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Fuzzy Based Switched Reluctance Motor for Reducing Torque Ripple

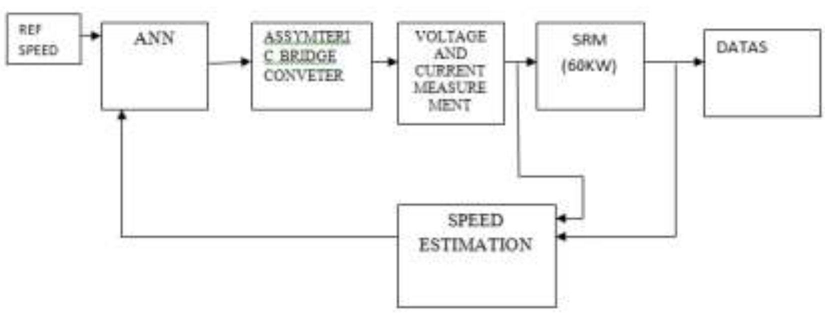
Ms.Vishnu Priya.R, Amathullah.A.S, Evanjelin.J.
Assistant Professor, Electrical and Electronics Engineering, IFET College of Engineering, Anna University, India.
Electrical and Electronics Engineering, IFET College of Engineering, Anna University, India.
Electrical and Electronics Engineering, IFET College of Engineering, Anna University, India.

Abstract: *Switched reluctance motor (SRM) drive with a novel Torque Distribution Function (TDF) for high-speed applications, in order to reduce torque ripple. The origin of torque pulsations in an SRM is due to the highly nonlinear & discrete nature of torque production mechanism. The total torque in an SRM is the sum of torques generated by each of the stator phases, which are controlled independently. Torque-ripple reduction in switched reluctance motors (SRM) has become a major research theme. In servo control applications or when smooth control is required at low speeds, reduction of the torque ripple becomes the main issue in an acceptable control strategy. In this paper Fuzzy logic controller with buck boost converter is used and ANN controller which performs tasks that a linear program cannot, such as the performance of conventional Proportional-Integral (PI) controller and PID controller are also considered.*
Keywords- *ANN Controller ,DC-DC Buck Boost Converter, Data Acquisition Techniques, Fuzzy Controller, Switched Reluctance Motor .*

I. Introduction

Today, before using a motor controller with real motor drive, it's a common industrial engineering practice to test a controller against a simulated motor model running in real-time. This has several advantages. For example, the simulated motor drive can be tested with borderline conditions that would damage a real motor, often a costly prototype. The motor itself may be under development in parallel to the controller and therefore not available for testing. while testing, a controller is interfaced with the real- time simulated motor drive through a set of proper I/Os: this approach is called hardware-in-the-loop(HIL) simulation. Such motor drive simulation is required by hybrid vehicle OEMs and other power electronic motor drive manufacturers to speed up development and testing time by using real-time simulation before conducting test on physical prototypes. At the production stage HIL simulation can also be used to verify code integrity with automatic correlation tests. The switched reluctance motor drive is interesting because of its low operating costs, rugged construction and simplicity of controller design. Since the rotor has no windings and no magnets, it's a good candidate for drive operation at high speed and in adverse environments. Position sensor reliability poses a more important problem in latter case. A developer or integrator of such drives will want to test the behavior of the drive in case of position sensor malfunction, for example. real-time simulator is be ideal to safely test this scenario. Sensor less drive designs pose other challenges related to sensor accuracy that could be overcome through the use of a real-time simulator. The real-time simulation of current-controlled drives poses other challenges, including simulator latency that can create a delay in hysteresis-type current controllers. This, in turn, can cause current overshoots that are usually not present in real drives. Several SRM models that are ready for real-time simulation are discussed in detail in references [6], [7], [8]. In these models, a key aspect is the flux linkage curve approximations by polynomial functions or tables. The switched reluctance machine has wound field coils of a DC motor for stator windings and has no coils or magnets on its rotor. A typical 8/6 pole SRM .In an SRM, the rotor is aligned whenever diametrically opposite stator poles are excited. At the same time, when two rotor poles are aligned to two stator poles, another set of stator poles is out of alignment with a different set of stator poles. Continuous torque production is therefore obtained by sequential excitation of the stator phases using a unipolar power converter with 2 IGBTs and 2 diodes for each leg. Well-known algorithms for controlling an SRM, such as advanced rise and commutation angles, adaptive control, fuzzy logic control, and neural network control have been proposed in the literature. Torque Distribution Function may be the most well-known method. There are many kinds of TDFs; developed by Husain [3] (denoted as TDF-I), Ilic-Spong [4] (denoted as TDF-II), and Krishnan [1] (denoted as TDF-III). In this paper, the authors present the topic of real-time simulation of switched reluctance motor drives using TDF-III, and also propose a novel Torque Distribution Function, based on TDF-III, for high-speed model applications. Next, a real-time simulation system for switched reluctance motor drives is demonstrated. It is implemented using a novel TDF for high-speed applications, in order to reduce torque ripple.

