5) Design a scaling adder circuit using an op-amp to give the output $V_o = -(3V_1 + 4V_2 + 5V_3)$

Ans For an inverting summer

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

Let $R_f = 120\,k\Omega$

$$\frac{R_f}{R_1} = 3 \Rightarrow R_1 = R_f/3 = 120k\Omega/3$$

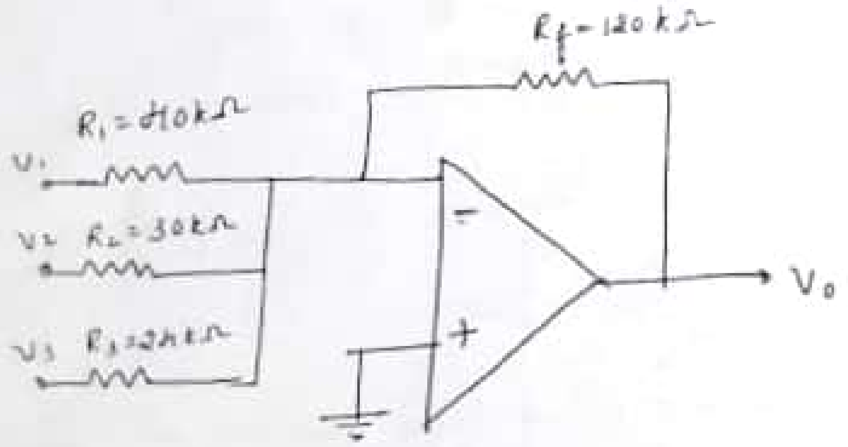
$$R_1 = 40\,k\Omega$$

$$\frac{R_f}{R_2} = 4 \Rightarrow R_2 = R_f/4 = 120k\Omega/4$$

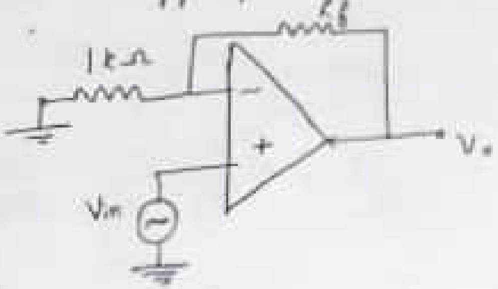
$$R_2 = 30\,k\Omega$$

$$\frac{R_f}{R_3} = 5 \Rightarrow R_3 = R_f/5 = 120k\Omega/5$$

$$R_3 = 24\,k\Omega$$



③ For op-amp shown in figure the gain required is 61. Determine the appropriate value of feedback resistance R_f.



From figure $R_1 = 1k\Omega$ and gain required is 61

$$Gain = \frac{V_o}{V_{in}} = 1 + \frac{R_f}{R_1}$$

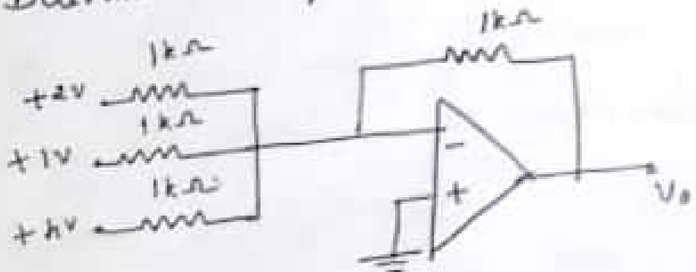
$$61 = 1 + \frac{R_f}{R_1}$$

$$\frac{R_f}{R_1} = 60$$

$$R_f = 60 \times 1k\Omega = 60k\Omega$$

$$\boxed{R_f = 60\,k\Omega}$$

④ Determine output voltage in below figure



$$V_{out} = -(V_{in1} + V_{in2} + V_{in3})\frac{R_f}{R_1}$$

$$= -(2+1+4)\frac{1k\Omega}{1k\Omega}$$

$$\boxed{V_{out} = -7V}$$

(4) Design the value of an inductor to be used in Colpitts oscillator to generate a frequency of 10 MHz. The circuit is used capacitor $C_1 = 100pF$ and $C_2 = 50pF$

Given

$C_1 = 100pF$

$C_2 = 50pF$

$f = 10MHz$

$L = ?$

$$C_{eq} = \frac{C_1C_2}{C_1+C_2} = 33.33\,pF$$

$$f = \frac{1}{2\pi\sqrt{LC_{eq}}} \Rightarrow L = \frac{1}{(2\pi f)^2 C_{eq}}$$

$$f = \underline{\underline{7.6\,\mu H}}$$

(5) Calculate frequency of oscillation of Hartley oscillator having $L_1 = 0.5\,mH$, $L_2 = 1\,mH$ and $C = 0.2\,\mu F$.

