Antilock Braking System

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Introduction

Antilock braking system (ABS) is safety system which prevents wheels on moving vehicle from locking up (or cease while rotating) while braking. ABS offers improved vehicles control over slippery surfaces by reducing the braking distance but it can also electronically control the front to rear brake bias, which we known as electronic brake force system, Traction system, Emergency brake assist or Electronic Stability Control.

In ABS breaking clever algorithm adjust the brake pressure to keep slip rotational near to 12%, where the frictional valve at maximum. This significantly reduces the braking distance.

By intelligent electronic braking distribution which is subsystem of modern ABS we can overcome the issue of instability of vehicle. An EBD (Electronic Brake Force Distribution) Yaw rate of the car relative slip of each wheel is measured. Just by reducing the pressure on the wheels with higher grip, we will be able to reduce the frictional force produced by these wheels. This will keep yaw torque and whole car under control.

In the past driver had to feather the gas pedal to prevent the drive wheel from spinning widely on slippery pavement. Today's vehicles employ electronic control to limit power delivery for driver eliminating wheel slip and helping the driver accelerate under control.

ABS Brake types

Anti-lock braking systems use different schemes depending on the type of brakes in use. They can be differentiated by the number of channels: that is, how many valves that are individually controlled—and the number of speed sensors.

1) **Four-channel, four-sensor ABS:** 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.

2) **Three-channel, four-sensor ABS:** There is a speed sensor on all four wheels and a separate valve for each of the front wheels, but only one valve for both of the rear wheels. Older vehicles with four-wheel ABS usually use this type.

3) **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. This system provides individual control of the front wheels, so they can both achieve maximum braking force. The rear wheels, however, are monitored together; they both have to start to lock up before the ABS will activate on the rear. With this system, it is possible that one of the rear wheels will lock during a stop, reducing brake effectiveness. This system is easy to identify, as there are no individual speed sensors for the rear wheels.

4) **Two-channel, four sensor ABS:** This system, commonly found on passenger cars from the late '80s through the mid-1990s, uses a speed sensor at each wheel, with one control valve each for the front and rear wheels as a pair. If the speed sensor detects lock up at any individual wheel, the control module pulses the valve for both wheels on that end of the car.

5) **One-channel, one-sensor ABS**: This system is commonly found on pickup trucks, SUVs, and vans with rear-wheel ABS. It has one valve, which controls both rear wheels, and one speed sensor, located in the rear axle. This system operates the same as the rear end of a three-channel system. The rear wheels are monitored together and they both have to start to lock up before the ABS kicks in. In this system it is also possible that one of the rear wheels will lock, reducing brake effectiveness. This system is also easy to identify, as there are no individual speed sensors for any of the wheels.

Literature review

Early system

ABS predates the modern systems that were introduced in the 1950s. In 1908, for example, J.E. Francis introduced his 'Slip Prevention Regulator for Rail Vehicles'.

In 1920 the French automobile and aircraft pioneer Gabriel Voisin experimented with systems that modulated the hydraulic braking pressure on his aircraft brakes to reduce the risk of tyre slippage. These systems used a flywheel and valve attached to a hydraulic line that feeds the brake cylinders. The flywheel is attached to a drum that runs at the same speed as the wheel. In normal braking, the drum and flywheel should spin at the same speed. However, when a wheel slows down, then the drum would do the same, leaving the flywheel spinning at a faster rate. This causes the valve to open, allowing a small amount of brake fluid to bypass the master cylinder into a local reservoir, lowering the pressure on the cylinder and releasing the brakes. The use of the drum and flywheel meant the valve only opened when the wheel was turning. In testing, a 30% improvement in braking performance was noted, because the pilots immediately applied full brakes instead of slowly increasing pressure in order to find the skid point. An additional benefit was the elimination of burned or burst tires.

The first proper recognition of the ABS system came later with the German engineer Karl Waessel in 1928.

By the early 1950s, the Dunlop Maxaret anti-skid system was in widespread aviation use in the UK, with aircraft such as the Avro Vulcan and Handley Page Victor and aircrafts which unusually had a Dunlop high pressure (200 Bar) pneumatic system in lieu of hydraulics for braking, nose wheel steering and landing gear retraction), being fitted with Maxaret as standard. Maxaret, while reducing braking distances by up to 30% in icy or wet conditions, also increased tire life, and had the additional advantage of allowing take-offs and landings in conditions that would preclude flying at all in non-Maxaret equipped aircraft.

