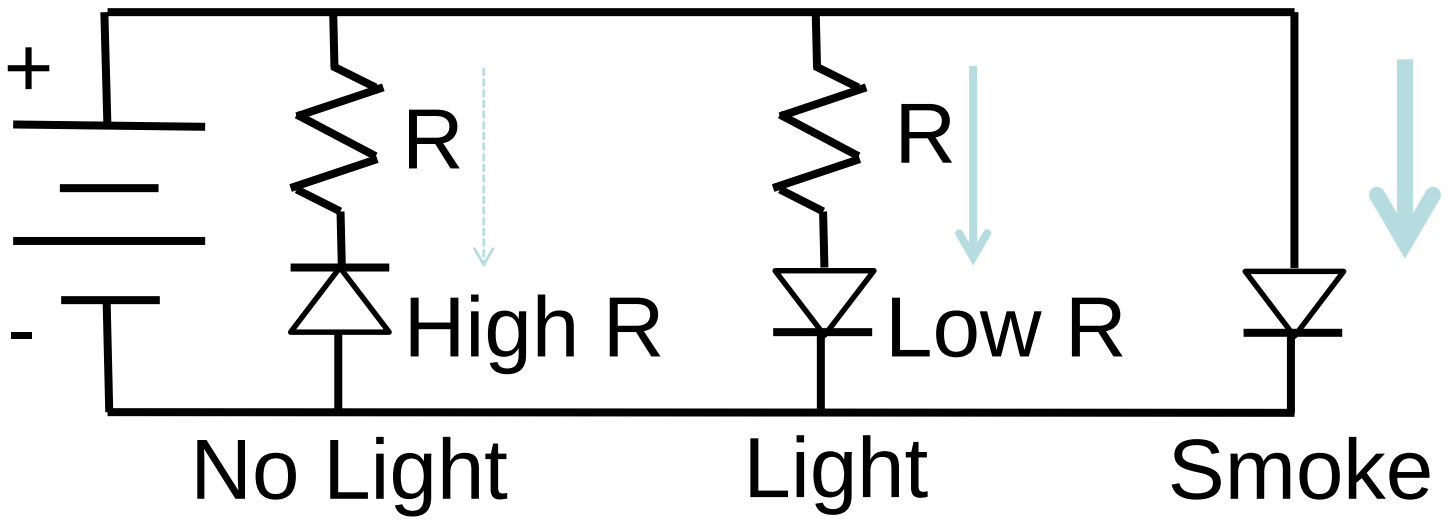
Introduction to Arduino HW Labs

- In the next six lab sessions, you'll attach sensors and actuators to your Arduino processor
- This session provides an overview for the devices
  - LED indicators
  - Text/Sound Output
  - Passive Sensors
  - Active Sensors
  - Buzzers/Motors
  - Servomotors

LED Indicators

- Any diode has high resistance in one direction and low resistance in the opposite direction
- An LED is a Light Emitting Diode
  - If it is carrying current, it emits light
  - If it carries too much current, it emits smoke ☹



Text Display

- Fixed text display devices can be sent characters to display in a bit matrix format
- ASCII characters can be transmitted serially to the device in the sequence desired for display
- It is possible to configure the bit matrix patterns for special characters that don’t correspond to any character in the ASCII code set
- Application: Cheap hand-held device displays

Sound Output

- Piezoelectric materials (certain ceramics) can be used to sense strain or generate vibrations
  - As a sensor, a PZ material generates an electric signal when exposed to levels of mechanical stress/strain
  - As a sound/ultrasound source, a PZ material expands and contracts when a varying voltage is applied to it
- Application: Cards that sing “Happy Birthday”
- Our text display device generates tones of various frequencies – hence it can produce sound output

Passive Sensors

- Passive sensors detect some physical signal from the external environment being monitored
- A passive sensor may detect
  - Electromagnetic energy (light, night vision, radio)
  - Acoustic energy (sound, ultrasound, vibration)
  - Seismic Energy (earthquakes, atomic bomb tests)
- They are not always as accurate as active sensors but their presence usually cannot be detected (useful for monitoring enemies on a battlefield)
- Usually low power requirements, e.g. batteries

