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Implementation of GA in Multi Segment Sliding Mode Control for Optimal Operation of Induction Motor

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***Abstract*—Induction motor is efficient motor and widely used in industries than the other motors. Several benefits of IM are simple construction, easy installation and high robustness. Induction motor is used for the different applications and performance requires velocity control, position control and accuracy control in various loading condition. Better performance is achieved by precise control. Classical control methods like DTC, VC, and SMC are used control of IM. Combination of Velocity and position control is known as Trapezoidal control command. Trapezoidal control command is suitable method for speed control of the Induction Motor. MS-SMC method is more suitable than the SMC method for the Trapezoidal control command of induction motor drive. From the recent years, numbers of works have been done by smart and intelligent techniques and GA is the one of the technique of speed control of IM.**

***Index Terms*— MSSMC, SMC, DTC, VC.**

I. INTRODUCTION

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, SMC and 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 MS-SMC is done by the researcher. But the available information about MS-SMC is only for speed control of SM and it is less IM is mostly used in industries. So, this review is very helpful to control of IM using conventional MS-SMC and propose smart controller using GA based MS-SMC for better performances like reduce chattering effect, incremental motion control etc.

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II. Objectives of Work

The main research objectives of this research work are to do a simulation for conventional, smart controller using GA with MS-SMC of IM and analyze its performance using simulation in MATLAB. Also, to enhance the performance of the system by employing a new control technique for IM and compare the performances of propose smart controller using GA based MS-SMC and conventional MS-SMC for IM.

III. GA Logic based Intelligent Control

The simulation model used in Simulink to study the response of GA based multi-segment sliding mode control. Here, in the GA based MSSMC is designed to set the gains of sliding segments through an algorithm. We can see the control block in the fig. 1 which is executed by the algorithm and it is connected after the sliding blocks S1, S2, S3, S4 and it set the control gains of sliding segments.

A. General Rules To Set Parameters Of Genetic Algorithm

Genetic algorithms (GAs) are computer-based search techniques patterned after the genetic mechanisms of biological organisms which have allowed such organisms (GAs), to adapt and flourish in changing, highly competitive environments for millions of years.

1) Population size: - It influences amount of search points in every generation. There is always a trade-off between diversity of population and computation time. The more population size in the Gas will increase the efficiency of searching, but it will time consuming. When the population is less GA may converge in too few generations to ensure a good solution. The population size usually ranges from five to ten times the number of searched variables.

2) Crossover Probability: - The crossover probability controls the rate at which solutions are subjected to crossover i.e. influences the efficiency of exchanging information. The higher the crossover probability the quicker the new solutions are generated & lower crossover rate may stagnate the search due to loss of exploration power. Typical values of the crossover probability are in the range 0.5-1.0.

3) Mutation Probability: - A large value of the mutation probability transforms the GA into a purely random search algorithm by eliminating the results of reproduction & crossover. While a certain value of the mutation probability is required to prevent the convergence of the GA to sub optimal solutions. A typical value of the mutation probability is in the range 0.0-0.1.

4) Chromosome length: - It influences the resolution of the searching result. The GAs with longer chromosome length will have the higher resolution, but it will increase the search space.

5) Number of Generations: - which influences the searching time and searching result. The GAs with larger search space and less population size, it needs more generations for a global optimum. Additionally, the set of the number of generations is dependent on the problem.

Sample Calculation of code length: (for total 9 variables)

For gain α1: Range [10 25]

= (α1max- α1min) *104 = (25-10) *104 = 150000

217<150000<218 - Length of α1 =18

TABLE I. Multi-segment sliding mode controller gain

Variable	Bit length	Low Range	High Range
α_1	18	10	25
β_1	17	5	15
α_2	18	5	25
β_2	18	5	20
α_3	18	10	25
β_3	17	5	15
α_4	22	200	550
β_4	21	100	300
f_0	18	2	20

B. Design Steps of Ga-Mssmc

Design procedure are mentioned below

Step–1

Select the parameter:

Step–2

Select the range of control gains:

Population size = popsize = 10
No. of generation = maxgen = 10
Crossover probability = pcross = 0.8
Mutation probability = Pm = 0.01

Step–3 Define and evaluate the fitness function to measure the performance of system

Ffit = 1-50SiFi + w1/ (1+|u|) i=1, 2…4

Where, Si = sliding segment, Fi = derivative of Si
u = torque current command

For gain a1: Range [10 25]
= (a1max-a1min) *104 = (25-10) *104
= 150000
217<150000<218 - Length of a1 =18

Step–4 Reproduce population of chromosome generated according to their fitness.

