CHAPTER 1.11

FREQUENCY RESPONSE

Statement for Q.1-3:

A parallel resonant circuit has a resistance of 2 kΩ and half power frequencies of 86 kHz and 90 kHz.

1. The value of capacitor is

(A) 6 μF (B) 20 nF
(C) 2 nF (D) 60 μF

2. The value of inductor is

(A) 4.3 mH (B) 43 mH
(C) 0.16 mH (D) 1.6 mH

3. The quality factor is

(A) 22 (B) 100
(C) 48 (D) 200

Statement for Q.4-5:

A parallel resonant circuit has a midband admittance of 25×10^{-3} S, quality factor of 80 and a resonant frequency of 200 krad/s.

4. The value of R is

(A) 40 Ω (B) 56.57 Ω
(C) 80 Ω (D) 28.28 Ω

5. The value of C is

(A) 2 μF (B) 28.1 μF
(C) 10 μF (D) 14.14 μF

6. A parallel RLC circuit has $R = 1$ kΩ and $C = 1$ μF. The quality factor at resonance is 200. The value of inductor is

(A) 35.4 μH (B) 25 μH
(C) 17.7 μH (D) 50 μH

7. A parallel circuit has $R = 1$ kΩ, $C = 50$ μF and $L = 10$ mH. The quality factor at resonance is

(A) 100 (B) 90.86
(C) 70.7 (D) None of the above

8. A series resonant circuit has an inductor $L = 10$ mH. The resonant frequency $\omega_o = 10^6$ rad/s and bandwidth is BW $= 10^3$ rad/s. The value of R and C will be

