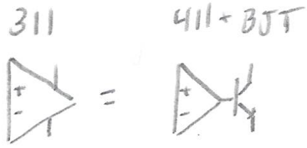
## Comparator basics.




The comparator is NOT designed to output anything but the two DC levels hooked to the "collector" or "emitter".

## Differences in specs

Slew rate (411) ⇆ Response time (311)

~ 10 V/μs

~ 150 ns for max $\Delta V$ ~ 30V

→ $30V / 150\,ns$ = {200 V/μs} (20x 411!)

comparable to slew rate.

Output currents

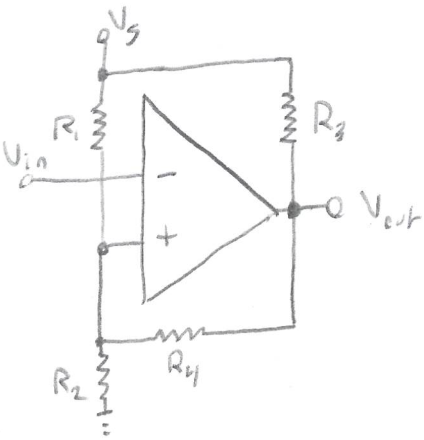
| | $I_o$ | $V_{out}$ |
|---|---|---|
| 411: | $I_o \leq$ 25mA at | $V_{out}$ = 10V |
| | 10 mA | 12.5V |
| | 0 mA | 15 V |
| 311: | 100 mA | 5V |
| | 45 mA | 10V |
| | 40mA | 15V |

311 can drive significantly more current! This is useful, but its fast response is very useful, especially in the primary application of comparators — digital logic! We'll see more of this in Lab 10.

## Schmitt trigger.

The positive feedback with attenuation gives this circuit a "memory" of sorts, by reacting to a threshold crossing with an instantaneous change in the threshold level.

This change is called hysteresis.




$$\text{KCL:}\quad \frac{V_+ - V_s}{R_1} + \frac{V_+ - 0}{R_2} + \frac{V_+ - V_{out}}{R_4} = 0 \qquad (V_+ \text{ node})$$

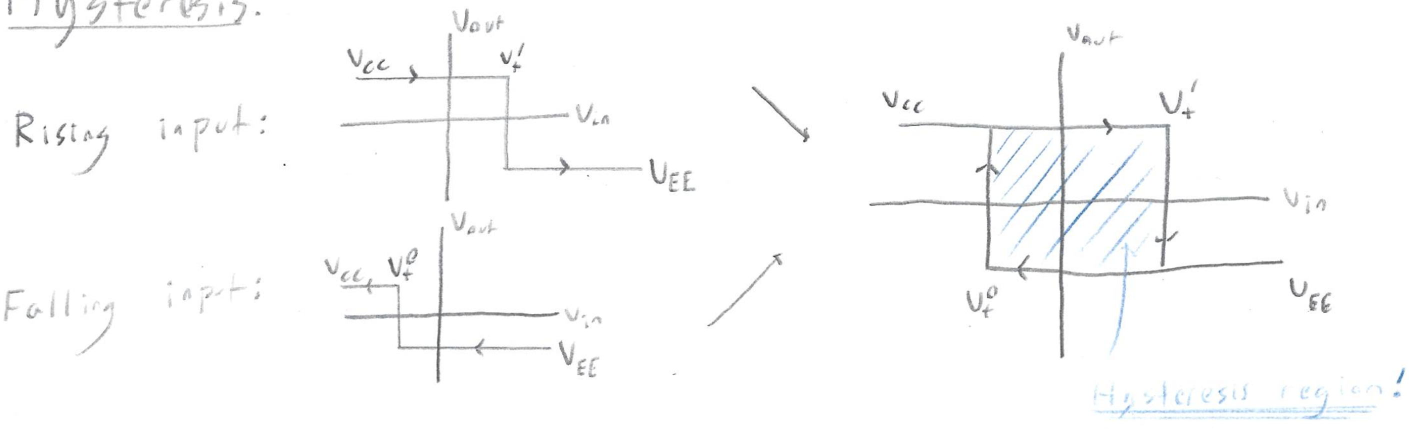
$$V_{out} = 0: \quad V_+^0 = \frac{R_4 R_2}{R_2 R_1 + R_4 R_1 + R_4 R_2} V_s$$

$$= \frac{R_2}{R_1 + R_2}\left[1 - \frac{R_1}{R_4}\,\frac{R_2}{R_1+R_2}\right] V_s + \mathcal{O}(R_4^{2})$$

$$V_{out} \neq 0: \quad V_+^1 = \left[\frac{R_2 R_4 (2R_1 + R_4)}{(R_4 R_2 + R_1 R_4 + R_1 R_2)(R_1 + R_4) - R_1 R_2 R_3}\right] V_s$$

$$= \frac{R_2}{R_1 + R_2}\left[1 + \frac{R_1}{R_4}\right] V_s \simeq V_0^+ + \frac{R_1}{R_4}\left(1 - \frac{R_2}{R_1 + R_2}\right).$$

## Hysteresis.




This prevents oscillations in the output caused by noise at the input.