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International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878 (Online), Volume-8 Issue-2, July 2019

ABS using Fuzzy Logic in MATLAB and Its Hardware Implementation

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Abstract*: This paper proposes a cheap and effective method to interface the concept of FUZZY LOGIC and (Antilock Braking System) ABS system used in cars and bikes for preventing the condition of wheel locking and wheel slipping and if wheel slipping occurs then how much of intensity of brake should be applied to keep the vehicle in control of the user. This decision is taken by Fuzzy System which makes decision based on user inputs namely Obstacle, Brake force and Slip ratio. The Fuzzy system gives an Pulse Width Modulation output based on three intensity levels of brake will be applied such as High Brake , Medium Brake and No Brake. Hardware Implementation consists of an MCU which is interfaced with an LCD and DC Series motor which displays intensity of brake applied and motor represents the motion of the actual wheel of a vehicle respectively.

Keywords: Anti-lock braking system (ABS), Fuzzy logic, GUI (Graphical User Interface), MCU (Microcontroller Unit), LCD (Liquid Crystal Display).

I. INTRODUCTION

Fuzzy logic is an intelligent decision making tool in Matlab used to make decision based on user inputs and outputs having rules which are defined in Matlab based on which it will take an effective decision for applying brakes. Thus the use of Fuzzy logic for ABS seems to be promising and effective [3].

Antilock-Braking Systems or ABS: An ABS is a safety system which prevents the wheels on a motor vehicle from locking up (or ceasing to rotate) and from sliding while braking. It focuses to minimize brake distance maintaining the control of vehicle even in the case hard braking [1].

Fuzzy Logic: It is a form of multi-valued logic. Fuzzy logic provides an intermediate state which is not the case with binary logics which has either 0 or 1 state. Fuzzy logic variables may have values that ranges between 0 and 1 [2].

Revised Manuscript Received on 30 July 2019.

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Importance of Fuzzy Logic in ABS: If fuzzy ABS is not present the braking force will reach a higher level which will result in locking up of wheels due to which the user will loose control of the vehicle which will lead to an accident. Due to this braking distance will also increase [4].

When ABS works with fuzzy as a decision making tool braking distance will be in limits as well as control of vehicle is also retained [5].

II. AI BASED ABS PROBLEM

In today's world AI based ABS systems are available which are a step ahead of Fuzzy based ABS systems. But the problem is with the cost. AI based ABS system are expensive and are not usually implemented in bikes, low model cars or any budget friendly vehicle. In compare to conventional braking systems Fuzzy based ABS systems can be used which is of low cost compared to AI based ABS systems and also provide more safety and automation compared to conventional braking systems reducing chances of accidents due to locking and slipping of wheels [6].

III. DESIGNING

For prototype designing inputs are taken from user by creating a Graphical User Interface in Matlab. But in an actual system these inputs will come from sensors. In these paper mainly three parameters are focused namely Obstacle, Brakeforce ,and Slip ratio which are the major factors for braking. These parameters are taken from user but in actual system they will come from their respective sensors. A Fuzzy System with 3 input parameters subranges of these 3 parameters is defined. Next step is to define rules in Fuzzy system in Matlab which are shown in the Figures below. The evaluation of this Fuzzy System in Matlab which will give PWM based output which also has 3 subranges High brake, No Brake and Medium Brake. This PWM output will be send to MCU using a 'Send' function created in Matlab used for serial communication between PC and MCU via a USB to TTL converter. MCU will control the speed of the motor accordingly.

