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Assignment - 2

Power Electronics

1. $V_{out} = 200V$, $f = 50Hz$, $V_m = 415V$

We know that

$$V_{out} = \frac{3\sqrt{2}}{\pi} V_m \cos\alpha$$

where

$\alpha \Rightarrow$ conduction Angle or firinge Angle

$$\cos^{-1}\left(\frac{V_{out} \times \pi}{3\sqrt{2}\, V_{max}}\right) = \alpha$$

$$\therefore \cos^{-1}(0.35685) = \alpha$$

$$\alpha = 69.093^\circ$$

2) Control Angle = 20°/40°/90°/120°

(i) 20° factor $= \frac{3}{\pi}\cos\alpha \Rightarrow \frac{3}{\pi}\cos 20^\circ = 0.897$

Average load = 0

$$\therefore \text{Avg Voltage}(V_{dc}) = \frac{3\sqrt{3}}{\pi} V_m \cos\alpha$$

$$= \frac{3\sqrt{3}}{\pi} \times 415 \cos 20^\circ$$

$$V_{dc} = 645.009V$$

$$\text{Average Current} = \frac{V_{dc}}{R} \Rightarrow \frac{645.009}{50} \Rightarrow 12.9$$

(ii) 40°

$$P_f = \frac{3}{\pi}\cos\alpha = \frac{3}{\pi}\cos 40^\circ = 0.732$$

Avg current

So Avg voltage

$$V_{dc} = \frac{3\sqrt{3}\,V_m}{\pi}\cos\alpha$$

$$\Rightarrow 525.82V$$

$$\text{Avg current} \Rightarrow \frac{V_{dc}}{50} = 10.51A$$

(iii) 90°

$$P_f = \frac{3}{\pi}\cos\alpha = \frac{3}{\pi}\cos 90^\circ = \frac{3}{\pi}(0) = 0$$

