Mid-term Quiz AY2324S2

ⓘ This is a preview of the published version of the quiz

Started: 4 Apr at 21:41

Quiz instructions

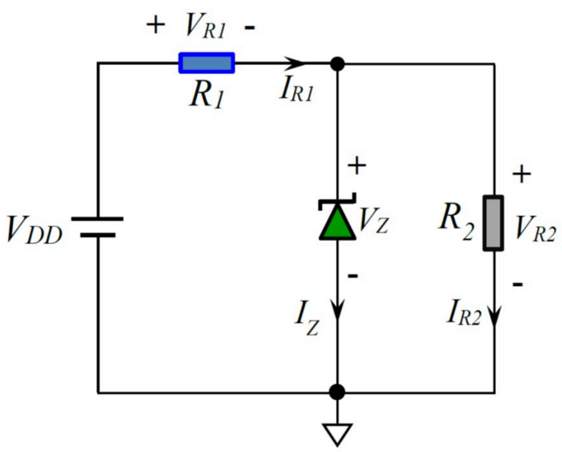
This Quiz has 4 questions -

- 2 Multiple Answers/Choice questions. with negative marking for Multiple Answers questions.
- 2 Fill-in-Multiple-Blanks questions. For numerical answers that are not whole numbers and larger than unity, express them to 2 decimal places with roundup, e.g., fill in 12.34 for 12.3354, 12.30 for 12.3. For numerical answers that are smaller than unity, express them to 2 significant figures, e.g. fill in 0.067 for 0.0666.

The duration of the Quiz is 60 minutes and the total mark is 100.

Question 1 10 pts

A voltage regulator circuit is shown below, where V_Z is the breakdown voltage of the Zener diode. Which of the following statement(s) is(are) TRUE?



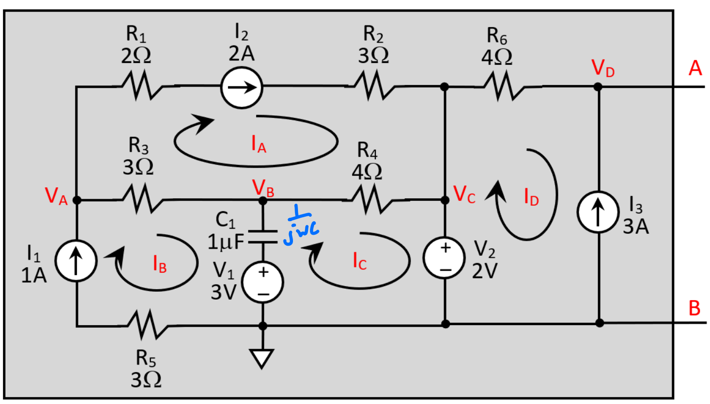
☐ For fixed values of V_{DD}, R_1 and V_Z, and $V_{DD} > V_Z$, the Zener current I_Z can be increased by decreasing the value of R_2.

☐ If V_{R2}, obtained using the voltage divider method by assuming that the Zener diode is an open circuit, is smaller than V_Z, it can be implied that the Zener diode is operating in the breakdown region with V_{R2} clamped at V_Z.

☐ If the power rating of the Zener diode is 0.8 W, it is safe to operate the voltage regulator circuit continuously if $V_{DD} > V_Z = 5$ V and $I_Z = 100$ mA.

☐ For fixed values of V_{DD}, R_2 and V_Z, and $V_{DD} > V_Z$, the Zener current I_Z can be increased by decreasing the value of R_1.

Question 2 10 pts



I_A= [Select] 2 A, I_B= [Select] 1 A, I_C= [Select] 1 A, I_D= [Select] -3 A.

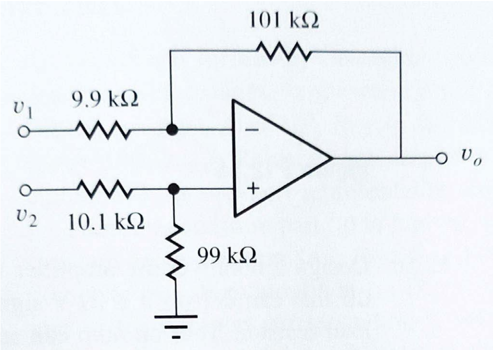
V_C= [Select] 2 V, V_B= [Select] -2 V, V_A= [Select] -5 V, V_D= [Select] 14 V.

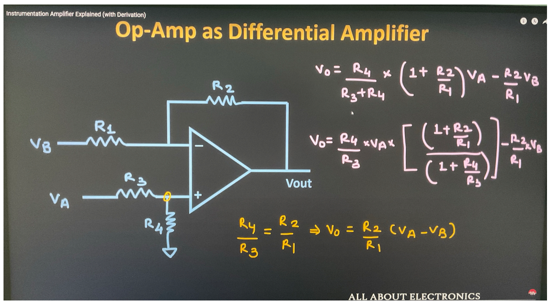
(Manually marked)

The whole network can be transformed into Thevenin Equivalent with:

V_{THV}= [Select] 14 V, R_{THV}= [Select] 4 Ω

Question 3 40 pts





The input voltages, v_1 and v_2, in the opamp amplifier circuit shown above are given as follows:

v_1 = 10 sin(120πt) + 0.25 sin(5000πt)

$v_2 = \underbrace{10 \sin(120\pi t)}_{\text{common-mode}} - \underbrace{0.25 \sin(5000\pi t)}_{\text{differential}/2}$

Assume that the opamp is ideal.

