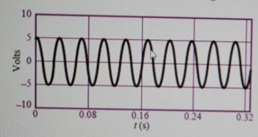
⚠ Moving to the next question prevents changes to this answer.

Question 2

The following figure represents a sinusoidal voltage in a Voltage vs. Time graph, where time is expressed in second.



Which of the following options best represents the frequency of the following sinusoidal signal?

- a. 30 Hz ✓
- b. 3.10 Hz
- c. 0.32 Hz
- d. 12.5 Hz

2.25 cycles in 0.08 s

⚠ Moving to the next question prevents changes to this answer.

$t = 0.08 \div 2.25$

$= 0.03556$

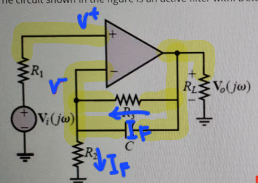
$$f = \frac{1}{T} = \frac{1}{0.03556}$$

$= 28.125\ Hz$

Moving to the next question prevents changes to this answer.

Question 3

The circuit shown in the figure is an active filter with. Determine the cutoff frequency (ω_0) and pass-band gain (A_V) of the filter.



$\boxed{v^+ = v^- \quad i_{in} = 0 \rightarrow i_s = -i_f}$

$$\frac{V_i - v^+}{R_1} = -\left(\frac{v^- - V_o}{\frac{R_3 \times \frac{1}{j\omega C}}{R_3 + \frac{1}{j\omega C}}} + \frac{v^-}{R_2}\right)$$

$$\frac{V_i - v^-}{R_1} + \frac{v^-}{R_2} = \frac{V_o - v^-}{\left(\frac{R_3}{1 + jR_3\omega C}\right)}$$

Given R_1=2kΩ, R_2=5kΩ, R_3=20kΩ, C=100nF.

- ω_0 = 500 rad/sec; A_V = 13.98 dB. ✓
- ω_0 = 500 rad/sec; A_V = 8.22 dB.
- ω_0 = 2000 rad/sec; A_V = 8.22 dB.
- ω_0 = 2000 rad/sec; A_V = 13.98 dB.

Moving to the next question prevents changes to this answer.

$$V_o = \frac{V^-}{R_2} \times \frac{R_3}{1 + jR_3 C\omega} + V^-$$

$$V_i = V^-$$

$$\frac{V_o}{V_i} = \frac{R_3}{R_2 + jR_3 C\omega} + 1$$

$$R_3 C\omega = 1$$

$$\omega = \frac{1}{20000 \times 100 \times 10^{-9}}$$

$$= 500\,\text{rad/s}$$

$$\text{gain} = 5 = \left|\frac{R_3}{R_2} + \right|$$

$$= 20 \log_{10} 5$$

$$= 13.98\,\text{dB}$$

✓

$$V_{in} = V^+ = V^-$$

$$I_F = \frac{V_o - V_i}{R_3 // C} = \frac{V_i}{R_2}$$

$$\frac{V_o}{//} - \frac{V_i}{//} = \frac{V_i}{R_2}$$

$$\frac{V_o}{//} = \frac{V_i}{R_2} + \frac{V_i}{//}$$

$$\frac{V_o}{V_i} = \left(\frac{1}{R_2} + \frac{1}{//}\right)(//)$$

$$= \frac{//}{R_2} + 1$$

$$= \frac{R_3 // C}{R_2} + 1$$

$$= \frac{R_3}{R_2(1 + j\omega C R_3)} + 1$$

$$\omega = \frac{1}{R_3 C}$$

$$1 + \frac{Z_F}{Z_S}$$

$$= 1 + \frac{R_3 // C}{R_2.}$$

$$\left(\frac{1}{R_3} + j\omega C\right)^{-1}$$

$$= \left(\frac{1 + j\omega C R_3}{R_3}\right)^{-1}$$

$$=$$

$$\frac{100 \times 10^3}{20 \times 10^3 (1 + j\omega (100 \times 10^{-9})(100 \times 10^3))}$$

$$=$$

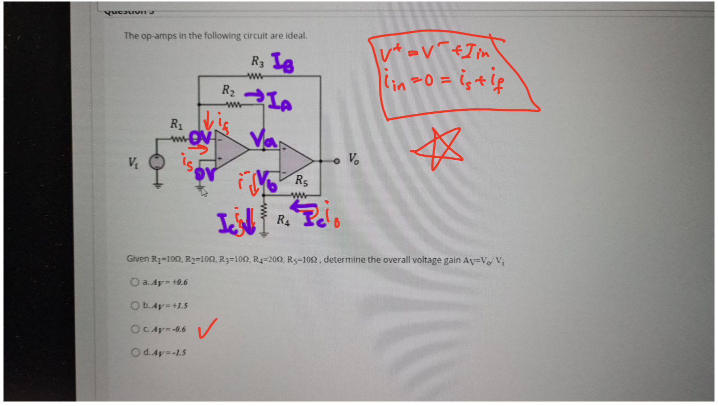
$$\omega_0 = 100$$

$$20 \log_{10} \left|\frac{R_3}{R_2} + 1\right|$$

$$= \frac{100}{20} + 1$$

$$6$$

$$15.$$



$V^- = V^+ = 0$ (gnd)

$i_s + i_f = 0$

$$\frac{V_i - V^-}{R_1} + \left(\frac{V^{B+} - V^-}{R_2} + \frac{V_0 - V^-}{R_3}\right) = 0 \qquad (1)$$

