DYNAMIC SIMULATION OF INDUCTION MOTOR IN STATOR REFERENCE FRAME

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ABSTRACT

In this paper is presented comprehensive study and Torque supervise of asynchronous machine build DTC procedure has been developed. Moreover emphasized in the thesis that the method of DTC supervise as well as certify the decoupled supervise of machine torque and machine stator flux. Various speed control scheme like scalar control, rotor resistance control, rotor energy recovery, and variable frequency control scalar frequency control and vector controller are discussed. To directly control the torque of asynchronous machine a suitable an analytical prototype has used. Matlab code has been developed for DTC of asynchronous machine applying SVM. The responds of speed, stator flux linkages, normalised torque, speed and d-q stator currents have been compared .The Matlab code has been developed for obtaining the effective responds of the asynchronous machine along PI Flux controller for speed regulation of asynchronous machine drive with regard to the similar asynchronous machine drive. To achieve a satisfactory respond is tune the PI controller applying a hit and trial approach. The resources developed in the course of current investigation could be easily used for further research work namely to evolve: PI Torque controller, coordinated speed torque controller etc.

Keyword **-** *Induction Motor, Voltage Source converter, Matlab Code, SVM, PI controller etc.*

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1. INTRODUCTION:

DTC is superior admirable supervise setup of torque supervise in asynchronous machine. It is treated as an alternate of the field oriented control (FOC) or vector supervise approach. Both supervise procedure are variant on basis of performance on the other hand intention are similar. Their purpose is to control adequately the torque and flux. Torque supervise of an asynchronous motor build direct torque control design has established and overall academic work granted in the exploration.

2. DIRECT TORQUE CONTROL IN STATOR REFERENCE FRAMES USING SPACE VECTOR MODULATION:-

Feedback control of torque and stator flux is being used by the direct torque control scheme that is figure out taken away the calculated stator voltage and currents. A stator mentioning configuration of the induction motor is used by the scheme. Stator coil flux-linkages control is used by scheme.

The quadrature and direct axes stationary coil flux linkages are

$$\lambda_{qs} = \int \left(V_{qs} - R_s i_{qs}\right) dt \qquad (2.1)$$

$$\lambda_{ds} = \int (V_{ds} - R_s i_{ds}) dt \qquad (2.2)$$

Here d & q axis elements are accomplish out of the abc inconstant through adopting the conversion

