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MODLING AND SIMULATION OF THREE PHASE INDUCTION MOTOR USING MATLAB

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Abstract: - The three-phase induction motor, also called an asynchronous motor, is the most commonly used type of motor in industrial applications. In particular, the squirrel- cage design is the most widely used electric motor in industrial applications. Electrical engineers and design engineers use normalized values for the variables. This paper presents dynamic modeling and simulation of 3-phase induction motor using dq axis transformation of normalized stator and rotor variables in the synchronous reference frame assisted by matlab/simulink. In this paper a new performances is presented of the three phase induction motor which is fed from a rectifier inverter system. Steady-state and dynamic performance analysis of the drive is done with the help of dc and ac mathematical models. MATLAB simulation of this drive is done using equivalent circuit model of the wound rotor induction motor. This drive is developed in the laboratory for a wound-rotor induction motor. Theoretical and experimental performances and simulation results are found as expected.

Keywords: - MATLAB/SIMULINK, induction motor, normalized value, dynamic modeling,

I. INTRODUCTION: - Induction Motors are the most commonly used motors in many applications. These are also called as Asynchronous Motors, because an induction motor always runs at a speed lower than synchronous speed. Synchronous speed means the speed of the rotating magnetic field in the stator.

There basically 2 types of induction
motor depending upon the type of input supply -
(i) Single phase induction motor and
(ii) Three phase induction motor.
Or they can be divided according to type of rotor -
(i) Squirrel cage motor and (ii) Slip ring motor or wound type

In a DC motor, supply is needed to be given for the stator winding as well as the rotor winding. an induction motor only the stator winding is fed with an AC supply. Alternating flux is produced around the stator winding due to AC supply. This alternating flux revolves with synchronous speed. The revolving flux is called as Rotating Magnetic Field.

The relative speed between stator RMF and rotor conductors causes an induced emf in the rotor conductors, according to the Faraday's law of electromagnetic induction. The rotor conductors are short circuited, and hence rotor current is produced due to induced emf. That is why such motors are called as induction motors.

Now, induced current in rotor will also produce alternating flux around it. This rotor flux lags behind the stator flux. The direction of induced rotor current, according to Lenz's law, is such that it will tend to oppose the cause of its production.

As the cause of production of rotor current is the relative velocity between rotating stator flux and the rotor, the rotor will try to catch up with the stator RMF. Thus the rotor rotates in the same direction as that of stator flux to minimize the relative velocity. However, the rotor never succeeds in catching up the synchronous speed. This is the basic working principle of induction motor of either type, single phase of 3 phase supply.

II.Synchronous Speed:

The rotational speed of the rotating magnetic field is called as synchronous speed.

$$Ns = \frac{120 \text{ x } f}{P} \quad \text{(RPM)}$$

Where, f = frequency of the spply

P = number of poles

Slip:

Rotor tries to catch up the synchronous speed of the stator field, and hence it rotates. But in practice, rotor never succeeds in catching up. If rotor catches up the stator speed, there won’t be any relative speed between the stator flux and the rotor, hence no induced rotor current and no torque production to maintain the rotation. However, this won't stop the motor, the rotor will slow down due to lots of torque, and the torque will again be exerted due to relative speed. That is why the rotor rotates at speed which is always less the synchronous speed.

The difference between the synchronous speed (N_s) and actual speed (N) of the rotor is called as slip.

$$\% \text{ slip} \quad s = \frac{Ns - N}{Ns} \text{ x } 100$$

As we all know the input to the three phase induction motor is three phase supply. So, the three phase supply is given to the stator of three phase induction motor.

Let, P_{in} = electrical power supplied to the stator of three phase induction motor,

V_L = line voltage supplied to the stator of three phase induction motor,

I_L = line current,

Cosφ = power factor of the three phase induction motor.