In 1958, a Royal Enfield Super Meteor motorcycle was used by the Road Research Laboratory to test the Maxaret anti-lock brake. The experiments demonstrated that anti-lock brakes can be of great value to motorcycles, for which skidding is involved in a high proportion of accidents. Stopping distances were reduced in most of the tests compared with locked wheel braking, particularly on slippery surfaces, in which the improvement could be as much as 30 percent. A fully mechanical system saw limited automobile use in the 1960s in the Ferguson P99 racing car, the Jensen FF, and the experimental all-wheel drive Ford Zodiac, but saw no further use; the system proved expensive and unreliable.

The first fully electronic anti-lock system was developed in the late 1960s for the Concorde aircraft.

Modern system

Chrysler, together with the Bendix Corporation, introduced a computerized, three-channel, four-sensor all-wheel ABS called "Sure Brake" for its 1971 Imperial. In 1970, Ford added an anti-lock braking system called "Sure-track" to the rear wheels of Lincoln Continentals as an option; it became standard in 1971. In 1971, General Motors introduced the "Trackmaster" rear wheel only ABS as an option on their rear-wheel drive Cadillac models and the Oldsmobile Toronado. In the same year, Nissan offered an EAL (Electro Anti-lock System) developed by Japanese company Denso as an option on the Nissan President, which became Japan's first electronic ABS.

Evolution of ABS

1971: Electronically controlled anti-skid brakes on Toyota Crown In 1972, four wheel drive Triumph 2500 Estates were fitted with Mullard electronic systems as standard. Such cars were very rare however and very few survive today.
1971: First truck application: "Antislittamento" system developed by Fiat Veicoli Industriali and installed on Fiat truck model 691N1.
1976: WABCO began the development of anti-locking braking system on commercial vehicles to prevent locking on slippery roads, followed in 1986 by the electronic braking system (EBS) for heavy duty vehicles.
1978: Mercedes-Benz W116 became the first production car to use an electronic four-wheel multichannel anti-lock braking system (ABS) from Bosch as an option from 1978 on.
1982: Honda introduced electronically controlled multi-channel ALB (Anti-Locking Brakes) as an option for the second generation of Prelude, launched worldwide in 1982 With ABS as a standard feature. From 1984 the ALB-system, as well as the other optional features from Honda, was no longer a standard feature in Norway.
In 1985 the Ford Scorpio was introduced to European market with a Teves electronic system throughout the range as standard. For this the model was awarded the coveted European Car of the Year Award in 1986, with very favorable praise from motoring journalists. After this success Ford began research into Anti-Lock systems for the rest of their range, which encouraged other manufacturers to follow suit. Since 1987 ABS has been standard equipment on all Mercedes Benz automobiles.
In 1988, BMW introduced the first motorcycle with an electronic-hydraulic ABS: the BMW K100. Yamaha Introduced the FJ1200 model with optional ABS in 1991. Honda followed suit in 1992 with the launch of its first motorcycle ABS on the ST1100 Pan European. In 2007, Suzuki launched its GSF1200SA (Bandit) with an ABS. In 2005, Harley-Davidson began offering an ABS option on police bikes.
In 1993, Lincoln became one of the first automobile companies to provide standard four-wheel anti-lock brakes AND dual air bags on all of their vehicles.

Market analysis

The increase in demand of consumers for advanced safety features in the automobile and stringent safety laws and regulations by various transport authorities are driving the growth of ABS. Leading automobile manufacturers are introducing Abs in traditional and electric vehicles which is further expected to boost the growth of market. However, in the fluctuations in the prices of raw material and the high cost of maintenance, restrain the market growth. Therefore ABS market has seen a remarkable growth in global

market and it is observed that its demand in the future is expected to grow with CAGR of 7%.
Market is segmented into two wheelers, passenger car and commercial vehicle. Passenger car is expected domain to dominate the ABS market due to increase in production of large number of passenger cars in countries such as China, India and Germany. Geographically ABS market has been divided into four major regions. Out of it Asia Pacific region is expected to grow with highest CAGR over the forecast period due to increasing diffusion rate of ABS. In Asia Pacific, China is projected to dominate the growth of ABS due to increased accidents and rules and regulations Imposed by government for installation of ABS.

