Basic Electronics

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Concepts

- Voltage
  - Electric potential difference
- Current
  - Flow of electric charge
  - By convention, we use positive numbers to represent a current flow from positive potential toward ground
- Resistance
  - Restriction to flow of electric charge

Connections

- Wire
  - Used to connect terminals of components
  - For our purposes, a wire has no resistance
    - Thus, it connects terminals of components with no loss – *i.e.,* as if the terminals of the components were directly connected to each other

Ohm's Law

- V = IR

  V is voltage measured in volts (V)
  I is current measured in amps (A)
  R is resistance measured in ohms (Ω)

- Current through a resistive component (including a metal conductor) is directly proportional to the potential difference across that component
  - The constant of that relationship is resistance

Symbols (1 of 2)

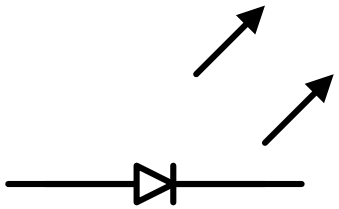
- Resistor

- SPST (Single-Pole Single-Throw) NO (Normally-Open) Switch

- SPST NO Pushbutton

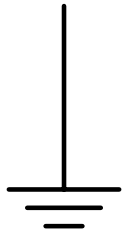
- Diode

- Light-Emitting Diode or LED



Symbols (2 of 2)

- Ground



Power Supply Voltage

- The voltage delivered to a circuit by a power supply is referred to as the “supply voltage”
- For NMOS circuits, this is designated by V_{CC}
- For CMOS circuits, this is designated by V_{DD}

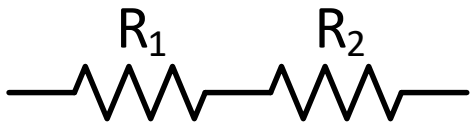
- Often V_{CC} and V_{DD} are used interchangeably

Digital Signals

- A voltage above a certain threshold will represent a one
  - Also called a “high” signal
- A voltage below a certain threshold will represent a zero
  - Also called a “low” signal

Multiple Resistors

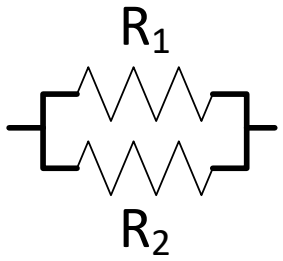
- Resistors in Series



  - Total resistance is the sum of the individual resistances

    $R_{total} = R_1 + R_2 + \ldots + R_n$

- Resistors in Parallel

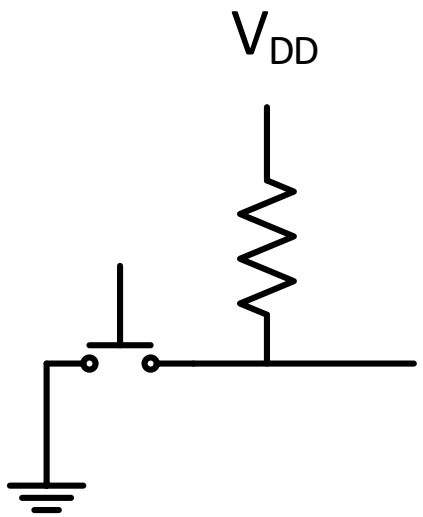


  - Total resistance is determined using this formula:

    $(1/R_{total}) = (1/R_1) + (1/R_2) + \ldots + (1/R_n)$

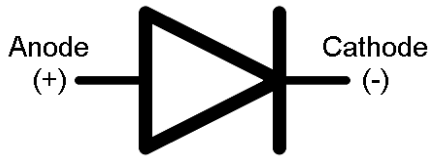
Using a Pull-Up Resistor

- Allows a SPST NO pushbutton to produce a high signal when not pressed and a low signal when pressed



Diode

- Device that allows current to flow in only one direction



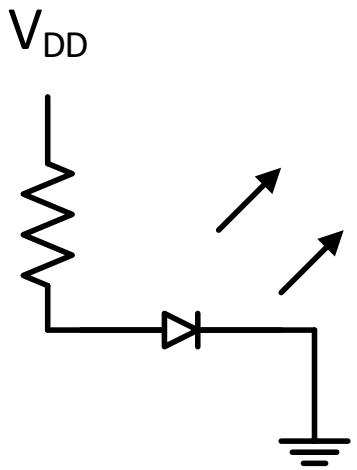
- Current can flow from anode to cathode
  - Very low resistance in this direction
  - This is the “forward direction”
- Current cannot flow from cathode to anode
  - Very high resistance in this direction
  - This is the “reverse direction”