$$i_{qs} = i_{as} \qquad (2.3)$$

$$i_{ds} = \frac{i_{cs} - i_{bs}}{\sqrt{3}} \qquad (2.4)$$

2.1 Voltage Source Inverter Fed Induction Motor Drives:-

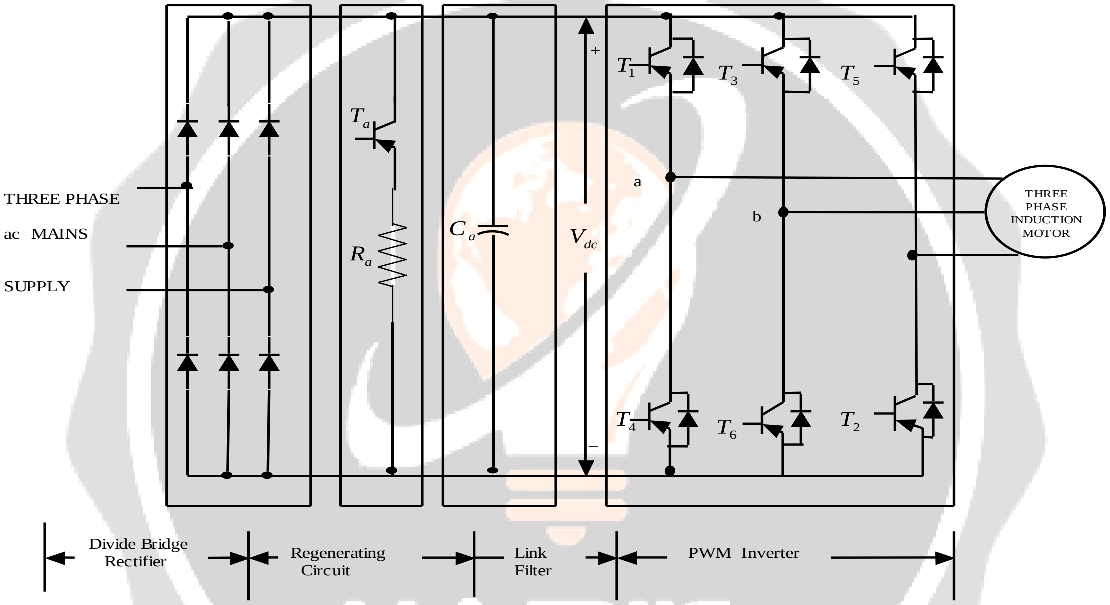

Fig- 2.1: Power-circuit configuration of the induction motor drive

2.2 Switching states of the Inverter:-

A set of switches is determining the terminal voltageV_a, S_a containing of T_1 and T_4 demonstrated in the table 2.2. V_a is undefined When the switching devices T_1 and T_4 and their antiparallel diodes are off. For line b and c also derive the switching of S_b and S_c sets. Possible switch stages along S_a, S_b, and S_c is total number of eight interpret in Table 2.2 using the following relationships:

Table -2.2: Switching states of inverter for phase a

T_1	T_4	S_a	V_a
on	off	1	V_{dc}
off	on	0	0

Table-2.3: Inverter switching states and machine voltages

States	s_a	s_b	s_c	V_a	V_b	V_c	V_{ab}	V_{bc}	V_{ca}	V_{as}	V_{bs}	V_{cs}	V_{qs}	V_{ds}
I	1	0	0	V_{dc}	0	0	V_{dc}	0	$-V_{dc}$	$\frac{2}{3}V_{dc}$	$-\frac{1}{3}V_{dc}$	$-\frac{1}{3}V_{dc}$	$\frac{2}{3}V_{dc}$	0
II	1	0	1	V_{dc}	0	V_{dc}	V_{dc}	$-V_{dc}$	0	$\frac{1}{3}V_{dc}$	$-\frac{2}{3}V_{dc}$	$\frac{1}{3}V_{dc}$	$\frac{1}{3}V_{dc}$	$\frac{V_{dc}}{\sqrt{3}}$
III	0	0	1	0	0	V_{dc}	0	$-V_{dc}$	V_{dc}	$-\frac{1}{3}V_{dc}$	$-\frac{1}{3}V_{dc}$	$\frac{2}{3}V_{dc}$	$-\frac{1}{3}V_{dc}$	$\frac{V_{dc}}{\sqrt{3}}$
IV	0	1	1	0	V_{dc}	V_{dc}	$-V_{dc}$	0	V_{dc}	$-\frac{2}{3}V_{dc}$	$\frac{1}{3}V_{dc}$	$\frac{1}{3}V_{dc}$	$-\frac{2}{3}V_{dc}$	0
V	0	1	0	0	V_{dc}	0	$-V_{dc}$	V_{dc}	0	$-\frac{1}{3}V_{dc}$	$\frac{2}{3}V_{dc}$	$-\frac{1}{3}V_{dc}$	$-\frac{1}{3}V_{dc}$	$-\frac{V_{dc}}{\sqrt{3}}$
VI	1	1	0	V_{dc}	V_{dc}	0	0	V_{dc}	$-V_{dc}$	$\frac{1}{3}V_{dc}$	$\frac{1}{3}V_{dc}$	$-\frac{2}{3}V_{dc}$	$\frac{1}{3}V_{dc}$	$-\frac{V_{dc}}{\sqrt{3}}$
VII	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VIII	1	1	1	V_{dc}	V_{dc}	V_{dc}	0	0	0	0	0	0	0	0

And machine phase voltages for a balanced system are :-

$$V_{as} = \frac{(V_{ab} - V_{ca})}{3} \qquad (2.5)$$

$$V_{bs} = \frac{(V_{bc} - V_{ab})}{3} \qquad (2.6)$$

$$V_{cs} = \frac{(V_{ca} - V_{bc})}{3} \qquad (2.7)$$

And the stator coil quadrature axis & direct axis voltages for individual phase are:-

$$V_{qs} = V_{as} \qquad (2.8)$$

$$V_{ds} = \frac{1}{\sqrt{3}}(V_{cs} - V_{bs}) = \frac{1}{\sqrt{3}}V_{cb} \qquad (2.9)$$

The stator quadrature axis and direct axis voltages for individual stage demonstrated in fig 2.3

