Unit -VI
Vehicle Management System

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- **Syllabus:**

- ABS system with layout and working, Electronic control of suspension – Damping control, Driver state monitoring (DSM),Supplementary Restraint System of air bag system, seat belts, Adaptive Cruise control, Vehicle security systems alarms, vehicle tracking system, Collision avoidance, Radar warning system, Introduction to Global Positioning Systems, Lane Departure Warning System, Tire Pressure Monitoring System, Smart parking assist system (SPAS)

History of ABS

- **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.

- **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.
- **Nowadays:-** Almost all new cars have ABS.

❖ Antilock Braking System (ABS)

- One of the most readily accepted applications of electronics in automobiles has been the antilock brake system (ABS).
- ABS is a safety-related feature that assists the driver in deceleration of the vehicle in poor or marginal braking conditions (e.g., wet or icy roads).
- In such conditions, panic braking by the driver (in non-ABS-equipped cars) results in reduced braking effectiveness and, typically, loss of directional control due to the tendency of the wheels to lock.
- In ABS-equipped cars, the wheel is prevented from locking by a mechanism that automatically regulates braking force to an optimum for any given low-friction condition.

- The physical configuration for an ABS is shown in Figure 8.12. In addition to the normal brake components, including brake pedal, master cylinder, vacuum boost, wheel cylinders, calipers/disks, and brake lines, this system has a set of angular speed sensors at each wheel, an electronic control module, and a hydraulic brake pressure modulator (regulator).

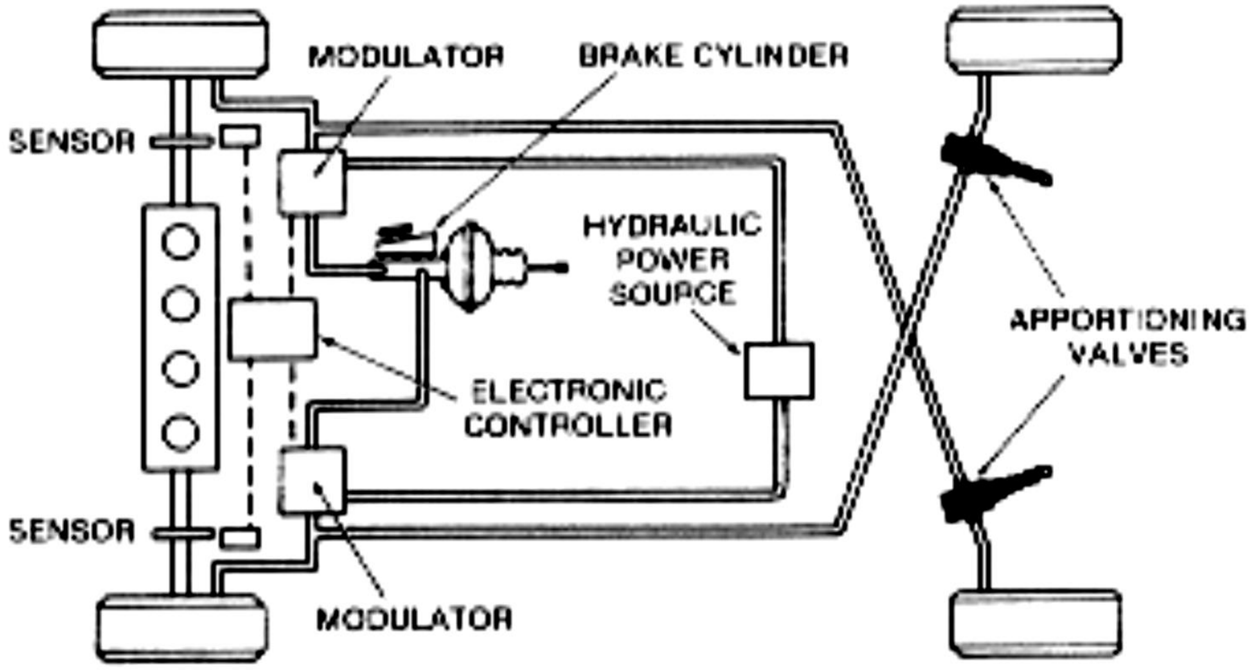
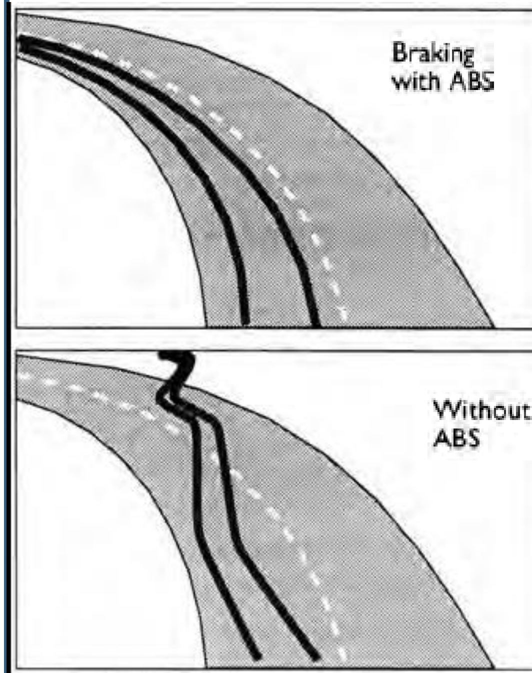


