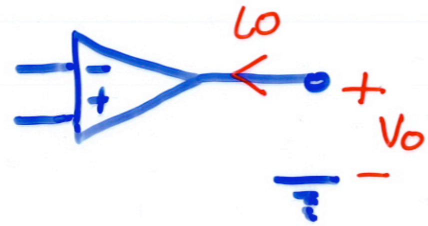
SATURATION IN OP-AMPS

Consider an opamp that can be modelled as being ideal apart from the saturation limits.

$$|v_o| \leq V_{sat}$$

$$|i_o| \leq i_{sat}$$



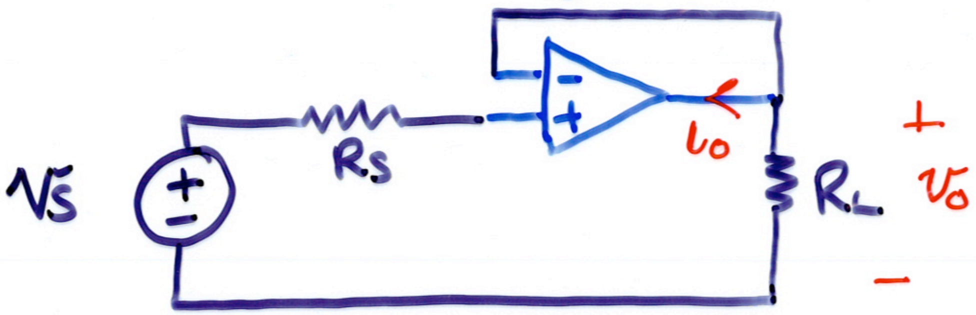
How does this affect circuit performance?

How do we analyze such an opamp in a circuit?

1. Assume it is acting in ideal mode.
2. Check the saturation limits
3. The output is determined either by the response in ideal mode or the smaller of the saturation limits

Let's consider an example.

Consider the following circuit



The opamp can be considered as being ideal, except for the saturation limits

$$|V_o| \leq V_{sat}$$

$$|i_o| \leq i_{sat}$$

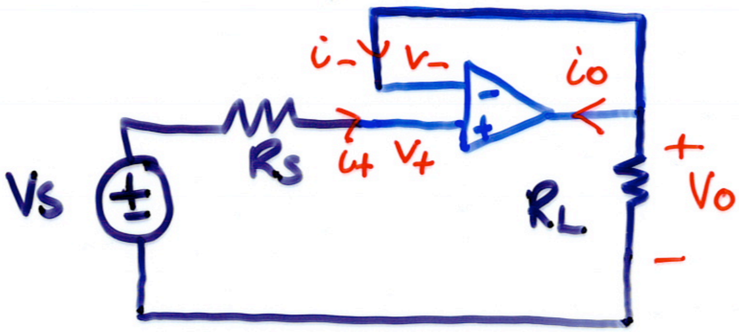
Find the values of V_s and R_L such that

(i) the op amp operates within the limits

(ii) the voltage is saturated.

(iii) the current is saturated

In each case, state the output voltage and current.



Assume that the op amp is ideal

$i_+ = 0 \Rightarrow V_+ = V_s$

$V_- = V_+ \Rightarrow V_- = V_s$

Short circuit feed back $\Rightarrow V_o = V_s$

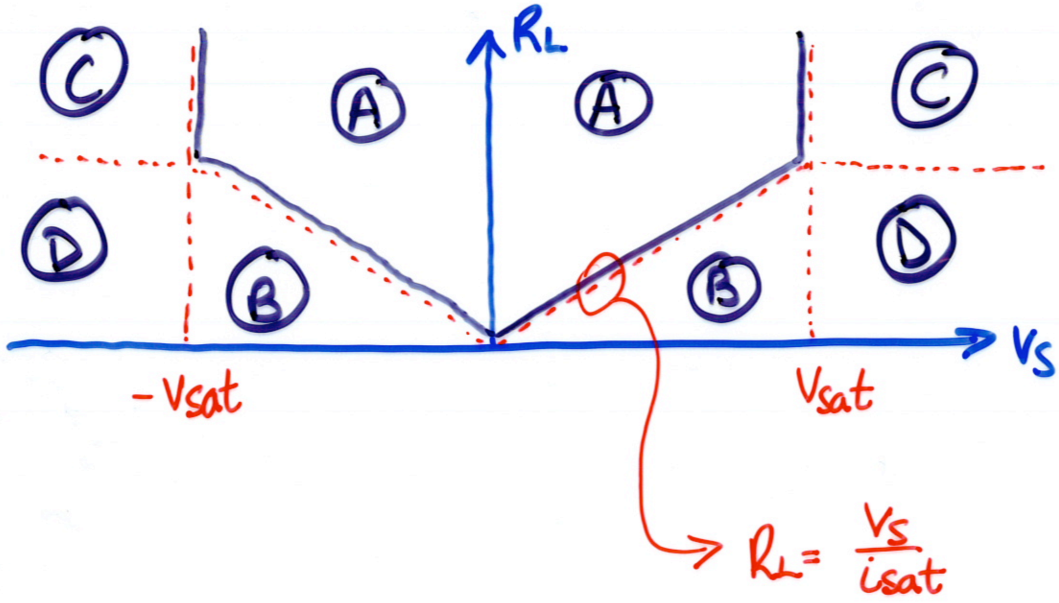
KCL at output node: $i_o + i_- + V_o/R_L = 0$

$i_- = 0 \Rightarrow i_o = -V_o/R_L$

Therefore, to operate in ideal mode, we must have

$|V_s| \leq V_{sat}$

$R_L \geq \dfrac{|V_s|}{i_{sat}}$



So in region (A) the op-amp acts in ideal mode.

What about region (B) ?

$|v_o| \leq V_{sat}$, but $|i_o| \geq i_{sat}$.

$\Rightarrow$ i_o saturates

$\Rightarrow$ $v_o = -\text{sgn}(v_s)\, i_{sat} R_L$

[redacted]

Regions Ⓒ and Ⓓ

$V_s > V_{sat}$

if op-amp were ideal $V_o = V_s$ would be greater than V_{sat}

$\Rightarrow$ V_o must be $\leq V_{sat}$

Let's look at region Ⓒ

In this region R_L is such that $\left|\frac{V_{sat}}{R_L}\right| \leq i_{sat}$

$\Rightarrow$ only the voltage saturates.

$\Rightarrow$ $V_o = \text{sgn}(V_s)\, V_{sat}$

$i_o = -\,\text{sgn}(V_s)\, V_{sat} / R_L$

Region Ⓓ

In this region, R_L is such that $\left|\frac{V_{sat}}{R_L}\right| \geq i_{sat}$

$\Rightarrow$ current saturates

$\Rightarrow$ $i_o = -\,\text{sgn}(V_s)\, i_{sat}$

$V_o = -\,\text{sgn}(V_s)\, i_{sat} R_L$