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ISSN: 0193 - 4120 Page No. 2692 - 2697

Fuzzy Logic Controller for Three level- NPC Inverter to Modified DTC SVM of Induction Motor

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Abstract:
Soft switching devices gained importance recently in Industries to have wavering speed supervision ofasynchronous machine(IM). Various speed regulation techniques such as constant flux supervisonl, scalar control and vector restraint have been proposed to regulate speed of asynchronous machine(Induction Motor). Recent advancements showsdominance supervision of flux and torque-SVM of asynchronous machine became fancy due to its simple structure in implementation, though two-level inverter suffers from disadvantages of flux and torque error. To eliminate above problem 3-Level NPC inverter with modified DTC-SVM is being implemented. In the proposed method sector identification for the space vector is eliminated, and becomes simpler in implementation. Design of PI controller becomes difficult where parameter variations are observed. To avoid this problem Rules based controller is used(i.e) FLC. The above approach is simulated in MATLAB/SIMULINK and results obtain9ed are satisfactory.

Keywords:*SVM,DTC-SVM,Fuzzy Logic Controller(FLC).*

I. INTRODUCTION

Induction machine is most suited motor for variable drives compared to synchronous machine owing to its constructional features of single excited system. However, induction machine model gives unsatisfactory operation in getting dynamic response due to parameter variations[1].

The recent developments in past twenty years led to the improvement in dynamic response faster with the help of switching devices, among them basic two modulation techniques namely SPWM and SVPWM were familiar, former being easy to implement and later requires particular switching sequence to obtain better speed control. The above two techniques requires high switching computational devices such as Microprocessors, DSP and FPGA to obtain gating signals.

To obtain swift response DTC emerges to be the best solution compared to field oriented control [2][3].FoCrequires rotor operating parameters and then computation of stator parameters which are sensitive to temperature and varies non-linear fashion [4]which depends on operating loads.Though DTC suffers from disadvantages of producing high torque and flux variations due to comparators[5] [6], thus making dynamic response poor at low speed. Hysteresis comparator s are used producing high ripples in currents of stator and rotor.

To overcome the above problem DTC SVM technique was proposed[7] and is easy when compared to FOC technique, but still it requires synthesizing the reference space vector which revolves in six sector. DTC SVM improves the dc bus bar utilization as such its fundamental voltage magnitude being greater than 15% compared to sine PWM Technique. Ripples of flux and torque can be reduced by increasing the level of inverters. The above technique is achieved by PI controller. Induction machine being nonlinear in nature tuning of PI is difficult. To subdue the raised problem rule drivencontroller(FLC) have been contemplated.

January - February 2020
ISSN: 0193 - 4120 Page No. 2692 - 2697

These fuzzy rules are best suited for producing less torque and flux ripples with three level inverter.

II. BASICS OF DTCSVM ALONG WITH NPC(3 LEVEL) INVERTER

Dominance supervision of flux and torque-SVMbeing discovered Takashi in 1985 by decoupling the flux and torque independently using Park's transformation and then retrieving the voltage space phasor with look up tables to control above mentioned parameter independently and the schematic is as exhibited in Fig.1.

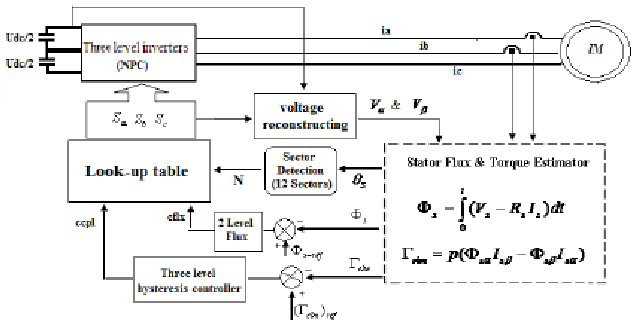

Fig1. NPC level-3 inverter using DTC-SVM

A. Direct torque control technique

From modeling of asynchronous machine stator flux obtained in innuendo frame(α-β)

$$\varphi_{s\alpha} =\cdot \int_{o}^{t} (V_{s\,\alpha} - i_{s\alpha} \quad r_s)dt \qquad (1)$$

$$\varphi_{s\beta} =\cdot \int_{o}^{t} (V_{s\,\beta} - i_{s\beta} \quad r_s)dt \qquad (2)$$

$$\varphi = \sqrt{(\varphi_{s\beta})^2 + \varphi_{s\alpha}{}^2} \qquad (3)$$

$$\theta_s = \tan^{-1}\left(\frac{\varphi_{s\beta}}{\varphi_{s\alpha}}\right) \qquad \mathbf{(4)}$$

