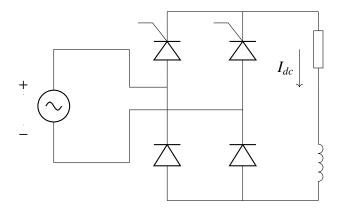
## GATE: EE - 59.2022

## 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)

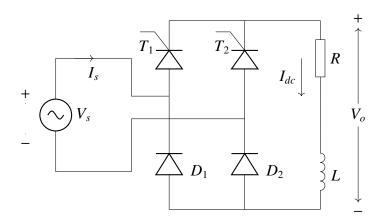


## **Solution:**

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

TABLE 1

A symmetrical single phase semi converter is shown below,



The Fourier series representation of supply current is given by:

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

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where,

$$a_o = \frac{1}{2\pi} \int_0^{2\pi} i_s(t) d\omega t \tag{2}$$

$$C_n = \sqrt{a_n^2 + b_n^2} \tag{3}$$

$$\theta_n = \tan^{-1} \left( \frac{a_n}{b_n} \right) \tag{4}$$

$$\implies a_o = \frac{1}{2\pi} \int_{\alpha}^{\pi} I_o d\omega t - \int_{\pi+\alpha}^{2\pi} I_o d\omega t = 0$$
 (5)

$$\implies a_n = \frac{1}{\pi} \int_{\alpha}^{\pi} I_o \cos n\omega t d\omega t - \int_{\pi+\alpha}^{2\pi} I_o \cos n\omega t d\omega t$$
 (6)

$$a_n = \begin{cases} \frac{-2I_o}{n\pi} \sin n\alpha & \text{for } n = 1, 3, 5... \\ 0 & \text{for } n = 2, 4..... \end{cases}$$
 (7)

$$\implies b_n = \frac{1}{\pi} \int_{\alpha}^{\pi} I_o \sin n\omega t d\omega t - \int_{\pi+\alpha}^{2\pi} I_o \sin n\omega t d\omega t$$
 (8)

$$b_n = \begin{cases} \frac{2I_o}{n\pi} (1 + \cos n\alpha) & \text{for } n = 1, 3, 5... \\ 0 & \text{for } n = 2, 4.... \end{cases}$$
 (9)

From (3):

$$\therefore C_n = \frac{2\sqrt{2}I_o}{n\pi} \left(\sqrt{1 + \cos n\alpha}\right) \tag{10}$$

$$\implies C_n = \frac{4I_o}{n\pi} \cos \frac{n\alpha}{2} \tag{11}$$

From (4):

$$\theta_n = \tan^{-1} \left( \frac{-\sin n\alpha}{1 + \cos n\alpha} \right) \tag{12}$$

$$\implies \theta_n = \frac{-n\alpha}{2} \tag{13}$$

From (1),(11) and (13):

$$I_s(t) = \sum_{n=1,3,5,...}^{\infty} \frac{4I_o}{n\pi} \cos \frac{n\alpha}{2} \sin \left(n\omega t - \frac{n\alpha}{2}\right)$$
 (14)

From Table 1:

$$(I_{s_1})_{peak} = \frac{4I_{dc}}{\pi} \cos\left(\frac{\alpha}{2}\right) \tag{15}$$

$$= \frac{4 \times 15}{\pi} \times \cos \frac{45^{\circ}}{2} \tag{16}$$

$$= 17.64A$$
 (17)