Figure 8.12

ABS system with layout and working

- The reason for the development of anti-lock brakes (ABS) is very simple. Under braking conditions, if one or more of the vehicle wheels locks (begins to skid), there are a number of consequences.
    - Braking distance increases.
    - Steering control is lost.
    - Abnormal tyre wear.
- The obvious result is that an accident is far more likely to occur. The **maximum deceleration of a vehicle is achieved when maximum energy conversion is taking place in the brake system.** This is the conversion of kinetic energy to heat energy at the discs and brake drums.

- The potential for this conversion process between a tyre skidding, even on a dry road, is far less. A good driver can pump the brakes on and off to prevent locking but electronic control can achieve even better results.
- ABS is becoming more common on lower price vehicles, which should be a significant contribution to safety. It is important to remember, however, that for normal use, the system is not intended to allow faster driving and shorter braking distances.
- It should be viewed as operating in an emergency only. Figure shows how ABS can help to maintain steering control even under very heavy braking conditions.



Requirements of ABS

Fail-safe system

- In the event of the ABS system failing the conventional brakes must still operate to their full potential. In addition, a warning must be given to the driver. This is normally in the form of a simple warning light.

Maneuverability must be maintained

- Good steering and road holding must continue when the ABS system is operating. This is arguably the key issue, as being able to swerve around a hazard whilst still braking hard is often the best course of action.

❖ **Immediate response must be available**

- Even over a short distance the system must react such as to make use of the best grip on the road. The response must be appropriate whether the driver applies the brakes gently or slams them on hard.

❖ **Operational influences**

- Normal driving and maneuvering should produce no reaction on the brake pedal. The stability and steering must be retained under all road conditions. The system must also adapt to braking hysteresis when the brakes are applied, released and then re-applied.
- Even if the wheels on one side are on dry tarmac and the other side on ice, the yaw (rotation about the vertical axis of the vehicle) of the vehicle must be kept to a minimum and only increase slowly in order to allow the driver to compensate.

❖ Controlled wheels

- In its basic form, at least one wheel on each side of the vehicle should be controlled on a separate circuit. It is now general for all four wheels to be separately controlled on passenger vehicles.

❖ Speed range of operation

- The system must operate under all speed conditions down to walking pace. At this very slow speed even when the wheels lock the vehicle will come to rest very quickly. If the wheels did not lock then, in theory, the vehicle would never stop!