(A) 100 μF, 10 Ω (B) 100 pF, 10 Ω
(C) 100 pF, 10 MΩ (D) 100 μF, 10 MΩ

9. A series resonant circuit has $L = 1$ mH and $C = 10$ μF. The required R for the BW 15.9 Hz is

(A) 0.1 Ω (B) 0.2 Ω
(C) 15.9 mΩ (D) 500 Ω

10. For the RLC parallel resonant circuit when $R = 8$ kΩ, $L = 40$ mH and $C = 0.25$ μF, the quality factor Q is

(A) 40 (B) 20
(C) 30 (D) 10

11. The maximum voltage across capacitor would be

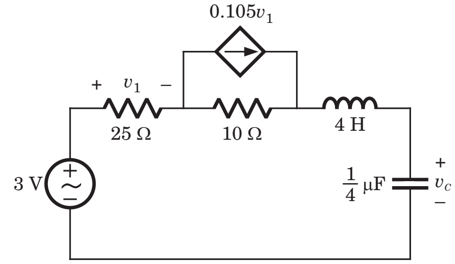


Fig. P1.11.11

(A) 3200 V (B) 3 V
(C) −3 V (D) 1600 V

12. For the circuit shown in fig. P1.1.11 resonant frequency f_o is

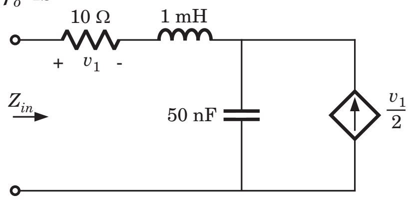


Fig. P1.11.12

(A) 346 kHz (B) 55 kHz

(C) 196 kHz (D) 286 kHz

13. For the circuit shown in fig. P1.11.13 the resonant frequency f_o is

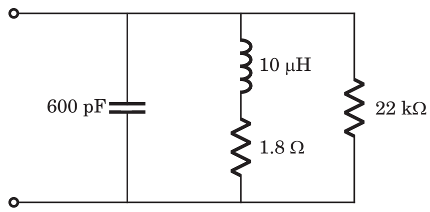


Fig. P1.11.13

(A) 12.9 kHz (B) 12.9 MHz

(C) 2.05 MHz (D) 2.05 kHz

14. The network function of circuit shown in fig.P1.11.14 is

$$H(\omega) = \frac{V_o}{V_1} = \frac{4}{1 + j0.01\omega}$$

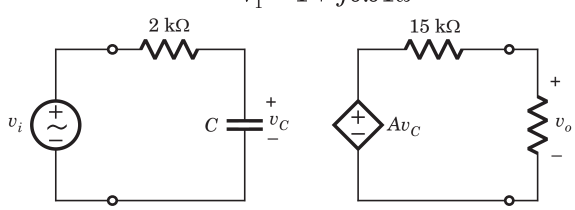


Fig. P1.11.14

The value of the C and A is

(A) 10 µF, 6 (B) 5 µF, 10

(C) 5 µF, 6 (D) 10 µF, 10

15. $H(\omega) = \frac{V_o}{V_i} = ?$

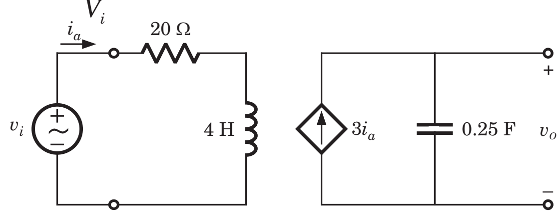


Fig. P1.11.15

(A) $\frac{0.6}{j\omega(1 + j0.2\omega)}$ (B) $\frac{0.6}{j\omega(5 + j\omega)}$

(C) $\frac{3}{j\omega(1 + j\omega)}$ (D) $\frac{3}{j\omega(20 + j4\omega)}$

16. $H(\omega) = \frac{V_o}{V_i} = ?$

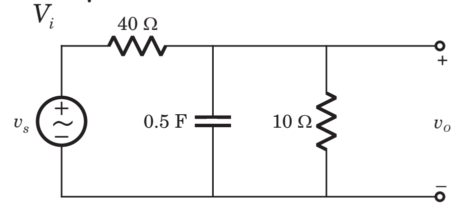


Fig. P1.11.16

(A) $(5 + j20\omega)^{-1}$ (B) $(5 + j4\omega)^{-1}$

(C) $(5 + j30\omega)^{-1}$ (D) $5(1 + j6\omega)^{-1}$

17. The value of input frequency is required to cause a gain equal to 1.5. The value is

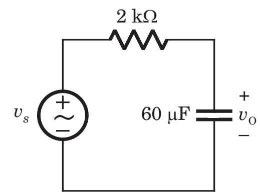


Fig. P1.11.17

(A) 20 rad/s (B) 20 Hz

(C) 10 rad/s (D) No such value exists.

18. In the circuit of fig. P1.11.18 phase shift equal to $-45°$ is required at frequency $\omega = 20$ rad/s . The value of R is

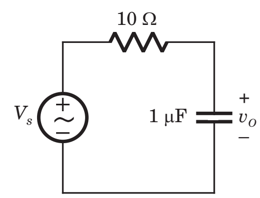


Fig. P1.11.18

(A) 200 kΩ (B) 150 kΩ

(C) 100 kΩ (D) 50 kΩ

19. For the circuit of fig. P1.11.19 the input frequency is adjusted until the gain is equal to 0.6. The value of the frequency is

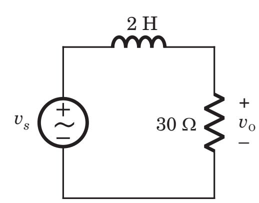


Fig. P1.11.19

(A) 20 rad/s (B) 20 Hz

(C) 40 rad/s (D) 40 Hz

31. Bode diagram of the network function V_o/V_s for the circuit of fig. P1.11.30 is

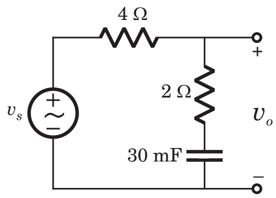
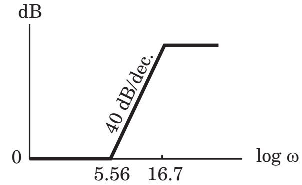
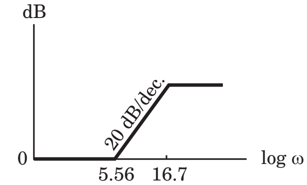