$V^{B+} = V^{B-}$

$$\Rightarrow \frac{V^{B-} - 0}{R_4} + \frac{V^{B-} - V_0}{R_5} = 0$$

$$\frac{V^{B-}}{R_4} + \frac{V^{B-}}{R_5} - \frac{V_0}{R_5} = 0$$

$$V^{B-}\left(\frac{1}{R_4} + \frac{1}{R_5}\right) = \frac{V_0}{R_5}$$

$$V^{B-} = V_0\left(\frac{1}{R_5}\right) \div \left(\frac{R_5 + R_4}{R_4 R_5}\right)$$

$$= V_0\left(\frac{R_4}{R_4 + R_5}\right) \qquad 2$$

$$\frac{V_i}{R_1} + \left(\frac{V_0\left(\frac{R_4}{R_4+R_5}\right)}{R_2} + \frac{V_0}{R_3}\right) = 0$$

$$V_0\left(\frac{\frac{R_4}{R_4+R_5}}{R_2} + \frac{1}{R_3}\right) = -\frac{V_i}{R_1}$$

$$\therefore A_V = \frac{V_0}{V_i} = -\left(\frac{1}{R_1}\right) \div \left(\frac{\frac{R_4}{R_4+R_5}}{R_2} + \frac{1}{R_3}\right)$$

$$= -\left(\frac{1}{10}\right) \div \left(\frac{\frac{20}{20+10}}{10} + \frac{1}{10}\right)$$

$$= -0.6$$

$$I_s = I_A + I_B$$

$$\frac{V_i}{R_1} = \frac{0 - V_a}{R_2} + \frac{0 - V_{out}}{R_3}$$

$$\frac{V_i}{R_1} = -\frac{V_a}{R_2} - \frac{V_{out}}{R_3}$$

$$\frac{V_i}{R_1} = -\frac{V_{out}\left(\frac{R_4}{R_5+R_4}\right)}{R_2} - \frac{V_{out}}{R_3}$$

$$\frac{V_i}{R_1} = -\frac{V_{out} R_4}{R_2(R_5+R_4)} - \frac{V_{out}}{R_3}$$

$$\frac{V_i}{R_1} = V_{out}\left(-\frac{R_4}{R_2(R_5+R_4)} - \frac{1}{R_3}\right)$$

$$\frac{V_{out}}{V_i} = \frac{1}{R_1}\left(-\frac{R_4}{R_2(R_5+R_4)} - \frac{1}{R_3}\right)^{-1}$$

$$= \frac{1}{10}\left(-\frac{20}{10(20+10)} - \frac{1}{10}\right)^{-1}$$

$$= -0.6$$

$$I_c = \frac{V_{out} - V_b}{R_5} = \frac{V_b}{R_4}$$

$$\frac{V_{out}}{R_5} - \frac{V_b}{R_5} = \frac{V_b}{R_4}$$

$$\frac{V_{out}}{R_5} = V_b\left(\frac{1}{R_4} + \frac{1}{R_5}\right)$$

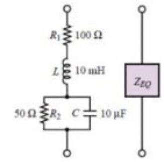
$$V_b = \frac{V_{out}}{R_5}\left(\frac{1}{R_4} + \frac{1}{R_5}\right)^{-1}$$

$$= \frac{V_{out}}{R_5}\left(\frac{R_5 R_4}{R_5 + R_4}\right)$$

$$= V_{out}\left(\frac{R_4}{R_5 + R_4}\right)$$

Question 5

Which of the following impedances best approximates the equivalent impedance of the following circuit, at frequency $\omega=10^4$ rad/sec?



- a. $Z_{EQ}=100\,e^{j\pi/2}\,\Omega$
- b. $Z_{EQ}=100+100\,e^{j\pi}\,\Omega$
- c. $Z_{EQ}=j100\,\Omega$
- d. $Z_{EQ}=100+j90\,\Omega$

$\left(\frac{1}{R_2}+j\omega C\right)^{-1}$

$=\left(\frac{1+R_2 j\omega C}{R_2}\right)^{-1}$

$=\frac{R_2}{1+R_2 j\omega C} = \frac{50}{1+50j(10^4)(10\times10^{-6})}$

$=\frac{50}{1+5j}\times\frac{1-5j}{1-5j}$

$=\frac{50-250j}{26}$

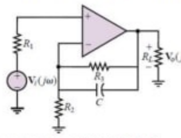
$R_2 \| C + L + R_1$

$\frac{R_2}{1+R_2 j\omega C}+j\omega L+R_1$

$\frac{50}{26}-\frac{250}{26}j+j(10^4)(10\times10^{-3})+100$

$=101.9+90.3j$

The circuit shown in the figure is an active filter with. Determine the cutoff frequency (ω_0) and pass-band gain (A_V) of the filter.



Given R_1=2kΩ, R_2=5kΩ, R_3=40kΩ, C=100nF.

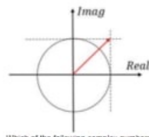
- ω_0 = 2000 rad/sec; A_V = 8.22 dB.
- ω_0 = 250 rad/sec; A_V = 8.22 dB.
- ω_0 = 250 rad/sec; A_V = 19.08 dB.
- ω_0 = 2000 rad/sec; A_V = 19.08 dB.

$1+\frac{Z_F}{Z_S}$

$=1+\frac{R_3 \| C}{R_2}$.