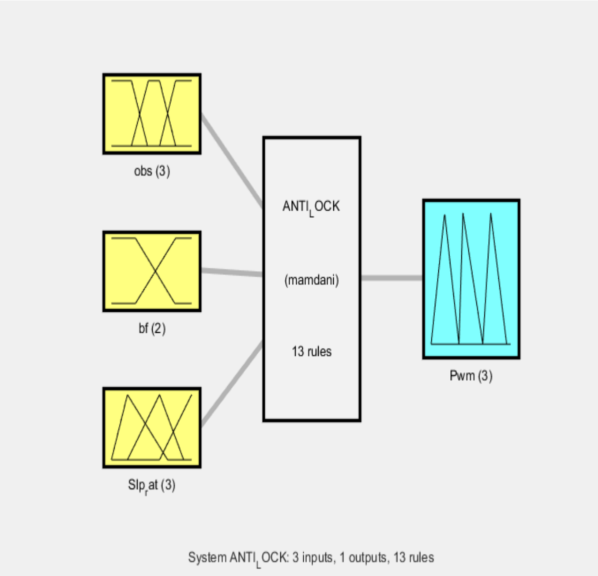


Figure-1 Fuzzy Logic System.

Design part of fuzzy logic in MATLAB as shown in Figure-2 which has 3 factors obstacle, brake force and slip ratio in which obstacle has 3 subranges:1.Very near 2.Near 3.No obstacle, Brake force has 2 subranges:1.Low 2. High, Slip ratio has 3 subranges:1.Safe 2.Critical 3.Unsafe as shown below:

```
a=newfis('ANTI_LOCK');

a=addvar(a,'input','obs',[0,100]);        %Parameter Obstacle

a=addmf(a,'input',1,'Very Near','trapmf', [-36 -4 25 45]);
a=addmf(a,'input',1,'Near','trapmf', [25 46 60 80]);
a=addmf(a,'input',1,'No Obstacle','trapmf', [60 80 104 136]);

a=addvar(a,'input','bf',[0,100]);        %Parameter Break Force
a=addmf(a,'input',2,'Low','trapmf',[-36 -4 30.03 79]);
a=addmf(a,'input',2,'High','trapmf',[30.03 80 126 127]);

a=addvar(a,'input','Slp_rat',[0,100]);        %Parameter Slip_ratio
a=addmf(a,'input',3,'Safe','trimf', [0 20 70]);
a=addmf(a,'input',3,'Critical','trimf',[20,60,90]);
a=addmf(a,'input',3,'Unsafe','trimf', [60 100 100]);

a=addvar(a,'output','Pwm',[0,100]);              %Parameter Pwm
a=addmf(a,'output',1,'Min','trimf',[0 17 35]);
a=addmf(a,'output',1,'Med','trimf',[35 40 65]);
a=addmf(a,'output',1,'Max','trimf',[65 75 95]);

       % mf1ofinp1 mf2ofinp2 mf3ofinp3 mf1ofout1, 1 and 1 for "and" condition
rulelist=[1 2 3 1 1 1;
          1 2 2 2 1 1;
          1 2 1 3 1 1;
          2 2 3 1 1 1;
          2 2 2 2 1 1;
          2 2 1 3 1 1;
          2 1 1 3 1 1;
          2 1 2 2 1 1;
          3 1 1 3 1 1;
          3 2 2 2 1 1;
          3 2 3 1 1 1;
          3 1 3 1 1 1;
          3 1 2 2 1 1];
```

Figure-2 Fuzzy Logic Implementation in MATLAB.

Also, a rulelist for this fuzzy logic is designed as shown in Figure-2 on the basis of which brake force will be applied.

