Chapter 3. Introduction to Electronics

Embedded Systems - Shape The World

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This chapter introduces electronics. We will learn Ohm's Law. This chapter is foundational, laying the ground work for the rer

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Learning Objectives:

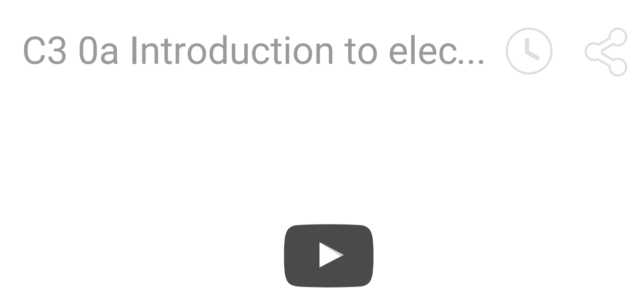
- Understand current, voltage, power, energy.
- Learn Ohm's Law.
- Understand Kirchoffs Voltage and Current Laws for circuit analysis
- Learn to recognize common circuit configurations like "voltage dividers" and "current dividers"

Video 3.0. Introductio

3.0. Introduction

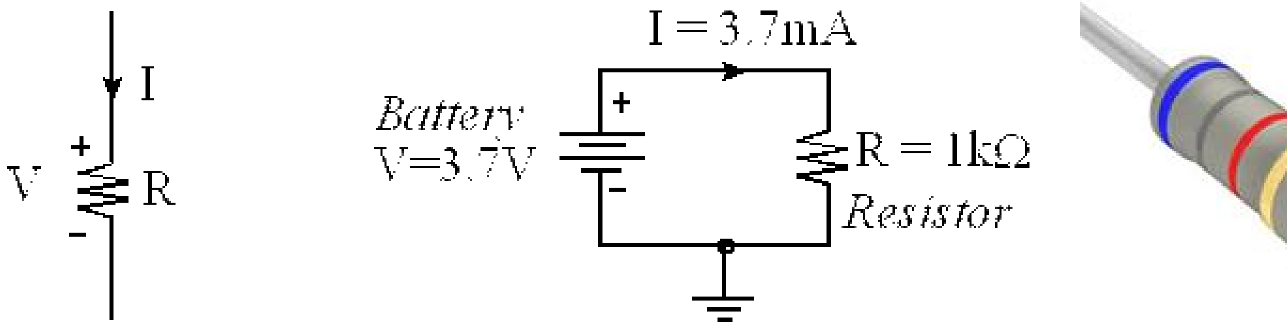
Most students reading this will have had some prior training in electronics. However, this brief section will pr electronics needed to understand electric circuits in this class. **Current**, *I*, is defined as the movement of electron (A) of current is 6.241×10^{18} electrons per second, or one coulomb per second. Current is measured at one point a travelling per second. Current has an amplitude and a direction. Because electrons are negatively charged, if the el left, we define current as flowing to the right. **Voltage**, *V*, is an electrical term representing the potential difference units of voltage are volts (V), and it is always measured as a difference. Voltage is the electromotive force or pot We will see two types of conducting media: a **wire** and a **resistor**. Wires, made from copper, will allow current t current to flow through a resistor will require energy. The electrical property of a resistor is resistance in ohms (Ω) a resistor with a resistance of 0 **Ω**. The basic relation between voltage, current, and resistance for a resistor is know can be written three ways:

$V = I * R$	*Voltage = Current * Resistance*
$I = V / R$	*Current = Voltage / Resistance*
$R = V / I$	*Resistance = Voltage / Current*



Video 3.1. Circuit Basics

The left side of Figure 3.1 shows a circuit element representation of a resistor, of resistance *R*. When clearly specify the two points across which the potential is defined. Typically we label voltages with + an potential to produce current from the + down to the –. When defining current we draw an arrow signifying voltage *V* is positive, then the current *I* will be positive meaning the current is down in this figure. F negative charge, the electrons are actually flowing up. According to the passive sign convention, we defin of the flow of positive charge (or the opposite direction of the flow of negative charge). The middle of Fi kΩ resistor placed across a 3.7V battery. 1 kΩ exactly the same as 1000 Ω, just like 1 km is the same as 1 3.7 mA of current will flow down across the resistor. 1 mA exactly the same as 0.001 A, just like 1 mm circuit, current flows clockwise from the + terminal of the battery, down across the resistor, and then back



Checkpoint 3.1: There is 1 V across a resistor, and 5 mA is flowing. What is the resistance?

Checkpoint 3.2: There is 2 V across a 100Ω resistor. How much current is flowing?

Checkpoint 3.3: What happens if you place a wire directly from + terminal to the –terminal of a battery?

There are two analogous physical scenarios that might help you understand the concept of voltage, current
is flowing water through a pipe. We place a large reservoir of water in a tower, connect the water through
bottom of the pipe, see Figure 3.2. In this case pressure is analogous to voltage, water flow is analogous
the faucet is analogous to electrical resistance. Notice that water pressure is defined as the potential
measured between two places. Pressure has a polarity and water flow has a direction. If the faucet is turne
infinite, and no water flows. If the faucet is turned all the way on, its resistance is not zero, but some fin
we are varying the fluid resistance. The fluid resistance will determine the amount of flow:

Flow = Pressure/Resistance

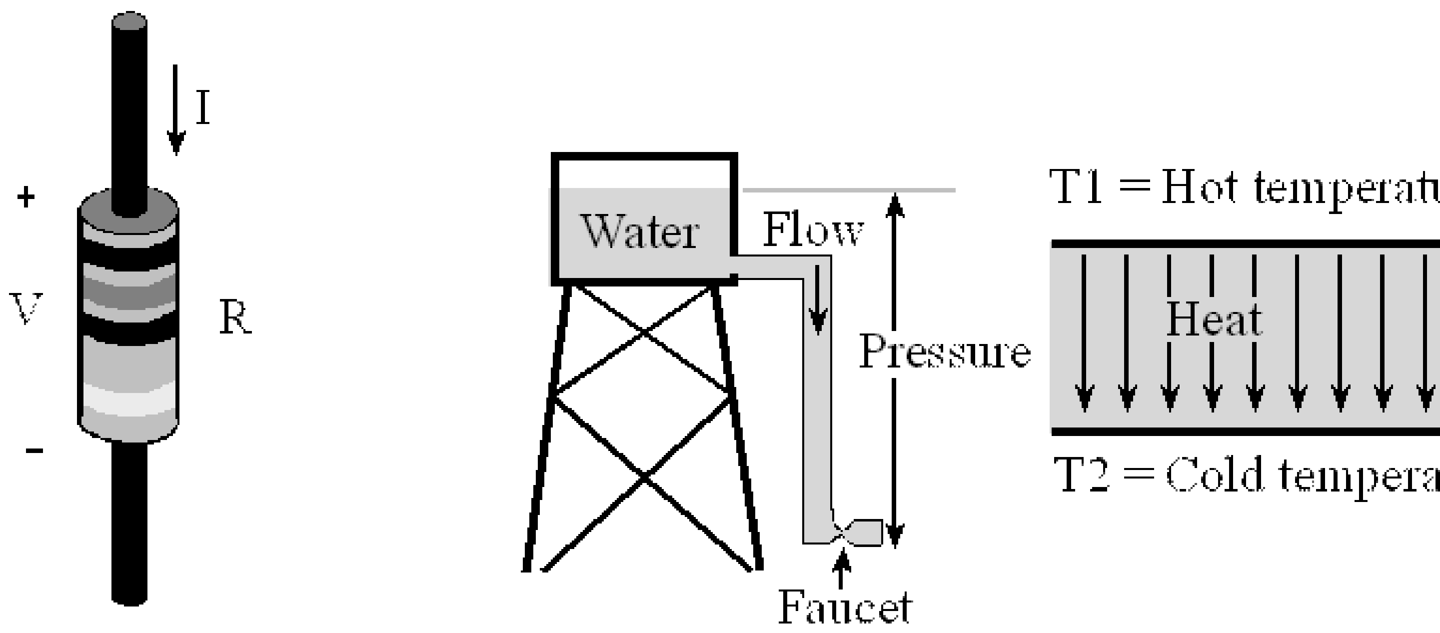


Figure 3.2. Three analogous physical systems demonstrating Ohm's Law.

Checkpoint 3.4: If pressure is measured in Newtons/m^2 (Pascal) and flow measured in m^3/sec, what are

A second analogy is heat flow across a solid. If we generate a temperature gradient across a solid, heat
cold side (right side of Figure 3.2). This solid could be a glass window on a house or the wall of your co
gradient is analogous to voltage, heat flow is analogous to current, and thermal resistance of the solid is

resistance is high, little heat will flow, and the coffee remains hot for a long time. The temperature d
resistance will determine the amount of flow:

Flow = (T1-T2)/Resistance

Checkpoint 3.5: If heat flow is measured in watts (Joules/sec) and temperature measured in °C, what are t

The R-value of insulation put in the walls and ceiling of a house is usually given in units per square area, e
flow across a wall is:

*Flow = Area * (T1-T2)/R-value*

Another important parameter occurring when current flows through a resistor is **power**. The power (*P* in
be calculated from voltage (*V* in volts), current (*I* in amps), and resistance (*R* in ohms). Interestingly, altho
–) and current has a direction, power has neither a polarity nor a direction.

$P = V * I$ *Power = Voltage * Current*

$P = V^2 / R$ *Power = Voltage² / Resistance*

$P = I^2 * R$ *Power = Current² * Resistance*

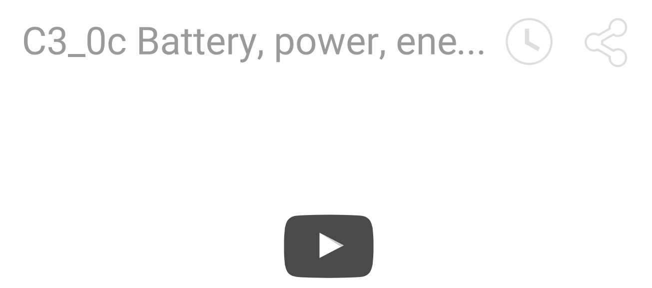
Checkpoint 3.6: There is 1 V across a resistor, and 5 mA is flowing. How much power is being dissipated

Checkpoint 3.7: There is 2 V across a 100Ω resistor. How much power is being dissipated?

The **energy** (*E* in joules) stored in a battery can be calculated from voltage (*V* in volts), current (*I* in am
manner similar to power, energy has neither a polarity nor a direction.

$E = V * I * t$ *Energy = Voltage * Current * time*

$E = P * t$ *Energy = Power * time*



Video 3.2. Batteries, Power and Energy

3.1. Electric Circuits

A switch is an element used to modify the behavior of the circuit (Figure 3.3). If the switch is pressed, i flow across the switch. If the switch is not pressed, its resistance is infinite, and no current will flow. I switch is less than 0.1Ω, but this is so close to zero, we can assume the ideal value of 0 in most cases. actually greater than 100MΩ, but this is so close to infinity that we can again assume the ideal value of inf involves a battery, a light bulb (modeled in this circuit as a 100Ω resistor), and a switch.

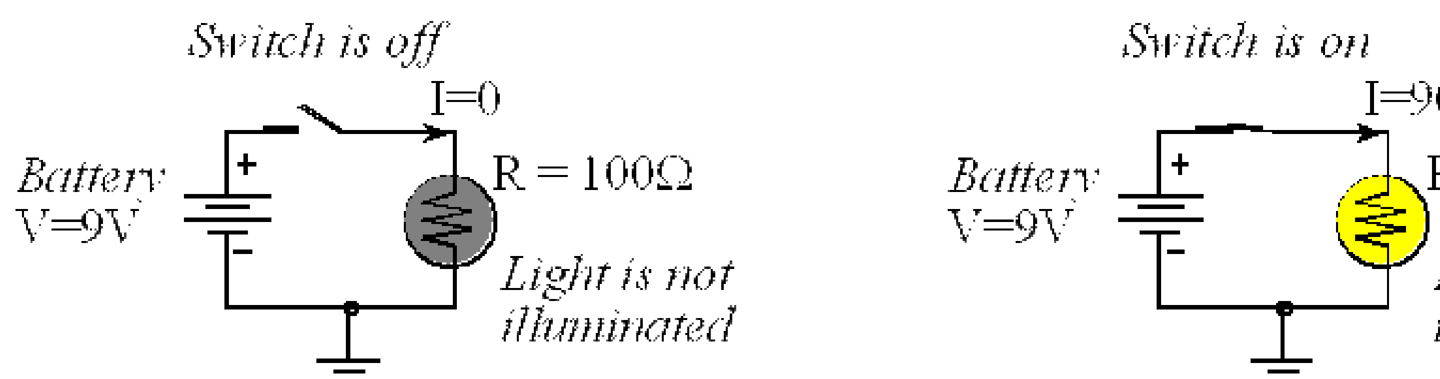


Figure 3.3. When the switch is open, no current can flow, and the bulb does not emit light. When the switch is closed, 90 mA of curren

Checkpoint 3.8 : If the switch is on, how much power is being dissipated in the bulb?

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