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Modelling, Analysis and Simulation ofSplit Phase Type Single Phase Induction Motor

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ABSTRACT: AC drive systems have been widely accepted for industrial applications. In general, they take the advantages of a higher power density and a higher efficiency than DC drive systems. This paper presents a novel chaotic-speed control of split-phase induction motor drives, especially for application to cooling fans. Based on the state vector analysis of the system, the d–qaxis model of the split phase induction motor is deduced. It reveals the periodicity and chaos for various system parameters. Mathematical analysis, computer simulation and experimental results are given to testify the proposed chaotic-speed fan.

Keywords: Single phase induction motor,bifurcation, chaos,non-linear,periodicity.

I. INTRODUCTION

Single-phase induction machines have a major industrial significance, being well suited for applications where cost is the dominant consideration, and performance requirements are modest.The split phase induction motor has two windings, the main winding and the auxiliary winding. These windings are displaced in space by 90 electrical. The auxiliary winding has higher current ratio between resistance and reactance, by designing it at a higher current density. In modeling performance characteristics of the induction motors, in question, circuit models of lumped parameters are still often used due to their simplicity and fast computation. At first approximation of the mathematical models linearity of magnetic circuit is assumed.

Chaos is aperiodic long term behavior in a deterministic system that exhibits sensitive dependence on initial conditions. Thistheory is a field of study in mathematics, with applications in several disciplines including physics, engineering, economics, biology, and philosophy.As the initial state of a practical system can only be specified with some tolerance, the long-term behaviour of a chaotic system can never be predicted accurately.

II. D-Q AXIS MODELLINGOF THE MOTOR

The D-Q model a single phase induction machine can be considered to be an unsymmetrical two phase induction machine. To build a Motor model, we need mainly The Stator and Rotor Voltage equations.Let us take the following motor

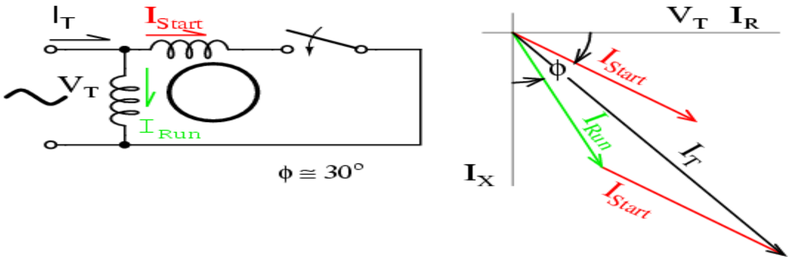

Fig1 :(a) Motor Model (b) Phasor diagram

Here we see that their exist some complexity of the voltage equations due to the time varying mutual inductances between stator and rotor circuits(circuits in relative motion).To eliminate the time varying variables we need a transformation tool. The general Transformation refers the motor variables to a reference frame that rotates at an arbitrary angular velocity.

Commonly Used Reference Frame :

Reference Frame speed	Interpretation
ω (unspecified)	Stationary circuit variables referred to the arbitrary reference frame
0	Stationary circuit variables referred to the stationary reference frame
ω_r	Stationary circuit variables referred to a reference frame fixed in the rotor
ω_e	Stationary circuit variables referred to the synchronously rotating reference frame

The voltage equation can be written as

$$v_{qs} = r_m i_{qs} + \frac{p}{\omega_b} \lambda_{qs}$$

$$v_{ds} = r_a i_{ds} + \frac{p}{\omega_b} \lambda_{ds}$$

$$0 = r'_r\, i'_{qr} + \frac{p}{\omega_b} \lambda'_{qr} - \frac{1}{k} \frac{\omega_r}{\omega_b} \lambda'_{qr}$$

$$0 = k^2 r'_r\, i'_{dr} + \frac{p}{\omega_b} \lambda'_{dr} + k \frac{\omega_r}{\omega_b} \lambda'_{dr}$$

The Flux equations

$$\lambda_{qs} = x_{lm} i_{qs} + x_m (i_{qs} + i'_{qr})$$

$$\lambda_{ds} = x_{la} i_{ds} + k^2 x_m (i_{ds} + i'_{dr})$$

$$\lambda'_{qr} = x'_{sr}\, i'_{qs} + x_m (i_{qs} + i'_{qr})$$

$$\lambda'_{dr} = k^2 x'_{sr}\, i'_{dr} + k^2 x_m (i_{ds} + i'_{dr})$$

Where K= D axis to Q axis turns ratio and K=1 also.