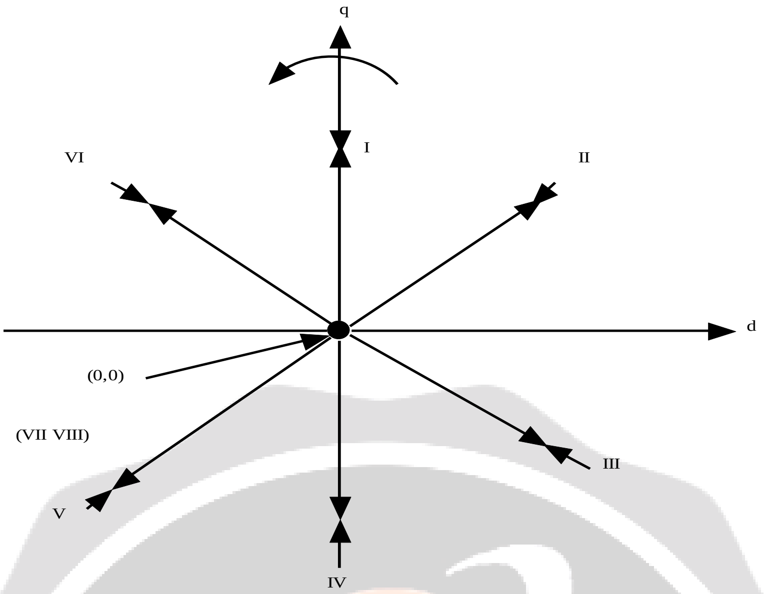

Fig- 2.3: The inverter output voltage corresponding to switching state

2.3 Flux control:

An identical revolving stator coil flux is useful, utilizes one of the sectors whenever. Magnitude of stator coil-flux phasor is λ_S and a momentary location is θ_{fs}. Correlative d and q axes elements are λ_{ds} and λ_{qs} subsequently. Let's assume that a feedback of stator flux is obtainable, allocate in the sector is determined from its position. Giving a 90^{o} phase shift determine the effective voltage phasor. One of them increases λ_s, the other decreases λ_s.

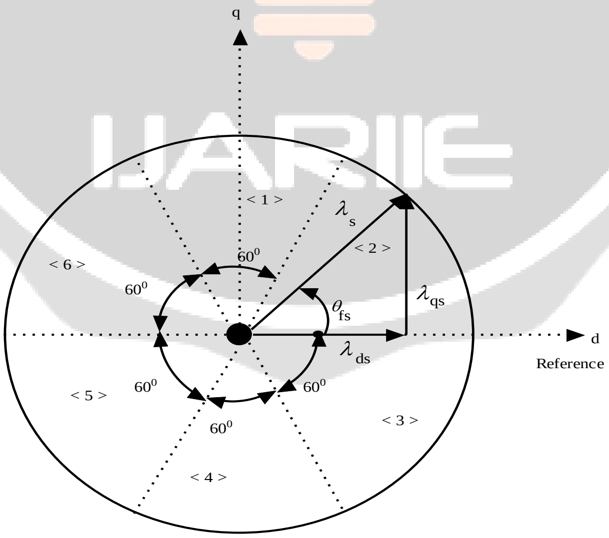

Fig-2.4: Division of sextant for stator flux-linkages identification

2.4 Torque control:

Differentiation of the require force to the force evaluated taken away the stator coil flux linkages and stator coil currents apply torque control like:-

$$T_e = \frac{3}{2}\frac{P}{2}\left(\lambda_{ds} i_{qs} - \lambda_{qs} i_{ds}\right)$$

Through a window comparator refine the error torque to proceeding automated product, S_T, in such a way as specified in the table2.4.

Table -2.4: Generation of S_T.

