LINEAR INTEGRATED CIRCUITS

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Unit 1 Adder (Summing Amplifier)

- Non-inverting input is grounded
- More than one input is connected to inverting input

$$V_{OUTN} = -\frac{R_F}{R_N}V_N$$

$$V_{OUT1} = -\frac{R_F}{R_1}V_1$$

$$V_{OUT2} = -\frac{R_F}{R_2}V_2$$

$$\boxed{V_{OUT} = -\left(\frac{R_F}{R_1}V_1 + \frac{R_F}{R_2}V_2 + \frac{R_F}{R_N}V_N\right)}$$

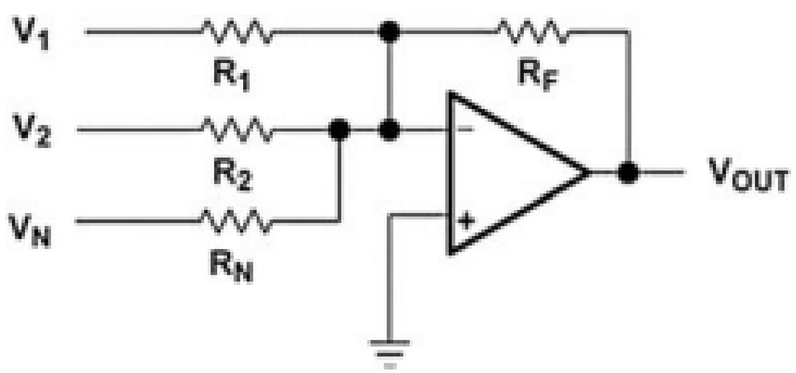


Figure 2.5

Circuit is also called summing amplifier

Unit 1 Summing Amplifier

Design a circuit whose output is $V_{out} = -2(3V_1+4V_2+2V_3)$

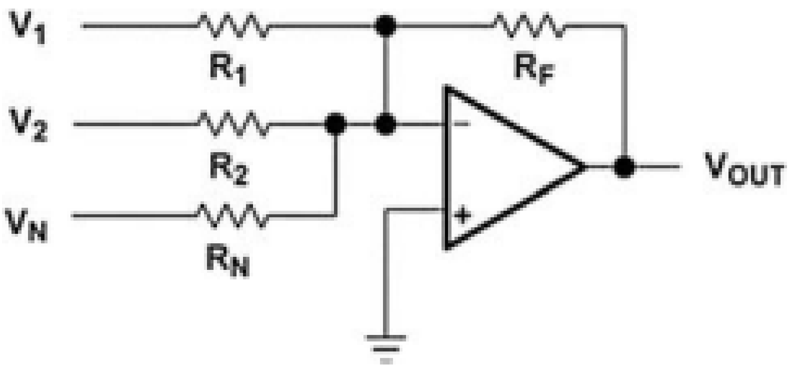


Figure 2.5

Answer is
RF = 10Kohm (Assume)
R1 = 1.6Kohm
R2 = 1.25Kohm
R3 = 2.5Kohm

- Amplifies difference between two signals applied at the input
- Superposition theorem is used to calculate output

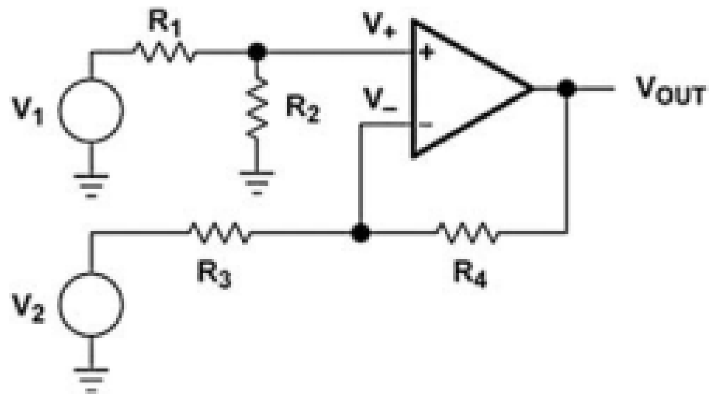


Figure 2.6

$$V_+ = V_1 \frac{R_2}{R_1 + R_2}$$

$$V_{OUT1} = V_+(G_+) = V_1 \frac{R_2}{R_1 + R_2}\left(\frac{R_3 + R_4}{R_3}\right)$$

