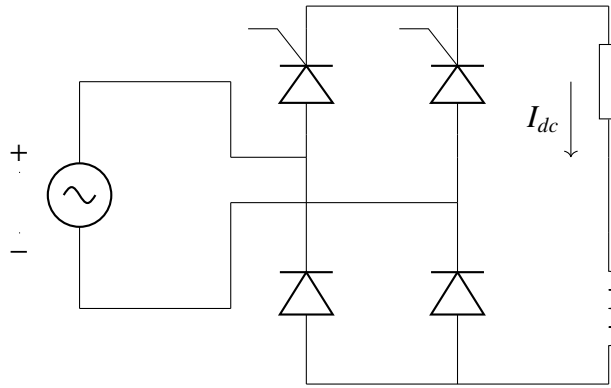


GATE: EE - 59.2022

EE23BTECH11013 - Avyaaz*

Question: For the ideal AC-DC rectifier circuit shown in the figure below, the load current magnitude is $I_{dc} = 15$ A and is ripple free. The thyristors are fired with a delay angle of 45° . The amplitude of the fundamental component of the source current, in amperes, is _____ (Round off to 2 decimal places). (GATE 59 EE 2022)

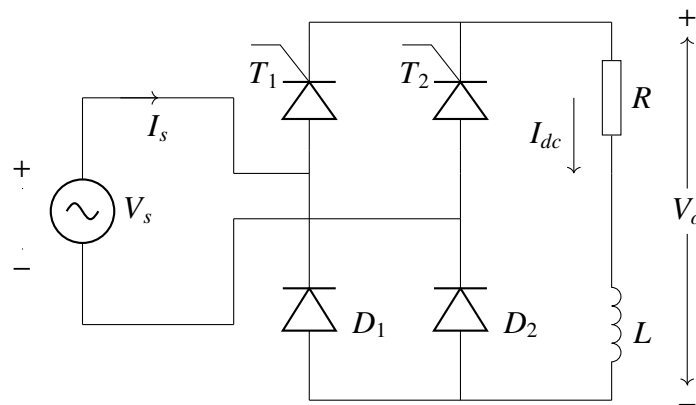


Solution:

Parameter	Description	Value
I_{dc}	Load current	15A
α	Firing angle	45°

TABLE 1

A symmetrical single phase semi converter is shown below,



We know that,

$$i_s(t) = I_o + \sum_{n=1}^{\infty} C_n \sin(n\omega t + \theta_n) \quad (1)$$

where,

$$C_n = \sqrt{a_n^2 + b_n^2} \quad (2)$$

$$\theta_n = \tan^{-1} \left(\frac{a_n}{b_n} \right) \quad (3)$$

$$\Rightarrow I_o = \frac{1}{2\pi} \int_{\alpha}^{\pi} I_o d\omega t - \int_{\pi+\alpha}^{2\pi} I_o d\omega t = 0 \quad (4)$$

$$\Rightarrow a_n = \frac{1}{\pi} \int_{\alpha}^{\pi} I_o \cos n\omega t d\omega t - \int_{\pi+\alpha}^{2\pi} I_o \cos n\omega t d\omega t \quad (5)$$

$$a_n = \frac{-2I_o}{n\pi} \sin n\alpha \quad \text{for } n = 1, 3, 5, \dots$$

$$= 0 \quad \text{for } n = 2, 4, \dots$$

$$\Rightarrow b_n = \frac{1}{\pi} \int_{\alpha}^{\pi} I_o \sin n\omega t d\omega t - \int_{\pi+\alpha}^{2\pi} I_o \sin n\omega t d\omega t \quad (6)$$

$$b_n = \frac{2I_o}{n\pi} (1 + \cos n\alpha) \quad \text{for } n = 1, 3, 5, \dots$$

$$= 0 \quad \text{for } n = 2, 4, \dots$$

From (2):

$$\therefore C_n = \frac{2\sqrt{2}I_o}{n\pi} \left(\sqrt{1 + \cos n\alpha} \right) \quad (7)$$

$$\Rightarrow C_n = \frac{4I_o}{n\pi} \cos \frac{n\alpha}{2} \quad (8)$$

From (3):

$$\theta_n = \tan^{-1} \left(\frac{-\sin n\alpha}{1 + \cos n\alpha} \right) \quad (9)$$

$$\Rightarrow \theta_n = \frac{-n\alpha}{2} \quad (10)$$

The Fourier series representation of supply current is given by:

From (1), (8) and (10):

$$I_s(t) = \sum_{n=1,3,5,\dots}^{\infty} \frac{4I_{dc}}{n\pi} \cos \frac{n\alpha}{2} \sin \left(n\omega t - \frac{n\alpha}{2} \right) \quad (11)$$

From Table 1:

$$(I_{s1})_{peak} = \frac{4I_{dc}}{\pi} \cos \left(\frac{\alpha}{2} \right) \quad (12)$$

$$= \frac{4 \times 15}{\pi} \times \cos \frac{45^\circ}{2} \quad (13)$$

$$= 17.64A \quad (14)$$

