Electronic Devices – EE090

Lecture 1&2 Quiz Solution

March 2020

Lecture 1

Question 1

1. Find the period T of the sinusoidal signal v(t) = 10sin(100πt) volts
2. What is the rms value of the signal given in question 1.
3. How to reduce the quantization error of a Analog to Digital Converter

Answer:

1. $T = \frac{2\pi}{\omega} = \frac{2\pi}{100\pi} = 0.02\ s$
2. $V_{rms} = \frac{Vpk}{\sqrt{2}} = \frac{10}{\sqrt{2}} = 5\sqrt{2} \approx 7.071$ volts
3. Increase **quantization levels.**

Question 2

1. What is the normal voltage gain if the voltage gain in dB is 20.
2. Why does an amplifier use dc bias.
3. What is the instantaneous value at the output of an amplifier at t = 0.1[s] if the DC component is 4[v] , and the ac component is 0.4cos(200πt)[v].

Answer:

1. Voltage gain Av (dB)≡ 20 log | Av |
   20 = 20 log | Av |
   => | Av | = 10
2. Use dc bias to operate the circuit near the middle of the transfer curve → **quiescent point**.
3. $v_O(t) = V_O + v_o(t)$
   $V_O = 4$ V
   $V_o(t) = 0.4\cos(200\pi t)$
   ⇨ $v_O(t) = 4 + 0.4\cos(200\pi t)$
   ⇨ $v_O(0.1) = 4 + 0.4\cos(200\pi * 0.1)$
   $= 4.4$ V

Question 3

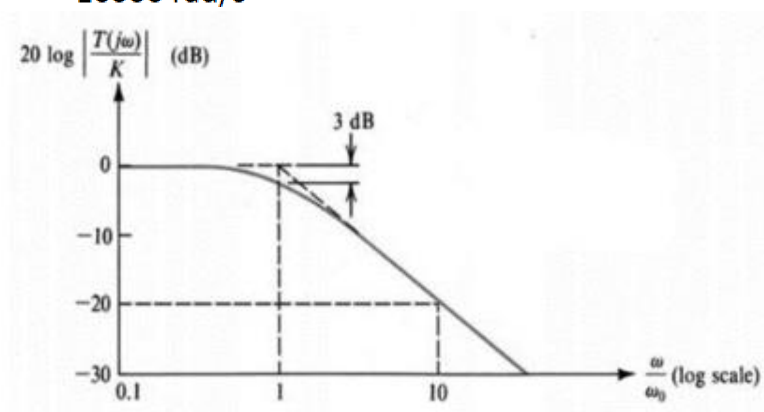
1. For Low Pass STC network, a resistor of 1kΩ, a capacitor of 0.1μF. Find 3dB frequency (or cutoff frequency). Sketch the magnitude of the frequency response.
2. For High Pass STC network, a resistor of 2kΩ, a capacitor of 0.01μF. Find 3dB frequency (or cutoff frequency). Sketch the magnitude of the frequency response.

Answer:

1.

$\omega_o = 1/\tau = 1/RC = 1/\ 10^3 \times 0.1 \times 10^{-6}$

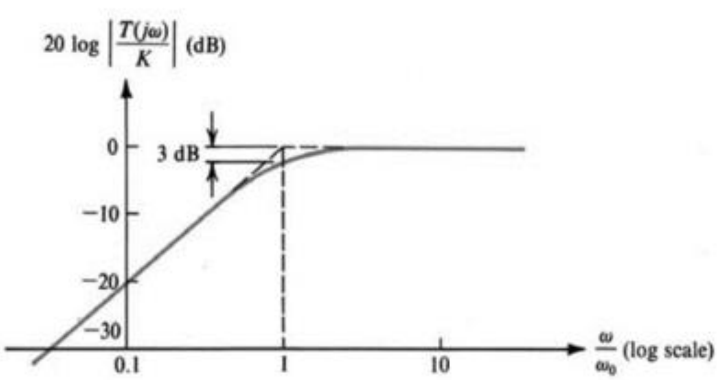
$= 10000$ rad/s



2.

