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: `lca2022` (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 × (Over tolerance)
vx = -12.4 V; ix = 18.5 e-3 A     BAD FORMAT! ×
vx = -12.4V; ix = 18.5mA          BAD FORMAT! ×
vx =-12.4V; ix =18.5mA            BAD FORMAT! ×
vx =-12.4V ix =18.5mA             BAD FORMAT! ×
vx =-12.4V. ix =18.5mA            BAD FORMAT! ×
```

`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 testargins:   # testargins: 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 /
```

```
v2(t) = 8 - 6*exp(-50*t)          GOOD FORMAT ✓
v2(t) = - 6*exp(-50*t) + 8        GOOD FORMAT ✓
v2(t) = 6*exp(-50*t) + 8          GOOD FORMAT × but wrong!
v2(t) = 8 - 6 exp(-t/0.02)        BAD! × syntax error

v(t) = 8 - 6*exp(-t/0.02)         BAD FORMAT! × QID not found
v2(t) : 8 - 6*exp(-t/0.02)        BAD FORMAT! × no QID specified
v2(t) = 8 - 6*e^(-t/0.02)         BAD! × unsupported operand
v2(t) = 8 - 6*exp(-time/0.02)     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*x`" and student's answer of "`f(x) = 0.101*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.

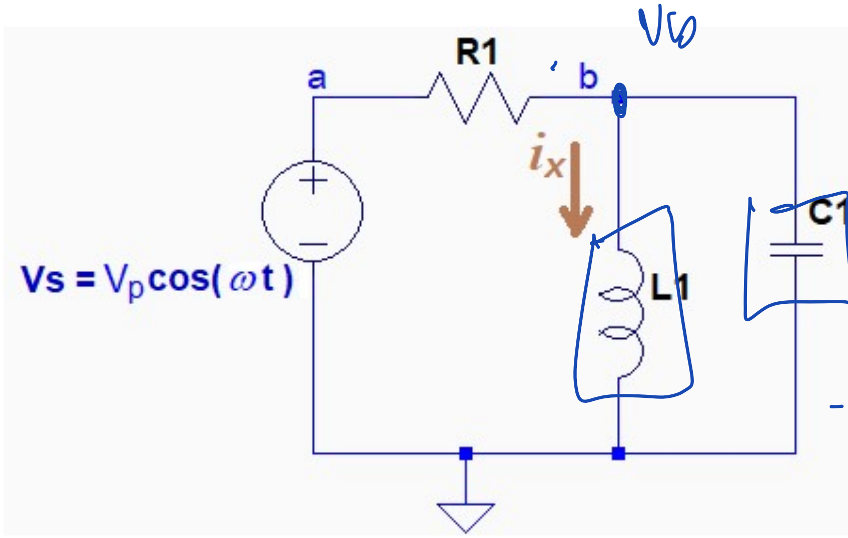
`Q2: VB(t) = 3*t`
`QID not found`
means that the right side (of the '=') may be misspelled, e.g., there might be a typo in `Q2: VB(t)`. Letter case is a common mistake, check if it is `Q2: Vb(t)`.

`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= 40Ω, L1= 400 mH, and C1= 500µF. The source has magnitude Vp = 20 V and angular frequency ω = 100 rad/s, answer the following questions on AC steady-state analysis.

$V = IZ$

$I = \frac{V}{Z}$



$\frac{1}{j400 \cdot 10^{-3} \cdot 100}$

$-\frac{j1}{40}$

Figure 1

Line 1. What is the phasor form of V_s? 20 cos(100t)
Line 2. What is the impedance of R1? 40
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. Vp cos(100t)
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: ZR1 = 0 + 0j
3  Q1.3: ZL1 = 0 + 0j
4  Q1.4: ZC1 = 0 + 0j
5  Vb: magnitude = 0 V, phase = 0 rad.        14.142135   -0.7853981
6  ix: magnitude = 0 A, phase = 0 rad.        0.353553    +0.7853981
7  Angular frequency = 0 rad/s, frequency = 0 Hz.   100   157.0796327
8  Q1.8: ix(t) = 0*t + 0*t**2 + 0*t**3 # python code
```

Grading: ePPPeeep
Report: Hint

0.353553*cos(100*t+0.7853981)

$\omega = 2\pi f$

$f = \frac{\omega}{2\pi}$

$Z_L = j\omega L$

$i_x = i_m \cos(\omega t + \phi)$

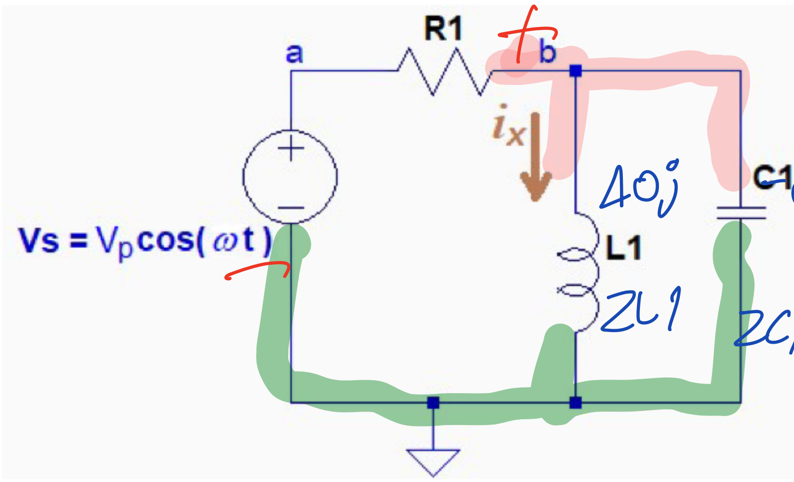
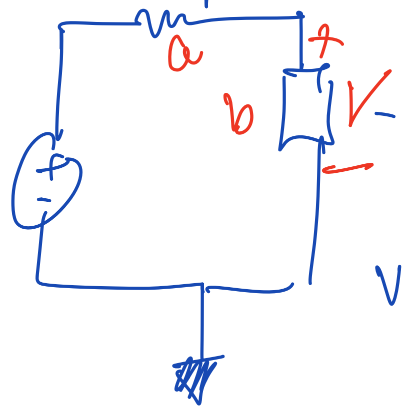


Figure 1

$$Z_L = \frac{1}{j\omega}$$

$$Z = j\omega L$$



40

$-20j$

$$V_b = \frac{-40j}{40-40j}$$

$$\frac{1}{Z_T} = \frac{\frac{1}{Z_{L1}} + \frac{1}{Z_{C1}}}{1}$$

$$V_b = \frac{Z_T}{(R1 + Z_T)} \times V_S$$

$$\frac{40j \cdot -20j}{40j + (-20j)}$$

$$Z_T = \frac{1}{\frac{1}{Z_{L1}} + \frac{1}{Z_{C1}}}$$

$$-\frac{400}{20j}$$

$$= 20j$$

Q2. Multiple Sources. Given the circuit in Figure 2 with *Vs(t)* = *5 cos(1256.637 t)* and *Ip(t)* = *0.075 cos(1256.637 t − π/2)*, answer the following questions on AC steady-state analysis.

