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Problem 39.13 (RHK)

We are given a LCR circuit with $\mathrm{E}=10\ \mathrm{V}$, $R=9.6\Omega$, $L=1.2\ \mathrm{H}$, and $C=1.3\ \mu\mathrm{F}$. *We have to find the amplitude of the voltage across the inductor at resonance. We have to answer whether the amplitude of the voltage across an inductor can be greater than the amplitude of the generator emf in an RLC circuit.*

Solution:

Let the generator emf be described by the function

$\mathrm{E}=\mathrm{E}_m \sin\omega t$,

And the current in the circuit be given by the function

$i=i_m \sin\left(\omega t-\phi\right)$.

At resonance

$$\omega=\frac{1}{\sqrt{LC}}$$

And the impedance of the *LCR* is *R*.

We have

$$\omega = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{1.2 \times 1.3 \times 10^{-6}}} \text{ rad s}^{-1} = 800.6 \text{ rad s}^{-1},$$

and

$$i_m = \frac{\mathrm{E}_m}{R} = \frac{10}{9.6} \text{ A} = 1.04 \text{ A}.$$

Voltage across the inductor is given by

$$V_{inductor} = L\frac{di}{dt} = L\omega i_m \cos\left(\omega t - \phi\right).$$

Therefore, the amplitude of the voltage across the inductor at resonance will be

$$V_{inductor} = L\omega i_m = 1.2 \times 800.6 \times \frac{10.0}{9.6} \text{ V} = 1000 \text{ V}.$$

From this example, we note that the amplitude of the voltage across an inductor can be greater than the amplitude of the generator emf in an *RLC* circuit.