Design and implementation of automatic gear shifting mechanism by using fuzzy logic controller

K.N Gunasekaran, Ramprakash M P, Vishal Arvind, A.Vishal Mohan

Abstract ***In this paper a fuzzy logic controlled automatic gear shifting mechanism designed using MAT lab Simulink software and validated using different vehicles. The various input to the system are engine speed, wheel speed, and engine load. From the various input values the FLC will take the decision on which gear should be selected and maintained for a particular engine conditions. The real time implementation of fuzzy logic controller is done using PIC microcontroller. The gear selection and shifting has been done by pneumatic piston and cylinder arrangement. This mechanism was adapted in motor cycle, light motor and heavy motor vehicle to implement automatic shifting mechanism and observed shifting time based on various applied pressure at constant load condition of the designed cylinder.***
Key word: transmission, fuzzy logic controller, pneumatic circuit

I. INTRODUCTION

I Automatic Gear Shifting Mechanism

Automatic manual transmission systems are acquiring wide acceptance during last one decade. The higher fuel efficiency and less complexity when compared to automatic gear shifting system together with ease of driving makes it most versatile and efficient transmission system nowadays [1]. Even though there are many advantages, the torque interruption from the engine during the gear shifting is still a research topic. The objective of Automatic Gear Shifting Mechanism (AGSM) is to engage starting and gear shifting while maintains the desirable noise level [2]. The power transmission from the engine is controlled by a transmission control unit (TCU) [3]. An existing manual transmission system with little modification can be converted as an AGSM by implementing sensors such as engine speed sensors, torque sensors etc. and actuators such as solenoid actuators. [4]

II. FUZZY LOGIC CONTROLLER

It is essential to control the automatic manual transmission system for better ride comfort and fuel efficiency. There are many methods adapted so far for controlling the gear shift sequence [5]. There are many factors which may affects the gear shifting decision such as vehicle speed, engine load, driver's intention, [6] and road/environmental conditions etc[7]. A fuzzy logic controller (FLC) is an intelligent controller [8] which can take decisions According to these input signals. The rules for FLC can be derived from the practical knowledge and from the experienced driver's opinion. As of now, by means of fuzzy logic controlling method to shift the gear automatically was the identified as a research gap. Similar work was carried out by the previous researchers by adopting another modular controlling technique.

III. DESIGN OF FUZZY LOGIC CONTROLLER

In the fuzzy logic control design one has to be able to describe the operation for that own language. In other word one has to describe the mandate for each language variable. The design of the FLC includes fuzzification, rule base and inference engine and defuzzification processes. In this paper engine angular speed and engine load are taken as input functions and gear shifting decision is taken as output. A Fuzzy rule base system can be tabulated using these two inputs and one output membership functions as shown in table 1

Table 1 Fuzzy rule base

Gear shifting decision for various load				
Angular Speed	Zero	Low	Medium	High
Very low	Urgent downshit	Urgent downshit	Urgent downshit	Urgent downshift
Low	maintain	maintain	Down shift	Urgent downshift
Medim	maintain	maintain	maintain	Down shift
High	Urgent up shift	up shift	up shift	Maintain
Very high	Urgent up shift	Urgent up shift	Urgent up shift	Urgent up shift

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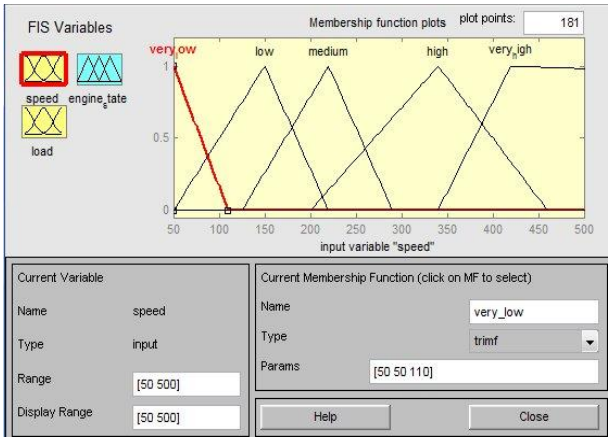

Figure 1 Input Values

A Mat Lab Environment

The fuzzy rule base can be created in the fuzzy tool box in mat lab 6 environments. The input and the output values are shown in the following fig.1. and fig.2.