$$V_{OUT2} = V_2\left(\frac{-R_4}{R_3}\right)$$

$$\boxed{V_{OUT} = V_1 \frac{R_2}{R_1 + R_2}\left(\frac{R_3 + R_4}{R_3}\right) - V_2 \frac{R_4}{R_3}}$$

When $R_1 = R_3$ and $R_2 = R_4$

$$\boxed{V_{OUT} = (V_1 - V_2)\frac{R_4}{R_3}}$$

Unit 1 Differential amplifier

Design a simple difference amplifier with an input impedance of 10 kΩ per leg, and a voltage gain of 26 dB.

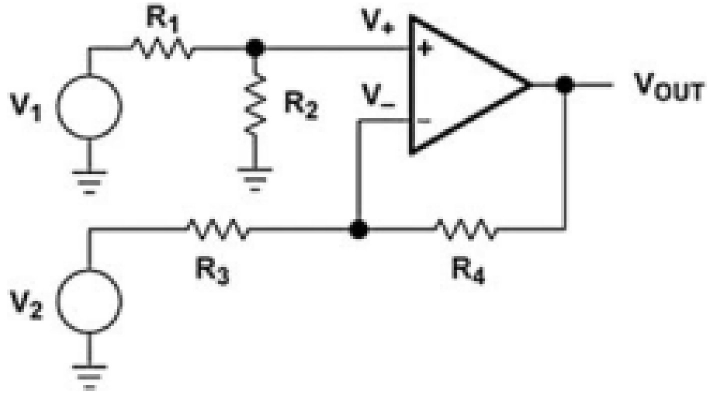


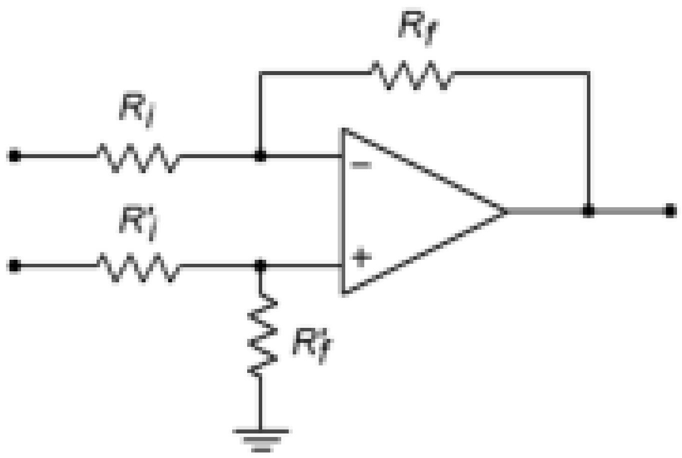
Figure 2.6

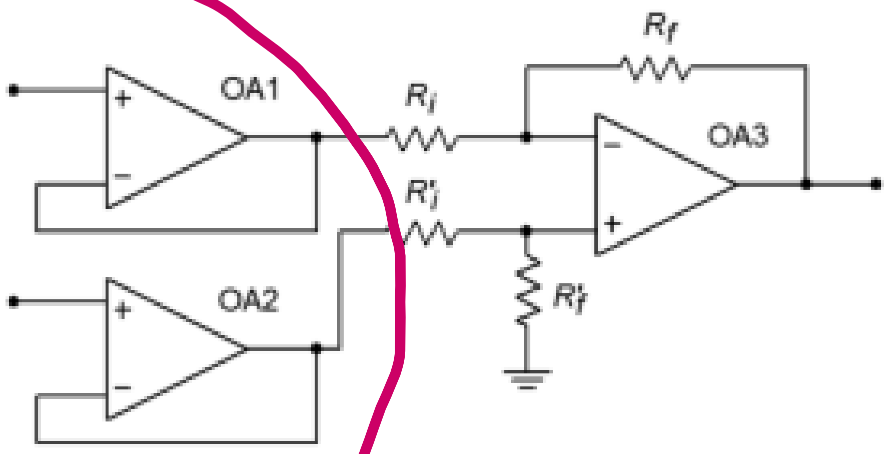
Answer is
R3 = 10Kohm
R4 = 200Kohm
R1 = 500ohm
R2 = 9.5Kohm

Unit 1 Instrumentation amplifier

- Specialized op amp
- Offers very high input impedance
- Derived from **differential amp**