: $\omega_o = 1/\tau = 1/\ RC = 1/2\times10^3 \times 0.01 \times 10^{-6}$

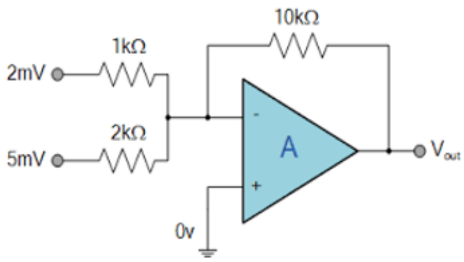
$= 50000$ rad/s



Lecture 2

Question 1

a)



What is the name of this circuir? Compute the value of output voltage

b) Design an inverting amplifier of an ideal op-amp with input impedance of 2kΩ and voltage gain of -4. Plot the circuit with component values.

Answer

a) The name of the circuit is the weighted summer using the inverting configuration

We have:

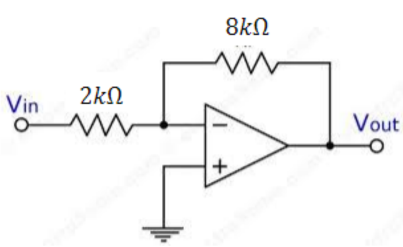
$$Vo = -\left(\frac{Rf}{R1}v1 + \frac{Rf}{R2}v2\right)$$
$$= -\left(\frac{10}{1} * 2 * 10^{-3} + \frac{10}{2} * 5 * 10^{-3}\right) = -45 * 10^{-3} = -45\ mV$$

b)

$$-\frac{Rf}{Ri} = -4$$

⇨ $Rf = 4 * Ri = 8k\Omega$

The circuit with component values:



Question2

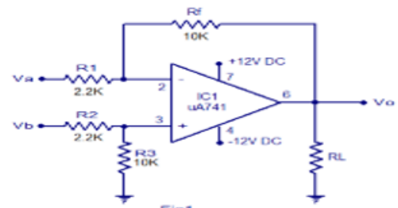
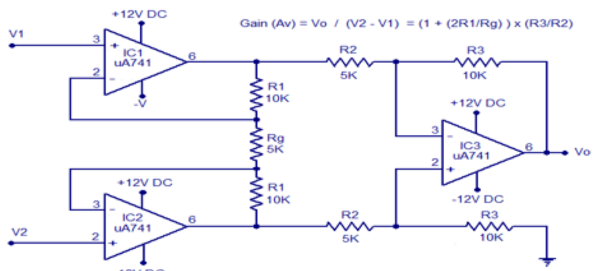


Fig1
Differential amplifier using one opamp

a) If v_a = - 0.8v and v_b = 1.8v what is the value v_o. What is the name of this circuit? What is the disadvantage of this circuit?



Instrumentation amplifier practical circuit diagram

b) If v_2 = 0.2 v and v_1 = - 0.4 v what is the value v_o. What is the name of this circuit? What is the input impedance of this circuit

Answer

a)

Since $R_f/R_1 = R_3/R_2$

⇨ $V_O = (V_b - V_a) * R_f/R_1$

$= (1.8-(-0.8)) * 10/2.2$

$= 11.82$ V

This is a differential amplifier using one op-amp with loaded output.

