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DYNAMIC CHARACTERISTICS OF LOADS

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ABSTRACT

The objective of this project is to analyze the dynamic characteristics of loads as well as the modelling approach using d-q analysis of induction motor. This addresses the impact of load modeling in particular induction motor. D-Q axis modeling which is universally acceptable to determine such analysis may be adopted using stator reference frame/rotor reference frame/synchronously rotating reference frame. In this project, a modular implementation of an induction machine model is described in a step-by-step approach.

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I. Introduction

When an electrical machine is simulated in circuit simulators, its steady state model is used, but for electrical drive studies, the transient behavior is also important. One advantage of Simulink over circuit simulators is the ease in modelling the transients of electrical machines and drives and to include drive controls in the simulation.

Simulink models can be made to run faster using "accelerator" functions or producing stand-alone Simulink models Both of these require additional expense and can be avoided if the simulation speed is not that critical. Each block solves one of the model equations, are accessible for control and verification purposes.

II. INDUCTION MACHINE

Among all types of ac machines, the induction machine, particularly the cage type, is most commonly used in industry. Three-phase sinusoidal currents are impressed in the three-phase stator winding, which are given as:

$i_a = I_m \cos w_e t$ …… (2.1)

$i_b = I_m \cos(w_e t - 2\pi/3)$ …… (2.2)

$i_c = I_m \cos(w_e t + 2\pi/3)$ ……..(2.3)

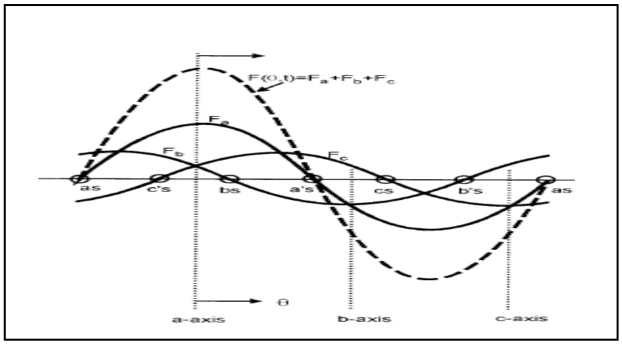

Figure 1: MMF distribution in three phase

III. SIMULINK IMPLEMENTATION

The fig. shows the simple simulation block diagram for a three phase, two levels PWM inverter.

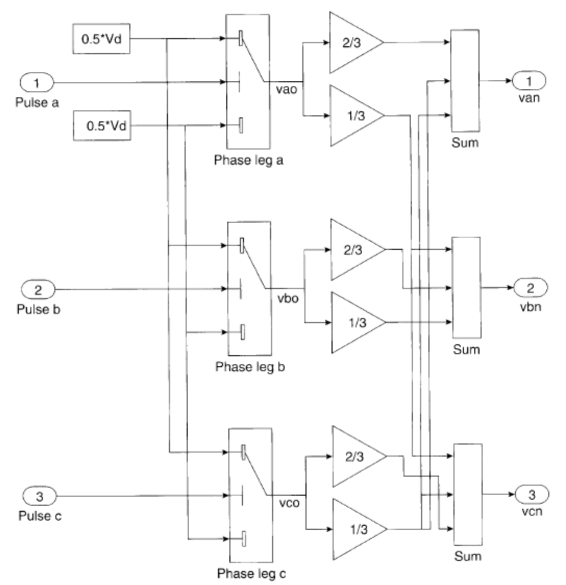

Figure 2: Simulation of three phase voltage fed inverter.

$V_{qs}{}^{s}$=2/3v_{an}-1/3v_{bn}-1/3v_{cn} ……(3.1)

$V_{ds}{}^{s}$=-1/√3 v_{bn}+1/√3 v_{cn} ……(3.2)

V_{qs}= $V_{qs}{}^{s}$cos w_{e}t - $V_{ds}{}^{s}$sin w_{e}t ….. (3.3)

V_{ds}= $V_{qs}{}^{s}$sin w_{e}t - $V_{ds}{}^{s}$sin w_{e}t …. (3.4)

IV. Simulation Dynamic d-q model

A 3-phase machine can be represented by an equivalent 2-phase machine,as d^{s}- q^{s} and d^{r}-q^{r} stator and rotor winding of motor