1.1.Block Diagram:



II. Torque Production Strategy

In SRM control strategies, each phase winding is excited separately in the rising slope of the inductance for the positive torque, and in the falling slope for negative torque. The overall torque of the motor is the sum of the phase torques. The inductance profile, phase current and voltage. Fig (2) represents torque production strategy

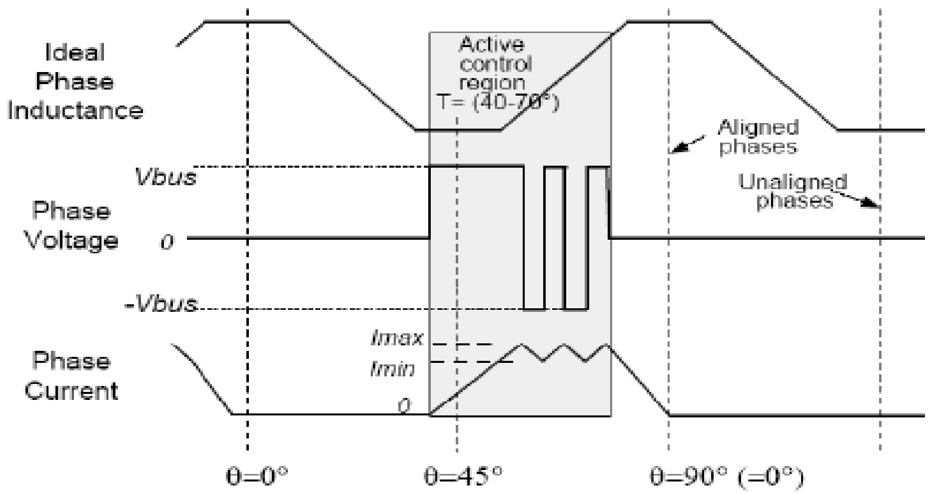


Fig.2 Torque Production Strategy

2.1.Model of the SRM:

In the SRM, there is a three-dimensional relationship between excitation current, rotor position and flux linkages [2]. Therefore, electromagnetic torque depends on both Inductance profile, phase current and voltage, excitation current and rotor position. Those relationships are presented. The machine under study also has a stator winding resistance equal to 0.2Ω and a rotational inertia of 0.1 kg.m2. This SRM model integrates its flux at each winding, considered as uncoupled. Its equation is where Iabc is the stator current inside the winding, R is the stator resistance and Vabc is the voltage across the stator windings. The current is then derived from the machine flux characteristics Ψabc (I, θ). Fig .2.1.a represents flux characteristics