❖ Other operating conditions

- The system must be able to **recognize aquaplaning** and react accordingly. It must also still operate on an uneven road surface. The one area still not perfected is braking from slow speed on snow. **The ABS will actually increase stopping distance in snow but steering will be maintained. This is considered to be a suitable trade-off.**
- A number of different types of anti-lock brake systems are in use, but all try to achieve the requirements as set out above.

- As with other systems, ABS can be considered as a central control unit with a series of inputs and outputs.
- An ABS system is represented by the closed loop system block diagram shown in Figure 15.2. The most important of the inputs are the wheel speed sensors, and the main output is some form of brake system pressure control.
- The task of the control unit is to compare signals from each wheel sensor to measure the acceleration or deceleration of an individual wheel.

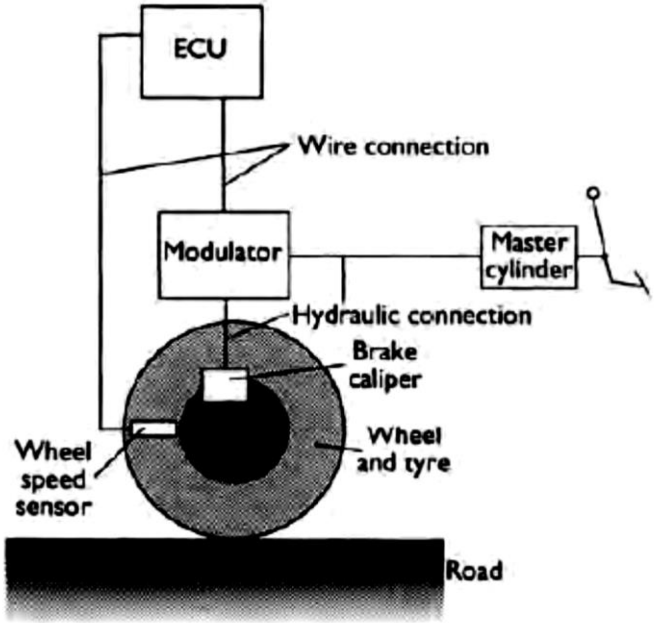


Figure 15.2 Anti-lock brake system

- From these data and pre-programmed look-up tables, brake pressure to one or more of the wheels can be regulated.
- Brake pressure can be reduced, held constant or allowed to increase. The maximum pressure is determined by the driver's pressure on the brake pedal. A number of variables are sensed, used or controlled by this system.

1. Pedal pressure

- Determined by the driver.

2. Brake pressure

- Under normal braking this is proportional to pedal pressure but under control of the ABS it can be reduced, held or allowed to increase.

3. Controlled variable

- This is the actual result of changes in brake pressure, in other words the wheel speed, which then allows acceleration, deceleration and slip to be determined.

4. Road/vehicle conditions

- Disturbances such as the vehicle load, the state of the road, tyre condition and brake system condition. From the wheel speed sensors the ECU calculates the following.

5. Vehicle reference speed

- Determined from the combination of two diagonal wheel sensor signals. After the start of braking the ECU uses this value as its reference.

6. Wheel acceleration or deceleration

This is a live measurement that is constantly changing.

7. Brake slip

- Although this cannot be measured directly, a value can be calculated from the vehicle reference speed. This figure is then used to determine when/if ABS should take control of the brake pressure.

