Circuit Debugging Cheatsheet

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Contents

1 Common Circuit Mistakes

1.1 Power, Ground, Pin-1

Check List

Have you checked

1. Connect all V_{DD}, V_{SS}, and GND?
2. Pin 1 of a chip at the right location?
3. Consume right amount of power (i.e., *current*)?

1.2 Connectivity, Probe Placement, and Soldering

Connectivity

Loose connection, Missed connection

1. Have you measured the **same** node's voltage at **different** test points?
2. Are they the same? Why not?

Soldering

Improper soldering

1. Have you checked all node voltages on a PCB using a benchtop digital multimeter (DMM)?
2. Are they expected?

1.3 Datasheet Specifications

● Have datasheets ready. ● Don't assume. ● Always verify.

Pin Diagram

Wrong Pin

1. Have you compared the pin names and descriptions on the datasheet with your circuit and the way you are using them?

Min Max Use Conditions

Using it Wrong

1. What is the minimal and maximum voltage a pin can withstand?
2. Is certain device parameter (e.g., β) a typical value or one that has guaranteed min-max?
3. How is the chip **supposed** to be used?

1.4 Layout

Applicable when you are designing your own PCB.

Breadboard Issues

Have you checked

1. Do you use any small current sensing resistor (R_{shunt})?
2. If yes, watch out for improper connections that add wire resistance to R_{shunt}.
3. Wire resistance $\approx 0.1\Omega$.

1.5 Equipment and Settings

Oscilloscope

● Seeing is believing. ● But oscilloscope can lie.

Common Pitfalls

1. Did you connect the ground for each lead?
2. Did you set the right settings for each channel (e.g., impedance, BW limit, DC/AC coupling, scale?)
3. The **trigger**: continuous or trigger only once?

Power Supplies

● You can prevent chip burning right at your power supply.

Always limit your output power!

Have you checked

1. Did you set a max I_{out} for each channel?
2. Manual or auto range for the V and I needed? Auto range can be problematic for some cases.

Digital Multimeter

● Benchtop DMM is usually better than Handheld DMM.

Understand the following

1. Do you know the expected accuracy of the reading (% of a range, or $\pm$ a fix value)?
2. General purpose or Hi-Z input?
3. Select the appropriate arrange for V and I reading

2 Global Debugging Strategy

Exhaustic

List all possible causes. Test them one by one.

Topographic

Split the circuits into halves or multiple sections.

1. **Forward**: Start from a functional node and work toward the bug.
2. **Backgard**: Begin from the bug and work back toward input.
3. **Split-half**: Split circuits in halves and determine which half contains the bug.

3 Debugging Mindset

Testing Mindset

> If a component ain't tested, it won't work.

Growth Mindset

> Debugging Circuit is a domain-specific skill that can be learned.

> Nobody is born with the debugging skill. Neither is anyone born to be incapable of it.

Emotions

> Debugging sucks. We know that. Just don't be angry or mad about it.

> Debugging is best done **systematically** than randomly.

> Debugging is really a blessing in disguise. You gain much deeper understanding of a circuit by fixing it.

> You will be the next Sherlock Holmes in ECE.

Value of Debugging

Do you know

- There is a dedicated role called **characterization** or **validation** engineers in the semiconductor industry. Their job is to catch bugs pre- or post-silicon.
- Almost all **new chips** have bugs. Even the most experienced designers see **surprises** on silicon.
- Debugging is nicknamed the **schedule killer**. Techniques that expedite debugging reduce time-to-market and ultimately, cost.