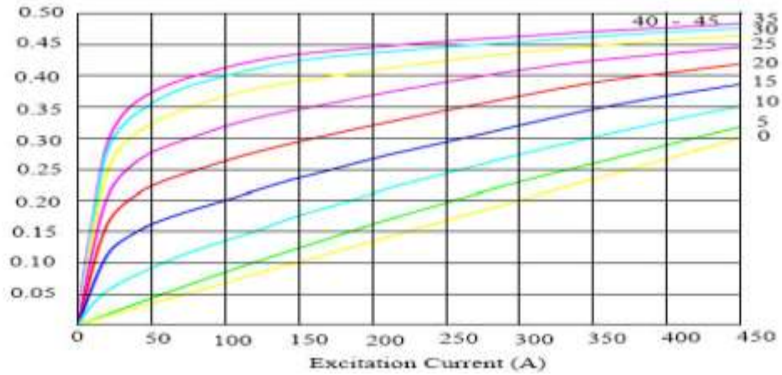


Fig.2.1.a Flux characteristics

The phase flux linkage depends on both rotor position and phase current. The model of an SRM can be described is shown in fig 2.1.b

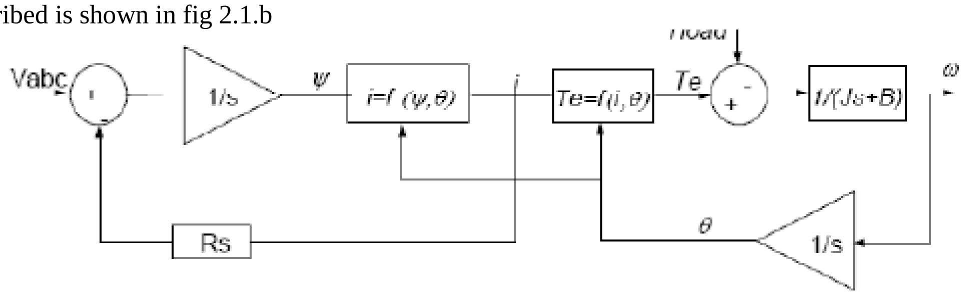


Fig.2.1.b.Model of an SRM

2.2Torque Distribution Functions

In many machines, such as ac and dc machines, the air gap torque is directly proportional to the excitation current (in a DC machine) or the transformed current variable (qaxis current in an AC machine). However, in the case of an SRM drive system, a three-dimensional non-linear relationship exists between the flux linkages, excitation current and rotor position. This means that the air-gap torque depends on both excitation current and rotor position. Therefore, in the SRM drive system, it is necessary to add the torque control to the control loop. The control configuration for an SRM drive system using TDF. The extraction of the excitation current reference from air-gap torque reference is made using a three-dimensional relationship.

III. Main Block With Fuzzy:

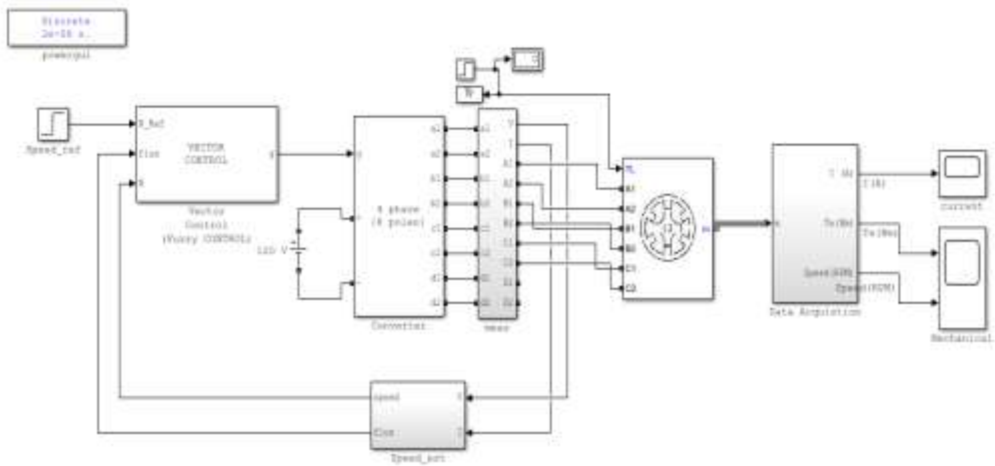


Fig.3.Fuzzy System

Speed and flux from the SRM motor is measured and given to the vector control , which gives information to SRM motor via commutator. By using data acquisition techniques required datas will be obtained as shown in above fig.3

