

# Antilock Braking System Controlled Using 555 Timer in Pneumatic System

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**Abstract:** In today's world, braking is the most important part in an automobile. Brakes are energy conversion devices, which convert kinetic energy of the vehicle into thermal energy and thus due to friction braking happen. In Antilock Braking System, we can prevent the locking of the wheel and hence skidding, using an Electro Mechanical Control System. The main issue behind the locking of the wheels is that, when we apply break it locks the wheel which cause skidding of wheel and because of that the driver lost the control over driving.

Around the world, 77% of the accident cases are due to wheel skidding problem, and 19% of them are cause of stopping distance. Antilock Braking system is the best solutions of both of the issues i.e. (Wheel skidding and stopping distance) that occur in the severebraking system.

Antilock Braking System allows the motion of the wheel to continuously interact with the road surface as directed by driver's steering input while braking, preventing the wheels from locking up (ceasing rotation) and therefore avoid skidding. In this paper we worked on PCABS i.e. pneumatically controlled Anti-lock Breaking System. The aim of this paper is to give a short overview of working of ABS system controlled using 555 timer using pneumatic systems. Basically ABS is based on hydraulic system but we have worked on pneumatic system.

**Keywords:** Introduction, Pneumatic System, ABS control algorithm, ABS Components, Empiric Experiment (Design of Test Derive):

## 1. INTRODUCTION:

In recent years, with advancement in design & technology, Disc brakes are fastly replacing drum brakes. ABS was first developed for Aircrafts braking system but soon started replacing the conventional braking system in trucks, cars and bikes. Recent improvements in ABS allow preventing wheel when accelerated on wet or slippery surface. An Antilock braking system (ABS) is a safety system that maintain driver control and stability of the vehicle (Like; Bikes, Cars, Trucks, Airways etc.) during emergency braking. In the present scenario of the breaking system (Conventional breaking system), while we apply brakes the wheels are locked & that helps in slowing down a rotated wheel but will not provide steering ability of the vehicle. The main function of the ABS is to curb the wheel locking and thus maintains both, steerability and vehicle stability assuring at the same time shorter stopping distances as compared to locked wheel breaking system on most road surfaces and therefore avoiding skidding.

In this paper we present the Antilock Breaking System (ABS) with pneumatic control. In pneumatic control ABS baking operation are performed by compressed air. In this procedure during a braking event, the function of the control system is to maintain maximum possible wheel grip on the road - without the wheel locking - by adjusting the pneumatic compressed air pressure to each brake by way of electronically controlled solenoid valves.

## 2. Components of Pneumatically controlled ABS:

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, anti-lock brakes benefit the wheels in two ways: i) stop faster ii) provide abilities to steer while wheel controller (driver) stop. To modulate the breaks individually to provide the above functionality and to prevent them from locking, ABS

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combined of both electronics and mechanical systems. As per pneumatic control ABS has the components that are;

**A. Pneumatic Control Unit:**

A Pneumatic control unit consists of compressor pump (vacuum tube), a reservoir tank (enables capacity storage on demand supply), a pressure regulator, directional proportional valves, Air lines and end use component or tool. The most important and basic part of pneumatic system is compressed air to transmit and control energy. It is used to operate systems and equipment from remote locations (i.e. inside wings, or external hatches).

Pneumatic System is high effective, durable and reliable, high adaptable to harsh environment, light weight, compact, sturdy and easily maintained. Pneumatic systems are used in several areas such as controlling train doors, automatic production lines, mechanical clamps, etc.

PCU components: The main PCU components include;

(i) Components that produce and transport compressed air: The production and transportation of compressed air components includes compressors and pressure regulating components. These components are responsible to produce the compressed air as well as to transport that compressed air, compressor and pressure regulators are responsible to perform these task.

**Compressor:**

Compressor can convert the mechanical energy from motors and engines into the potential energy in compressed air. It is able to compress air to the required pressures. It may be linear and rotary.

**Pressure regulating component:**

Pressure regulator is able to provide pressure stability when variation occurs in the compressed air. It is formed by various components, each of which has its own pneumatic symbol:

- a) **Filter:** can remove impurities from compressed air before it is fed to the pneumatic components.
- b) **Pressure regulator:** to stabilize the pressure and regulate the operation of pneumatic components.
- c) **Lubricator:** To provide lubrication for pneumatic components.

(ii) Components that consume compressed air: It includes those components that are responsible to consumption of this compressed air in various ways. It includes execution components (cylinders), directional control valves and assistant valves.

