Indian Institute of Technology
Hyderabad

Design Elements
Analog and Integrated Circuits

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1 Problem Statement

We are required to build an LED blinker for the Neuromodulation lab that blinks every time a pulse is generated by the SoC. We must also make sure that the blinking is captured by the camera placed 15 feet away.

2 Approach Taken

The approach taken to light the LEDs would be to use the Mosfet as a voltage-dependent current source to power the LEDs that are connected in parallel. The Gate of the Mosfet will be connected to the (GPIO) pin of an SoC, and the source will be connected to the Ground.

$$V_{gs} = 3.3\text{V} \tag{1}$$

Then we will connect the drain to the resistor, and the other end of the resistor is connected to the cathode of the LED while the anode is connected to the SoC, which implies:

$$V_{ds} = 5\text{V} \tag{2}$$

3 Simulation of the System

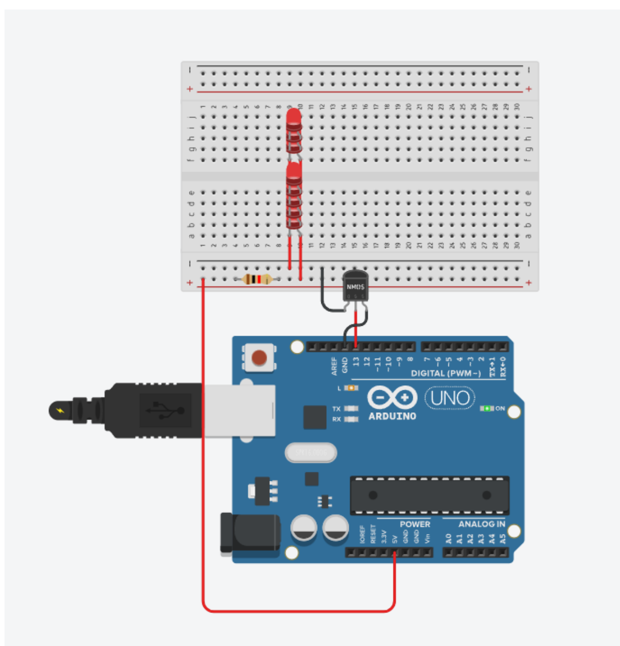

Figure 1: Arduino Simulation of the Circuit

4 Mosfet Characteristics

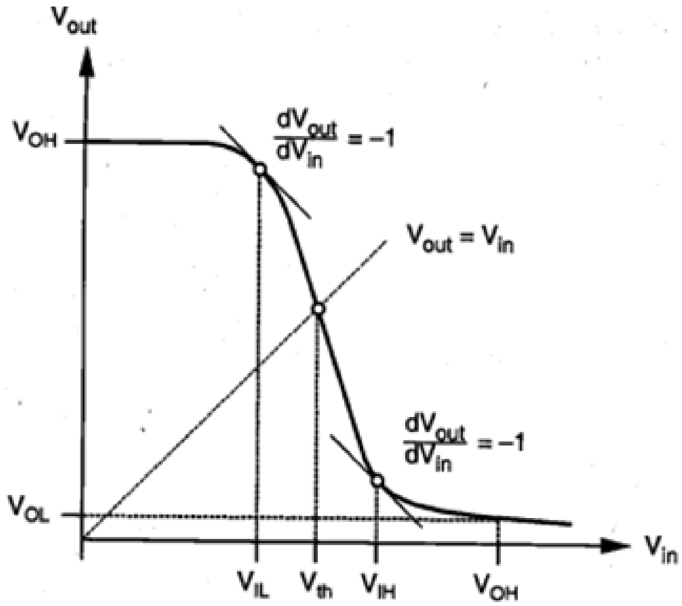

Figure 2: Voltage Transfer Characteristics of a Mosfet

As we can observe from the graph, the minimum value of V_{in} is V_{th}, and the maximum value of V_{in} is $V_{th} + \frac{-1+\sqrt{1+2V_s kR}}{kR}$ for the Mosfet to operate in the saturation zone. The value of V_s and R must be taken such that V_{gs} lies within the range of V_o.

The overall benefit of using this system over directly connecting the LEDs is direct control over i_{ds} by changing the gate voltage.

the forward voltage of the LED is between 1.2 to 3.6 V, and the forward current is between 10 to 30 mA.

$$80\,\text{mA} < I_d = \frac{k}{2}(V_{gs} - V_t)^2 < 240\,\text{mA} \tag{3}$$

5 Limitations in Design

There would be a voltage drop across the drain of the Mosfet:

$$V_o = V_s - i_d R$$

This can lead to a decrease in the brightness of LEDs depending on the voltage drop.

The Mosfet may heat up due to excessive current passing through it. Power is also dissipated by the current-limiting resistor connected across the LED.

6 Powering the SoC

There are several options for powering the Arduino-based SoC:

- **USB Power:** Most Arduino boards can be powered via a USB connection from a computer or a USB wall adapter. The board has an onboard voltage regulator that steps down the USB voltage to the required voltage.
- **Battery Power:** You can power an Arduino using batteries, such as AA or AAA batteries, through the onboard voltage regulator or directly, depending on the Arduino model.

7 Modeling the Problem

- Ideal Voltage Source (SoC GPIO):
  - The SoC's GPIO pin can be represented as an ideal voltage source.
  - It provides a control voltage to the gate of the MOSFET.
- MOSFET Model:
  - The Mosfet in the saturation zone can be modeled as a voltage-dependent current source.
- Resistor:
  - The resistor connected in series with the LED can be modeled as an ideal resistor.
- LEDs (Light Emitting Diodes):
  - LEDs can be approximated as ideal diodes.
  - They have no voltage drop across them in this assumption.
  - We have assume the LED's to have linear V-I characteristics even though they have non linear V-I characteristics

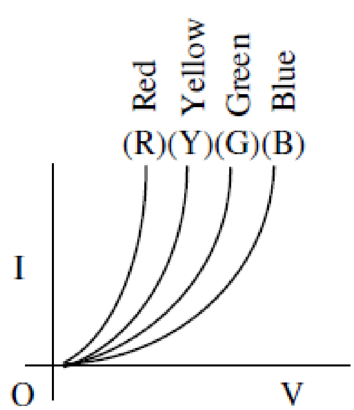

Figure 3: I-V Characteristics of a LED

The Link of the TinkerCad Simulation https://shorturl.at/yM147