3.1.Fuzzy Controller:

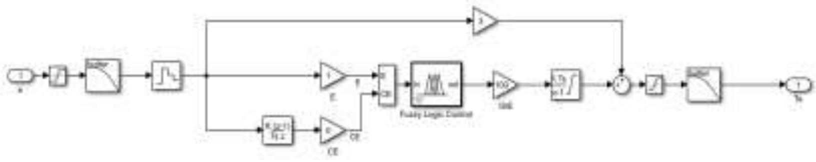
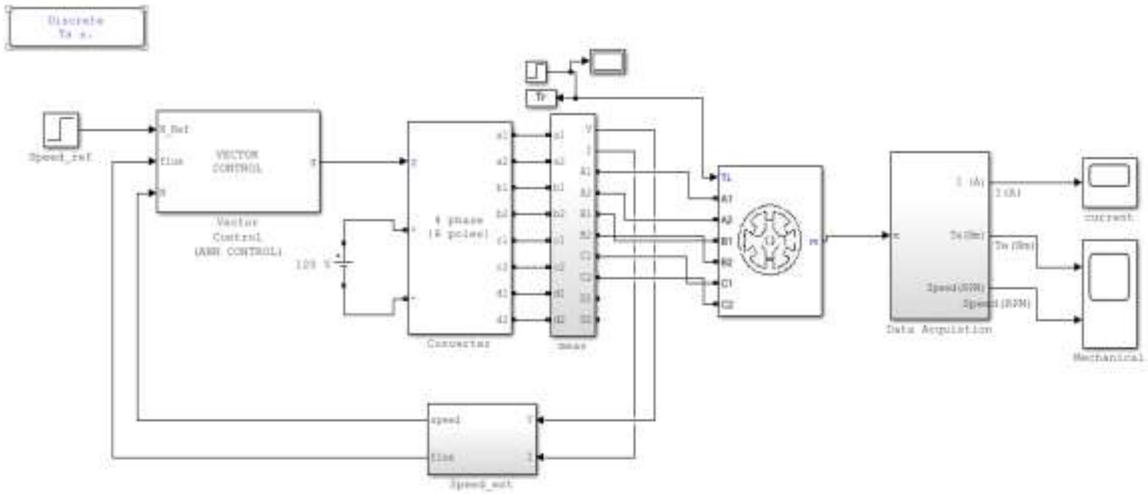


Fig.3.1.Fuzzy Controller

Fuzzy logic system can be defined as a fuzzy system which utilizes a mathematical system to analyze analog input in terms of logical variables which use continuous values between 0 and 1 unlike the classic or digitalized logical which utilize digital values high(1) or low(0). Fuzzy control systems have been successfully applied to a wide variety of practical problems. The controllers may perform better than conventional model-based controllers, especially when applied to processes difficult to model, with uncertainties. The fuzzy rules for resetting rate are constructed to damp overshoot in response by resetting accumulated control input and to make response faster under large incremental control input. Rules for calculating incremental control input (du) and resetting rate(r).

