

Massachusetts Institute of Technology
Department of Electrical Engineering and Computer Science
 6.685 Electric Machines

Problem Set 12

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A large induction motor intended to drive a fan can be represented by the simple equivalent circuit with the following parameters:

Stator Resistance	R_1	0.295	Ω
Rotor Resistance	R_2	0.277	Ω
Stator Leakage Reactance	X_1	2.61	Ω
Rotor Leakage Reactance	X_2	3.24	Ω
Magnetizing Reactance	X_m	61.3	Ω

This motor is subjected to an across-the-line start, and in this problem set we will simulate that start. For each part,

1. The machine starting only inertia equal to $60kg - m^2$, and
2. The machine driving a fan load. For the purpose of this problem, assume that power drawn by the fan is exactly a cubic function of speed, so that load torque is proportional to speed squared. Assume that the fan load would be equal to 600 kW at synchronous speed (which you will not, of course, quite achieve).

The fan is operated by a voltage source that is 60 Hz, 4160 volts, RMS, line-line. (Be careful to get phase voltage right here!). It is an 8-pole machine so its synchronous speed is 900 RPM.

For each part of the problem, calculate and plot:

1. Speed (RPM) vs. time (simulate for 5 seconds).
2. Real power drawn from the source over the same time.
3. Reactive power drawn from the source

The three cases to simulate are really three different and progressively more detailed models of the machine. These are:

1. A 'First Order' model which assumes that the stator and rotor are both in *electrical* steady state so that the only dynamic (state) variable is rotor speed.
2. A 'Third Order' model which uses the rotor variables (ψ_{dr} and ψ_{qr} and, of course, rotor speed but which assumes that stator variables can be either neglected or assumed to be in steady state conditions. You can also ignore stator resistance in calculating the stator quantities.
3. A 'Fifth Order' model in which both stator and rotor variables are important.

Of course we are ignoring the possibility of deep bar (diffusion) effects here, so these simulations may not be all that realistic, but they do have some interesting features. Try to plot all three sets of plots on equivalent sets of axes so that the important features of each can be seen.