A review on Smart Controller for Multi-Segment Sliding Mode Control of Induction Motor

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Abstract: Nowadays Induction motors is widely used in the industry due to its easy construction, high robustness and satisfactory efficient. Here, several advantages of induction motor consist like simple construction, reliable and relatively low cost, high efficiency and high robustness. The various application of Induction motor in industry like paper and textile mills, machine tools, robotics, heat pumps, rolling mills, etc. The control of motors used in high performance servo drives requires the torque accuracy control, velocity control, and position control in different operating conditions. Precise control model is required to get better performance. There are various methods to solve the defined problems using the classical control methods, to the conventional methods like DTC, VC, SMC, MS-SMC to the hybrid control methods. MS-SMC method is more suitable than the SMC method for the incremental motion control of induction motor drive. In recent years, neural networks and fuzzy logic have attracted a number of researchers to work on the speed control of Induction Motors as these methods had yielded very good results. Numerous advances have been made by various researchers on this topic so far.

Index Terms **- DTC (direct torque control), VSC (Variable structure control), SMC (Sliding Mode Control), MSSMC (Multi-segment Sliding Mode Control), FLC (Fuzzy Logic Control), GA (Genetic Algorithm), PIC (PI controller), PID (PID controller)**

I. INTRODUCTION

In last decades, DC motors have been widely used in industry for the different applications. But as Compare to AC motors DC motors are very expensive because of its commutators and brushes. In industries, undesirable sparks are not allowed in some applications and it is produced by such arrangement in DC motor and for that AC drives are better solution.

AC drives like synchronous motor and induction motor are widely used in the industries due to its easy construction, high robustness and satisfactory efficient. Here, several advantages of induction motor consist like simple construction, reliable and relatively low cost, high efficiency and high robustness. The various application of Induction motor in industry like paper and textile mills, machine tools, robotics, heat pumps, rolling mills, etc.

The control of AC drives is more complex than DC drives and the main reasons for that is complexity like need of variable frequency, machine parameter variations. Various control methods of induction motor drives are used, and these are scalar control, VC, DTC, and flux-oriented control.

The control of motors used in high performance servo drives requires the torque accuracy control, velocity control, and position control in different operating conditions. Precise control model is required to get better performance and it is difficult to construct because of the external parameter variations. For Robust performance, PI type control methods are not suitable in the variations of external parameters variation during operation.

VSC or SMC method is very effective way to control a system because of the many advantages like insensitivity to parameter variations, external load disturbance rejection, and fast dynamic responses. The control is nonlinear, and it can be applied to a linear or nonlinear plant. VSC or SMC has been widely used in the position and velocity control for both types of motors. VSC or SMC system can be divided into two phases: the reaching phase and the sliding phase. The robustness of a VSC system lies on its sliding phase. In robots, elevators and cranes, load can be move at a specific position at specific time and after completion of task second command is initiated. This kind of motion is called incremental motion and for the different applications different speed command profile are designed. Trapezoidal speed command profile is commonly used in such type of speed command profile and it includes three parts: (a) constant acceleration; (b) constant speed; and (c) constant deceleration. In conventional VSC or SMC technique, constant acceleration and velocity cannot be designed.

MS-SMC method is more suitable than the SMC method for the incremental motion control of induction motor servo drive. This study also shows that the reaching phase of the sliding mode control does not exist in the multi-segment sliding mode control, because the system dynamics are in the sliding mode at the start. The robustness of the controlled system can be assured from start to finish. Multi-segment sliding mode control techniques have been applied an induction motor or compare the performance under different loading condition.

Here, a multi-segment sliding mode control technique is to control the IM machine, though, simulation providing the speed command and the flux control which is robust to the external parameter variations. Variation of motor parameters during operation discredits performance of the controllers. Use of the MS-SMC method, due to its external disturbance impeaches, strong robustness, and simple design provides very good achievements for motor operation and robustness of the control law against the perturbation. A motion control system having two loops i.e., speed loop and position loop with one multi-segment sliding mode controller which follows the trapezoidal speed command profile has been used.

