Steady State Analysis Of Synchronous Motor Using Scilab Open Source Software

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Abstract

Steady state analysis is a necessary technique that used to analyses the behavior of any machine under different operating condition. This type of analysis is required to design a suitable controller to provide the stability to the machine. In this paper, mathematical modeling of Synchronous Motoris presented. Scilab based open source software used to solved these mathematical equations to analyses the steady state behavior of the machine.

1. Introduction

Operation of the Synchronous motors are mostly same as like induction motors except it operate at constant speed and required the external DC source for excitation. Otherwise both the motors have rotor and stator winding and the stator creates the rotating magnetic field across its stator windings. The rotor of the synchronous motor always remains in lock with the rotating magnetic field and run the synchronous speed [1-2].

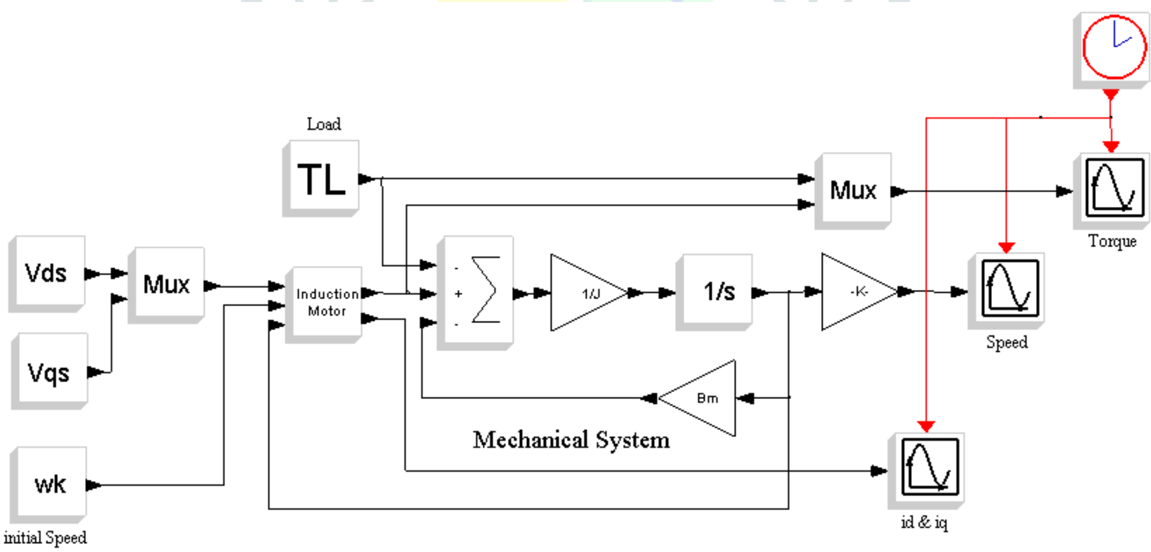

Figure 1: Block diagram of Synchronous Motor

A Synchronous motor mostly required a damper winding to provide self starting torque as the motor is not a self-starting motor as like induction motor as it only produced the torque at rated or synchronous speed. Damper winding mostly connected in the series with the field windings as shown in Figure 2.It is also known as aux. winding which help the synchronous motor to developed the starting torque[3-4].

2. Modeling equations

This simulation consists of a Synchronous motor sub-model provides with the modeling of rotor and stator equations as shown in Fig. 2.These equations used to calculate the output current as well as the electromagnetic torque and a mechanical system to yield the rotor speed. The detailed modeling equation used to design the sub-model has been below in Eq. 1-4.

$$d(f_{ds})/dt = w_0(v_{ds} - R_s\, i_{ds} + w_m\, f_{qs})$$

$$d(f_{qs})/dt = w_0(v_{qs} - R_s\, i_{qs} - w_m\, f_{ds})$$

$$d(f_{fl})/dt = w_0(v_f - R_f\, i_{fl})$$

$$d(f_{kd})/dt = -w_0(R_{kd}\, i_{kd})$$

$$d(f_{kq})/dt = -w_0(R_{kq}\, i_{kq})$$

$$I = L^{-1} F$$

Where:

$$F = \begin{bmatrix} f_{ds} \\ f_{qs} \\ f_{kd} \\ f_{kq} \\ f_{fl} \end{bmatrix} I = \begin{bmatrix} I_{ds} \\ I_{qs} \\ I_{kd} \\ I_{kq} \\ I_{fl} \end{bmatrix}$$

$$L = \begin{bmatrix} L_{al} + L_{md} & 0 & L_{md} & 0 & L_{md} \\ 0 & L_{al} + L_{mq} & 0 & L_{mq} & 0 \\ L_{md} & 0 & L_{md} + L_{kd} & 0 & L_{md} \\ 0 & L_{mq} & 0 & L_{mq} + L_{kq} & 0 \\ L_{md} & 0 & L_{md} & 0 & L_{md} + L_{fl} \end{bmatrix}$$