8. Vehicle deceleration

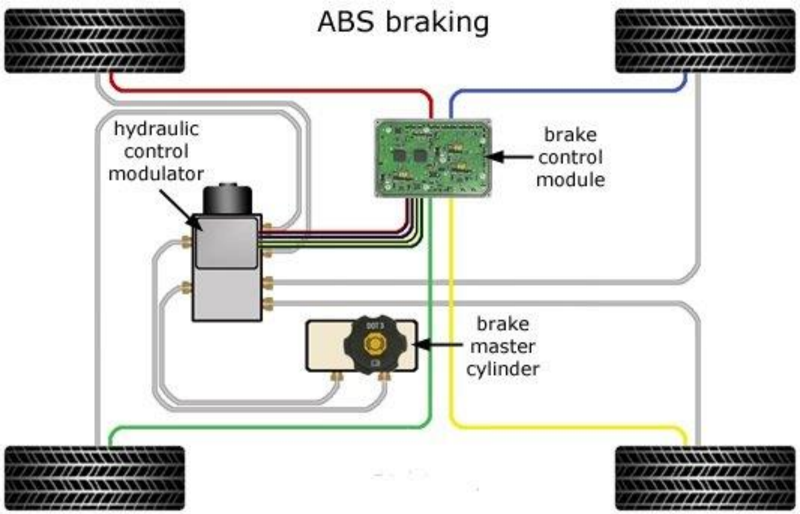
- During brake pressure control, the ECU uses the vehicle reference speed as the starting point and decreases it in a linear manner. The rate of decrease is determined by the evaluation of all signals received from the wheel sensors. Driven and non-driven wheels on the vehicle must be treated in different ways as they behave differently when braking. A logical combination of wheel deceleration/ acceleration and slip is used as the controlled variable. The actual strategy used for ABS control varies with the operating conditions.