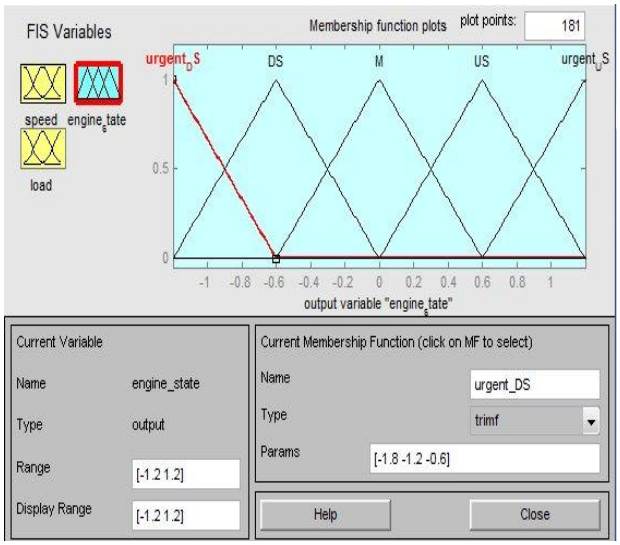

Fig. 2. Output state

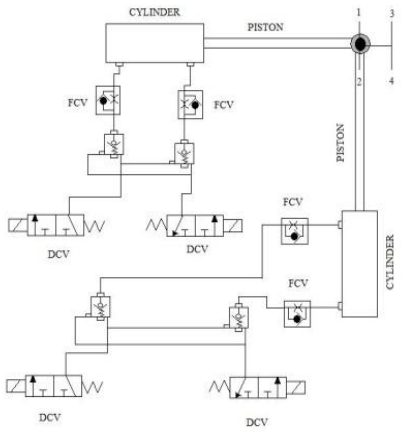

Fig.3. Pneumatic Circuit

B .Hardware Components Design

1. PIC 16F877A microcontroller

PIC 16F877A microcontroller is used here for implementing the intelligent controller. The PIC16F877A features 256 bytes of EEPROM data memory, self-programming, an ICD, 2 Comparators, 8 channels of 10-bit Analog-to-Digital (A/D) converter, 2 capture/compare/PWM functions, the synchronous serial port can be configured as either 3-wire Serial Peripheral Interface (SPI) or the 2-wire Inter-Integrated Circuit (I²C) bus and a Universal Asynchronous Receiver Transmitter (USART). All of these features make it ideal for more advanced level A/D applications in automotive, industrial, appliances and consumer applications

2. Sensors

There are two input sensors are used to get input signals to the controller. A magnetic speed pick up sensor is used to measure the input speed and a potentiometer based throttle position sensor is used to measure the engine load.

3. Actuators

Two pneumatic pistons are used to shift the gear shifting mechanism. The 4/2 direction control valve and flow control valves are used to control the air flow. The pneumatic control circuit is shown in the figure.

IV. PNEUMATIC CIRCUIT DESIGN

The Pneumatic motion is selected for gear shifting owing to its large load acceptance and ease of adaptability in the car. Also the gear shift should be quick. The basic components design is explained in detail. The fig.3 is the basic pneumatic circuit diagram for the gear selection and actuation. The circuit is verified by festo fluid circuit simulation software.

1. Cylinder Design

Load required to move the selector rod or to change the gear F=30 Kg

Pressure built in the compressor unit P=10 bar

To find:

Cylinder dimensions D, L=?

1.1 Cylinder Diameter (D)

$$P=F/A$$

$$(10*10^5)*(\pi/4)*D^2 = 30*9.81$$

D=0.0194 m = **20 mm**

1.2 Cylinder Length (L)

Cylinder length L= Stroke Length+ Piston thickness+ Clearance

L= 26+10+7 = 43 mm

L=**43mm**

Cylinder diameter= 20mm

Cylinder length= 43mm

V. ELECTRONIC CIRCUITS

The circuit for the speed sensor and throttle positon sensor are shown in fig.4 and fig 5. The speed sensor detects wheel speed and sends the appropriate signals to the ECU. The LM 117 series of adjustable 3 terminal positive voltage terminals is used as throttle position sensor.

