unit 4 tutorial sheet

Saturday, December 28, 2024 11:09 PM

unit 4 tutorial s...

Subject:

Tutorial-4

1. In the voltage follower circuit, op amp used is ideal in all respects, except it has a finite gain, A. Determine v_o/v_{in}. If A is equal to 1000, calculate the error of the gain from that of the voltage follower with an ideal op amp.
2. Draw the summer circuits, using two ideal op amps, and calculate the different resistor values to obtain a) $v_o = 2v_1-4v_2+6v_3$ b) $v_o = v_1+3v_2+5v_3-7v_4-9v_5-11v_6$, where v_1, v_2, v_3, v_4, v_5 and v_6 are the available inputs.
3. The output signal of an op amp with a slew rate of 2.5V/μs, has a peak to peak value of 18V. Find the maximum frequency for undistorted output voltage.
4. An op amp has a differential gain of 2×10^4 and a CMRR of 86dB. Determine the output, if the differential input is 10μV and the common mode input is 10mV.
5. In the circuits of figs 7, 8 and 9, determine the output voltage, v_o. Assume the op amps to be ideal.

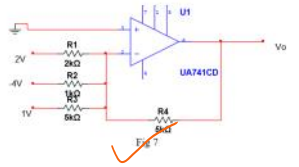

Fig 7

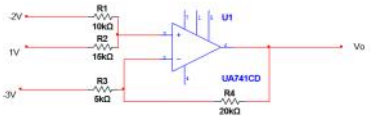

Fig 8

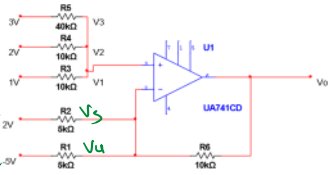

Fig 9

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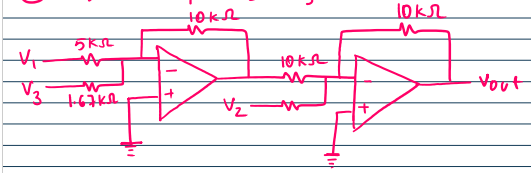
① $A = 1000$

$\frac{V_o}{V_{in}} = A_V = \frac{A}{1+A} = \frac{1000}{1+1000}$

$A_V = 0.99$

Error $= 1 - A_V = 0.01$

② a) $V_o = 2V_1 - 4V_2 + 6V_3$



Assuming $R_f = 10k\Omega$,

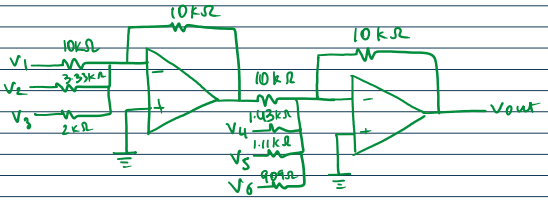
$V_o = -\left[\frac{R_f}{R_1}V_1 + \frac{R_f}{R_2}V_2 + \frac{R_f}{R_3}V_3\right]$

$\frac{R_f}{R_1} = 2 \Rightarrow R_1 = \frac{10k}{2} = 5k\Omega$

$\frac{R_f}{R_2} = 4 \Rightarrow R_2 = \frac{10k}{4} = 2.5k\Omega$

$\frac{R_f}{R_3} = 6 \Rightarrow R_3 = \frac{10k}{6} = 1.67k\Omega$

b) $V_o = V_1 + 3V_2 + 5V_3 - 7V_4 - 9V_5 - 11V_6$



Assuming $R_f = 10k\Omega$

$V_o = -\left[\frac{R_f}{R_1}V_1 + \frac{R_f}{R_2}V_2 + \frac{R_f}{R_3}V_3\right]$

$\frac{R_f}{R_1} = 1 \Rightarrow R_1 = \frac{10k}{1} = 10k\Omega$

$\frac{R_f}{R_2} = 3 \Rightarrow R_2 = \frac{10k}{3} = 3.33k\Omega$

$\frac{R_f}{R_3} = 5 \Rightarrow R_3 = \frac{10k}{5} = 2k\Omega$

$V_o = -\left[\frac{R_f}{R_4}V_4 + \frac{R_f}{R_5}V_5 + \frac{R_f}{R_6}V_6\right]$

$\frac{R_f}{R_4} = 7 \Rightarrow R_4 = \frac{10k}{7} = 1.43k\Omega$

$\frac{R_f}{R_5} = 9 \Rightarrow R_5 = \frac{10k}{9} = 1.11k\Omega$

$\frac{R_f}{R_6} = 11 \Rightarrow R_6 = \frac{10k}{11} \approx 0.91k\Omega \approx 909\Omega$