Condition	S_T
$\left(T_e^* - T_e^\wedge\right) > \delta T_e$	1
$-\delta T_e < \left(T_e^* - T_e^\wedge\right) < -\delta T_e$	0
$\left(T_e^* - T_e^\wedge\right) < -\delta T_e$	-1

δT_e is the Torque window passable above the demanded torque. Whereas the blunder rises above δT_e, it is time to raise the torque, indicating it by a +1 gesture. If the torque blunder is positive and negative torque window, then the voltage phasor might be at zero state. If the torque blunder is lesser δT_e, it measure to require for regeneration, symbolized through –1 rationality gesture. Explanations of S_T is in this way: when it is 1 amount to rising the voltage phasor, 0 express to put it at zero, - 1 desires decelerate the voltage phasor back of the flux phasor to produce reclamation. To achieve the switch states of the inverter, synthesizing the flux blunder product, the torque blunder product S_T, and the sector of the phasor S_θ, and it is accustomed in table 4.4

Table -2.5: Switching states for possible S_λ, S_T, and S_θ

		S_θ					
S_λ	S_T	<1>	<2>	<3>	<4>	<5>	<6>
1	1	VI (1,1,0)	I (1,0,0)	II (1,0,1)	III (0,0,1)	IV (0,1,1)	V (0,1,0)
1	0	VIII (1,1,1)	VII (0,0,0)	VIII (1,1,1)	VII (0,0,0)	VIII (1,1,1)	VII (0,0,0)
1	-1	II (1,0,1)	III (0,0,1)	IV (0,1,1)	V (0,1,0)	IV (1,1,0)	I (1,0,0)
0	1	V (0,1,0)	VI (1,1,0)	I (1,0,0)	II (1,0,1)	III (0,0,1)	IV (0,1,1)
0	0	VII (0,0,0)	VIII (1,1,1)	VII (0,0,0)	VIII (1,1,1)	VII (0,0,0)	VIII (1,1,1)
0	-1	III (0,0,1)	IV (0,1,1)	V (0,1,0)	VI (1,1,0)	I (1,0,0)	II (1,0,1)

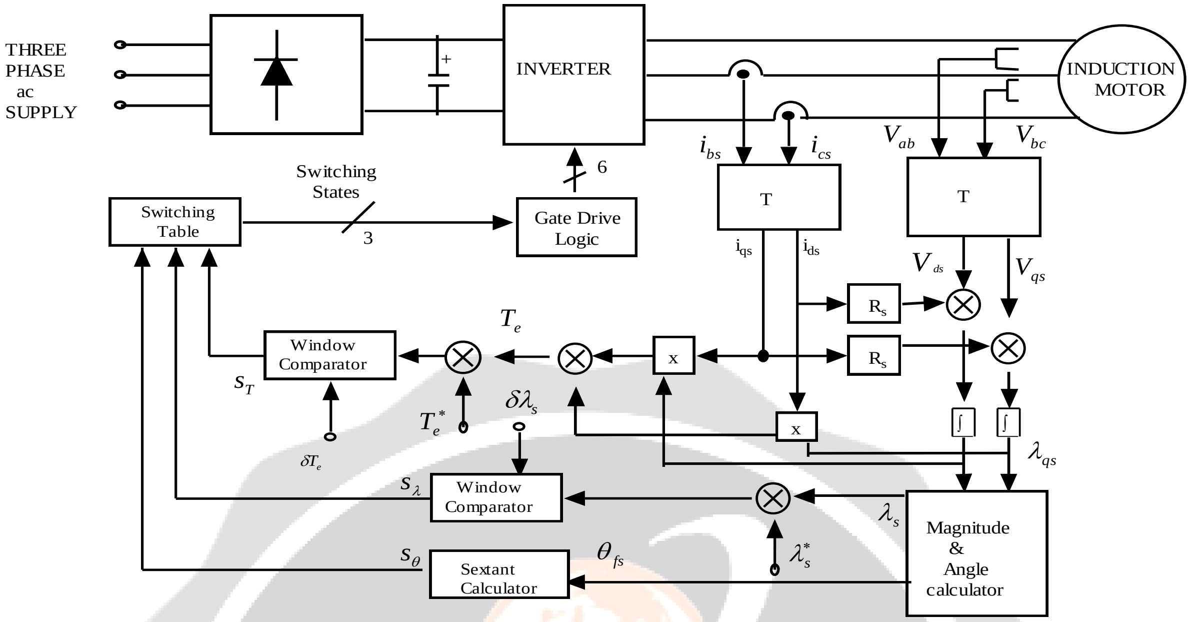

Fig- 2.5: Block diagram schematic of the direct torque (self) induction motor drive