Disadvantage: Large R_1 can be used to increase R_i but R_F will become impractically large to maintain required gain.

b)

$$Vo = (V2 - V1)\left(2 \cdot \frac{R1}{Rg} + 1\right)\frac{R3}{R2}$$

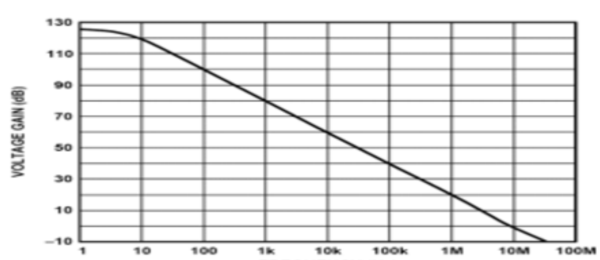
$$= (0.2 - (-0.4))\left(2 \cdot \frac{10}{5} + 1\right)\frac{10}{5} = 6\,V$$

This circuit is an instrumentation amplifier.

The input impedance of this circuit is infinite.

Question 3

a) Referring to the Figure, the voltage gain of 0dB corresponds approximately to 10 MHz. What is the name of that frequency (10 MHz)?. If ω_b = 10 Hz what is the DC voltage gain (ω = 0) in dB and in normal values? Find ω_{3dB} if the voltage gain is 50 dB



Open-Loop Gain vs. Frequency

b) If the SR (Slew Rate) of an op-amp is 13 V/µsec and maximum output voltage of the sinusoidal signal (no distortion) is 4V. Find the maximum frequency that can accept.

Answer

a. The name of the 10 MHz frequency is unity-gain bandwidth (ω_T)

$$\omega_T = A_{Vo}\,\omega_b \rightarrow A_{Vo} = \frac{\omega_T}{\omega_b} = \frac{10*10^6}{10} = 10^6 = 120\ dB.$$

Note: $A_{Vo} \sim 120\ dB$ *is accepted according to the given figure.*

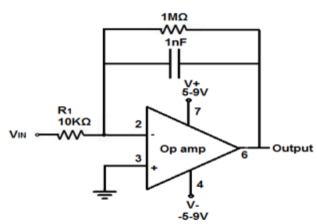
w3dB= |Avo|*wb/|G|= $\frac{10^6}{316} * 10 = 31.6k$ (rad/s)

b)

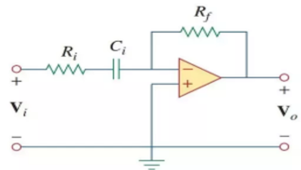
$$f_M = \frac{SR}{2\pi * V_{0\,max}} = \frac{13}{10^{-6} * 2\pi * 4} = 517253.565\ Hz$$

Question 4

a) Referring to the Figure, what is the name of this circuit? Compute 3dB frequency (cutoff frequency). Find the frequency at which the gain is unit. Find the gain at DC (ω = 0).



b) Referring to the Figure, what is the name of this circuit? If R_i = 10kΩ, C_i = 0.01μF, and R_f = 20kΩ, Compute 3dB frequency (cutoff frequency). Find the frequency at which the gain is unit. Find the gain as ω → ∞.



Answer:

a)

- The name of the circuit is the Miller Integrator with parallel feedback resistance.
- Cutoff Frequency : $w_{3dB} = \frac{1}{R_f * C} = \frac{1}{1*10^6*1*10^{-9}} = 1000\ rad/s$
- The frequency at which the gain is unit:

$$w_{unity} = \frac{1}{R_1 * C} = \frac{1}{10 * 10^3 * 1 * 10^{-9}} = 100 * 10^3\ rad/s$$

- Gain at DC (w=0): $\frac{-R_f}{R_1} = \frac{1*10^6}{10*10^3} = 100$

b)

- The name of the circuit is the Differentiator with series resistance.
- Cutoff Frequency:

$$w_{3dB} = \frac{1}{R_i * C_i} = \frac{1}{10 * 10^3 * 0.01 * 10^{-6}} = 10000\ rad/s$$

- The frequency at which the gain is unit:

$$w_{unity} = \frac{1}{R_f * C_i} = \frac{1}{20 * 10^3 * 0.01 * 10^{-6}} = 5000\ rad/s$$

- The gain as ω → ∞: $\frac{-R_f}{R_i} = \frac{20*10^3}{10*10^3} = 2$