

EN811100 LINEAR CIRCUIT ANALYSIS

Quiz 4

Instructions:

There are 5 problems. The 70% of total points will be counted as full scores.

The submission is through Autolab (<https://autolab.en.kku.ac.th>).

The submission system allows an infinite number of submissions, but due to performance drop from heavy load, to lessen the unnecessary load a version penalty is implemented. A student can submit as many as 5 versions without any penalty. After that, **each version over 5 is subjected to 5% penalty.**

Due date is shown on the system.

Late submission will be penalized 50%.

How to write an acceptable answer

Student's answers will be graded with policy: 1ca2022 (tolerance < 0.001).

Note: tolerance is the largest difference the grader allows when tests student's answer. It may be less straightforward for option **p** or **P**. (See below) Therefore, students are advised to answer with higher precision than 0.001.

Grading option: e (engineering prefix) means (1) text must be exactly matched. (2) **Each number must be well spaced (there is space before and after a number).** (3) A number can be written in a regular format, using engineering prefix or scientific notation.

E.g., Given reference: **vx = -12.4 V; ix = 18.5 mA**

vx = -12.4 V; ix = 18.5m A	GOOD FORMAT /
vx = -12.4 V; ix = 18.5 mA	GOOD FORMAT /
vx = - 12.4 V; ix = 0.0185 A	GOOD FORMAT /
vx = -12.4 V; ix = 18.5e-3 A	GOOD FORMAT /
vx = - 12.4009 V; ix = 0.0185 A	GOOD FORMAT / (Still within tolerance)
vx = - 12.401 V; ix = 0.0185 A	GOOD FORMAT x (Over tolerance)
vx = -12.4 V; ix = 18.5 e-3 A	BAD FORMAT! x
vx = -12.4V; ix = 18.5mA	BAD FORMAT! x
vx =-12.4V; ix =18.5mA	BAD FORMAT! x
vx =-12.4V ix =18.5mA	BAD FORMAT! x
vx =-12.4V. ix =18.5mA	BAD FORMAT! x

Grading option: l (linear equation) means a linear equation must be written with each term well-spaced.

Each term can be written as a constant, a single variable, or a coefficient-variable pair. A coefficient-variable pair must start with coefficient following by a space then a variable. Constants and coefficients can be written in a regular format, using engineering prefix or scientific notation.

E.g., given reference: **-10 + v1 + 4 i2 = 0**

- 10 + v1 + 4 i2 = 0	GOOD FORMAT /
v1 + 4 i2 = 10	GOOD FORMAT /
2 v1 + 8 i2 = 20	GOOD FORMAT /
2k v1 + 8k i2 = 20k	GOOD FORMAT /
2e3 v1 + 8e3 i2 = 20e3	GOOD FORMAT /
8e3 i2 = 20e3 - 2e3 v1	GOOD FORMAT /
- 10 + 2 v1 + 4 i2 = v1	GOOD FORMAT /
- 10 + v1 + 4.0009 i2 = 0	GOOD FORMAT / (Still within tolerance)
- 10 + v1 + 4.001 i2 = 0	GOOD FORMAT × (Incorrect)
- 10 + v1 + 3.999 i2 = 0	GOOD FORMAT × (Incorrect)
- 10 + 4 i2 = 0	GOOD FORMAT × (# terms mismatches)
- 10 + 4 i2 + v1 + v2 = 0	GOOD FORMAT × (# terms mismatches)
- 10 + 4 i2 + v2 = 0	GOOD FORMAT × (Miss v1)
- 10 + 4 i2 + v1 = v1	GOOD FORMAT × (Incorrect)
- 10 + 4 i2 + v1 = v1	GOOD FORMAT × (Incorrect)
-10e-8 + 1e-8 v1 + 4e-8 i2 = 0	GOOD FORMAT × (Magnitude too small)
- 10 + v1 + 4i2 = 0	BAD FORMAT! ×
-10+v1+4i2 = 0	BAD FORMAT! ×
- 10 + v 1 + 4 i 2 = 0	BAD FORMAT! ×
- 1 0 + v1 + 4 i2 = 0	BAD FORMAT! ×

Grading option: p (python code) means the answer is interpreted as a python code and it will be run as a python code. The answer will be separated into 2 parts: prefix and the code.

E.g., **v2(t) = 8 - 6*exp(-t/0.02)** will be separated into prefix **v2(t)** and python code **8 - 6*exp(-t/0.02)**. The pycode will be run using lambda function assignment with all standard python functions and math functions, i.e., the code must work when put into a context such as:

```
from math import *

student_fn = lambda t: 8 - 6*exp(-t/0.02)

for argin in testargs: # testargs: List of values, e.g., [0.001, 0.003, 0.006]
    val = student_fn(argin)
```

Note all math functions are imported directly. This mean:

exp(t) is evaluable, but **math.exp(t)** is NOT.

The prefix must match what the question asks exactly. The python code part is student's answer.

E.g., given a correct answer is **v2(t) = 8 - 6*exp(-t/0.02)**,

v2(t) = 8 - 6*exp(-t/0.02) **GOOD FORMAT /**

$v_2(t) = 8 - 6 \cdot \exp(-50 \cdot t)$
 $v_2(t) = - 6 \cdot \exp(-50 \cdot t) + 8$
 $v_2(t) = 6 \cdot \exp(-50 \cdot t) + 8$
 $v_2(t) = 8 - 6 \exp(-t/0.02)$

GOOD FORMAT /
 GOOD FORMAT /
 GOOD FORMAT × but wrong!
 BAD! × syntax error

$v(t) = 8 - 6 \cdot \exp(-t/0.02)$
 $v_2(t) : 8 - 6 \cdot \exp(-t/0.02)$
 $v_2(t) = 8 - 6 \cdot e^{(-t/0.02)}$
 $v_2(t) = 8 - 6 \cdot \exp(-time/0.02)$

BAD FORMAT! × QID not found
 BAD FORMAT! × no QID specified
 BAD! × unsupported operand
 BAD! × 'time' is not defined

Note that difference in the answer is checked through the evaluation of the function, not in a symbolic form. E.g., an expected answer of function “ $f(x) = 0.1 \cdot x$ ” and student’s answer of “ $f(x) = 0.101 \cdot x$ ” will be over the tolerance when tested with $x = 10$ (or any $x > 1$). With $x = 10$, reference is 1, evaluation of student’s answer is 1.01 and the difference is 0.01, which is over the tolerance 0.001. Using multiple digits more precise than the test tolerance is highly recommended.

Grading option: P (python code as an answer as well as complex as a reference) is similar to **p** (python-code mode), but it also not allows a complex number. For LCA, we will reserve this mode for a complex number as an answer.

E.g., Given reference: **Z = 400 + 300j**

Z = 400 + 300j	GOOD FORMAT /
Z = 400 + 300j	GOOD FORMAT / (extra space)
Z = 400 + 300j	GOOD FORMAT / (space)
Z = 400+ 300j	GOOD FORMAT / (space)
Z = 400+300j	GOOD FORMAT / (space)
Z = 0.4e3 + 0.3e3j	GOOD FORMAT / (sci. notation)
Z = 300j + 400	GOOD FORMAT / (order)
Z = 400.0007 + 299.9993j	GOOD FORMAT / (Still within tolerance)
Z = 400.0009 + 299.9991j	GOOD FORMAT × (Over tolerance)
Z = 400 + j300	BAD FORMAT! × (!order)
Z = 400 + 300 j	BAD FORMAT! × (!space)
Z = 400 + 0.3Kj	BAD FORMAT! × (!engineering prefix)

Remark! Student’s “Z = 0 + 300j” can match reference “Z = 300j” without any problem. The complex-number answer (or whatever on the left side of the ‘=’ sign) is a python code.

How to read Autograder feedback

Example

```
lca2022: report mode: Hint ; tol: 0.001 ; grading mode: leppP
lca2022: # reference lines: 5
lca2022: # submitted lines: 5
lca2022: feedback: line 0
lca2022: * student : - V1 + 100 i2 + Vx - 12.002 = 0
lca2022: * feedback: Linear: incorrect
lca2022: feedback: line 1
lca2022: * student : i1 = 23.14e-3 A; V1 = 12.402 V
lca2022: * difference: #####
lca2022: * student : Q1: i(t) = 0.3*cos(100*t + -1.)
lca2022: * feedback: over tolerance
lca2022: * student : Q2: VB(t) = 3*t
lca2022: * feedback: QID not found
lca2022: * student : Q3: S 2 + 4j
lca2022: * feedback: No QID specified
```

tol: 0.001 ; grading mode: leppP

tol: 0.001 means all numbers are graded with tolerance 0.001.

grading mode: leppP means 5 lines are expected in the answer.

- l means the (first) line is graded as a linear equation.
- e means the (second) line is graded in an engineering prefix mode.
- p means the (third and fourth) line (after '=') is graded in a python mode.
- P means the (fifth) line is graded in a python mode against python code reference. (LCA reserves this for a complex number as an answer.)

- V1 + 100 i2 + Vx - 12.002 = 0 is the submitted answer.

Linear: incorrect

means that this equation is incorrect.

i1 = 23.14e-3 A; V1 = 12.402 V

#####

means that the first mismatch is found here on the 12.402.

Q1: i(t) = 0.3*cos(100*t + -1.)

over tolerance

means that the function is in a good format, but it is either incorrect or its precision is over the tolerance.

Q2: VB(t) = 3*t

QID not found

means that the right side (of the '=') may be misspelled, e.g., there might be a typo in Q2: VB(t). Letter case is a common mistake, check if it is Q2: Vb(t).

Q3: S 2 + 4j

No QID specified

means that the QID mark (i.e., '=' for LCA) is missing. It should be Q3: S =
2 + 4j



Q1. Phasor Analysis. Given the circuit in Figure 1 with $R1=40\Omega$, $L1=400\text{ mH}$, and $C1=500\mu\text{F}$. The source has magnitude $V_p = 20\text{ V}$ and angular frequency $\omega = 100\text{ rad/s}$, answer the following questions on AC steady-state analysis.

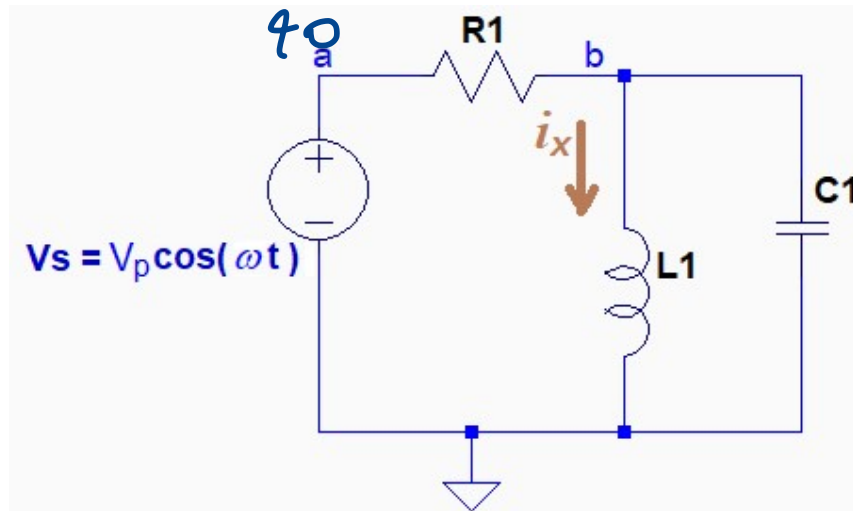


Figure 1

- Line 1. What is the phasor form of V_s ?
 Line 2. What is the impedance of $R1$?
 Line 3. What is the impedance of $L1$?
 Line 4. What is the impedance of $C1$?
 Line 5. Deduce the nodal voltage V_b in a phasor form.
 Line 6. Deduce i_x in a phasor form.
 Line 7. What is the angular frequency of i_x ?
 Line 8. Deduce i_x in time domain.

Write your answers in the following format. (Edit the *italic gray*, but keep the **bold black**.)

1	Vs: magnitude = 0 V, phase = 0 rad.
2	Q1.2: $Z_{R1} = 0 + 0j$
3	Q1.3: $Z_{L1} = 0 + 0j$
4	Q1.4: $Z_{C1} = 0 + 0j$
5	Vb: magnitude = 0 V, phase = 0 rad.
6	ix: magnitude = 0 A, phase = 0 rad.
7	Angular frequency = 0 rad/s, frequency = 0 Hz.
8	Q1.8: $i_x(t) = 0*t + 0*t**2 + 0*t**3$ # python code

Grading: ePPPeep

Report: Hint

1. $V_p = 20$ phase = 0
2. $Z_{R_1} = 40 + 0j$
3. $Z_{L_1} = j\omega L = j(2\pi \cdot 100)(400 \times 10^{-3})$
 $= 0 + 40j$
4. $Z_{C_1} = \frac{1}{j\omega C} = 0 - 20j$

5. find V_b

$$\frac{V_b - 20}{Z_{R_1}} + \frac{V_b}{Z_{L_1}} + \frac{V_b}{Z_{C_1}} = 0$$

$$\frac{V_b}{Z_{R_1}} + \frac{V_b}{Z_{L_1}} + \frac{V_b}{Z_{C_1}} = \frac{20}{Z_{R_1}}$$

$$V_b \left(\frac{1}{Z_{R_1}} + \frac{1}{Z_{L_1}} + \frac{1}{Z_{C_1}} \right) = \frac{20}{Z_{R_1}}$$

$$V_b = \frac{20}{Z_{R_1} \left(\frac{1}{Z_{R_1}} + \frac{1}{Z_{L_1}} + \frac{1}{Z_{C_1}} \right)}$$

$$V_b = 10 - 10i = 14.14214$$

$$\text{phase} = -0.7853982$$

$$6. \quad i_x = \frac{V_b}{Z_{L_1}} = -0.25 - 0.25i$$

$$= 0.3535534$$

$$\text{phase} = -2.356194$$

$$7. \quad \omega = 100 \quad f = \frac{\omega}{2\pi} = \frac{100}{2\pi}$$

$$= 15.91549$$

$$8. \quad i(x) = 0.3535534 e^{jx} \cos(100t - 2.356194)$$

Q2. Multiple Sources. Given the circuit in Figure 2 with $V_s(t) = 5 \cos(1256.637 t)$ and $I_p(t) = 0.075 \cos(1256.637 t - \pi/2)$, answer the following questions on AC steady-state analysis.

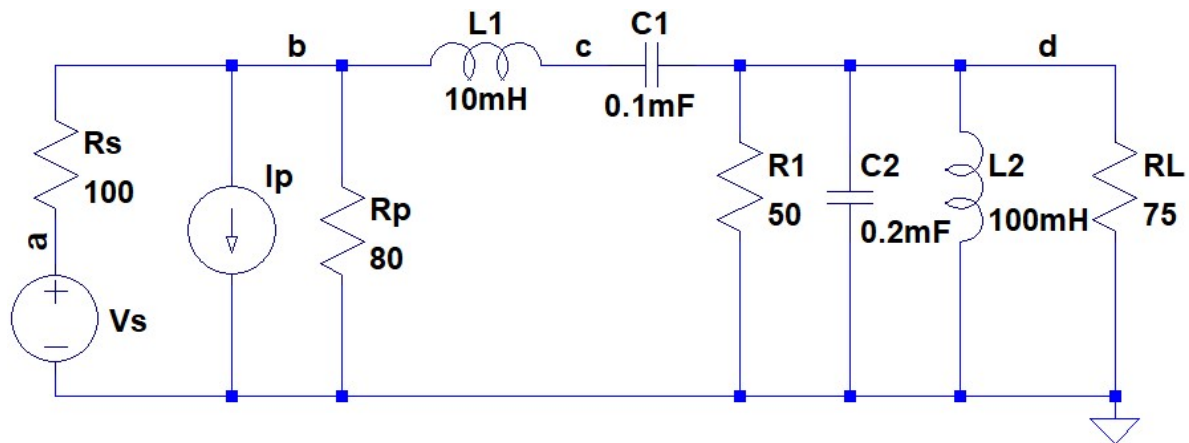


Figure 2

- Line 1. What are the angular frequency and the phasor of V_s ?
 Line 2. What are the angular frequency and the phasor of I_p ?
 Line 3. What is the impedance of $L1$?
 Line 4. What is the impedance of $L2$?
 Line 5. What is the impedance of $C1$?
 Line 6. What is the impedance of $C2$?
 Line 7. What are the impedances of R_s , R_p , R_1 and R_L ?
 Line 8. Deduce the nodal voltage V_b in a phasor form.
 Line 9. Deduce the nodal voltage V_d in a phasor form.
 Line 10. What is the angular frequency of V_d ?
 Line 11. Deduce V_d in time domain.
 Line 12. Deduce the voltage gain (magnitude of V_d/V_b).

Write your answers in the following format. (Edit the *italic gray*, but keep the **bold black**.)

1	V_s: ang. freq. = <i>θ</i> rad/s, magnitude = <i>θ</i> V, phase = <i>θ</i> rad.
2	I_p: ang. freq. = <i>θ</i> rad/s, magnitude = <i>θ</i> A, phase = <i>θ</i> rad.
3	Q2.3: Z_{L1} = <i>$\theta + \theta j$</i>
4	Q2.4: Z_{L2} = <i>$\theta + \theta j$</i>
5	Q2.5: Z_{C1} = <i>$\theta + \theta j$</i>
6	Q2.6: Z_{C2} = <i>$\theta + \theta j$</i>
7	Z_{R_s} = <i>θ</i> ohm, Z_{R_p} = <i>θ</i> ohm, Z_{R_1} = <i>θ</i> ohm, Z_{R_L} = <i>θ</i> ohm.
8	V_b: magnitude = <i>θ</i> V, phase = <i>θ</i> rad.
9	V_d: magnitude = <i>θ</i> V, phase = <i>θ</i> rad.
10	Angular frequency = <i>θ</i> rad/s, frequency = <i>θ</i> Hz.
11	Q2.11: $V_d(t)$ = <i>$\theta * t + \theta * t ** 2 + \theta * t ** 3$</i> # python code
12	Gain = <i>θ</i> (V/V).

Grading: eePPPPeeeee

Report: Hint

$$1. \omega = 1256.637 \quad \text{mag} = 5 \text{ V}, \quad \text{phase} = 0$$

$$2. \omega = 1256.637 \quad \text{mag} = 0.075, \quad \text{phase} = -1.570796$$

$$3. Z_{L1} = j\omega L_1 = 0 + 12.56637j$$

$$4. Z_{L2} = j\omega L_2 = 0 + 125.6637j$$

$$5. Z_{C1} = \frac{1}{j\omega C_1} = 0 - 7.957748j$$

$$6. Z_{C2} = \frac{1}{j\omega C_2} = 0 - 3.978874j$$

$$7. Z_{R5} = 100, \quad Z_{R6} = 80, \quad Z_{R1} = 50, \quad Z_{R2} = 75$$

8.

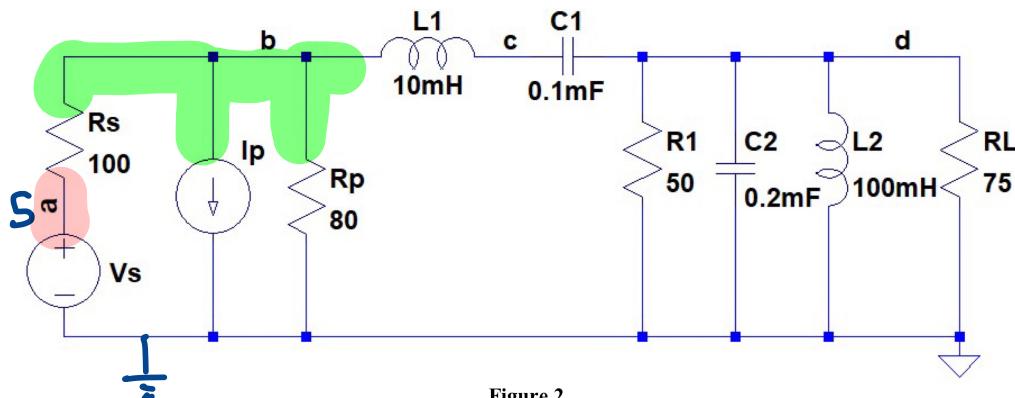


Figure 2

Node

$$\text{at } V_b \rightarrow \frac{V_b - 5}{100} + 0.075 + \frac{V_b}{80} + \frac{V_b - V_d}{Z_{L1} + Z_{C1}} = 0$$

$$Z_T = \frac{1}{Z_{R1}} + \frac{1}{Z_{C1}} + \frac{1}{Z_{L2}} + \frac{1}{Z_{R2}}$$

Q3. Band-Pass Filter. Given the circuit in Figure 3a with $V1$, $V2$, and $V3$ have the same magnitude $5V_p$, same phase 0 rad, but different frequencies 100 , 200 , and 300 Hz, respectively, answer the following questions on AC steady-state analysis.