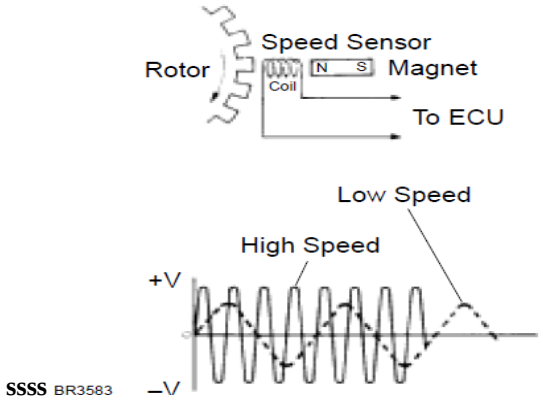

Fig.4 Magnetic pick up speed sensor

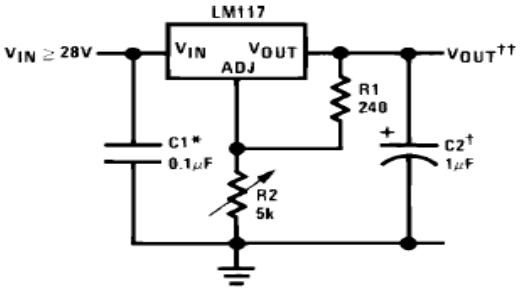

Fig.5 1.2V-25V adjustable regulator

VI. RESULT & DISCUSSION

The fuzzy logic controller for intelligent gear shifitng was designed in the MAT lab environment based on the expert knowledge data and the rule base were created accordingly. The input to the systems such as engine speed and engine load were acquired using magnetic pick up sensor and throttle positon sensor. The apparatus for automatic gear shifting has been designed using pneumatic cylinders and dirction control vales. The gear shifting at required speed level and engine load is achieved using PIC micro controller. The gear slection and shifting were done quick and smooth manner.

I.MOTOR CYCLE

Table 2. Motor cycle response

Applied Load for 10 Kg			
Pressure in bar	2	3	4
Gear shifting time in sec	14	8	6
Noise Level in db	3	12	5

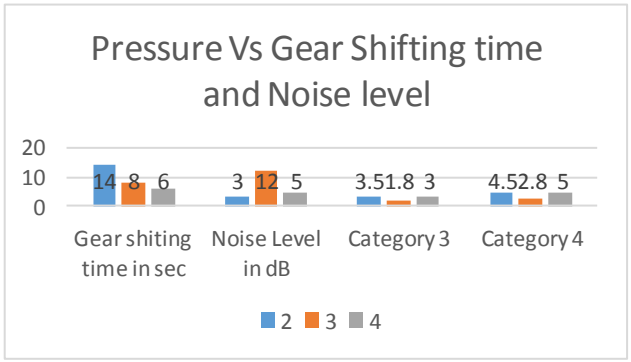

Fig 6. Varying Presure Response for MC

From the Motor Cycle the shifting mechanism operates with help of pneumatic force in the pressure of 2,3 and 4 bar respectively. The responses were measured with the help of stop watch and noise level measured with the help of decible meter. From the figure 6 and table 2 it was observed that increasing the pressure from 2 bar to 4 bar, the shifting time decrease quickely. But noise level varies from 3 db to 12 db. The optimal level of motor cycle shifting mechanism operates 4 bar pressure. From that it attains 8 second of shifting time and 5 db of noise level. Also it operates smothly engaged with the gear sets.

II.LIGHT MOTOR VECHILE

Table 3. Light Motor vechile response

Applied Load in 30 Kg			
Pressure in bar	8	10	12
Gear shifting time in sec	16	10	8
Noise Level in db	6	8	14

