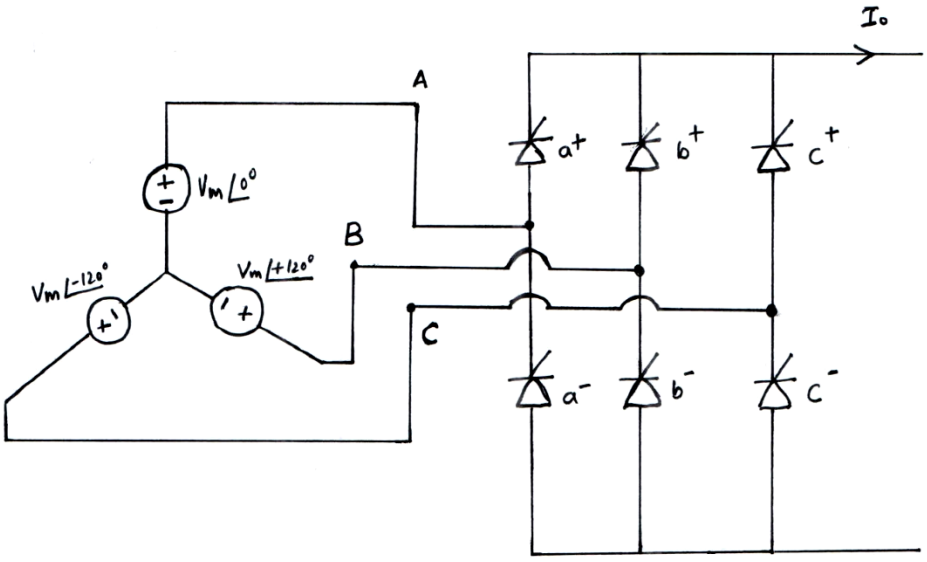
Punjab Engineering College, Chandigarh (Deemed to be University)
Department of Electrical Engineering
EL1009 (Power Electronics) Midterm Examination/2022-23 (ODD)
DB/PE-MT/20221013(Thursday)/11:30-13:00 Hrs

Q1. A single phase fully controlled thyristor converter bridge is feeding an R-L Load with R=100 Ω and L=10 mH. The AC side input voltage is 220 V (RMS). The converter is operating at a firing angle of 30 degrees. Determine the average output voltage and average current through the R-L load on DC Side. **[15]**

Q2. A three phase thyristorized full bridge converter is connected to a three phase source as shown in the figure. The converter is required to be fired sequentially. Write the sequence in which converter thyristors are required to be fired along with governing voltages of each device for measurement of delay. Assume that continuous ripple free current is drawn from the DC side. **[10]**



Q3. The maximum and minimum value of the instantaneous output voltage of a 3-pulse convertor feeding an R-L load drawing continuous current from the convertor are 338.84 volt and zero respectively. The line voltage of the three-phase system is 415 V (RMS). Determine the average output voltage of the convertor and the average current drawn from the DC side if value of R=10 Ω and L=0.1H. **[15]**

Do not write/mark anything on the question paper except your Name & SID

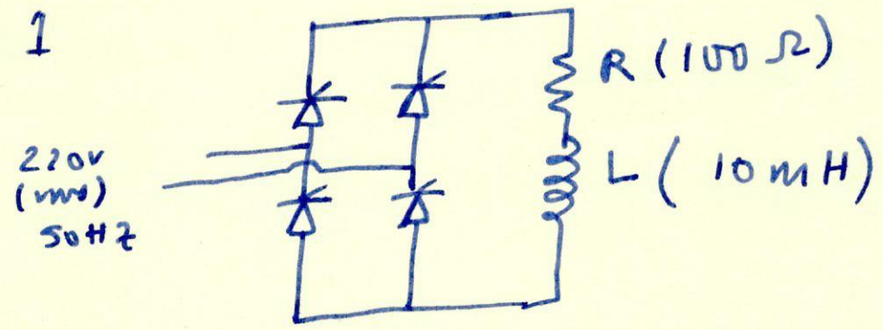
Name: _____ **SID: _____**

Sharing of any kind of stationery items/calculators during the course of examination will be treated as <u>UNFAIR MEANS CASE</u>