GA is global, parallel search methods mimic natural genetic operations. They simultaneously evaluate many points in the search space; hence it has more probability of convergence into a global solution. GAs is widely used for tuning gains of the different control systems like PID, FLC, ANFIS and SMC etc. In the work focus has been given for designing SMC using ANFIS. The parameters of SMC are tuned using GA in order to analyze the effect on performance of an overall system. Simulation results will be developed to highlight the performance of the robust control method under load disturbances and parameter variations with adaptive control.

II. LITERATURE REVIEW

The recent trend for industries and all power transmitting system widely involves electro-mechanical system and for that electrical ac-dc drives are widely adopted. Above all AC drives the induction motors have been widely used in the industries due to its advantages like simple built, high robustness, reliable and suitable operation and more over relatively low cost. But the control and evaluation of behavior of induction motors are more complex than other drives. The main reasons for that is complexity like need of variable frequency, machine parameter variations. The need to understand the various speed control techniques for an induction motor is an important task which motivates the researcher to improve design and performance of an induction motor. There are many researchers who had developed conventional control ways like VC, DTC, PI controller, SMC and MS-SMC. Study of mathematical model and simulation model for MS-SMC is done by the researcher. But the available information about MS-SMC is less. The earlier research work done for the same is as discussed below with respective references.

The speed control techniques using VC and DTC of induction motor are developed by researchers Sadegh Vaez-Zadeh, Ehsan Jalali 33 and A. Shiri, A. Vahedi and A. Shoulaie 35. But the main problem of the indirect vector control is that it depends on machine's parameters. These parameters are affected by variation in temperature and saturation level of the machine. Also, Biranchi Narayan Kar, Satish Choudhury et. al 6 described comparison of indirect vector control and PI controller as control technique of an induction motor. But under fluctuating loading condition the machine characteristic is nonlinear and for that P-I controller fails to give optimum performance.

Several researchers, Biranchi Narayan Kar, Satish Choudhary et. al6, Mr. Hardik A. Shah and Mrs. Ami T. Patel24, Abdelkrim Benchaib, and Ahmed Rashid 1, and S.M Mahmoud, L. Chrifi Alaoui et. al32 addressed the problem of the parameter variation and load torque disturbances and Sliding Mode Control (SMC) was used for good dynamic response in terms of less settling time, rise time and peak time for an induction motor. Different sliding surface and different control techniques like rotor flux control1 and field orientation control method32 of induction motor are discussed for linear and nonlinear controllers. Also, Faa Jeng Lin, Sheng Lyin Chiu, Kuo Kai Shyu11 has discussed a novel sliding mode controller with an integral operation switching surface and provide insensitivity to parameter variation, external disturbance and fast dynamic response for synchronous motor drive. Among them developed control methods, SMC can offer many good properties as well. These merits of SMC have been employed in the speed and position control of AC drives. However, the chattering exists in the practical application of SMC systems cannot be implemented due to this chattering problem and may lead to high frequency disturbance and cause uncertain instabilities. In a report on SMC, Kou Cheng Hsu, et al18 developed an enhanced fuzzy SMC for a linear IM to achieve the position tracking achievement. F.J. Lin and S.L. Chiu7 developed fuzzy with adaptive sliding mode control for position control of permanent-magnet synchronous servo motor drive. Guorong Liu and Xizheng Zhang14 studied a speed estimation and control strategy for IM servo drive using SMC with radial basis function neural network (RBF-NN). Neural network controller with sliding mode provides high performance and robust w.r.to parameter variation and external load disturbance. F.J. Lin, W.D. Chou and Huang8 had developed an adaptive SMC based real time genetic algorithm for an IM drive. An adaptive SMC with an integral operation switching surface is formulated, in which a simple adaptive algorithm is utilized to estimate the bound of uncertainties. Since the adaptation parameters for the above adaptive algorithm are constants, favorable returns usually cannot be achieved due to the existing problems. Therefore, a real time GA is developed to improve the performance of an adaptive SMC IM servo drive system. Also, Sinn Cheng Lin and Yung Yaw Chen40 had developed a combination of both GA and fuzzy based SMC for IM drive. The position tracking problem of fuzzy with SMC is overcome by both GA and fuzzy controller with sliding mode controller and get faster dynamic response than conventional FSMC. Moreover, with help of conventional and smart controller designed with SMC posed their respective advantage like insensitivity to parameter variations and external load disturbance rejection, and good dynamic responses. Here, SMC cannot use for incremental motion control of AC motors.