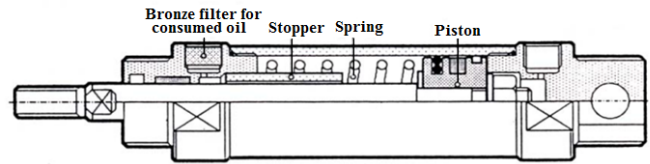
**(a) Execution component:**

It provides a rectilinear or rotary movement; it includes cylinder pistons, pneumatic motors, etc. Rectilinear motion is

produced by cylinder pistons, while pneumatic motors provide continuous rotations. Various cylinders are there, such as single acting cylinders and double acting cylinders.

**(i) Single acting cylinder:**

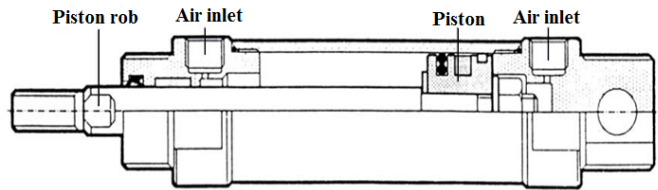
It has only one entrance that allows compressed air to flow through. Therefore, it can only produce thrust in one direction. The piston rod is propelled in the opposite direction by an internal spring, or by the external force provided by mechanical movement or weight of a load.



Cross Section of a Single acting cylinder

**(ii) Double acting cylinder**

In a double acting cylinder, air pressure is applied alternately to the relative surface of the piston, producing a propelling force and a retracting force (Fig below). As the effective area of the piston is small, the thrust produced during retraction is relatively weak. The impeccably tubes of double acting cylinders are usually made of steel. The working surfaces are also polished and coated with chromium to reduce friction.



Cross Section of a Double acting cylinder

**(b) Directional control valve**

Directional control valves ensure the flow of air between air ports by opening, closing and switching their internal connections. Their classification is determined by the number of ports, the number of switching positions, the normal position of the valve and its method of operation. Common types of directional control valves include 2/2, 3/2, 5/2, etc. The first number represents the number of ports; the second number represents the number of positions.

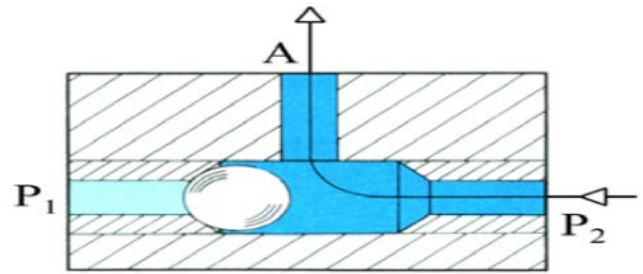
**(c) Control valve**

A valve that controls the flow of air called control valve; it include non-return valves, flow control valves, shuttle valves, etc.

a) **Non-return valve:** It allows air to flow in one direction only. When air flows in the opposite direction, the valve will close. It's also known as poppet valve.

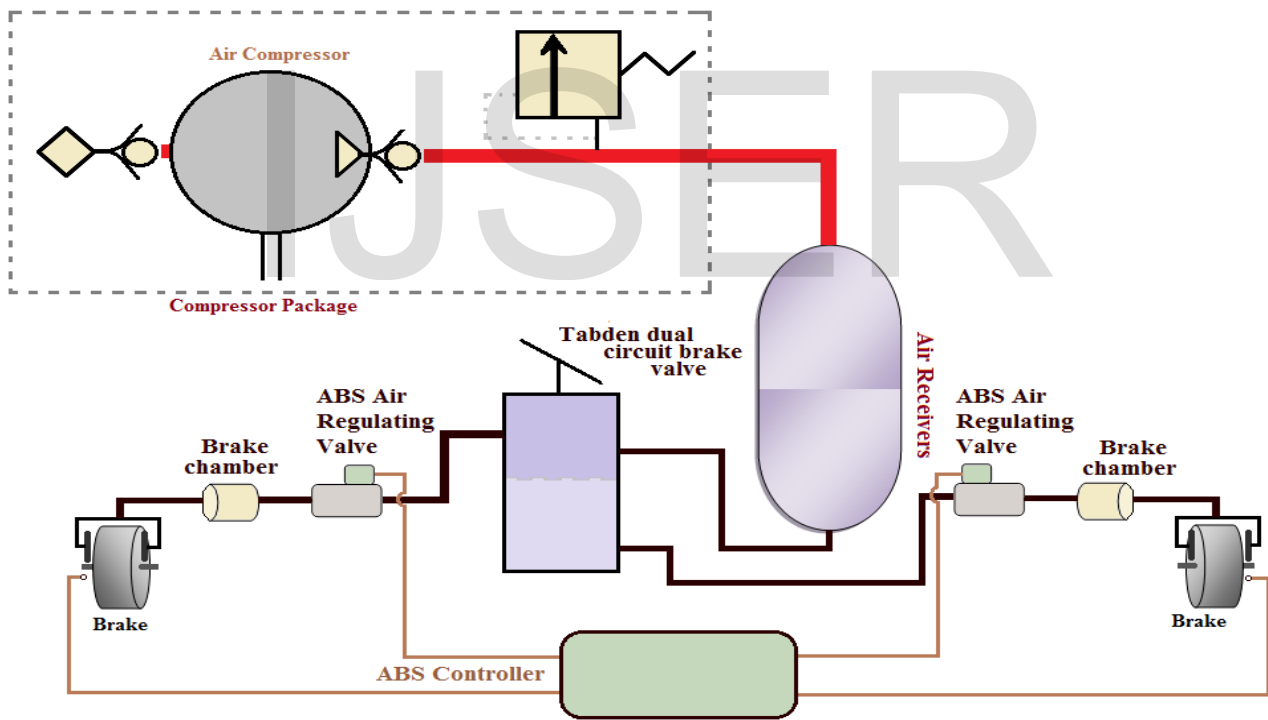
b) **Flow control valve:** A flow control valve is formed by a non-return valve and a variable throttle.

