ECE 431 Homework #3 (Due – Wednesday, February 19, 2020)

Problem 3.1

The two-winding magnetic circuit of Fig. 3.1 has a winding on a fixed yoke and a second winding on a movable element. The movable element is constrained to motion such that the lengths g of both air gaps remain equal.

a) Find the self-inductances of windings 1 and 2 in terms of the core dimensions and the number of turns.
b) Find the mutual inductance between the two windings.
c) Find the coenergy $W'_{fld}(i_1,i_2)$
d) Find an expression for the force acting on the moveable element as a function of the winding currents

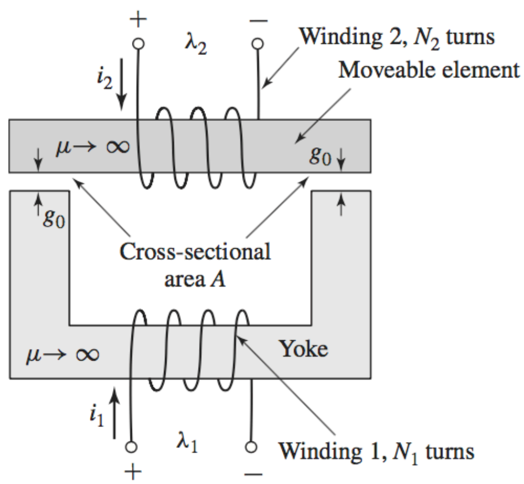
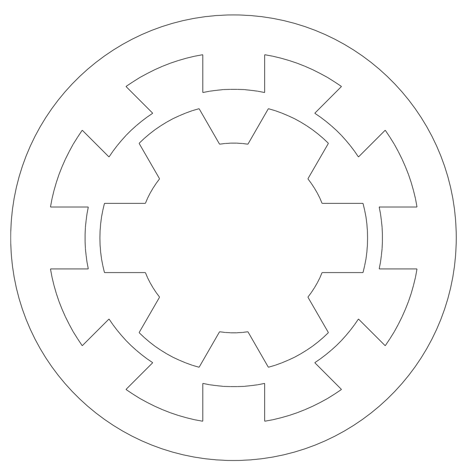


Fig. 3.1 Two-winding magnetic circuit

Problem 3.2

A variable reluctance machine has a 8/6 configuration, as illustrated below. There are four winding sets, not shown, in counter-clockwise sequence on the stator poles as a, b, c, d, a', b', c', d'. Each winding can have either positive or negative current imposed on it. The position shown is the reference position at zero degrees. (Hint: printing and cutting out the diagram can be helpful to visualizing the rotation)



a) Given that only one winding set is used at a time, provide the sequence the winding sets should be activated in, such that machine rotates in the counter-clockwise direction.

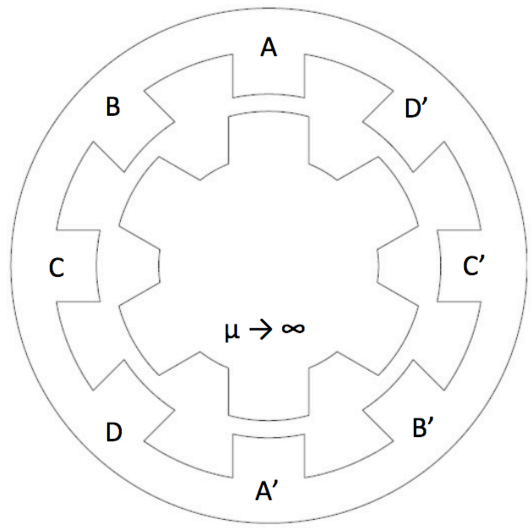
b) If the currents are switched sequentially each 0.1 ms, how fast will the motor rotate, assuming the inductance is small?

c) It is proposed that to increase the precision of the machine, the machine is switched such that one or two winding sets are switched on simultaneously in an alternating pattern (1-2-1-2 windings, this is called half stepping). What sequence should be used for clockwise rotation in this case? What would be the speed if the currents are switched at the same frequency?

Problem 3.3

A switched reluctance machine with an 8/6 configuration has the following parameters:

- -Rotor outer radius = 6 cm
- -Air gap, g = 1 mm
- -Rotor pole angle = $\pi/6$ rad
- -Stator pole angle = $\pi/6$ rad
- -Axial length, l = 10 cm
- -Total turns per phase = 100



Assume infinite reluctance when the poles are unaligned, and ignore the effects of fringing and saturation.

a) Starting from the position as shown, using single phase excitation, what should be the excitation sequence to obtain a clockwise rotation of the rotor.

b) How fast would the rotor spin (in rpm) if excitation is applied at a frequency of two pulses per millisecond?

c) Phase A current is set to 1A, with all other currents set to zero. Plot the phase A inductance and torque as a function of θ as the rotor is rotated counter-clockwise.

d) If the rotor and stator pole angles are both reduced to $\pi/8$, plot the new phase A inductance and torque under the same conditions.