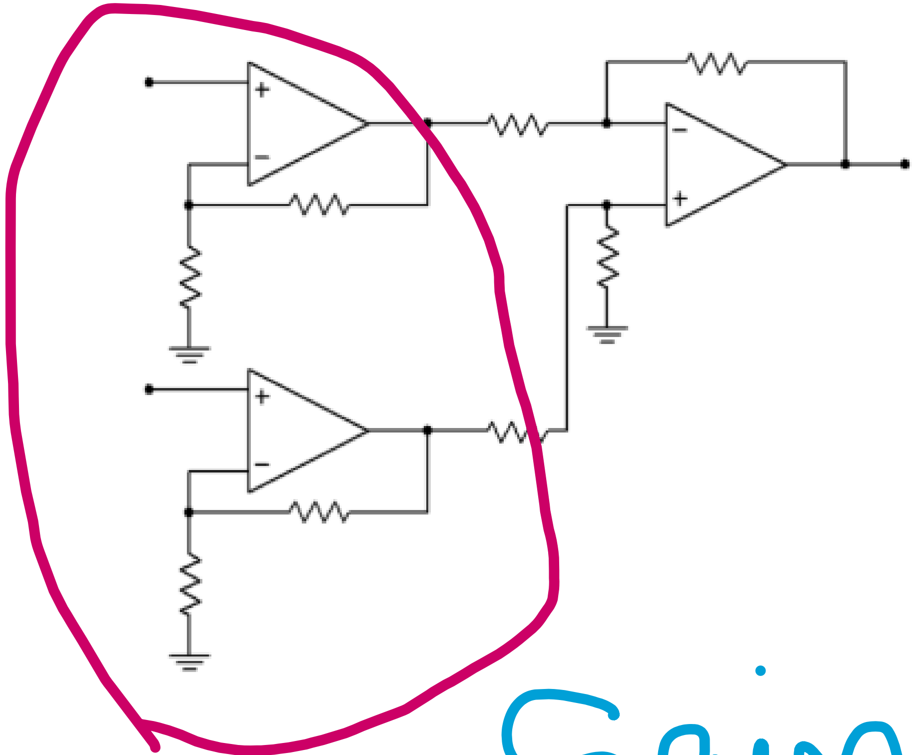
Buffer



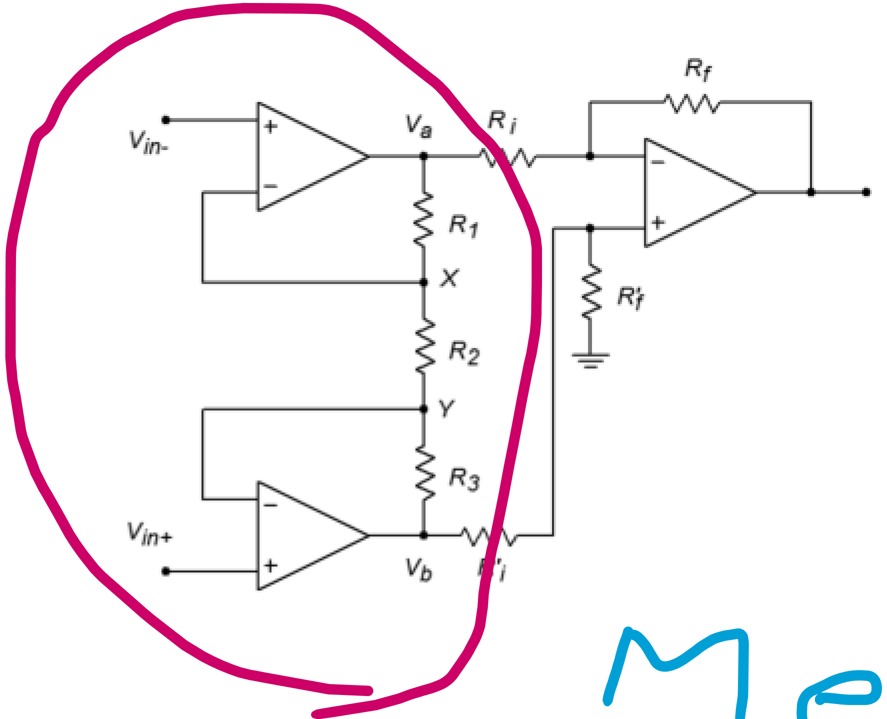


Unit 1 Instrumentation amplifier

- Specialized op amp with higher precision
- Derived from differential amp



Gain



Merge

Unit 1 Instrumentation amplifier Analysis

From Difference amp relation,

$$V_{out} = \frac{R_f}{R_i}(V_b - V_a)$$

From Ideal op amp relation,

$$V_x = V_{in-}$$
$$V_y = V_{in+}$$

The output voltage V_a must equal V_x plus the drop across R_1.

$$V_a = V_x + V_{R1}$$

Voltage drop across R_1 is given by,

$$V_{R1} = R_1 I_{R1}$$
$$V_{R1} = R_1 I_{R2}$$

Current I_{R2} is given by,

$$I_{R2} = \frac{V_x - V_y}{R_2}$$

Value of V_a is given by,

$$V_a = V_x + \frac{R_1(V_x - V_y)}{R_2}$$

After substitution,

$$V_a = V_{in-} + \frac{R_1(V_{in-} - V_{in+})}{R_2}$$

$$V_a = V_{in-} + \frac{R_1}{R_2}(V_{in-} - V_{in+})$$

