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LECTURE - 41

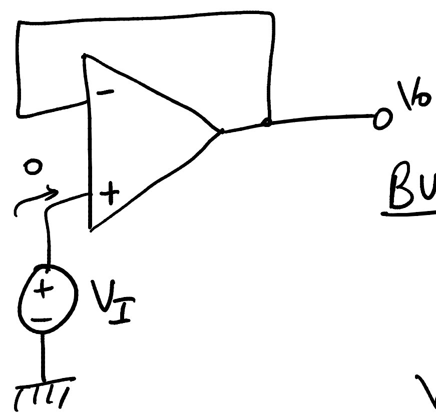
APPLICATION OF NON-INVERTING AMPLIFIER IS A VOLTAGE FOLLOWER

$$A_V = 1 + \frac{R_2}{R_1}$$

IF R_1 IS $\infty\,\Omega$ [O.C]

$$A_V = \frac{V_O}{V_I} = 1 \quad \leftarrow \text{UNITY GAIN}$$

SINCE GAIN IS INDEPENDENT OF $R_2 \therefore R_2 = 0$



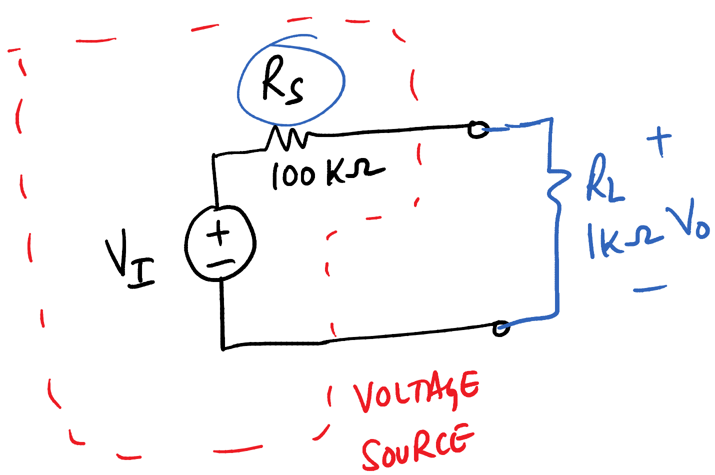
BUFFER

$R_{IN} = \infty\,\Omega$

$R_O = 0\,\Omega$

$V_O = V_I$

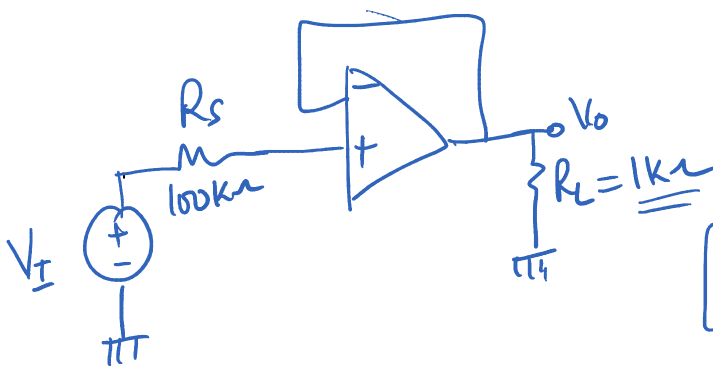
$A_V = 1$



$$\frac{V_O}{V_I} = \frac{1K}{1K + 100K} \approx 0.01$$

$$\boxed{V_O = 0.01\, V_I}$$

LOADING EFFECT!



OP-AMP HAS LOW Ro

IDEAL Ro = 0Ω

$V_O = V_I$

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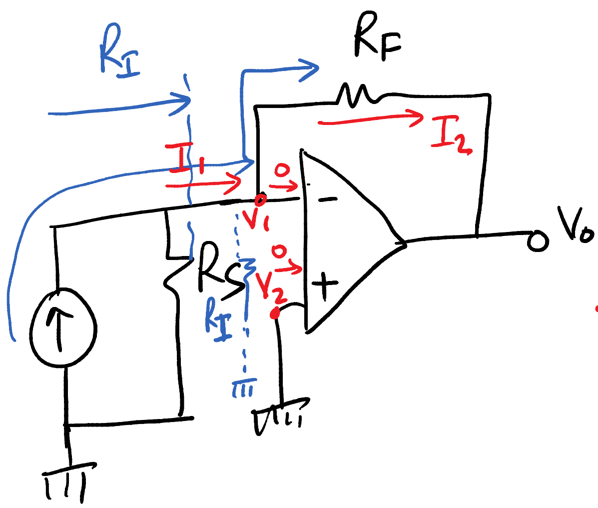
CURRENT TO VOLTAGE CONVERTER

I TO V CONV.