c) **Shuttle valve:** Shuttle valves are also known as double control or single control non-return valves. A shuttle valve has two air inlets 'P1' and 'P2' and one air outlet 'A'. When compressed air enters through 'P1', the sphere will seal and block the other inlet 'P2'. Air can then flow from 'P1' to 'A'. When the contrary happens, the sphere will block inlet 'P1', allowing air to flow from 'P2' to 'A' only.



**Cross Section of Shuttle Valve**

The layout of the pneumatic control unit founded in a typical commercial vehicle is presented in figure (PCU in ABS). The compressed air is provided by an engine-driven compressor and is collected in storage air reservoirs. Compressed air in these air reservoirs is supplied to break valve and relay valve. The driver applies the brake by pressing the brake pedal mounted on the brake valve. This action meters the compressed air from the supply ports of the brake valve to its delivery ports from where it travels through hoses to the brake chambers mounted on the axles.



**Figure: Pneumatic control Unit with ABS**

**B. Electronic Control Unit (ECU):**

Whenever the brake apply the Electronic control unit (ECU) reads signals from electronic sensors monitoring wheel rotation. An electronic control unit is connection of different components;

- (i) **A step down transformer:** It is being installed to our controller circuit to step down the voltage supply from 220V A.C. to 24V A.C.
- (ii) **Rectifier circuit:** This circuit being installed to provide D.C. voltage, hence in our model it converts 24V A.C. to 24V D.C.

- (iii) **Voltage regulator circuit:** the voltage regulator circuit consists of the 7805 IC. 7805 IC regulate the input voltage and produced 5V D.C. constant voltage irrespective of the input voltage.
- (iv) **A 555 timer:** A 555 timer is an integrated circuit, which is used in a variety of timer, pulse

generation and oscillator applications. The main function of 555 timer in our experiment is to set an electrical signal path with is either high (1) or low (0) after a delay, or constantly oscillate with a square wave or other waveform.

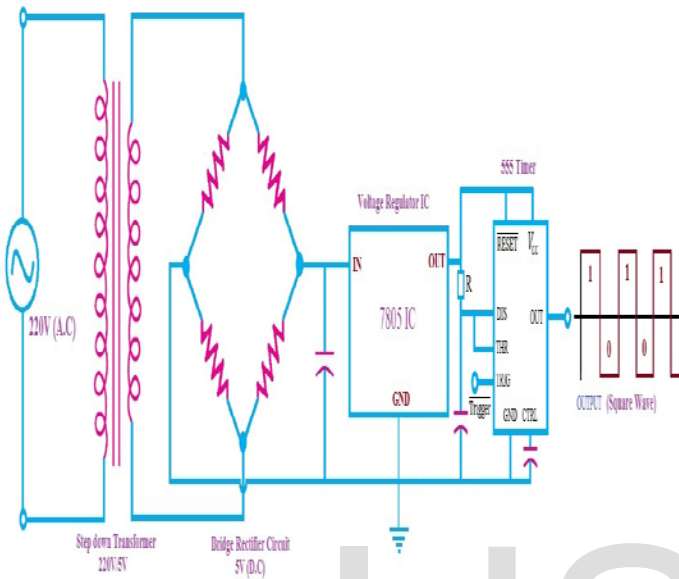


Figure: Electronic control Unit of ABS

**C. Wheel Speed Sensors:**

A wheel speed sensor provides the more precision or effective operation performance. Wheel speed sensor measure the speed of the wheels, or a distance or angle covered per unit of time.