Where $\varphi_{s\alpha}$ and $\varphi_{s\beta}$ are stator flux in reference frame(α-β)and the electromagnetic torque is given by

$$\tau = (\frac{P}{2})(\varphi_{s\alpha} i_{s\beta} - \varphi_{s\alpha} i_{s\beta}) \qquad (5)$$

B. Three Level Inverter of VSI

Three Level neutral point clamped inverter operates with minimum switches when compared to contemporary inverter and depicted in Fig 2.

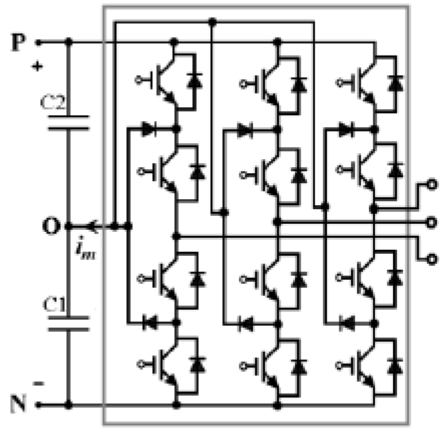

Fig 2. Neutral point Clamped 3 level inverter

The switches are made to operate in certain sequence to obtain the desired level of output voltages and is shown in the below table.1

Table.1 Switching Combinations

S_1	S_2	S_3	S_4	V_i	State
ON	**ON**	OFF	OFF	E/2	2
OFF	**ON**	**ON**	OFF	0	1
OFF	OFF	**ON**	**ON**	-E/2	0

III. DTC-SVM OF N LEVEL INVERTER

Togethighest achievable peak magnitude of the main significantphase voltage in definiteintonation, existing prevailing mode voltage, Xoffset1, is summed to the attributed phase voltages where the grandeur of Xoffset1 is given by,

X offset1= - (Xmax+Xmin)/2 (6)

Where,

Xmax = Highest grandeur of the three specimen reference phase voltages, in a specimen interval.

January - February 2020
ISSN: 0193 - 4120 Page No. 2692 - 2697

XVmin= Lowest grandeur of the three sampled specimenphase voltages, in a specimen interval.
i.e. Xmax = max (Van,Vbn,Vcn)
Xmin = min (Van,Vbn,Vcn)
The summation of the trivialapproach voltage, Xoffset1, ends up with effective electrical converter change vectors subsistence targeted by an exceedingly specimen interval, creating SPWM approach comparable to the SVPWM accession. Mathematical statement (6) relies on actualcertitude that, in an exceedingly specimen interval, the allusion section that possess lowest grandeur (termed the min phase) crosses the triangular carrier 1st and incitement the primary changeover within theelectrical converter change state. whereas the reference section, that possess themost grandeur (termed the max-phase), changeover the carrier last and inducement the last change transformation states swank an exceedingly 2 level SVPWM theme.

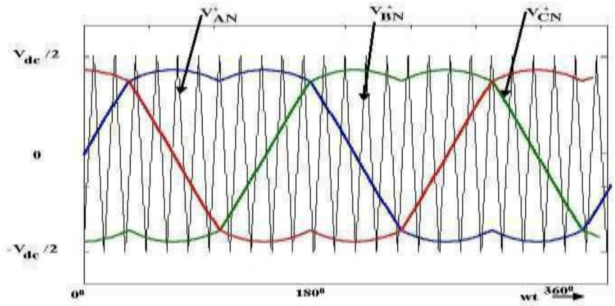

Fig.3 Sampled reference phase voltages

Steps tangled in the prospective Method

The following methodology has been developed and the steps involved are,

Step1: obtain the sampled amplitudes of VAN, VBN and VCN from present specimen interval

Step: 2 Evaluate the time proportionate of phase voltages, i.e. *Tas, Tbsand Tcs.*

Step: 3 Get Toffset1 using Tmax and Tmin, Tmax, Tmin are the maximum and minimum of *Tas,Tbs* and *Tcs*

Step: 4 Determine*Teffective.*
Step: 5 Determine *Ta cross, Tb cross and Tc cross.*

Step:6 Sort Ta cross,Tb cross and Tc cross to determine Tfirstcross,Tsecond cross and Tthird cross

i. *The maximum of Ta cross,Tb cross and Tc cross is Tthird cross.*

ii. *The minimum of Ta cross,Tb cross and Tc cross is Tfirstcross.and the remaining one is Tsecond cross.*

Step:7 Assign first_cross_phase, second_cross_phase and third_cross_ phase bestow to the phase which resolve Tfirstcross,Tsecond cross and Tthird cross.