PHOTODETECTOR → PHOTO DIODE →
OUTPUT IS CURRENT



SINCE $V_2 = 0$
$V_1 = 0$ VIRTUAL GROUND THEORY!

$$R_I = \frac{V_1}{I_1} \approx 0\,\Omega$$

$R_S >> R_I$

$$I_1 = I_s = I_2$$

$$\frac{V_o - V_1}{R_F} = -I_2$$

$$V_o = -I_2 R_F$$

$$\boxed{V_o = -I_s R_F}$$

$$\boxed{V_o \propto I_s}$$

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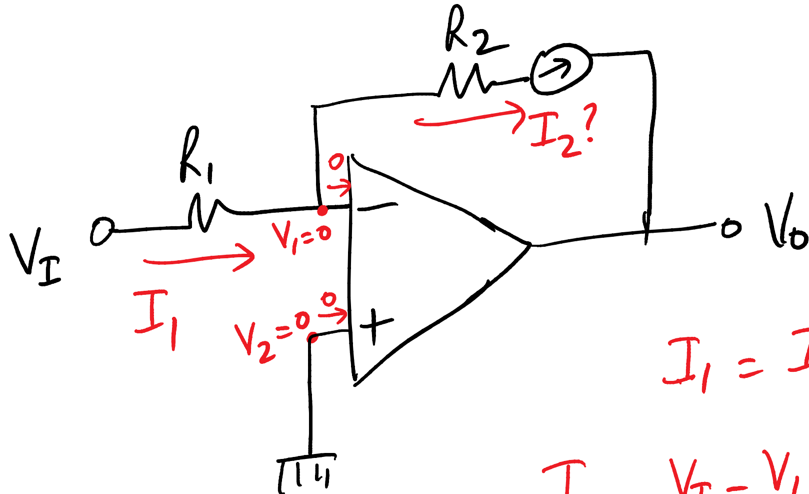
V TO I CONVERTER

TO DRIVE A MAGNETIC COIL USING A VOLTAGE SOURCE!



$$I_1 = I_2$$

$$I_1 = \frac{V_I - V_1}{R_1} = \frac{V_I}{R_1}$$

$$\boxed{I_2 = \frac{V_I}{R_1}}$$

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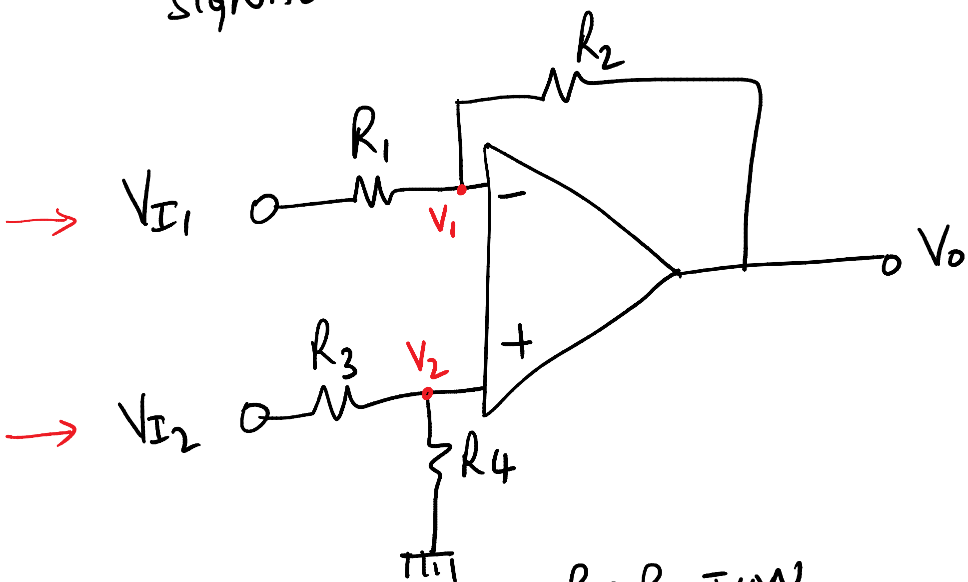
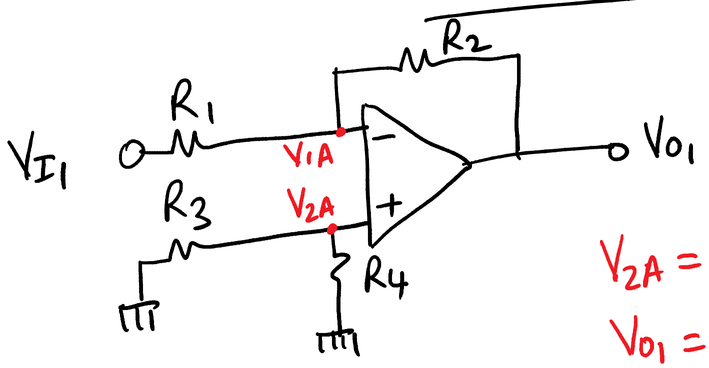
DIFFERENCE AMPLIFIER