Given

$L_1 = 0.5\,mH$

$L_2 = 1\,mH$

$C = 0.2\,\mu F$

$$f = \frac{1}{2\pi\sqrt{L_{eq}C}}$$

$$L_{eq} = L_1 + L_2 = 1.5\,mH$$

$$f = \underline{\underline{9.18\,kHz}}$$ Sol.

(6) In a Hartley oscillator $L_1 = 20\,\mu H$, $L_2 = 2\,mH$ and C is variable. Find range of C if frequency is to be varied from $1\,MHz$ to $2.5\,MHz$. Neglect mutual inductance.

given

$L_1 = 20\,\mu H$

$L_2 = 2\,mH$

$f_1 = 1\,MHz$

$f_2 = 2.5\,MHz$

$L_{eq} = L_1 + L_2 = \underline{\underline{2.02\,mH}}$

$f_1 = 1\,MHz$ & $f = \frac{1}{2\pi\sqrt{L_{eq}C}}$

$$C_1 = \frac{1}{(2\pi f_1)^2 L_{eq}} = 12.539\,pF$$

$f_2 = 2.5\,MHz$

$$C_2 = \frac{1}{(2\pi f_2)^2 L_{eq}} = \underline{\underline{2.006\,pF}}$$

Problems

① Determine the voltage gain of the op-amp circuit shown in figure a

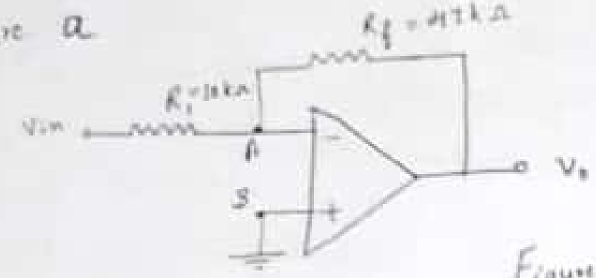


Figure ⓐ

Given

$R_1 = 10k\Omega$

$R_f = 47k\Omega$

The circuit is inverting amplifier.

$$Gain = \frac{V_o}{V_{in}} = \frac{-R_f}{R_1} = \frac{-47k\Omega}{10k\Omega} = \underline{\underline{-4.7}}$$

② A sine wave of 0.5V peak voltage is applied to an inverting amplifier using $R_1 = 10k\Omega$ and $R_f = 50k\Omega$ It uses the supply voltage of $\pm 12V$. Determine output

If now the amplitude of input sine wave is increased to 5V, what will be the possible output ?

Case 1 : For inverting amplifier $Gain = \frac{-R_f}{R_1} = \frac{-50k\Omega}{10k\Omega} = -5$

If $V_{in} = 0.5V \Rightarrow V_o = V_{in} \times Gain = 0.5 \times 5 = \underline{\underline{12.5V}}$ peak

The output waveform is inverted is inverted with respect to input

Case 2 : If $V = 5V$

$V_o = V_{in} \times Gain = 5 \times 5 = 25V$ peak

But practically op-amp output saturates at $\pm 12V$ as i.e. at supply voltage used. So portion above +12V and −12V will be clipped and output will be 180° phase shifted w.r.t input.

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Problems

1) In a RC phase shift oscillator, the phase shift n/w uses resistances each of 4.7 kΩ and capacitors each of 0.47 μF find frequency of oscillation.

Given

$R = 4.7 k\Omega$

$C = 0.47 \mu F$

$$f = \frac{1}{2\pi\sqrt{6}\,RC}$$

$$f = \frac{1}{(2\pi)(\sqrt{6})(4.7\times10^{3})(0.47\times10^{-6})}$$

$$\underline{\underline{f = 29.415 \text{ Hz}}}$$

Design RC phase shift oscillator using CE amplifier for frequency 900 KHz.

$f = 900 KHz$

Let $C = 1 pF$

$$f = \frac{1}{2\pi\sqrt{6}\,RC}$$

$$R = \frac{1}{(2\pi)\sqrt{6}\,(900\times10^{3})(1\times10^{-12})}$$

$$\underline{\underline{R = 72.1941 \text{ k}\Omega}}$$

In a Colpitts oscillator the desired frequency is 500 KHz estimate L, assuming C = 1000 pF

For Colpitts oscillator $C_1 = C_2 = C = 1000 pF$

$$C_{eq} = \frac{C_1 C_2}{C_1 + C_2} = 500 pF$$

$$f = \frac{1}{2\pi\sqrt{L C_{eq}}} \Rightarrow L = \frac{1}{(2\pi f)^2 C_{eq}}$$

$$L = 202.64 \mu H$$