Electrical power input to the stator, $P_{in} = \sqrt{3} V_L I_L \cos\varphi$

A part of this power input is used to supply stator losses which are stator iron loss and stator copper loss. The remaining power i.e (input electrical power – stator losses) is supplied to rotor as rotor input.

So, rotor input $P_2 = P_{in}$ – stator losses (stator copper loss and stator iron loss).

Now, the rotor has to convert this rotor input into mechanical energy but this complete input cannot be converted into mechanical output as it has to supply rotor losses. Since the iron loss depends upon the rotor frequency, which is very small when the rotor rotates, so it is usually neglected. So, the rotor has only rotor copper loss. Therefore the rotor input has to supply these rotor copper losses. After supplying the rotor copper losses, the remaining part of Rotor input, P_2 is converted into mechanical power, P_m.

Let P_c= rotor copper loss,

I_2 = rotor current under running condition,

R_2= rotor resistance,

P_m is the gross mechanical power developed.

$P_c = 3I_2^2R_2$

$P_m = P_2 - P_c$

Now this mechanical power developed is given to the load by the shaft but there occur some mechanical losses like friction and windage losses. So, the gross mechanical power developed has to supply these losses. Therefore the net output power developed at the shaft, which is finally given to the load, is P_{out}.

$P_{out} = P_m$ – Mechanical losses (friction and windage losses).

III.Efficiency of Three Phase Induction Motor

Efficiency is defined as the ratio of the output to that of input,

$$Efficiency,\ \eta = \frac{output}{input}$$

Rotor efficiency of the three phase induction motor ,

$$= \frac{rotor\ output}{rotor\ input}$$

= gross mechanical power developed / rotor input

$$= \frac{P_m}{P_2}$$

Three phase induction motor efficiency,

$$= \frac{power\ developed\ at\ shaft}{electrical\ input\ to\ the\ motor}$$

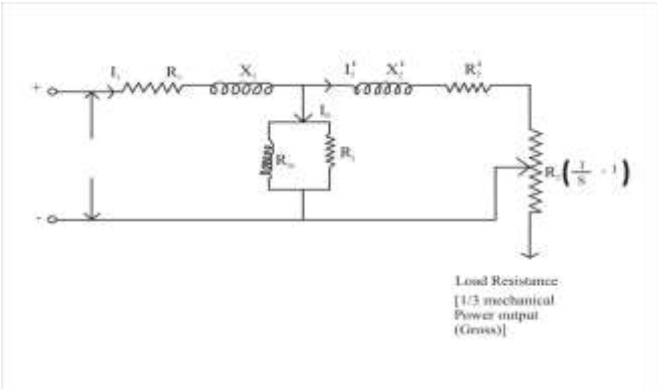
Three phase induction motor efficiency

$$\eta = \frac{P_{out}}{P_{in}}$$

IV.Equivalent circuit of an induction machine

Considering the equivalent circuit, if the injected voltage is increased, the rotor current will be reduced, resulting in a reduction in the available torque generated by the motor. If there is a load applied to the motor, the rotor will slow down, resulting in an increase in slip. As slip increases, the effective voltage seen by the stator will be reduced (the actual voltage physically induced in the rotor, due to the stator, will increase). As a result, rotor current will increase. This process allows the machine to find a new steady state where the induced rotor current produces enough torque to equal the load torque.

Analysis of operation



Equivalent circuit diagram of a three phase induction machine

WE know the gross Mechanical power is given by

$$P_m = P_G - 3I'^2_2R'_2$$

$$= 3I'^2_2R'_2(1/s-1) = (1-s)P_G$$

This means that the gross mechanical power output is three times (three-phase) the

Electrical power absorbed in resistance $R'_2(1/s-1)$.

Where R'_2/s is represented as.

$$R'_2/2=R'_2+R'_2(1/s-1)$$

It is notice from Eq.that the mechanical power output is a fraction (1-s) of the total power delivered to the rotor. While a fraction s of it is dissipated as the rotor.