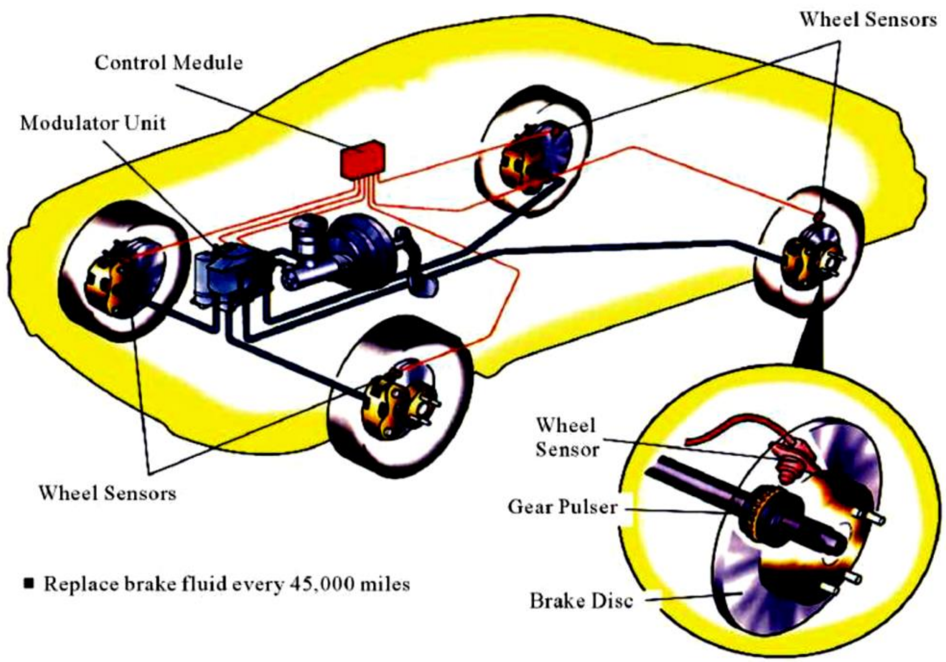
Slip Ratio

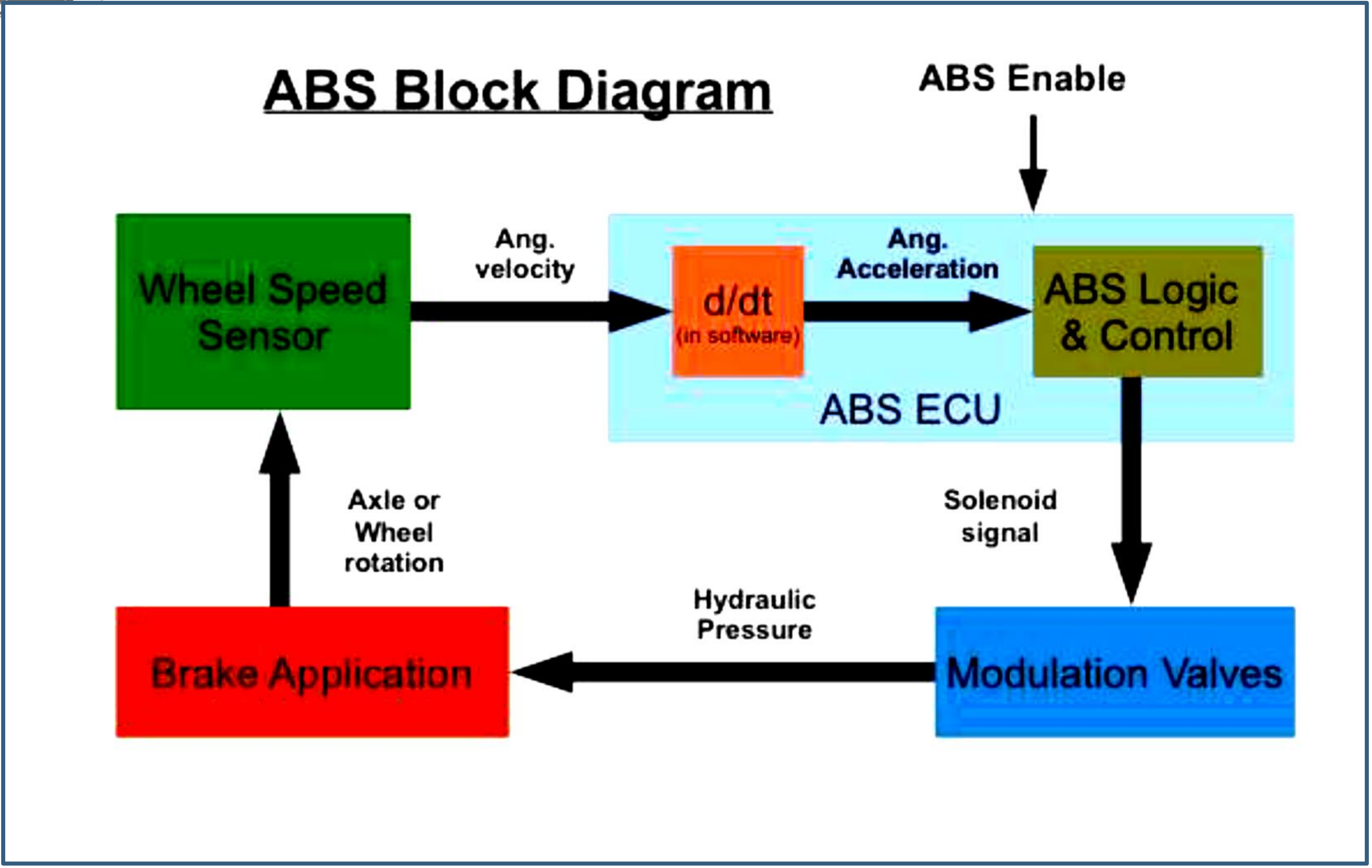
- When the brake pedal is depressed during driving, the wheel speed decreases and the vehicle speed does as well.
- The decrease in the vehicle speed, however, is not always proportional to the decrease in the wheel speed.
- The non-correspondence between the wheel speed and vehicle speed is called "slip" and the magnitude of the slip is expressed by the "slip ratio" which is defined as follows:

Slip ratio = (Vehicle speed – Wheel speed)/Vehicle speed × 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.


ABS braking
hydraulic control modulator
brake control module
brake master cylinder


Wheel Sensors
Control Medule
Modulator Unit
Wheel Sensor
Gear Pulser
Brake Disc
Wheel Sensors
Replace brake fluid every 45,000 miles


ABS Block Diagram
ABS Enable
Wheel Speed Sensor
Ang. velocity
d/dt
(in software)
Ang. Acceleration
ABS Logic & Control
ABS ECU
Solenoid signal
Axle or Wheel rotation
Hydraulic Pressure
Brake Application
Modulation Valves

❑ 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.
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.