POWER ELECTRONICS EL1009 Midterm Solutions

DOE → 13/10/22
11:30 – 1:00

Ans 1



$$V_m \sin \omega t - iR - L\frac{di}{dt} = 0$$

$$i(t) = \frac{V_m}{|Z|}\sin(\omega t - \phi) + A e^{-Rt/L}$$

$R = 100 \quad L = 10\,mH \quad \omega = 2\pi 50$

$$\omega L = 10 \times 10^{-3} \times 2\pi 50$$
$$= \pi$$

$$\Rightarrow |Z| = \sqrt{100^2 + \pi^2} = 100.04933$$

$$\tan\phi = \frac{\omega L}{R} = \frac{\pi}{100} \Rightarrow \phi = 1.799^\circ$$

$$i\left(\frac{\pi}{6\omega}\right) = 0 \Rightarrow 0 = \frac{220\sqrt{2}}{100.04933}\sin\left(30^\circ - 1.799^\circ\right) + A e^{\frac{-100t}{10\times10^{-3}}}$$

$$\Rightarrow 3.1097 \sin(30^\circ - 1.799^\circ) + A e^{-10000t} = 0$$

$$\Rightarrow 1.46955 + A e^{-\frac{10000\pi}{6\omega}} = 0$$

$$1.46955 + A e^{-16.667} = 0$$

$$\Rightarrow A = -25434648.03$$

$$i(t) = 3.1097 \sin(\omega t - 1.799^\circ) - 25434648.03\, e^{-10000t}$$

$i\left(\frac{\beta}{w}\right) = 0$ $\quad \beta =$ extinction angle

$$\Rightarrow 3.1097 \sin(\beta - 1.799^\circ) - 25434648.03\, e^{-\frac{10000\beta}{w}} = 0$$

$$\Rightarrow 3.1097 \sin(\beta - 0.031398) - 25434648.03\, e^{-31.83\beta} = 0$$

$$\pi = 3.14 \rightarrow f(\beta) = 0.097$$

$$\beta = 3.1729 \text{ radians}$$

$$= 181.79377880^\circ .$$

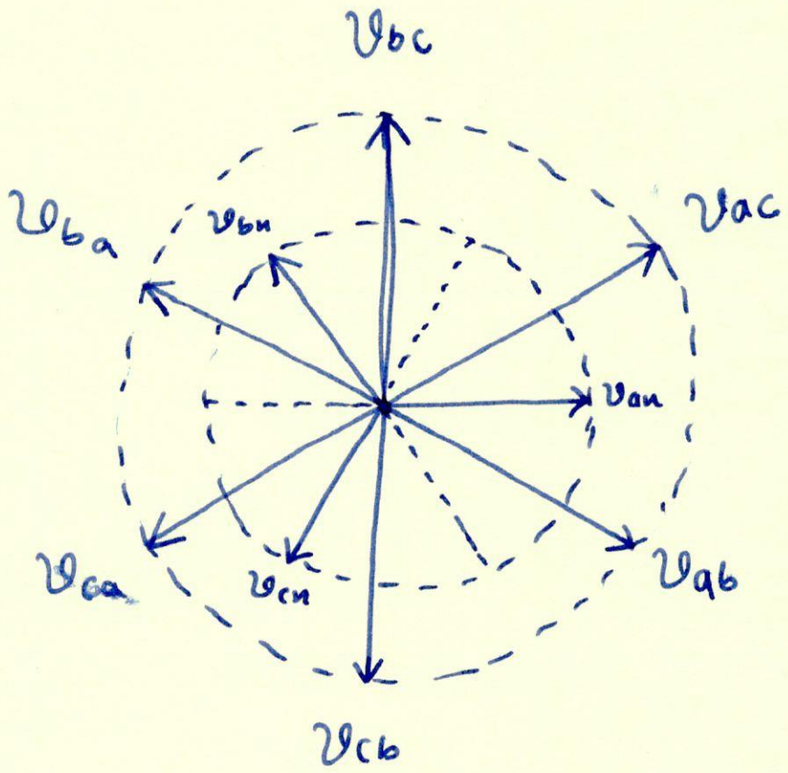
$$\langle v_0 \rangle = \frac{1}{\pi/w} \int_{\alpha/w}^{\beta/w} V_m \sin wt \, dt$$

