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ANTILOCK BRAKING SYSTEM USING FUZZY LOGICS AND NEURAL NETWORK

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Abstract: Recently, various electronic control techniques and control systems, such as anti-lock braking system, traction control system, and so on are being developed greatly and applied widely to improve the ride comfort, safety and operation stability in vehicle. Recently, various electronic control techniques and control systems, such as anti-lock braking system, traction control system, and so on are being developed greatly and applied widely to improve the ride comfort, safety and operation stability in vehicle. Many theories and design methods for antilock braking systems have been proposed several literatures for decades. Researchers have considered a lot of control strategies and methods of anti-lock braking systems, which have been demonstrated effective for ABS system.

***IndexTerms* - Fuzzy, Neural, Control System, ABS System**

INTRODUCTION

Now computers are increasingly in driving-related tasks in some commercial vehicles. As evident from literature, collision warning and avoidance systems are currently of prime interest in present automotive research and development. However, none of these papers investigated regarding simultaneous control of ABS and CAS. In this paper we make an attempt to control both ABS and CAS together and control logic is fuzzy logic based. Moreover, this is implemented in HCS12 microcontroller using CAN protocol and important results are brought out.

$$\lambda = \frac{V_g - V_t}{V_g}$$

The braking force or the adhesion coefficient of braking force (µf) measured in the direction the wheel is turning is function of slip. µf depends on a number of factors, and the main ones are:

a) Road Surface Material Condition

b) Tire material, inflation pressure, tread depth, tread pattern and construction.

Figure shows the relationship between the braking effort (µf) and the amount of slip. Graph is divided into two areas: stable and unstable. In the stable zone, balance exists between the braking effort applied and the adhesion of the road surface. Non-slip braking is possible. In unstable zone when the critical slip (l) is passed, nobalance exists and the wheel will lock, unless the braking force is reduced. The value of critical slip can vary from 8% to 30% depending on road conditions. As the slip ratio increases, the adhesion, will peak and then decline. After the peak, the rotating tire can then lock up abruptly thus resulting in even less adhesion. Asphalt (wet or dry) has a peak braking efficiency at approximately 20% slip ratio. Derivation of a mathematical model for such a complex system would be a tedious task if not impossible due the nonlinear and nondeterministic characteristics of all of the involved components. Since fuzzy logic is ideally suited to handle non lineararities, a fuzzy system was chosen to control the ABS system.

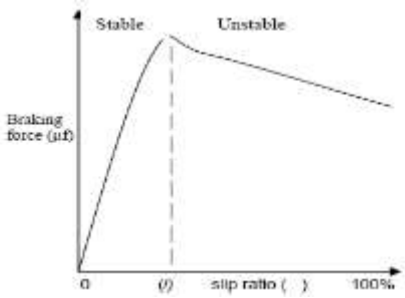


Figure-1 Relation between Brake Force and Slip

Stability Considerations

Three dynamic modes of a semi-trailer that experiences wheel lock-up are shown in Figure 3. 'Steer-wheel lock-up' is stable in that the vehicle continues generally straight ahead however steer-ability is lost. Braking effort from the rear wheels tends to straighten the combination vehicle out.'Drive-wheel lock-up' can result in jack-knife, which is sideways sliding of the drive axle group (*prime-mover jack-knife*) resulting in the vehicle 'folding up'. The prime-mover provides some of the braking retardation for the trailer when it is moderately or heavily laden. This force is transmitted via the kingpin and it causes an equal and opposite reaction on the prime-mover which may produce a twisting moment on it. If theretardation from the trailer tri-axle group is low as a result of poor brake balance the trailer tends to over-ride the prime-mover and this exacerbates the tendency to jack-knife. If the retardation force from the trailer tri-axle group is proportionately strong then the tendency is to pull the vehicle straight however, this situation will often be associated with 'trailer-wheel lock-up'. If the trailerwheels lock-up the trailer may swing sideways (*trailer swing*). On combination there are retarding or over-riding forces from the following trailer that can lessen or exacerbate the trailer swing. Severe trailer swing on the lead-trailer causes a *trailer jack-knife* mode.