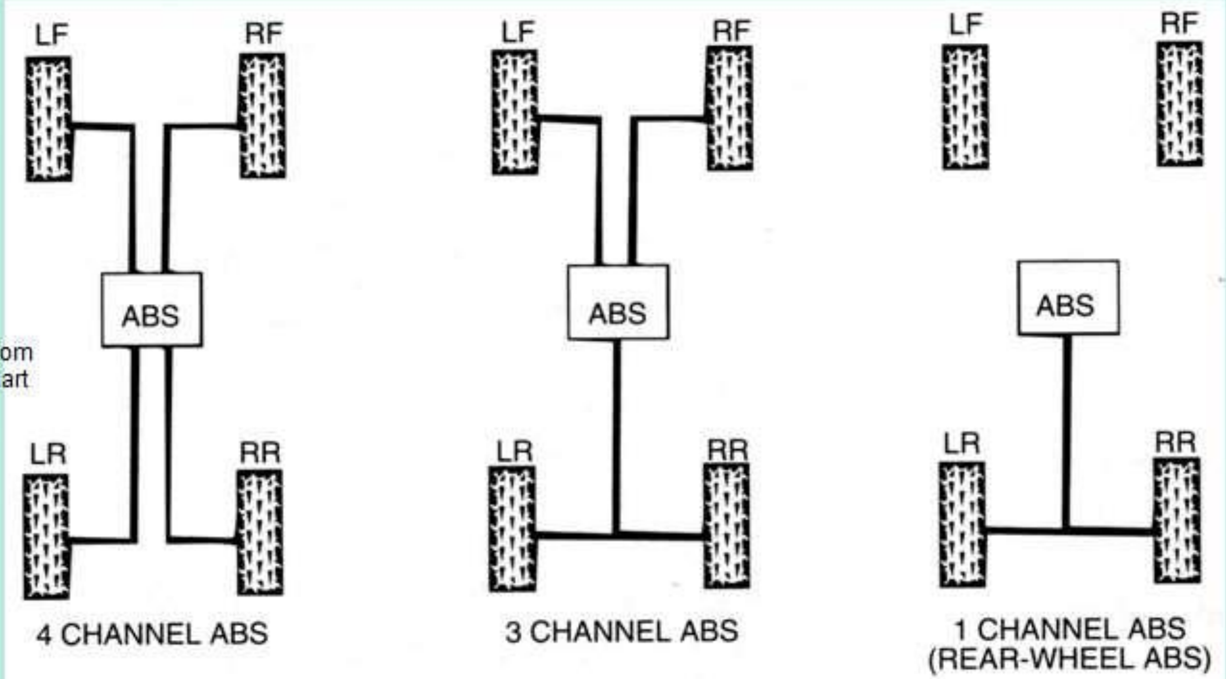
3. **ABS Modulator/Valves**; some system have separate valves for each wheel with a modulator to control them. Other systems they are combined. In either case they work with the controller and the pump to add or release pressure from the individual wheels brakes to control the braking.
4. **ABS Pumps**; since the ABS modulator/valves can release pressure from the individual wheels brakes there needs to be a way to restore the pressure when required. That is what the ABS pumps job is. When the pump is cycling, the driver may experience a slight pedal vibration. This cycling is happening many times per second and this slight vibration is natural.

❑ Configurations of ABS

Configuration Options:

- One Channel
- Three Channel
- Four Channel.

A Channel refers to how the control over the hydraulic brake pressure is organized.



