LECTURE 1 OP-AMP

Introduction of Operation Amplifier (Op-Amp)

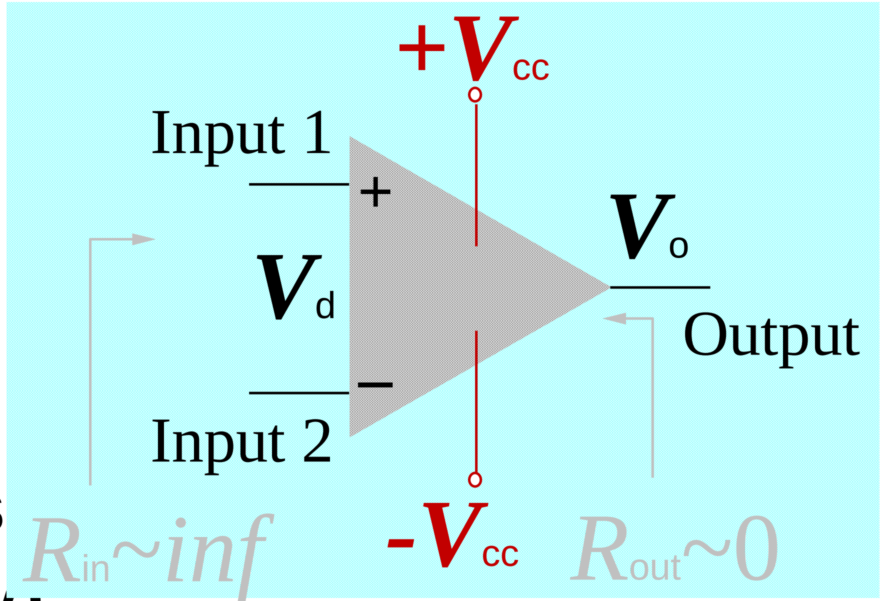
Analysis of ideal Op-Amp applications

Comparison of ideal and non-ideal Op-Amp

Non-ideal Op-Amp consideration

OPERATIONAL AMPLIFIER (OP-AMP)

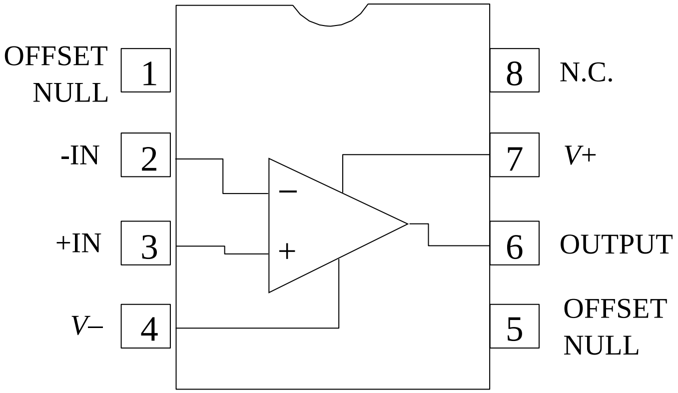
- **Very high differential gain**
- **High input impedance**
- **Low output impedance**
- **Provide voltage changes (amplitude and polarity)**
- **Used in oscillator, filter and instrumentation**
- **Accumulate a very high gain by multiple stages**



$$V_o = G_d V_d$$

G_d : differential gain normally very large, say 10^5

IC PRODUCT



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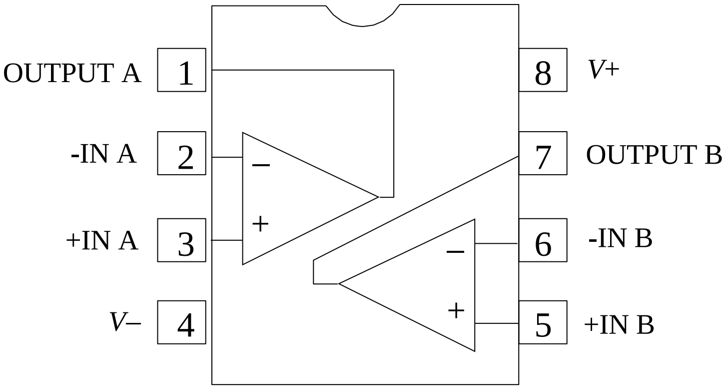
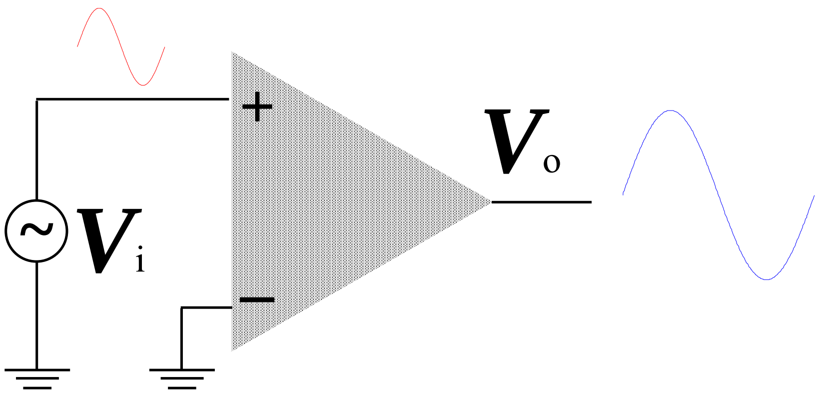
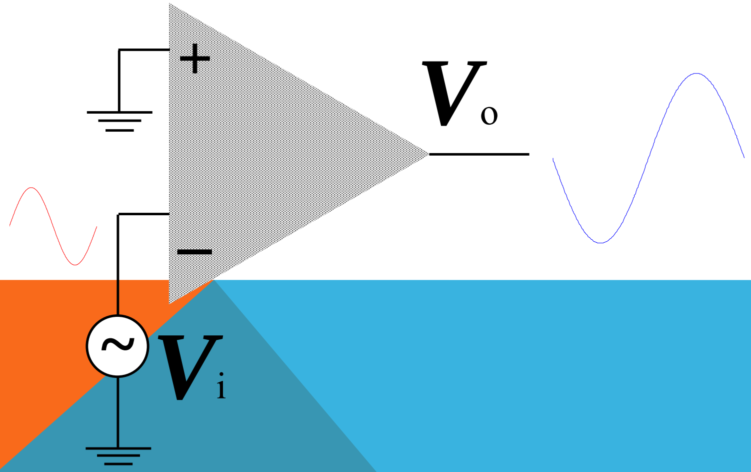