$=1+$

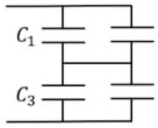
The figure below represents the complex plane, a vector (arrow) and the unitary circle.



Which of the following complex numbers best represents the vector?

- [x] $\sqrt{2}\,e^{j\pi/4}$
- [ ] $\sqrt{2}$
- [ ] $2\,e^{j\pi/2}$
- [ ] $2\,e^{j\pi}$

Capacitors in series/parallel.



With reference to the figure, determine the equivalent capacitance when C1 = 8 mF, C2 = 12 mF, C3 = 7 mF, C4 = 23 mF.

- Ceq = 42 mF
- Ceq = 12 mF
- Ceq = 27 mF
- Ceq = 184 mF

Question 3

Evaluate (5 + 4*j) * (5 - 4*j) where j is the unitary imaginary number.

- 41
- 9
- 25 + 16*j
- 25 - 16*j

	1	5j
1	1	5j
−5j	−5j	25

$-25j^2$

$=25$

$(\sqrt{-1})^2$

$=-1$

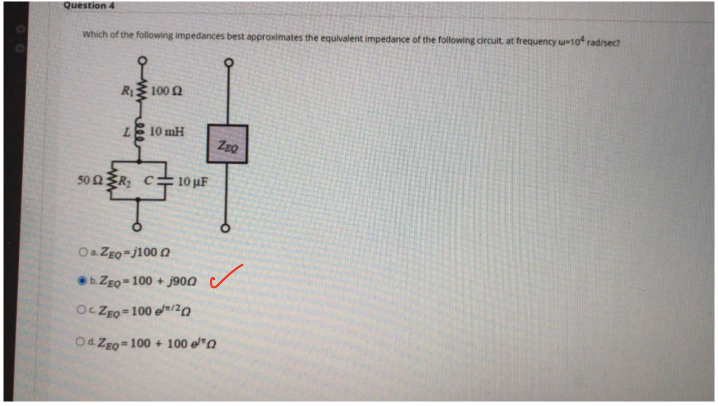
If Vin = 5∠20° and Vout = 10∠45°, in phasor format (amplitude ∠ angle), which of the following phasors best represent the ratio Vout / Vin ?

- 0.5∠-15°
- 15∠65°
- 2∠15°
- 5∠-15°

Question 3

Denoting by j the unit imaginary number, which of the following identities is true?

- $|1+j^2|=\sqrt{2}$
- $j^3=j$
- $j+\pi=0$
- $1+e^{j\pi}=0$



Question 4

Which of the following impedances best approximates the equivalent impedance of the following circuit, at frequency $\omega=10^4$ rad/sec?

- a. $Z_{EQ} = j100\ \Omega$
- b. $Z_{EQ} = 100 + j90\Omega$ ✓
- c. $Z_{EQ} = 100\, e^{j\pi/2}\Omega$
- d. $Z_{EQ} = 100 + 100\, e^{j\pi}\Omega$

$$\left(\frac{1}{R_2} + \frac{1}{\frac{1}{j\omega C}}\right)^{-1} = \left(\frac{1}{R_2} + j\omega C\right)^{-1}$$

$$= \left(\frac{1+j\omega C R_2}{R_2}\right)^{-1}$$

$$= \frac{R_2}{1+j\omega C R_2}$$

$$\therefore Z_{eq} = 100 + j(10^4)(10\times10^{-3}) + \frac{50}{1+j(10^4)(10\times10^{-6})\times 50}$$

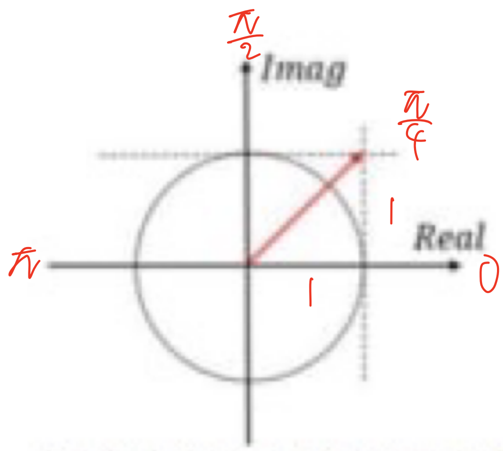
$$= 100 + j100 + \frac{50}{1+j5} \times \frac{1-j5}{1-j5}$$

$$= 100 + j100 + \frac{50 - j250}{1+25}$$

$$= 100 + j100 + \frac{50}{26} - j\frac{250}{26}$$

$$= \underline{101.923 + j90.384}$$

The figure below represents the complex plane, a vector (arrow) and the unitary circle.

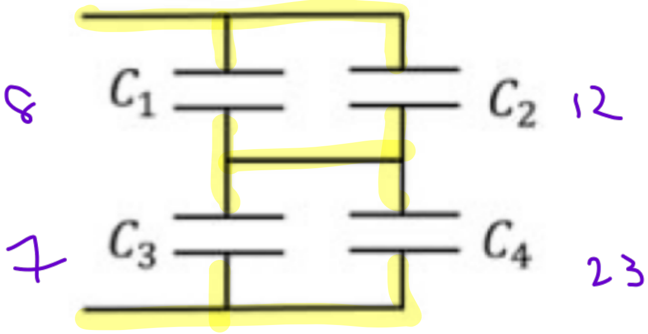


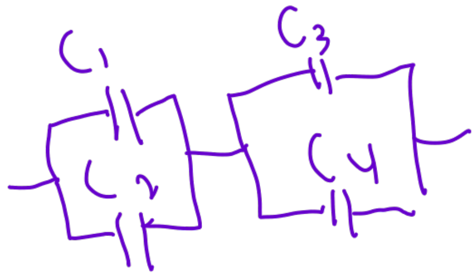
Which of the following complex numbers best represents the vector?