Step: 8 Determine*Tga, Tgb and Tgc.*

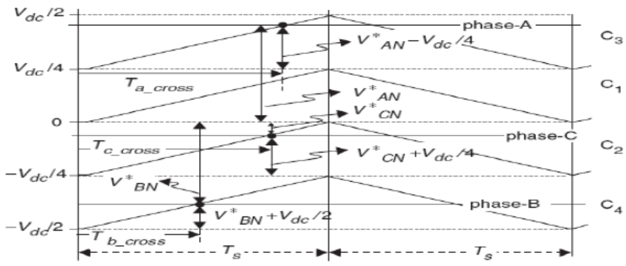

Fig 4.Ta_cross,Tb-cross and Tc_cross

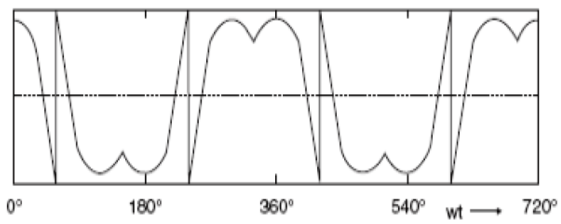

Fig 5. Traces of Ta_cross for modulation index 0.4

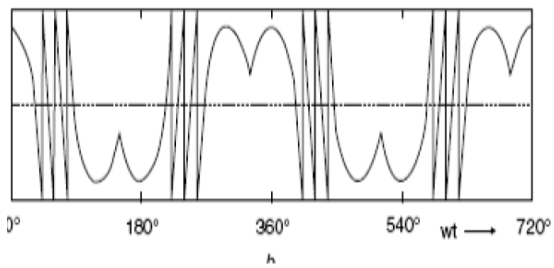

Fig.6 Traces of Ta_Cross for modulation index 0.8

January - February 2020
ISSN: 0193 - 4120 Page No. 2692 - 2697

The above technique produces the following advantages

1. Voltage or current harmonic distortion is low
2. Effective bus bar utilization
3. Can be extended to over modulation range
4. The three phase quantities are treated as single

IV. PROPOSED DTC-SVM OF 3 LEVEL INVERTER USING FUZZY LOGIC CONTROLLER

In the past research Lotfi A Zadeh, described the fuzzy controllers, and extensively used , as such it has vital role in artificial Intelligence control. Existing PI controllers are very sensitive to motor parameters. In a non linear control system like Induction motor controlling the operation of speed of motor can be easily done. The inputs require any parameter where there is error and change in error fuzzy logic has a provision of implementing, in the present scenario two input variable are chosen(i.e) flux and torque out of which torque error is elaborated and in the same way flux error which is not shown here . Once the variables are chosen rules are framed to get the gating signals which produce desired output below tables are used for torque and flux error.

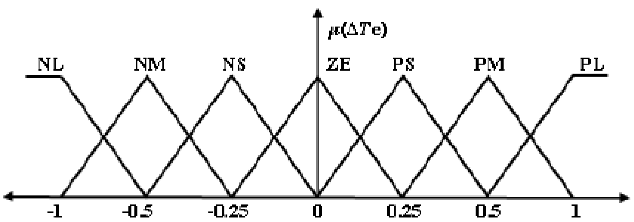

Fig.7 Torque error membership function

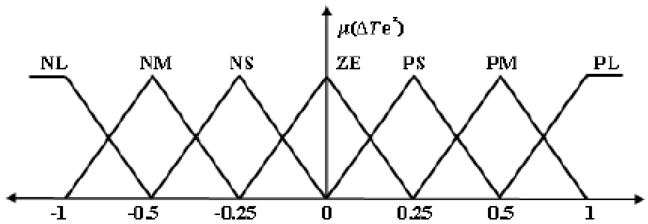

Fig.8 Represents the change in error and its membership function

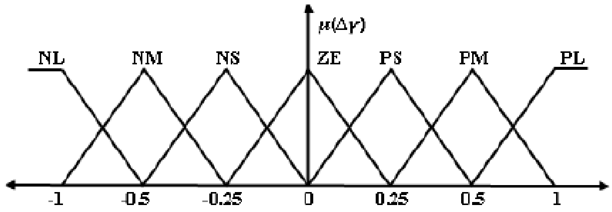

Fig.9 Output variable of above to input parameters

The above input parameters have seven linguistic variable such as Nl(Negative low) , PL(Positive large),….e.t.c