The prominent players in the automobile ABS market includes Robert Bosch GmbH (Germany), Continental AG (Germany), Autoliv Inc. (Sweden), Nissin Kogyo Co. Ltd. (Japan), Hitachi Automotive Systems, Ltd. (Japan) and Advics Co., Ltd (Japan).

SWOT Analysis

- **Strengths**

1. It reduces the stopping distance.
2. It improves the steer ability during braking.
3. It improves the stability and provides safety
4. It shares the infrastructure of a traction control system, where each wheel has traction on the road. That makes it easy for manufacturers to install both of these features at the factory.

- **Weakness**

1. 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.

2. Expense. An 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 an ABS in a vehicle.

3. Delicate systems. It's easy to cause a problem in an 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.

- **Opportunities**

1. The same algorithm can be implemented in most of the Value Added Functions (VAF) of the Active safety system like Cruise Control (CC), Adaptive Cruise Control (ACC), Hill Hold Control (HHC), Hill Decent Control (HDC), Brake Disc Wiping (BDW), etc., and add value to the value added functions.
2. This can also be utilized by the autonomous car and potentially improves the performance not only the active safety products but also in the areas like driver assistance, passive safety.
3. This algorithm can also detect the lane change and compare it with the steering input. If there is a lane change without the steering input, then it can warn the driver that vehicle is moving out without his control and assist him to take necessary action to control the vehicle.

- **Threats**

1. The most common ABS problems occur when sensors become contaminated with debris or metal shavings.
2. Malfunctions also occur when sensor wiring becomes damaged, resulting in intermittent or no continuity, false feedback causes the ABS to trigger when it shouldn’t, or not function when it should.

Requirement creation (High level requirement)

Requirement no.	**Requirement Description**	**Hardware requirement**	**Software requirement**
1	Sensors (Encoders)	Speed Wheel sensors, Steering wheel angle sensor Gyroscopic sensor	Assembly language
2	CAB controller	Microcontroller Arm series	
3	ECU	Digital electronic controller, microcontroller, nonvolatile memory,	Embedded C
4	warning light	ABS and Brake warning LED’s	
5	Actuators	Relay, voltage stabilizer	
6	Hydraulic control unit	Solenoid Valve pairs, pump, accumulator	
7	Master cylinder		

Table no.1 high level requirement

Feature	**Stakeholders requirement**	**Systems requirement**
Control of steering	Should increase steering ability and vehicle stability during braking	Good steering & road holding
Fail safe electrical/electronic system	If the electrical/electronic system fails, the ABS should shut off, returning the vehicle to normal braking.	Gentle breaking and proper brake system, No reaction on the pedal,
Self-diagnosing system	Built-in system makes have to maintenance checks quick and easy.	Maintained yaw rate,
Diagnostic tool compatibility	ABSs should compatible with industry standard hand-held and computer-based diagnostic tools	Controlled wheel at least one wheel on each side should be controlled on seperste ckt.
ABS Malfunction Indicator Lamp	Should Informs the driver or technician that an ABS fault has occurred.	Must operate at all speed conditions operate on uneven road surface, snow, gravels

