

EE 302 PS 04 - SOLUTIONS

Chapter 2

Questions: None

Problems: 11, 14, 16, 17, 20, 21

Critical Thinking: None

Problem 11

$$X_C = \frac{1}{\omega C} = \frac{1}{2\pi f C} = \frac{1}{2\pi(2 \times 10^9 \text{ Hz})(7 \times 10^{-12} \text{ F})} = 11.37 \Omega$$

Problem 14

$$X_L = \omega L = 2\pi f L \longrightarrow f = \frac{X_L}{2\pi L} = \frac{300 \Omega}{2\pi(2 \mu\text{H})} = 23.873 \text{ MHz}$$

Problem 16

$$f_r = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{(0.55 \mu\text{H})(22 \text{ pF})}} = 45.754 \text{ MHz}$$

Problem 17

$$f_r = \frac{1}{2\pi\sqrt{LC}} \longrightarrow L = \frac{1}{(2\pi f)^2 C} = 977.25 \text{ nH} = 0.97725 \mu\text{H}$$

Problem 20

There are many ways to tackle this problem. One way is to recall that cutoff frequencies (a.k.a. “half-power points”) are where power is one half of the peak power. The factor of one half corresponds to a -3 dB drop (actually, -3.01 dB). A -3 dB drop is a reduction in voltage by 0.707 (equivalently, a multiplication by $1/\sqrt{2}$). This is seen readily when converting -3 dB to a voltage ratio.

$$P_{\text{cutoff,dBm}} - P_{\text{pk,dBm}} = -3.01 \text{ dB} \longrightarrow \frac{V_{\text{cutoff}}}{V_{\text{pk}}} = 10^{-3.01/20} = 0.707$$

Thus, we can see that the cutoff voltage is the peak voltage scaled by a factor of 0.707:

$$V_{\text{cutoff}} = 0.707V_{\text{pk}} = 0.707(4.5 \text{ mV}) = 3.18 \text{ mV}$$

Now we present an alternate way to look at this problem:

$$V_{\text{cutoff}} = \frac{V_{\text{pk}}}{\sqrt{2}} = \frac{4.5 \text{ mV}}{\sqrt{2}} = 3.18 \text{ mV}$$

First, note that $1/\sqrt{2} = 0.707$. But, where did this relationship between V_{pk} and V_{cutoff} come from? The following discussion is a derivation of the above relationship and may help you understand the relationship between peak voltage and cutoff voltage. The cutoff point is defined to be the point where **power** drops to **one-half of the peak power** (see the ratio below). The power, and thus voltage values, at both the upper-frequency and lower-frequency cutoffs is the same ($P_{\text{cutoff}} = P_1 = P_2 = 0.5P_{\text{pk}}$ and $V_{\text{cutoff}} = V_1 = V_2 = 0.707V_{\text{pk}}$):

$$\frac{P_{\text{cutoff}}}{P_{\text{pk}}} = \frac{1}{2}$$

Power is proportional to voltage squared ($P \propto V^2$), so the following relationship exists:

$$\frac{P_{\text{cutoff}}}{P_{\text{pk}}} = \left(\frac{V_{\text{cutoff}}}{V_{\text{pk}}} \right)^2 = \frac{1}{2}$$

Thus, we can relate V_{cutoff} to V_{pk} :

$$\frac{V_{\text{cutoff}}}{V_{\text{pk}}} = \frac{1}{\sqrt{2}} \longrightarrow V_{\text{cutoff}} = \frac{V_{\text{pk}}}{\sqrt{2}}$$

Truly, this is a good relationship to understand. It is also very useful to recognize that $1/\sqrt{2} = 0.707$ and that both of these correspond to -3 dB:

$$\frac{1}{\sqrt{2}} = 0.707 \iff -3 \text{ dB}$$

Problem 21

$$Q = \frac{f_r}{\text{BW}} = \frac{4 \text{ GHz}}{36 \text{ MHz}} = 111.11$$