GATE 2022 33.BM

EE23BTECH11012 - Chavan Dinesh*

Question: A series RLC circuit with $R = 10\Omega$, $L = 50mH$ and $C = 100\mu F$ connected to 200 V, 50 Hz supply consumes power P. The value of L is changed such that this circuit consumes same power P but operates with lagging power factor. The new value of L is ____ mH (rounded off to two decimal places). (GATE 33 BM 2022)

Solution:

Parameter	Description	Value
R	Resistance	10Ω
C	Capacitance	$100\mu F$
L_{old}	Inductor	$50mH$
L_{new}	New Inductor	
Z_{old}	Old Impedance	
Z^*	New Impedance	

TABLE 1

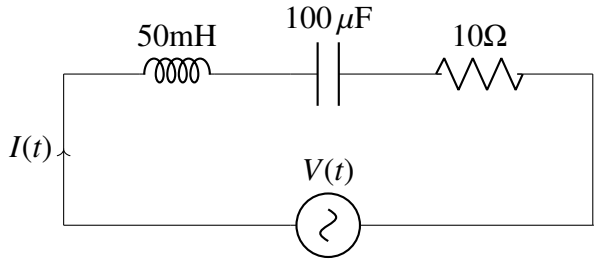
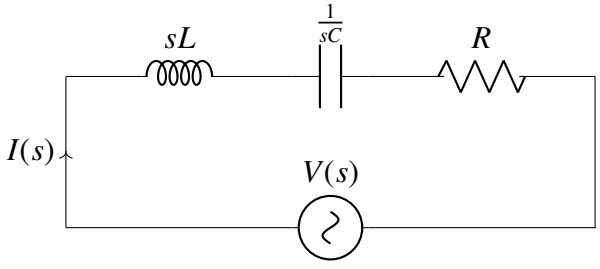


Fig. 1

From Fig. 1

In s - domain,



$$Z = R + sL_{old} + \frac{1}{sC} \tag{1}$$

As the circuit consumes same power P but operates with lagging power factor :

The new impedance(Z^*) will be :

$$Z^* = R + sL_{new} + \frac{1}{sC} \tag{2}$$

Comparing the imaginary parts of the Z^*:

$$sL_{old} + \frac{1}{sC} = -\left(sL_{new} + \frac{1}{sC}\right) \tag{3}$$

Taking $s = j2\pi f$:

$$j\left(2\pi f L_{old} - \frac{1}{2\pi f C}\right) = -j\left(2\pi f L_{new} - \frac{1}{2\pi f C}\right) \tag{4}$$

From Table 1:

$$L_{new} \approx 152.7\text{mH} \tag{5}$$