Light-Emitting Diode (LED)

- An LED will emit light when current flows through it in the forward direction
- Because it has very low resistance in this direction, connecting an LED directly across a power supply would produce very high current
  - LEDs will burn out if subjected to high current
  - Therefore, we must limit the current than can flow through an LED
  - We do this by placing a resistor in series with each LED
    - By the rule for resistors in series, we know that the resistance of the resistor and the LED in series is at least the resistance of the resistor

LED Circuit That Limits Current

- The resistor in series with each LED is referred to as a “current-limiting resistor”



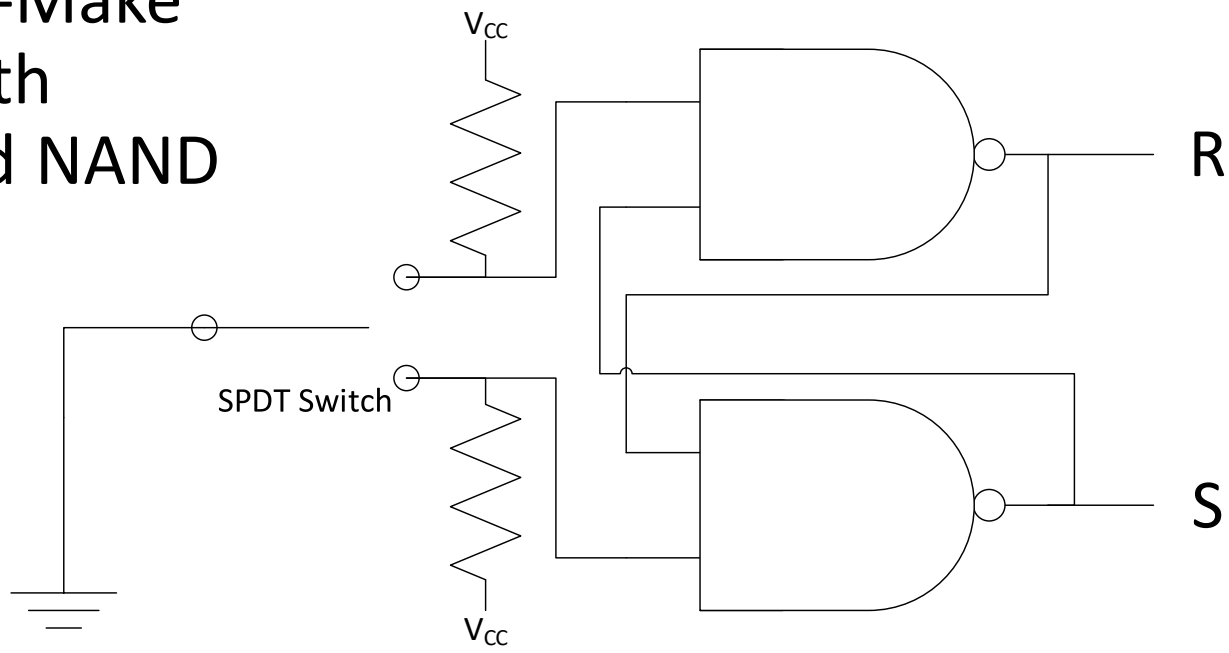
If VDD is 3.3V and the resistor is 1.0KΩ, then according to Ohm’s Law, the maximum current through the LED is
I = V/R = 3.3/1000 = 0.0033 Amps = 3.3 mA

Switch Contact Bounce

- When a switch is closed or opened, the contacts in the switch do not simply connect or disconnect, respectively
- Instead the contacts tend to bounce
  - Similar to what happens when an object is dropped onto a table
- If seeing a single transition is important, the output of the switch needs to be *debounced*
  - There are several ways to do this

Debouncing Using a SPDT Switch

- Uses an SPDT (Single-Pole Double-Throw) Switch that is Break-before-Make combined with cross-coupled NAND Gates



Debouncing Using Analog Hardware

- Use an analog circuit to dampen the signal
- This is the technique that is used on the Altera DE2-70 and DE2-115 boards that we use in CSCI E-93: Computer Architecture

Debouncing Using Software

- After seeing a transition on the input, delay for longer than the contact bounce time period