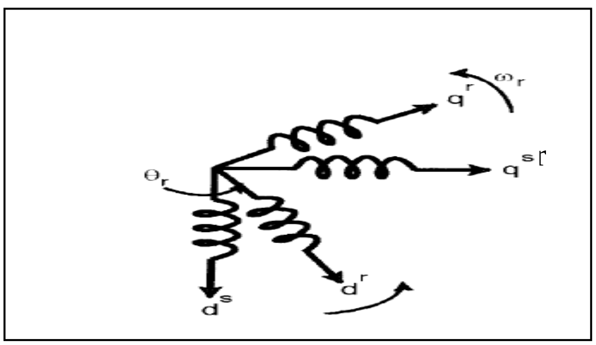

Figure 3 Equivalent two phase machine

Figure 3: Equivalent two phase machine

V. Axes Transformation

The voltage v_{ds}^{s} and v_{qs}^{s}can be resolved in to as-bs-cs components and can be representd in the matrix form as

$$\begin{bmatrix} Vas \\ Vbs \\ Vcs \end{bmatrix} = \begin{bmatrix} \cos\theta & \sin\theta & 1 \\ \cos(\theta - 120°) & \sin(\theta - 120°) & 1 \\ \cos\ (\theta + 120°) & \sin(\theta + 120°) & 1 \end{bmatrix} = \begin{bmatrix} Vqs \\ Vds \\ Vos \end{bmatrix}$$

$v_{qs}^{e} = v_{qs}^{s}\cos\theta e - v_{ds}^{s}\sin\theta e$ ……….. (3.5)

$v_{ds}^{e} = v_{qs}^{s}\sin\theta e + v_{ds}^{s}\cos\theta e$ …………. (3.6)

$v_{qs}^{s} = v_{qs}^{e}\cos\theta e + v_{ds}^{e}\sin\theta e$ …………(3.7)

$v_{ds}^{s} = - v_{qs}^{e}\cos\theta e + v_{ds}^{e}\sin\theta e$ ………... (3.8)

VI. Synchronously rotating reference frame

$|V_{qs}^{s} = R_s i_{qs}^{s} + d/dt(\varphi_{qs}^{s})$ ……………(3.9)

$V_{ds}^{s} = R_s i_{ds}^{s} + d/dt(\varphi_{ds}^{s})$ …………...(3.10)

$V_{qs} = R_s i_{qs} + d/dt(\varphi_{qs}) + w_e\varphi_d$ ………….. (3.11)

$V_{ds}=R_s i_{ds}+d/dt(\varphi_{ds}^{s})+w_e\varphi_{qs}$ ………… (3.12)

Since the rotor actually moves at speed w_r, the d-q axes fixed on the rotor move at a speed w_e- w_r relative to the synchronously rotating frame.:

$V_{qr} = R_r i_{qr} + d/dt(\varphi_{qr}) + (w_e - w_r)\varphi_{dr}$ … (3.13)

$V_{dr} = R_r i_{dr} + d/dt(\varphi_{dr}) – (w_e - w_r)\varphi_{qr}$ …… (3.14)

Torque is defined as:

$T_e = \frac{3}{2}(P/2)\varphi_m \times I_r$ .... (3.15)

VII. Stationary frame – Dynamic Model

The dynamic model in stationary frame can be derived simply by substituting $w_e = 0$.

$V_{qs}^{s} = R_s i_{qs}^{s} + d/dt(\varphi_{qs}^{s})$ ....(3.16)

$V_{ds}^{s} = R_s i_{ds}^{s} + d/dt(\varphi_{ds}^{s})$ .... (3.17)

Finally, the torque equation is expressed as

$T_e = \frac{3}{2} wb(P/2)(Fdsiqs - Fqsids)$ ....(3.18)

