Introduction to Electronics

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Today we will be covering:

• Voltage (V)
• Current (I)
• Fundamental Electronic Components
  Batteries  Resistors  Diodes  LEDs
  Buttons  Potentiometers  Capacitors
• Circuit Diagrams
• Simple Circuit Designs
• ELECTRICITY => presence and flow of electric charge

• Electric current (I) is measured in Amperes

• Electric potential (V) is measured in Volts

• These are analogous to flow and pressure in plumbing
Current (I)

• Rate of flow of electric charge

• 1 Ampere = 1 Coulomb per second

• Quantity of electric charge (coulombs) passing a given point in the circuit per unit time.
Voltage (V)

• Energy per unit charge

• 1 Volt = 1 Joule per Coulomb

• Difference is electric potential between two different points in a circuit.

• Analogous to pressure
Power (W)

- 1 Watt = 1 Volt x 1 Ampere
- 1 Watt = 1 Joule per second
- \[ 1W = \frac{\text{Joule}}{\text{Coulomb}} \times \frac{\text{Coulomb}}{\text{second}} \]
- Situation is more complex for AC or mains power
Resistance (Ω)

- Measurement of the resistance to current flow in an electric circuit

- Measured in Ohms

- 1 Ohm (1 Ω) = 1 Volt per Amp
Ohm’s Law

• $V = I \times R$

• $R = \frac{V}{I}$

• $I = \frac{V}{R}$
Kirchoff’s Laws

Voltage Law
The sum of the voltages around a closed loop is equal to zero

Current Law
The sum of all currents into and out of a circuit node is equal to zero
Series and Parallel Circuit Construction

Series
- Voltage divides across components
- Current remains the same around the whole loop

Parallel
- Voltage stays the same
- Current divides across the loops
Voltage Sources

Battery: Direct Current

Supplies constant voltage
Current can vary
Resistors

- Used to control the current in a circuit
- Non-directional
<table>
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<th>COLOR</th>
<th>1st BAND</th>
<th>2nd BAND</th>
<th>3rd BAND</th>
<th>MULTIPLIER</th>
<th>TOLERANCE</th>
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<td>0</td>
<td>1Ω</td>
<td>± 1% (F)</td>
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<tr>
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<td>1</td>
<td>10Ω</td>
<td>± 2% (G)</td>
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<td>± 0.5% (D)</td>
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<td>±0.1% (B)</td>
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<tr>
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<td>5</td>
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<td>±0.05%</td>
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<tr>
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<tr>
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<tr>
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<td>0.01</td>
<td>± 10%</td>
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</table>

Electronix Express / RSR
http://www.elexp.com
1-800-972-2225
In NJ 732-381-8020
Serial and Parallel Behaviors (Resistors)

Series
• \( Rt = R_1 + R_2 \)

Parallel
• \( Rt = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2}} \)
Diodes

- Used to maintain current direction
- Voltage drop across a diode is (roughly) constant
- Directional: current flows in one direction, not in the other
Light Emitting Diodes (LEDs)

• Special type of diode that emits light. Amount of light is proportional to current.
• Current must be limited with external resistor
Diode Voltage-Current Relationship

- \( I = I_s \left( \frac{qV}{e kT} - 1 \right) \)
- \( I_s \) = reverse leakage current
- \( V \) = forward voltage across diode
- \( e \) = Euler’s number = 2.71828...
- \( q \) = electron charge = 1.60217657 \( \times 10^{-19} \) C
- \( k \) = Boltzmann’s constant = \( 1.3806488 \times 10^{-23} \frac{kg \cdot m^2}{K \cdot s^2} \)
- \( T \) = temperature in Kelvin (room temperature \( \sim 300K \))
Solderless Breadboards

- Numbers & letter labels just for reference
- Groups of 5 connected
- All connected, a “bus”
- Not connected
Let There Be Light!
Potentiometers

- Variable resistor
- Constant resistance between A & B
- Variable resistance on W (middle leg aka wiper)
Mood Lighting
Buttons and Switches

• Provide a controlled break point in the circuit
• We have one button
  • Single Pole – controls just one circuit
  • Single Throw – just two positions, on or off
  • Momentary – on only when pressed
Now You See It, Now You Don’t
Capacitors

• Storage tanks for charge – they resist sudden changes in voltage
• Can be used to smooth out voltages
• Measured in Farads
• \[ F = \frac{A \times s}{V} \]
• We have two types, electrolytic and ceramic

Electrolytic
• Directional
• Uses liquid dielectric

Ceramic
• Non-directional
• Uses solid ceramic dielectric
Capacitor Voltage-Current Relationship

\[ I(t) = C \frac{dV}{dt} \]

- Passes no current in response to a constant voltage
- Passes current only in response to a time-varying voltage
- Solution of Kirchoff’s Laws requires differential equations
- Solutions tend to be exponentials
Series and Parallel Behavior (Capacitors)

**Series**

- \( Ct = \frac{1}{1 + \frac{1}{C_1} + \frac{1}{C_2}} \)

**Parallel**

- \( Ct = C_1 + C_2 \)
Backup Supply
Integrated Circuits: 555 Timer

- Adjustable oscillator
- On the market since 1971
- Controlled by connecting resistors & capacitors to the pins
-Datasheet has:
  - Pin-outs
  - Min/max values
  - Theory of operation
  - Example circuits
Blinking an LED
It’s Alive!
Next Steps

I will be teaching a more advanced electronics class in April. What should I teach?

• Power
  • Power supplies, voltage regulators, power transistors, H-bridges

• Op-Amps
  • Amplifiers, voltage followers, current sources, oscillators

• Digital Logic
  • Buffers, comparators, level converters, logic gates