- [x] $\sqrt{2}\,e^{j\pi/4}$
- [ ] $\sqrt{2}$
- [ ] $2\,e^{j\pi/2}$
- [ ] $2\,e^{j\pi}$

$\sqrt{1^2 + 1^2}$

Capacitors in series/parallel.



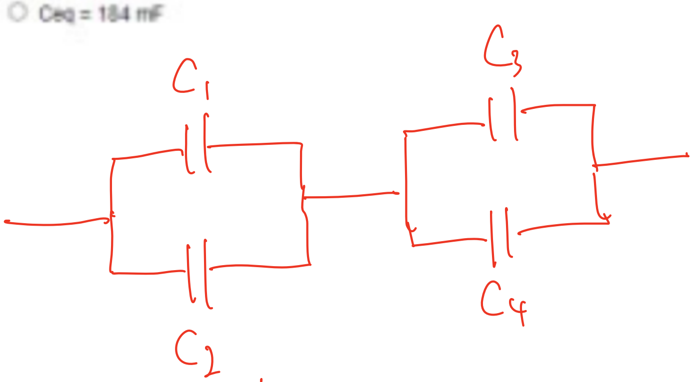


$8+12$
$= 20$

$7+23$
$= 30$

With reference to the figure, determine the equivalent capacitance when C1 = 8 mF, C2 = 12 mF, C3 = 7 mF, C4 = 23 mF.

- ○ Ceq = 42 mF
- ✓ Ceq = 12 mF
- ○ Ceq = 27 mF
- ○ Ceq = 184 mF



$$\left(\frac{1}{20} + \frac{1}{30}\right)^{-1}$$

$$= 12$$

$$C_{eq} = \left(\frac{1}{C_1+C_2} + \frac{1}{C_3+C_4}\right)^{-1} =$$

$$= \left(\frac{1}{8+12} + \frac{1}{7+23}\right)^{-1}$$

$$= 12\,mF \;//$$

$$\frac{1}{13+7} + \frac{1}{11+19}$$

$$= \frac{1}{20} + \frac{1}{30}$$

Question 3

Evaluate (5 + 4*j) * (5 - 4*j) where j is the unitary imaginary number.

- ✓ 41
- 9
- 25 + 16*j
- 25 - 16*j

$(5+4j) \times (5-4j)$

$= 25 - 20j + 20j - 16(-1)$

$= 41$

$(5+4j) \times (5-4j)$

Question 3

Denoting by j the unit imaginary number, which of the following identities is true?

- ○ $|1+j^2|=\sqrt{2}$ ✗
- ○ $j^3=j$ ✗
- ○ $j+\pi=0$ ✗
- ○ $1+e^{j\pi}=0$ ✓

$$|1+j^2|=\sqrt{2}$$

$$|0|=\sqrt{2} \quad \times$$

$$j^3=j \qquad j^2 j=-j \quad \times$$

$$|1+j^2|=|1-1|=0 \quad \times$$

$$j+\pi=\sqrt{\pi^2+1^2}\angle\tan^{-1}\left(\frac{1}{\pi}\right)$$

$$=3.296\angle 0.308 \quad \times$$

$$1+e^{j\pi}=0 \quad ✓$$

$$e^{j\pi}=-1$$

$$1\angle\pi=-1$$

$$1\cos\pi+1\sin\pi=-1$$

$$-1+0=-1$$

//

If Vin = 5∠20° and Vout = 10∠45°, in phasor format (amplitude ∠ angle), which of the following phasors best represent the ratio Vout / Vin ?

- ○ 0.5∠-15°
- ○ 15∠65°
- ✓ ○ 2∠15°
- ○ 5∠-15°

Question 3

Denoting by *j* the unit imaginary number, which of the following identit

$V_{in} = 5\angle 20^\circ$

$V_{out} = 10\angle 45^\circ$

$$\frac{V_{out}}{V_{in}} = \frac{10\angle 45^\circ}{5\angle 20^\circ}$$

$$= \frac{10e^{j45^\circ}}{5e^{j20^\circ}}$$

$$= 2e^{j25^\circ}$$

$$= 2\angle 25^\circ$$

$$= 1.813\hat{i} + 0.845\hat{j}$$

$$\frac{V_{out}}{V_{in}} = \frac{10\angle 45}{5\angle 20}$$

$$= 2\angle 25$$

pic 3: $V^- = V^+$

$i_s + i_f = 0$

$$\frac{V_i - V^-}{R_1} + \frac{V_0 - V^-}{R_3} + \frac{V^{B+} - V^-}{R_2} = 0$$

$$\frac{V_i}{R_1} + \frac{V_0}{R_3} + \frac{V^{B+}}{R_2} = 0 \quad \text{—— } ①$$