VII. SIMULATION RESULT

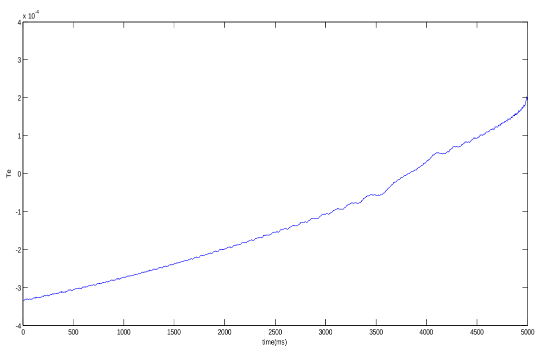

Figure 4: Torque

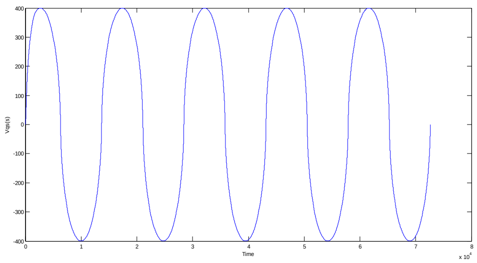

Figure 5: Vqs

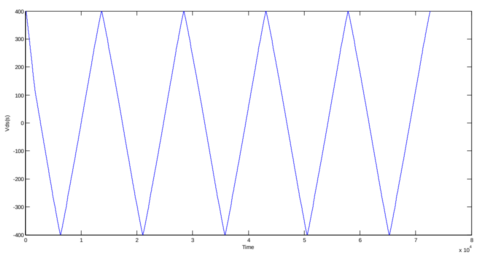

Figure6: Vds

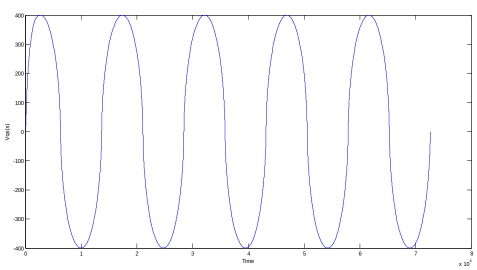

Figure 7: Van

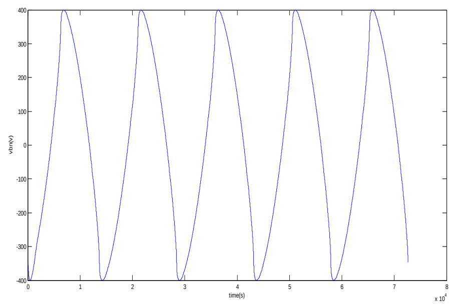

Figure 8: Vbn

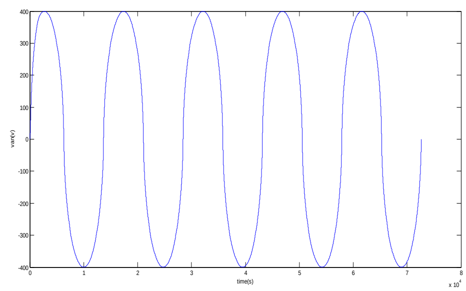

Figure 9: Vcn

VIII. CONCLUSION

The induction motor is the best choice for loads requiring low starting torques and substantially constant speeds because of its ruggedness, simplicity, low cost and reduced maintenance charges. So, in this Project, implementation of Simulink model for induction machine simulation has been introduced. With this model, the user has asses to all the internal variables for getting an insight into the machine operation.

In the modeling of the induction motor, the three phase stator equations are converted into two phase equations in different reference frames by d-q model theory. Individual parameter equations are solved in each block. Finally, the operation of the model is to simulate dynamic model of an induction motor which is carried out by the determination of torque of an induction motor.

TABLE 1: PARAMETERS

Parameters	Value
Rs	0.6
Rr	0.4
Xls	0.9424
Xlr	2.324
Xm	37.699
Wr	12.566
Ws	314.159
Wb	314.159

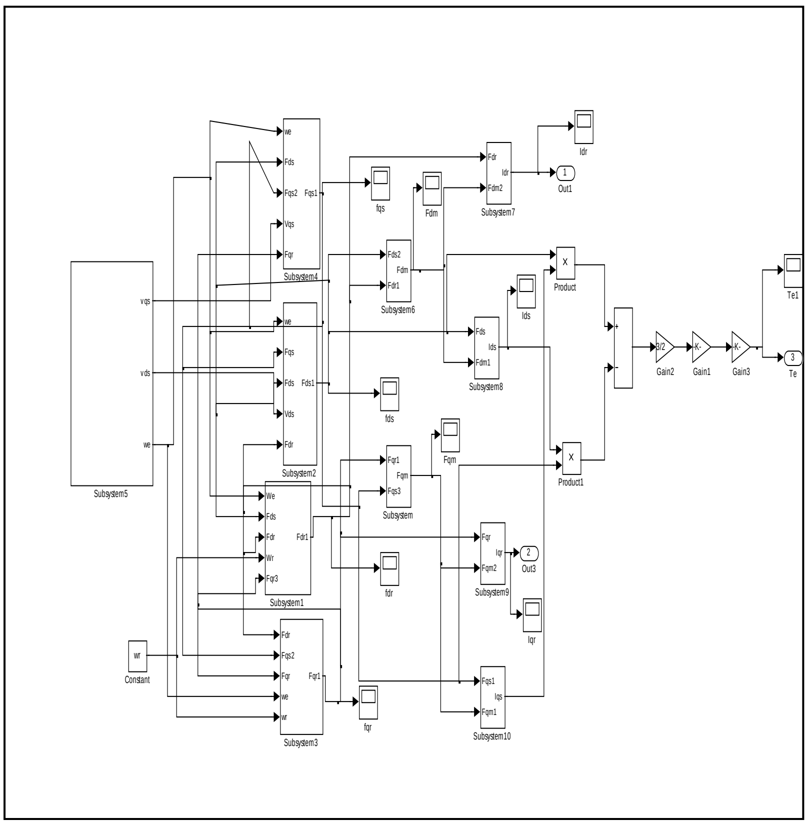

Figure10: Induction machine dynamic model implementation in Simulink.

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