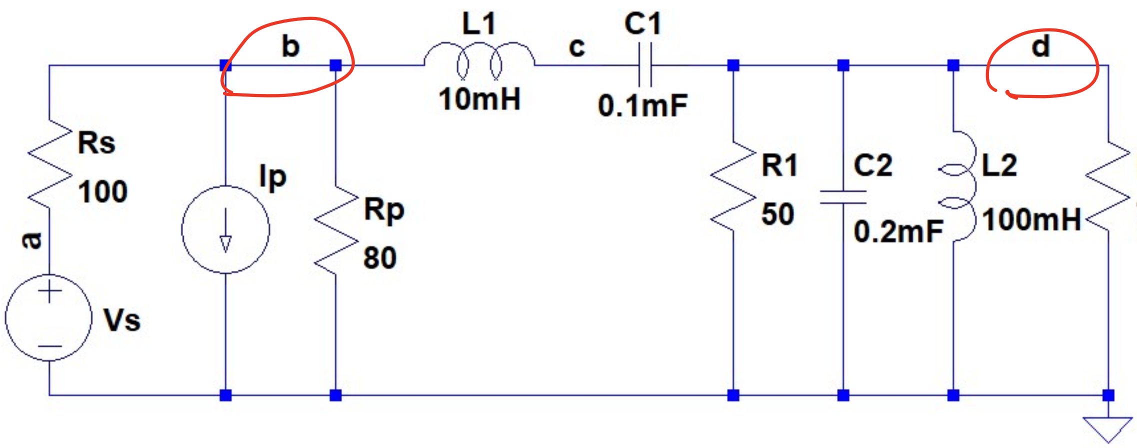


Figure 2

w

Line 1. What are the angular frequency and the phasor of *Vs*?
Line 2. What are the angular frequency and the phasor of *Ip*?
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 is the impedances of Rs, Rp, R1 and RL?
Line 8. Deduce the nodal voltage *Vb* in a phasor form.
Line 9. Deduce the nodal voltage *Vd* in a phasor form.
Line 10. What is the angular frequency of *Vd*?
Line 11. Deduce *Vd* in time domain.
Line 12. Deduce the voltage gain (magnitude of *Vd/Vb*).

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

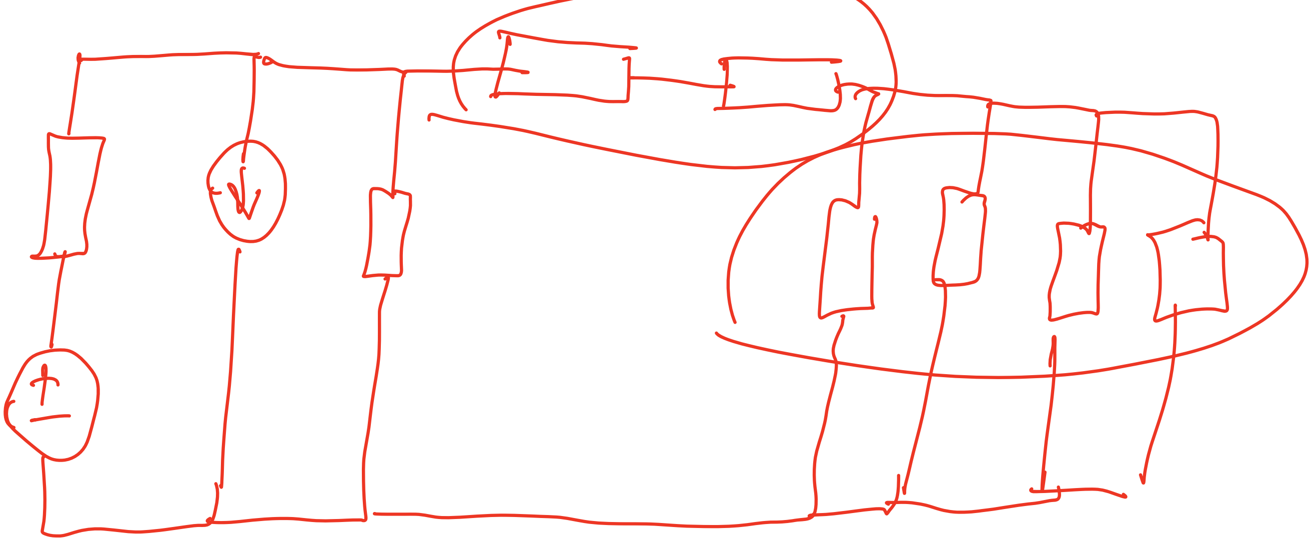
```
 1 Vs: ang. freq. = 0 rad/s, magnitude = 0 V, phase = 0 rad.
 2 Ip: ang. freq. = 0 rad/s, magnitude = 0 A, phase = 0 rad.
 3 Q2.3: ZL1 = 0 + 0j
 4 Q2.4: ZL2 = 0 + 0j
 5 Q2.5: ZC1 = 0 + 0j
 6 Q2.6: ZC2 = 0 + 0j
 7 ZRs = 0 ohm, ZRp = 0 ohm, ZR1 = 0 ohm, ZRL = 0 ohm.
 8 Vb: magnitude = 0 V, phase = 0 rad.
 9 Vd: magnitude = 0 V, phase = 0 rad.
10 Angular frequency = 0 rad/s, frequency = 0 Hz.
11 Q2.11: Vd(t) = 0*t + 0*t**2 + 0*t**3 # python code
12 Gain = 0 (V/V).
```

Arg(Vd)

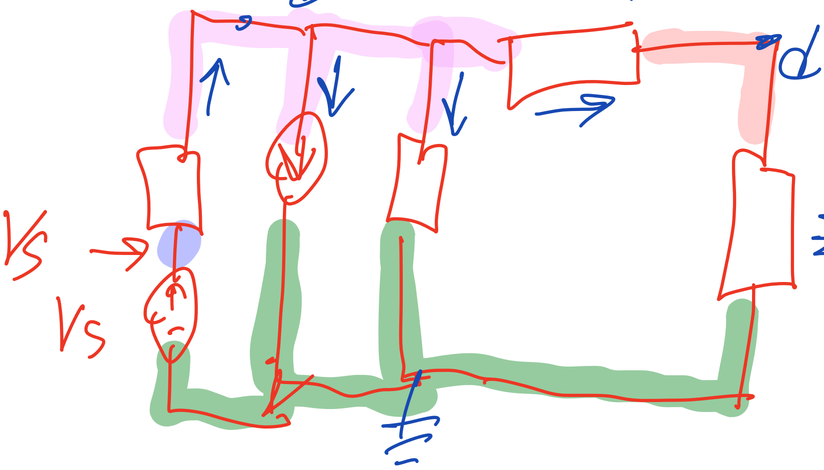
Grading: eePPPPeeeepe
Report: Hint

$Vd(t) = V_m \cos(wt+\phi)$

Mod(Vd)