Avg voltage = 0

$$\text{Avg current} = \frac{V_{dc}}{50} = 0\ A$$

(iv) 120° $P_f = -0.477$

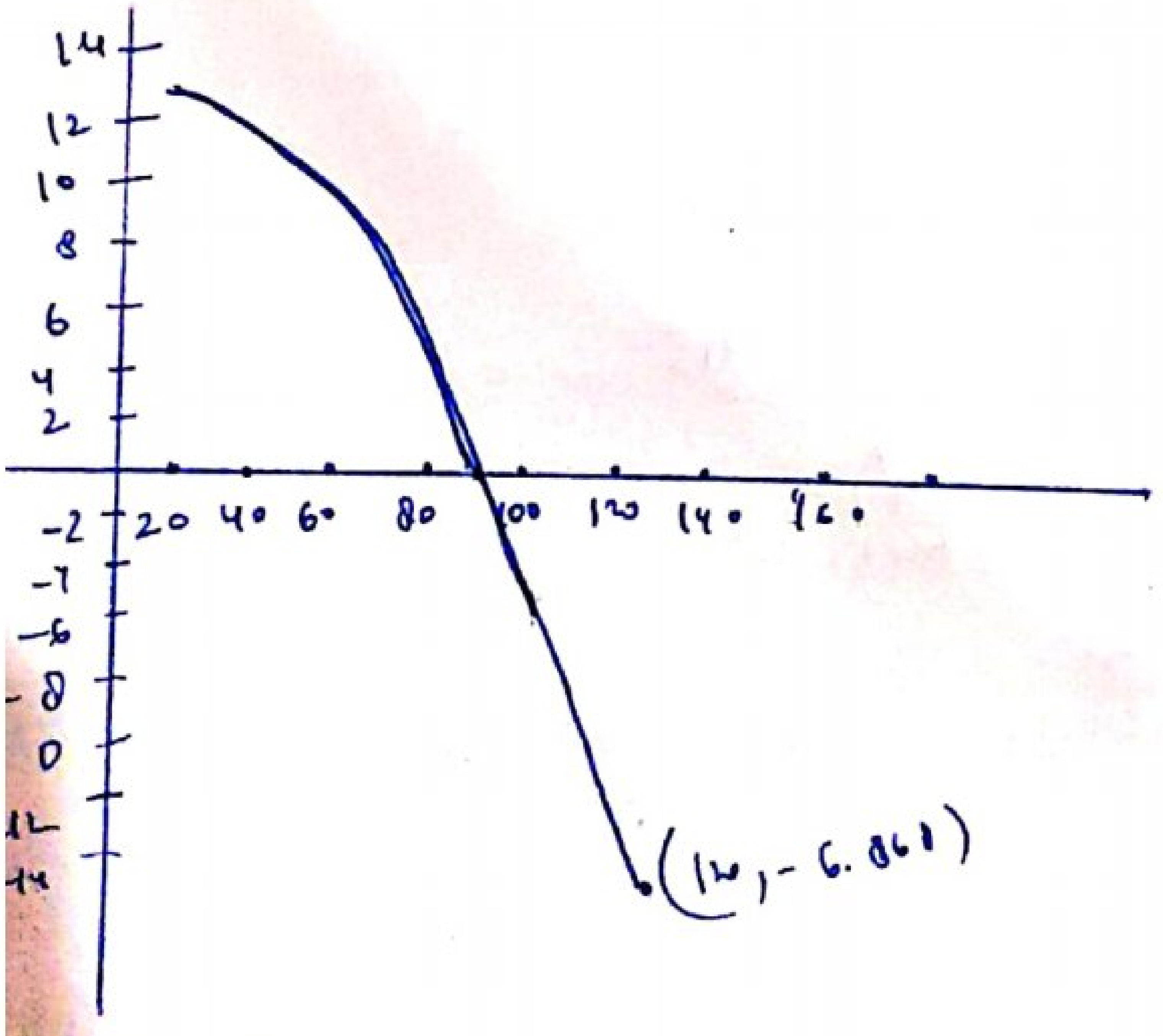
$$\text{Avg Voltage} = \frac{3\sqrt{3}\,V_{in}\cos 120}{\pi} = 686.4 \times \cos 120$$