Dual op-amp 1458 device

SINGLE-ENDED INPUT

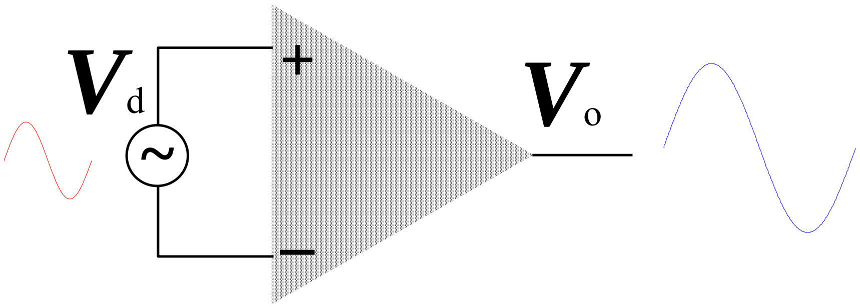


- + terminal : Source
- – terminal : Ground
- 0° phase change

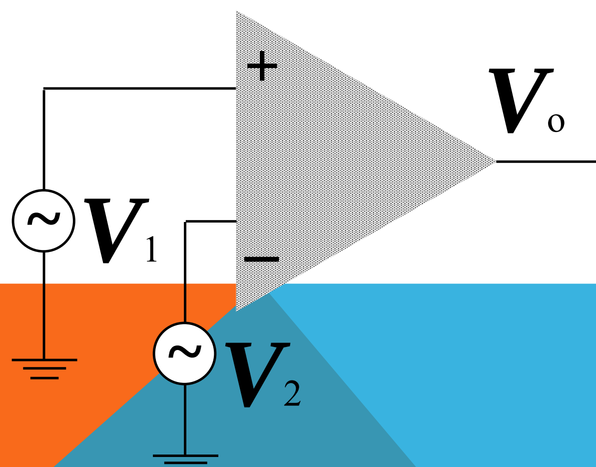


- + terminal : Ground
- – terminal : Source
- 180° phase change

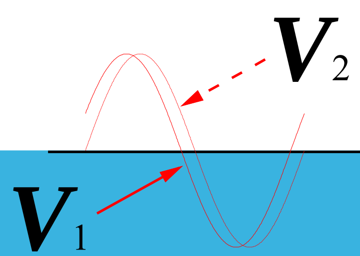
DOUBLE-ENDED INPUT



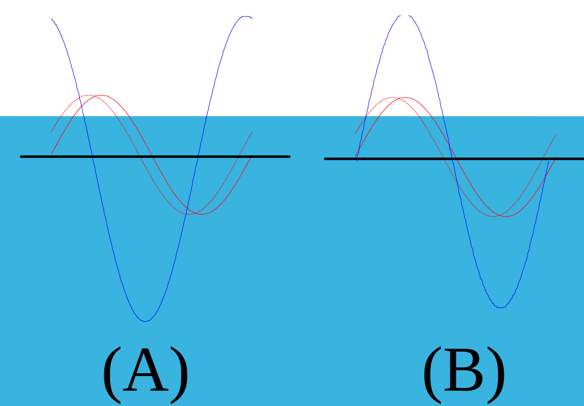
- Differential input
- $V_d = V_+ - V_-$
- 0^o phase shift change between V_o and V_d