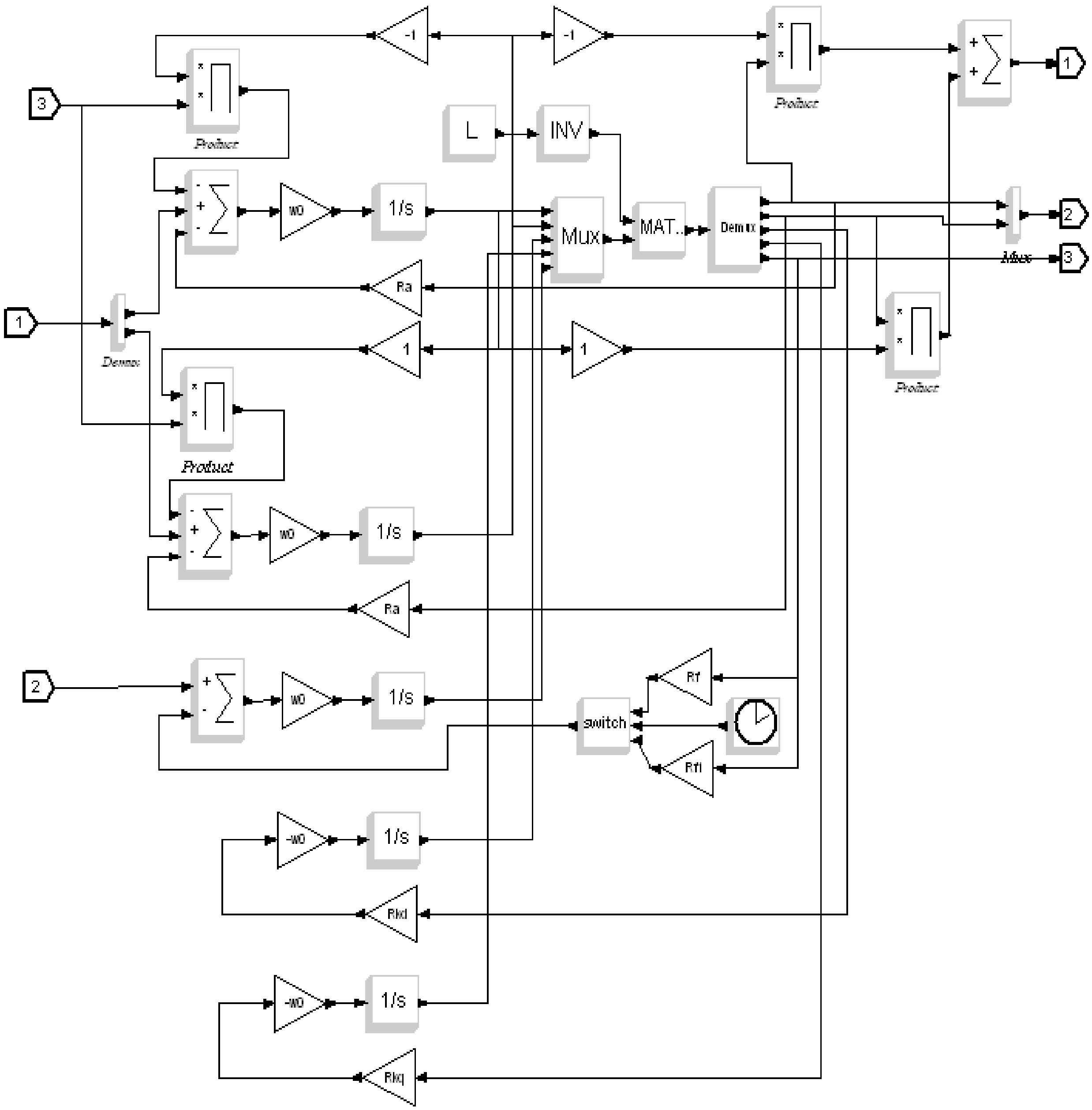

Figure 2: Sub-model of Synchronous Motor

3. Results and Discussion

In order to represent the steady state analysis using the given Scilab simulation model [5], the parameters of Synchronous Motor are give in Table 1. For running the simulation, one step input, Va applied across it as a armature and field. With due to that the motor start increase its speed as shown in Fig. 3. After getting the constant speed across output, a load has been applied across it at 0.8 second. With the application of the load the effect on the motor torque and the current has been shown in Fig. 4 and 5.