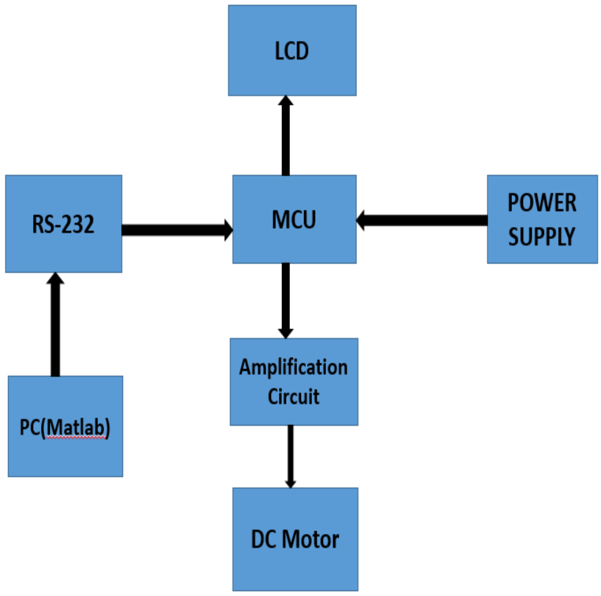


Figure-3 Block Diagram for Hardware Implementatation

The block diagram for hardware implementation is shown in Figure-3.As stated above the input from user on the basis of the 3 parameters, which will come from GUI designed in Matlab but in actual system these parameters will be measured by their respective sensors and then fed to MCU. MCU used here in this is Atmega8 which is a High performance, low power 8-bit MCU operating at 5V. Power consumption in active state is 3.6mA and in idle state is 1mA. Amplification Circuit will be used to run the DC Motor which represents the state of brake force applied. MCU will be connected to a PC having Matlab Software for the fuzzy logic and for providing parameters [7].The simulation results are shown in Figure-4 to Figure-7.The hardware implementation outputs are shown in Figure.8.

IV. SIMULATION RESULT

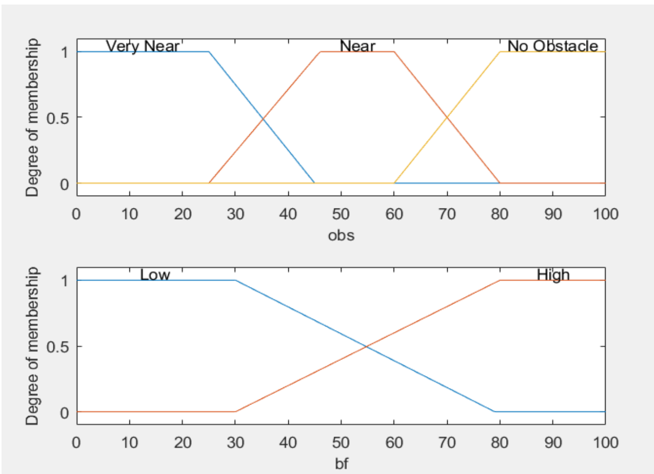


Figure-4 Obstacle and Brake force Subranges.

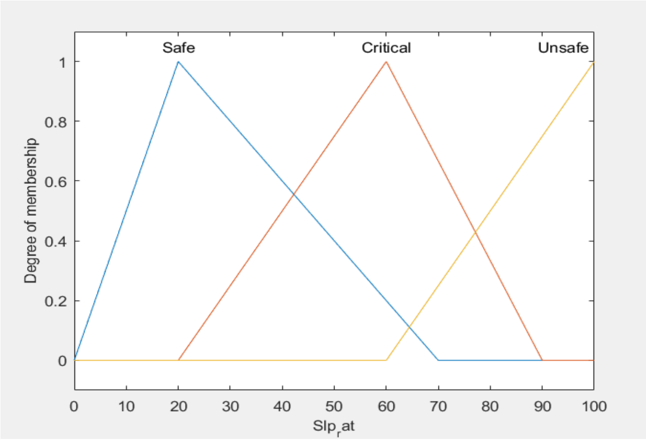


Figure-5 Slip ratio Subranges.