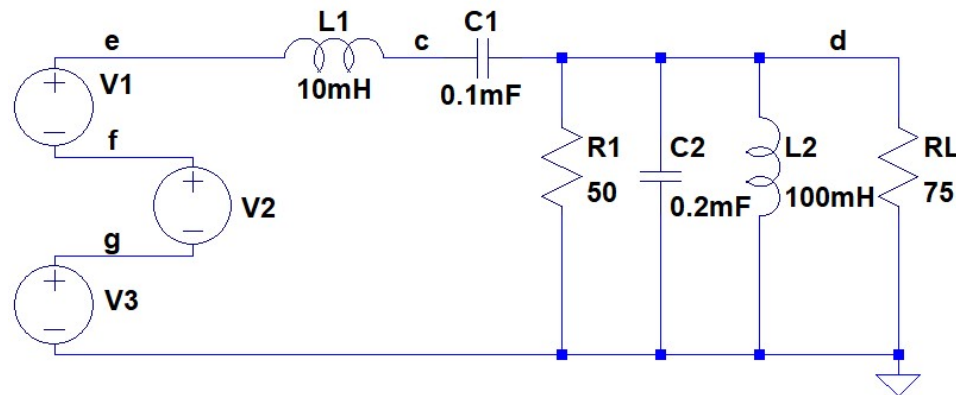


Figure 3a

- Line 1. Use superposition to deduce the effect on V_e from $V1$ acting alone.
 Line 2. Use superposition to deduce the effect on V_d from $V1$ acting alone.
 Line 3. Deduce the effect on V_d from $V1$ acting alone in time domain.
 Line 4. Deduce the gain (magnitude of V_d/V_e) from $V1$ acting alone.
 Line 5. Use superposition to deduce the effect on V_e from $V2$ acting alone.
 Line 6. Deduce the effect on V_d from $V2$ acting alone in time domain.
 Line 7. Deduce the gain (magnitude of V_d/V_e) from $V2$ acting alone.
 Line 8. Deduce the effect on V_d from $V3$ acting alone in time domain.
 Line 9. Deduce the gain (magnitude of V_d/V_e) from $V3$ acting alone.
 Line 10. Deduce the total effect on V_d from all sources in time domain.

Hint!

1. When the circuit involves sources of different frequencies, superposition may be handy.
2. Notice a part between terminals e-0 to terminals d-0 is identical to what in Figure 2.

Write your answers in the following format. (Edit the *italic gray*, but keep the **bold black**.)

1	V1 alone, V_e: magnitude = 0 V, phase = 0 rad, frequency = 0 Hz.
2	V1 alone, V_d: magnitude = 0 V, phase = 0 rad, frequency = 0 Hz.
3	Q3.3: V1 alone, $V_d(t) = 0*t + 0*t**2 + 0*t**3$ # python code
4	V1 alone, Gain(V_d/V_e) = 0 (V/V).
5	V2 alone, V_e: magnitude = 0 V, phase = 0 rad, frequency = 0 Hz.
6	Q3.6: V2 alone, $V_d(t) = 0*t + 0*t**2 + 0*t**3$ # python code
7	V2 alone, Gain(V_d/V_e) = 0 (V/V).
8	Q3.8: V3 alone, $V_d(t) = 0*t + 0*t**2 + 0*t**3$ # python code
9	V3 alone, Gain(V_d/V_e) = 0 (V/V).
10	Q3.10: Totally, $V_d(t) = 0*t + 0*t**2 + 0*t**3$ # python code

Grading: eepeepep

Report: Hint

Remark the circuit in Figure 3a is specified in SPICE as

```
V1 e f SINE(0 5 100 0 0 90)
L1 e c 10mH
C1 c d 0.1mF
R1 d 0 50
RL d 0 75
C2 d 0 0.2mF
L2 d 0 100mH
V2 f g SINE(0 5 200 0 0 90)
V3 g 0 SINE(0 5 300 0 0 90)
```

Note: SINE(0 5 100 0 0 90) *means* $5 \sin(2\pi 100 t + \pi/2)$.

Fun fact! This kind of circuits is called a band-pass filter (BPF) for its behavior that some range of frequencies has a much higher gain than the others. BPF is used extensively in a telecommunication system.

Figure 3b shows gain over a range of frequencies. This gain profile shows strong BPF behavior and frequency around 196 Hz receives much higher gain than the others.

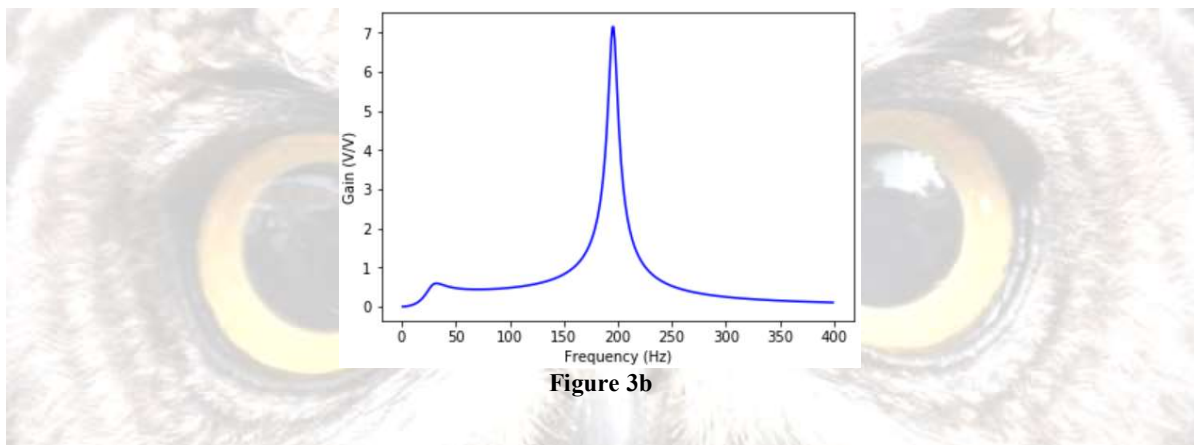


Figure 3b

Q4. Coupling Capacitor. Given the circuit in Figure 4 with V1 as a DC source of 1V and V2 as an AC source of magnitude 0.8V, frequency 100 KHz, answer the following questions on steady-state analysis.

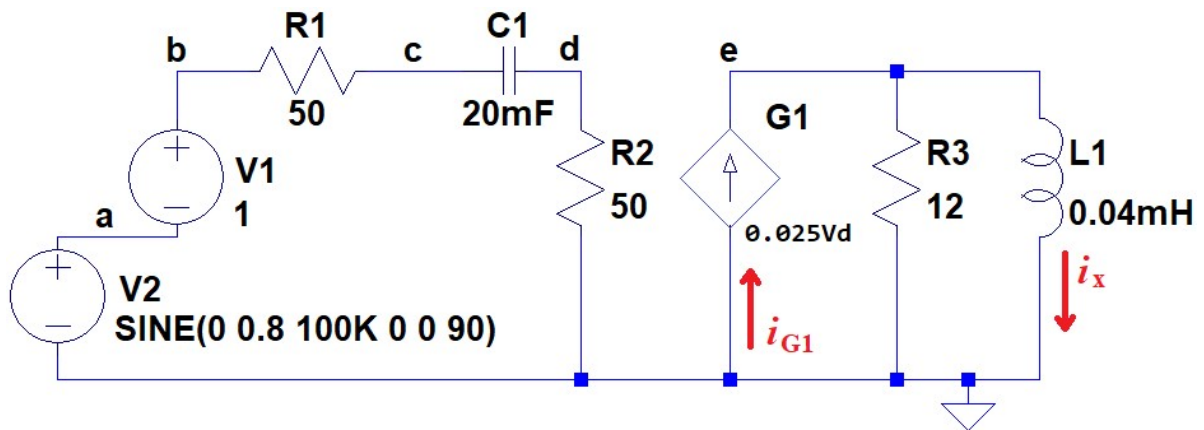


Figure 4a. Note: SINE(0 0.8 100K 0 0 90) means $0.8 \sin(2\pi 100K t + \pi/2)$.

- Line 1.* When V2 acting alone, what is V2 in a phasor form?
- Line 2.* Use superposition to deduce the effect on nodal voltage V_c , in time domain, from V2 acting alone.
- Line 3.* Use superposition to deduce the effect on nodal voltage V_d , in time domain, from V2 acting alone.
- Line 4.* Use superposition to deduce the effect on i_{G1} , in time domain, from V2 acting alone.
- Line 5.* Use superposition to deduce the effect on i_x , in time domain, from V2 acting alone.
- Line 6.* Use superposition to deduce the effect on V_c , in time domain, from V1 acting alone.
- Line 7.* Use superposition to deduce the effect on V_d , in time domain, from V1 acting alone.
- Line 8.* Use superposition to deduce the effect on i_{G1} , in time domain, from V1 acting alone.
- Line 9.* Use superposition to deduce the effect on i_x , in time domain, from V1 acting alone.
- Line 10.* Deduce the total effect on i_x from all sources in time domain.

Hint!

1. When the circuit involves sources of different frequencies, superposition may be handy.
2. When considering DC source acting alone, recall DC steady-state analysis (Chapter 7). We do not need phasor analysis for DC steady-state. This is incredibly easy.
3. This question gives you a glimpse of how practical circuits utilize LCA.

Write your answers in the following format. (Edit the *italic gray*, but keep the **bold black**.)