Step–5 select a pair of chromosomes for mating from the current population. Parent chromosomes are selected with probability related to their fitness.

Step–6 create a pair of chromosome by applying the genetic operator, crossover and mutation.

Step–7 Repeat step-5 until the size of new chromosome equal to the size of initial population.

Step–8 replace the initial chromosome population with the new population.

Step–9 go to step-3, to evaluate the new population and repeat the process until the new generation becomes less than maximum generation.

IV. Design and Simulation

The rotor rotates by control object for 6π in 2 second and its following trapezoidal speed control profile with αd1 =43.1rad⁄s^2 , ω_d =10.78rad⁄s, αd2=-43.1rad⁄s^2 , t_1= 0.25s , t_2=1.75s and t_3=2s. The control gains α_i and β_i of the MSSMC are set as α_1=15, β_1=10, α_2=12, β_2= 10, α_3=15, β_3=10, α_4=300, β_4=200 & T_0=12. Meanwhile the method undercurrents in the $S_4=X_2+CX_1=0$ meet at a rate of e^(-ct) with the value of c=10 are becoming and have 0.4 such settling times.

V. Software Development and Result Discussion

To investigate the effectiveness of the proposed controller, three cases with parameter variations in load torque disturbances are considered. The following cases are tested in the simulation for convention MS-SMC and FLC based MS-SMC:

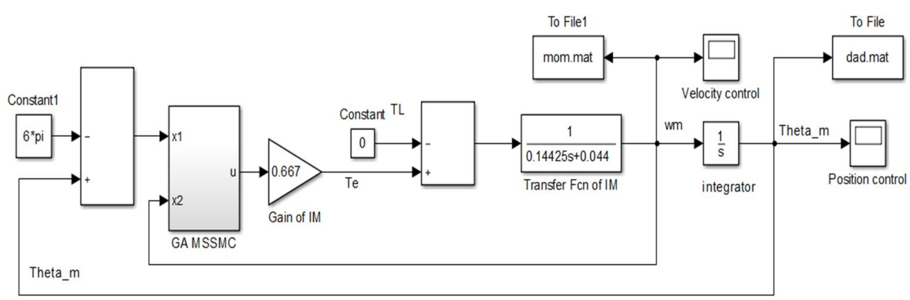

Fig. 1 Simulation model of GA based multi-segment sliding mode control

To examine the success of proposed controller, total different five cases are considered in load torque disturbances for parameter deviations. Here, parameters like Jm-Moment of Inertia, Bm-Damping coefficient and Tl-load torque are taken into consideration to test the results for different loading conditions for velocity and position control. In the simulation results of Velocity and Position Control, the disturbances or chattering are observed in trapezoidal speed control command mostly in run segment (second sliding) for different loading conditions and in different smart controller as mentioned above. Trapezoidal wave is divided in four slides and times are 0 to 0.25 Sec, 0.25 to 1.75 Sec and 1.75 Sec to 2 Sec... Mainly, chattering reduction and fast time response is the main purpose of the thesis and minimizes the humming problem, vibration problem and hence reduces the losses of IM.

Here, results are obtained for different cases for velocity control and position control using conventional MSSMC and GA based MSSMC strategies as mentioned below:

Simulation results are shown in fig. 4, 5, 8, 9, 12, 13 for velocity control and fig. 6, 7, 8, 9, 14, 15 for position control, respectively**.** As we can see in fig. 4, 5 time response is good and chattering effect is also minimum for Load torque is 0 and Jm, Bm is ideal. As we know with zero load torque, there is no effect on performance of IM with the ideal value of parameters of IM. Also in fig. 13, 14, 15, 16 for position control there is no change in response. Finally, from the result we can say that chattering reduction with GA-MSSMC is better for trapezoidal speed control technique for different loading conditions.

