Electronic Component Selection
Why is it important to choose the right part?

- Cost
- Efficiency
- This

- PCB fire caused by choosing the wrong capacitor
- Cap wasn’t rated for voltage and failed short
- >100 Amps through the board from 600V bus
Assumptions Made in This Presentation

You know:

- What an electronic component is
- What voltage, current, and power are
- What an electrical circuit is
Topics Covered Today

- Resistors
- Capacitors
- Integrated Circuits
- Light Emitting Diodes
- Operational Amplifiers
Passive Components: Resistors

- Resistors do one thing: dissipate power

\[ P = I^2 \cdot R = \frac{V^2}{R} \] (generally in watts or mW)

- Resistors in series or parallel can distribute the load
Resistors: Important Considerations

- Make sure it meets the **Voltage** and **Power** spec
- Calculate power using Ohm’s law or SPICE analysis
- Power must be *derated* for high temperature applications

<table>
<thead>
<tr>
<th>Type / Code</th>
<th>Power Rating (Watts) @ 70°C</th>
<th>Maximum Working Voltage (V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CF18</td>
<td>0.125W</td>
<td>250V</td>
</tr>
<tr>
<td>CF14</td>
<td>0.25W</td>
<td>350V</td>
</tr>
<tr>
<td>CF12</td>
<td>0.5W</td>
<td>350V</td>
</tr>
<tr>
<td>CF1</td>
<td>1W</td>
<td>500V</td>
</tr>
</tbody>
</table>

Resistor specs pulled from a datasheet

[https://www.seielect.com/catalog/SEI-CF_CFM.pdf](https://www.seielect.com/catalog/SEI-CF_CFM.pdf)
Resistors: Special Cases

- High tolerance (≤1%) not needed for most designs
- High power/tolerance: You get what you pay for!

<table>
<thead>
<tr>
<th>COLOR</th>
<th>1ST BAND</th>
<th>2ND BAND</th>
<th>3RD BAND</th>
<th>MULTIPLIER</th>
<th>TOLERANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1Ω</td>
<td>± 1% (F)</td>
</tr>
<tr>
<td>Brown</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>10Ω</td>
<td>± 2% (G)</td>
</tr>
<tr>
<td>Red</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>100Ω</td>
<td>± 0.5% (D)</td>
</tr>
<tr>
<td>Orange</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>1KΩ</td>
<td>± 0.25% (C)</td>
</tr>
<tr>
<td>Yellow</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>10KΩ</td>
<td>± 0.10% (B)</td>
</tr>
<tr>
<td>Green</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>100KΩ</td>
<td>± 0.05%</td>
</tr>
<tr>
<td>Blue</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>1MΩ</td>
<td>± 0.05%</td>
</tr>
<tr>
<td>Violet</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>10MΩ</td>
<td>± 0.05%</td>
</tr>
<tr>
<td>Grey</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>0.1Ω</td>
<td>± 5% (J)</td>
</tr>
<tr>
<td>White</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>0.01Ω</td>
<td>± 10% (K)</td>
</tr>
<tr>
<td>Gold</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>0.1Ω</td>
<td>± 10% (K)</td>
</tr>
<tr>
<td>Silver</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>0.01Ω</td>
<td>± 10% (K)</td>
</tr>
</tbody>
</table>

- 2%, 5%, 10% 4-Band-Code
- 560k Ω ± 5%

- 0.1%, 0.25%, 0.5%, 1% 5-Band-Code
- 237 Ω ± 1%
Passive Components: Capacitors

- Capacitors do many, many jobs
- They are essentially just wells for charge
- Some types are better suited for certain apps.
Overlapping Applications of Capacitor Types

Ceramic Capacitors
- HF Coupling or Blocking
- HF Decoupling or Bypassing
- DC/DC-Converter <500 W
- Power Ceramic Caps
- DC/DC-Converter >500 W
- DC/AC, AC/AC Converter > 500 W
- Frequency Converter
- Spot Welding

Film Capacitors
- Timing
- Sample-and-Hold A/D Converter
- EMI/RFI Suppression
- Temperature Compensating
- Coupling or Blocking
- Decoupling or Bypassing
- Smoothing
- Noise Filtering
- Voltage Doubling
- Lighting Ballast
- Power Factor Correction (PFC)
- Motor Control
- Motor Run
- Snubbing
- Power Film Caps
- Flashtube Ignition
- UPS Buffering
- Audio Crossover
- DC Link
- Motor Start
- DC Buffering

