EE3124 Test 1 (Solution)

Name: **Student No.:**

Q1 – Please summarize the differences and similarities between Turbogenerator (Thermal Power Plants) and Hydroelectric Generator (Hydropower Plants). (15 pts)

Solution

Features: Turbogenerator (50 Hz)

High rotating speed: 3000 r/min for 2-pole machine in Coal plant, 1500 r/min for 4-pole machine in Nuclear plant.

Round rotor (turbo generator).

Generator with long shaft but small diameter size due to higher speed and less pole-pair.

Features: Hydroelectric Generator (50 Hz)

Low rotating speed: 150 r/min for 40-pole, 300 r/min for 20-pole. In general, less than 1000 r/min.

Salient pole (hydro generator).

Generator with short shaft but big diameter size due to lower speed and more pole-pair.

Q2 – A magnetic circuit with a single air gap is shown as follows. The core dimensions are

Cross-sectional Area $A_c = 3.8\ \text{cm}^2$

Mean core length $l_c = 30$ cm

Gap length $g = 1.5$ mm

$N = 80$ turns

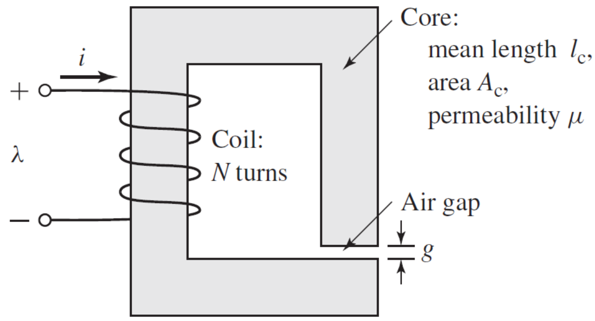
Assume that the core is of a specified relative permeability (μ_r=3000) and neglect the effects of fringing fields at the air gap and leakage flux.

(a) Calculate the reluctance of the core R_c and that of the gap R_g. For a current of $i = 1.8$ A, calculate (10 pts)

(b) the total flux φ, (5 pts)

(c) the flux linkages λ of the coil, and (5 pts)

(d) the coil inductance L. (5 pts)



Solution

(a)

$$\mathcal{R}_c = \frac{l_c}{\mu A_c} = \frac{l_c}{\mu_r \mu_0 A_c} = 0.21\times10^6 \quad \text{A/Wb}$$

$$\mathcal{R}_g = \frac{g}{\mu_0 A_c} = 3.141\times10^6 \quad \text{A/Wb}$$

(b) $\Phi = \dfrac{NI}{R_c + R_g} = 4.297\times10^{-5} \quad \text{Wb}$

(c) $\lambda = N\Phi = 3.438\times10^{-3} Wb$

(d) $L = \dfrac{\lambda}{I} = 1.91 mH$

Q3 - A DC series motor takes 35 A at 220 V and runs at 1000 rpm. If the armature and field resistances are 0.25 Ω and 0.15 Ω, respectively and the iron and friction losses are 600 W, find the torque developed in the armature. What will be the output power of the motor? (20 pts)

Solution

Armature torque is given by $T_a = \dfrac{E_a I_a}{2\pi N}$

$$E_a = V - I_a(R_a + R_{se}) = 220 - 35\times(0.25+0.15) = 206V$$

$$N = \frac{1000}{60} = \frac{50}{3} r.p.s; T_a = 206\times\frac{35}{2\pi(50/3)} = 68.85 Nm$$

Copper loss in armature series-field resistant=35×35×0.4=490 W

Iron and friction losses = 600 W; Total losses = 490+600 = 1090 W

Motor input power = 220×35=7700 W

Motor output power = 7700-1090=6610 W

Q4 – A 25-kW 125-V separately excited DC machine is operated at a constant speed of 3000 r/min with a constant field current such that the open-circuit armature voltage is 127 V. The armature resistance is 0.03 Ω.
Compute the armature current, terminal power, and electromagnetic power and torque when the terminal voltage is
(a) 130 V and (20 pts)
(b) 124 V. (20 pts)

Solution

(a)

$V_t = 130\text{V}$ and $E_a = 127\text{V}$,

$$I_a = \frac{V_t - E_a}{R_a} = \frac{130-127}{0.03} = 100\text{A}$$

In the motor direction, and the power input at the motor terminal is

$$V_t I_a = 130 \times 100 = 13kW$$

The electromagnetic power is given by

$$E_a I_a = 127 \times 100 = 12.7kW$$

In this case, the dc machine is operating as a motor and the electromagnetic power is hence smaller than the motor input power by the power dissipated in the armature resistance.
Finally, the electromagnetic torque is given

$$T_{mech} = \frac{E_a I_a}{\omega_m} = \frac{12.7 \times 10^3}{(3000 \times 2\pi / 60)} = 40.425\text{N}\cdot\text{m}$$

(b)

In this case E_a is larger than Vt and henc armature current will flow out of the machine, and thus the machine is operating as a generator. Hence

$$I_a = \frac{E_a - V_t}{R_a} = \frac{127-124}{0.03} = 100\text{A}$$

and the terminal power is

$$V_t I_a = 124 \times 100 = 12.4\text{kW}$$

The electromagnetic power is

$$E_a I_a = 127 \times 100 = 12.7\text{kW}$$

and the electromagnetic torque is

$$T_{mech} = \frac{12.7 \times 10^3}{(3000 \times 2\pi / 60)} = 40.425\text{N}\cdot\text{m}$$