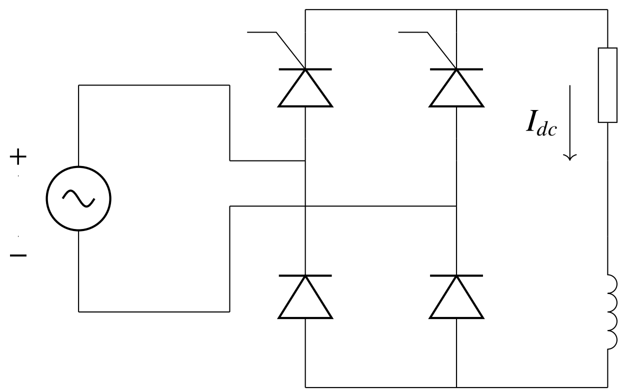
GATE: EE - 59.2022

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)

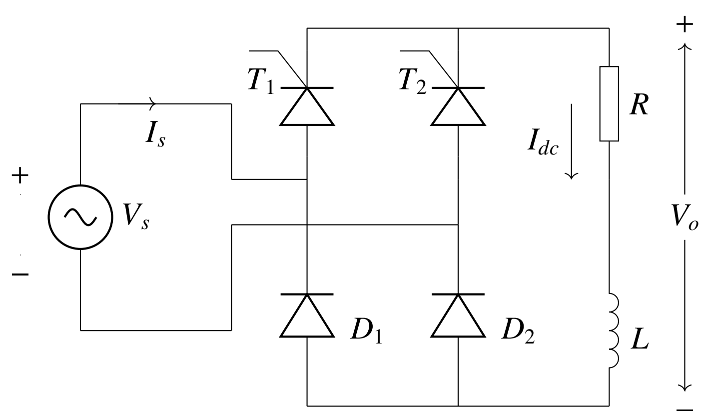


Solution:

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,

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

where,

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

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

$$\implies I_o = \frac{1}{2\pi}\int_{\alpha}^{\pi} I_o d\omega t - \int_{\pi+\alpha}^{2\pi} I_o d\omega t = 0 \tag{4}$$

$$\implies a_n = \frac{1}{\pi}\int_{\alpha}^{\pi} I_o \cos n\omega t d\omega t - \int_{\pi+\alpha}^{2\pi} I_o \cos n\omega t d\omega t \tag{5}$$

$$a_n = \frac{-2I_o}{n\pi}\sin n\alpha \qquad \text{for n = 1,3,5...}$$
$$= 0 \qquad \text{for n = 2,4.....}$$

$$\implies b_n = \frac{1}{\pi}\int_{\alpha}^{\pi} I_o \sin n\omega t d\omega t - \int_{\pi+\alpha}^{2\pi} I_o \sin n\omega t d\omega t \tag{6}$$

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

From (2):

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

$$\implies C_n = \frac{4I_o}{n\pi}\cos\frac{n\alpha}{2} \tag{8}$$

From (3):

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

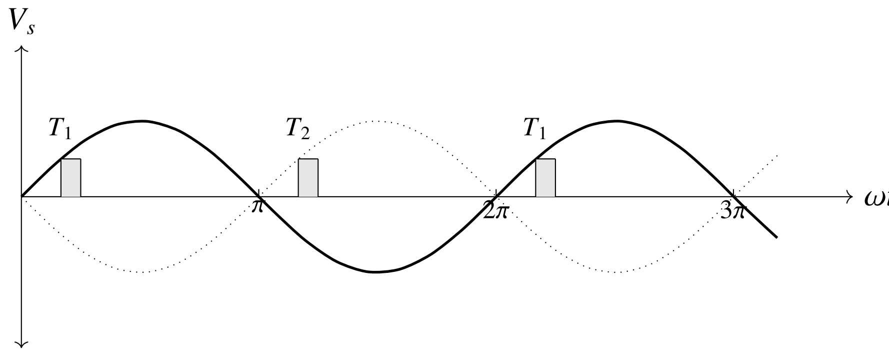
$$\implies \theta_n = \frac{-n\alpha}{2} \tag{10}$$

