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Power control scheme of variable speed motor using FLC for EV application

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ABSTRACT:

Energy efficiency is crucial in electric vehicles (EVs) and hybrid electric vehicles (HEVs) because there is a limit on the quantity of energy that can be stored. The high stability, cheap price, and minimal losses of the induction motor all contribute to the higher efficiency of the device. Additionally, even when there is just a moderate load on it, it gets a current that is higher than what is necessary for its operation. The purpose of this investigation is to offer a control approach for electric vehicle (FLC) applications that is based on opaque logic control. The FLC controller is able to enhance the initial power distribution while also consuming less energy. The functionality of the controller is tested virtually with the MATLAB/SIMULINK software suite in order to validate its performance. Conventional proportional-integral-derivative controllers are outperformed by simulation approaches in terms of time-domain responsiveness and quick rejection of system-related disturbances. As a consequence of this, the asynchronous motor's primary losses have been greatly cut down, which has led to an increase in the efficiency of the drive system. It is utilized for the purpose of determining whether or not the suggested control system is in full accordance with the findings of the simulation.

KEYWORDS: Fuzzy Logic Controller, Vector controller of IM, Proportional Integral Derivative Controller, Membership Function

1 INTRODUCTION

The widespread use of fossil fuels has risen, particularly over the course of the previous several decades, which has led to an increase in the atmospheric concentration of CO2. The rise in sea level that is expected as a result of climate change and global warming is one of the primary motivating factors for the requirement for worldwide actions to decrease carbon dioxide. Because the transportation sector is responsible for 20 percent of all CO2 emissions, major increases in fuel economy for vehicles are required. Electric vehicles (EVs), in addition to being more effective, environmentally kinder, and quieter, also require less energy overall. Both the effectiveness and the price of the drive are significantly influenced by the particular kind of electric machine that is installed. However, electric machinery is the only kind of powertrain It may be used in hybrid electric cars and electric vehicles (HEVs). Induction motors, often known as IMs, and synchronous motors are the two primary kinds of machinery that are found in electric vehicles. A propulsion motor for an electric vehicle (EV) needs to have the following qualities: high efficiency to increase the driving range; high torque density to provide adequate propulsion power during start-up, charging, and acceleration; and good flow control capabilities to expand the speed range of static power. These qualities allow for the expansion of the speed range over which static power can be applied. Even though its hazards are greatly raised in EV applications, IM is still a popular choice for traction propulsion because of its durability, low cost, and little maintenance needs. This is despite the fact that the dangers are significantly increased. The capacity of the machine is decreasing. The primary obstacles that prevent their widespread implementation in the transportation industry are their low power density, high weight, slow charging rates, and lengthy battery lives. Because of this, EV management demands efficient energy management. PID control, which stands for proportional, integral, and derivative, is one of the components that is utilized the most frequently in industrial drives due to its effectiveness and ease of implementation. In addition, PID controllers are utilized in a wide variety of control loops and applications within the industrial sector. When operating circumstances change as a consequence of aging components or a changing work environment, significant performance losses may occur. These performance losses may be caused by either. Intelligent management strategies, such as Blur Logic Control (FLC), which take into account the fact that it is difficult and unexpected to develop a precise analytical model of a controlled system, may perform very well. The FLC system offers a number of useful ideas that, when implemented, make using language tags significantly easier. The control of an electric vehicle's overall energy usage has been the subject of this concept's application in a few previous studies. Given that FLC is a modeless control strategy, it is possible for it to function even in the absence of a system's mathematical model. When the system is getting close to its established fault zones, the FLC system controller needs to be configured with the necessary features in order to maximize the performance of the electric vehicle's traction. Finding suitable transactions that have a short growth time, a small amount of static error, and the lowest overshoot is one of the numerous achievements that FLC has accomplished. Nevertheless, the design techniques that are used nowadays focus a larger premium on reducing the amount of fixed losses. Traditional induction machines that are built for high stability efficiency can have considerable and high maximum current losses during transport with variable flux connections. These losses can occur during the transport of the machine. The transient mechanical damage that commonly occurs in the traction motor drive of an electric vehicle (EV) when it is being operated in a dynamic driving cycle is the primary subject of this body of study. The research that has been done on electric vehicle applications has shown a variety of control systems. Examples of fundamental linear approaches include sliding mode control, Direct torque control and field-oriented control. Use of a finite element approach, an adaptive model reference system, and an optimized main power scheme known as the Golden Section Method can reduce the amount of energy lost owing to secondary winding harmonic losses.