VI. Conclusion

Finally, we have studied that the incremental motion control of IM in various loading conditions. Our focus is to develop GA based MSSMC for IM and overcome the problems finding in conventional MSSMC technique like chattering in various loading condition. In this work, designing have been done the simulation of smart controller using GA in MSSMC with the help of MATLAB. After the simulation of GA based MSSMC for IM in MATLAB/SIMULINK, we have studied that GA based smart controller give the better result (reduced chattering) for MSSMC for IM in various loading conditions. But main drawback of FLC is seen that it took more execution time for given task compared to conventional MSSMC method for IM.

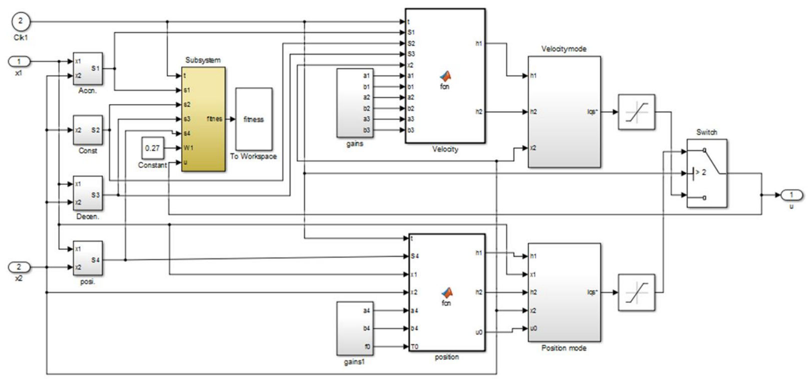

Fig. 2 Simulation model of MSSMC using GA

Case 1: $J_m = J_m B_m = B_m T_l = 0$ N for velocity (speed) control

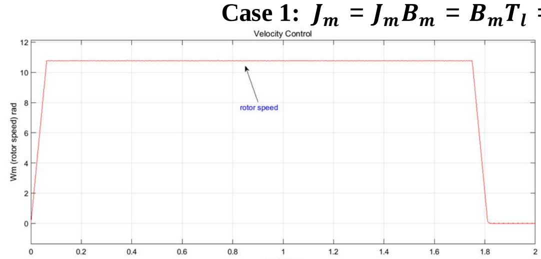

Fig. 3 Velocity Control with conventional MSSMC for case-1

Fig. 4 Velocity Control with GA based MSSMC for case-1

Case 1: $J_m = J_m B_m = B_m T_l = 0$ N for acceleration (position) control

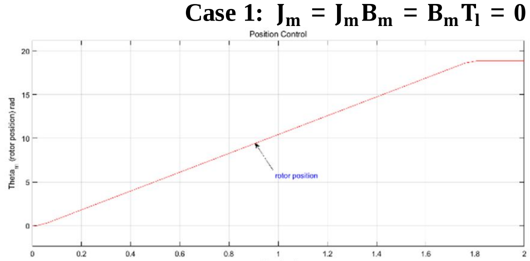

Fig. 5 Position Control with conventional MSSMC for case-1

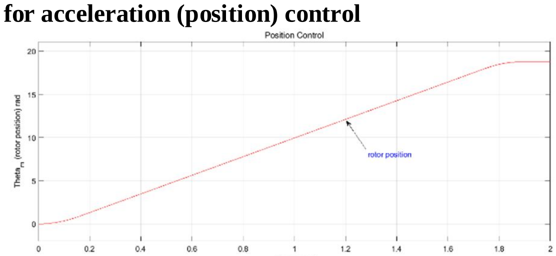