Here we used Stationary Reference frame.

$$v_{qs}^{s} = v_{ds}^{s} = v_{s}$$

The Torque equation is given by

$$T_e = \frac{p}{2}\frac{X_{mq}}{\omega_b}\left(i_{qs}^{s} i_{dr}^{'s} - i_{ds}^{s} i_{qr}^{'s}\right)$$

$$T_e = T_L + J\frac{d\omega_r}{dt} + B_m\omega_r$$

$$\begin{bmatrix} v_{qs}^{s} & v_{ds}^{s} & 0 & 0 \end{bmatrix} = \begin{bmatrix} R_{qs} + \frac{p}{\omega_b}X_{qs} & 0 & \frac{p}{\omega_b}X_{mq} & 0 \\ 0 & R_{ds} + \frac{p}{\omega_b}X_{ds} & 0 & \frac{p}{\omega_b}X_{md} \\ \frac{p}{\omega_b}X_{mq} & -\frac{\omega_r}{\omega_b}X_{md} & R_{qr}^{'} \frac{p}{\omega_b}X_{qr}^{'} & -\frac{\omega_r}{\omega_b}X_{dr}^{'} \\ \frac{\omega_r}{\omega_b}X_{mq} & \frac{p}{\omega_b}X_{md} & \frac{\omega_r}{\omega_b}X_{qr}^{'} & R_{dr}^{'} + \frac{p}{\omega_b}X_{dr}^{'} \end{bmatrix} \cdot \begin{bmatrix} i_{qs}^{s} & i_{ds}^{s} & i_{qr}^{'s} & i_{dr}^{'s} \end{bmatrix}^{T}$$

where,

R_{dr} = Direct axis rotor resistance,

R_{qr}= Q-axis rotor resistance,

L_{lds}= Direct axis stator leakage inductance,

L_{lqs}= Q-axis stator leakage inductance,

L_{md} =Direct axis mutual inductance,

L_{ldr} = Direct axis rotor leakage inductance,

X_{md} = Direct axis magnetizing reactance,

L_{lqr} = Q-axis rotor leakage inductance,

L_{mq} = Q-axis mutual inductance,

ω_r = Rotor angular speed and

ω= Speed of the reference frame,

X_{mq} = Q-axis magnetizing reactance.

Rqs = Q-axis stator resistance

III. MATLAB/SIMULINK MODELLING

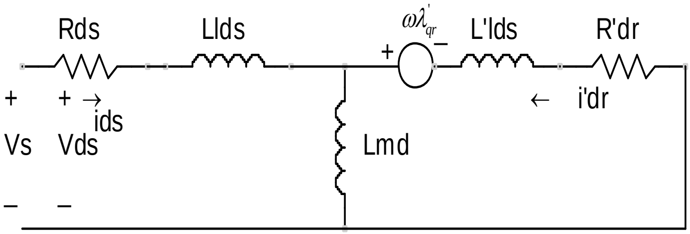

Figure 2: *Equivalent D-axis model of the induction motor*

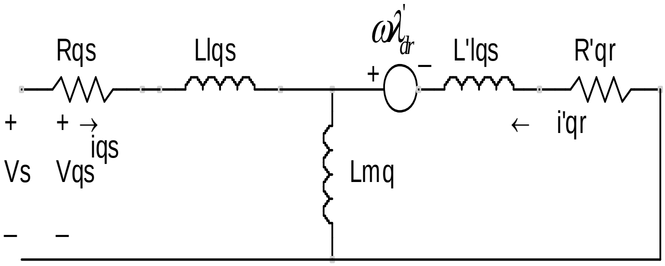

Figure 3: *Equivalent Q-axis model of the induction motor*

III. MATLAB/SIMULINK MODELLING

The Two (main and auxiliary) stator windings are displaced 90 degree in space.The modelling of the single phase induction motor projects the non-linear model of the system.The variation of system settling points with the variation of system parameters is defined as bifurcation of the system. Here we vary the operating voltage keeping other variables constant. It can be observed that the chaotic speed waveforms gives the well-known chaotic properties, namely random-like but bounded oscillations. Physically, these chaotic motions reveal the unbalanced status of the interaction between the magnetic fields by the main winding and the auxiliary winding.Also, these waveforms are a-periodic and very sensitive to the initial condition.