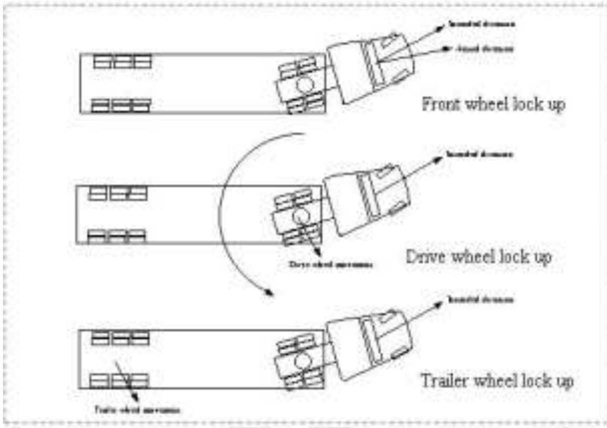


Figure - 2 Three dynamic modes of a semi-trailer that is experiencing tyre-pavement slip or skidding**.**

Antilock System Configuration

The purpose of ABS operation is to prevent a controlled wheel from locking-up. It does this by monitoring the wheel speed of **sensed** wheels and predicts when lock-up is imminent. The brake air pressure to the **controlled** wheels is then either held or released in a controlled way to allow the sensed wheel to turn at optimum wheel slip speed (< 10% slip). Additionally the ABS may disable the auxiliary brake system (retarder).

There are three elements to a typical ABS system:

- The **Electronic Control Module**, which monitors the wheel speed signals, computes the slip-performance on the sensed wheels and operates the modulator valves.
- The **Wheel Sensors** produce a signal with a frequency proportional to wheel speed; and
- The **Modulator Valve** that is controlled by the ECM to either block the brake air line to the brake chambers (thereby holding the brake pressure) orexhaust the brake line to the chambers (thereby reducing brake effort).

The potential benefits of ABS are:

- ➢ Improved vehicle stability under braking.
- ➢ Shorter stopping distances.
- ➢ Improved driver control when braking on slippery surfaces.
- ➢ Protection against jack knife.
- ➢ Reduction in tyre flat spotting – particularly on trailers.

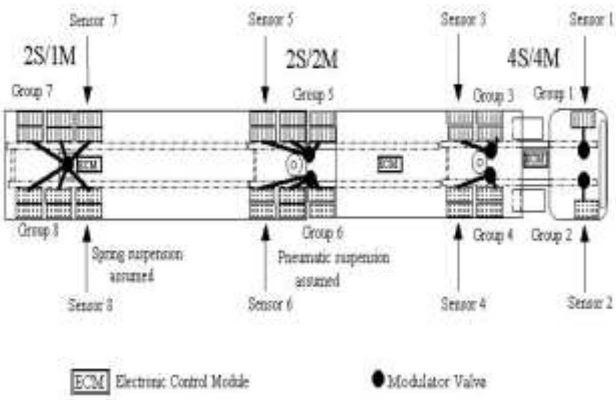


Figure-3(Electronic ABS)

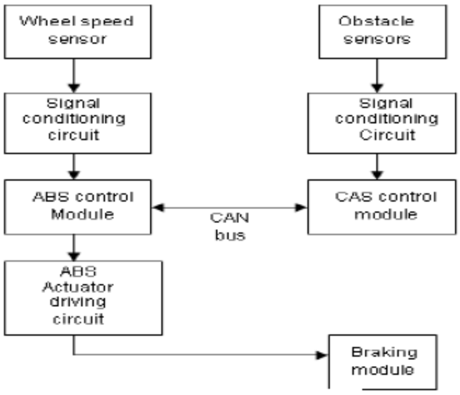


Figure- 4 Block diagram of setup

Integrated control of ABS with CAS

The slip ratio is inferred from the comparison of the deceleration of all four wheels and sometimes also by comparison with an on-vehicle accelerometer. The road condition (coefficient

of friction between tire and road) can be inferred by observing the slip ratio resulting from a given braking force. Wheel speed sensors are employed to detect the circumferential velocity of braked wheel and vehicle road speed. Slip ratio is calculated using equation. To determine the actual road conditions, reference values of slip ratio at different brake torques for different road conditions like wet, dry and ice are stored. Detected slip ratio and braking torque is comparedwith stored reference values. Slip ratio is not constant for different road surfaces such as dry, wet or icy asphalt. Based on brake force and slip ratio, type of road is detected. The table I consists of references to identify the road condition is given below, by comparison, type of road is detected.