Seek Controller (SC), an adaptive quadratic interpolation-based algorithm, and slip control, which employs a nine-rule blur controller, are utilized to improve IM drive damage by making use of the frequency produced by changes in input speed error. Both of these controllers are used to improve IM drive damage. An FLC-based technique that can be used for EV applications is suggested by this body of work. The effect that each controller (PID and FLC) has on the performance of the IM is analyzed and contrasted. The following are the primary contributions that have been made as a direct result of this effort: Efficiency is a measure of energy expenses, and the primary challenges are slowing down more than was originally projected and increasing the total cost of the propulsion system throughout its whole life cycle. The total amount of available driving power has an effect on the efficiency of the inverter.

2 CIRCUIT DESCRIPTION

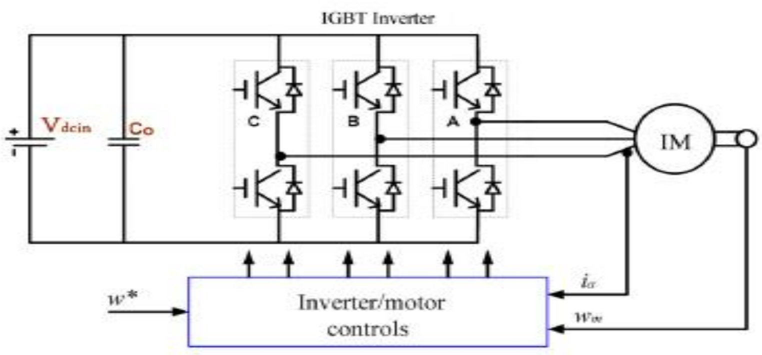


Fig. 1 *EV drive with an IM*

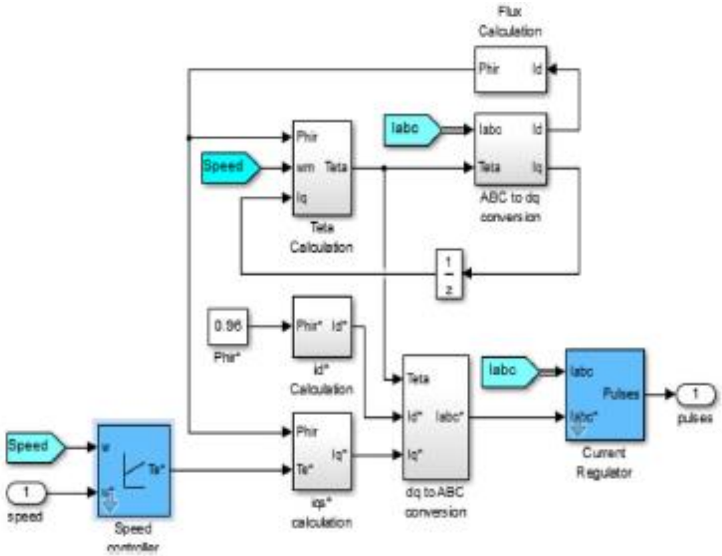


Fig. 2 *Control system of IM*

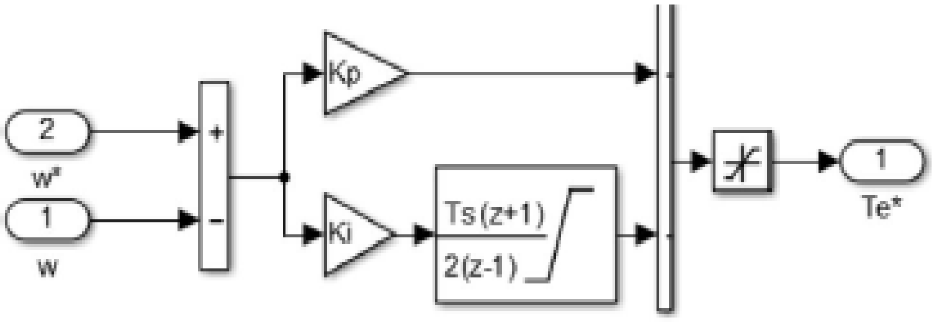


Fig. 3 *Block diagram of the conventional PID controller*

Figure 1 depicts battery EVs, which are cars that are powered only by electricity and consist of the following three primary components: first and foremost, an electric engine structure; normally, only one electrical device, which is commonly an AC three-phase, is present. The wheel is the point of connection for both the differential and the gearbox. The battery, which is connected to the gadget via an electrical DC/AC power connection tied to the control system, artificially stores the energy. In addition, there is a battery that serves as a power reserve and is located within the device. The electric machine finally responded to the flow driver's request using a three-stage recurrence and voltage control structure. The brake and/or gas pedals are attached to this structure depending on the context. The footing power for the wheels is provided