* AMPLIFIES ONLY THE DIFFERENCE BETWEEN TWO SIGNALS AND REJECTS ANY COMMON SIGNALS TO THE TWO TERMINALS.

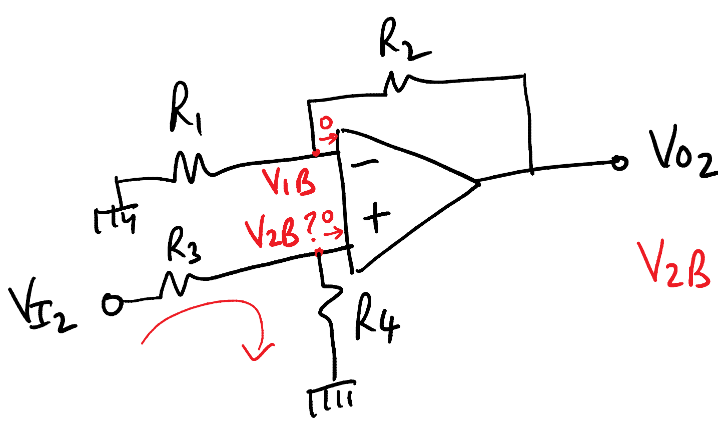


SUPERPOSITION



$$V_{2A} = 0$$

$$V_{o1} = -\frac{R_2}{R_1}(V_{I1}) \quad \cdots \text{(1)}$$



$$V_{2B} = \frac{V_{I2} R_4}{R_3 + R_4}$$

$V_{1B} = V_{2B}$ → NON-INV AMP

$$V_{1B} = V_{2B}$$

$$V_{O2} = \left(1 + \frac{R_2}{R_1}\right) V_{1B} = \left(1 + \frac{R_2}{R_1}\right)\left(\frac{R_4}{R_3 + R_4}\right) V_{I_2} \quad \text{...②}$$

$$V_O = V_{O1} + V_{O2}$$

$$= \left(1 + \frac{R_2}{R_1}\right)\left(\frac{R_4}{R_3 + R_4}\right) V_{I_2} - \frac{R_2}{R_1} V_{I_1}$$