Table 2. Rule base fuzzy controller of torque membership function

ΔTe \ ΔTe^*	NL	NM	NS	ZE	PS	PM	PL
NL	NL	NL	NL	NL	NM	NS	ZE
NM	NL	NL	NL	NM	NS	ZE	PS
PM	NL	NL	NM	NS	ZE	PS	PM
ZE	NL	NM	NS	ZE	PS	PM	PL
PS	NM	NS	ZE	PS	PM	PL	PL
PM	NS	ZE	PS	PM	PL	PL	PL
PL	ZE	PS	PM	PL	PL	PL	PL

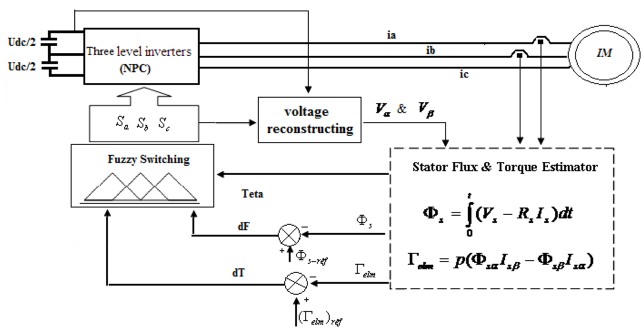

Fig.10 Fuzzy Controller for DTC-SVM of 3 level Inverter

V. RESULTS AND CONCLUSION

Simulation results are performed for the below rated machineshown in table 3.

Table 3.Motor Parameters

Rated Power	1.5Kw
Rated Voltage, Frequency	440V.50Hz
Rs,Rr(ohm)	3.03,2.56
Ls ,Lr(mh)	35,35
P(Poles)	2
J(Kg-m^2)	0.0048

