EE 334

QUIZ 3

FEBRUARY 20, 2020

- You have **50 minutes** to answer the questions.
- Total marks: **20**.
- Please write your **name** and **roll number** at appropriate places.
- You can solve the problems in the supplementary sheets provided. Note that supplementary sheets **will not** be graded.
- For non-MCQ questions, write down the **key steps** of your solution of the problems in the space provided.

$325.3 \times \frac{\sqrt{3}}{\sqrt{2}}$

Name: Kaustav Dey **Roll number:** ____________

1. The **peak** value of the phase-to-neutral voltage of a balanced three-phase star connected load is 325.3 V. The rms value of the line-to-line voltage is 398.4 V. **1 mark**

2. The rms value of the line currents of a balanced three-phase delta connected load is 10 A. The rms value of the delta branch currents is 5.77 A. $10/\sqrt{3}$ A **1 mark**

3. The units of active power, reactive power and apparent power are W, VAr and VA respectively. **2 marks**

4. The rating of a Δ-Y connected three-phase transformer is given as 100 MVA, 15 kV/110 kV, 50 Hz. Here 100 MVA refers to **1 mark**

   (a) total three phase active power, (b) total three phase apparent power,
   (c) per phase active power, (d) per phase apparent power.

5. The rating of a Δ-Y connected three-phase transformer is given as 100 MVA, 15 kV/110 kV, 50 Hz. Here 110 kV refers to **1 mark**

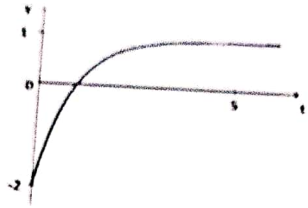
   (a) line-to-line rms voltage, (b) line-to-neutral peak voltage,
   (c) line-to-line peak voltage, (d) line-to-neutral rms voltage.

6. The synchronous speed of a 50 Hz, 20 poles synchronous machine is 300 rpm. **1 mark**

$\frac{120 \times 50}{20}$

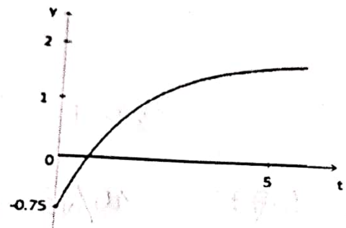
7. Which of the following plots captures the unit step response of $G(s) = \frac{1-2s}{1+s}$? 1 mark

(A)

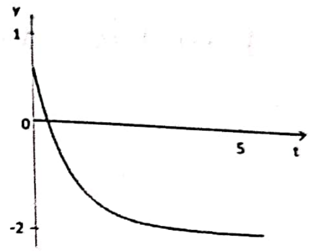


(B)

(C)



(D)



$$\left[G(s) = 1+sT_1 / 1+sT_2 \right]$$

Initial response $y(t=0^+) = \lim_{s\to\infty} G(s) \cdot 1$

Transient gain $= -2$.

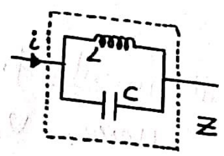
Steady State $y(t=\infty) = \lim_{s\to 0} G(s) \cdot 1$

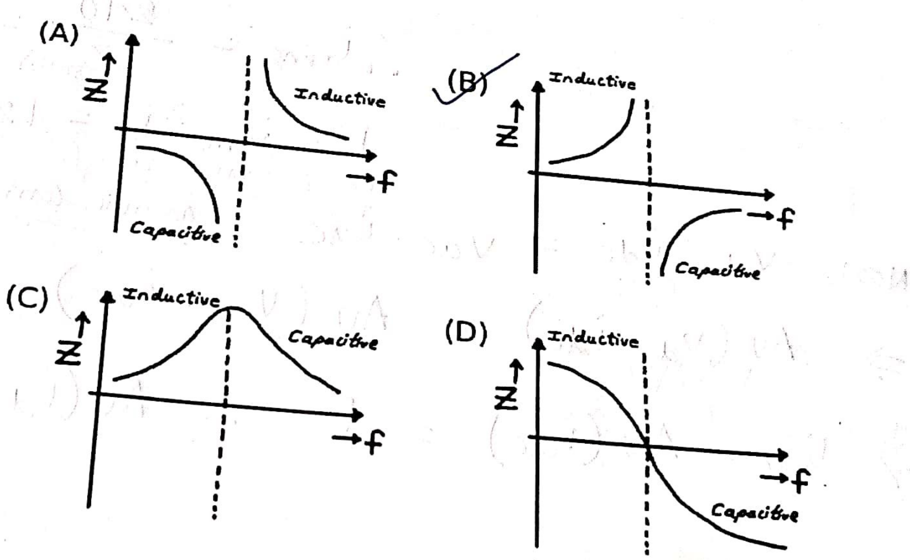
Steady State Gain $= 1$.

Time constant of response : $T_2 = 1s$.

Cont.

8. A parallel L-C component is shown below. Which of the following plots captures the imaginary part of the equivalent impedance $Z(j\omega)$ as a function of $\omega = 2\pi f$? 2 marks





$$Z = (j\omega L) \,||\, \left(\frac{1}{j\omega C}\right) = \frac{j\omega L \cdot \frac{1}{j\omega C}}{j\omega L - j\frac{1}{\omega C}}$$

$$= \frac{1}{j}\left[\frac{L/C}{\omega L - 1/\omega C}\right]$$

$$= j\,\frac{L/C}{\frac{1}{\omega C} - \omega L}$$

$$\lim_{\omega \to 0} Z(j\omega) = 0.$$

For small ω,

$1/\omega C > \omega L$, so

$\text{Im}(Z(j\omega)) > 0.$

and $Z(j\omega) \approx j\omega L.$

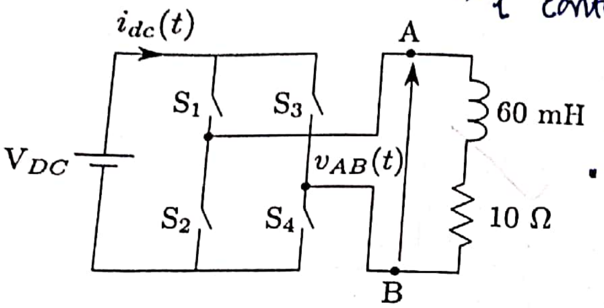
Similarly, $Z(j\omega) \approx \frac{1}{j\omega C}$ in high frequency range.

Cont.

9. A voltage source converter (VSC) based device is connected to an R-L component as shown in the figure. The converter switching strategy and inductance are chosen such that the harmonics in the load current is negligible*. The fundamental frequency of the inverter output voltage $v_{AB}(t)$ is 50 Hz. If the rms value of the fundamental component of $v_{AB}(t)$ is 240 V and the dc voltage V_{DC} is 500 V, then the average value of the dc side current $i_{dc}(t)$ is ______ A.

3 marks

*i contains only fundamental component



Here, $V_{AB\,rms} = 240$ V.

$\therefore i_{rms} = \dfrac{240}{Z_{(50Hz)}} = 11.248$ A.

$P = i_{rms}^2 R = 1265.19$ W.

Now, $V_{dc}\, i_{dc} = V_{ac} \cdot i_{ac}$ (assume converter is lossless)

$\Rightarrow Av(V_{dc}\, i_{dc}) = Av(V_{ac} \cdot i_{ac})$

$\Rightarrow V_{dc} \cdot Av(i_{dc}) = P \quad \therefore Av(i_{dc}) = \dfrac{P}{V_{dc}}$

$= 2.53$A.

10. A 50 MVA, 20 kV synchronous generator is supplying a load. The field voltage is regulated using the following control strategy

$$E_{fd}(s) = \frac{0.2}{1+0.01s}(V_{ref}(s) - V_t(s)).$$

It is found that when the reference voltage V_{ref} has been set to 20 kV, the field voltage E_{fd} required (in steady state) is 100 V. The terminal voltage V_t in steady state will be

1 mark

(a) 20.5 kV (b) 19.5 kV (c) 19.9 kV (d) 20.1 kV (e) 20 kV.

At steady state,

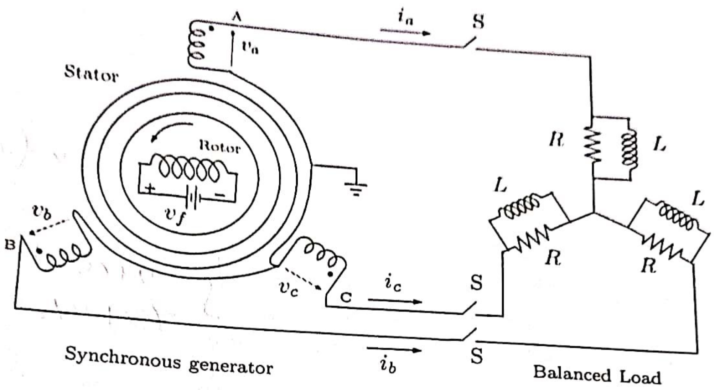
$$\lim_{s\to 0} E_{fd}(s) = \lim_{s\to 0} \frac{0.2}{1+0.01s}\left(V_{ref}(s) - V_t(s)\right).$$

$$0.1 = 0.2 \times \left[20 - \lim_{s\to 0} V_t(s)\right]$$

$$\therefore \lim_{s\to 0} V_t(s) = 20 - 0.5 = 19.5\text{ kV}.$$

Cont.

11. A 2-pole, 50 Hz synchronous generator is kept in open-circuit condition as shown in the figure. The field voltage v_f is applied such that the rated three-phase balanced voltages appear at the stator terminals. The speed and the field voltage v_f of the synchronous machine is kept **constant**. If the stator terminals are now connected to a balanced three-phase star connected R-L load by closing the switch S, then in steady state. Tick all the option(s) that is/are correct. **3 marks**



(a) the relative angle between the rotating stator and rotor fluxes is constant and is determined by the nature of load (values of R and L),

(b) the flux due to the stator currents rotates at 50 Hz in the same direction as that of the field flux,

(c) the relative angle between the rotating stator and rotor fluxes is varying and is determined by the nature of load (values of R and L),

(d) the resultant flux (due to the stator and rotor currents) is changed due to this connection,

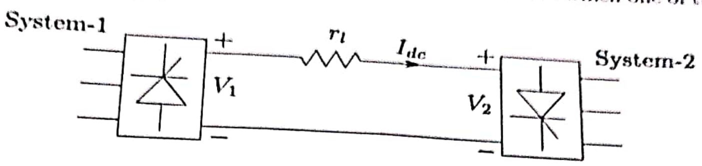
(e) the flux due to the stator currents rotates at 50 Hz in the opposite direction as that of the field flux,

(f) the flux due to stator currents does not rotate at 50 Hz.

Cont.

12. Consider an HVdc link which uses thyristor based line-commutated converters as shown in the figure. For a power flow of 750 MW from system-1 to system-2, the voltages at the two ends, and the current, are given by: $V_1 = 500$ kV, $V_2 = 485$ kV and $I_{dc} = 1.5$ kA. If the direction of power flow is to be reversed (that is, from system-2 to system-1) without changing the electrical connections, then which one of the following combinations is feasible?

1 mark



(a) V_1 = -500 kV, V_2 = -485 kV and I_{dc} = 1.5 kA $\longrightarrow$ Infeasible. $\left(I_{dc} \neq \frac{V_1 - V_2}{r_l}\right)$

~~(b)~~ V_1 = -485 kV, V_2 = -500 kV and I_{dc} = 1.5 kA

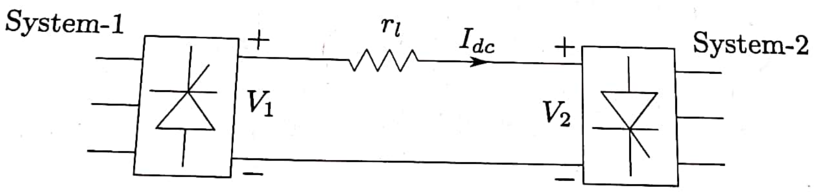
(c) V_1 = 500 kV, V_2 = 485 kV and I_{dc} = -1.5 kA

(d) V_1 = -500 kV, V_2 = -485 kV and I_{dc} = -1.5 kA

} Current cannot reverse.

13. Consider a 500 kV, 1000 MW HVdc link which uses thyristor based line-commutated converters as shown in the figure. The HVdc link is operating at $V_1 = 500$ kV, $V_2 = 490$ kV. The line resistance (r_l) of the HVdc link is 5 Ω. The link is therefore delivering 980 MW to System-2. The power supply to System-2 is to be reduced to 950 MW using converter firing angle control at both stations. Assuming that if all the following operating conditions are achievable using converter control, which of the following would you prefer and why?

2 marks



(a) V_1 = 485 kV, V_2 = 475 kV and I_{dc} = 2 kA

(b) V_1 = 490 kV, V_2 = 480.1 kV and I_{dc} = 1.98 kA

~~(c)~~ V_1 = 499.7 kV, V_2 = 490 kV and I_{dc} = 1.94 kA

(d) V_1 = 392.5 kV, V_2 = 380 kV and I_{dc} = 2.5 kA

1) At minimum current, losses will be minimum.

2) Also dc voltages are higher, implying α is lesser. So, $(\cos\alpha)$ will be better. Converters will draw lesser reactive power.

(Any one of the above reasons is required to be written)

The End.

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ent AVRs.