1	V2 alone, V2: magnitude = 0 V, phase = 0 rad, frequency = 0 Hz.
2	Q4.2: V2 alone, $V_c(t) = 0*t + 0*t**2 + 0*t**3$ # python code
3	Q4.3: V2 alone, $V_d(t) = 0*t + 0*t**2 + 0*t**3$ # python code
4	Q4.4: V2 alone, $i_{G1}(t) = 0*t + 0*t**2 + 0*t**3$ # python code
5	Q4.5: V2 alone, $i_x(t) = 0*t + 0*t**2 + 0*t**3$ # python code
6	Q4.6: V1 alone, $V_c(t) = 0*t + 0*t**2 + 0*t**3$ # python code
7	Q4.7: V1 alone, $V_d(t) = 0*t + 0*t**2 + 0*t**3$ # python code
8	Q4.8: V1 alone, $i_{G1}(t) = 0*t + 0*t**2 + 0*t**3$ # python code
9	Q4.9: V1 alone, $i_x(t) = 0*t + 0*t**2 + 0*t**3$ # python code
10	Q4.10: Totally, $i_x(t) = 0*t + 0*t**2 + 0*t**3$ # python code

Grading: eppppppppp

Report: Hint

Fun fact! Capacitor C1 in Figure 4a couples AC relation between two sides of its terminals, while keeping the DC aspects separated. This coupling capacitor is used extensively in electronic circuits. Figure 4b shows simulated signals. Notice the DC component does not get through, V_c and V_d are having very similar shapes, but V_c with a DC offset (shifting up), while V_d has no DC offset---it is oscillating around 0.

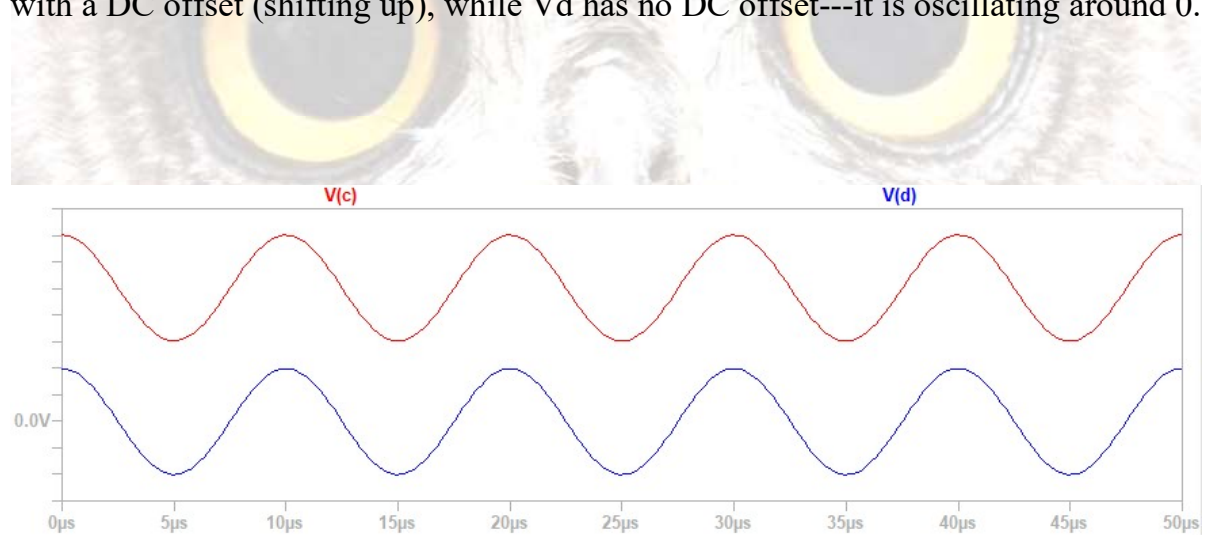


Figure 4b. Simulated signal.

Q5. Bypassing Capacitor. Given the circuit in Figure 5 with V1 as a DC source of 12V and V2 as an AC source of magnitude 0.2V, frequency 500 Hz, answer the following questions on AC steady-state analysis.

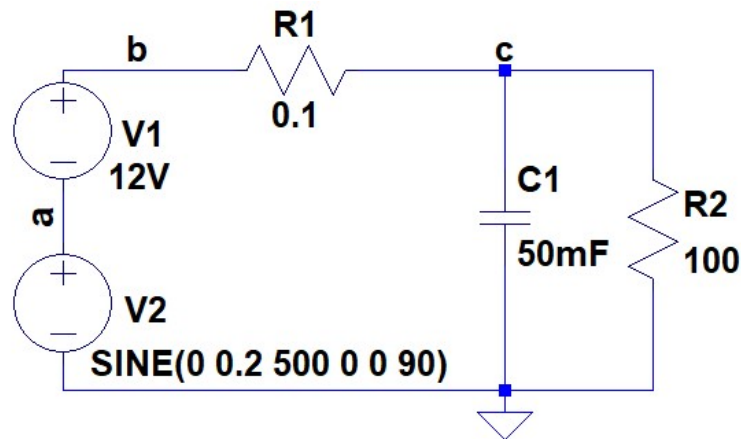


Figure 5a

- Line 1. Use superposition to deduce the effect on V_b from $V1$ acting alone.
 Line 2. Use superposition to deduce the effect on V_c from $V1$ acting alone.
 Line 3. Use superposition to deduce the effect on V_b from $V2$ acting alone.
 Line 4. Use superposition to deduce the effect on V_c from $V2$ acting alone.
 Line 5. Deduce the total effect on V_b from all sources in time domain.
 Line 6. Deduce the total effect on V_c from all sources in time domain.
 Line 7. Compute the ripple voltage in V_b . Note the ripple voltage, $ripple(V_x) = \max(V_x) - \min(V_x)$.
 Line 8. Compute the ripple voltage in V_c .