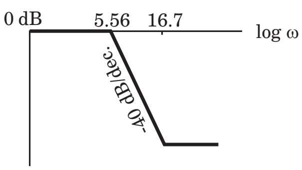
Fig.P1.11.30



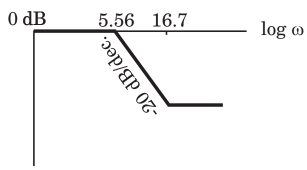
(A)



(B)



(C)



(D)

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SOLUTIONS

1. (B) $BW = \omega_2 - \omega_1 = 2\pi(90 - 86)\text{k} = 8\pi$ krad/s

$$BW = \frac{1}{RC} \Rightarrow C = \frac{1}{R\,BW} = \frac{1}{8\pi \times 10^3 \times 2 \times 10^3}$$

$= 19.89$ nF

2. (C) $\omega_o = \dfrac{(\omega_1 + \omega_2)}{2} = \dfrac{2\pi(90 + 86)\text{k}}{2} = 176\pi$ krad/s

$$\omega_o = \frac{1}{\sqrt{LC}} \Rightarrow L = \frac{1}{\omega_o^2} C$$

$$= \frac{1}{(176\pi \times 10^3)^2(20 \times 10^{-9})} = 0.16 \text{ mH}$$

3. (A) $Q = \dfrac{\omega_o}{B} = \dfrac{176\pi\text{k}}{8\pi\text{k}} = 22$

4. (A) At mid-band frequency $Z = R$, $Y = \dfrac{1}{R}$

$$R = \frac{1}{25 \times 10^{-3}} = 40\ \Omega$$

5. (C) $Q = \omega_o RC$

$$\Rightarrow C = \frac{Q}{\omega_o R} = \frac{80}{200 \times 10^3 \times 40} = 10\ \mu\text{F}$$

6. (B) $Q_o = R\sqrt{\dfrac{C}{L}} \Rightarrow 200 = 10^3\sqrt{\dfrac{10^{-6}}{L}}$

$\Rightarrow L = 25\ \mu$H

7. (C) $Q_o = R\sqrt{\dfrac{C}{L}} = 10^3\sqrt{\dfrac{50 \times 10^{-6}}{10 \times 10^{-3}}} = 70.7$

8. (B) $\omega_o = \dfrac{1}{\sqrt{LC}}$

$$\Rightarrow C = \frac{1}{10 \times 10^{-3} \times (10^6)^2} = 100 \text{ pF}$$

$$BW = \frac{R}{L} \Rightarrow R = 10 \times 10^{-3} \times 10^3 = 10$$

9. (A) $BW = \dfrac{R}{L}$

$$\Rightarrow \frac{R}{1 \times 10^{-3}} = 15.9 \times 2\pi = 0.1\Omega$$

10. (B) $Q = R\sqrt{\dfrac{C}{L}}$

$$= 8 \times 10^3 \sqrt{\frac{0.25 \times 10^{-6}}{40 \times 10^{-3}}} = 20$$

11. (A) Thevenin equivalent seen by L–C combination

$$3 = v_1 + 10\left(\frac{v_1 - 0.105 v_1}{125}\right) \Rightarrow v_1 = 100$$

$$I_{sc} = \frac{1100}{125} = 0.8 \text{ V}$$

Open Circuit : $v_1 = 0, \quad v_{oc} = 3$ V

$$R_{TH} = \frac{3}{0.8} = 3.75\,\Omega, \; \omega_o = \frac{1}{\sqrt{LC}} = 1000$$

$$Q_o = \frac{\omega_o L}{R} = \frac{1000 \times 4}{3.75} = 1066.67$$

$$|v_C|_{\max} = Q_o v_{TH} = 1066.67 \times 3 = 3200 \text{ V}$$

12. (B) Applying 1 A at input port $V_1 = 10$ V

voltage across 1 A source

$$V_{test} = 10 + j\omega 10^{-3} - \frac{j}{\omega 50 \times 10^{-9}}(5 + 1)$$

$$Z_{in} = V_{test}$$

At resonance Im $\{Z_{in}\} = 0$

$$\Rightarrow \quad \omega_o 10^{-3} = \frac{6}{\omega_o 50 \times 10^{-9}} \quad \Rightarrow \quad \omega_o = 346 \text{ kHz}$$

$$f_o = 55 \text{ kHz}$$

13. (C) $Y = j\omega 600 \times 10^{-12} + \dfrac{1}{2 \times 10^3} + \dfrac{1}{1.8 + j\omega 10^{-5}}$

$$= j\omega 6 \times 10^{-10} + 45.45 + \frac{1.8 - j\omega 10^{-5}}{3.24 + \omega^2 10^{-50}}$$