Active Sensors

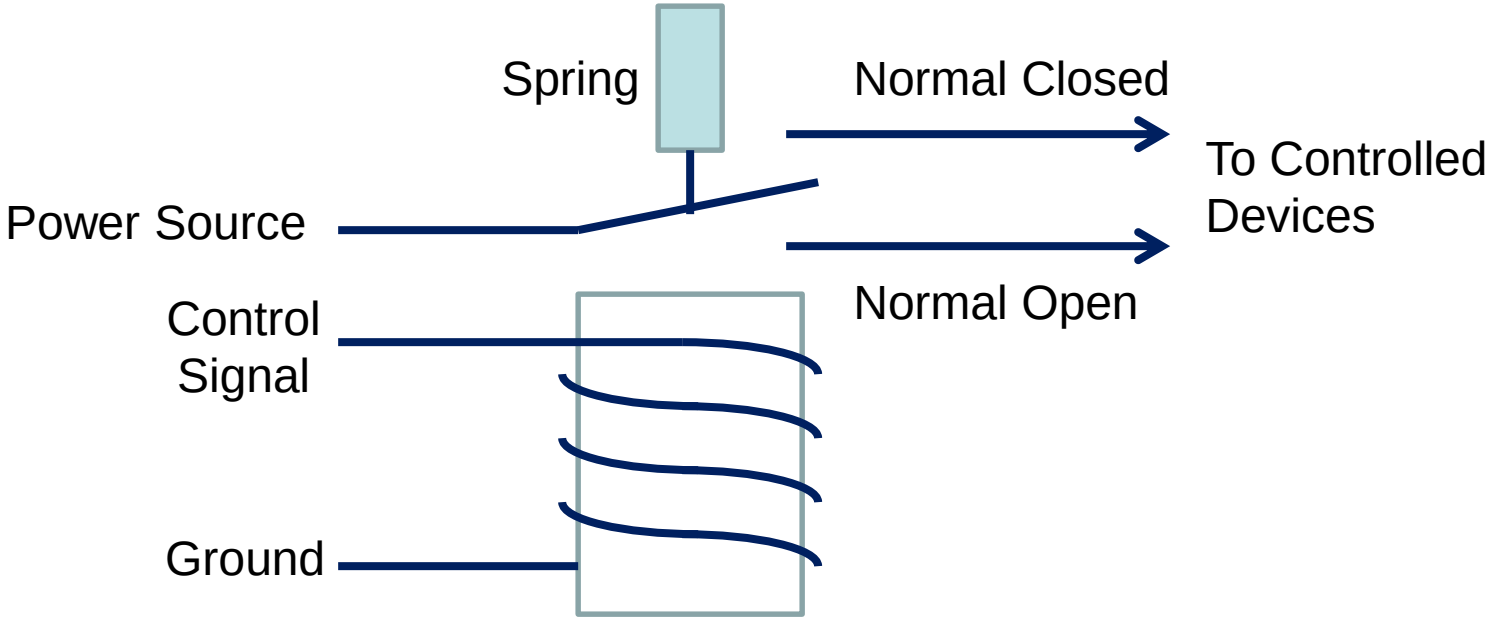
- Active sensors generate a physical signal and then detect the reaction to it from the environment
- An active sensor may generate and detect:
  - Radio signals and echo returns (radar)
  - Acoustic signals and echo returns (ultrasound, sonar)
  - Light signals and echo returns (laser ranging, scanners)
- Disadvantages of an active sensor:
  - It can be detected by whomever it is monitoring
  - It may require a lot of power to generate the signal

Buzzers / Motors

- Controlling a high current device may need to be done using an external electronic switch
- Example high current devices
  - Motors
  - Solenoids / Electromagnets
- Electronic switches
  - Electromechanical Relays
  - Transistors