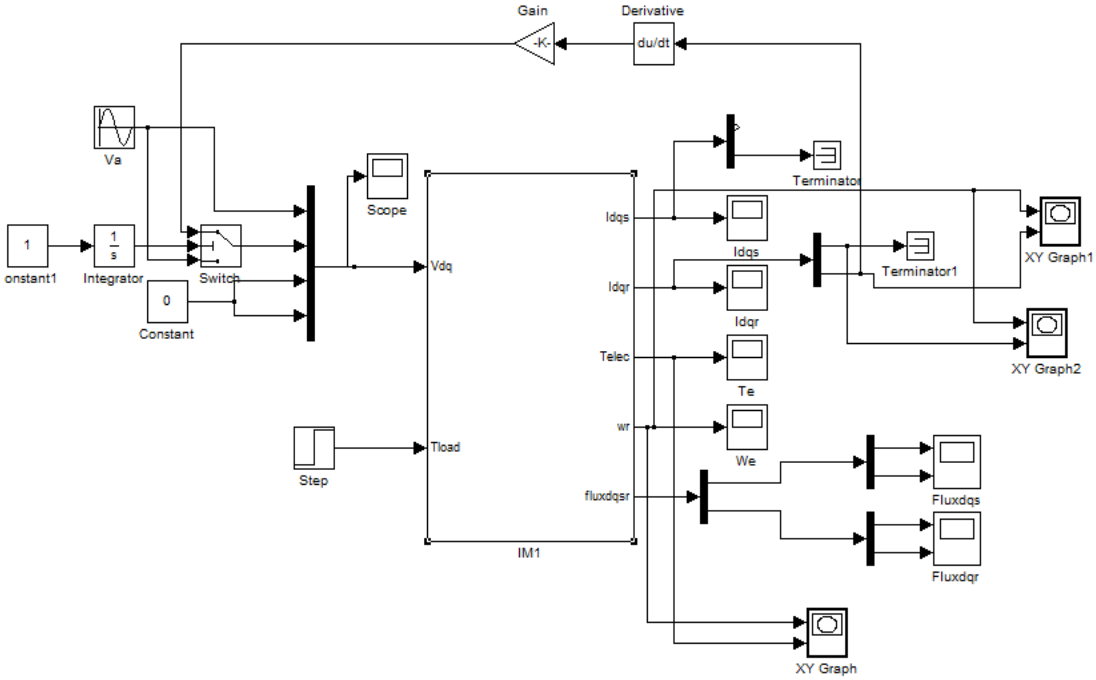

Figure 4: Dynamic model of a split phase induction motor.