$$ZT1 = ZL_1 + ZC_1$$

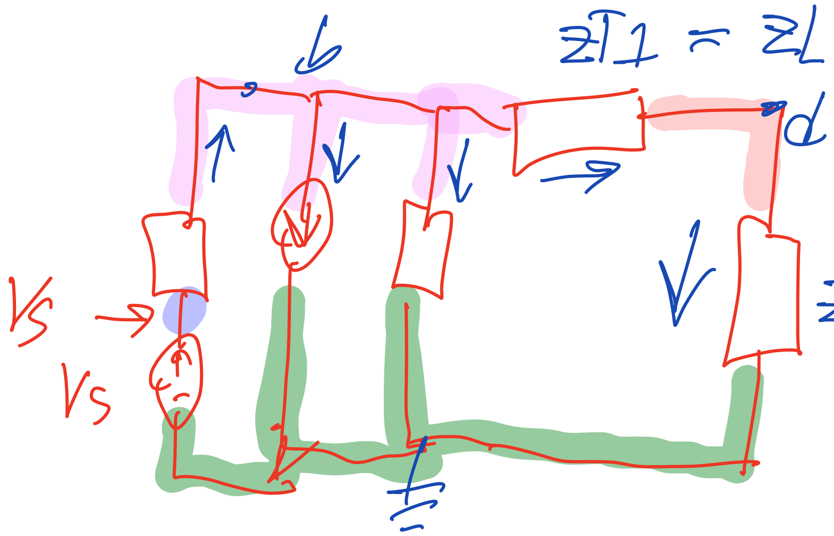


$$ZT_2 = \frac{1}{\frac{1}{ZR1} + \frac{1}{ZC_2} + \frac{1}{ZL_2} + \frac{1}{ZRL}}$$

$$\frac{Vs - Vb}{ZRS} - IP - \frac{Vb - 0}{ZRP} - \frac{Vb - Vd}{ZT1} = 0$$

$$\frac{Vs}{ZRS} - \frac{Vb}{ZRS} - IP - \frac{Vb}{ZRP} - \frac{Vb}{ZT1} + \frac{Vd}{ZT1} = 0$$

$$-\left(\frac{1}{ZRS} + \frac{1}{ZRP} + \frac{1}{ZT1}\right) Vb + \left(\frac{1}{ZT1}\right) Vd = IP - \frac{VS}{ZRS}$$



$Z_{T1} = Z_{L1} + Z_{C1}$

$$Z_{T2} = \frac{1}{\frac{1}{Z_{R1}} + \frac{1}{Z_{C2}} + \frac{1}{Z_{L2}} + \frac{1}{Z_{RL}}}$$

@ node d

$$\frac{V_b - V_d}{Z_{T1}} - \frac{V_d - 0}{Z_{T2}} = 0$$

$$\frac{V_b}{Z_{T1}} - \frac{V_d}{Z_{T1}} - \frac{V_d}{Z_{T2}} = 0$$

$$\left(\frac{1}{Z_{T1}}\right) V_b - \left(\frac{1}{Z_{T1}} + \frac{1}{Z_{T2}}\right) V_d = 0$$

$$-\left(\frac{1}{ZRS}+\frac{1}{ZRP}+\frac{1}{ZT1}\right)Vb+\left(\frac{1}{ZT1}\right)Vd = IP-\frac{VS}{ZRS}$$

$$\left(\frac{1}{ZT_1}\right)Vb-\left(\frac{1}{ZT_1}+\frac{1}{ZT2}\right)Vd = 0$$

$$\begin{array}{cc}
Vb & Vd \\
\multicolumn{2}{c}{\left[\begin{array}{cc} -\left(\frac{1}{ZRS}+\frac{1}{ZRP}+\frac{1}{ZT_1}\right) & \frac{1}{ZT_1} \\ \frac{1}{ZT_1} & -\left(\frac{1}{ZT_1}+\frac{1}{ZT2}\right) \end{array}\right]}
\end{array}
\left[\begin{array}{c} IP-\frac{VS}{ZRP} \\ 0 \end{array}\right]$$

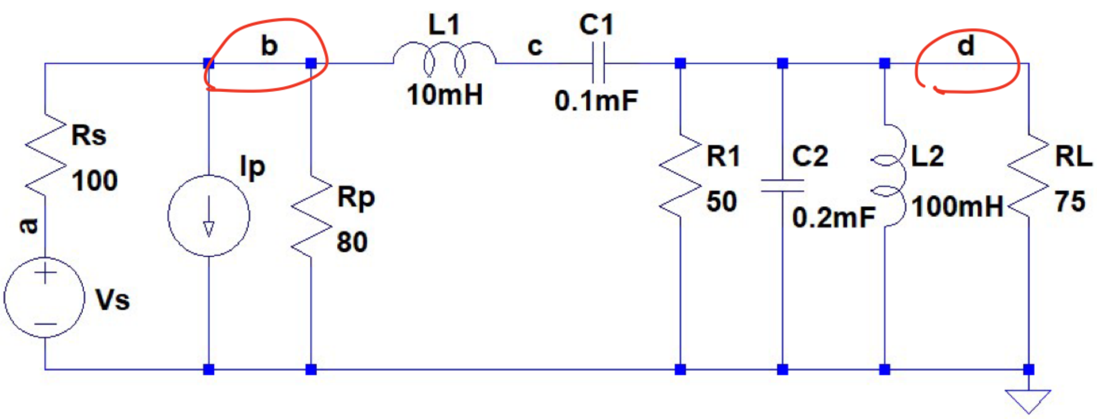
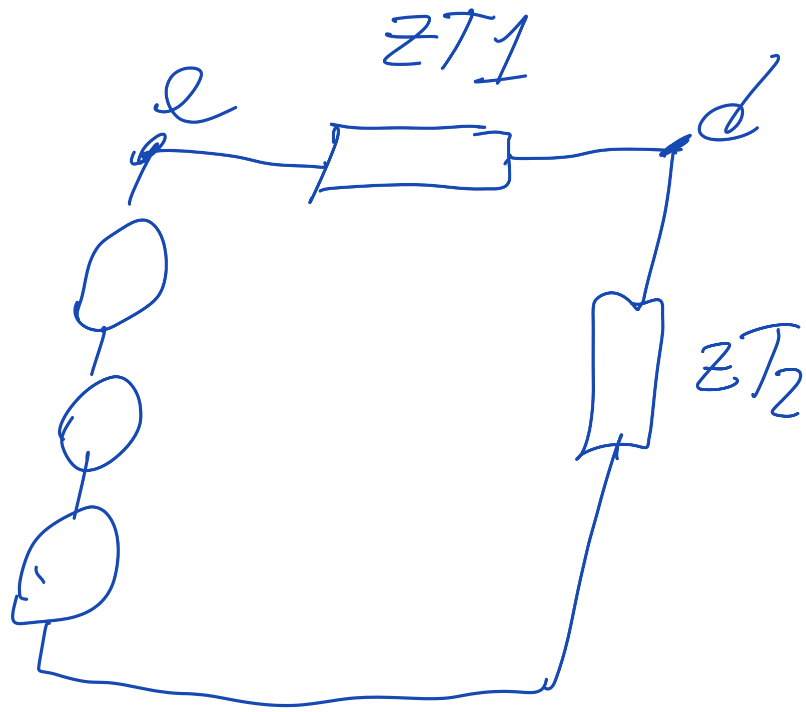
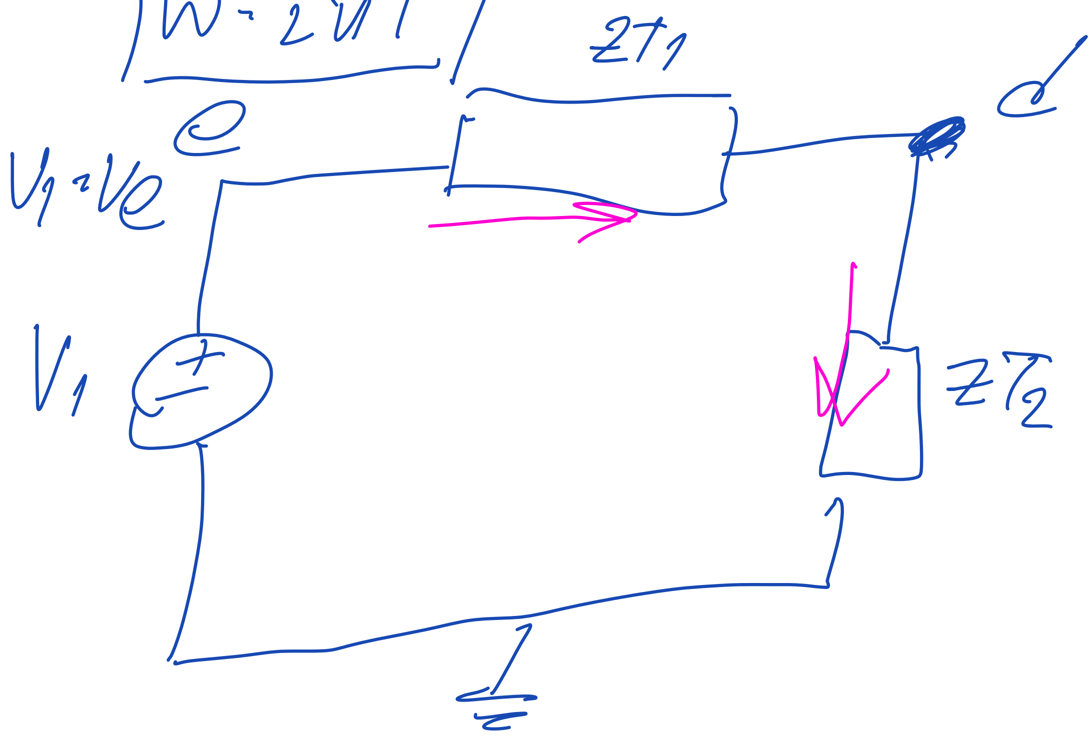


