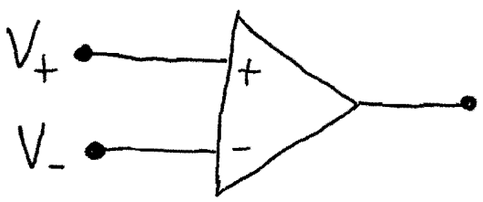
Comparator Circuits:

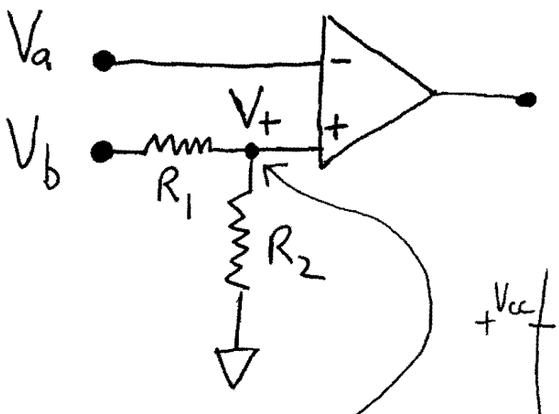
Think of a bare-bones op-amp setup,



$$V_{out} = \begin{cases} +V_{cc} \text{ if } V_+ > V_- \\ -V_{cc} \text{ if } V_- > V_+ \end{cases}$$

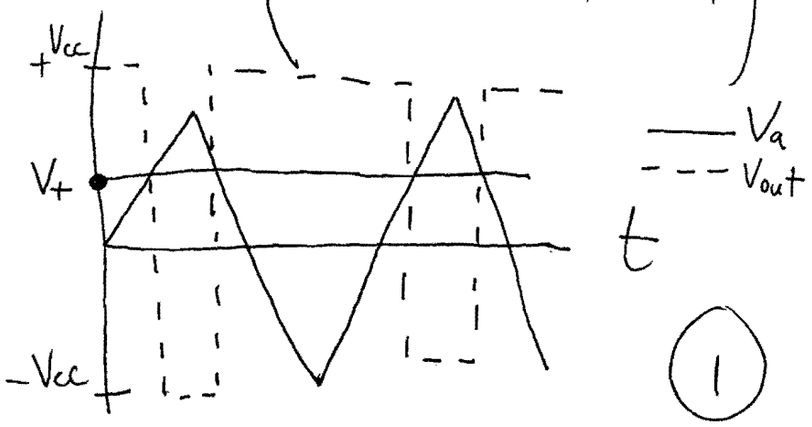
whichever input is bigger produces railed output in the same polarity because $V_{out} = G(V_+ - V_-)$ and $G \cong 10^5$.

Simple Comparator:

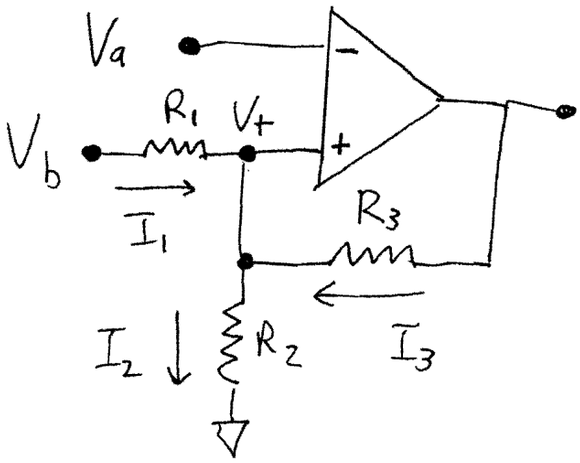


$$V_{out} = \begin{cases} +V_{cc} \text{ if } V_+ > V_a \\ -V_{cc} \text{ if } V_+ < V_a \end{cases}$$

$$V_+ = \left(\frac{R_2}{R_1 + R_2}\right) V_b$$



Schmitt Trigger Comparator:



$V_{out} = +V_{cc}$ if $V_+ > V_a$
$-V_{cc}$ if $V_+ < V_a$

The schmitt trigger is a comparator w/ positive feedback. V_+ can take on two different values depending on whether $V_{out} = \pm V_{cc}$.

Case 1: ($V_{out} = +V_{cc}$)

$I_1 + I_3 = I_2$ (Conservation of current)

$$\frac{V_b - V_+}{R_1} + \frac{V_{cc} - V_+}{R_3} = \frac{V_+}{R_2}$$

which leads to:

$$\frac{V_b}{R_1} + \frac{V_{cc}}{R_3} = V_+ \underbrace{\left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right)}_{(R_{123})^{-1}}$$

when $V_{out} = +V_{cc}$

$$V_+ = \frac{R_{123}}{R_1} V_b + \frac{R_{123}}{R_3} V_{cc}$$

Using the same conservation of current laws and $V_{out} = -V_{cc}$ yields: Case 2: ($V_{out} = -V_{cc}$)

$$V_+ = \frac{R_{123}}{R_1} V_b - \frac{R_{123}}{R_3} V_{cc}$$

when $V_{out} = -V_{cc}$