$$V^{B+} = V_0 \times \frac{R_4}{R_4 + R_5} \quad \text{—— } ②$$

$$\frac{V^{B+} - 0}{R_4} + \frac{V^{B+} - V_0}{R_5} = 0$$

$$\frac{V^{B+}}{R_4} + \frac{V^{B+}}{R_5} = \frac{V_0}{R_5}$$

$$V_{B+}\left(\frac{1}{R_4} + \frac{1}{R_5}\right) = \frac{V_0}{R_5}$$

$$\frac{V_0}{V_{B+}} = R_5\left(\frac{R_5 + R_4}{R_4 R_5}\right)$$

$$= \frac{R_5 + R_4}{R_4}$$

$$\therefore \frac{V_i}{R_1} + \frac{V_0}{R_3} + V_0 \frac{R_4}{R_4 + R_5} \times \frac{1}{R_2} = 0$$

$$V_0\left(\frac{1}{R_3} + \frac{R_4}{R_2(R_4 + R_5)}\right) = -\frac{V_i}{R_1}$$

$$\frac{V_0}{V_i} = -\frac{1}{R_1} \times \frac{1}{\left(\frac{1}{R_3} + \frac{R_4}{R_2(R_4 + R_5)}\right)}$$

$$= -0.8$$

$R_1 = R_2 = R_3 = R_4 = 10\,\Omega$

$R_5 = 30\,\Omega$

pic 5: $V^+ = V^-$

$I_{in} = 0 = I_s + I_f$ —— ☆

$$\left(\frac{1}{R_3} + j\omega C\right)^{-1} = \left(\frac{1 + j\omega C R_3}{R_3}\right)^{-1}$$

$$\frac{V_i - V^+}{R_1} = 0 \quad \text{—— ①}$$

$$\frac{V_i - V^+}{R_1} = 0$$

$$\frac{V_i}{R_1} - \frac{V^+}{R_1} = 0$$

$$\therefore V_i = V^+ = V^-$$

$I_s = -I_f$

$$-\left(\frac{V^- - V_0}{\frac{R_3}{1 + j\omega C R_3}} + \frac{V^-}{R_2}\right) = 0$$

$$\therefore \frac{V_0}{\frac{R_3}{1 + j\omega C R_3}} = \frac{V^-}{R_2} + \frac{V^-}{\frac{R_3}{1 + j\omega C R_3}}$$

$$V_0 = V^-\left(\frac{1}{R_2} \times \frac{R_3}{1 + j\omega C R_3} + 1\right)$$

$V_i = V^- = V^+$

$$\frac{V_0}{V_i} = \frac{1}{R_2} \times \frac{R_3}{1 + j\omega C R_3} + 1$$

$$\therefore \text{gain} = \frac{R_3}{R_2} + 1$$

$$= 11$$

$$20 \log 11 = 20.83\,dB$$

$$\omega C R_3 = 1$$

$$\omega = \frac{1}{C R_3} = 200 \text{ rad/s}$$

pic 7

$$V^+ = V^-$$

$$i_{in} = 0 = i_s + i_f$$

$$\frac{V_i - V^+}{R_1} = 0$$

$$\therefore V_i = V^+ = V^- \quad \text{—— (1)}$$

$$\frac{V^-}{R_2} + \frac{V^- - V_0}{\frac{R_3 \frac{1}{j\omega C}}{R_3 + \frac{1}{j\omega C}}} = 0$$

$$\frac{V^-}{R_2} + \frac{V^-}{\frac{R_3}{1+j\omega CR_3}} = \frac{V_0}{\frac{R_3}{1+j\omega CR_3}}$$

$$V_0 = V^- + \frac{V^-}{R_2} \times \frac{R_3}{1+j\omega CR_3} \quad \text{—— (2)}$$

$$\frac{V_0}{V_i} = 1 + \frac{R_3/R_2}{1+j\omega CR_3} \quad ☆$$

$$\text{gain} = 1 + \frac{R_3}{R_2}$$

$$= 1 + \frac{10000}{5000} = 3$$

$$= 20\log_{10} 3 = 9.54\,dB$$

$$\omega CR_3 = 1$$

$$\omega = \frac{1}{100\times10^{-9} \times 10000} = 1000 \text{ rad/s}$$

Pic 10

$V^+ = V^-$

$i_{in} = 0 = i_s + i_f$

$$\frac{V_i - \cancel{V_A}^{\to 0}}{R_1} + \frac{V_0 - \cancel{V_A}^{\to 0}}{R_3} + \frac{V^{B+} - \cancel{V_A}^{\to 0}}{R_2} = 0 \quad \text{——— } 1$$

$V^{B+} = V^{B-}$

$$\frac{V^{B-}}{R_4} + \frac{V^{B-} - V_0}{R_5} = 0$$

$$V^{B-}\left(\frac{1}{R_4} + \frac{1}{R_5}\right) = \frac{V_0}{R_5}$$

$$V^{B-}\left(\frac{R_5 + R_4}{R_4 R_5}\right) = \frac{V_0}{R_5}$$

$$V^{B-} = V_0\left(\frac{R_4}{R_5 + R_4}\right) \quad \text{——— } 2$$

$$\frac{V_i}{R_1} + \frac{V_0}{R_3} + \frac{V_0}{R_2}\left(\frac{R_4}{R_5 + R_4}\right) = 0$$

$$V_i\left(\frac{1}{R_1}\right) = V_0\left(-\frac{1}{R_3} - \frac{R_4/R_2}{R_5 + R_4}\right)$$

$$\frac{V_0}{V_i} = \frac{1}{R_1} \div \left(-\frac{1}{R_3} - \frac{R_4/R_2}{R_5 + R_4}\right)$$