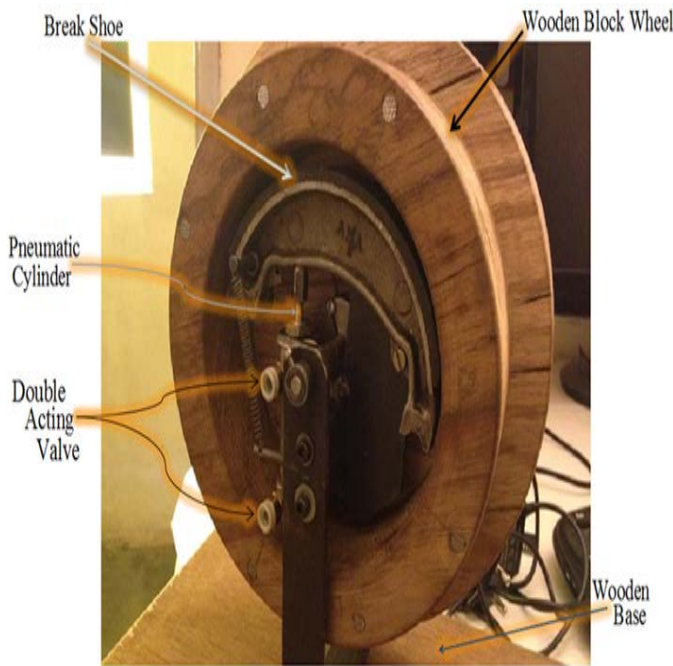
**3. ABS control algorithm:**

The model of ABS controller design is based on a discrete-time nonlinear controller. The wheel speed is regulated by a commanded brake torque, which is applied to the wheel. However, in automotive systems, the values, such as wheel speed, are related with commands which control the solenoid valves. There are holding and decreasing solenoid valves and they lie in each isolated ABS brake modulator.

In the ABS control algorithm model have vehicle estimate, wheel slip rate calculation, wheel stopping calculations (Breaking Force, Wheel Lock, and Brake Torque), wheel error calculation, wheel slip control, position control, Current control, and duty control.

The application of brakes generates a force that impedes a vehicles motion by applying a force in the opposite direction [31][8]. During severe braking scenarios, a point is obtained in which the tangential velocity of the tire surface and the velocity road surface are not the same. This term is referred to as slip ratio and is the ratio between the tangential

velocity of the tire and the true ground speed of the vehicle and is expressed as:  $V_g$  is circumferential velocity of braked wheel and  $V_t$  is vehicle road speed. 0% is slip of free rolling wheel and 100% for locked wheel. The braking force or the adhesion coefficient of braking force ( $\mu_f$ ) measured in the direction the wheel is turning is function of slip.  $\mu_f$  depends on a number of factors, and the main ones are:



Free Body Diagram of our experimenta work with wooden wheel and ABS is controlled by Pneumatic Cylinder

- a) Road surface material condition
- b) Tyre material, inflation pressure, treads depth, tread pattern and construction.

$$\lambda = \frac{v_g - v_t}{v_g}$$

The fiction coefficient varies with the condition of the road surface. It is a function of slip rate. During the vehicle braking, the ABS controller uses based on the mathematical braking calculation, are given as follows;

The wheel slip rate  $s$  is defined by:

$$s_{ij} = \frac{v_{Fuz} - \omega R}{v_{Fuz}} = \frac{v - R\omega_{ij}}{v}$$

The wheel acceleration is defined by:

$$a_{wheel} = \frac{\delta v_{wheel}}{\delta t} \approx \frac{\Delta v_{wheel}}{\Delta t}$$

Where,  $i = F$  (Front) and  $R$  (Rear),  $j = L$  (Left) and  $R$  (Right), and wheel speed and vehicle speed are defined by  $v_{wheel}$  and  $v_{Fuz}$  respectively [4][6]. The value of slip rate  $s = 0$  characterizes the free motion of the wheel. That is to say that there is no friction force. If the value is  $s = 1$ , then the wheel is locked ( $\omega = 0$ ) [2].

