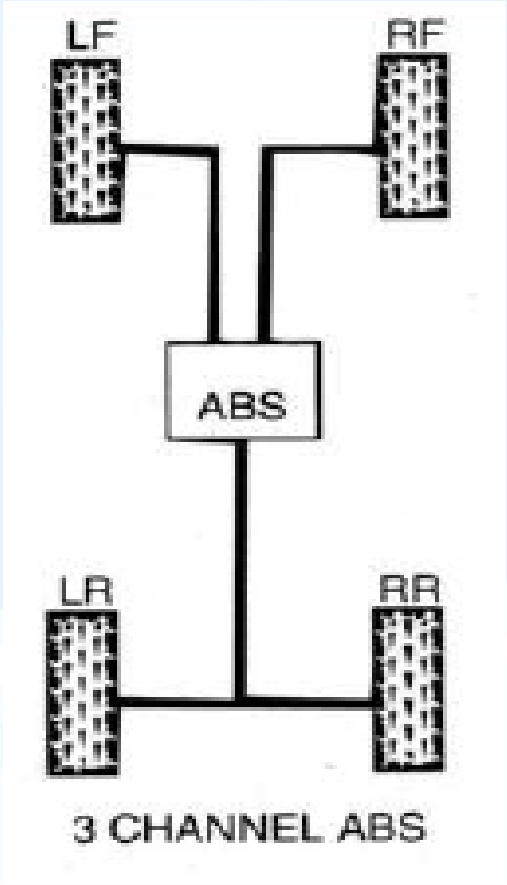
This system is commonly found on pickup trucks with rear-wheel ABS. It has one valve, which controls both rear wheels, and one speed sensor, located in the rear axle.



1 CHANNEL ABS
(REAR-WHEEL ABS)

Three-channel, Three-sensor ABS

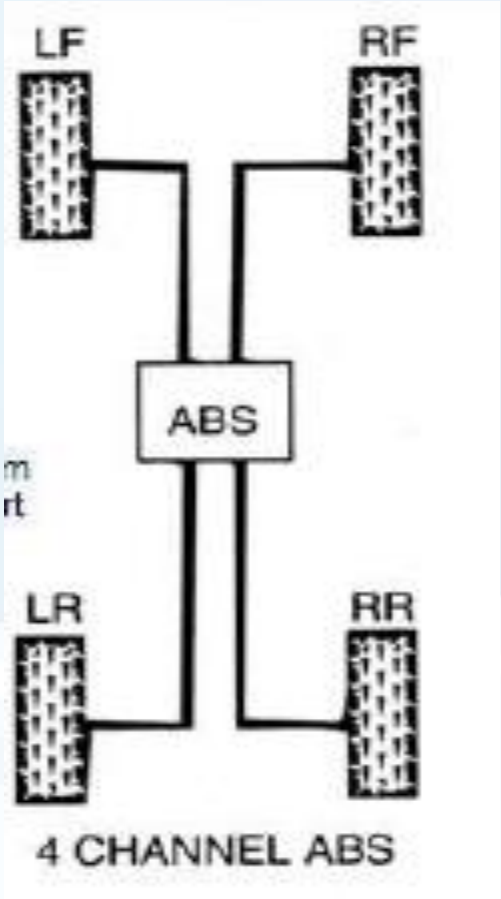
This scheme, commonly found on pickup trucks with four-wheel ABS, has a speed sensor and a valve for each of the front wheels, with one valve and one sensor for both rear wheels. The speed sensor for the rear wheels is located in the rear axle.



3 CHANNEL ABS

Four-channel, Four-sensor ABS

This is the best scheme. There is a speed sensor on all four wheels and a separate valve for all four wheels. With this setup, the controller monitors each wheel individually to make sure it is achieving maximum braking force.



Advantages & Disadvantages

ADVANTAGES

- It allows the driver to maintain directional stability and control over steering during braking
- Safe and effective
- Automatically changes the brake fluid pressure at each wheel to maintain optimum brake performance.
- ABS absorbs the unwanted turbulence shock waves and modulates the pulses thus permitting the wheel to continue turning under maximum braking pressure.

DISADVANTAGES

- It is very costly
- Maintenance cost of a car equipped with ABS is more.

General Information

GENERAL INFORMATION

- Statistics show that approximately 40 % of automobile accidents are due to skidding.

- These problems commonly occur on vehicle with conventional brake system which can be avoided by adding devices called ABS.

- If there is an ABS failure, the system will revert to normal brake operation. Normally the ABS warning light will turn on and let the driver know there is a fault.

Summary

SUMMARY

- The antilock braking system controls braking force by controlling the hydraulic pressure of the braking system, so that the wheels do not lock during braking.

- The antilock braking system prevents wheels locking or skidding, no matter how hard brakes are applied, or how slippery the road surface. Steering stays under control and stopping distances are generally reduced.

THANK YOU

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Are there any Questions?