At resonance Im $\{Y\} = 0$

$$\omega_o 6 \times 10^{-10}(3.24 + \omega_o^2 10^{-10}) - \omega_o 10^{-5} = 0$$

$$3.24 + \omega_o^2 10^{-10} = 16.67 \times 10^3 \omega_o = 12.9 \text{ Mrad/s}$$

$$f_o = \frac{\omega_o}{2\pi} = 2.05 \text{ MHz}$$

14. (C) $V_C = \dfrac{\dfrac{V_i}{jC\omega}}{2 \times 10^3 + \dfrac{1}{jC\omega}} = \dfrac{V_i}{1 + j2 \times 10^3 C\omega}$

$$V_o = AV_c \frac{(15\text{k})}{16\text{k} + 30\text{k}} = \frac{2AV_c}{3} = \frac{2AV_i}{3(1 + j2 \times 10^3\, C\omega)}$$

$$\Rightarrow \quad \frac{V_o}{V_i} = \frac{\dfrac{2A}{3}}{1 + j2\pi \times 10^3 C\omega}$$

$$\frac{2A}{3} = 4 \quad \Rightarrow \quad A = 6, \quad 2 \times 10^3 C = 0.01$$

$$\Rightarrow \quad C = 5\,\mu\text{F}$$

15. (A) $I_a = \dfrac{V_i}{20 + j4\omega}, \quad V_o = \dfrac{3I_a}{0.25 j\omega}$

$$\frac{V_o}{V_1} = \frac{3}{j\omega(5 + j\omega)} = \frac{0.6}{j\omega(1 + j0.2\omega)}$$

16. (A) $Z_1 = \dfrac{\dfrac{10}{j\omega(0.51)}}{\dfrac{1}{j\omega 0.5} + 10} = \dfrac{10}{1 + j3\omega}$

$$\frac{V_o}{V_i} = \frac{Z_1}{40 + Z_1} = \frac{\dfrac{10}{1 + j5\omega}}{\dfrac{10}{1 + j5\omega} + 40}$$

$$= \frac{10}{50 + j200\omega} = (5 + j20\omega)^{-1}$$

17. (D) $H(\omega) = \dfrac{V_o}{V_i} = \dfrac{1}{1 + j\omega RC}$

$$\text{gain} = \frac{1}{\sqrt{(1 + \omega^2 RC)}}$$

For any value of ω, R, C gain ≤ 1.

Thus (D) is correct option.

18. (D) $H(\omega) = \dfrac{V_o}{V_s} = \dfrac{1}{1 + j\omega CR}$

phase shift $= -\tan^{-1} \omega CR = -450°$

$\omega CR = 1,$

$20 \times 1 \times 10^{-6} R = 1 \quad \Rightarrow \quad R = 50$ kΩ.

19. (A) $H(\omega) = \dfrac{V_o}{V_s} = \dfrac{R}{\sqrt{1 + j\omega L}}$

$$\text{gain} = \frac{R}{\sqrt{R^2 + \omega^2 L^2}} = \frac{30}{\sqrt{900^2 + 4\omega^2 + 0.6}}$$

$$\omega = \frac{\sqrt{50^2 - 30^2}}{2} = 20 \text{ rad/s}$$

20. (A) $H(\omega) = \dfrac{V_o}{V_s} = \dfrac{1}{1 + j\omega CR} = \dfrac{1}{1 + j}$