Brake force(%)	Slip ratio(%)	Type of Road
10	20	Icy
20	50	Icy Wet
50	95	Wet
80	50	Wet-dry
90	20	Dry

The fuzzy rule base used for the integrated control of ABS with CAS is:

IF Obstacle IS Very Near AND Applied Brake force is high AND Slip Ratio is Unsafe THEN PWM is Minimum
IF Obstacle IS Very Near AND Applied Brake force is high AND Slip Ratio is Critical THEN PWM is Medium
IF Obstacle IS Very Near AND Applied Brake force is high AND Slip Ratio is Safe THEN PWM is Maximum.
IF Obstacle IS Near AND Applied Brake force is High AND Slip Ratio is Unsafe THEN PWM is Minimum
IF Obstacle IS Near AND Applied Brake force is High AND Slip Ratio is Critical THEN PWM is Medium
IF Obstacle IS Near AND Applied Brake force is High AND Slip Ratio is Safe THEN PWM is Maximum.
IF Obstacle IS Near AND Applied Brake force is Low AND Slip Ratio is Safe THEN PWM is Maximum.
IF Obstacle IS Near AND Applied Brake force is Low AND Slip Ratio is Critical THEN PWM is Medium
IF No Obstacle IS Near AND Applied Brake force is Low AND Slip Ratio is Safe THEN PWM is Maximum
IF No Obstacle IS Near AND Applied Brake force is High AND Slip Ratio is Critical THEN PWM is Medium
IF No Obstacle IS Near AND Applied Brake force is High AND Slip Ratio is Unsafe THEN PWM is Minimum
IF No Obstacle IS Near AND Applied Brake force is Low AND Slip Ratio is Unsafe THEN PWM is Minimum
IF No Obstacle IS Near AND Applied Brake force is Low AND Slip Ratio is Critical THEN PWM is Medium