3. SIMULATIONS AND RESULTS:

SIMUALTION FOR DIRECT TORQUE CONTROL SCHEME

For the schemeR_r, L_s, L_r, L_m, J, P,T_{load} bring into play with view to initialisation,. This approach calls regeneration supervise of torques and stationary flux, which are estimated out of the evaluated stator voltage and currents. The scheme uses stator flux-linkages control. The scheme build stator resistance and on no other constant. To control their flux and torque, in this method requires the location of the flux phasor. The torque, flux and velocity blunders are determined in the beginning that forces to the most favorable pulse selection for VSI switch, the three phase voltage values, obtained at the output of the VSI, are used for the calculation of I_{ds},I_{qs}, λ_{ds}, λ_{qs}after abc to dq0 transformation.. Then calculation of electromagnetic torque, actual speed, stator, flux, estimated torque and estimated speed follows on the basis of which the torque, flux and speed errors are generated. It is proposed to evolve a suitable speed controller for a typical induction motor in the present investigations. The following curves indicate the motor response obtained with the help of MATLAB code developed.

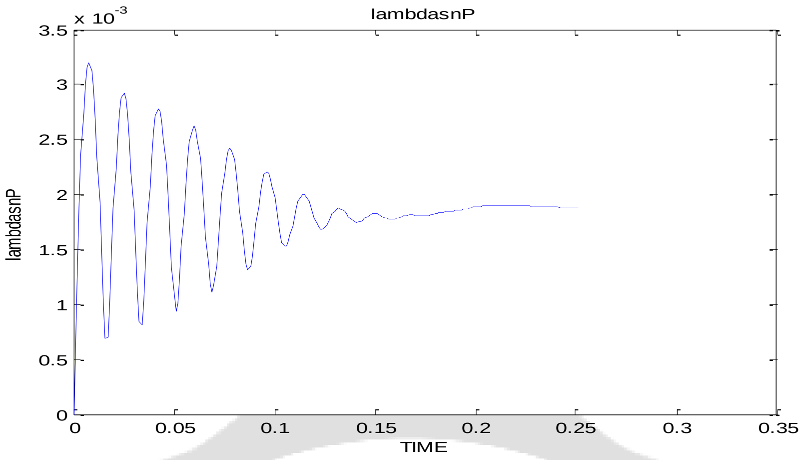

Fig- 3.1: Graph between stator flux linkages and time.