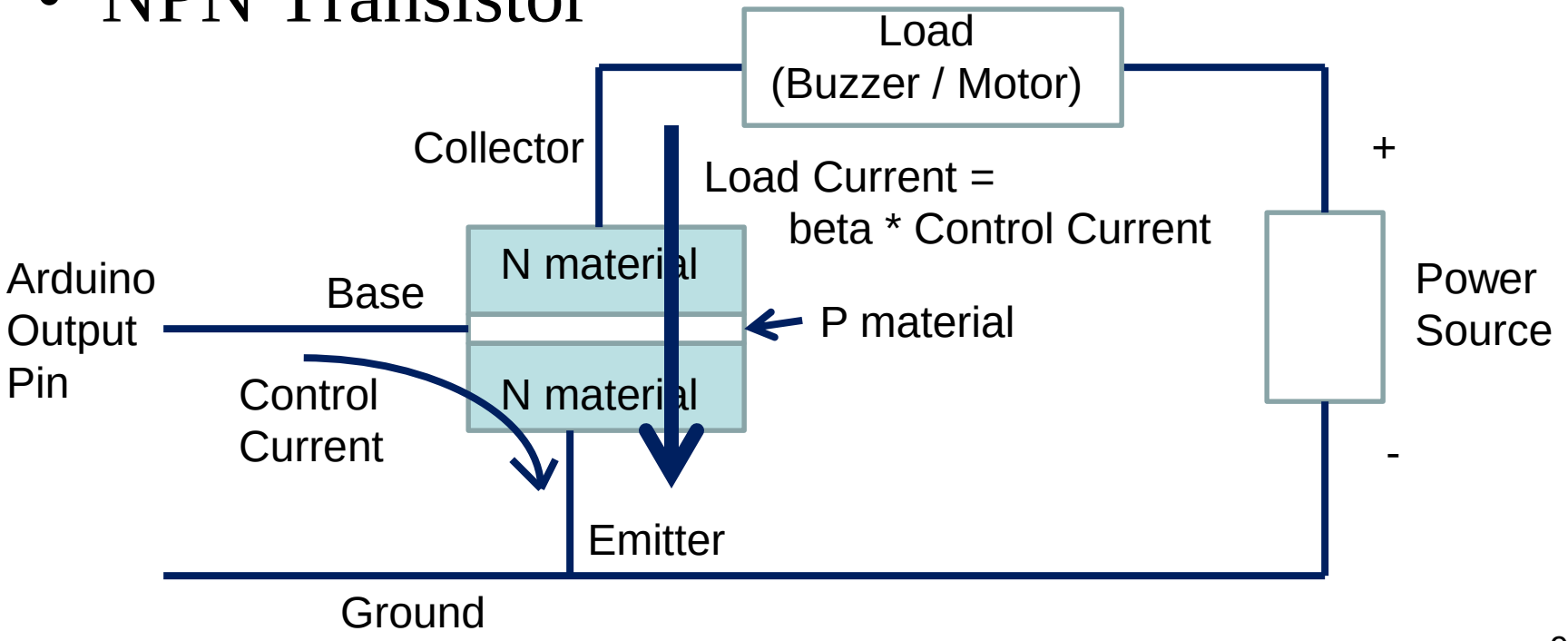
Buzzers / Motors

- Relays have a metal frame, an electromagnetic coil, and a spring to control an electrical switch
- Contacts can be normal open or normal closed



Buzzers / Motors

- Solid state transistors allow a small current to be amplified and control a larger current to a “load”
- NPN Transistor

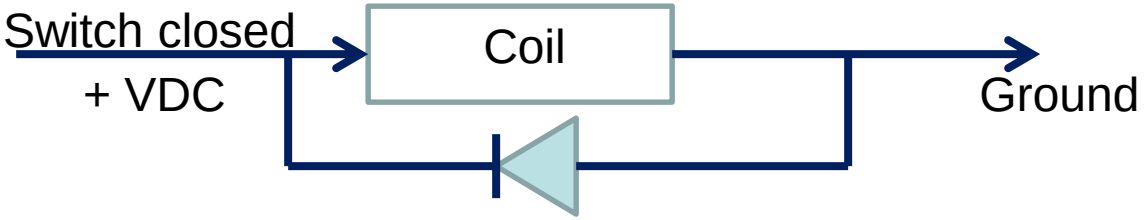


Suppressing “Back EMF”