Figure 2



$$\boxed{w = 2\pi f}$$



$$\frac{V_1 - Vd}{ZT_1} - \frac{Vd - 0}{ZT_2} = 0$$

$$\frac{V_1}{ZT_1} - \frac{Vd}{ZT_1} - \frac{Vd}{ZT_2} = 0$$

$$\frac{V_1}{ZT_1} = \frac{Vd}{ZT_1} + \frac{Vd}{ZT_2}$$

$$\frac{V_1}{ZT_1} = \left(\frac{1}{ZT_1} + \frac{1}{ZT_2}\right) Vd$$

$$Vd = \frac{V_1}{ZT_1\left(\frac{1}{ZT_1} + \frac{1}{ZT_2}\right)}$$

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

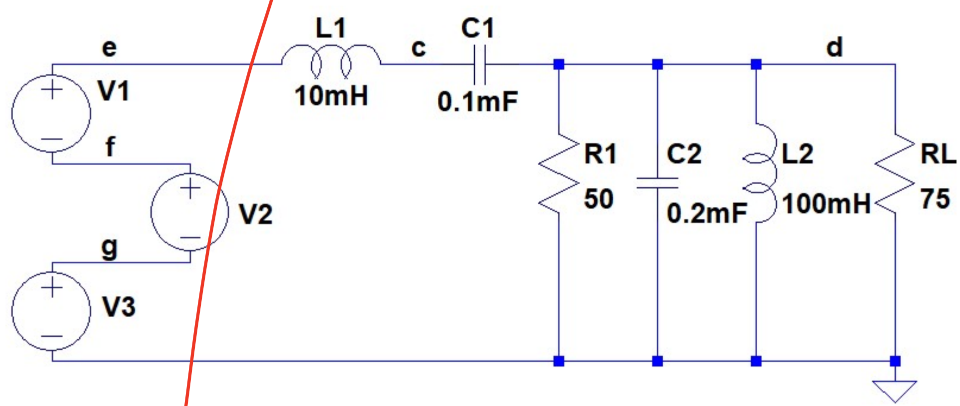


Figure 3a

Line 1. Use superposition to deduce the effect on *Ve* from *V1* acting alone.
Line 2. Use superposition to deduce the effect on *Vd* from *V1* acting alone.
Line 3. Deduce the effect on *Vd* from *V1* acting alone in time domain.
Line 4. Deduce the gain (magnitude of *Vd*/*Ve*) from *V1* acting alone.
Line 5. Use superposition to deduce the effect on *Ve* from *V2* acting alone.
Line 6. Deduce the effect on *Vd* from *V2* acting alone in time domain.
Line 7. Deduce the gain (magnitude of *Vd*/*Ve*) from *V2* acting alone.
Line 8. Deduce the effect on *Vd* from *V3* acting alone in time domain. 5 100
Line 9. Deduce the gain (magnitude of *Vd*/*Ve*) from *V3* acting alone.
Line 10. Deduce the 2.401496* cos(100t + 0.754830941) sources in time domain.

- 3.16782 - 4.002031j 200

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

5

-4.167824 - 4.0020318

1.231695? * cos(300t - 3.030144496)

-0.2448108 - 0.0273971j

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

```
 1  V1 alone, Ve: magnitude = 5 V, phase = 0 rad, frequency = 100 Hz.
 2  V1 alone, Vd: magnitude = 2.401 V, phase =    rad, frequency =    Hz.
 3  Q3.3: V1 alone, Vd(t) =
 4  V1 alone, Gain(Vd/Ve) = 0 (V/V).
 5  V2 alone, Ve: magnitude = 0 V, phase = 0 rad, frequency = 0 Hz.
 6  Q3.6: V2 alone, Vd(t) = 0*t + 0*t**2 + 0*t**3 # python code
 7  V2 alone, Gain(Vd/Ve) = 0 (V/V).
 8  Q3.8: V3 alone, Vd(t) = 0*t + 0*t**2 + 0*t**3 # python code
 9  V3 alone, Gain(Vd/Ve) = 0 (V/V).
10  Q3.10: Totally, Vd(t) =    0*t**2 + 0*t**3 # python code
```

Grading: eepeepepep
Report: Hint

.52027 cos(200t - 2.240366)

2. . . .2422i

0+9.63 2309 0j

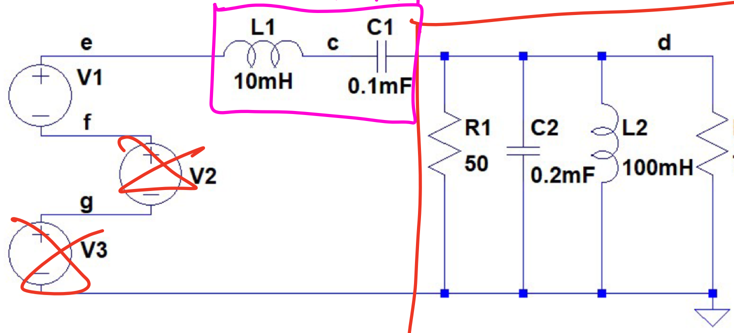


Figure 3a

V_1 alone $f = 100$ Hz

5

2.401496   0.15448 30941   100

-100

2.401496 * cos(100t + 0.7548 30941)

- 3.16782 - 4.002031j   200

5

25.52027 cos(200t - 2.240366)

- 3.167824 - 4.0020318

1.2316957 * cos(300t - 3.03014496)

-0.2448108 - 0.027397i

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.

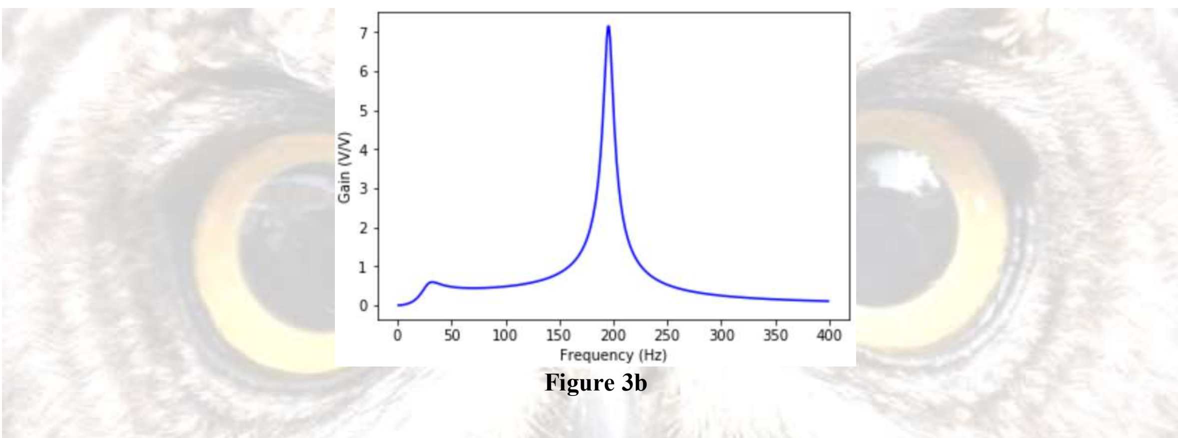
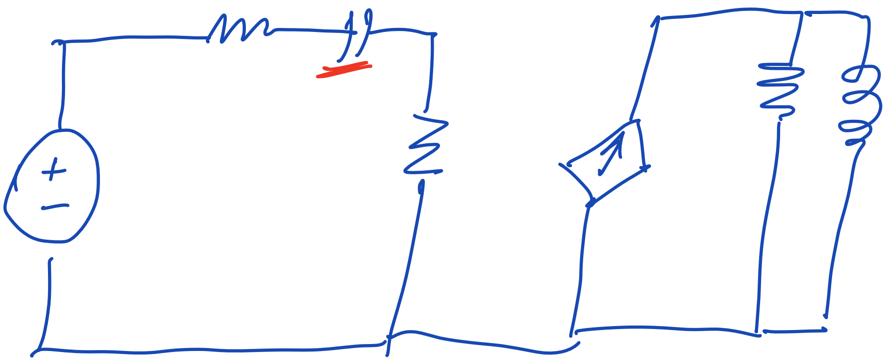
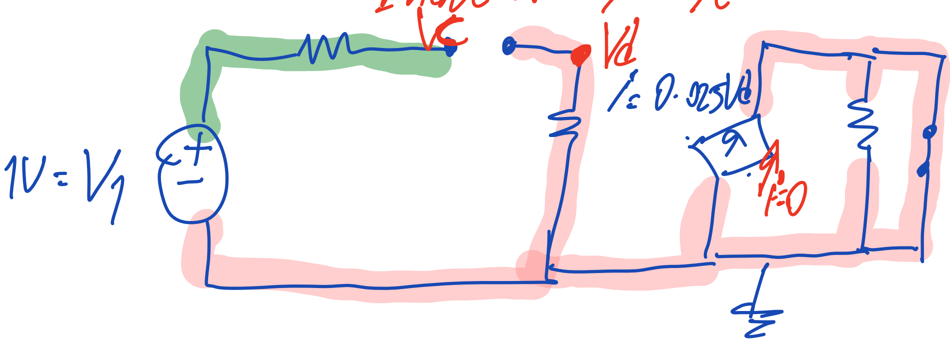


Figure 3b



when stedy state
Capacitor $\Rightarrow$ OC.

Inductor $\Rightarrow$ SC.



$V_d = 0$

KCL

V_1 acting alone $\quad i_{G1} = 0\ A$

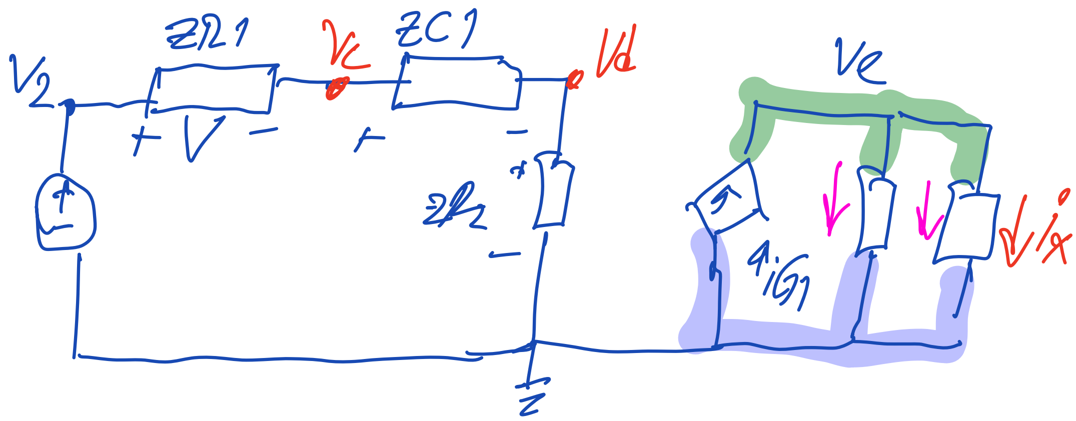
$i_x = 0\ A$

$V_C = 1V$

$f = 100e3$

$w = 2 \times pi \times f$

$V_2 = 0.8 \angle 0$



$$Vd = \left(\frac{ZR_2}{ZR_1 + ZC_1 + ZR_2}\right) V_2$$

$$V = \left(\frac{ZR_1}{ZR_1 + ZC_1 + ZR_2}\right) V_2$$

$$iG1 = 0.025\, Vd$$

$$iG_1 - \frac{Ve}{ZR3} - \frac{Ve}{ZL1} = 0$$

$$V = V_2 - Vc$$

$$Ve = ?$$

$$Vc = V - V_2$$

$$V = V_2 - V_C$$

$$Vc = V_2 -$$

$$i_x = \frac{Ve - 0}{ZL1}$$

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.

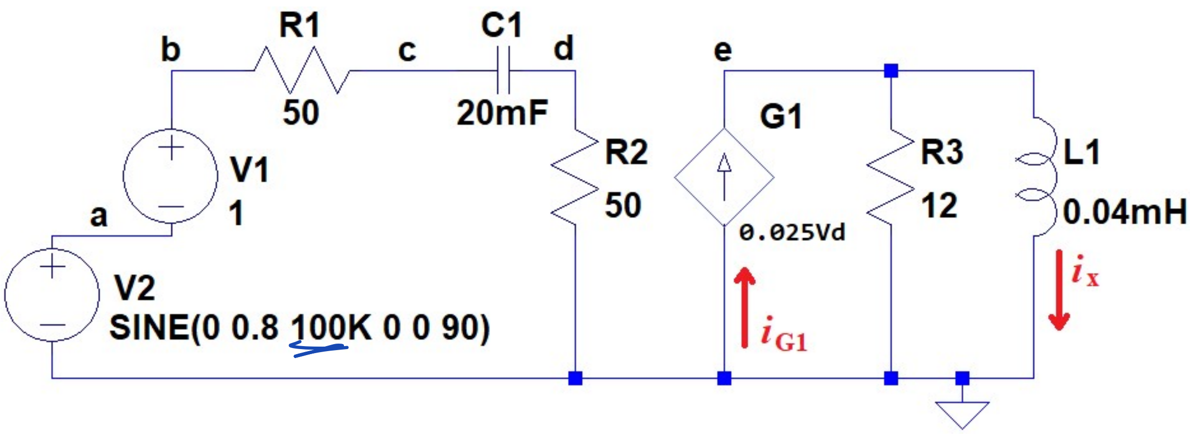
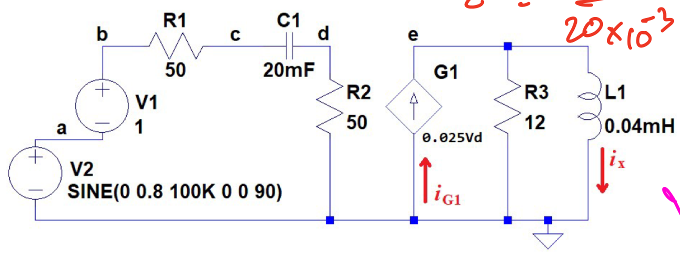


Figure 4a. Note: SINE(0 0.8 100K 0 0 90) means *0.8 sin(2π 100K t + π/2)*.

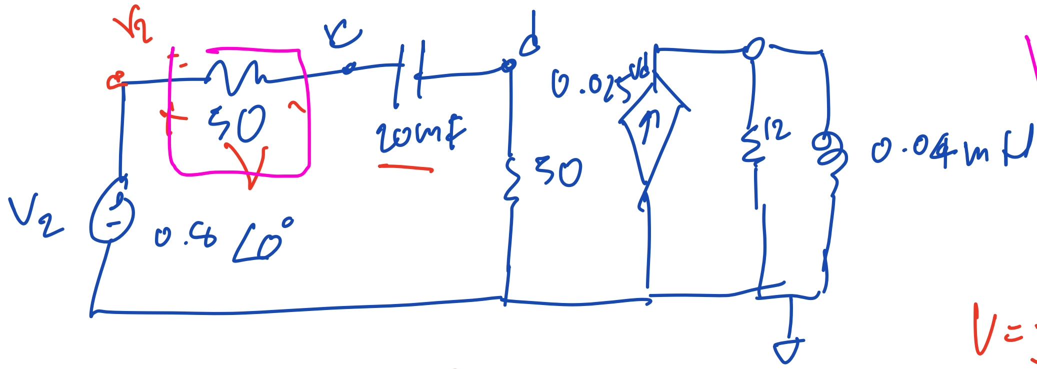
Line 1. When V2 acting alone, what is V2 in a phasor form?
Line 2. Use superposition to deduce the effect on nodal voltage *Vc*, in time domain, from *V2* acting alone.
Line 3. Use superposition to deduce the effect on nodal voltage *Vd*, in time domain, from *V2* acting alone.
Line 4. Use superposition to deduce the effect on *iG1*, in time domain, from *V2* acting alone.
Line 5. Use superposition to deduce the effect on *ix*, in time domain, from *V2* acting alone.
Line 6. Use superposition to deduce the effect on *Vc*, in time domain, from *V1* acting alone.
Line 7. Use superposition to deduce the effect on *Vd*, in time domain, from *V1* acting alone.
Line 8. Use superposition to deduce the effect on *iG1*, in time domain, from *V1* acting alone.
Line 9. Use superposition to deduce the effect on *ix*, in time domain, from *V1* acting alone.
Line 10. Deduce the total effect on *ix* 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.

$$Z = \frac{1}{20\times10^{-3}\,(2\pi\,(100k))}$$



$V_2 - V_C \rightarrow V_R$



$V_C = \boxed{V_2 - V_R}$

$V = IR$

$$-V_2 + I(50) + IZ_C + I50 = 0$$

$$Z_C = -j12566.37$$

$$I(50 - j12566.37 + 50) = V_2$$

$$I = \frac{0.8\angle 0^\circ}{100 - j12566.37} =$$

$$I = 4.9947e{-07} + 6.321033e{-05}\,i$$

$$V_C = 0.79975 - 0.0031605\,j$$

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

V2 alone, V2: magnitude = ~~0~~ 0.8 **V, phase =** *0* **rad, frequency =** ~~0~~ 100×10^3 **Hz.**

```
Q4.2: V2 alone, Vc(t) = 0*t + 0*t**2 + 0*t**3 # python code
Q4.3: V2 alone, Vd(t) = 0*t + 0*t**2 + 0*t**3 # python code
Q4.4: V2 alone, iG1(t) = 0*t + 0*t**2 + 0*t**3 # python code
Q4.5: V2 alone, ix(t) = 0*t + 0*t**2 + 0*t**3 # python code
Q4.6: V1 alone, Vc(t) = 0*t + 0*t**2 + 0*t**3 # python code
Q4.7: V1 alone, Vd(t) = 0*t + 0*t**2 + 0*t**3 # python code
Q4.8: V1 alone, iG1(t) = 0*t + 0*t**2 + 0*t**3 # python code
Q4.9: V1 alone, ix(t) = 0*t + 0*t**2 + 0*t**3 # python code
Q4.10: Totally, ix(t) = 0*t + 0*t**2 + 0*t**3 # python code
```

Grading: epppppppppp
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, Vc and Vd are having very similar shapes, but Vc with a DC offset (shifting up), while Vd has no DC offset---it is oscillating around 0.