$$V_a = V_{in-} + V_{in-}\frac{R_1}{R_2} - V_{in+}\frac{R_1}{R_2}$$

$$V_a = V_{in-}\left(1 + \frac{R_1}{R_2}\right) - V_{in+}\frac{R_1}{R_2}$$

By a similar derivation, the equation for V_b is found

$$V_b = V_{in+}\left(1 + \frac{R_3}{R_2}\right) - V_{in-}\frac{R_3}{R_2}$$

For gain matching R_3 is set equal to R_1. And after substitution

$$V_{out} = \frac{R_f}{R_i}\left(\left(V_{in+}\left(1 + \frac{R_1}{R_2}\right) - V_{in-}\frac{R_1}{R_2}\right) - \left(V_{in-}\left(1 + \frac{R_1}{R_2}\right) - V_{in+}\frac{R_1}{R_2}\right)\right)$$

After combining terms,

$$V_{out} = \frac{R_f}{R_i}\left((V_{in+} - V_{in-})\left(1 + \frac{R_1}{R_2}\right) + (V_{in+} - V_{in-})\frac{R_1}{R_2}\right)$$

$$\boxed{V_{out} = (V_{in+} - V_{in-})\left(\frac{R_f}{R_i}\right)\left(1 + 2\frac{R_1}{R_2}\right)}$$

THANK YOU

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