Electro-Optics

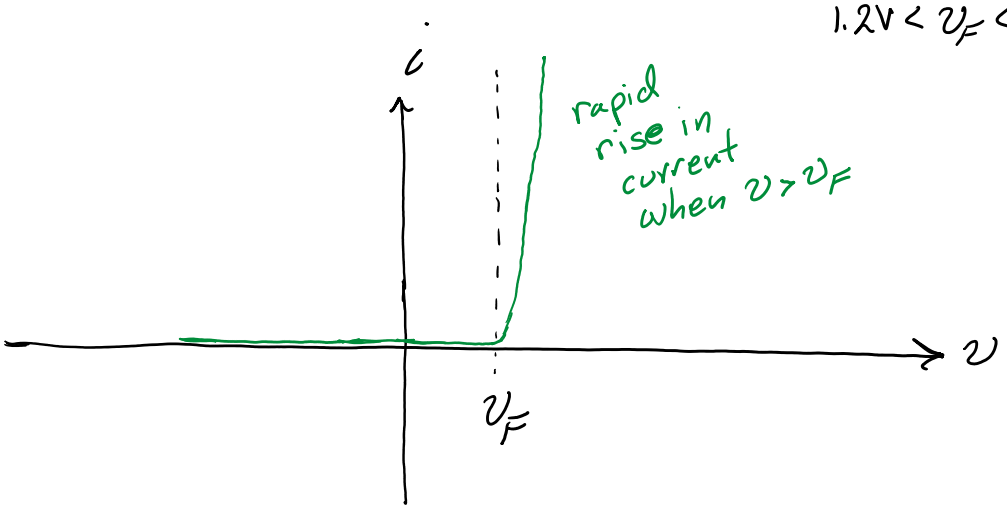
Will consider:
1. LEDs: Light Emitting Diodes
2. Phototransistor

LED

Used as indicator lights and illumination.

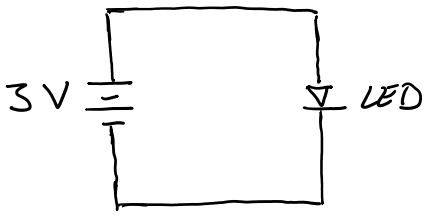
current-voltage relationship

$1.2V < v_F < 3.6V$



LED's act like regular diodes, but emit light and have higher activation voltages.

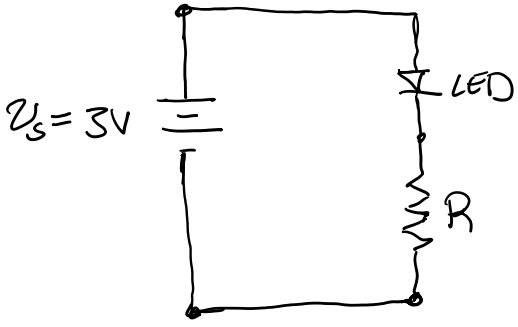
Suppose we want to use an LED. How to setup a circuit to drive the LED?



$v_F = 2.7V$

The problem with this is that the current flow will likely exceed the max allowable current of the LED.

An easy fix: add a resistor in series with the LED

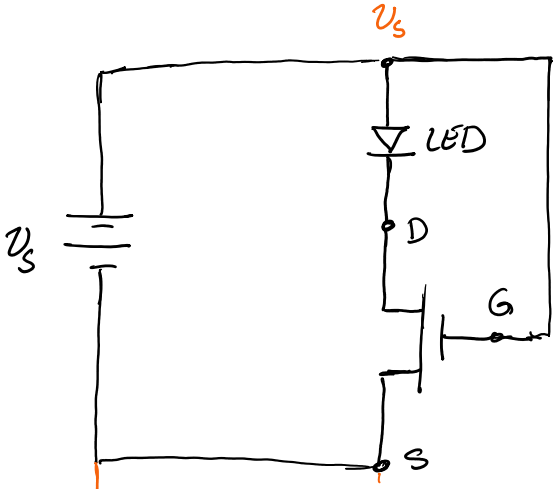


Resistor limits current flow.