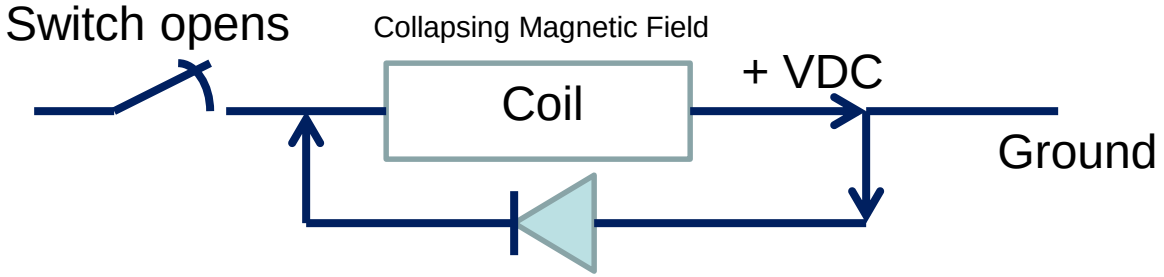
- When the circuit providing current to a coil of wire is shut off, the collapsing magnetic field produces a large voltage - briefly making the coil try to supply power back to the rest of the circuit
- This called a Back Electromotive Force (EMF)
- Application: Ignition coils in automobile engines to fire the spark plugs (Ouch - Don’t touch!!)
- It can damage other parts of the electronics such as the transistors controlling the coil current

Suppressing “Back EMF”

- We put a diode in parallel with the coil oriented in the opposite direction to normal current flow
  - The diode does not carry any current while the coil current is present – It is reverse polarized



  - The diode short circuits the current generated by the transient back EMF when coil current is turned off

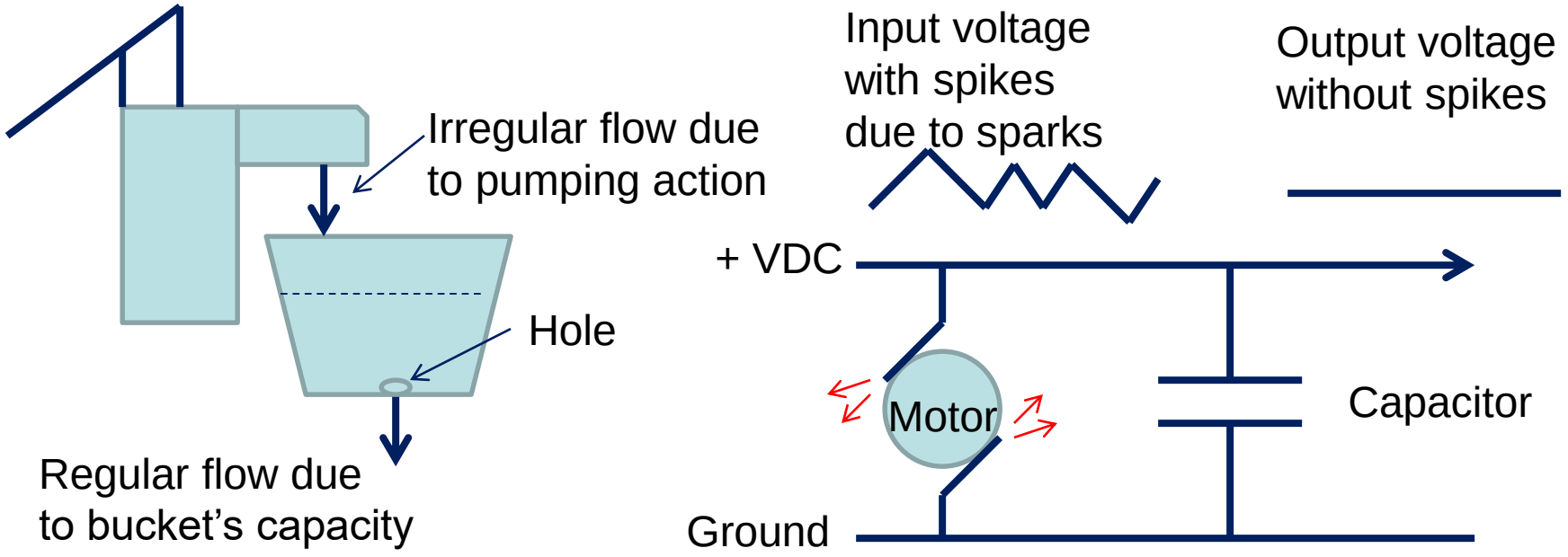


Suppressing Voltage Spikes

- Some power sources or loads can cause voltage spikes on the power lines to the other electronic parts causing errors in their operation
  - Example: The commutator in a motor
- A capacitor across the power lines absorbs these spikes – smoothing out the voltage on the lines
- A capacitor works like a “bucket” for electric charge