$$= -0.6$$

pic 11

$V^+ = V^-$

$i_{in} = 0 = i_s + i_f$

$$\frac{V_i - \cancel{V^-}\to 0}{R_1} + \frac{V_o - \cancel{V^-}\to 0}{R_3} + \frac{V^{B+} - \cancel{V^-}\to 0}{R_2} = 0 \quad \text{—— (1)}$$

$$\frac{V^{B-}}{R_4} + \frac{V^{B-} - V_o}{R_5} = 0$$

$$V^{B-}\left(\frac{1}{R_4} + \frac{1}{R_5}\right) = \frac{V_o}{R_5}$$

$$V^{B-} = V_o \frac{1}{R_5}\left(\frac{R_4 R_5}{R_4 + R_5}\right)$$

$$= V_o \left(\frac{R_4}{R_4 + R_5}\right) \quad \text{—— (2)}$$

$$\frac{V_i}{R_1} + \frac{V_o}{R_3} + \frac{1}{R_2} V_o \frac{R_4}{R_4 + R_5} = 0$$

$$V_o\left(\frac{1}{R_3} + \frac{R_4/R_2}{R_4 + R_5}\right) = V_i\left(-\frac{1}{R_1}\right)$$

$$\therefore \frac{V_o}{V_i} = -\frac{1}{R_1} \div \left(\frac{1}{R_3} + \frac{R_4/R_2}{R_4 + R_5}\right)$$

$$\approx -0.8 \;//$$

pic 14

$V^+ = V^-$

$i_{in} = 0 = i_s + i_f$

$$\frac{V_i - V^+}{R_1} = 0$$

$\therefore V_i = V^+ = V^-$ —— 1

$$\frac{V^-}{R_2} + \frac{V^- - V_0}{\frac{R_3 \frac{1}{j\omega C}}{R_3 + \frac{1}{j\omega C}}} = 0$$

$$\frac{V^-}{R_2} + \frac{V^-}{\frac{R_3}{1+j\omega CR_3}} = \frac{V_0}{\frac{R_3}{1+j\omega CR_3}}$$ —— 2

$$\therefore V_0 = V_i \left(1 + \frac{R_3/R_2}{1+j\omega CR_3}\right)$$

$$\frac{V_0}{V_i} = \left(1 + \frac{R_3/R_2}{1+j\omega CR_3}\right)$$

$$\text{gain} = 1 + \frac{R_3}{R_2} = 1 + \frac{50000}{5000} = 11$$

$$= 20\log_{10} 11$$

$$= 20.83 \text{ dB}$$

$\omega CR_3 = 1$

$$\omega = \frac{1}{100\times10^{-9} \times 50000} = 200 \text{ rad/s}$$

pic 3

$$V^+ = V^- = 0$$

$$i_{in} = 0 = i_s + i_f$$

$$\frac{V_i - V^-}{R_1} + \frac{V_o - V^-}{R_3} + \frac{V^{2+} - V^-}{R_2} = 0$$

$$\frac{V_i}{R_1} + \frac{V_o}{R_3} + \frac{V^{2+}}{R_2} = 0 \quad \text{——— } (1)$$

$$V^{2+} = V^{2-}$$

$$\frac{V^{2-} - 0}{R_4} + \frac{V^{2-} - V_o}{R_5} = 0$$

$$V^{2-}\left(\frac{1}{R_4} + \frac{1}{R_5}\right) = \frac{V_o}{R_5}$$

$$V^{2-} = V_o \times \frac{1}{R_5}\left(\frac{1}{R_4} + \frac{1}{R_5}\right)^{-1}$$

$$= V_o \times \frac{1}{R_5}\left(\frac{R_4 + R_5}{R_4 R_5}\right)^{-1}$$

$$= V_o\left(\frac{R_4}{R_4 + R_5}\right) \quad \text{——— } (2)$$

$$\frac{V_i}{R_1} + \frac{V_o}{R_3} + V_o\left(\frac{R_4}{R_4 + R_5}\right) \times \left(\frac{1}{R_2}\right) = 0$$

$$\frac{1}{R_1} + \frac{V_o}{V_i} \times \frac{1}{R_3} + \frac{V_o}{V_i} \times \frac{R_4/R_2}{R_4 + R_5} = 0$$

$$\frac{V_o}{V_i} = -\frac{1}{R_1} \div \left(\frac{1}{R_3} + \frac{R_4/R_2}{R_4 + R_5}\right)$$

$$= -0.8 \;//$$

Pic 5

$V^+ = V^-$

$i_{in} = 0 = i_s + i_f$

$$\frac{V_i - V^+}{R_1} = 0$$

$\therefore V_i = V^+ = V^-$

$$\frac{V^- - 0}{R_2} + \frac{V^- - V_0}{\frac{R_3 \times \frac{1}{j\omega C}}{R_3 + \frac{1}{j\omega C}}} = 0$$

$$\frac{V_i}{R_2} + V_i\left(\frac{j\omega C R_3 + 1}{R_3}\right) = V_0\left(\frac{1 + j\omega C R_3}{R_3}\right)$$

$$\therefore \frac{V_0}{V_i} = \left(\frac{1}{R_2} + \frac{j\omega C R_3 + 1}{R_3}\right) \times \left(\frac{R_3}{1 + j\omega C R_3}\right)$$