$$= \frac{w}{\pi} \frac{V_m}{w} \left[-\cos wt \right]_{\alpha/w}^{\beta/w}$$

$$= \frac{V_m}{\pi} (\cos\alpha - \cos\beta) = \underline{184.7529\ V}$$

$$\langle i_0 \rangle = \frac{184.7529}{100} = \underline{1.847529\ A} .$$

Ans 2 :-



⇒ Sequence of peak of line voltage are

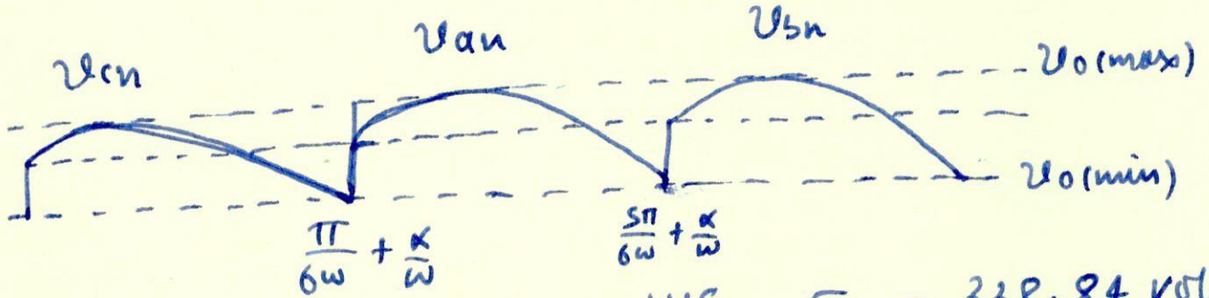
ab cb ca ba bc ac

⇒ Sequence in which thyristor pairs are find are

a^+b^- c^+b^- c^+a^- b^+a^- b^+c^- a^+c^-

CONDUCTING PAIR	INCOMING PAIR	INCOMING DEVICE	GOVERNING VOLTAGE
a^+c^-	a^+b^-	b^-	v_{cb}
a^+b^-	c^+b^-	c^+	v_{ca}
c^+b^-	c^+a^-	a^-	v_{ba}
c^+a^-	b^+a^-	b^+	v_{bc}
b^+a^-	b^+c^-	c^-	v_{ac}
b^+c^-	a^+c^-	a^+	v_{ab}

Ans 3 :-



peak phase voltage $= \frac{415}{\sqrt{3}} \times \sqrt{2} = 338.84$ volts $= V_m$

$v_{o(max)}$ = peak phase voltage $= 338.84$.

$$v_{o\,min} = v_{cn}\Big|_{\frac{\pi}{6\omega}+\frac{\alpha}{\omega}} = v_{an}\Big|_{\frac{5\pi}{6\omega}+\frac{\alpha}{\omega}}$$

$$v_{cn} = V_m \sin(\omega t + 120^\circ)$$

$$v_{o(min)} = V_m \sin\left(\alpha + \frac{\pi}{6} + \frac{2\pi}{3}\right) = V_m \sin\left(\frac{5\pi}{6} + \alpha\right)$$

$$= 0$$

$$\Rightarrow \quad \alpha = \frac{\pi}{6}$$

$$\langle v_o \rangle = \frac{3\sqrt{3} V_m}{2\pi} \cos\alpha = \frac{3\sqrt{3}}{2\pi}\ 338.84 \times \frac{\sqrt{3}}{2}$$

$$= \underline{242.67\ V}$$

$$\langle i_o \rangle = \frac{\langle v_o \rangle}{R} = \frac{242.67}{10} = \underline{24.267\ A}.$$

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