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

Problem Set 11

Issued November 19, 2005
Due November 30, 2005

Problem 1: Circuit Fault Figure 1 shows a simple situation: a voltage source is suddenly shorted through a resistor and inductor in series. Assume the following:

$$\begin{aligned} v(t) &= 170\cos 377t \\ R &= 10\text{m}\Omega \\ L &= 2.65\text{mHy} \end{aligned}$$

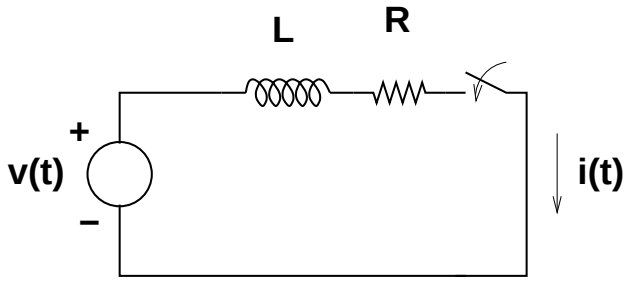

Figure 1: Simple Fault

1. If the switch is closed at time $t = 0$, what is current $i(t)$?
2. Note you found a current that includes a sine wave with the same frequency as the source and a decaying 'DC offset'. Can the time the switch is closed be selected to make this DC offset zero? If so, what is that time?

Problem 2: Turbogenerator All problem concerns a large synchronous generator which has the following parameters, expressed in per-unit:

Synchronous, d- axis reactance	x_d	2.2	
Synchronous, q- axis reactance	x_q	2.0	
Transient, d- axis reactance	x'_d	0.45	
Subtransient, d- axis reactance	x_d"	0.22	
Subtransient, q- axis reactance	x_q"	0.22	
Transient, open-circuit time constant	T_do'	5.0	s
Subtransient, open-circuit time constant	T_{do}"	0.2	s
Subtransient, open-circuit time constant	T_{qo}"	0.3	s
Inertial Constant	H	4.0	s
Armature Time Constant	T_a	0.1	s

1. Find equivalent *equal mutuals* circuit models for the d- and q- axes for this machine. Assume for this purpose that the stator leakage inductance is $x_{al} = 0.1$ per-unit.

2. What are the actual parameters (in ohms) of the reactive and resistive parameters for these models, on a machine base of 1100 MVA, 26 kV, line-line, RMS?
3. The generator is operated initially unloaded, with terminal voltage equal to 1.0 per-unit. A sudden, symmetrical short circuit is imposed just at the instant when the flux is a maximum in Phase A. Using classical methods (i.e. those you can pick out of the text), compute and plot the current in Phase A as a function of time.
4. Using MATLAB, simulate this transient.
5. Estimate e_q" during the transient, using 'classical' methods.
6. Now, what happens if the machine is operated at rated current, unity power factor, when the terminals are suddenly open circuited. Ignoring the initial voltage spikes and speed change, calculate terminal voltage as a function of time.
7. Calculate and plot the *transient* torque angle curve for this machine, assuming that steady state operation is at rated load, unity power factor. Also calculate a (fictional) torque-angle curve that assumes the d-axis transient reactance on both axes.
8. The machine is operating into an infinite bus at rated load, unity power factor when it is suddenly disconnected. After a period of time it is re-connected. How long can that period be for the machine to regain synchronous operation (i.e. what is the critical reclosing time?). Use equal area and compare the two curves you just derived.
9. Simulate this transient. How good is equal area in this case?