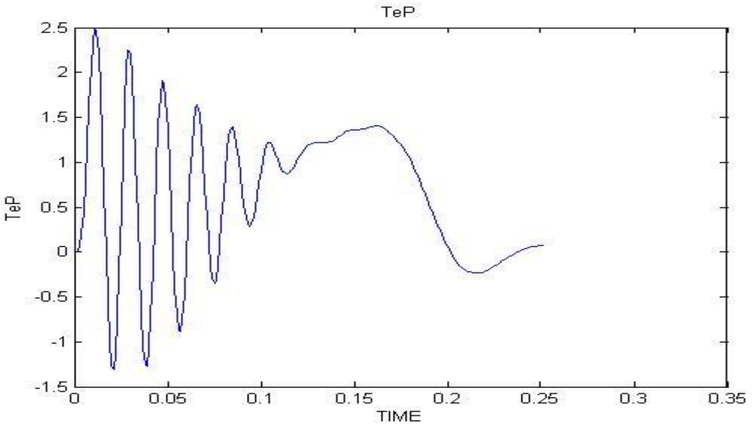

Fig- 3.2: Graph between normalised torque and time

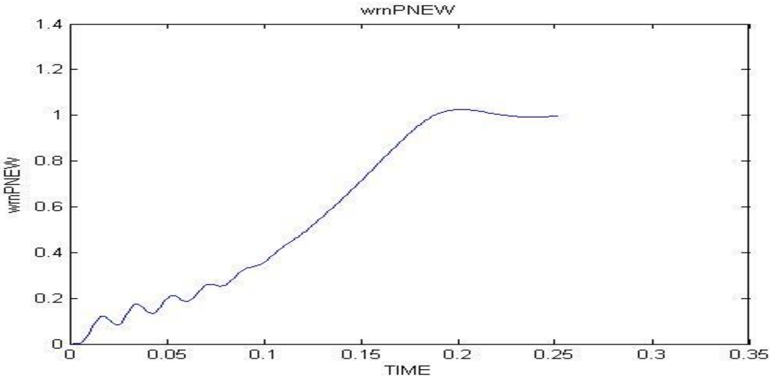

Fig-3.3: Graph between speed and time

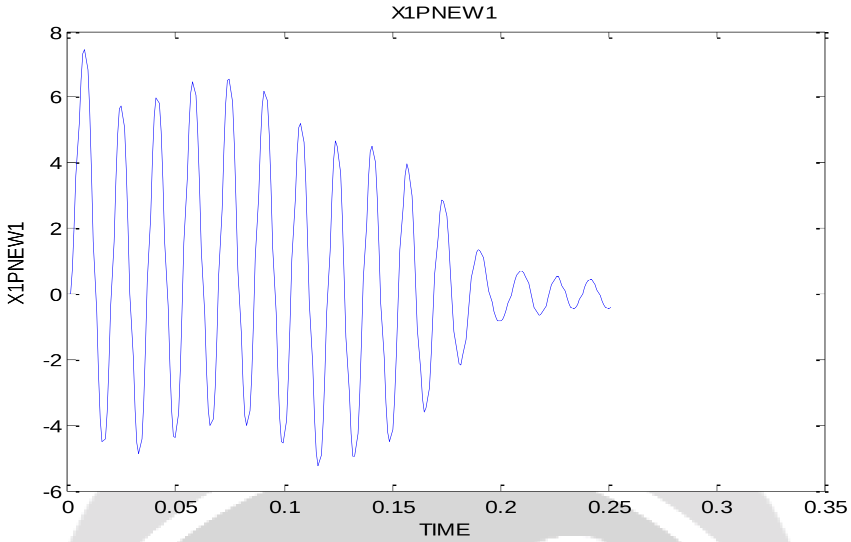

Fig-3.4: Graph between q-axis stator current and time.

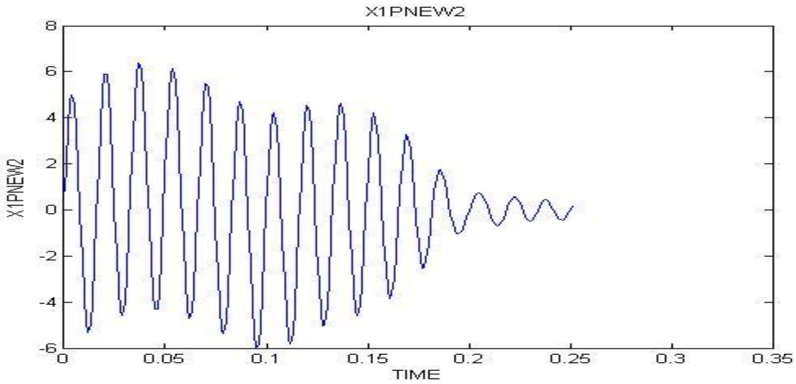

Fig-3.5: Graph between d-axis stator current and time.

The respond curves indicated above exactly match with those given in the reference [9].

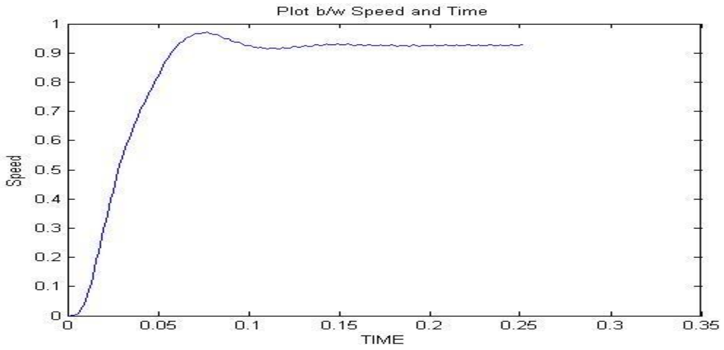

Fig- 3.6(a): Graph between speed and time when $K_{PL} = 0.020, K_{iL} = 0.06, T = 0.01$

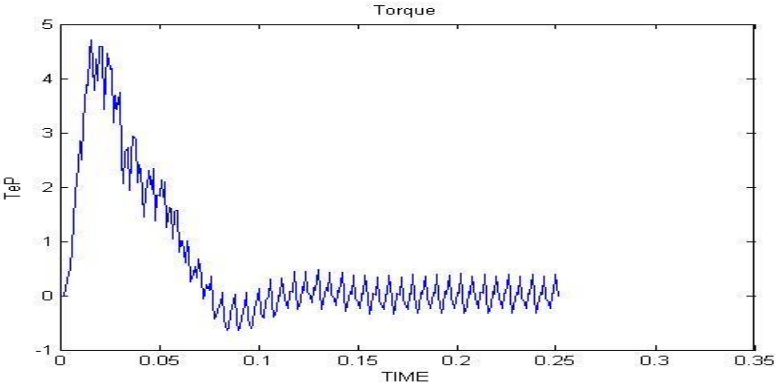

Fig- 3.6 (b): Graph between Torque and time when $K_{pL} = 0.020, K_{iL} = 0.06, T = 0.01$