by the three-stage electric machine shown in Figure 1. The differential will apply force to both the left and right wheels, and the gear ratio will make the transition from a powerful electric motor shaft speed compared to low wheel speed as rapidly as possible. An inverter controls the machine's speed that transforms the direct current (DC) from the battery into a three-stage alternating current (AC). It is essential to consider the possibility of individual component failures when conducting an analysis of the effects of making use a non-essential EV for the power chain stretching from the matrix to the wheels. In order to advance the electric vehicle (EV) framework into the essential activities, it is our responsibility to establish the appropriate regulators for criticism. When applied to applications involving EVs, FLC approaches have the potential to enable the implementation of a regulator that lacks adequate flexibility, adaptability, and power.

3 VECTOR CONTROL OF INDUCTION MOTOR

Monitoring the phase currents in the stator and converting them into a complex (space) vector are both done. This current is converted into a vector rotation coordinate system by the rotor that is located within the machine. In order to accomplish this, you need to be aware of the location of the rotor. As a consequence of this, the measurement of at least one velocity is required, and the position may be determined by adding up the several velocity values.

When the stator current vector is multiplied by the magnetizing inductance Lm, a secondary electric vehicle for the power grid. After that, the rotor no-load time constant is divided by Lr / Rr to arrive at the correct solution, which is H. A low-pass filter with a rotor that has a low resistance to inductance ratio.

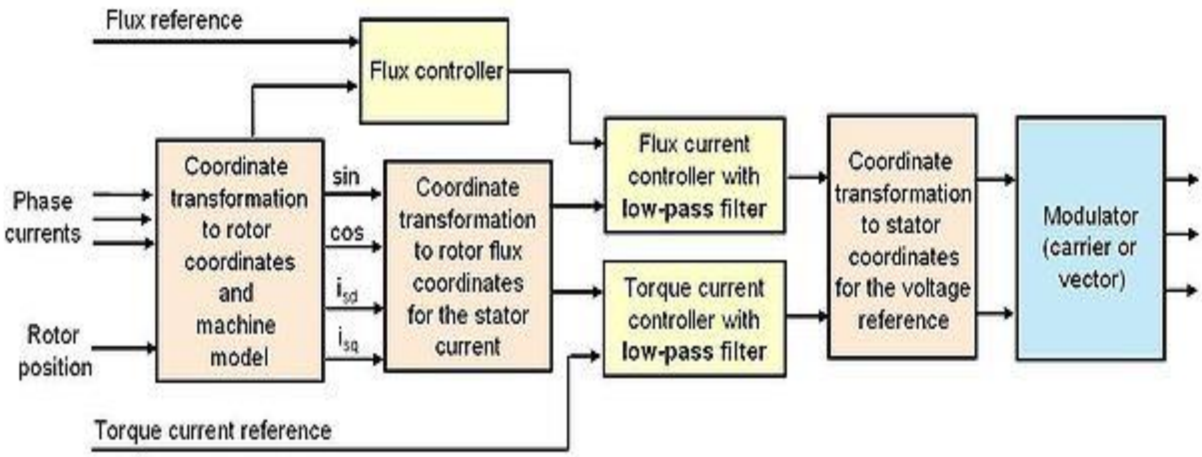
The rotor flux link vector is then used to align the real x-axis rotor flux with the link vector after the stator current vector has been translated into a coordinate system by employing the rotor flux link vector.

