MODELLING OF ELECTRICAL MACHINES

Tutorial Sheet 4

Ψ/i modelling of permanent magnet machines

1). Fig..1 shows a simple permanent magnet circuit. The coil which has 1000 turns, has a measured flux-linkage of 625mWb turns when it is not carrying current. If the cross-section area of the iron limbs is 2500mm^2 , estimate the magnitude of the currents at which saturation begins to occur, for current polarities which both aid and oppose the magnet flux (assume that the material saturates at around 1.6T, and below this value of flux density it is a good approximation to being infinitely permeable).

2) Fig. 2 shows measured flux-linkage versus rotor angle characteristics for a simple single phase generator. What is the average value of incremental inductance for currents in the range 0-500mA at rotor angles of 20^o and 60^o ?
Explain why the generator produces the same torque per amp for both 500mA and 1A even though the flux linkage at a given rotor position is higher with 1A flowing in the phase winding.
What is the rms open-circuit voltage produced by the generator when its shaft is driven at 8000 rpm ? (assume that the variation of flux-linkage with rotor angle is sinusoidal and that eddy current losses in the stator laminations are negligible)

3) Fig3. shows measured flux-linkage versus rotor angle characteristics for one phase of a three phase brushless machine with 8 rotor poles.
a) If the motor is wound with a concentrated winding, how many stator teeth are there?
b) What is the value of incremental phase inductance at a rotor angle of +90^o for current of 200A?
c) For operation at high speed, the commutation interval is shifted from the normal -60^o to +60^o interval to an interval -80^o to 40^o. What is the average torque produced by the motor over both the original interval and the shifted interval for currents of 50A and 200A? (i.e. 4 values in total).
d) Plot the instantaneous torque over the interval -60^o to +60^o for a current of 50A (use 10^o intervals)
e) Plot the torque produced per unit of copper loss in the phase over the interval -60^o to 60^o (again use 10^o intervals). i.e. (T/I^{2}R).
f) How could the efficiency be improved while still maintaining the same average output torque over the interval -60^o to +60^o ? (Restrict your answer to modification of the control electronics rather than modifications to the machine)
g) At what rotor angles is the open circuit induced phase emf zero and a maximum?
h) Why is usually preferable to operate a machine below saturation ?
i) Can you think of any instances where operation well beyond saturation might be justified?

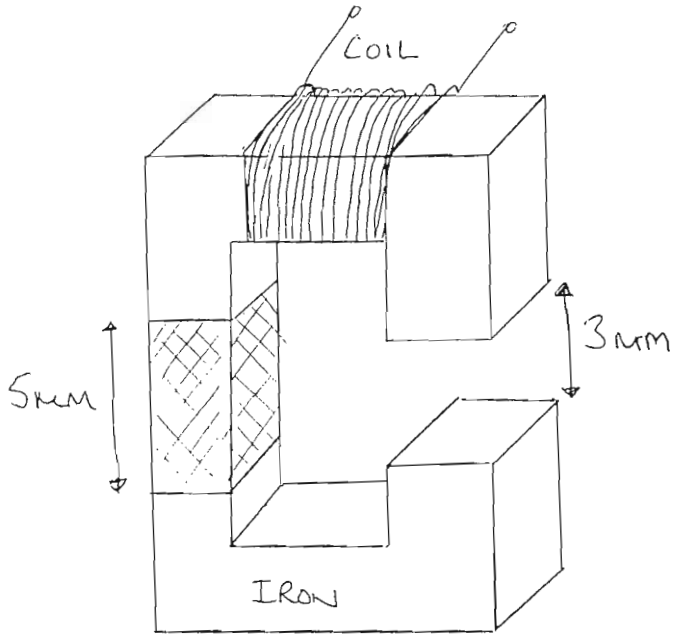

FIG 1. PERMANENT MAGNET CIRCUIT FOR QUESTION 1.