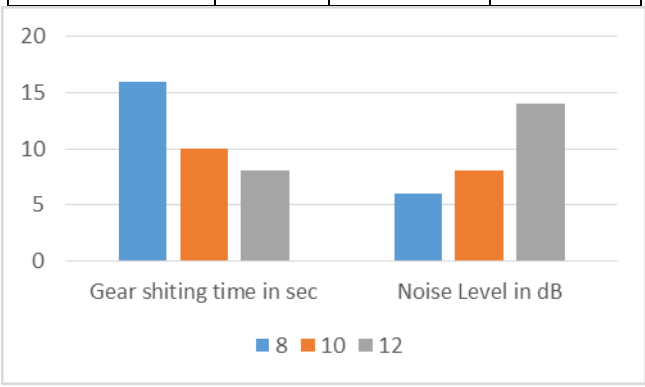

Fig 7. Varying Pressure response for LMV

From the Light Motor vechile the shifting mechanism operates with help of pneumatic force in the pressure of 8,10 and 12 bar respectively. The responses were measured with the help of stop watch and noise level measured with the help of decible meter From the figure 7 and table 3 it was observed that increasing the pressure from 8 bar to 12 bar, the shifting time decrease quickely. But noise level varies from 6 db to 14 db. The optimal level of motor cycle shifting mechanism operates 10 bar pressure.

From that it attains 10 second of shifting time and 8 db of noise level. Also it operates smothly engaged with the gear sets.

III.HEAVY MOTOR VECHILE

Table 4. Heavy Motor vechile response

Applied Load in 50 Kg			
Pressure in bar	16	18	20
Gear shifting time in sec	13	7	6
Noise Level in db	20	30	25

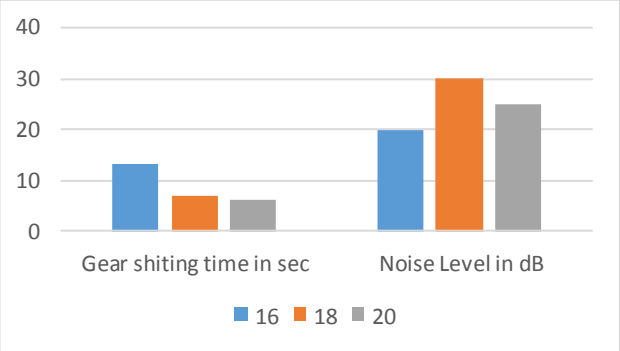

Fig 8 Varying Pressure response for HMV

From the Heavy Motor vechile the shifting mechanism operates with help of pneumatic force in the pressure of 16,18 and 20 bar respectively. The responses were measured with the help of stop watch and noise level measured with the help of decible meter From the figure 8 and table 4 it was observed that increasing the pressure from 16 bar to 20 bar, the shifting time decrease quickely. But noise level varies from 20 db to 30 db. The optimal level of motor cycle shifting mechanism operates 16 bar pressure. From that it attains 13 second of shifting time and 20 db of noise level. Also it operates smothly engaged with the gear sets.

VII. CONCLUSION

The following findings can be concluded from this work Designed the automatic gear shifiting mechanism control by means of fuzzy logic controller with help of pneumatic circuit Based on the vechile angular speed and engine load taken from magentic pickup sensor and throttle position sensors repectively.the gear position tend to change automatically with the help of fuzzy logic controller via pneumatic unit setup The MAT lab simulation was carried out to get the optimum results based on the input parameters taken, This Fuzzy logic controlled programe unit along with the pneumatic circuit was suitable to convert conventional gear box into automatic gear box The simple cost effective mechanism will adapt for all type of conventional gear box in automobiles in all weather condition in different terrains.

REFERENCE

1. Hiroshi Kuroiwa, Naoyukai Ozakai, Takashi Okada, Masaru Yamasaki(2013), "Next generation fuel efficient automated manual transmission", Hitachi Review Vol. 53, no.4
2. M B Celik and R bayir(2017) "fault detection in internal combustion engines using fuzzy logic", DOI: 10.1243/09544070JAUTO 366,VOL 221
3. Cheok and Kobayashi(1996) " A fuzzy logic based smart automatic windshield wiper", IEEE control system,0272-1708/96 VOl 164
4. Mashadi B, Kazemkhani A and Baghaei R Lakeh (2006), 'an automatic gear shifting strategy for manual transmissions', Department of automotive engineering, Iran University of science and technology, Tehran, Iran.
5. Galvagno E, Velardocchia M, Vigilani A (2016) 'A model for fly wheel automatic assisted manual transmission'
6. Ronald K jurgen (2001) "actuators" automotive electronic series,SAE international.
7. U Kiencke and L. Nielsen(1998), "automotive control system", SAE International,
8. Okada, et al (2017). "Gear Shift control technique for auto-shift manual transmission system with torque assist mechanism" JSAE transaction, No.2, vol. 33.

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