Hint!

1. Maximum of sinusoid is at the positive peak. Minimum of sinusoid is at the negative peak. See Figure 5b for visualization.
2. Only sinusoid commits in the ripple. DC does not involve.

Write your answers in the following format. (Edit the *italic gray*, but keep the **bold black**.)

1	Q5.1: V1 alone, $V_b(t) = 0*t + 0*t**2 + 0*t**3$ # python code
2	Q5.2: V1 alone, $V_c(t) = 0*t + 0*t**2 + 0*t**3$ # python code
3	Q5.3: V2 alone, $V_b(t) = 0*t + 0*t**2 + 0*t**3$ # python code
4	Q5.4: V2 alone, $V_c(t) = 0*t + 0*t**2 + 0*t**3$ # python code
5	Q5.5: Totally, $V_b(t) = 0*t + 0*t**2 + 0*t**3$ # python code
6	Q5.6: Totally, $V_c(t) = 0*t + 0*t**2 + 0*t**3$ # python code
7	Ripple(V_b) = 0 Vpp.
8	Ripple(V_c) = 0 Vpp.

Grading: ppppppee

Report: Hint

Fun fact! Capacitor C1 in Figure 5 bypasses the high-frequency signal to the ground, allowing a more stable DC signal, as ripple of V_c is much smaller than that of V_b .

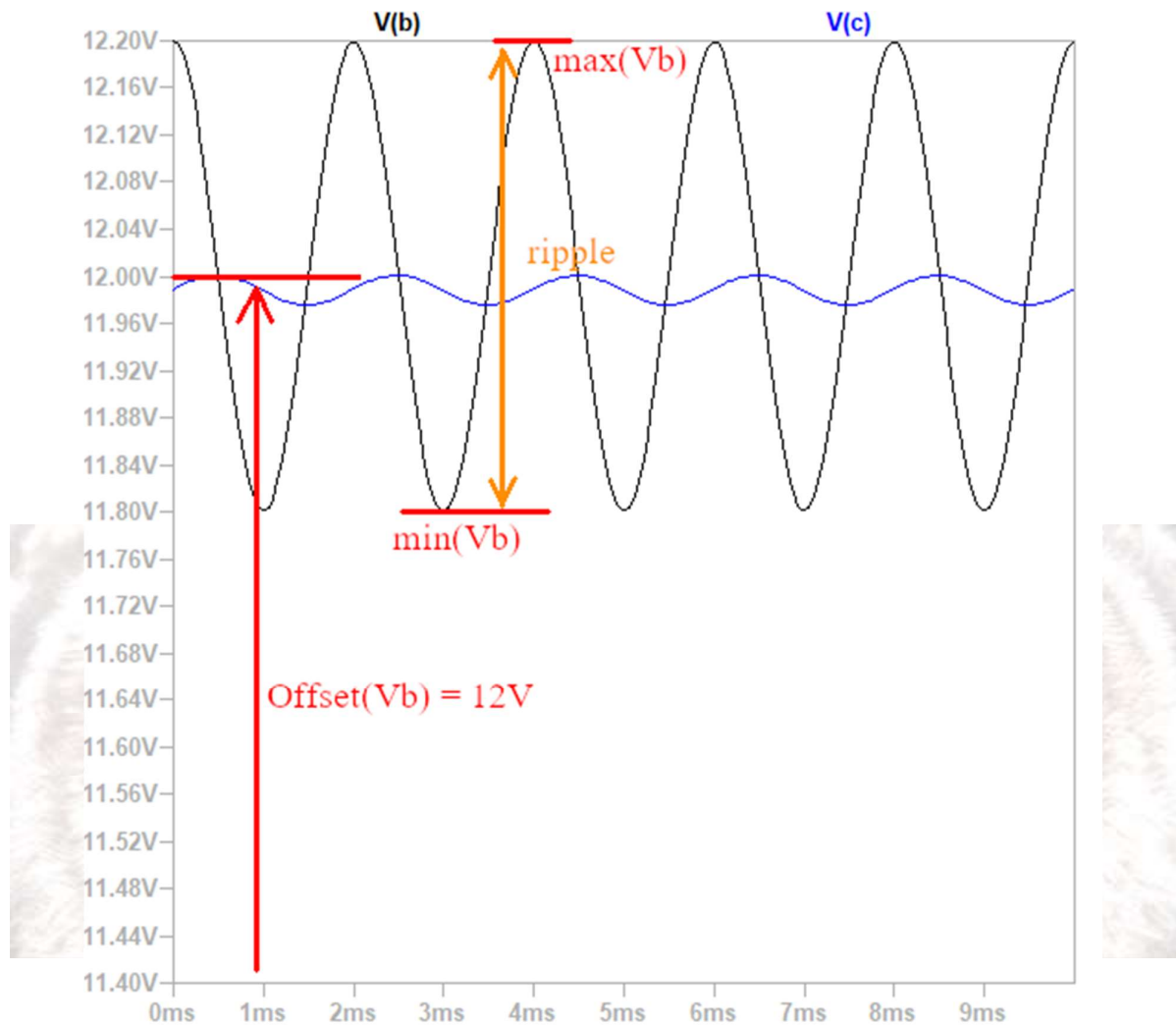


Figure 5b. Visualization of ripple.

---THE END---