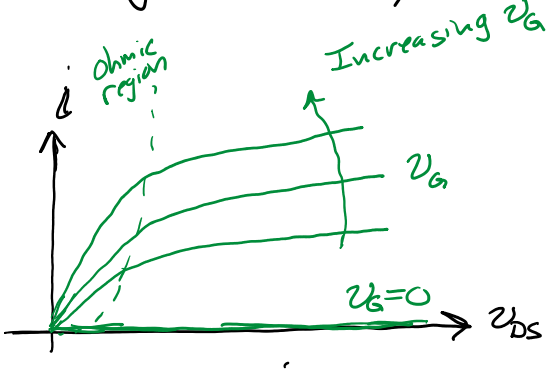
For analysis, assume voltage across LED is $\approx v_F$. Then select R such that

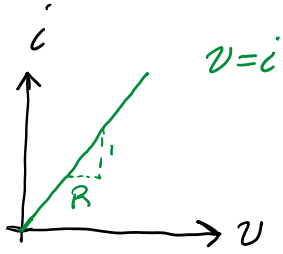
$$i = \frac{v_s - v_F}{R} < i_{max}$$

This works, but it lacks efficiency. We lose power due to the resistor R.



Holds MOSFET at min R

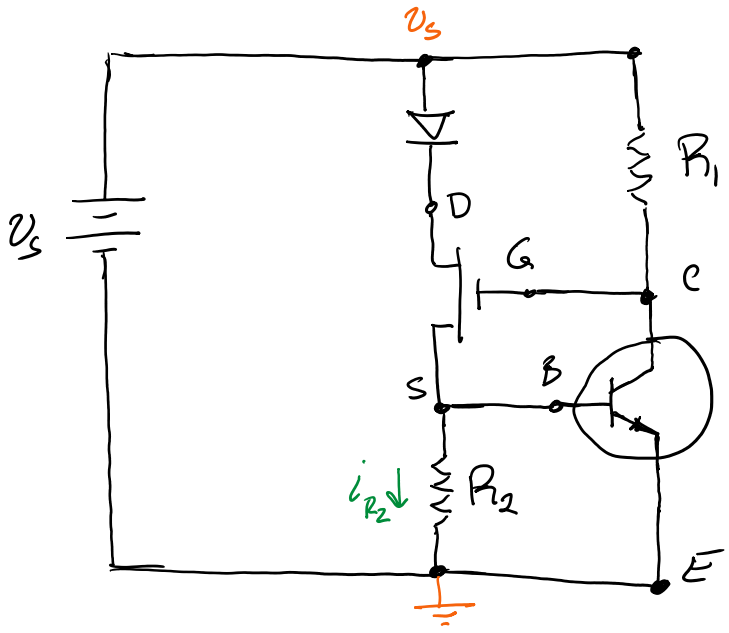




$v = iR \Rightarrow i = \frac{v}{R}$

MOSFET at min R

Let $i_* < i_{max}$ is the max allowable current flow through the LED



Size R_2 s.t. the voltage at the top of R_2 equals the activation voltage of the NPN when $i_{R_2} = i_*$

How this works:

1. When $i_{R_2} < i_*$,
   - No current flow from C to E through NPN
   - Never current flow through gate of MOSFET
   - No current flow through R_1
   - Gate voltage is $v_G = v_s$.
   - $i_{LED} = i_{R_2} < i_*$

2. When $i_{LED} = i_*$
   a) NPN goes into active state & acts as a current amp.

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b) NPN draws current flow through R_1

c) Gate voltage drops due to voltage drop across R_2

d) Effective resistance of the MOSFET increases

e) Current flow through LED is limited by increased resistance of MOSFET