Power Electronics Education Electronic Book

Welcome to PEEEB

Tutorial 3: Diode Rectifiers

Presenter: Dr. Firuz Zare

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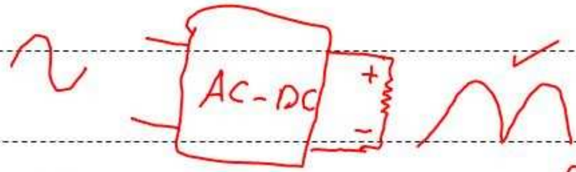
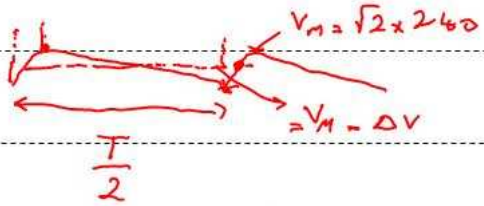
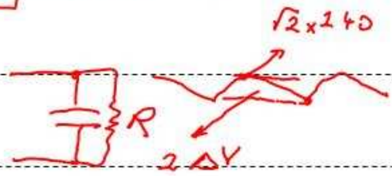
Q1: A single-phase diode rectifier with R-C load is connected to a grid with 240 V and 50 Hz. Find C value to have 20V ripple on the output side when output power is 100 watts.

$V_{in} = \sqrt{2} \times 240 \times \sin\left(\frac{2\pi t}{T}\right)$

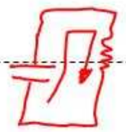






$\frac{V_{out}}{R} = i_R = \frac{V_m - \Delta V}{R}$

$C \frac{dv_c}{dt} = i_c \Rightarrow \qquad C \times \frac{-2\Delta V}{\frac{T}{2}} = -i_R$



$-C \times \frac{4\Delta V}{T} = -\left(\frac{V_m - \Delta V}{R}\right)$

$4Cf\Delta V = \frac{V_M - \Delta V}{R}$

$? \leftarrow R = \frac{V_{out}}{I} = \frac{V_{out}^2}{P_{out}}$

P_{out}

$4CfR\Delta V = V_M - \Delta V$

$f = 50\,Hz$

$\Delta V = 20\,V$

$\Delta V(1 + 4RCf) = V_m$

$\boxed{\Delta V = \frac{V_M}{1 + 4RCf}}$

$V_M = \sqrt{2} \times 240$

?

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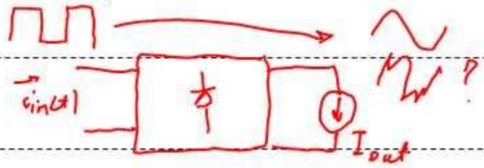
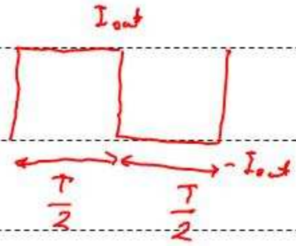
Q2: A single-phase diode rectifier is connected to a pure inductive load in which the load current, I_{out} is constant. Find the input current and its harmonics.



$$i_{in}(t) = \frac{a_0}{2} + \sum a_n \cos\left(\frac{2\pi t}{T}\times n\right) + b_n \sin\left(\frac{2\pi t}{T}\times n\right)$$

? ✓ ✓ ? ?

$$a_0 = \frac{2}{T}\int_0^T i_{in}(t)\, dt \rightarrow 0 \Rightarrow a_0 = 0$$



$$✓\ a_n = \frac{2}{T}\int_0^T i_{in}(t) \cos\left(\frac{2\pi t}{T}\times n\right) dt$$

$$✓\ b_n = \frac{2}{T}\int_0^T i_{in}(t) \sin\left(\frac{2\pi t}{T}\times n\right) dt$$

$$a_n = \frac{2}{T}\int_0^{\frac{T}{2}} I_{out} \times \cos\left(\frac{2\pi t}{T}\times n\right)dt + \frac{2}{T}\int_{\frac{T}{2}}^{T}(-I_{out}) \times \cos\left(\frac{2\pi t}{T}\times n\right)dt$$

$$= \frac{2 I_{out}}{\cancel{T}} \times \left(\frac{\cancel{T}}{2\pi n}\right) \sin\left(\frac{2\pi t}{T}\times n\right)\Big|_0^{T/2} + \frac{(-2 I_{out})}{\cancel{T}} \times \left(\frac{\cancel{T}}{2\pi n}\right) \sin\left(\frac{2\pi t}{T}\times n\right)\Big|_{\frac{T}{2}}^{T}$$

$$\sin\left(\frac{2\pi \, T/2}{T}\times n\right) = \sin(\pi n) = 0$$

$$\sin(0) = 0$$

$$\sin\left(\frac{2\pi T}{T}\times n\right)$$

$$\sin(2\pi n) = 0$$

$a_n = 0$

$b_n = ?$

$$b_n = \frac{2}{T}\int_0^{\frac{T}{2}} I_{out} \times \sin\left(\frac{2\pi t}{T}\times n\right) dt + \frac{2}{T}\int_{\frac{T}{2}}^{T} (-I_{out}) \times \sin\left(\frac{2\pi t}{T}\times n\right) dt$$

$$= \frac{2 I_{out}}{\cancel{T}} \times \left(\frac{-\cancel{T}}{2\pi n}\right) \cos\left(\frac{2\pi t}{T}\times n\right)\Bigg|_0^{T/2} + \frac{2\times(-I_{out})}{\cancel{T}} \times \left(\frac{-\cancel{T}}{2\pi n}\right) \times \cos\left(\frac{2\pi t}{T}\times n\right)\Bigg|_{T/2}^{T}$$

$$= \frac{-\cancel{2} I_{out}}{\cancel{2}\pi n}\left[\cos\left(\frac{2\pi T}{2T}\times n\right) - \cos(0)\right] + \frac{2 I_{out}}{2\pi n}\left[\cos\left(\frac{2\pi T}{T}\times n\right) - \cos\left(\frac{2\pi T}{2T}\times n\right)\right]$$

$$= \frac{-I_{out}}{\pi n}\left[\cos(n\pi) - 1\right] + \frac{I_{out}}{\pi n}\left[\cos(2\pi n) - \cos(\pi n)\right]$$

$n = 2, 4, 6 \ldots \rightarrow 0$, since $\cos(n\pi) = 1$, $\cos(2\pi n) = 1$

$n = 1, 3, 5, \ldots \rightarrow$ $\cos(n\pi) - 1 = -2$, $\cos(2\pi n) = 1$, $\cos(\pi n) = -1$, $\cos(2\pi n) - \cos(\pi n) = 2$

$$\frac{2 I_{out}}{\pi n} + \frac{2 I_{out}}{\pi n} = \frac{4 I_{out}}{\pi n}$$

$$b_1 = \frac{4 I_{out}}{\pi}$$

$$b_3 = \frac{4 I_{out}}{\pi 3}$$

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