In the ABS system for each break controlled having a break line with a valve. Form beginning to end of the ABS activation each control loop phase categories into three positions:

- 1) **Pressure Build-up Position:** In this position the valves are open. Pressure from the master cylinder is passed right through to the brake and the shoe is slide with the rotated wheel.

- 2) **Pressure Holding Position:** In this, valves block the break lines, isolating that brake from the master cylinder. This position prevents the pressure from rising further should the driver push the brake pedal harder.
- 3) **Pressure Release Position:** Valve releases some of the pressure from the brake; due to ABS prevent form the wheel lockup.

During the initial brake phase, the pressure increases quickly. Then by adjusting the input, holding and decreasing pressure are applied. When road condition is confirmed, the control pressure will switch to the proper level. The control algorithm cycle in this subsystem includes holding, slow increasing and decreasing pressure. These control loop phase ("pressure build-up", "pressure holding" and "pressure release") is determined by the overcoming of a threshold [4]. The ABS control algorithm is described as:

$$\text{if } s > S_H \begin{matrix} S_{valve1}=1 \\ S_{valve2}=1 \end{matrix} \quad (\text{Pressure release})$$

$$\text{else if } s > S_L \begin{matrix} S_{valve1}=0 \\ S_{valve2}=0 \end{matrix} \quad (\text{Pressure build - up})$$

$$\text{else } \begin{matrix} S_{valve1}=1 \\ S_{valve2}=1 \end{matrix} \quad (\text{Pressure holding})$$

Where,  $S_{valve1}$  and  $S_{valve2}$  are the control signals of the ABS compressed air regulating valve.  $S_H$  and  $S_L$  are threshold, and generally  $S_H = 0.25$  and  $S_L = 0.1$ .

#### 4. Empiric Experiment (Design of Test Derive):

The focal scenario of our experiment is to determine whether the existence of behavioral adaptation could be inferred from differences in observed operating speeds (Stopping distance, Steerability and Stability) between ABS system and Non-ABS system vehicles in real world conditions.

The laboratory setup of ABS of our experiment consists of one rolling wheel (We uses a wooden wheel), when the wheel is animated or rolling at a certain spend ABS system is activated to stopping the wheel without locking the wheel. In order to accelerate the wheel a flat DC motor is coupled on it. When the driver (controller) wants to stopping the wheel, controller activated the control circuit, resulting controlling circuit sends the signal to the connected pneumatic valve (two stock valve) and it opens the forward stroke of the piston and few micro second ( $\mu$  sec) it sends the signal to the valve to retract the piston and the piston comes with the reverse stoke. During the forward stroke the horse break shoe (two wheeler) slides with the wheel and the wheel locks and during the reverse stroke of the piston the wheel unlocks. This whole process is repeats until the control circuit is activated.

The Free body diagram of this experimental work is described in the above figure. Although the model is quite simple, it preserves the fundamental characteristics of an actual system. In deriving the dynamic equation of the system, several assumptions are made.

#### Stopping Vehicle Calculation:

Braking Force:

The total braking force required can simply be calculated using Newton's Second Law, I.e.;

$$F = ma$$

And the value of acceleration is calculated by the

$$V^2 = U^2 + 2as$$

Where F defined as Braking force, m (Wheel mass), a (acceleration), V (last velocity), U (initial velocity), s (stopping distance).

Wheel Lock:

The braking force (F) can only be generated if the wheel does not lock because the friction of a sliding wheel is much lower than a rotating one. The maximum braking force possible on any particular axle before wheel lock is given by:

$F_A = M_{W_{dyn}} * g * \mu_r$ , Where;  $F_A$  is defined the total possible braking force on the axle (N),  $M_{W_{dyn}}$  is the dynamic axle mass, g is acceleration due to gravity,  $\mu_r$  is the coefficient of friction between the road and tire.

Brake Torque:

Brake torque is responsible to decide which wheel will need braking to generate sufficient braking force, due to that torque calculation is required to applying the brake force.

#### FOUNDATION BRAKE:

Disc Effective Radius  
Clamp Load  
Brake Factor

#### 5. Conclusion:

In this paper, a PCABS system has been developed for evaluating commercial vehicles braking system. The hardware part of the system includes the pneumatic brake mechanism. The software part of the PCABS includes the electric control unit, which includes 555 times chips etc. The braking operation of PCABS will be more stable and the performance of ABS system will be increased due to the continuous alternatively period of time PCABS providing the controlling strategy to Driver.

As per future aspects this technology becomes very powerful for in breaking system. The only constraint is that we need to install a compressor to the system that will make the system

bulky and needs an extra space too. We can use this technology for our future braking systems.

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