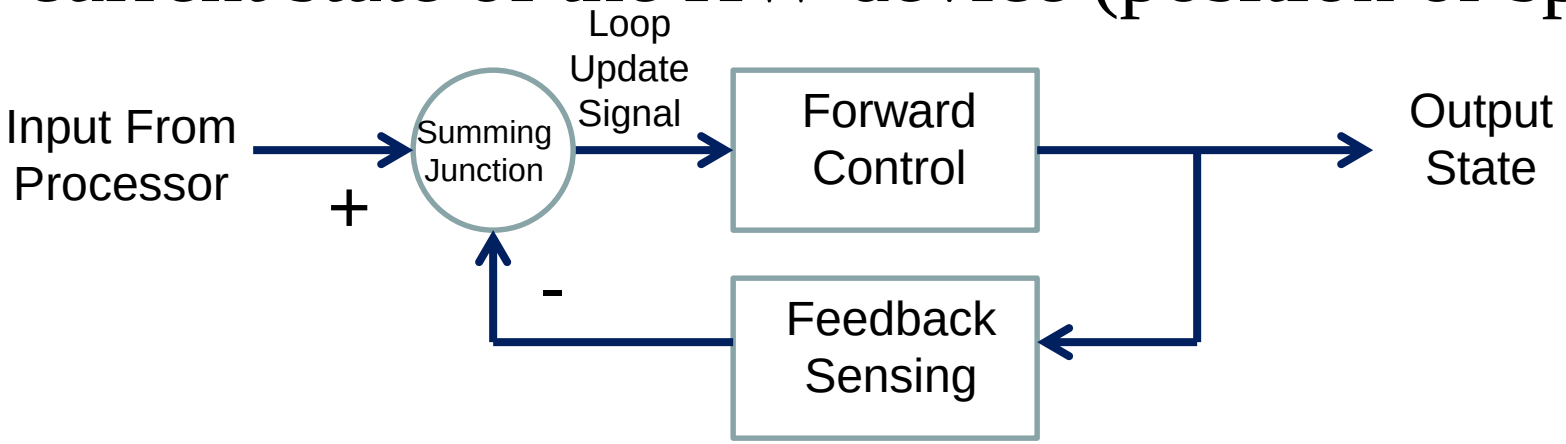
Suppressing Voltage Spikes

- Water and Electricity Analogy



Servomotors

- There are two types of servomotors
  - Standard (Controlled Position)
  - Continuous Rotation (Controlled Speed/Direction)
- A servomotor contains a feedback circuit that compares input from SW to information about the current state of the HW device (position or speed)



Servomotors

- A standard servomotor can be used to control the position of a valve, electronic control knob, steering wheel position, robotic arm position, etc.
- The desired position is compared to the current position and a loop update signal causes motion toward the desired position and stopping there

Servomotors

- A continuous rotation servomotor can be used to move a robotic device, material in an assembly line, paper in a copier, fax, or printer, etc.
- The desired speed and direction is compared to the current speed and direction and a loop update signal causes the device to speed up, slow down, stop, or reverse direction
- A calibration step to “zero the speed” when the control input is set to zero is usually required

Potentiometers

- In Labs 9 and 10, you will use a potentiometer as a manual input controller for the servomotors
- A potentiometer is some times referred to as a "variable resistor", but it is a variable tap on a resistor spanning a signal or power and ground
- There are 3 poles:
  - The two end poles are on opposite ends of a resistor
  - The center pole "wiper" turns along the resistor to vary the resistance between it and each of the ends based on a mechanical input such as a manual dial

Potentiometers

- The schematic for a potentiometer: