EE7566 Spring 2019

Project: Effect of Number of Poles on IPMSM Performance

Aim: To show the trade-offs that need to be considered in selecting the pole-pair number of an electric machine.

Project description:

- Select an existing IPMSM, i.e. Prius 2004 machine that has 8 poles (4 pole-pairs).
- Design 6-pole and 10-pole versions of this machine by keeping the rotor OD (outer diameter), air-gap length and stator ID (inner diameter) constant. Keep the number of slots per pole 6 for all machines, so that 6-pole machine has 36 slots, 8-pole machine has 48 slots and 10-pole machine 60 slots. Assure that all the machines have the same total slot area, slot area times number of slots and slot depth.
- Adjust the outer diameter of stator, stator OD, such that maximum flux density in stator back iron, stator core connecting teeth, is 2 T at maximum current.
    - Assume a 400 A maximum current amplitude for 8-pole machine, and re-calculate this value for the other machines by keeping current density in slots constant (you can adjust number of turns or/and coil thickness in the slot area). 6-pole machine has higher slot area so a higher maximum ampere turns and 10 pole machine has lower.
      Hint: Define stator OD as a variable and perform magneto static or transient parametric sweep at maximum current.
- Compare the stator ODs of the designs, calculate the volume of the machines (Do not forget end winding length).
- In the second part, you need to calculate the induced back-EMF and losses of all the designs.
    - At 1500 rpm without phase excitation (no-load), compare your induced voltages and core loss in stator results.
    - Do the 6-8-10 pole designs have different induced voltages? Explain considering the selected number of turns and electrical frequency of the machines.
    - At 1500 rpm at maximum peak current calculate core losses in the stator and also copper losses in phase windings.
    - Which two design factors are effecting the total stator core losses in the stator?
- Comment on the trade-offs that need to be considered when selecting the number of pole pairs?
- **Extra credits:**
    - Calculate the Ψ_{PM}, L_d and L_q of 8-pole (original design) and 10-pole machines in Ansys Maxwell.
    - Determine the maximum speed of these machines at which the maximum torque calculated before can be generated at a DC-link voltage equal to 500 V, which is the definition of base speed, (use the voltage limit that is derived at the class for SV-PWM).
    - Calculate maximum electrical freq. of each design and propose a switching freq.
    - Comment on your results.