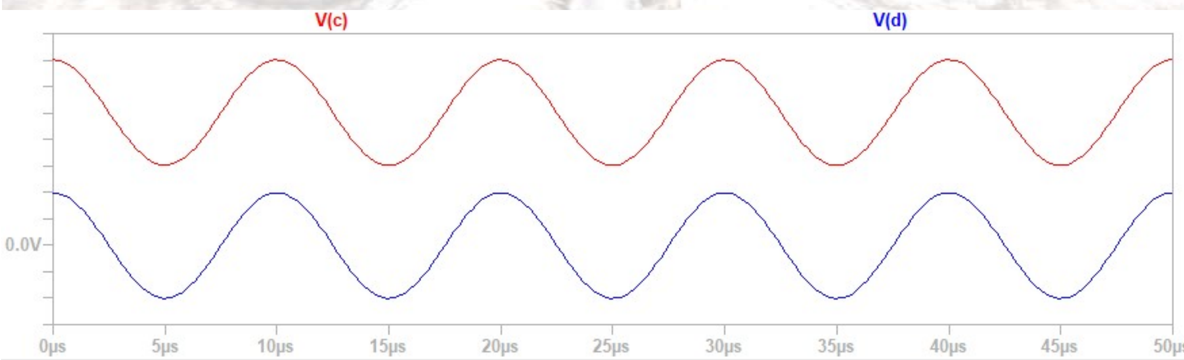
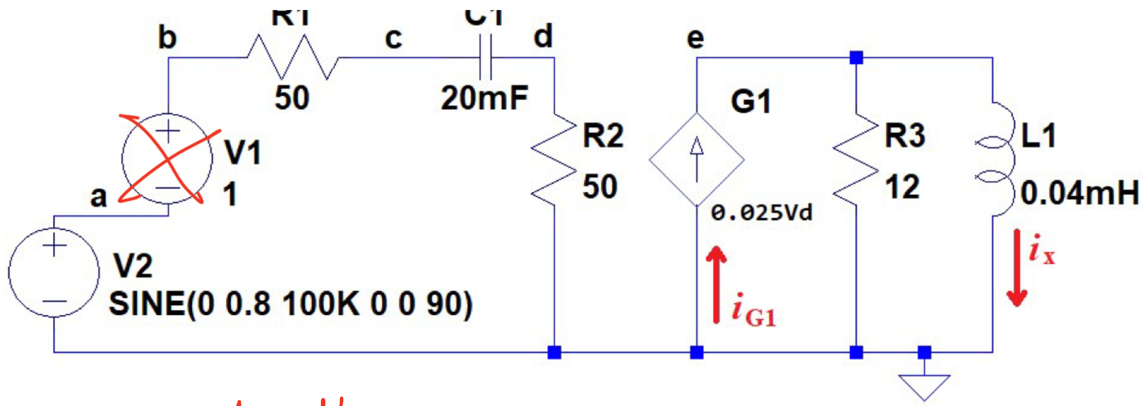
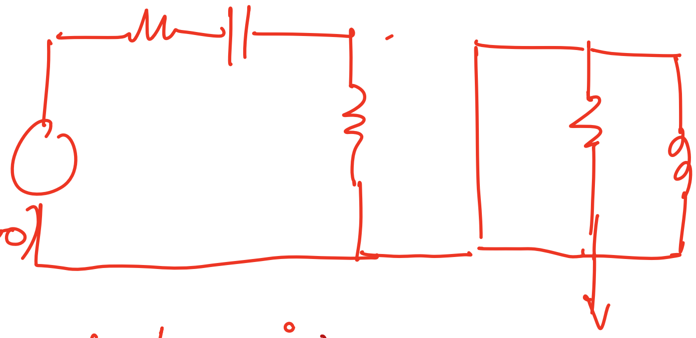


Figure 4b. Simulated signal.





0.8 sin(100kt + 90)

0.8 cos(90° − 100k t + 90°)

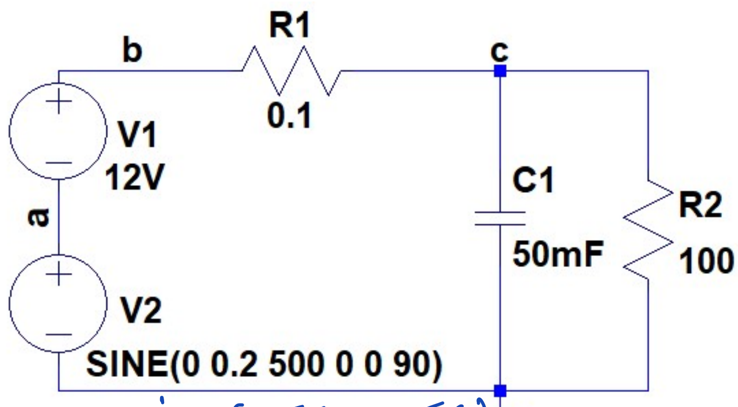
V_2 alone

$$\frac{d\,v(t)}{dt} + v(t) = V_s$$

$$v(t) = A\,e^{-vt}$$

10^5

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.



$0.2 \sin(2\pi 500 + \pi/2)$

Figure 5a

Line 1. Use superposition to deduce the effect on *Vb* from *V1* acting alone.
Line 2. Use superposition to deduce the effect on *Vc* from *V1* acting alone.
Line 3. Use superposition to deduce the effect on *Vb* from *V2* acting alone.
Line 4. Use superposition to deduce the effect on *Vc* from *V2* acting alone.
Line 5. Deduce the total effect on *Vb* from all sources in time domain.
Line 6. Deduce the total effect on *Vc* from all sources in time domain.
Line 7. Compute the ripple voltage in *Vb*. Note the ripple voltage, *ripple(Vx)* = *max(Vx) – min(Vx)*.
Line 8. Compute the ripple voltage in *Vc*.

AC

ripple 2 Vp

```
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, Vb(t) =  12
2  Q5.2: V1 alone, Vc(t) =
3  Q5.3: V2 alone, Vb(t) =
4  Q5.4: V2 alone, Vc(t) =
5  Q5.5: Totally, Vb(t) =
6  Q5.6: Totally, Vc(t) =
7  Ripple(Vb) = 0 Vpp.
8  Ripple(Vc) = 0 Vpp.
```

Grading: pppppppee
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 *Vc* is much smaller than that of *Vb*.