To make sure that the load can be moved to the stated position with stated time, a desired speed control system has to design beforehand. Incremental motion control is named by the trapezoidal speed control profile and it has three segments: (a) constant acceleration, (b) constant speed and (c) constant deceleration. However, constant acceleration and speed cannot be obtained using conventional SMC method. Accordingly, MS-SMC technique is designed by Kuo Kai Shyu, and Chiu Keng Lai19 and Faa Jeng Lin, Kuo Kai Shyu, Chih Hong Lin9 in accordance with the trapezoidal speed command profile for synchronous reluctance motor11 and PMLSM servo drive9. Also, from the comparison of conventional SMC and MS-SMC, the MS-SMC for SRM and PMLSM is fully satisfied the desired velocity control and acceleration in incremental motion. Also, GA based MS-SMC is developed by W.D. Chow, F.J. Lin, K. K. Shyu40 for incremental motion control of an IM to reduce the chattering response due to external load disturbance. so, real time GA is applied in MS-SMC. GA based MS-SMC scheme can be reduced higher amount of chattering in torque current command and also provide the good dynamic response of the rotor position control are maintained to external load disturbances.

Finally, with the above surveyed work I found that it is necessary to design such system which includes MS-SMC with coordination of fuzzy and neural controller which will overcome different deficiency of above-mentioned control strategies. Most widely industry uses induction motor and for the same I inspire to highlight merits of smart controller using MS-SMC in collaboration with Neuro-fuzzy based controller which fulfill following criteria:

• Reduces almost chattering and smooth operation

- Take minimum response time
- Speed command profile can be improved
- Reliability with high efficiency
- And moreover, robust design

Editor Problem Formulations

The first part of the research step is to assess the existing information and literature review in the relevant field and to identify the problem and solve it. In the above sections, it is an attempt to study the research works of various authors across the world in the field of speed control of electrical AC machines, as it finds much application, especially in the industrial drives. Thus, the problem of controlling the speed of electrical AC machines, i.e., an induction motor, was considered. The main objective is to design an effective controller for the speed control of IM, which will overcome all the drawbacks of the controlling methods employed by various researchers so far.

The second part of the research step is to solve the identified speed control problem that has been defined. There are various methods to solve the defined problems using the classical control methods, to the conventional methods like DTC, VC, SMC, MS-SMC to the hybrid control methods. In recent years, neural networks and fuzzy logic have attracted a number of researchers to work on the speed control of Induction Motors as these methods had yielded very good results. Numerous advances have been made by various researchers on this topic so far. A combo of fuzzy and artificial neural networks with MS-SMC is thus believed to be an effective method to control the speed of induction motors.

III. IMPORTANCE of work

Widely, IM have been universally used in the industry due to its merits like simple built, high robustness, reliable and good operation and more over relatively low cost. But the control and evaluation of behavior of induction motors are more complex than other drives. The main reasons for that is complexity like need of variable frequency, machine parameter variations and main problem found chattering in current and due to performance of the drives became poor. Hence, many researchers who had developed conventional control techniques like VC, DTC, PI controller, SMC and multi-segment sliding mode control (MS-SMC).

Except MS-SMC, all the control techniques are used only for one segment either speed control or position control. Study of mathematical modeling and simulation modeling for multi-segment sliding mode control (MS-SMC) is done by the researcher. But the available information about multi-segment sliding mode control is only for speed control of synchronous motor and also it is less while induction motor is mostly used in industries. So, this review is very helpful to control of induction motor using conventional MS-SMC and propose smart controller using Fuzzy-Neuro MS-SMC for better performances like reduce chattering effect, incremental motion control etc…

IV. OBJECTIVES of work

The main research objectives of this research work are to do a simulation for conventional MS-SMC controller, smart controller using fuzzy and neural network collaborating with MS-SMC of induction motor and analyze its performance using simulation in MATLAB software. Also, to enhance the performance of the system by employing a new control technique for induction motor and compare the performances of propose smart controller using fuzzy-neuro MS-SMC and conventional MS-SMC for induction motor.