Table no.2 Low level requirement

Diagrams

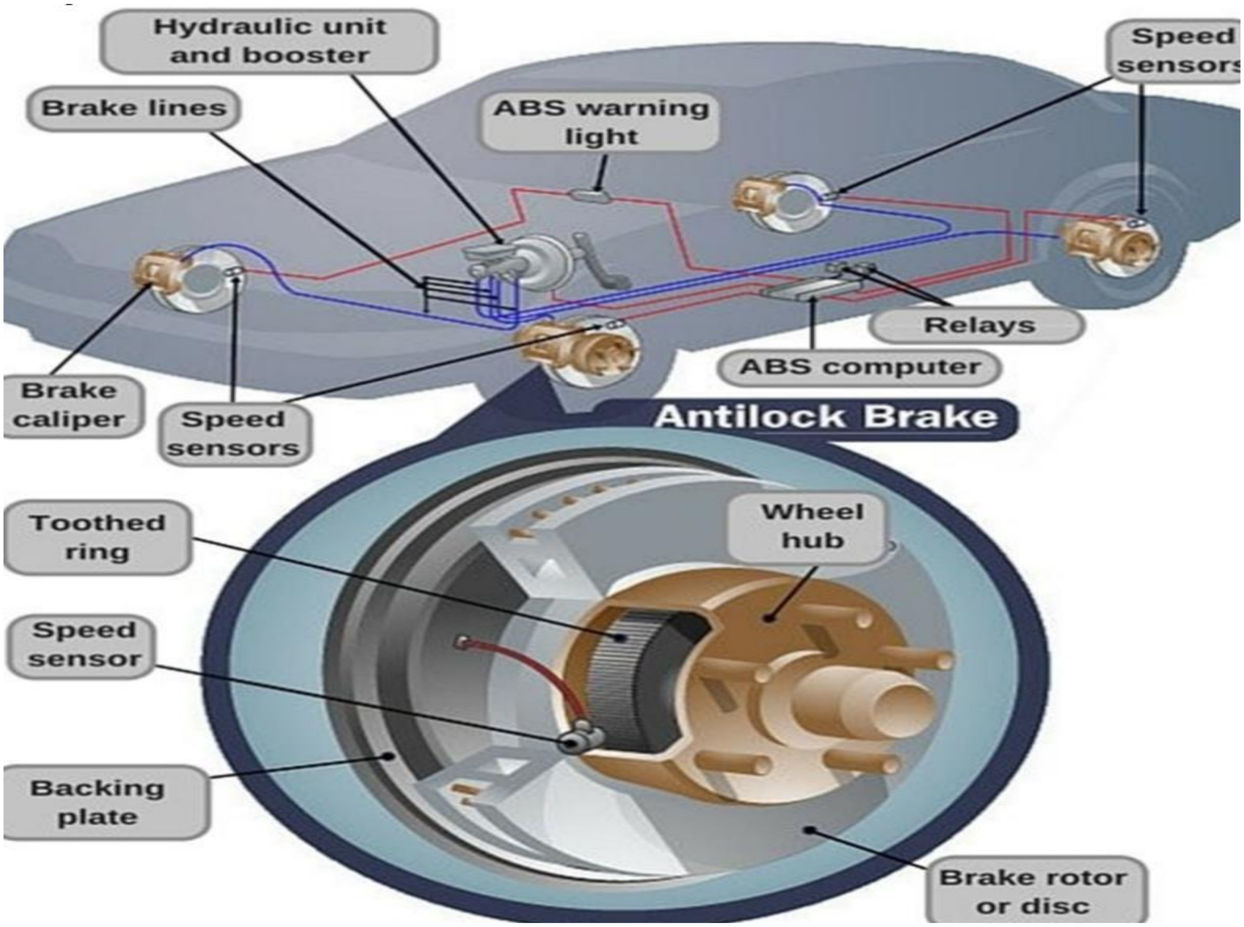


Fig 1 Structural Diagram 1 of ABS

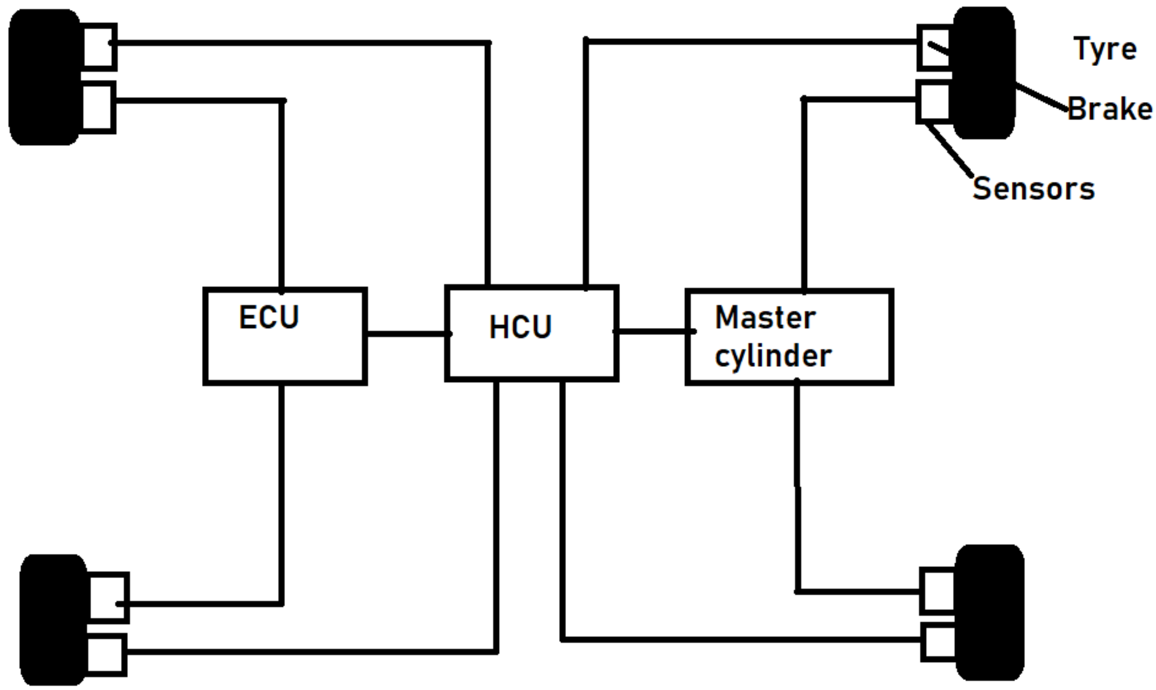


Fig 2 Structural Diagram 2 of ABS

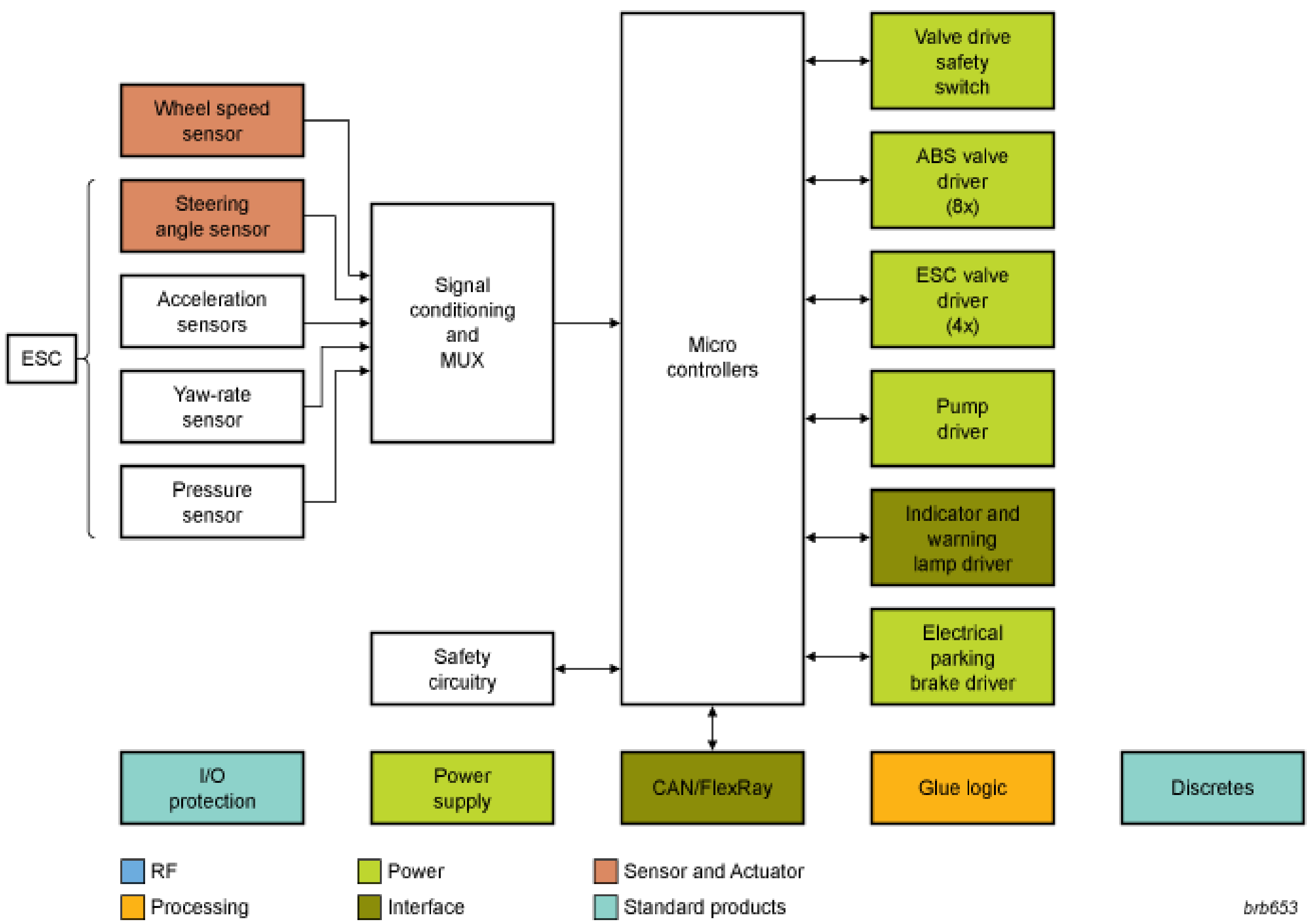


Fig 3 Behavioral Diagram 1 of ABS