Visual from ChekChart

1. One-channel, one-sensor ABS

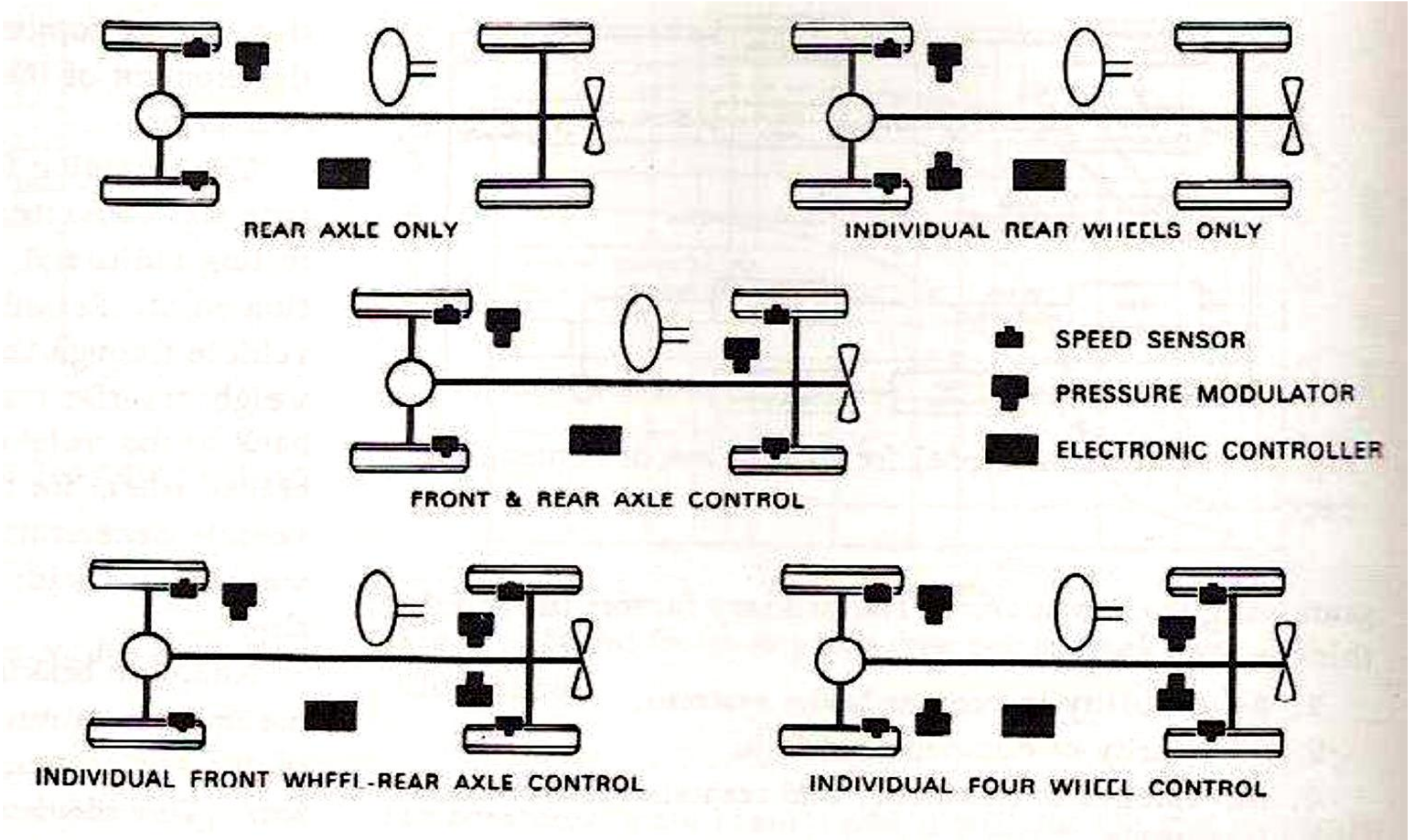
- This system is commonly found on pickup trucks with rear-wheel ABS. It has one valve, which controls both rear wheels, and one speed sensor, located in the rear axle.

2. 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. 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.


REAR AXLE ONLY
INDIVIDUAL REAR WHEELS ONLY
FRONT & REAR AXLE CONTROL
SPEED SENSOR
PRESSURE MODULATOR
ELECTRONIC CONTROLLER
INDIVIDUAL FRONT WHEEL-REAR AXLE CONTROL
INDIVIDUAL FOUR WHEEL CONTROL