$$\Rightarrow -343.4V$$

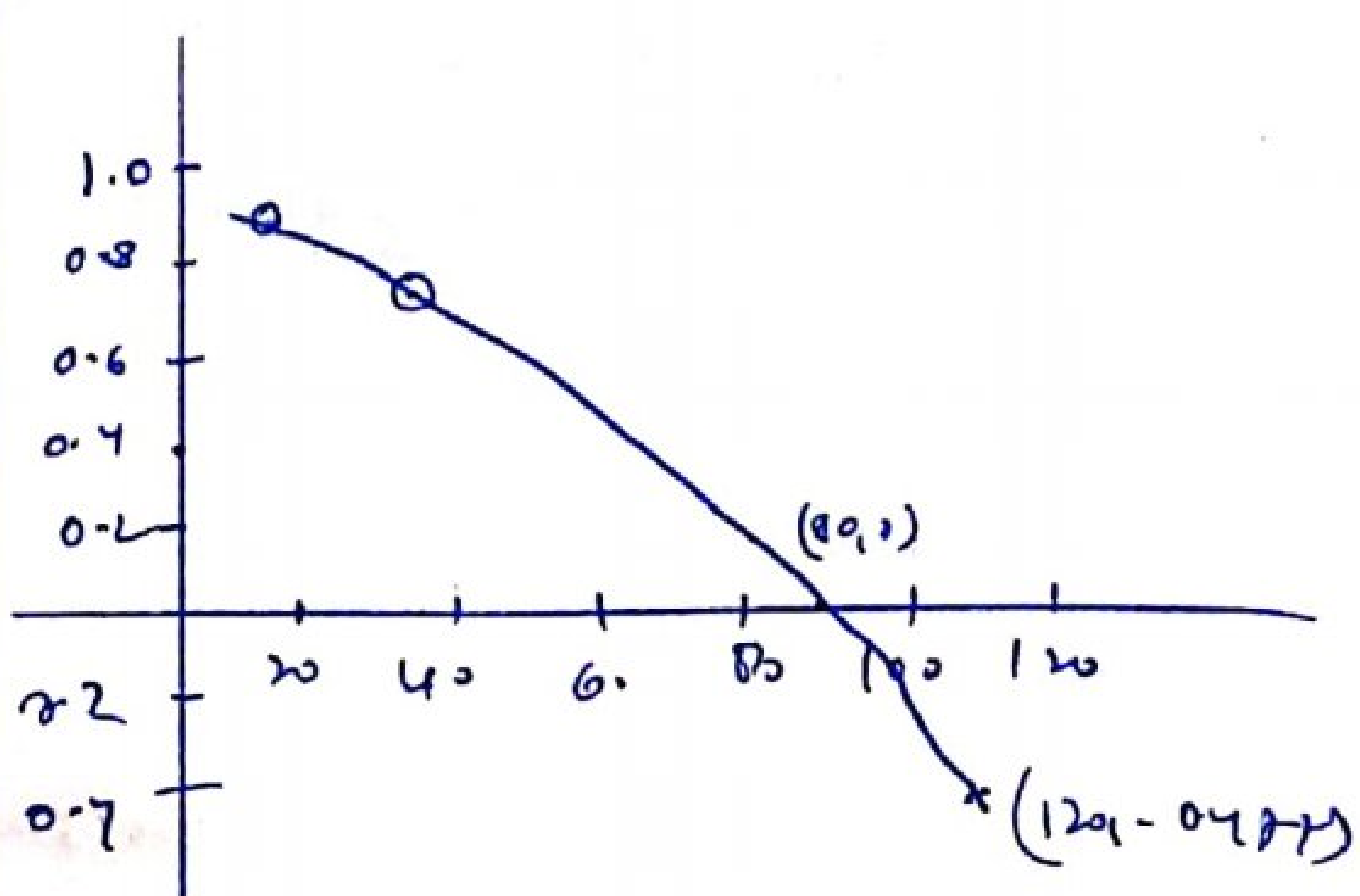
$$\text{Avg current} = \frac{\text{Avg voltage}}{50} \Rightarrow -\frac{343.4}{50} = -6.868A$$