Within the context of this rotor flux alignment coordinate system, the actual x-axis component of the stator current vector is responsible for controlling both the rotor flux linkage and the fake motor torque.

It is common practice to make use of PI controllers in order to bring these currents to their desired setpoints. The bang-bang method of controlling the current, on the other hand, offers more dynamics and is more predictable.

The controller outputs for the PI controllers are determined by the components x and y of the voltage reference vector for the stator. Decoupling is a technique that is widely used in controller output in order to increase control performance. This technique is necessary because considerable, rapid variations in speed, current, and flux linkage can cause cross-coupling between the x and y axes. Low-pass filtering of the input or output of the PI regulator is commonly necessary to minimize current ripple clipping caused by transistor switching and control changes. This is the case because low-pass filtering reduces the frequency of current ripple. Regrettably, filtering also restricts the dynamic range of control. As a consequence of this, higher power drives, such as servo drives, need for a noticeably higher switching frequency in order to accomplish the desired level of minimum filtering (often more than 10 kHz).

Indications of voltage are supplied in the form of a modulator, which determines the necessary pulse widths for the stator by employing one of a variety of pulse width modulation (PWM) techniques. Indications of voltage are frequently converted into a fixed coordinate system by the utilization of the rotor's d-q coordinates. alters phase voltages as well as transistors, primarily IGBTs, in line with the setting.



3.1 Description of proposed FLC

The non-direct characteristics of AC engines, in particular the squirrel confine enrollment engine (SCIM), make it challenging to keep this issue under control. This is due to the fact that several components, most notably rotor protections, change depending on the circumstances under which they are used. Therefore, for EV applications, the conventional control innovation (PID) has to be improved by making use of the powerful FLC. The following factors need the highest care, in descending order of importance:

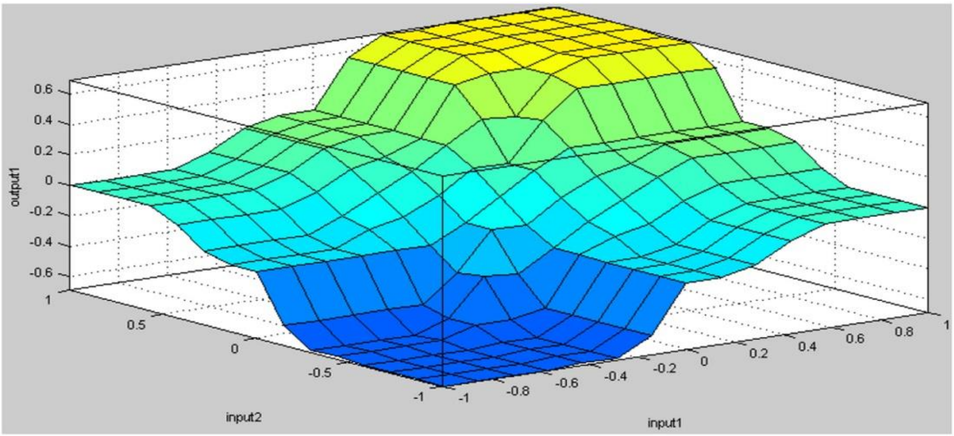
(I) the predominance of weak standards that are produced locally by specialists for a variety of control problems;

(ii) choosing the participation activities and making modifications to them;

(iii) choosing the appropriate scaling factors, or.