Copper-loss. It is then evident that high-slip operation of the induction motor would be highly

Inefficient. Induction motor are therefore, designed to operate at low slip (2-8%) at full-load.

Rotor speed is

$$w= (1-s)w_s\ ,\ rad(mech.)/s$$

The electromagnetic torque developed is then given by

$$(1-s)w_sT=P_m=(1-s)P_G$$

or $$T=P_G/w_s=3I'^2_2(R'_2/2)/w_s$$

V.SIMULATION &RESULTS

The simulation results of open-loop ac drive system, classical optimal control system and matlab simulation based optimal control system are presented. All these results are supported by figures that compare the three above-mentioned systems. The performance of poly phase induction motor is checked first without any controller and then with the help of IGBT inverter Control controller. The simulink model is developed with the help of Matlab Simulation .The simulation is carried out for 3HP, 460 V squirrel cage induction motor drive using six step gate turn over thyrstier is shown in figure.

The project simulation is done in “MATLAB” software. The paper describes the design of the control stage and presents the result obtained the motor. This type of control is well justified in applications requiring a constant V/f speed control such as pumps, machine tools, mills etc. An analysis of the steady state equivalent circuit was done in order to establish the equations that justify the use of the scalar control method. The open loop speed controls of motor drive simulation results are presented. Experimental and simulated results were used to demonstrate the feasibility of the proposed solution.