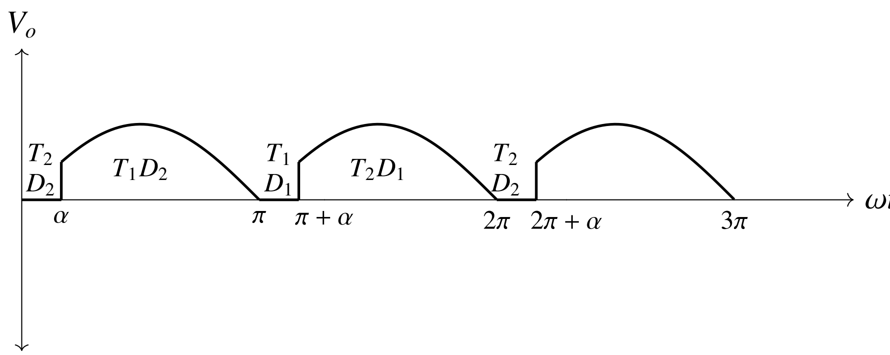
The Fourier series representation of supply current is given by:
From (1),(8) and (10):

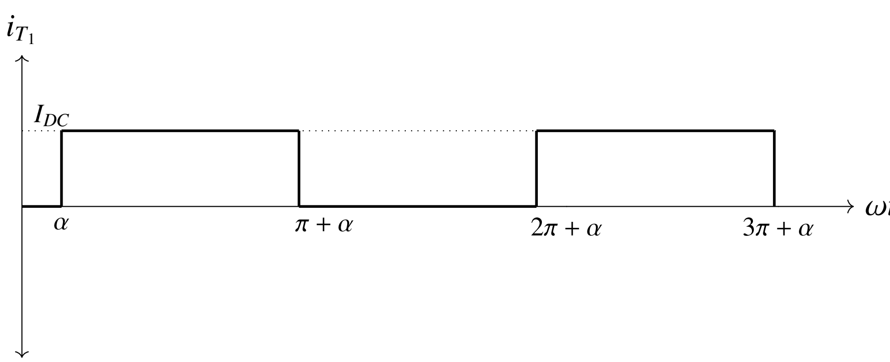
$$I_s(t) = \sum_{n=1,3,5...}^{\infty} \frac{4I_{dc}}{n\pi}\cos\frac{n\alpha}{2}\sin\left(n\omega t - \frac{n\alpha}{2}\right) \tag{11}$$

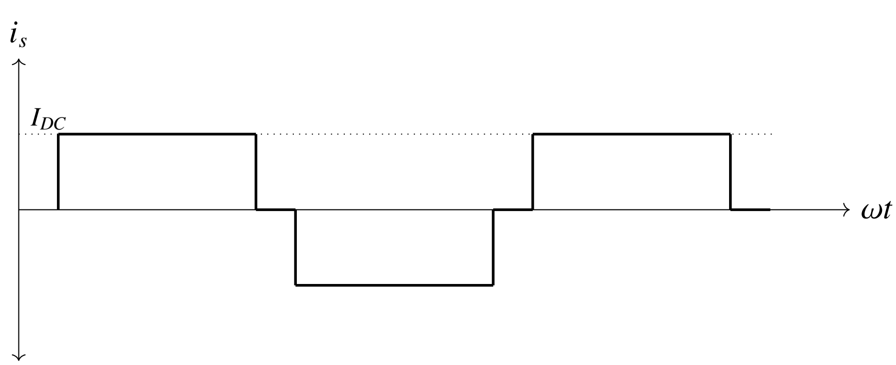
From Table 1:

$$(I_{s_1})_{peak} = \frac{4I_{dc}}{\pi}\cos\left(\frac{\alpha}{2}\right) \tag{12}$$
$$= \frac{4 \times 15}{\pi} \times \cos\frac{45°}{2} \tag{13}$$
$$= 17.64A \tag{14}$$


V_s
T_1
T_2
T_1
π
2π
3π
ωt


V_o
T_2
D_2
T_1D_2
T_1
D_1
T_2D_1
T_2
D_2
α
π
$\pi + \alpha$
2π
$2\pi + \alpha$
3π
ωt


i_{T_1}
I_{DC}
α
$\pi + \alpha$
$2\pi + \alpha$
$3\pi + \alpha$
ωt


i_s
I_{DC}
ωt