Fig. 6 Position Control with GA based MSSMC for case-2

Case 2: $J_m = J_m B_m = B_m T_l = 5$ Nm for Velocity (speed) control

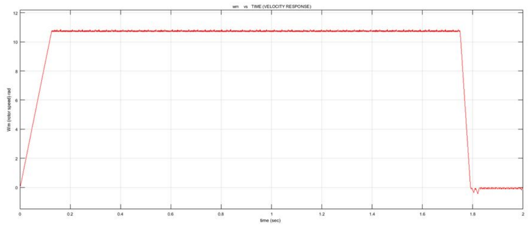

Fig. 7 Velocity Control with conventional MSSMC for case-2

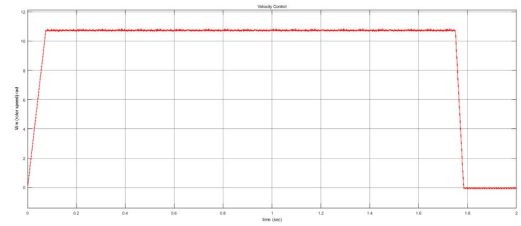

Fig. 8 Velocity Control with GA based MSSMC for case-2

Case 2: $J_m = J_m B_m = B_m T_l = 5$ Nm for acceleration (position) control

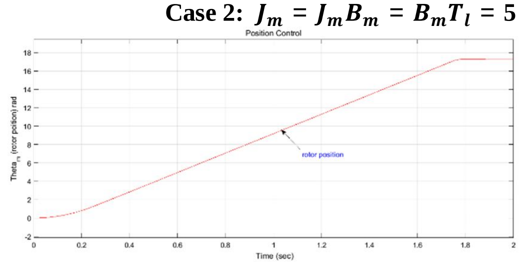

Fig. 9 Position Control with conventional MSSMC for case-2

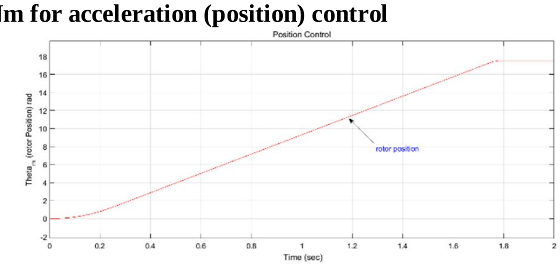

Fig. 10 Position Control with fuzzy based MSSMC for case-2

Case 3: $J_m = J_m B_m = B_m T_l = 7.5$ Nm for Velocity (speed) control

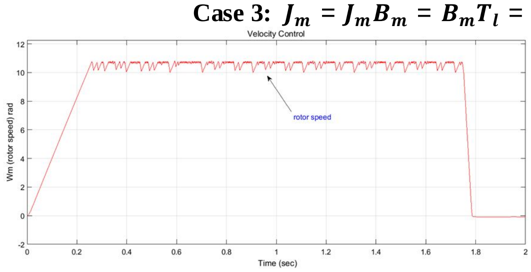

Fig. 11 Velocity Control with conventional MSSMC for case-3

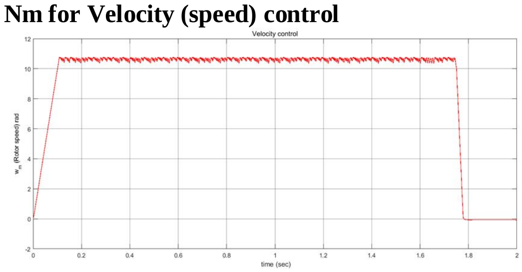

Fig. 12 Velocity Control with GA based MSSMC for case-3

Case 3: $J_m = J_m B_m = B_m T_l = 7.5$ Nm for acceleration (position) control

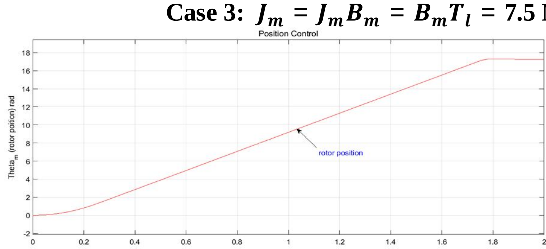

Fig. 13 Position Control with conventional MSSMC for case-3

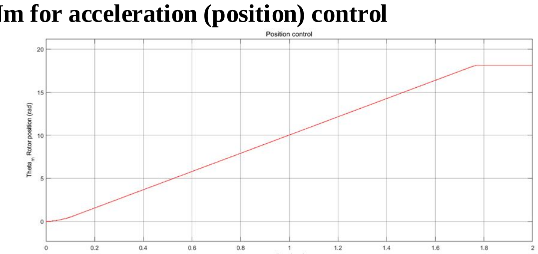

Fig. 14 Position Control with fuzzy based MSSMC for case-3

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