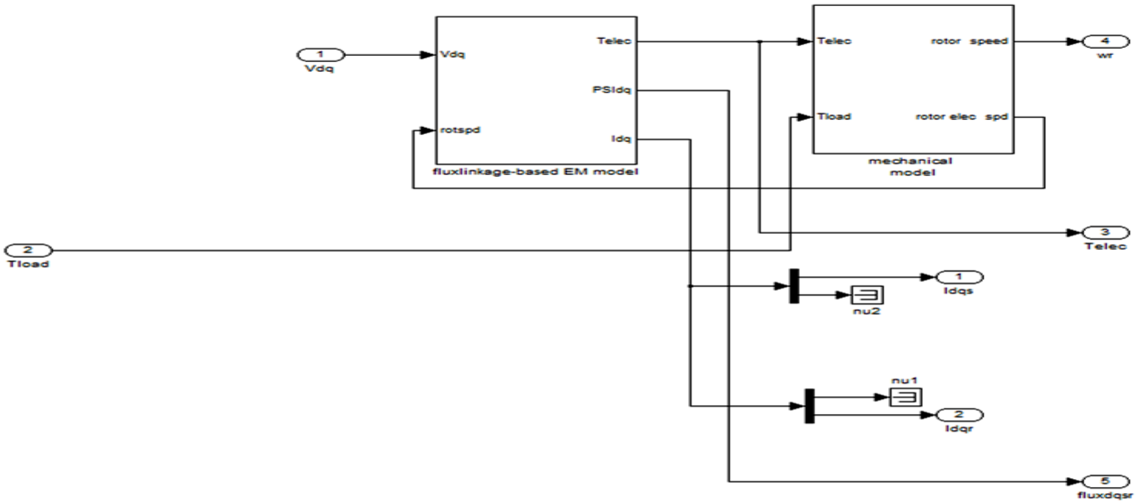

Figure 5: Sub-systems modellingfor the induction motor

IV. MOTOR PARAMETERS

Parameters	Value	Parameters	Value
Pair Of Poles	1	L_{lqr}	0.3105 H
R_{dr}	20 Ω	L_{mq}	0.3528 H
R_{qr}	20 Ω	J	2.310e-4Kg-m^2
L_{lds}	0.111 H	B_m	1.470e-4 N.m.s
L_{lqs}	0.4111 H	L_{md}	0.2448 H
R_{qs}	4.5Ω	R_{sd}	9.5 Ω
L_{ldr}	0.2767 H	Frequency (f)	40Hz

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V. RESULTS AND SIMULATIONS

Case 1:When voltage = 160V periodicity has been observed in speed waveform. i.e. period 1 has been achieved .

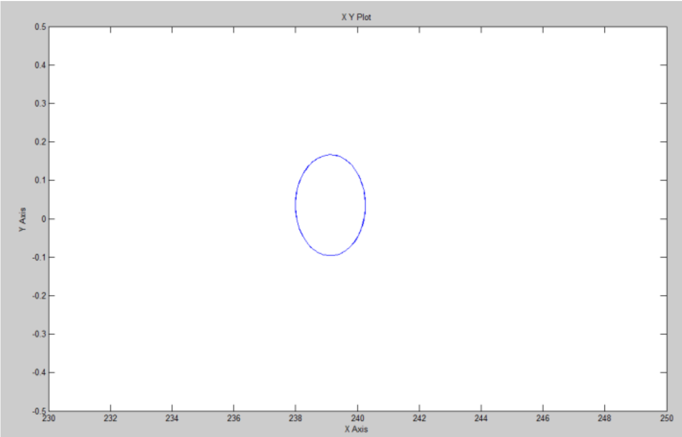

Fig 6: ids Vs Speed

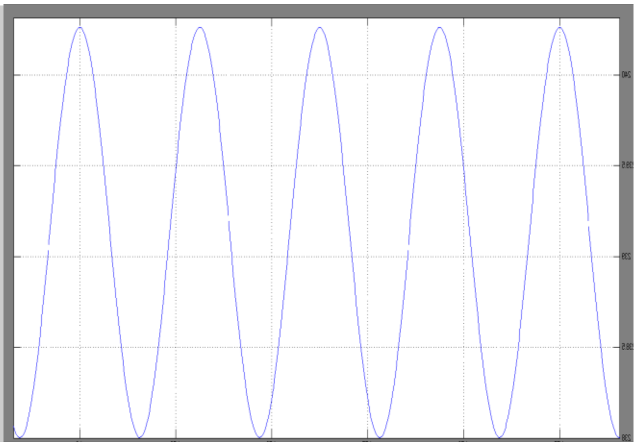

Fig 7: Speed waveform

Case 2:- As the motor operating voltage changes to 180 volt the phenomenon changes and the speed waveform periodicity has been changed from one to two(period 5).

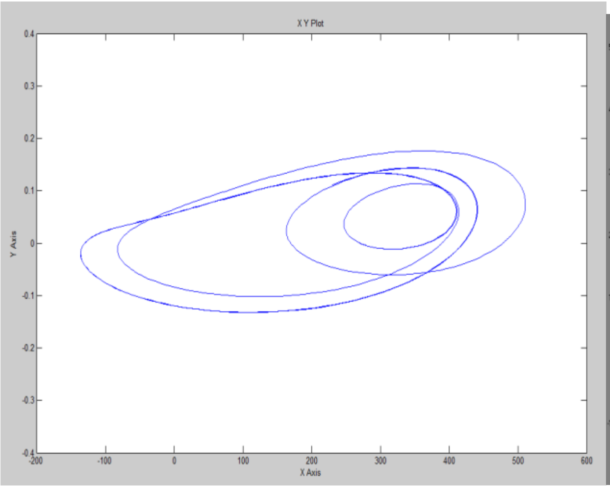

Fig 8: ids Vs Speed

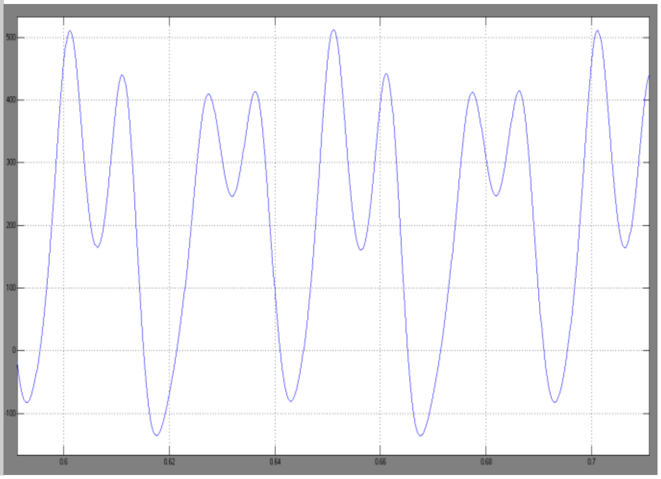

Fig 9: Speed waveform

Case 3 :Periodicity becomes too large to determine and the system become chaotic.Here voltage = 220 V

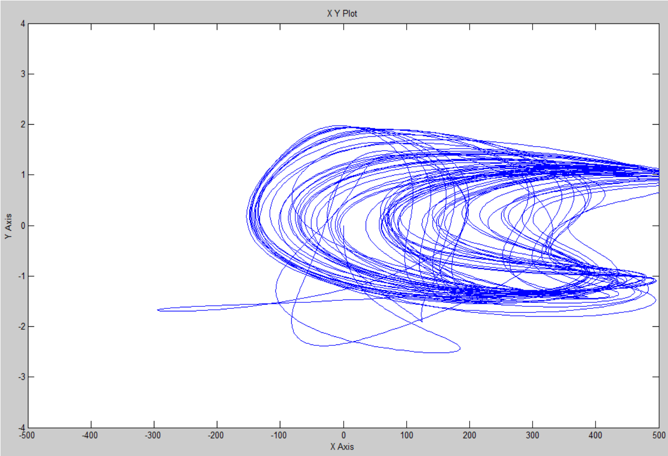

Fig 10: ids Vs Speed

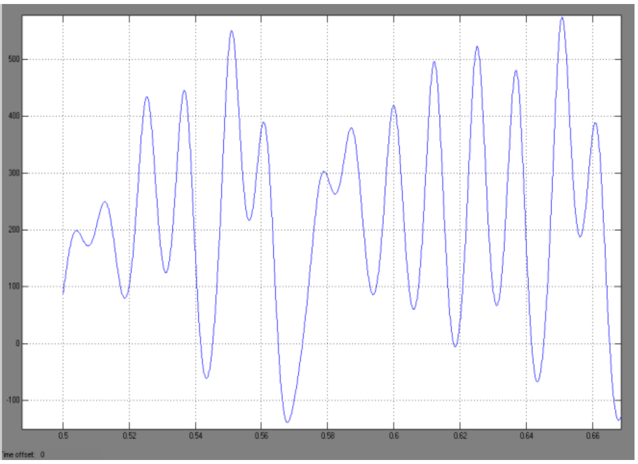

Fig 11: Speed waveform

VI. CONCLUSION

The non-linear phenomenon in split-phase induction motors are observed as the voltage(V) is varied.This paper firstly proposed a novel chaotic-speed split phase type SPIM drive for application to cooling fans. Figures have shown above represents the speed waveforms and the corresponding phase-portraits, at various periodic-speed operations, i.e. the period-1, period-5 and chaotic operations. As the voltage increases the angular speed becomes chaotic. We found lots of application of chaotic speed of induction motor such as cooling system, mixture grander, air compressor etc.These waveforms are consistent with the well-known phenomenon of inevitable torque pulsation. It should be noted that once the operating condition are known, the motor parameter whose variation bringing chaos may be more than one possible.The proposed chaotic motion can be adopted to improve heat transfer and hence the cooling effect for homogeneity.

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