$$= \frac{1}{R_2} \times \frac{R_3}{1 + j\omega C R_3} + 1$$

$$= \frac{R_3/R_2}{1 + j\omega C R_3} + 1$$

when $\omega \to 0$, $H \to \frac{R_3/R_2}{1} + 1$

when $\omega \to \infty$, $H \to 0$

$\therefore$ gain $= R_3/R_2 + 1 = \frac{50000}{5000} + 1 = 11$

$20\log_{10} 11 = 20.83\,dB$

$WCR_3 = 1$

$W = \frac{1}{100 \times 10^{-9} \times 50000} = 200$ rad/s

$f = \frac{1}{T}$

$T = 0.08 \div 2.25$

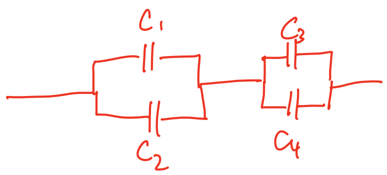
$\therefore f = 28.125 Hz$

$R_{eq} = 100 + j\omega L + \frac{50 \frac{1}{j\omega C}}{50 + \frac{1}{j\omega C}}$

$= 100 + j\omega L + \frac{50}{1 + j\omega C50} \times \frac{1 - j\omega C50}{1 - j\omega C50}$

$= 100 + j\omega L + \frac{50 - j\omega C 2500}{1 + \omega^2 C^2 \times 50^2}$

$= 101.923 + j\,99.038\ \Omega$



$C_{eq} = \left(\frac{1}{C_1 + C_2} + \frac{1}{C_3 + C_4}\right)^{-1}$

$= \left(\frac{1}{20} + \frac{1}{30}\right)^{-1}$

$= 12mF$

$(5 + j4)(5 - j4)$

$= 25 + 16 = 41$ //

$\frac{10\angle 45^\circ}{5\angle 20^\circ} = 2\angle 25^\circ$

$|1 + j^2| = |1 + (-1)| = 0 \neq \sqrt{2}$

$j^3 = j^2 j = -1j = -j \neq j$

$\pi + j = \sqrt{\pi^2 + 1} \angle \tan^{-1}\frac{1}{\pi} \neq 0$

$1 + e^{j\pi} = 0$

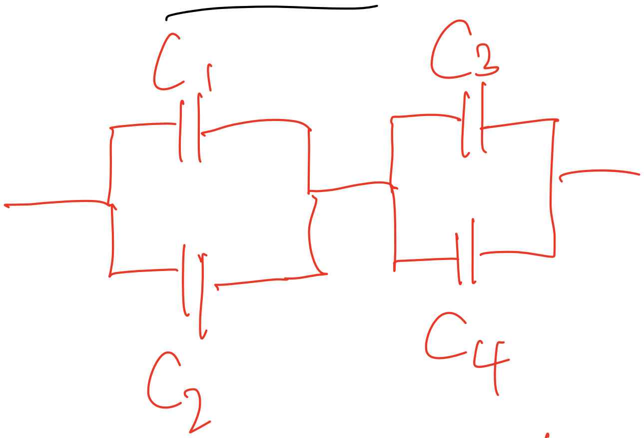
$1 + 1\angle\pi = 0$

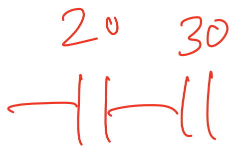
$1 + (-1) = 0$

CA2

1)

actual





$$C_{eq} = \left(\frac{1}{13+7} + \frac{1}{7+23}\right)^{-1}$$

$$= 12mF \quad //$$

2) $$100 + j\omega L + \frac{50 \times \frac{1}{j\omega C}}{50 + \frac{1}{j\omega C}}$$

$$= 100 + j100 + \frac{50}{50j\omega C + 1} \times \frac{1 - j\omega C 50}{1 - j\omega C 50}$$

$$= 100 + j100 + \frac{50 - j\,2500\,\omega C}{1 + (\omega C 50)^2}$$

$$= 100 + \frac{50}{1 + (50\omega C)^2} + j100 - j\left(\frac{2500\,\omega C}{1 + (50\omega C)^2}\right)$$

$$= 101.923 + j\,90.38$$

$$= 100 + j90\,\Omega$$

3) $\left| 1+j^2 \right| = \left| 1+(-1) \right| = 0 \neq \sqrt{2}$

$j^3 = j^2 j = -1j = -j \neq j$

$\bar{a}+j \neq 0$

$1+e^{j\pi} = 1+1\angle\pi = 1+\cos\pi+\sin\pi$

$= 1+(-1) = 0$ ✓

4) $R_1 = R_2 = R_3 = R_5 = 10\Omega$, $R_4 = 20\Omega$

$V^+ = V^- = 0$

$i_{in} = 0 = i_s + i_f$

$$\frac{V_i - V^-}{R_1} + \frac{V_0 - V^-}{R_3} + \frac{V^{2+} - V^-}{R_2} = 0$$

$$\frac{V_i}{R_1} + \frac{V_0}{R_3} + \frac{V^{2+}}{R_2} = 0 \quad \text{———} \quad (1)$$