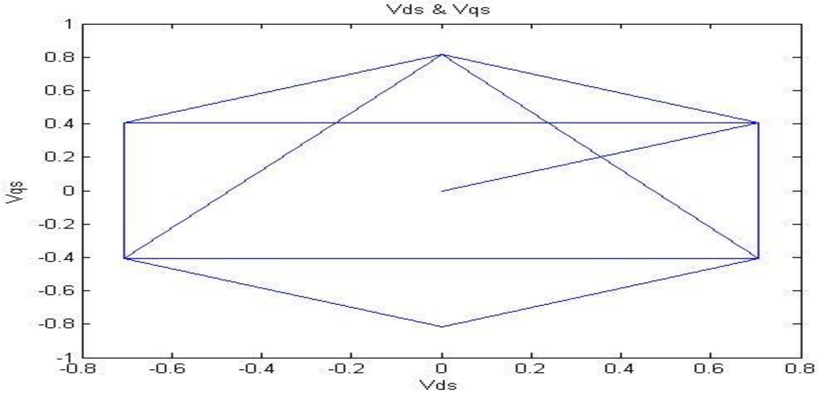

Fig- 3.6(c): Graph between d and q axis stator voltages when $K_{pL} = 0.020, K_{iL} = 0.06, T = 0.01$.

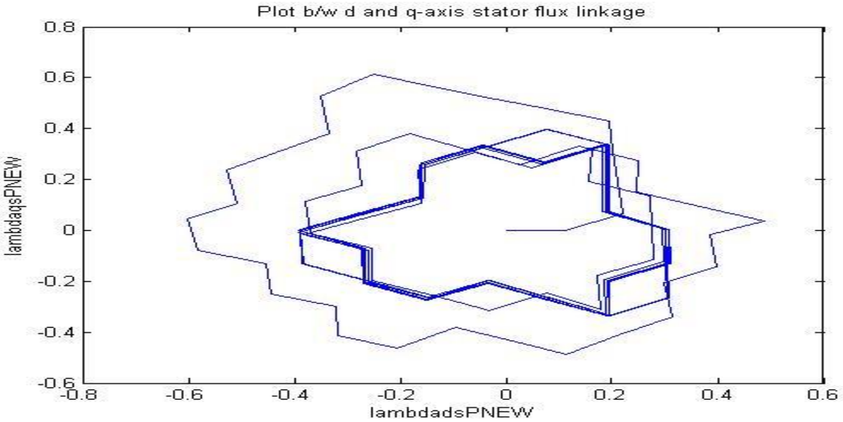

Fig- 3.6(d): Graph between d and q axis stator flux when $K_{pL} = 0.020, K_{iL} = 0.06, T = 0.01$

The response curves indicate that the gain setting corresponding to combination $K_pL=0.020$, $K_iL=0.06$, $T=0.01$is best for speed control of induction motor drive considered for investigation.

4. CONCLUSION:-

1. With regard to DTC of asynchronous machine drive bring into play an applicable mathematical model has been bring into play with regard to DTC of asynchronous machine drive taken away the resources [9]. The torque, velocity and velocity blunders are estimated in the beginning that advances to the advantageous pulse selection with regard to voltage source inverter switch. To determine the inverter switching state Space vector modulation is use.
2. With regard to direct torque control of asynchronous machine applying SVM a MATLAB code has developed. The acknowledgement of stator flux linkages, normalized torque, speed and direct axis –quadrature axis stator coil currents have compare to the particular described in [9]. The respond accomplished in the current inspection are coordinating with the respond like accustomed in [9].
3. For obtaining the effective respond of the asynchronous machine the MATLAB code has develop along a PI flux controller in spite of speed governing of the asynchronous machine drive for the similar asynchronous machine drive like in (1) beyond. To accomplish a satisfactory respond is tune the PI controller applying a hit and trial approach.

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