IF $\boxed{\dfrac{R_4}{R_3} = \dfrac{R_2}{R_1}}$ DESIGN CRITERIA

$$\therefore \quad \boxed{V_O = \frac{R_2}{R_1}\left(V_{I_2} - V_{I_1}\right)}$$

NOTE: → IF $V_{I_2} = V_{I_1} \Rightarrow V_O = 0$

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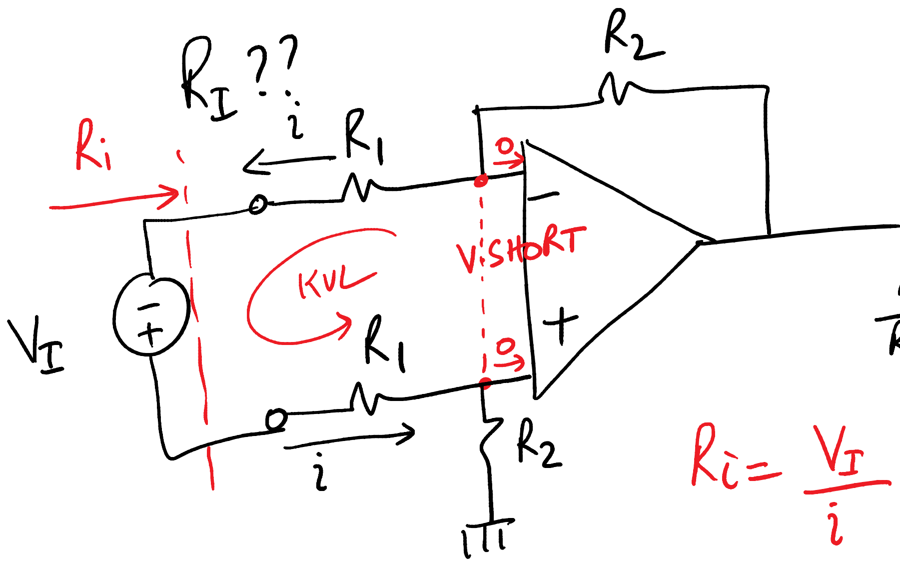
$$A_d = \frac{V_o}{V_{I_2} - V_{I_1}} = \frac{R_2}{R_1}$$

CLOSED LOOP DIFFERENTIAL GAIN



$$\frac{R_4}{R_3} = \frac{R_2}{R_1}$$

$$R_i = \frac{V_I}{i}$$

KVL LOOP

$$R_1 i + R_1 i = V_I$$

$$\frac{V_I}{i} = 2R_1$$

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Ex

GAIN = 30

$$\frac{R_2}{R_1} = \frac{R_4}{R_3} = 30$$

$$R_2 = 30 R_1 \Rightarrow R_2 > R_1$$

IF GAIN TO BE LARGE ↑↑ R_1 ↓↓

$R_I = 2R_1$ ↓↓

∴ NOT POSSIBLE TO GET HIGH GAIN AND HIGH R_I

* IF $\frac{R_4}{R_3} \neq \frac{R_2}{R_1}$ AND $V_{I_1} = V_{I_2} \Rightarrow$ OUTPUT $\neq 0$

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DEFINE COMMON MODE INPUT ⇒

$$V_{CM} = \frac{V_{I_1} + V_{I_2}}{2}$$

A_{CM} → COMMON MODE GAIN $= \frac{V_o}{V_{CM}}$

IDEAL CASE → $V_o = 0$ ⇒ $A_{CM} = 0$

DEFINE → CMRR → COMMON MODE REJECTION RATIO

$$= \left| \frac{A_d}{A_{CM}} \right|$$

$$(CMRR)_{dB} = 20 \log_{10} \left| \frac{A_d}{A_{CM}} \right|$$

DESIRED ↑↑↑↑

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Ex

$$\frac{R_2}{R_1} = 10 \qquad \frac{R_4}{R_3} = 11$$

CMRR??

$$V_o = \left(1+\frac{R_2}{R_1}\right)\left(\frac{R_4/R_3}{1+R_4/R_3}\right)V_{I_2} - \frac{R_2}{R_1}V_{I_1}$$

$$= (1+10)\left(\frac{11}{1+11}\right)V_{I_2} - 10\,V_{I_1}$$

$$= 10.0833\,V_{I_2} - 10\,V_{I_1}$$

$$V_{I_1} = V_{CM} - \frac{V_d}{2}$$

$$V_{I_2} = V_{CM} + \frac{V_d}{2}$$

\# $V_d = V_{I_2} - V_{I_2}$, $V_{CM} = \frac{V_{I_1} + V_{I_2}}{2}$ } SOLVE

$$V_o = 10.0833\left(V_{CM} + \frac{V_d}{2}\right) - 10\left(V_{CM} - \frac{V_d}{2}\right)$$

$$V_o = 10.042\,V_d + 0.0833\,V_{CM}$$

\# $V_o = A_d V_d + A_{CM} V_{CM}$ (COMPARE)

$$A_d = 10.042$$

$$A_{CM} = 0.0833$$

$$(CMRR)_{dB} = 20\log_{10}\left(\frac{10.042}{0.0833}\right) \approx 41.6\,dB$$