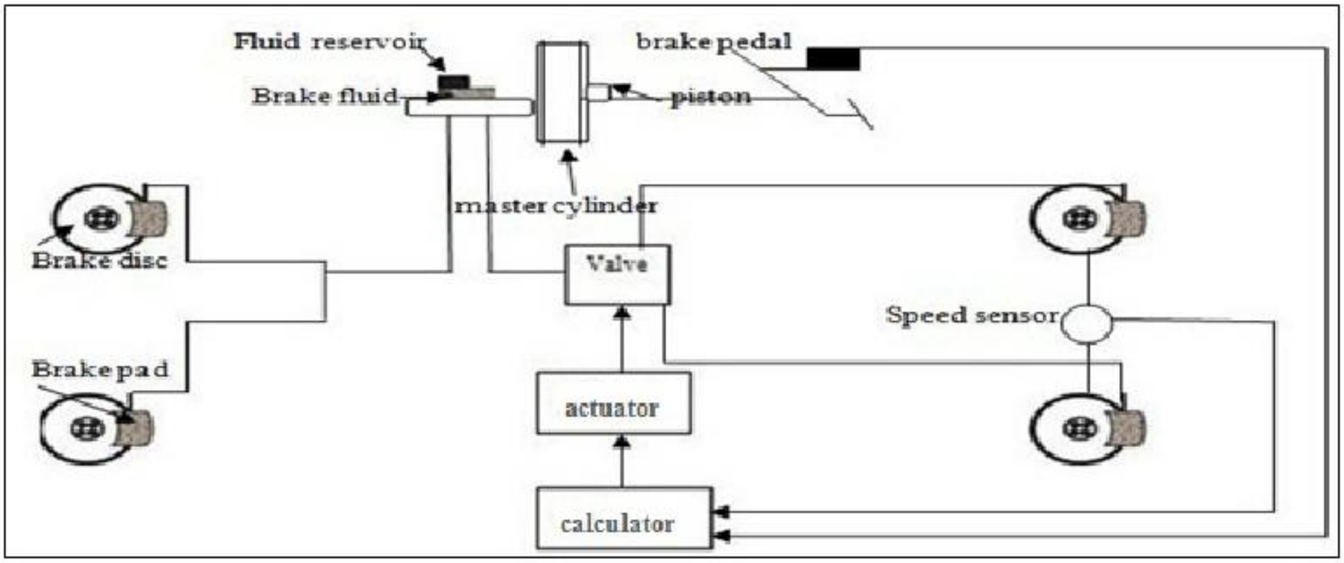


Fig 4 Behavioral Diagram 2 of ABS

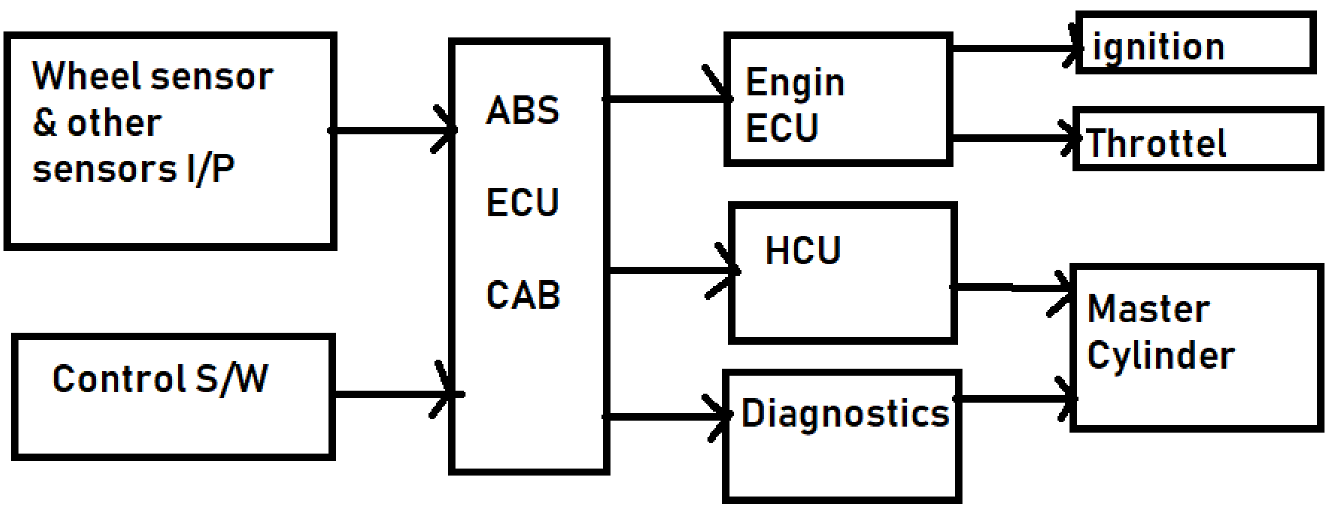


Fig 5 Block Diagram of ABS System

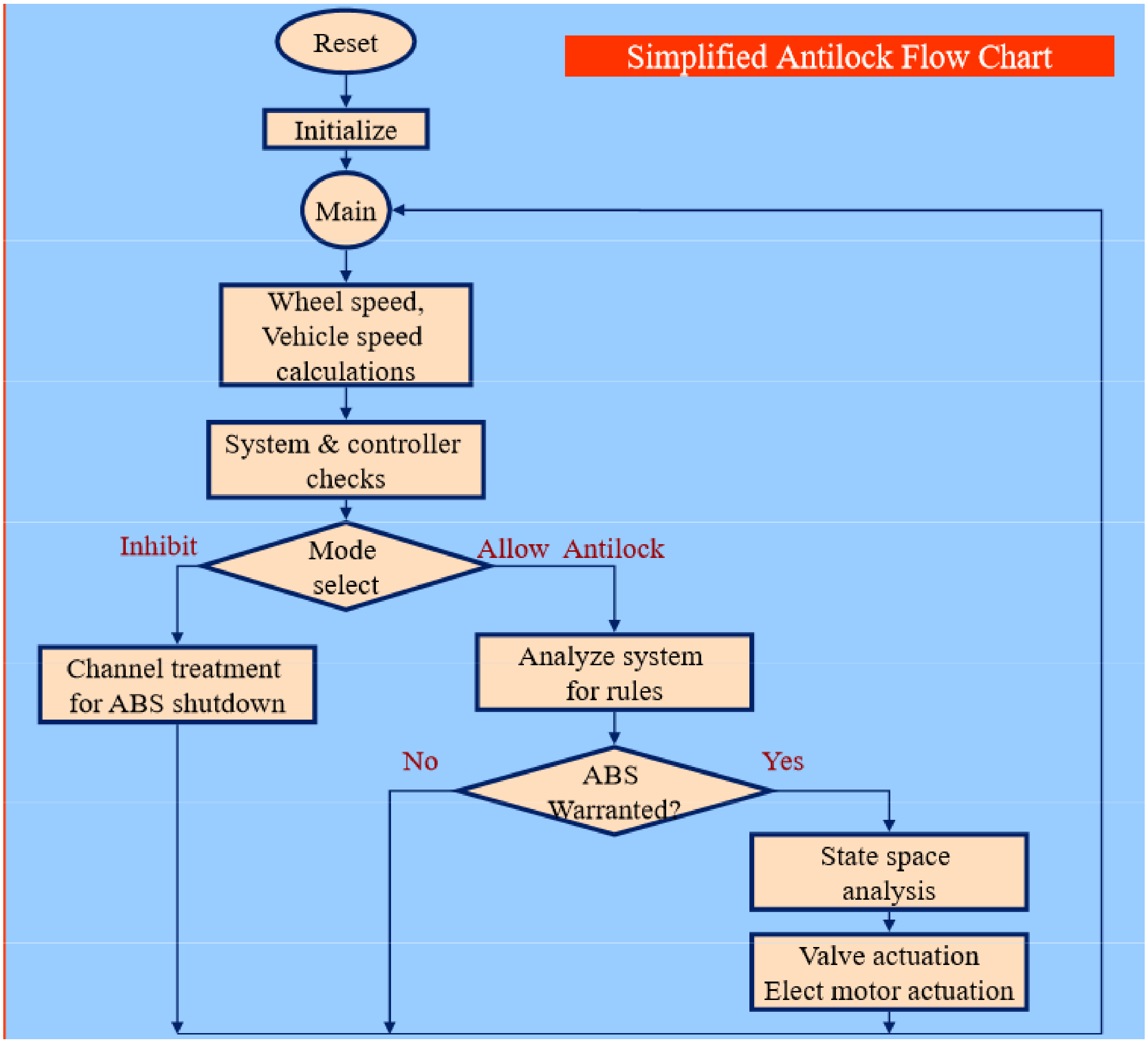


Fig 6 Flowchart of ABS system

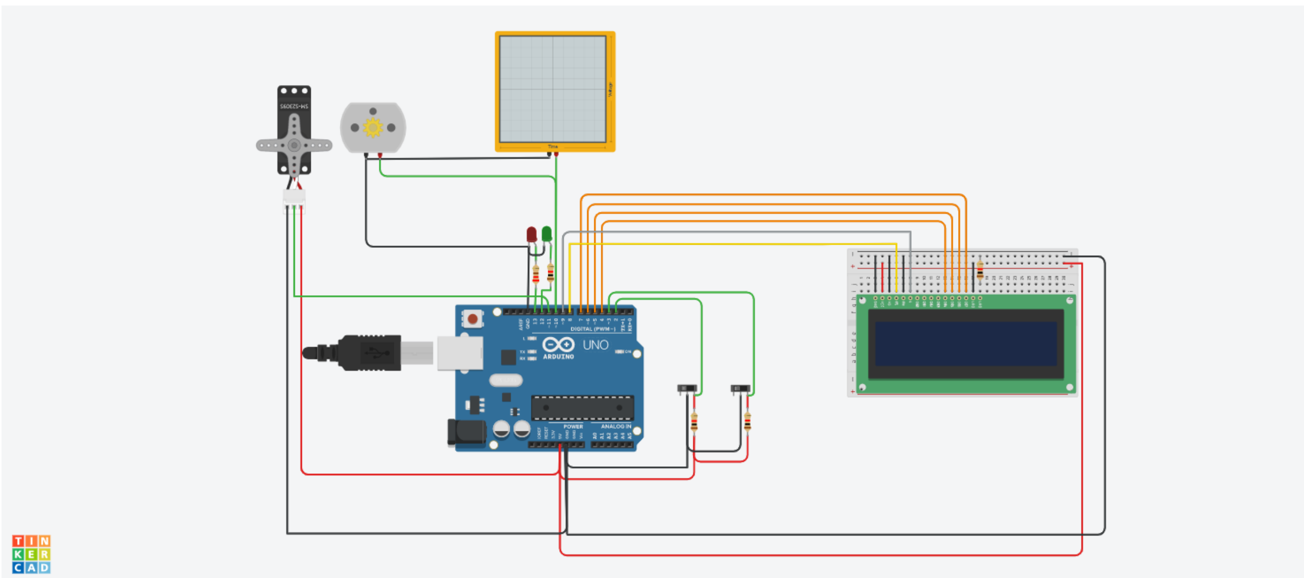
Test cases against requirement

Test case Id	Purpose of test	Expected output	Actual output	Validation
1	Sensor signal testing	gather all necessary data	Data received form sensors should transfer output components	pass
2	ABS malfunction indicators lamp testing	Indicators showing malfunction in ABS	Indicator should when ABS isn't working even after given condition is encountered	fail
3	Checking ABS working	Checking ABS is coming	ABS is activated	Pass

3	Checking ABS working	into action when necessary and shows on display	when threshold speed is encountered and display condition of ABS activation	pass

Table no. 3 Test cases analysis

ThinkerCad circuit:



Circuit of Anti-lock braking system testing

Thinkercad circuit link:

https://www.tinkercad.com/things/eO4S0GfbrrF-copy-of-anti-lock-braking-system/editel?tenant=circuits?sharecode=KgRbbVr0joYEXZb0z-kRVWfb7kSSSk-ZdBdZ8_ZH1Fs?sharecode=KgRbbVr0joYEXZb0z-kRVWfb7kSSSk-ZdBdZ8_ZH1Fs