ELL 203 Electromechanics
Minor Test-2 SETA

Date and Time: 28/09/2019 11:00-12:00 hrs
Venue : LH 111
Max Marks: 20

1. Please do not ask for any clarifications.
2. In "TRUE" or "FALSE" questions, no marks will be awarded unless the reason is specified.

A. STATE "TRUE" OR "FALSE" AND GIVE REASON(S): (**3 X 2=6 MARKS**)

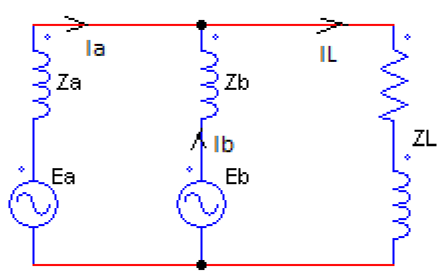
i) A DC machine's armature core always should be laminated.
True. It should be laminated to reduce eddy current losses because the induced emf/current in the armature of a DC machine is AC which is converted into DC by split ring brush arrangement.

ii) Two three-phase transformers A and B, each of 100 kVA, 400/1kV, 50 Hz rating with Y-Δ and Δ-Δ connections respectively, can successfully be operated in parallel to share a common 3-phase load, provided their equivalent impedances are comparable.
False. The voltages of the primary and secondary, the connections, frequency and phase sequence should match for two transformers to operate in parallel apart from their equivalent impedances being comparable. Here, the connections do not match.

iii) In a DC machine, the angle between field and armature fluxes are continuously changing making its analysis really difficult.
False. The split ring and brush arrangement allows the armature and field fluxes to be always at quadrature to each other to maximize torque production. This makes the analysis of the DC machines also to be carried out easily.

B. T Derive the expressions for (i) circulating current between two transformers operating in parallel on no-load condition (ii) load sharing between them, **when their no-load secondary voltages are marginally different**. Two single-phase transformers A and B of 100 kVA and 200 kVA ratings respectively with voltage ratios of 1kV/2kV have no-load voltages of 2010V and 1996V on the HV side while being connected to a 1kV source on the LV side. If their pu impedances (on their own bases) are 0.02+j0.06 and 0.018+j0.054 respectively, then (iii) calculate the circulating current between them on no-load condition. (iv) Determine the kVA sharing between the two transformers when the total load power is 240kVA at unity power factor, ignoring the difference in their no-load secondary voltages. **(DERIVATIONS+CALCULATIONS: 3.5+3.5 MARKS)**

Derivations: done in the class



When no-load, IL=0; so, there will be circulating current from Ea to Eb which is given by (Ea-Eb)/(Za+Zb).
Ia = -Ib under this condition (as per KVL)
For transformer A Zbase = 40Ω (HV side)
For transformer B, Z base = 20Ω(HV side)

So, Za -=0.8+j2.4 Ω and Zb =0.36+j1.08 Ω
I circulating = (2010-1996) V/(0.8+j2.4+0.36+j1.08)Ω = 14/3.668 = 3.8165 A
S_L=240 kVA Sa= S_L *Zb/(Za+Zb) =74.46 kVA Sb= S_L *Za/(Za+Zb) = 166.19 kVA

C. An electromagnetic system has a λ-i relationship as

$$\sqrt{\lambda} = \frac{5\,i}{g}$$

where g = air gap length. For an AC current $i = 2\sqrt{2}\,\mathrm{Sin}(314t)$ and g=1 cm, determine the average mechanical force on the moving part using (i) W_f and (ii) W_f'. **(4 MARKS)**

SOLUTION:

$i = 0.2*g\sqrt{\lambda}$ For an i_{rms} of 2 A, λ in Web $=10^6$

$Wf = \int i d\lambda = 0.13333g\lambda^{(3/2)}$

$-\partial Wf/\partial g = 0.1333\lambda^{(3/2)} = -1.333\text{x}10^8$ N

$Wf' = \int \lambda di = \int (5i/g)^2 di = 25i^3/3g^2$

Force $= \partial Wf'/\partial g = -50i^3/(3g^3) = -1.333\text{x}10^8$ N

D. A DC shunt generator has the following data for the open circuit characteristic, while being run at 800 rpm.

Eg (V)	0	30	58	83	103	120	135	147	156.8
I_f (A)	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8

Calculate the critical field circuit resistance ($R_{f\ Critical}$) for this generator at 800 rpm. If the machine is driven at 1000 rpm and if the field circuit resistance is 245Ω, what will be the no-load terminal voltage for this generator in steady state (assuming voltage build-up has happened) and how much would be the field current at this operating point? (**3 MARKS**)

SOLUTION:

Rf Critical at 800 rpm (from OCC) =initial slope of OCC= 30/0.1 = 300 Ω
Machine is driven at 1000 rpm. OCC at this speed is given by

Eg (V)	0	37.5	72.5	103.75	128.75	150	168.75	183.75	196
I_f (A)	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8

In steady state $I_f R_f$ = Eg=Vt under open-circuit condition
196/0.8 = 245Ω. So, Final no-load terminal voltage at 1000 rpm and Rf =245Ω is 196V corresponding field current =0.8A