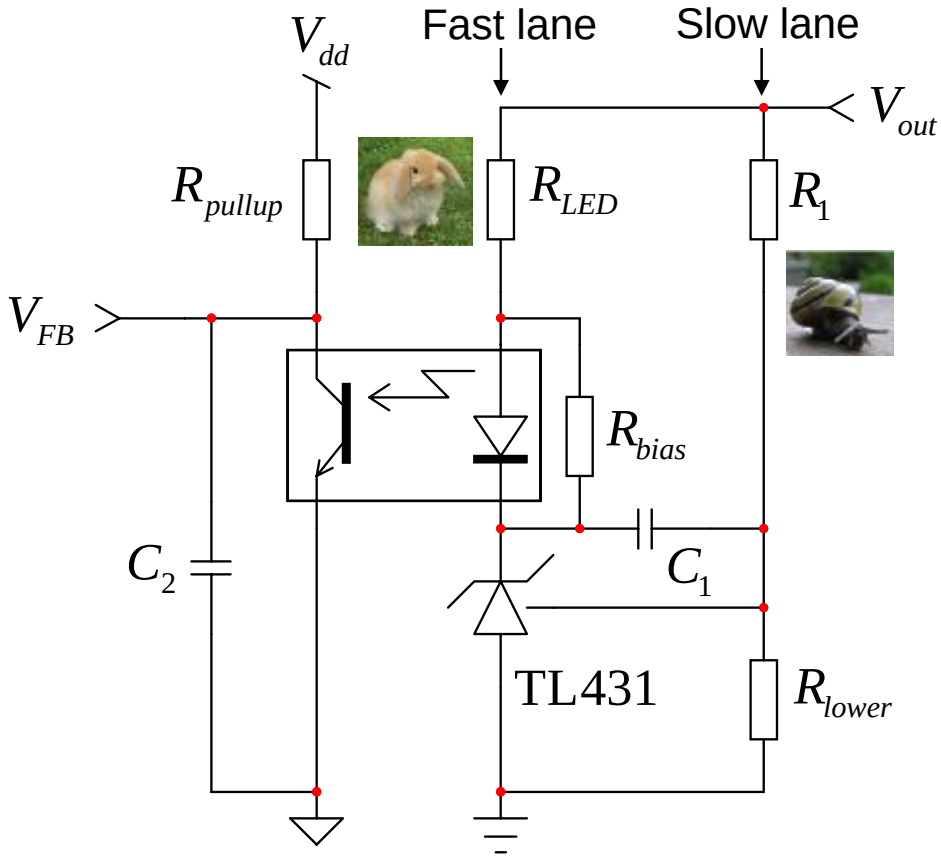
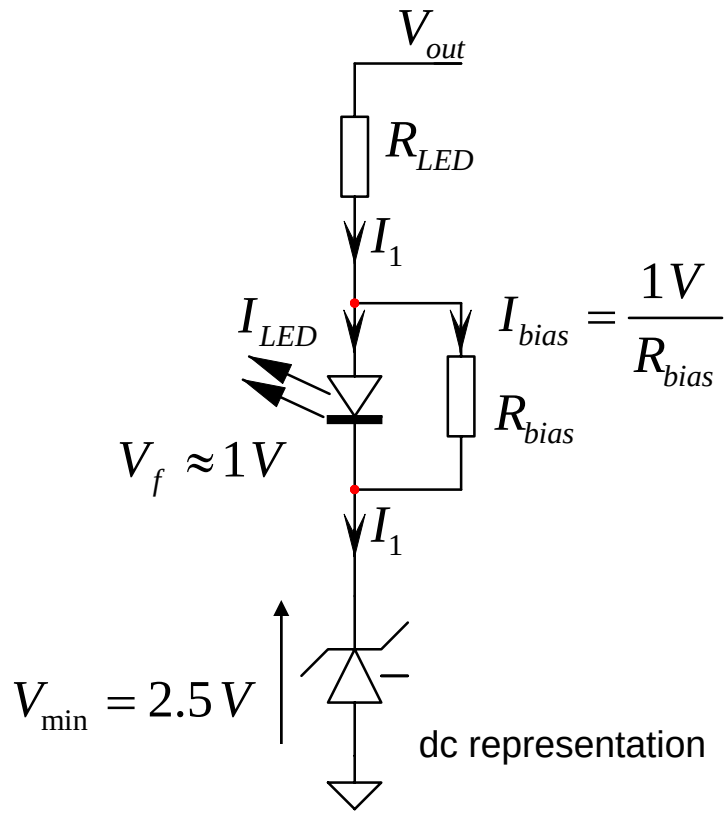
The TL431 Programmable Zener