Plot

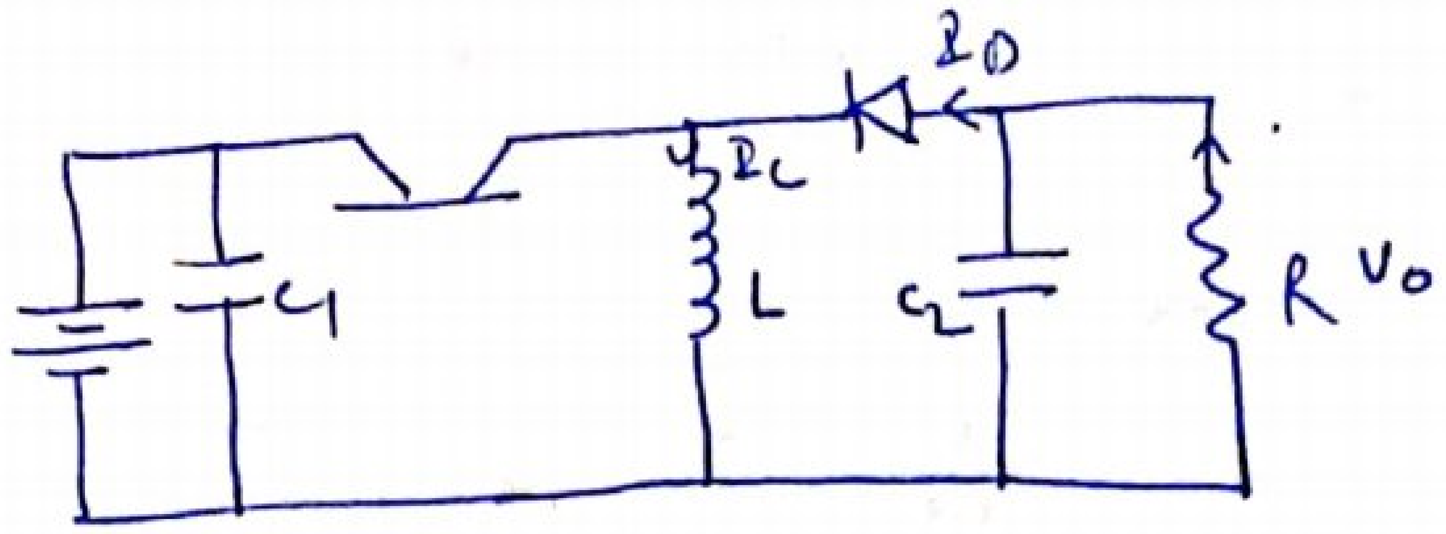
Control Angle v/s Avg Load current :-



Control Angle v/s Power factor



② Buck Boost Converter



Mode 1 → switch is ON

$$T_{ON} = DT$$

where D = Duty cycle

$$D = \frac{T_{ON}}{(T_{ON}+T_{Off}) = T}$$

∴ voltage inductor

$$(V_L)_{ON} = V$$

Mode-2 → switch off

$$T_{off} = (1-D)T$$

$$(V_{L\,off}) = -V_0$$

As per volt-second across inductor

$$(V_L)_{ON} T_{ON} + (V_L)_{off} T_{off} = 0$$

$$V(DT) + (-V_0)(1-D)] = 0$$

$$VDT = V_0(1-D)T$$

$$V_D = V_0(1-D)$$

$$V_0 = \frac{V_D}{1-D}$$ → o/p voltage of a Buck Boost Converter

\# Derivation of duty cycle from the above equation

$$\frac{V_0}{V} = \frac{D}{1-D}$$

$$\frac{1-D}{D} = \cancel{\frac{D}{D}}\,\frac{V}{V_0}$$

$$\frac{1}{D} = \frac{V}{V_0}+1 \quad \left[\frac{V_0}{V+V_0} = D\right]$$ Duty cycle of Buck Boost converter

we know that

$$L\frac{d}{dt}i_L = V_L$$

Integrating during the ON Time

$$\int_0^{T_{ON}} \frac{L\,di_L\,dt}{dt} = \int_0^{T_{ON}} v_L\,dt$$

$$\Delta i_L = \frac{1}{L} V_{LON} T_{ON}$$

$$D i_L = \frac{1}{L} V_{in} T_{ON}$$

$$D i_L = \frac{1}{L} V_D T$$

$$\Delta i_L = \frac{VD}{fL} \Big\} \text{ ripple current formula}$$

we know that

$$c\frac{dv_c}{dt} = i_c$$

& during ON Time $i_c = -i/p = -i.$

Therefore

$$\frac{c\,dv_c}{dt} = \frac{i_L - i_o}{\text{for total time}}$$

$$\Delta V_L = \frac{1}{C} T_{ON} i_o$$

$$\Delta V_L = \frac{1}{C} \Delta T \frac{V_o}{R.}$$

$$\Delta V_C = \frac{1}{C}\frac{D}{F} \frac{V_{in} D}{1-D} = \frac{V_{in} D^2}{cf(1-D)R}$$

Critical Inductance

$$V = L\frac{di}{dt}$$

$$V = L\omega t \; \frac{I_{peak}}{DT}$$

$$V = L\omega t \; \frac{2 I_{avg}}{DT}$$

$$L\omega = \frac{V_1 DT}{2(\text{[illegible]})}$$

$$L_C = \frac{(1-D)R}{2f}$$

$$\# \left[C_L = \frac{1-K}{16 L f^2} \right]$$