③ $SR = 2.5V/\mu S$

$2V_m = 18V \Rightarrow V_m = 9V$

$f_m = 9$

$f_m = \frac{SR}{2\pi V_m} = \frac{2.5/10^{-6}}{2(3.14)(9)}$

$f_m = 44.23\,KHz$

④ $A_d = 20k$

$CMRR(\rho) = 86dB$; $86 = 20\log\rho$

$\rho = 10^{4.3}$

$\rho = 19.95k$

$V_d = 10\mu V$

$V_c = 10mV$

$\rightarrow f = \frac{A_d}{A_C}$

$A_C = \frac{A_d}{\rho} = \frac{20k}{19.95k}$

$A_C = 1.0025$

$\rightarrow V_{oc} = A_C V_c = 1.0025 \times 10^{-2}$

$V_{oc} \approx 0.01002V$

$\rightarrow V_{od} = A_d V_d = 20k \times 10\mu = 0.2V$

$\rightarrow V_o = V_{od} + V_{oc}$

$V_o = 0.21002V$

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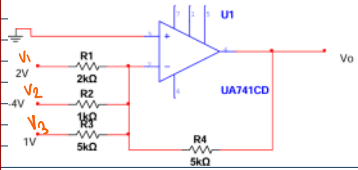
5) Fig 7



$V_o = -R_f\left(\frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3}\right)$

$= -5k\left(\frac{2}{2k} + \frac{-4}{1k} + \frac{1}{5k}\right)$

$= -5(1 - 4 + 0.2)$

$= -5(-2.8)$

5) fig 8

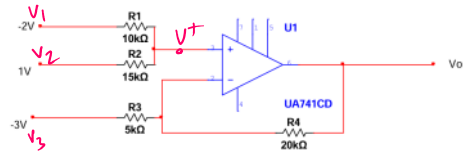


Fig 8

$V_{o2} = \left(1 + \frac{R_4}{R_3}\right)V^+ = \left(1 + \frac{20k}{5k}\right)\left(\frac{-4}{5}\right)$

$V^+ = \frac{R_2}{R_1+R_2}V_1 + \frac{R_1}{R_1+R_2}V_2 = \frac{15k}{3}(-2) + \frac{10k}{2}(1)$

$= -5K\left(\frac{2}{2K} + \frac{-4}{1K} + \frac{1}{5K}\right)$

$= -5(1-4+0.2)$

$= -5(-2.8)$

$= 14V$

$V_{02} = \left(1+\frac{R_4}{R_3}\right)V^+$

$= \left(1+\frac{20K}{5K}\right)\left(\frac{-4}{5}\right)$

$V_{02} = -4V$

$V_{01} = -R_4\left(\frac{V_3}{R_3}\right)$

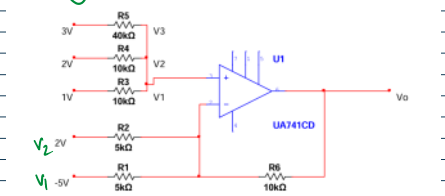
$= -20K\left(\frac{-3}{5K}\right)$

$V^+ = \frac{R_2}{R_1+R_2}V_1 + \frac{R_1}{R_1+R_2}V_2$

$= \frac{15K}{10K+15K}\times(-2) + \frac{10K}{10K+15K}\times(1)$

$= \frac{-6}{5} + \frac{2}{5} = \frac{-4}{5}$

5) fig 9.



$V_{01} = 12V$

$\rightarrow V_o = V_{01} + V_{02}$

$= 12 - 4$

$V_o = 8V$

10 10 40

1 2 3

$10K \| 40K = \frac{10K \cdot 40K}{10K+40K} = 8K$

$\frac{10K}{4} \quad \frac{10K \cdot 10K}{10K+10K}$

$V_{01} = -R_f\left(\frac{V_1}{R_1} + \frac{V_2}{R_2}\right)$

$= -10K\left(\frac{-5}{5K} + \frac{2}{5K}\right)$

$= -2(-3)$

$= 6V$

$V_{02} = \left(1+\frac{R_f}{R_4}\right)V^+$

$R_1 \| R_2$

$= \left(1+\frac{10K}{5K \| 5K}\right)\frac{5}{3}$

$5K \| 5K = \frac{5K \cdot 5K}{5K+5K}$

$= (1+4)\frac{5}{3}$

$= 5\times\frac{5}{3}$

$= \frac{25}{3}$

$= 8.33$

$V^+ = \frac{R_4 \| R_5}{R_3 + R_4 \| R_5}V_2 + \frac{R_3 \| R_5}{R_4 + R_3 \| R_5}V_4 + \frac{R_3 \| R_4}{R_5 + R_3 \| R_4}V_5$

$= \frac{10K \| 40K}{10K + 10K \| 40K}\times 1 + \frac{10K \| 40K}{10K + 10K \| 40K}\times 2 + \frac{10K \| 10K}{40K + 10K \| 10K}\times 3$

$= \frac{8K}{18K} + \frac{8K}{18K}\times 2 + \frac{5K}{45K}\times 3$

$= \frac{8K}{18K}\times 3 + \frac{1}{3}$

$6K$

$= \frac{4}{3} + \frac{1}{3} = \frac{5}{3}$

$V_o = 14.33$