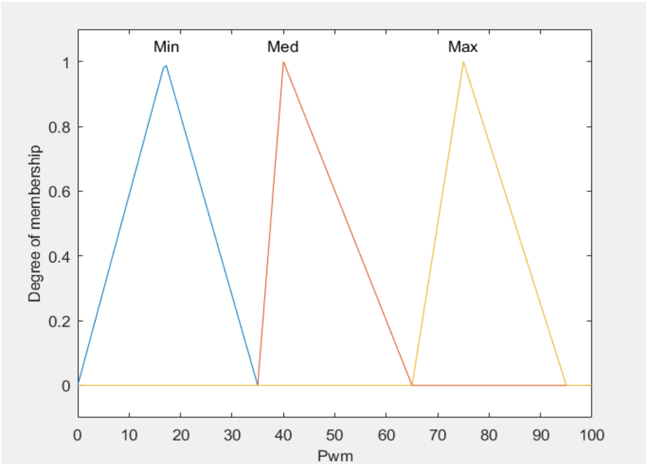
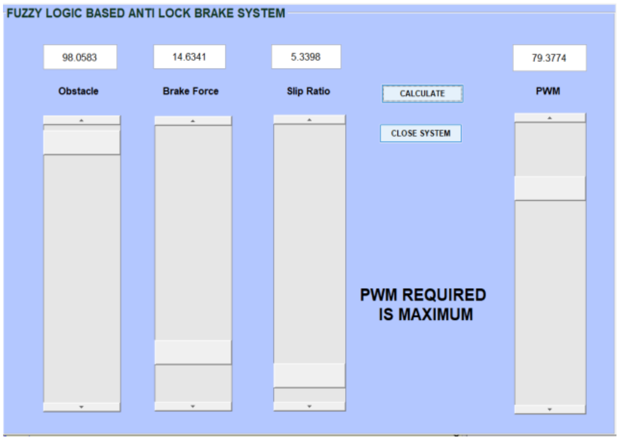
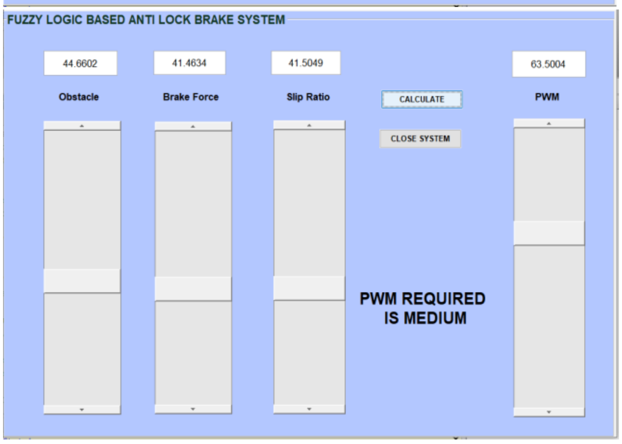


Figure-6 PWM output Subranges.





