IN-2023

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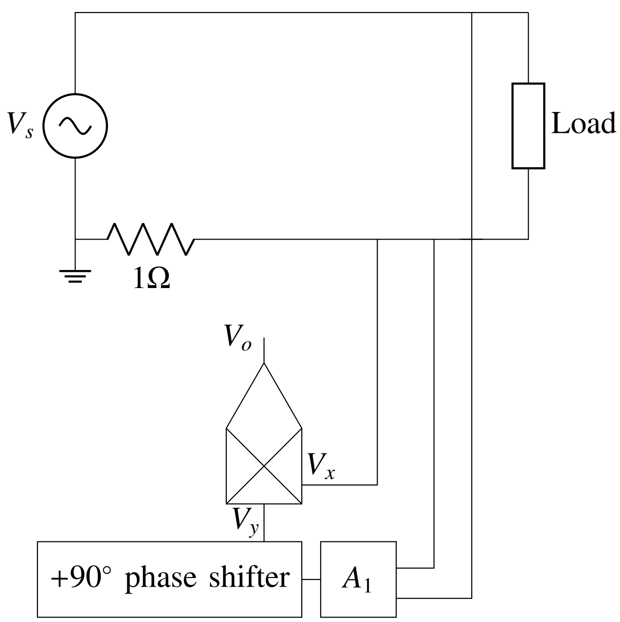
QUESTION:

61. In the diagram shown, the frequency of the sinusoidal source voltage V_s is 50 Hz.The load voltage is 230 V (RMS), and the load impedance is $\frac{230}{\sqrt{2}}+j\frac{230}{\sqrt{2}}$ Ω. The value of attenuator $A_1=\frac{1}{50\sqrt{2}}$.The multiplier output voltage $V_o = \frac{V_xV_y}{1V}$, where V_x and V_y are the inputs. The magnitude of the average value of the multiplier output V_0 is __________________ V

Parameter	Description	Value
V_s	sinusoidal Source voltage	230 V(RMS)
V_1	voltage across attenuator	
$V_x and V_y$	inputs voltages	
A_1	attenuator	$\frac{1}{50\sqrt{2}}$
Z	Load Impedance	$\frac{230}{\sqrt{2}} + j\frac{230}{\sqrt{2}}$ Ω
V_0	output voltage	$V_0 = \frac{V_xV_y}{1V}$

TABLE I
VARIABLES



Solution:

1) Let the curret in load be I

$$I = \frac{V_s(peak)}{Z} \tag{1}$$
$$= \frac{230\sqrt{2}}{\frac{230}{\sqrt{2}} + j\frac{230}{\sqrt{2}}} \tag{2}$$
$$= \sqrt{2}(1-j) \tag{3}$$

2) voltage at attenuator

$$V_1 = V_sA_1 \tag{4}$$
$$= 230\frac{1}{50\sqrt{2}}V \tag{5}$$
$$= \frac{4.6}{\sqrt{2}}V \tag{6}$$

$$V_y = 4.6\sin(\omega t + 90°) \tag{7}$$
$$V_x = I \times 1\Omega \tag{8}$$
$$= 2\sqrt{2}\sin(\omega t - 45°) \tag{9}$$
$$V_0 = 9.2\sqrt{2}(\frac{\cos(135) - \cos(2\omega t)}{2}) \tag{10}$$
$$= 4.6 - 4.6\sqrt{2}\cos(2\omega t) \tag{11}$$
$$\tag{12}$$

3) Let f(t)= $4.6 - 4.6\sqrt{2}\cos(2\omega t)$

$$V_o < avg > = \frac{1}{T}\int_0^T (4.6 - 4.6\sqrt{2}\cos(2\omega t))\,dt \tag{13}$$
$$= \frac{\omega}{\pi}\left[\int_0^{\frac{\pi}{\omega}} 4.6\,dt - 4.6\sqrt{2}\int_0^{\frac{\pi}{\omega}} \cos(2\omega t)\,dt\right] \tag{14}$$
$$= \frac{\omega}{\pi}\left[4.6\frac{\pi}{\omega} - 4.6\sqrt{2}\left[\frac{\sin(2\pi)}{2\omega}\right]\right] \tag{15}$$
$$= 4.6 \tag{16}$$

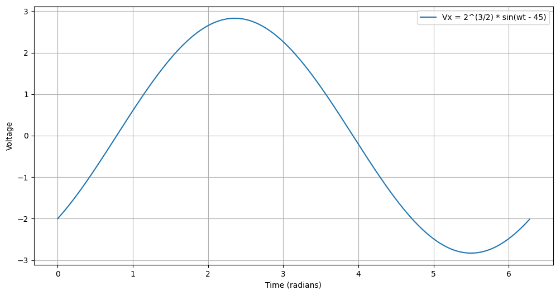


Fig. 1. $plotofV_x$

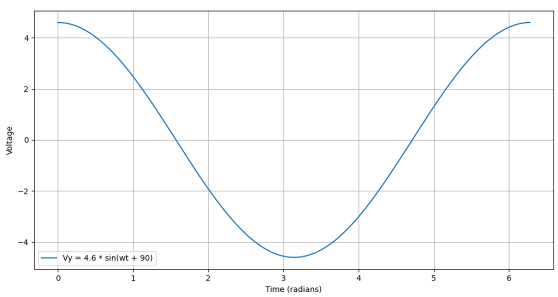


Fig. 2. $plotofV_y$

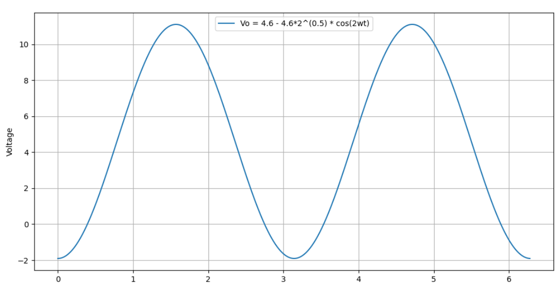


Fig. 3. $plotofV_o$