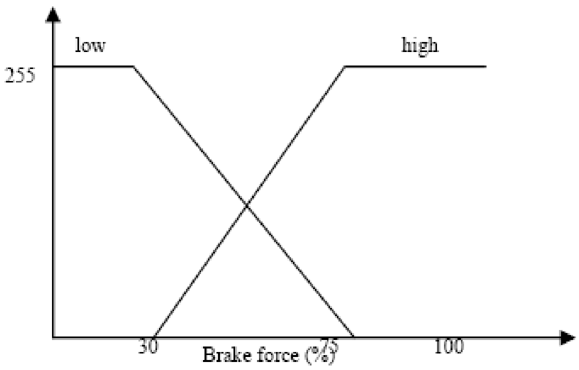


Figure -5 Applied brake force fuzzy set

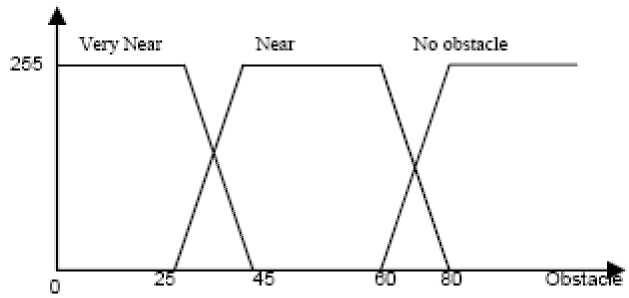


Figure-6 Obstacle fuzzy set

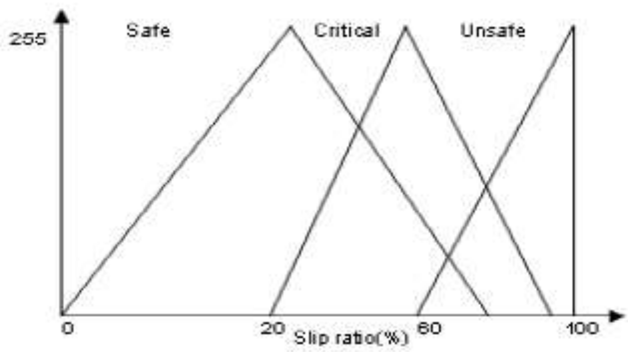


Figure- 7 Slip Ratio fuzzy set

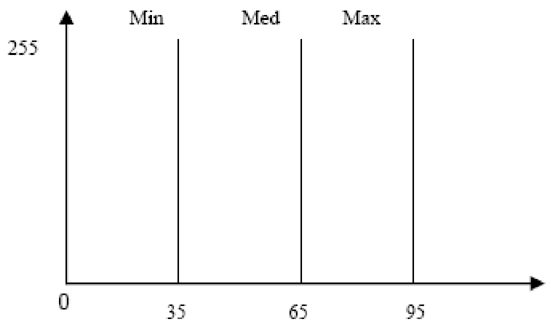
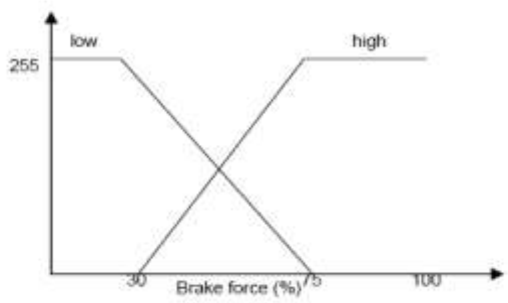
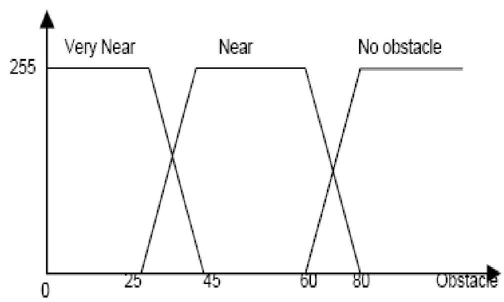


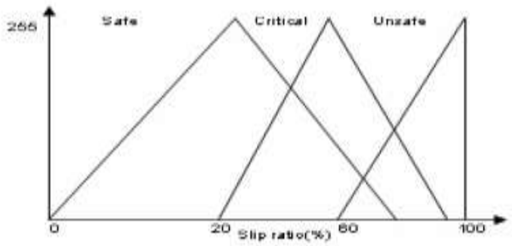
Figure-8 PWM fuzzy set

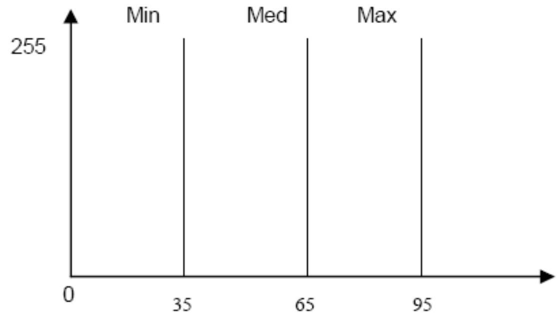
RESULT AND DISCUSSION

This section shows the Data Frames which got in the Logic Analyzer and verified. The message frames from CAS is transferred to ABS module. ABS module takes the decisions based on messages which it has received from CAS. CAS has to send three different messages: Very Near; Near and No Obstacle and according to designed rule base PWM output is produce as shown in figures below.









PWM Output

CONCLUSIONS AND FUTURE SCOPE

Electromagnetic brakes are important supplementary retardation equipment in addition to the regular friction brakes. They have been used in heavy vehicles such as coaches, buses, or trucks under conditions such as reducing speed on motorways and trunk roads, and braking for prolonged periods during down slope operations. New types of electromagnetic brakes have been under development for lighter vehicles as well. Regular friction brakes have an outstanding and vital load absorbing capability if kept cool. Electromagnetic brakes help friction brakes to retain this capability under all conditions by absorbing energy at a separate location based on a totallydifferent working principle. In this study, we proposed a modified static mathematical model for the electromagnetic brakes. A sliding mode controller is designed and simulated for a nominal vehicle model under different road surface conditions. Microcontroller implementation of electromagnetic anti-lock braking system is evaluated. The performance of the modified mathematical model for electromagnetic brake is better than the other three models available in the literature in a least-square sense. There is only one "global" model which can be used at both low speed and high speed regions. Unfortunately, this model does not agree with the experimental results in the high speed region. Based on the phenomena summarized from observation in the high speed region, we modified the old "global" model by taking the "reluctance effect" into account. After this modification, we can model the speed-torque relationship more accurately.

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