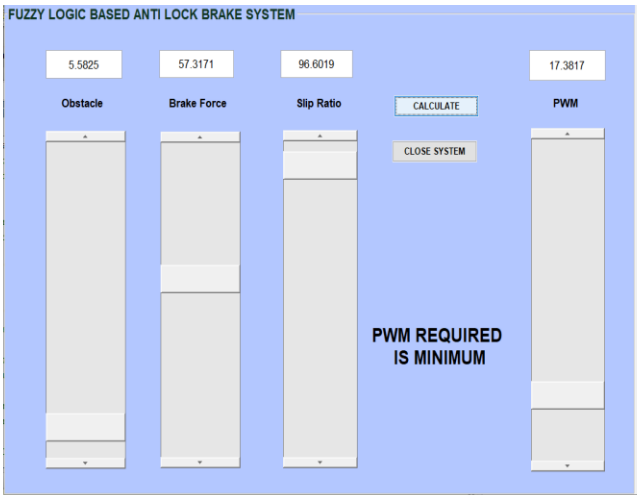
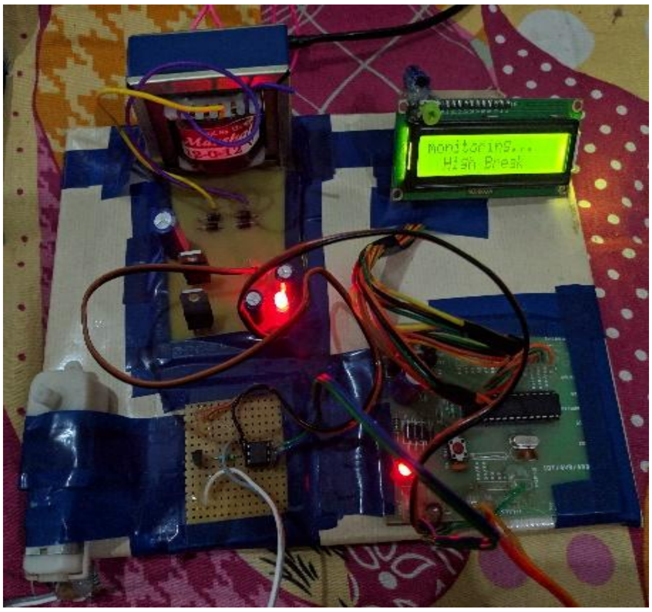
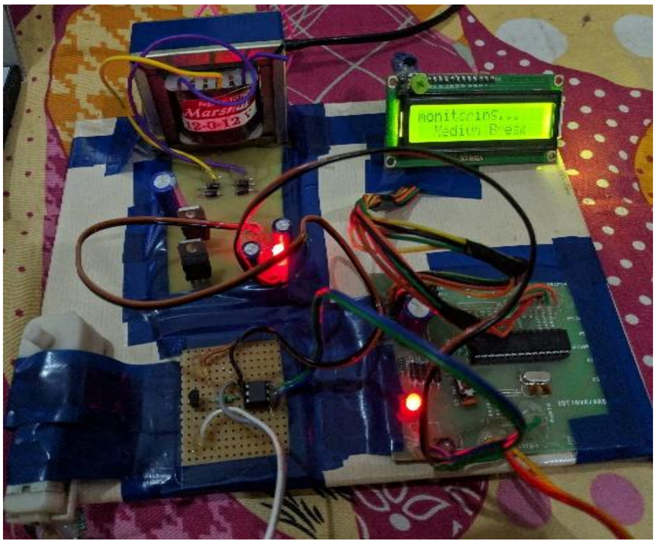


Figure-7 Intensity of Brake for different user inputs





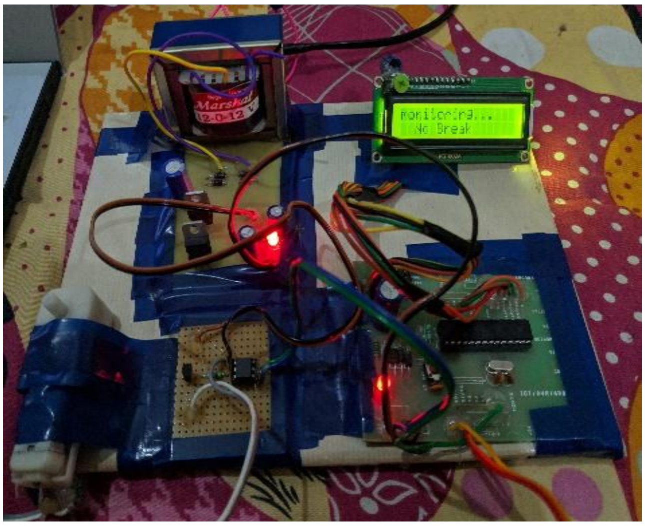


Figure-8 Hardware Implementation Outputs

V. CONCLUSION

The advantage of using Fuzzy logic is that we can tune and modify fuzzy rules according to our requirements which secure its future needs. Intermediate state in Fuzzy logic helps in providing different intensities of brakes like Low, Medium or High. This flexibility of Fuzzy System simplifies the development and also reduces the time required to develop the system. The cheap cost of this system makes it very much usable for budget friendly vehicles. The safety provided by this system in vehicles for braking can be lifesaving for the users.

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