$V^{2+} = V^{2-}$

$$\frac{V^{2-} - 0}{R_4} + \frac{V^{2-} - V_0}{R_5} = 0$$

$$V^{2-}\left(\frac{1}{R_4} + \frac{1}{R_5}\right) = \frac{V_0}{R_5}$$

$$V^{2-} = V_0\left(\frac{1}{R_5}\right)\left(\frac{1}{R_4} + \frac{1}{R_5}\right)^{-1}$$

$$= V_0\left(\frac{1}{R_5}\right)\left(\frac{R_5 + R_4}{R_4 R_5}\right)^{-1}$$

$$= V_0\left(\frac{R_4}{R_5 + R_4}\right) \quad \text{———} \quad (2)$$

$$\therefore \frac{V_i}{R_1} + \frac{V_0}{R_3} + V_0\left(\frac{R_4/R_2}{R_5 + R_4}\right) = 0$$

$$\therefore \frac{V_0}{V_i} = -\frac{1}{R_1} \div \left(\frac{1}{R_3} + \frac{R_4/R_2}{R_5 + R_4}\right)$$

$$= -0.6$$

5) $R_1 = 2k\Omega$, $R_2 = 10k\Omega$, $R_3 = 100k\Omega$, $C = 100nF$

$$V^+ = V^- = V_i$$

$$i_{in} = 0 = i_s + i_f$$

$$\frac{V^-}{R_2} + \frac{V^- - V^o}{\frac{R_3 \frac{1}{j\omega C}}{R_3 + \frac{1}{j\omega C}}} = 0$$

$$V_i\left(\frac{1}{R_2}\right) + V_i\left(\frac{R_3 + \frac{1}{j\omega C}}{R_3 \frac{1}{j\omega C}}\right) = V_o\left(\frac{R_3 + \frac{1}{j\omega C}}{R_3 \frac{1}{j\omega C}}\right)$$

$$1 + \left(\frac{1}{R_2}\right) \times \frac{R_3 \frac{1}{j\omega C}}{R_3 + \frac{1}{j\omega C}} = \frac{V_o}{V_i}$$

$$\frac{V_o}{V_i} = 1 + \frac{1}{R_2}\left(\frac{R_3}{1 + j\omega C R_3}\right)$$

$$= 1 + \frac{R_3 / R_2}{1 + j\omega C R_3}$$

$$\omega = \frac{1}{CR_3}$$

$$= \frac{1}{100 \times 10^{-9} \times 100000} = 100 \text{ rad/s}$$ //

$$\text{gain} = 1 + \frac{R_3}{R_2}$$

$$= 1 + \frac{100000}{10000}$$

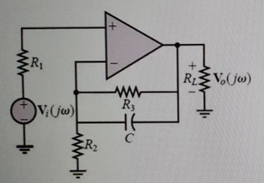
$$= 11$$

$$20\log_{10} 11 = 20.83\text{dB}$$ //

Moving to the next question prevents changes to this answer.

Question 3

The circuit shown in the figure is an active filter with. Determine the cutoff frequency (ω_0) and pass-band gain (A_V) of the filter.



Given R_1=2kΩ,R_2=5kΩ,R_3=20kΩ,C=100nF.

- ω_0 = 500 rad/sec; A_V = 13.98 dB.
- ω_0 = 500 rad/sec; A_V = 8.22 dB.
- ω_0 = 2000 rad/sec; A_V = 8.22 dB.
- ω_0 = 2000 rad/sec; A_V = 13.98 dB.

Moving to the next question prevents changes to this answer.

$V^+ = V^-$

$I_{in} = 0 = I_s + I_F$

$$\frac{V_i - V^+}{R_1} = 0$$

$$V_i = V^+ \quad \text{——} \quad (1)$$

$$\frac{V^- - 0}{R_2} + \frac{V^- - V_0}{\frac{R_3}{1+j\omega CR_3}} = 0$$

$$V^-\left(\frac{1}{R_2}\right) + V^-\left(\frac{1+j\omega CR_3}{R_3}\right) = V_0\left(\frac{1+j\omega CR_3}{R_3}\right)$$

$$\therefore V_{in}\left(\frac{1}{R_2} + \frac{1+j\omega CR_3}{R_3}\right) = V_0\left(\frac{1+j\omega CR_3}{R_3}\right)$$

$$\frac{V_0}{V_{in}} = \frac{\left(\frac{1}{R_2} + \frac{1+j\omega CR_3}{R_3}\right)}{\left(\frac{1+j\omega CR_3}{R_3}\right)}$$

$$= \frac{1}{R_2} \times \frac{R_3}{1+j\omega CR_3} + 1$$

$$= 1 + \frac{R_3/R_2}{1+j\omega CR_3}$$

$$\omega CR_3 = 1$$

$$\omega = \frac{1}{CR_3}$$

$$= \frac{1}{100\times10^{-9} \times 20000}$$

$$= 500 \text{ rad/s}$$

$$\left(\frac{1}{R_3} + \frac{1}{\frac{1}{j\omega C}}\right)^{-1}$$

$$= \left(\frac{1}{R_3} + j\omega C\right)^{-1}$$

$$= \left(\frac{1+j\omega CR_3}{R_3}\right)^{-1}$$

$$= \frac{R_3}{1+j\omega CR_3}$$

$$\text{gain} = \left|\frac{V_{out}}{V_{in}}\right|$$

when $\omega \to 0$, $|H| = 1 + \frac{R_3}{R_2}$

$\omega \to \infty$, $|H| = 1$

$\therefore$ Low Pass filter

$$\text{gain} = 1 + \frac{R_3}{R_2} = 5$$

$$20\log_{10} 5 = 13.98\,dB$$