V. RESEARCH METHODOLOGY

The researcher will gather relevant primary and secondary sources and to study well. In industries, induction motor is widely used in different applications. Here, the first step is to study the IM and speed control of IM using different control strategies.

Whereas, the SMC and of MS-SMC techniques were better than the other techniques. Hence, second step is to study the SMC and MS-SMC techniques using their block diagram shown in fig.1.

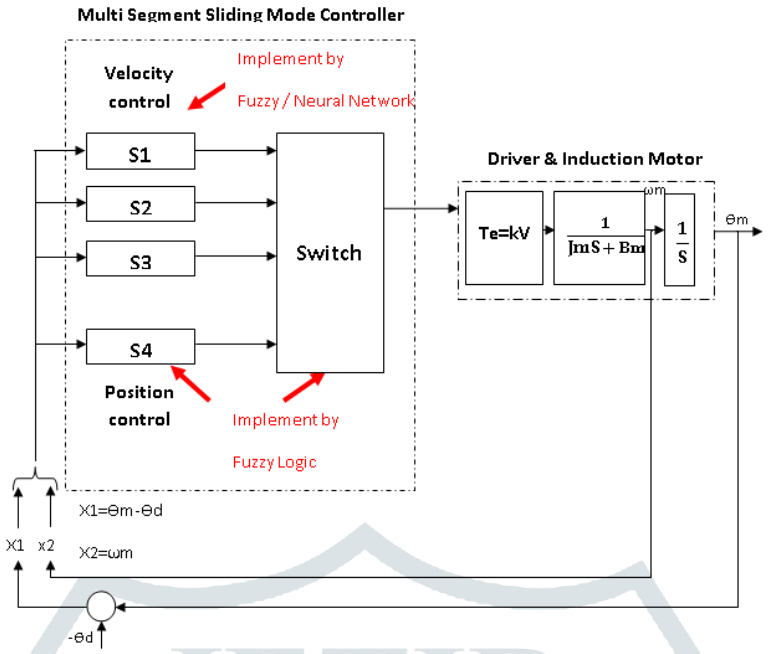

Fig.1 1 Proposed robust multi-segment sliding mode controller for induction motor

Furthermore, it is seen that MS-SMC technique overcame the drawbacks of SMC for speed control of IM. Hence, the next is to design and simulate conventional and mathematical model of MS-SMC for acceleration, run, and deceleration (velocity control) and position control of IM using Matlab simulation tools.

Main goal of this research work is to design and simulate the smart controller using FLC, ANN AND GA based MSSMC of IM using Matlab simulation tools as shown in above fig. 2.1 and to analyze the performances of IM for various loading conditions. Finally, it will also look comparison between the performances of propose smart controller using fuzzy, ANN and GA based MS-SMC and conventional MS-SMC for Induction Motor and identify the optimal control technique with fast response.

The overall objectives of work in the proposed dissertation shall consist of the following:

- To study the different control strategy of Induction Motor especially that of SMC and MSSMC and find out and the drawbacks of them.
- A literature survey of the latest trends available in the conventional MSSMC for Induction Motor.
- Study, Design and Development of the smart control techniques like FLC (Fuzzy Logic), ANN (Artificial Neural Network) and GA (Genetic Algorithm) using Matlab Simulation Tools.

Here, all work has been carried out in MATLAB Simulation using various tools available in it. After making efforts in simulation models, results are obtained with desired goal and analyze the results for different loading conditions.

Compare and analyze the result using the Mamdani based simulation model of fuzzy logic control, ANN based simulation model and GA based simulation model of MSSMC for Induction Motor for different loading conditions.

VI. Conclusion

With these serves, it is concluded that the main objective is to design an effective controller for reduction in chattering and harmonics during speed control of Induction Motor, which will overcome all the drawbacks of the controlling methods employed by various researchers so far is overcome by the advance version of Multi-segment sliding mode control using fuzzy and/or neural. And this smart controller is robust controller for induction motor.

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