IV. Main Block With Ann:



4.1.ANN CONTROLLER: Fig 4.1 ANN controller

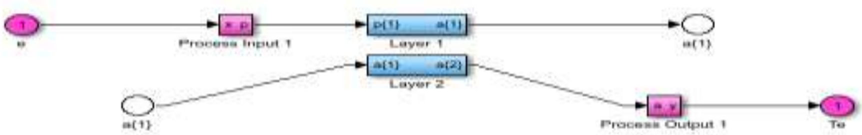
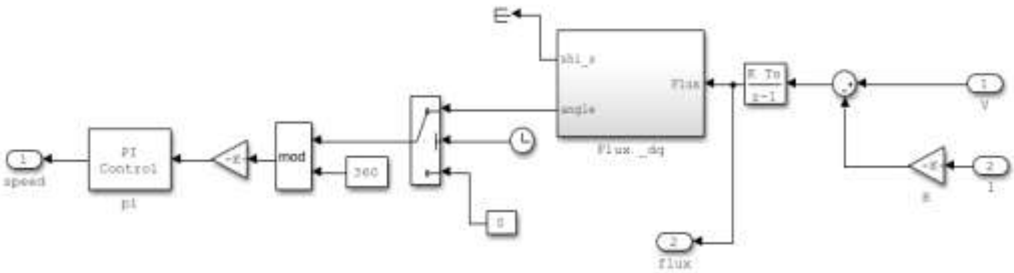


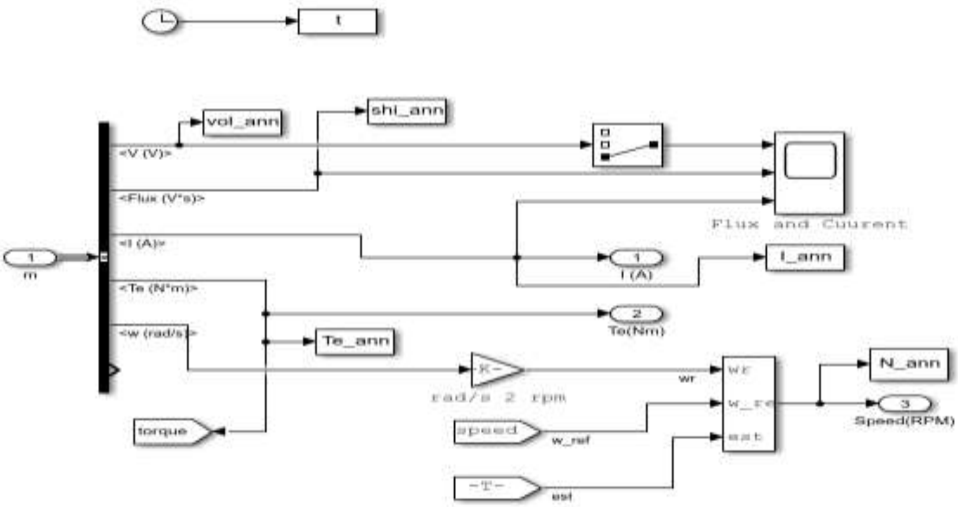
Fig 4.1 ANN controller

A neural network can perform tasks that a linear program cannot. When an element of the neural network fails, it can continue without any problem by their parallel nature. A neural network learns and does not need to be reprogrammed. It can be implemented in any application and without any problems. They may require less tuning effort than conventional controller. A three layer feed forward structure with two nodes in the input layer is used. The output layer of the ANN consists of only one neuron, while the number of neurons in the hidden layer is five. The input vector consists of the motor speed error, and the previous output of the ANN. The previous output of the ANN is added to the input vector as a stabilizing signal. The activation function used is the sigmoid function in both hidden and output layer. Increasing the number of neurons in the hidden layer has the advantages of reducing the rising time (Tr) and the maximum overshoot (M.O.S). Where i f is the activation function, ij w is the weighting factor, j x is the input signal, and i b is the bias. The most commonly used activation functions are nonlinear, continuously varying types between two asymptotic values -1 and +1. They are called tan sigmoid function.

V. Speed Estimation:



Data Acquisition:



VI. Conclusion:

SRM with fuzzy controller is designed to obtain wide range of speed characteristics. The SRM is first properly designed to perform its charging and discharging operation controls. Fuzzy controller which feeds data to the SRM motor and the values will be get from data acquisition techniques, which overcomes the disadvantage of torque ripple content in SRM motor.

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