Phase shift $= -\tan^{-1} \omega CR = -45°$

$$\text{gain} = \frac{1}{|j + 1|} = \frac{1}{\sqrt{2}} = 0.707$$

21. (B) BW$= \omega_2 - \omega_1 = 2\pi(456 - 434) = 44\pi$

$$\omega_o = 2\pi f_o = Q\text{BW} = 20 \times 44\pi$$

$$f_o = 440 \text{ Hz}$$

22. (C) $f_o = \dfrac{1}{2\pi\sqrt{LC}}$

$$= \frac{1}{2\pi\sqrt{360 \times 10^{-12} \times 240 \times 10^{-6}}} = 541 \text{ kHz}$$

$$f_o = \frac{1}{2\pi\sqrt{50 \times 10^{-12} \times 240 \times 10^{-6}}} = 1.45 \text{ MHz}$$

23. (B) $f_o = \frac{1}{2\pi}\sqrt{\frac{1}{LC} - \frac{R^2}{L^2}}$

$$\frac{R}{L} = \frac{400}{240 \times 10^{-6}} = \frac{10^7}{6}$$

$$\frac{1}{LC} = \frac{1}{240 \times 10^{-6} \times 120 \times 10^{-12}} = \frac{10^{16}}{288}$$

$$\frac{R}{L} < \frac{1}{LC}, \quad f_o = \frac{1}{2\pi\sqrt{LC}} = 938 \text{ kHz}$$

24. (B) $\omega_o = \frac{1}{RC}$, R and C should be as small as possible.

$$R = (3.3)\frac{(1.8)}{3.3 + 1.8} = 1.165 \text{ k}\Omega$$

$$C = (10)\frac{(30)}{(10 + 30)} = 7.5 \text{ pF}$$

$$\omega = \frac{1}{1.165 \times 7.5 \times 10^{-9}} = 114.5 \times 10^6 \text{ rad/s}$$

25. (D) $R' = K_m R = 800 \times 12 \times 10^3 = 9.6 \text{ M}\Omega$

$$L' = \frac{K_m}{K_f L} = \frac{800}{1000} 40 \times 10^{-6} = 32 \,\mu\text{F}$$

$$C' = \frac{C}{K_m} K_F = 30 \times \frac{10^{-9}}{80} \times 1000 = 0.375 \text{ pF}$$

26. (A) $L'C' = \frac{LC}{K_f^2} \quad \Rightarrow \quad K_f^2 = \frac{4 \times 20 \times 10^{-3} \times 10^{-6}}{1 \times 6}$

$$\Rightarrow \quad K_f = 2 \times 10^{-4}$$

$$\frac{L'}{C'} = \frac{L}{C} K_m^2 \quad \Rightarrow \quad K_m^2 = \frac{(1)(20 \times 10^{-6})}{(2)(4 \times 10^{-3})}$$

$$\Rightarrow \quad K_m = 0.05$$

27. (D) $\omega_c = 2\pi f_c = \frac{1}{RC}$

$$\Rightarrow \quad R = \frac{1}{2\pi \times 20 \times 10^3 \times 0.5 \times 10^{-6}} = 15.9\,\Omega$$

28. (A) R_{TH} across the capacitor is

$$R_{TH} = (1\text{k} + 4\text{k}) \,||\, 5\text{k} = 2.5 \text{ k}\Omega$$

$$f_c = \frac{1}{2\pi \times 2.5 \times 10^3 \times 40 \times 10^{-9}} = 1.06 \text{ kHz}$$

29. (B) $\omega_c = 2\pi f_c = \frac{1}{RC}$

$$\Rightarrow \quad R = \frac{1}{2\pi \times 15 \times 10 \times 10^{-6}} = 1.06 \text{ k}\Omega$$

30. (B) $20 \log H = 20 \log \frac{1}{\omega^2} = -40 \log \omega$

31. (D) $\frac{V_o}{V_s} = \frac{2 + \frac{1}{j\omega 30 \times 10^{-3}}}{6 + \frac{1}{j\omega 30 \times 10^{-3}}} = \frac{1 + \frac{j\omega}{16.67}}{1 + \frac{j\omega}{3.56}}$

-20 dB/decade line starting from $\omega = 5.56$ rad/s

20 dB/decade line starting from $\omega = 16.67$ rad/s

Hence -20 dB/decade line for $5.56 < \omega < 16.67$

parallel to ω axis to $\omega > 16.67$

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