Homework 02

Date: 24/11/2020

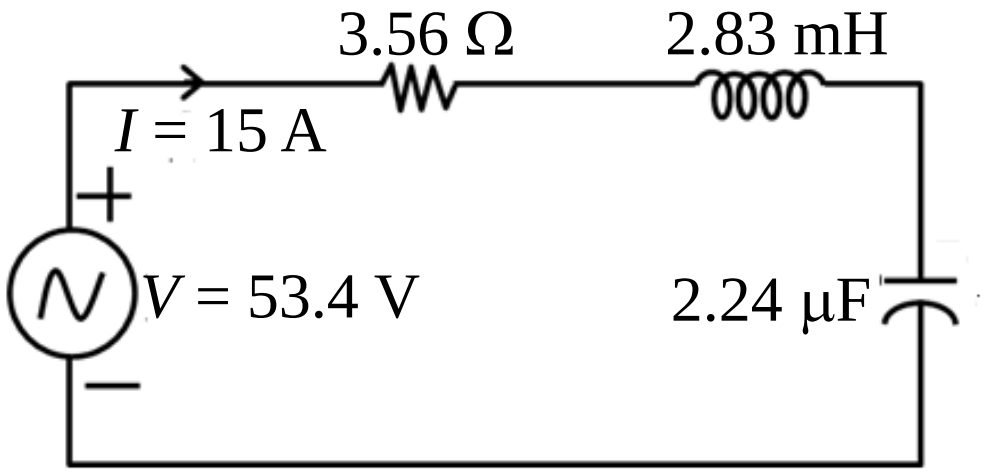
Problem 01: Design a series resonance circuit for the following specifications:

Supply voltage: 15 A

Maximum power consumption: 800 W

Resonance frequency: 2 kHz

Per unit Bandwidth: 0.1



$$I = 15\ \text{A}, \qquad f_{sr} = 2000\ \text{Hz}, \qquad P = 800\ \text{W}$$

$$\text{Per}-\text{unit Bandwidth} = 0.1 = \frac{1}{Q_{sr}}$$

$$R = \frac{P}{I^2} = 3.56\ \Omega, \qquad X_L = X_C = RQ_{sr}$$

$$L = \frac{X_L}{2\pi f_{sr}} = 2.83\ \text{mH}, \qquad C = \frac{1}{2\pi f_{sr} X_C} = 2.24\ \mu\text{F}$$

Homework 02

Date: 24/11/2020

Problem 02: At resonance condition, an *RLC* series circuit consumed 800 W at 100 V supply. Calculate (***a***) the current and the impedance at resonance condition, (***b***) the impedance, current and power at cut-off frequencies.

Ans.: (***a***) $I = I_{max} = 8$ A, $Z = R = 12.5$ ohm

(***b***) $Z_{HPF} = 17.68$ ohm, $I_{HPF} = 5.66$ A, $P_{HPF} = 400$ W

$V = 100$ V, $P_{max} = 800$ W

$$(a)\ I = I_{max} = \frac{P_{max}}{V} \qquad R = \frac{V}{I} = \frac{P}{I^2} = \frac{V^2}{P} \qquad Z = R$$

$$(b)\ Z_{HPF} = \sqrt{2}R \qquad I_{HPF} = \frac{1}{\sqrt{2}} I_{max} \qquad P_{HPF} = \frac{1}{2} P_{max}$$

Homework 02

Date: 24/11/2020

Problem 03: At cut-off frequency, an *RLC* series circuit consumed 1000 W with 20 A supply current. Calculate (***a***) the impedance at cut-off frequency, (***b***) the impedance, current and power at resonance condition.

Ans.: (***a***) R = 2.5 ohm, Z_{HPF} = 3.54 ohm

(***b***) Z = 2.5 ohm, I_{max} = 28.28 A, P_{max} = 2000 W

$$I_{HPF} = 20 \text{ A}, \qquad P_{HPF} = 1000 \text{ W}$$

$$(a)\ R = \frac{P_{HPF}}{I_{HPF}^2} \qquad Z_{HPF} = \sqrt{2}R$$

$$(b)\ Z = R \qquad I_{\text{max}} = \sqrt{2}I_{HPF} \qquad P_{\text{max}} = 2P_{HPF}$$

Homework 02

Date: 24/11/2020

Problem 04: For the series *RLC* combination as shown in the following figure:

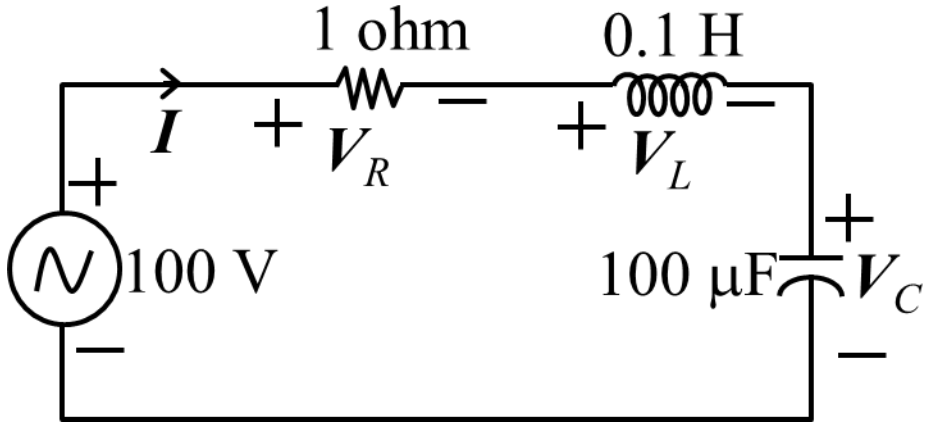
(***a***) find the angular frequency and the frequency to obtain the **maximum current**.