January - February 2020
ISSN: 0193 - 4120 Page No. 2692 - 2697

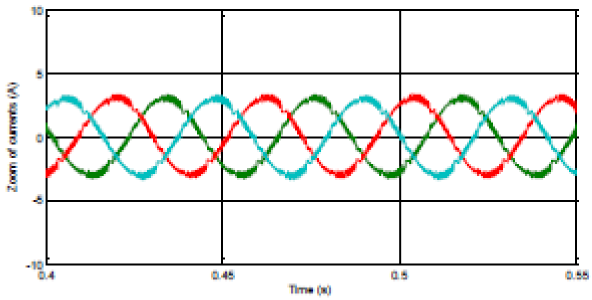

Fig.11. Stator current of Conventional DTC-SVM

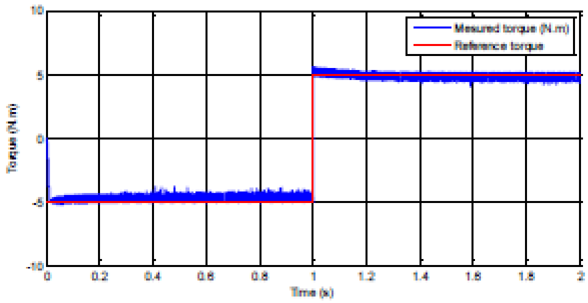

Fig.12. Speed of Conventional DTC-SVM

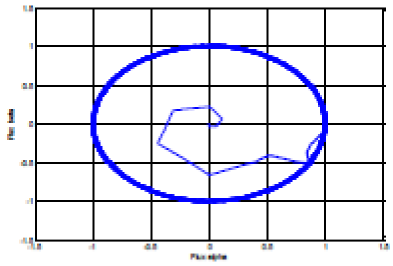

Fig.13. Stator flux path of Conventional DTC-SVM

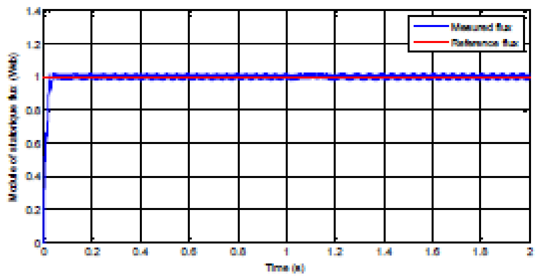

Fig 14.Electromagnetic torque .of Conventional DTCSVM

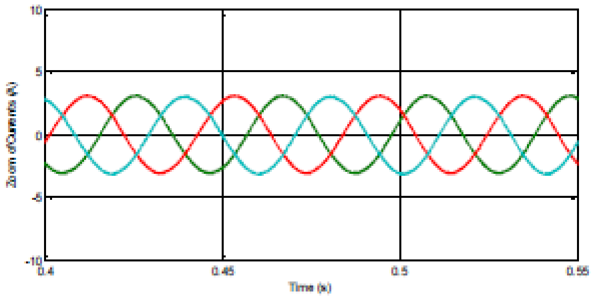

Fig.15. Stator current of Proposed Fuzzy DTCSVM

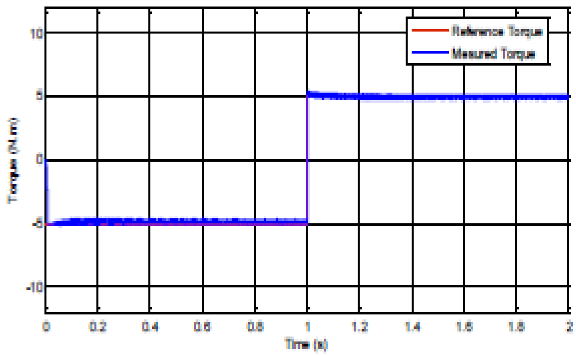

Fig.16. Speed ofProposed Fuzzy l DTCSVM

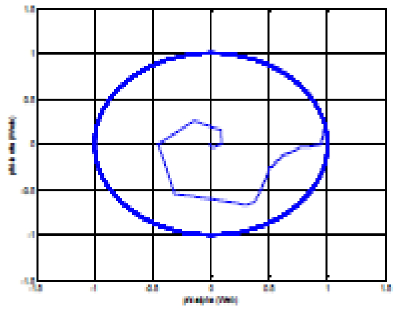

Fig.17. Stator flux path ofProposed Fuzzy DTC SVM

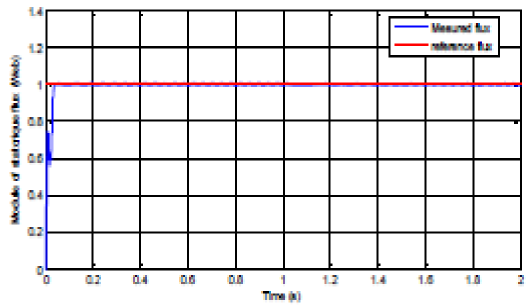

Fig.18. Electromagnetic torque of proposed Fuzzy DTCSVM

From the above graphs it is concluded that the dynamic response of the proposed Fuzzy DTC-SVM is far better than that of conventional DTC SVM

January - February 2020
ISSN: 0193 - 4120 Page No. 2692 - 2697

VI. REFERENCES

1. R-T Bui, “Nonlinear Predictive Control with Disturbance Observer for Induction Motor Drive,” IEEE International Symposium on Industrial Electronics, vol. 1in the year 2006
2.
3. Takahashi, T. Noguchi, “A new quick-response and high-efficiency control-strategy of an induction motor”, IEEE Transactions on Industry Applications, Vol. IA 22, No. 5, pp. 820-827 in the year, 1986.
4.
5. C.S Babu “Multilevel Inverter with less no.of switches adopting advance modulation strategies”,ICPEC in the year 2013
6. [11] D.Casadei, G.Serra, and A.Tani “improvement of direct torque control performance by using a discrete SVM technique”, 29th Annual IEEE Power Electronics Specialists Conference PESC 98, 1998, pp. 997-1003, Vol.2, 1998.
7. M.Gopnath, “ A new SVPWM for NPC multilev inverter” ICGCCEE in the year 2014.
8. Jerome Jovithe”An result oriented investigation on Multi Inverter of solar power usage” Energy systems in the year 2013
9. M.Z.Rifqi, A.Jidan, M.N.Oyhman, R.N.P.Nagarajan, M.H.Jopri's "minimization of 3-L CHMI torque in DTC," 7 IEEE Power Engineering and Optimization Conference (PEOCO), presented in the year 2013
10. V.Madhusudhan “ Comparison of single -phase dc link inverter with PWM approach “SEISCON in the year 2011
11. P .Latha “Effective Torque ripple reduction for Permanent synchronousmachine ant colony technique” International Journal of Fuzzy system in the year 2015