Table 1: Parameters used in Modelling

S.No	Parameters	Values
1	D-axis Inductance, *Ld*	1.15
2	Q-axis inductance, *Lq*	0.70
3	D-axis damper Inductance, *Lkd*	0.32
4	Q-axis damper inductance, *Lkq*	0.26
5	D-axis resistance, *Rkd*	0.2
6	Q-axis resistance, *Rkq*	0.2
7	Field Discharge Resistance, *Rfd*	0.185
8	Field Resistance*Rf*	0.015
9	Friction Coefficient, *Bm*	0.00001
10	Inertia Constant, *J*	2
11	Step Time of Load, *TL*	10
12	Initial Load, *Intload*	0.2
13	Final Load, *finload*	1
14	Armature Voltage, *Va*	1
15	Step size, *Stsize*	0.001
16	Simulation time, *Tf*	15

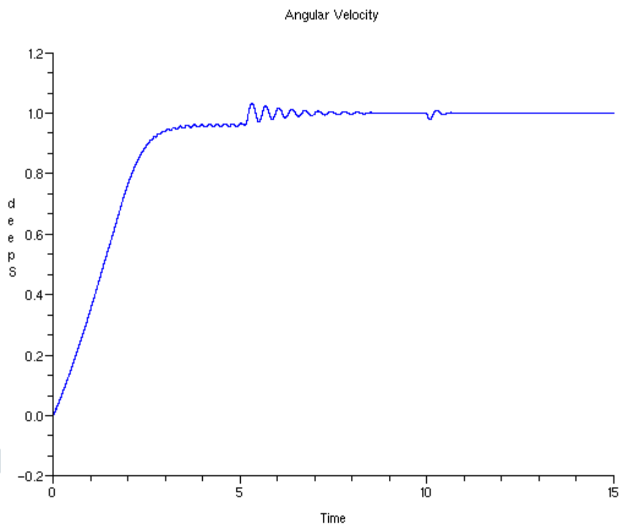

Figure 3: Angular velocity of Synchronous Motor

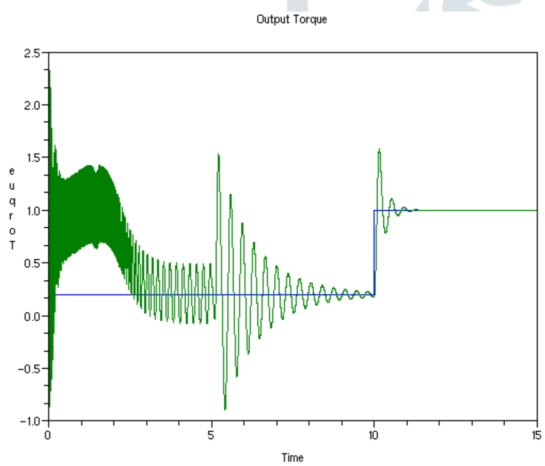

Figure 4: Output Torque of Synchronous Motor

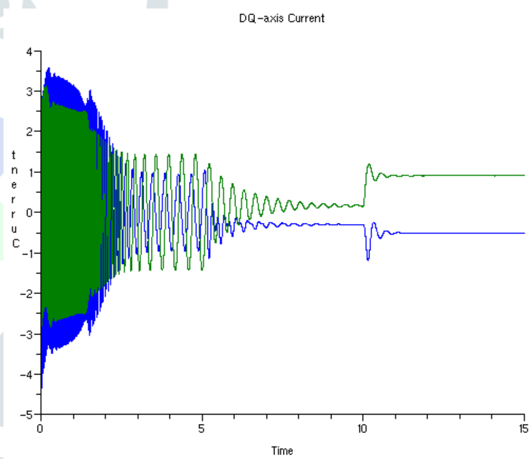

Figure 5: Armature current of Synchronous Motor

4. Conclusion

This paper presents the Steady-state response of the Synchronous Motorin the Scilab open source environment. The result shows the stable operation of the Synchronous Motor with the application of the load across it. This paper presents the usefulness of the developed model of Synchronous Motor for steady state analysis.

References

[1] P.C.Sen, DC MACHINES, Principles of Electrical Machines & Power Electronics, 3rd Ed. USA, John Wiley& Sons,1996,ch 4,sec 4.5,pp 124-188

[2] Amir Faizy, Shailendra Kumar, DC motor control using chopper, NIT Rourkela 2011.

[3] Gopal.K.Dubey, dc Motor Drives,Fundamentals of Electrical Drives 2nd Ed.,India, Narosa Publishers,2001,ch 5,sec 5.5,pp 87-122

[4] The Mathworks. [Online]. Available: http://www.mathworks.com

[5] Scilab home page. [Online]. Available: http://www.scilab.org/