4 SIMULATION STUDIES

As can be seen in, the simulation takes into account both of these possibilities by making use of the simulink and power sum toolboxes that are along with the MATLAB application. In the first case study, a PID controller was utilized to achieve regulation of a 50-horsepower IM. During the first five seconds of operation, the three-phase voltage and current are recorded and programmed. This takes place simultaneously. The probe is used to keep an eye on both the acceleration curve and the torque that is produced as a result. When it comes to the second scenario, FLC has complete command of the motor. Figures 4 and 5 show a comparison of the response of the PID controller with the response of the FLC. The temporal behavior of the outputs and acceleration have both been improved thanks to the data that was supplied in relation to the amplitude of the initial currents. Using the strategy that was proposed and keeping the component order the same would result in the phase current having fewer components that cause loss. The method lessens the occurrence of fluctuations in speed and improves the efficiency with which actual torque is increased. The harmonic velocity waveforms for the PID model and the FLC model, respectively, are shown in Figures 12 and 13. These waveforms are illustrated for the PID model first. PID and FLC have both been utilized in a number of different simulated experiments to regulate speed of an IM. The effectiveness of the controller is tested by gradually shifting the speed reference while keeping a constant load torque, as shown in Figures 1 and 2. This process is depicted in both of these figures. 14-16. PID and FLC performance are compared with regard to peak overshoot, settle time, and rising time in Table 4, which takes into account many levels of speed input. Table 4 indicates, with the exception of the rise time at 1145, that FLC reacts more rapidly to multi-level speed input than PID does in both the transient and increase times (RPM). Because of this, FLC fared better than PID did in terms of performance. In addition, the FLC has shown an enhanced ability to manage the speed of the three-phase IM and has provided an accurate and speedy reaction to practically every static-error and overshoot. In a variety of simulation studies, The IM speed has been controlled using both PID and FLC for applications involving EVs. Numerous operating circumstances, including reference speed and applied load, were used in the simulations. Analyses and comparisons of the performance of the PID and FLC were carried out. The performance of the FLC during load interruptions and its speed responsiveness at a variety of reference speeds are displayed in Figures 6 and 7, respectively. The outcomes of the simulation are shown in Fig. after 20 seconds have passed. The automobile is completely stopped at the beginning of time t = 0, and then there occurs a sharp deceleration of 70 percent on the accelerator. When the car has used up 10 kW of electricity, which happens at t = 0.8 s, the vehicle will continue to operate in electric mode. The brakes are applied at a rate of 70 percent for a duration of 12 s. After starting the electric motor, the battery is allowed to discharge for a period of four seconds while being charged. At t = 16 s, a rapid depressing of the gas pedal brings the percentage of gas back down to 70 percent.



Crisp input/output map

Δwe	***we***				
	NB	**NS**	**Z**	**PS**	**PB**
NB	NB	NB	NS	NS	Z
NS	NB	NS	NS	Z	PS
Z	NS	NS	Z	PS	PS
PS	NS	Z	PS	PS	PB
PB	Z	PS	PS	PB	PB

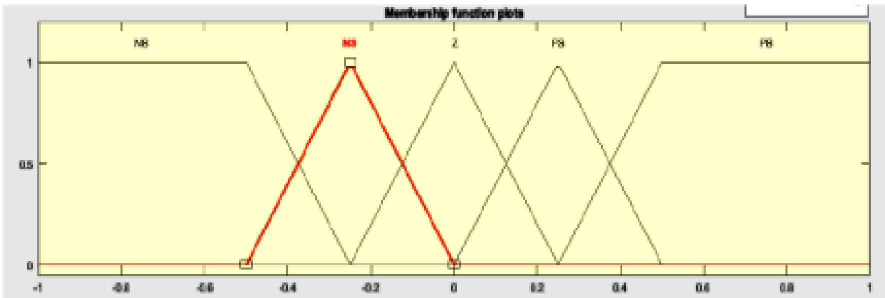


Fig. 5 *Membership function of FLC (we), (Δwe), (Δu)*

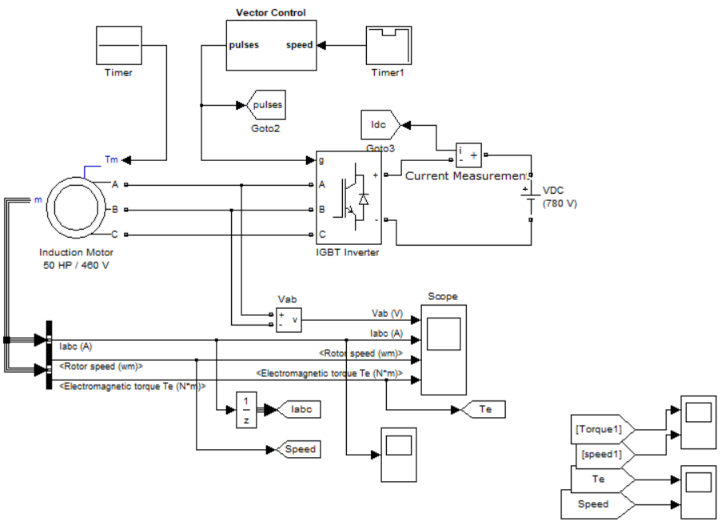


Fig 4. Simulated circuit

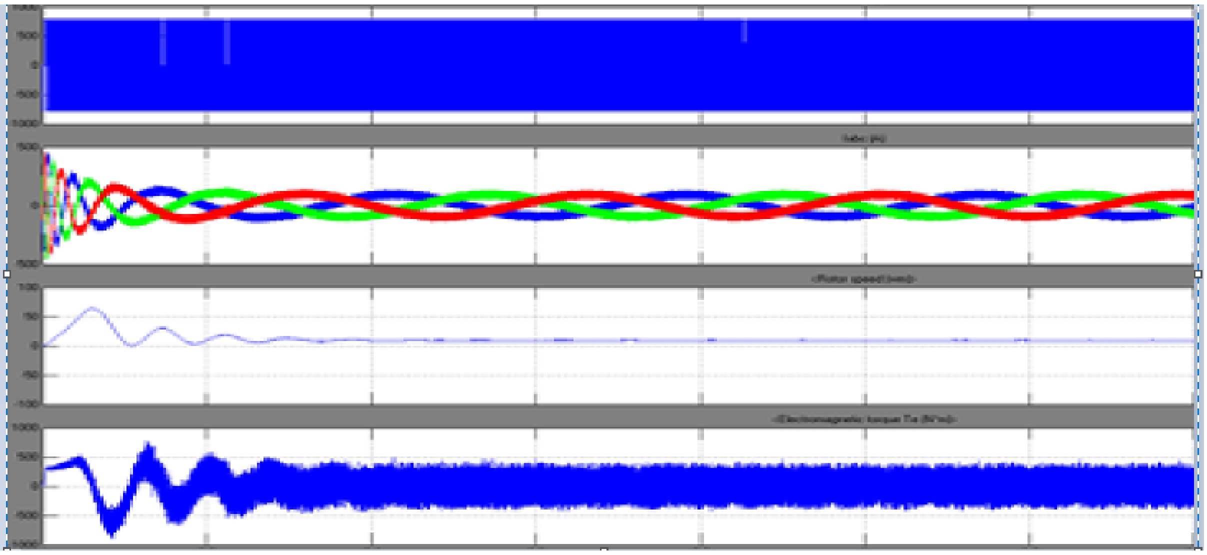


Fig 5. Voltage, stator currents speed and torque response of the system

5 CONCLUSION

While operating at full load, the IM can receive more electricity than is required. As a result of this excess energy, heat is created. FLC can be used at this time to limit passive power transmission and save more energy. The appropriate controller term is produced by using speed error and error change, which are inputs to the blur controller, in the external loop. In this study, simulation was used to analyze a 50-horsepower electric car operated by IM. B. Overshoot, fixed-state error, rising time, and settling time are a few of the performance metrics that are measured. The outcomes demonstrated that the suggested system's phase current was composed of low loss, small-amplitude, and consistently grouped components. The damage amplitude for the actual steady state torque is frequently reduced. This boosts system efficiency and produces constant torque. In terms of rise time, settle time, and peak shooting, In comparison to a normal PID controller, the simulation results of the proposed FLC scheme show improved stability and performance. Experimental findings that agreed with the outcomes of the modeling were used to validate the suggested control system.

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