Power Electronics Education Electronic Book

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Tutorial 4: Controlled Rectifiers

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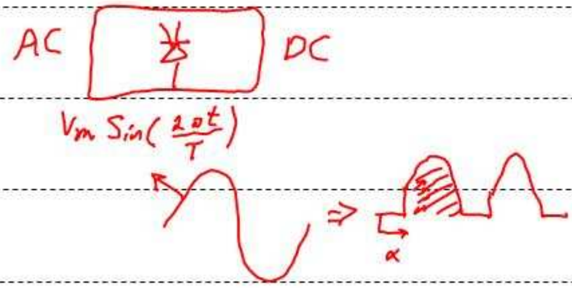
Q1: A single-phase full-wave controlled rectifier with a pure resistive load is connected to a power supply of 240V and 50 Hz.

(a) What are firing angles to obtain 100 V and 50 V?

(b) Compare the results with an inductive load (continuous current) ?

$$V_{out} = \frac{V_m}{\pi}\left[1 + \cos(\alpha)\right]$$



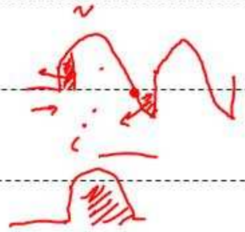
$$100 = \frac{\sqrt{2}\times 240}{\pi}\left[1 + \cos(\alpha)\right] \quad \pi \rightarrow 3.14$$

$$\frac{314}{\sqrt{2}\times 240} = 1 + \cos(\alpha)$$

$$\cos(\alpha) = \frac{314}{\sqrt{2}\times 240} - 1 \longrightarrow \alpha = 94^{\circ}$$

$$\cos(\alpha) = \frac{50\times 3.14}{\sqrt{2}\times 240} - 1 \longrightarrow \alpha = 122^{\circ}$$

$$V_{out} = \frac{2V_m}{\pi} \cos(\alpha)$$



$$100 = \frac{2 \times \sqrt{2} \times 240}{3.14} \times \cos(\alpha)$$

	L	R
$\cos(\alpha) = \frac{314}{\sqrt{2} \times 480} \Rightarrow$	$\alpha_{100} = 62^\circ$ ✓	$\alpha_{100} = 94^\circ$ ✓
$\cos(\alpha) = \frac{50 \times 3.14}{\sqrt{2} \times 480} \Rightarrow$	$\alpha_{50} = 76^\circ$ ✓	$\alpha_{50} = 122^\circ$ ✓

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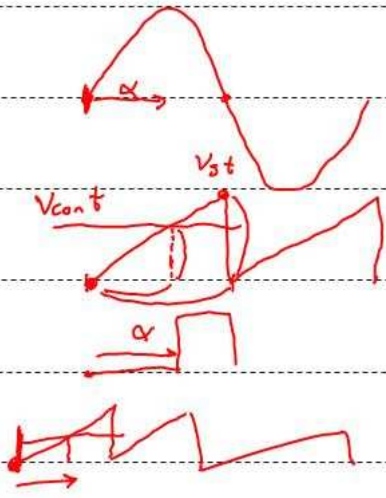
Q2: Compare a linear and a nonlinear firing angle control circuits for a controlled rectifier.

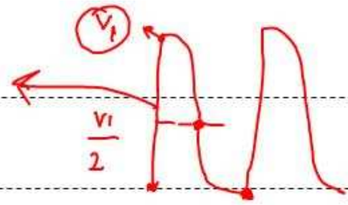
$$\frac{\alpha}{\pi} = \frac{V_{cont}}{V_{st}} \Rightarrow \alpha = \frac{\pi V_{cont}}{V_{st}}$$

$$V_{out} = \frac{2V_m}{\pi} \cos(\alpha)$$

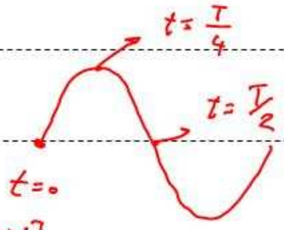
$$V_{out} = \frac{2V_m}{\pi} \cos\left(\frac{\pi V_{cont}}{V_{st}}\right)$$



$$f(t) = \frac{V_1\left[\cos\left(\frac{2\pi t}{T}\right)+1\right]}{2}$$



$$f(0) = \frac{V_1\left[\cos(0)+1\right]}{2} = \frac{V_1 \times 2}{2} = V_1$$



$$f\left(\frac{T}{2}\right) = \frac{V_1\left[\cos\left(\frac{2\pi T}{2T}\right)+1\right]}{2} = \frac{V_1}{2}\left[\cos(\pi)+1\right] = 0$$

($\cos(\pi) \rightarrow -1$)

$$f\left(\frac{T}{4}\right) = \frac{V_1\left[\cos\left(\frac{2\pi}{T}\times\frac{T}{4}\right)+1\right]}{2} = \frac{V_1\left[\cos\frac{\pi}{2}+1\right]}{2} = \frac{V_1}{2}$$

($\cos\frac{\pi}{2} \rightarrow 0$)

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$$\overline{V_{out}} = \frac{2V_m}{\pi} \cos(\alpha)$$

$$V_{cont} = \frac{V_1 \left[\cos\left(\frac{2\pi t}{T}\right) + 1\right]}{2} \Rightarrow \cos(\alpha) = \frac{2 V_{cont}}{V_1} - 1$$

$$\overline{V_{out}} = \frac{2V_m}{\pi} \left[\frac{2 V_{cont}}{V_1} - 1\right]$$

$$\overline{V_{out}} = K \cos(K_1 V_{cont})$$

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