Aluminum Electrolytic Capacitors
- Power Line Buffering

Engineering Innovation Center – EIC
Decoupling Capacitors

- Typically small (0.1μF - 1μF) capacitors
- Connected directly between $V_{DD}$ and GND
- Transient filter, prevents harmful power fluctuations
- Circuit not acting right? Try adding a decoupling capacitor
Capacitors: Important Considerations

- Choose a high enough **Voltage** rating or your cap will pop.
- Caps can be polar (dielectric/tantalum) or nonpolar.
- **Do not** use polar caps in reverse voltage/AC applications.
Integrated Circuits (ICs)

- Sometimes referred to as a “chip” or “microchip”
- Datasheet has a “pinout,” shows what each pin does
- “NC” stands for “no connection” – not internally connected
Integrated Circuits: Considerations

- Pay attention to the **absolute maximum ratings**
- Exceeding these can destroy your device
- Best practice: choose ICs that all run on the same voltage

### Absolute Maximum Ratings

<table>
<thead>
<tr>
<th></th>
<th>LM741A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Voltage</td>
<td>( \pm 22 \text{V} )</td>
</tr>
<tr>
<td>Power Dissipation</td>
<td>500 mW</td>
</tr>
<tr>
<td>Differential Input Voltage</td>
<td>( \pm 30 \text{V} )</td>
</tr>
<tr>
<td>Input Voltage</td>
<td>( \pm 15 \text{V} )</td>
</tr>
<tr>
<td>Output Short Circuit Duration</td>
<td>Continuous</td>
</tr>
<tr>
<td>Operating Temperature Range</td>
<td>(-55^\circ \text{C} \text{ to } +125^\circ \text{C})</td>
</tr>
</tbody>
</table>
Light Emitting Diodes (LEDs)

- Many types/packages: high power, indicator, RGB, chip, etc
- Consumes current to emit light
- Very easy to destroy if you don’t plan your circuit!
How to Not Destroy LEDs

- LEDs drop voltage, but have *no* effective resistance!
- They REQUIRE a series resistor! (sometimes built-in)
- What you need:
  - Power rail voltage (you choose this)
  - Voltage drop across the LED
  - LED rated current

Peak refers to instantaneous current. Design under the max, *not the peak*!
How to Not Destroy LEDs: Part II

• Let’s say we choose our power rail to be 3.3V

• And we want to use this LED

\[
3.3V_{RAIL} - 2.1V_{LED\_DROP} = 1.2V_{RES}
\]

\[
\frac{V_{RES}}{I_{LED}} = \frac{1.2V}{5mA} = \frac{1.2V}{0.005A} = 240\Omega
\]

• So we need a 240 ohm resistor in series with our LED

• Think of the rated current as a super bright maximum

• You can usually get away with as little as 20% of \(I_{LED}\)
Operational Amplifiers

- Some of the most widely used components in the world
- This is because they are so versatile – hundreds of uses
- How to use an op-amp could be an entire course
- We will only talk about three special types of op-amps
Op Amps: Unity Gain

- Has a gain of 1 across the frequency range
- Essentially a signal buffer
- Useful when connecting a low-current device to something that requires lots of current or has a low input impedance
Op Amps: Optically Isolated

- Not to be mistaken for an opto-isolator
- Isolates input from output with LED/Phototransistor combo
- Good if you need to amplify a signal across power regimes
Op Amps: Instrumentation Amp

- Specially tuned 3-OpAmp circuit built into a chip
- Very high gain and sensitivity, very low noise
- Designed just for interfacing with weak analog signals
- If you have analog sensors, you should be using an instrumentation amp

To the right: Internal schematic for a 14-pin instrumentation amp IC
Today, we covered...

- Resistors – Importance of Wattage/Tolerance
- Capacitors – Same with Voltage
- Integrated Circuits – Maximum Ratings
- Light Emitting Diodes – Not Destroying
- Operational Amplifiers – 3 Types of Amp
Questions?

L.E.D. Zeppelin