(a) Applying ideal opamp analysis, an expression for the output voltage v_o in terms of the input voltages, v_1 and v_2, is found to be:

v_o = -10.202 v_1 + 10.165 v_2

a) $V_o = \left(-\frac{101k}{9.9k}\right)V_1 + \left(\frac{99k}{10.1k+99k}\right) \times \left(1+\frac{101k}{9.9k}\right)V_2$

$= -10.202\,V_1 + 10.165\,V_2$ //

(b) From the given input voltages, v_1 and v_2 above, the differential-mode input voltage v_{id} is:

v_{id} = 0.5 sin(5000 πt)

(or) -0.5

vid = v1 - v2 (or) v2 - v1

(c) From the given input voltages, v_1 and v_2 above, the common-mode input voltage v_{icm} is:

v_{icm} = 10 sin(120 πt)

vicm = (v1 + v2) / 2

$-10.202\,(10\sin(120\pi t) + 0.25\sin(5000\pi t))$
$+\,10.165\,(10\sin(120\pi t) - 0.25\sin(5000\pi t))$
$= -102.02\sin(120\pi t) - 2.5505\sin(5000\pi t)$
$+\,101.65\sin(120\pi t) - 2.54125\sin(5000\pi t)$
$= \boxed{-0.37\sin(120\pi t) - 5.0915\sin(5000\pi t)}$

vo = -0.37 sin(120pi t) - 5.09 sin(5000pi t)

(d) From the results in parts (a) and (b) above, the differential-mode gain A_{OL} is calculated to be -10.18 (or) 10.18

$A_{OL} = \frac{V_{od}}{V_{id}} = \frac{5.09}{0.5}$

AoL = -5.09 / 0.5 (or) -5.09 / (-0.5)

(e) From the results in parts (a) and (c) above, the differential-mode gain, the common-mode gain A_{CM} is calculated to be -0.037 (or) 0.037

$A_{cm} = \frac{V_{o,cm}}{V_{i,cm}} = \frac{-0.37}{10}$

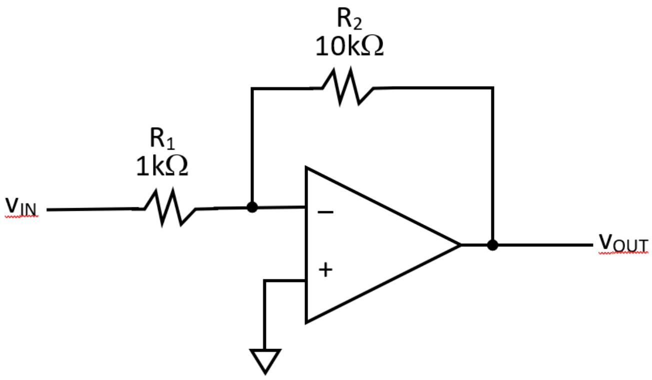
Acm = -0.37 / 10

(f) From the results in parts (d) and (e) above, the common-mode rejection ratio (CMRR) is calculated to be 48.8 dB.

$CMRR = 20\log\left(\frac{A_{OL}}{A_{cm}}\right) = 20\log\left(\frac{10.18}{0.037}\right)$

$= 48.79\,dB$

Question 4 40 pts



The opamp has GBW of 1 MHz, slew rate of 0.5 V/μs, v_n= 100 nV/$\sqrt{Hz}$.

1) The closed-loop 3dB bandwidth of the inverting amplifier shown above is 90.91 kHz.

$f_{3dB,CL} = GBW \times \frac{R_1}{R_1+R_2} = 1M \times \frac{1k}{1k+10k} = 90.91k$

2) When v_{IN} is $0.1 \times \sin(2\pi \times 50k \times t)$, the v_{OUT} wil be amplified to peak amplitude of 1 or -1 V with frequency of 50 kHz without any issue.

inverting with gain: 10 $\left(-\frac{R_2}{R_1}\right)$

3) The resulting rms output noise due to opamp for this inverting amplifier would be 415.7 μV.

$V_{out,n} = \sqrt{(V_n)^2 \times f_{3dB} \times \frac{\pi}{2}} \times \left(1+\frac{R_2}{R_1}\right) = 415.7\mu V$

4) If the opamp is slew rate limited when the output has peak amplitude of 1V, the maximum frequency the inverting amplifier can handle is 79.58 kHz.

V_p

$2\pi f \times 1 < 0.5V/\mu s$

$f < 79.57kHz$

5) If the opamp is slew rate limited with the maximum allowable frequency being 50 kHz, the output peak amplitude allowable for v_{OUT} would be 1.59 V, and the input peak amplitude allowable for v_{IN} would be 159.15 mV.

$V_{in} = \frac{V_{out}}{gain} = \frac{1.59}{10} = 159.15mV$

$2\pi(50k) \times V_p < 0.5V/\mu s$

$V_p < 1.59V$

6) The output peak amplitude is 1V. In order for the inverting amplifier to have identical maximum operating frequency determined by both the GBW and slew rate, the resulting $R_1/(R_1+R_2)$ ratio should be 0.0796 . Hence, R_1 should be 1 kΩ and R_2 should be 11.57 kΩ.

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$2\pi f \times 1 < 0.5V/\mu s$

$f < 79.58kHz$

Since they want identical max operating frequency,

$79.58k = 1M \times \frac{R_1}{R_1+R_2}$

$\frac{R_1}{R_1+R_2} = 0.07958$

≈ 0.0796

$\frac{1k}{1k+R_2} \approx 0.0796$

$1k = 0.0796(1k) + 0.0796 R_2$

$0.0796 R_2 = 920.4$

$R_2 = 11.56k\Omega$