(***b***) At resonance, calculate (***i***) the current, (***ii***) the voltage drop across the resistance, the inductance, and the capacitance, (***iii***) the power, the reactive power consume by inductor, the reactive power supplied by capacitor, the net reactive power, and the apparent power.

(***c***) Calculate the lower cut-off frequency, and the higher cut-off frequency.

(***d***) At cutoff frequency: calculate (***i***) the impedance, (***ii***) the current, and (***iii***) the power.

(***e***) Calculate (***i***) the bandwidth, (***ii***) the quality factor, and (***iii***) the per-unit-bandwidth.



$V = 100\ \text{V}, \qquad R = 1\ \Omega,$

$L = 0.1\ \text{H}, \qquad C = 100\ \mu\text{F}$

(**a**) $f_{sr} = \dfrac{1}{2\pi\sqrt{LC}} = 50.35 \text{ Hz}$

(**b**) $X_L = X_C = 2\pi f_{sr} L = \dfrac{1}{2\pi f_{sr} C} = 31.62 \ \Omega$

$$I = I_{\max} = \frac{V}{R} = 100 \text{ A}$$

$$V_R = V = IR = 100 \text{ V}$$

$$V_L = V_C = IX_L = IX_C = 3162 \text{ V}$$

$$P = P_{\max} = I^2 R = 10000 \text{ W or } 10 \text{ kW}$$

$$Q_L = I^2 X_L = 316200 \text{ Var} \quad \text{or } 316.2 \text{ kW}$$

$$Q_C = -I^2 X_C = -316200 \text{ Var} \quad \text{or } -316.2 \text{ kW}$$

$$Q = Q_L + Q_C = 0$$

$$S = P = 10000 \text{ VA or } 10 \text{ kVA}$$

$$(\boldsymbol{c})\quad f_{sl} = f_{sr} - \frac{R}{4\pi L} = 49.57\ \text{Hz}$$

$$f_{sh} = f_{sr} + \frac{R}{4\pi L} = 51.16\ \text{Hz}$$

$$(\boldsymbol{d})\quad Z_{HPF} = \sqrt{2}R = 1.414\ \Omega$$

$$I_{HPF} = \frac{1}{\sqrt{2}} I_{\max} = 7.07\ \text{A}$$

$$P_{HPF} = \frac{1}{2} P_{\max} = 5000\ \text{W}$$

$$(\boldsymbol{e})\quad BW = f_{sh} - f_{sl} = \frac{R}{2\pi L} = 1.6\ \text{Hz}$$

$$Q_{sr} = \frac{X_L}{R} = \frac{X_C}{R} = \frac{f_{sr}}{BW} = 31.62$$

$$\text{Per} - \text{unit Bandwidth} = \frac{BW}{f_{sr}} = \frac{1}{Q_{sr}} = 0.032$$

Homework 02

Date: 24/11/2020

Problem 05: As inductor (L) is varied to produce resonance in a series circuit containing R=60 ohms, X_C = 150 ohms, and f=50 Hz, (***i***) find the value of inductance and the voltage drop across inductor (L) at resonance, and (***ii***) find the voltage drop across the inductor (L) and the value of inductance when the drop across inductor (L) is a maximum if 800 V are impressed.

$$V = 800\ \text{V}, \qquad R = 60\ \Omega, \qquad X_C = 150\ \Omega, \qquad f = 60\ \text{Hz}$$

$$(i)\ \ X_L = X_C \qquad L = \frac{X_L}{2\pi f} \qquad Z = R \qquad I = \frac{V}{Z} \qquad V_L = IX_L$$

Ans.: (***i***) L = 398.09 mH; V_L =1999.5 V

$$(ii)\ \ X_L = \frac{R^2 + X_C^2}{X_C} \qquad L = \frac{X_L}{2\pi f} \qquad Z = \sqrt{R^2 + (X_L - X_C)^2} \qquad I = \frac{V}{Z} \qquad V_L = IX_L$$

Ans.: (***ii***) L = 461.78 mH; V_L =2154.12 V

Homework 02

Date: 24/11/2020

Problem 06: If the impressed voltage on a series circuit containing 80 ohms resistance, 120 ohms inductive reactance at 100 cycles, and a variable capacitance is 400 V, (***i***) find the value of capacitance and the voltage drop across capacitor (C) at resonance, and (***ii***) find the voltage drop across the capacitor (C) and the value of capacitance when the drop across capacitor (C) is maximum.

$$V = 400 \text{ V}, \qquad R = 80 \ \Omega, \qquad X_L = 120 \ \Omega, \qquad f = 100 \text{ Hz}$$

(*i*) $X_C = X_L$ $\qquad C = \dfrac{1}{2\pi f X_C}$ $\qquad Z = R$ $\qquad I = \dfrac{V}{Z}$ $\qquad V_C = IX_C$

Ans.: (***i***) C = 13.27 μF; V_C = 600 V

(*ii*) $X_C = \dfrac{R^2 + X_L^2}{X_L}$ $\qquad C = \dfrac{1}{2\pi f X_C}$ $\qquad Z = \sqrt{R^2 + (X_L - X_C)^2}$ $\qquad I = \dfrac{V}{Z}$ $\qquad V_C = IX_C$

Ans.: (***ii***) C = 9.19 μF; V_C = 721.05 V