- The TL431 lends itself very well to optocoupler control





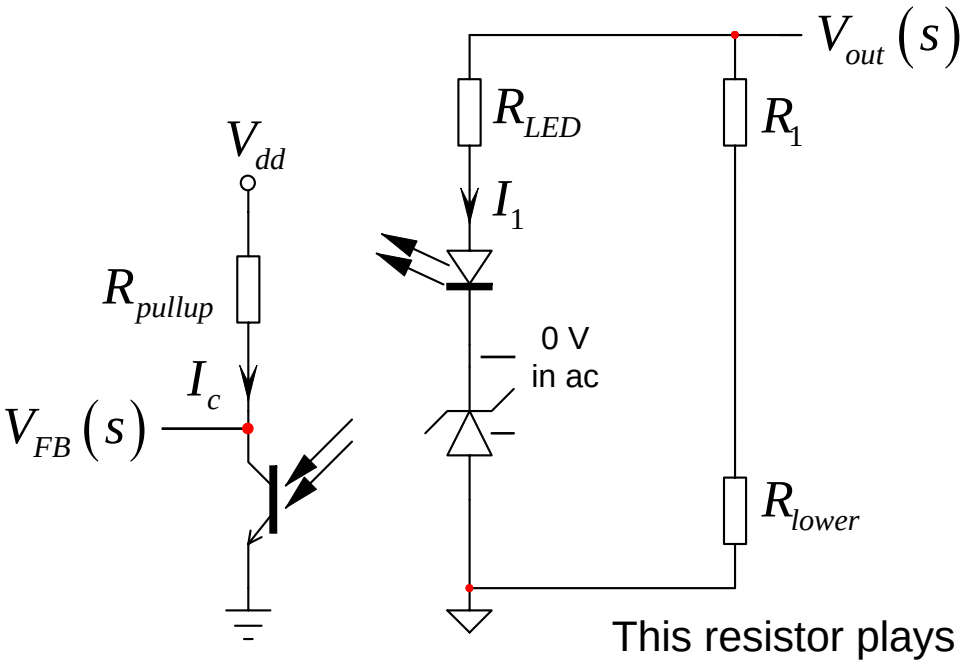
- R_{LED} must leave enough headroom over the TL431: upper limit!

The TL431 Programmable Zener

- This LED resistor is a design limiting factor in low output voltages:

$$R_{LED,\max} \le \frac{V_{out} - V_f - V_{TL431,\min}}{V_{dd} - V_{CE,sat} + I_{bias}\mathrm{CTR}_{\min} R_{pullup}} R_{pullup}\mathrm{CTR}_{\min}$$

- When the capacitor C_1 is a short-circuit, R_{LED} fixes the fast lane gain



$$V_{FB}(s) = -\mathrm{CTR} \cdot R_{pullup} \cdot I_1$$

$$I_1 = \frac{V_{out}(s)}{R_{LED}}$$

$$\frac{V_{FB}(s)}{V_{out}(s)} = -\mathrm{CTR}\frac{R_{pullup}}{R_{LED}}$$

This resistor plays a role in dc too!

The TL431 – the Static Gain Limit

- Let us assume the following design:

$V_{out} = 5\,V$
$V_f = 1\,V$
$V_{TL431,\min} = 2.5\,V$
$V_{dd} = 4.8\,V$
$V_{CE,sat} = 300\,mV$
$I_{bias} = 1\,mA$
$\mathrm{CTR}_{\min} = 0.3$
$R_{pullup} = 20\,k\Omega$

$$R_{LED,\max} \le \frac{5-1-2.5}{4.8-0.3+1m\times 0.3\times 20k}\times 20\mathrm{k}\times 0.3$$

$$\Downarrow$$

$$R_{LED,\max} \le 857\,\Omega$$

$$\Downarrow$$

$$G_0 > \mathrm{CTR}\frac{R_{pullup}}{R_{LED}} > 0.3\frac{20}{0.857} > 7\ or \approx 17\ dB$$

- In designs where R_{LED} fixes the gain, G_0 cannot be below 17 dB

$\Rightarrow$ You cannot “amplify” by less than 17 dB