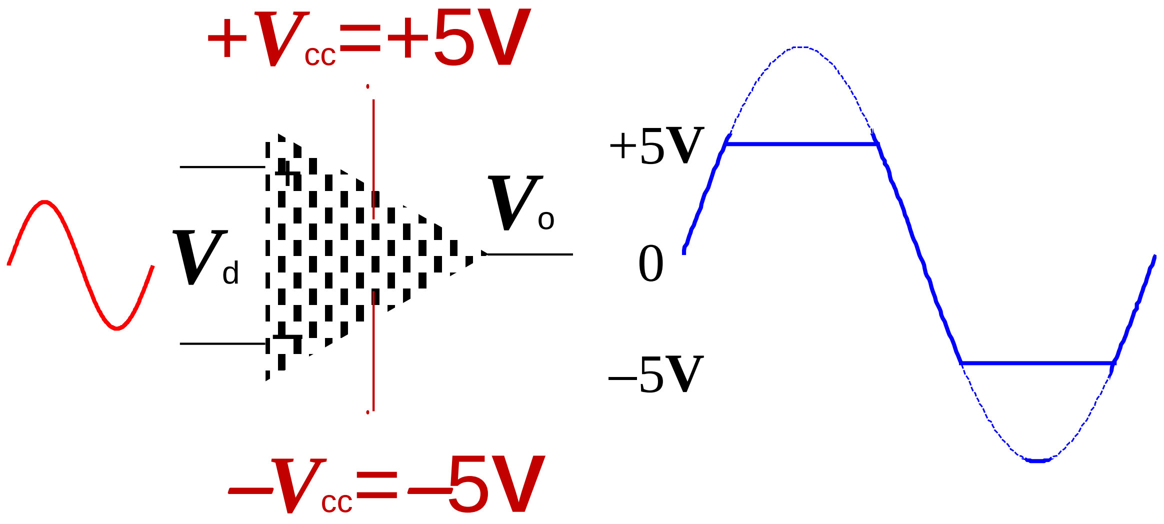
Qu: What V_o should be if,



Ans: (A or B) ?



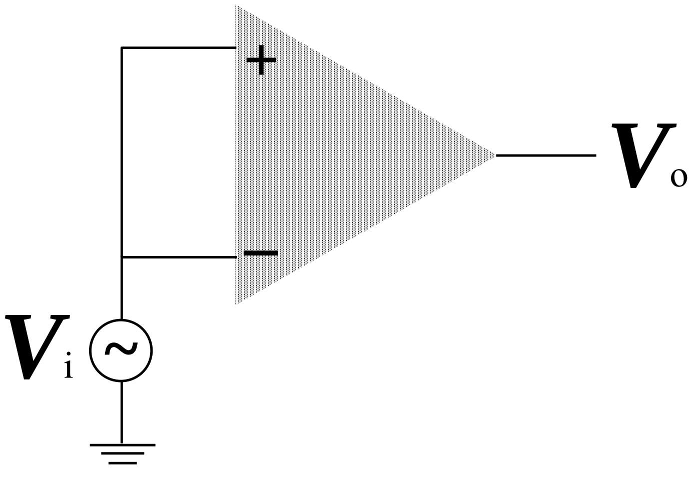
DISTORTION



The output voltage never excess the DC voltage supply of the Op-Amp

COMMON-MODE OPERATION

- Same voltage source is applied at both terminals
- Ideally, two input are equally amplified
- Output voltage is ideally zero due to differential voltage is zero
- Practically, a small output signal can still be measured



Note for differential circuits:
Opposite inputs : highly amplified
Common inputs : slightly amplified

$\Rightarrow$ Common-Mode Rejection

COMMON-MODE REJECTION RATIO (CMRR)

Differential voltage input :

$$V_d = V_+ - V_-$$

Common voltage input :

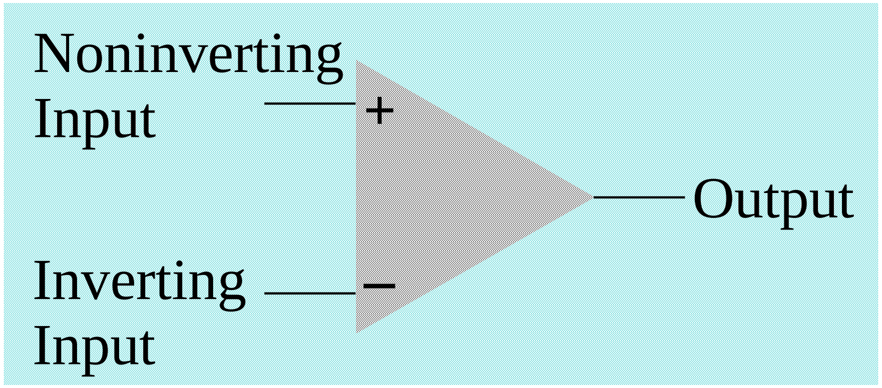
$$V_c = \frac{1}{2}(V_+ + V_-)$$

Output voltage :

$$V_o = G_d V_d + G_c V_c$$

G_d : Differential gain

G_c : Common mode gain



Common-mode rejection ratio:

$$\mathrm{CMRR} = \frac{G_d}{G_c} = 20\log_{10}\frac{G_d}{G_c}\ \text{(dB)}$$

Note:

When $G_d >> G_c$ or CMRR $\rightarrow \infty$

$\Rightarrow V_o = G_d V_d$