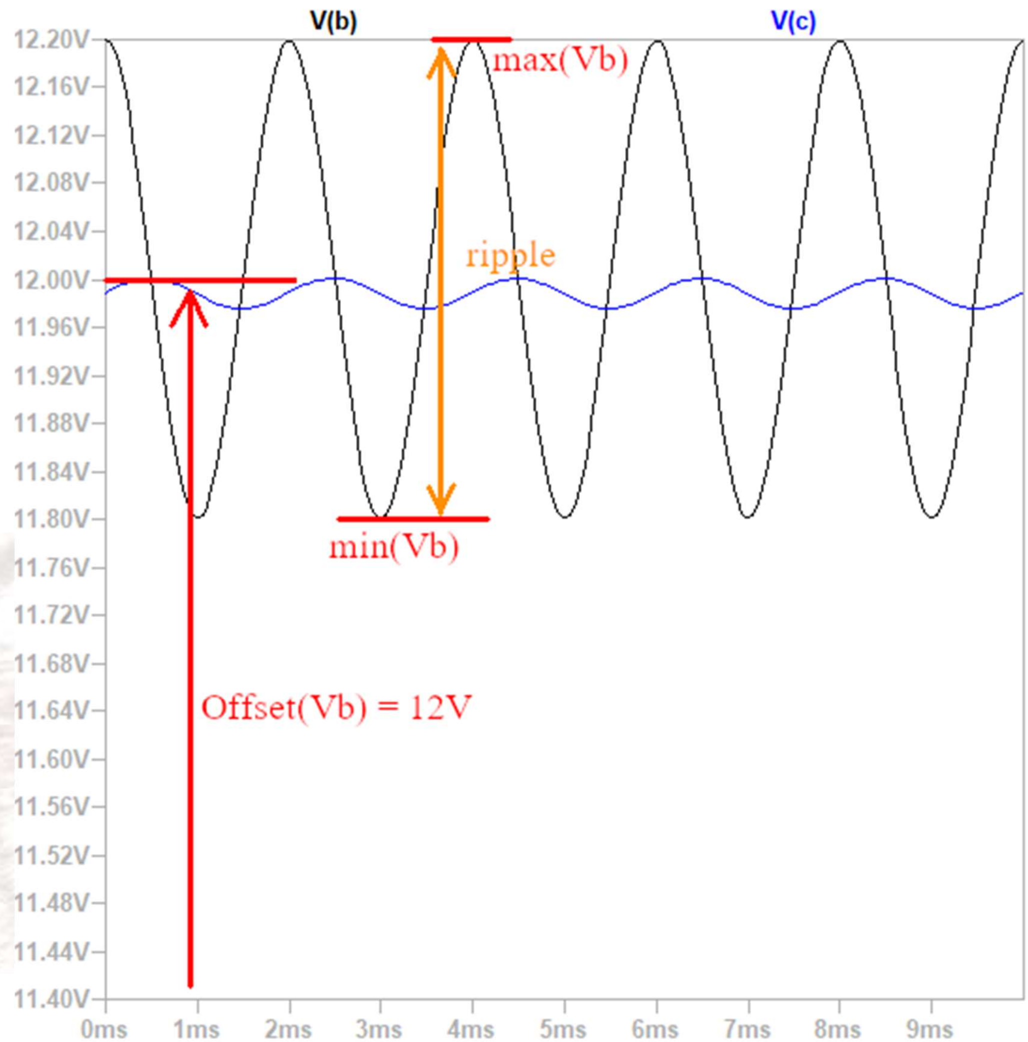
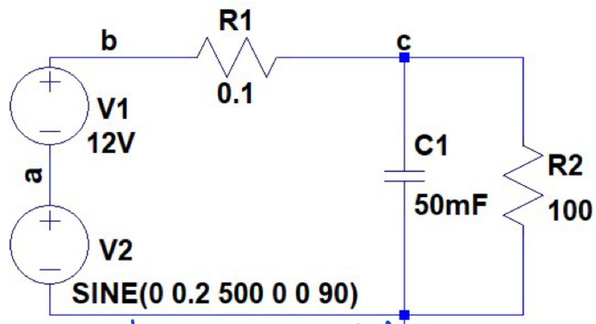


Figure 5b. Visualization of ripple.

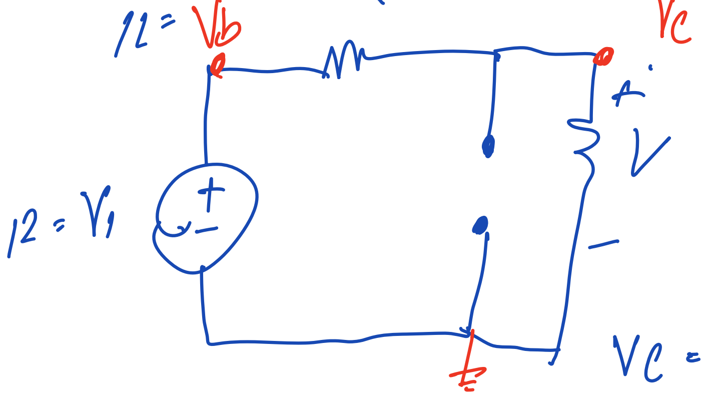
---THE END---



$0.2 \sin(2\pi 500 + \pi/2)$

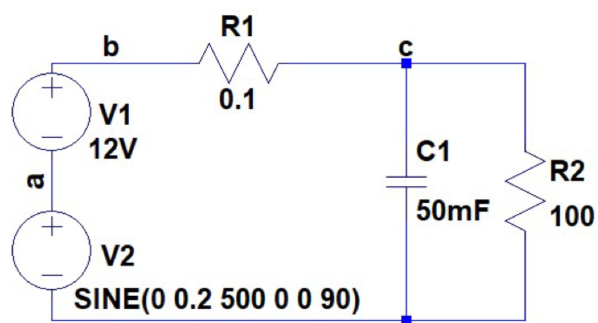
Figure 5a

$0.2\angle 0$



$$V_C = \left(\frac{100}{100+0.1}\right)(12)$$

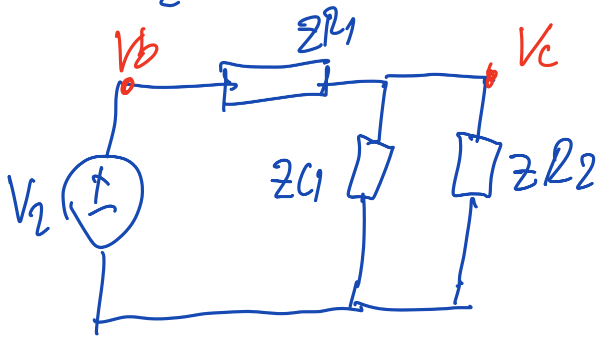
$$V_b = 12$$

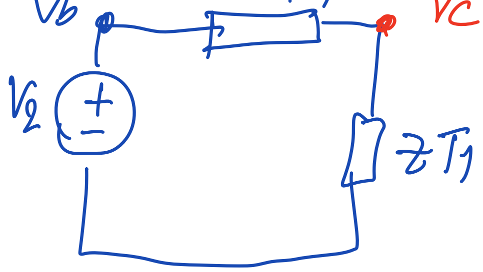


$0.2 \sin(2\pi 500 + \pi/2)$

Figure 5a

$V_2 = 0.2\angle 0$





$$Z_{T1} = \frac{1}{\frac{1}{Z_{C1}} + \frac{1}{Z_{C2}}}$$

$$V_b = V_2$$

$$V_c = \left(\frac{Z_{T1}}{Z_{T1} + Z_{R1}}\right)(V_2)$$