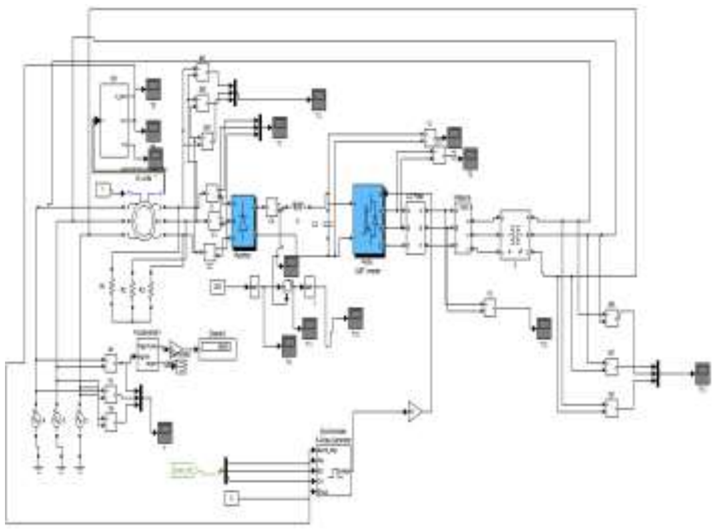


Figure: - Matlab simulation of three phase induction machine

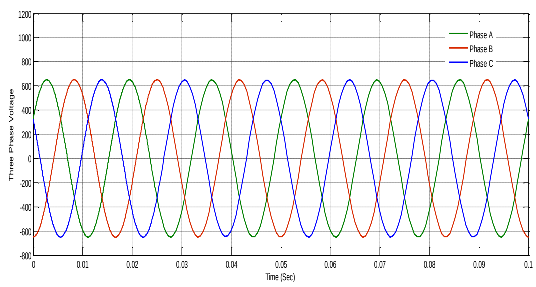


Figure Wave form of three phase supply voltage

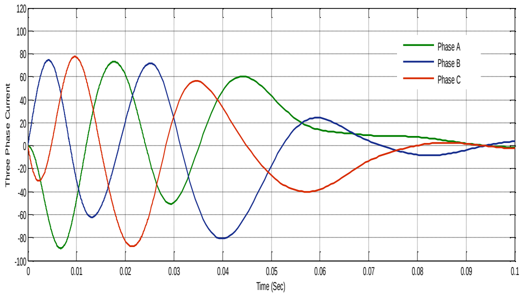


Figure Wave form of three phase supply Current

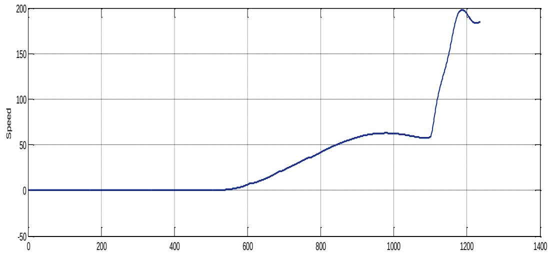


Figure Wave form of Speed

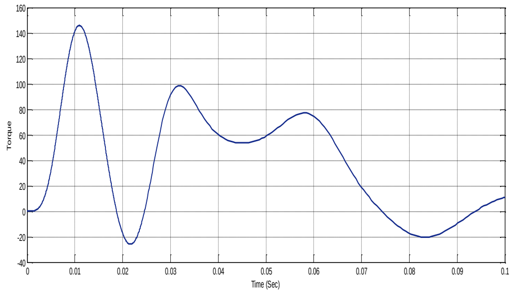


Figure Wave form of Torque

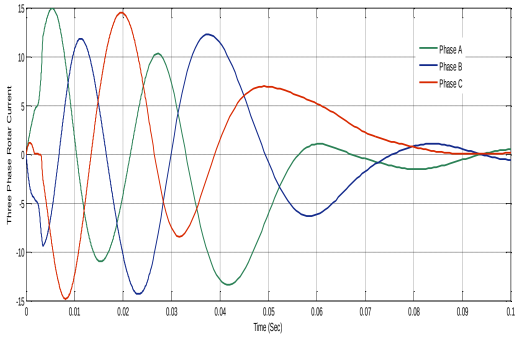


Figure Wave form of output voltage across rotor

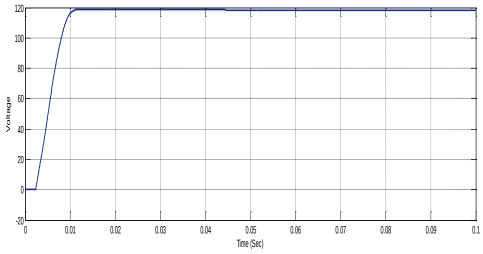


Figure Wave form of output voltage across rectifier

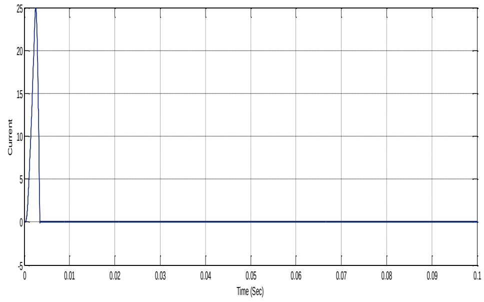


Figure Wave form of output current across rectifier

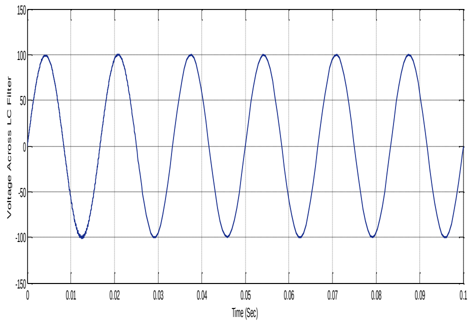


Figure Wave form of output voltage across LC filter

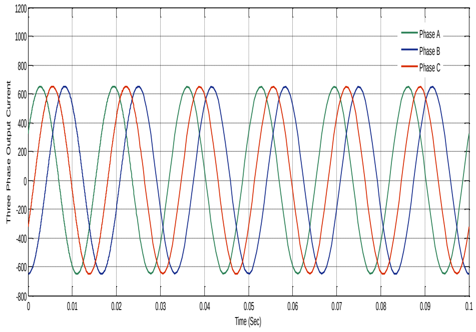


Figure Wave form of output voltage across the transformer

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