University of Colorado Boulder

Electrical and Computer Engineering

ECEN3730 Practical PCB Design Manufacture

LABORATORY REPORT

Lab 18: Measure the in-rush current and operation current of a board

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1 Introduction

In this lab, we explore a method for measuring the inrush current and steady-state current draw from a power supply. The technique involves using a sense resistor in series with the power rail to convert current into a voltage that can be observed with an oscilloscope or other device. We hope to see the degree of inrush currents in a circuit.

2 Objectives

1. Measure and analyze the inrush current.
2. Investigate the impact of inrush current.
3. Determine the value of the sense resistor required to convert current into a measurable voltage.

3 Lab setup

For this experiment, we chose a circuit to analyze the inrush current. I used my board 2. This was a 555 timer with some LEDs on the output.

In order to measure the current I added a sense resistor to the power rail. We need to add it in series for it to produce a voltage proportional to the current in the circuit.

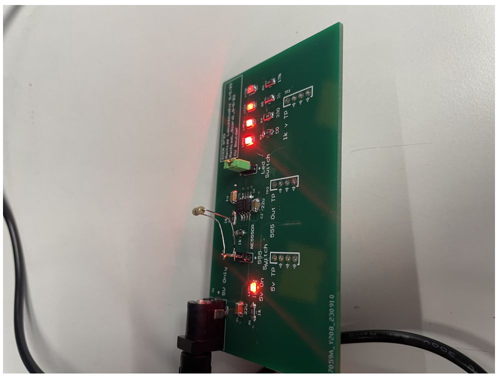

Figure 1: Lab setup

4 Measuring a Current

Every electronic circuit consumes a certain amount of current, and this current varies with the circuit's load. Initially, upon connecting the circuit to the power supply, there is a substantial inrush current. This is caused by circuit elements, with capacitors being the big culprit. Initially an unchared capacitor acts like a short circuit. To measure this current, a sense resistor is placed in series with the power source. The sense resistor should be chosen carefully to show a measurable voltage without significantly affecting the circuit's operation. For steady-state measurements, the resistor value should not cause a significant voltage drop, and should not consume too much power.

We chose a 1.5 ohm resistor. The current through the circuit will not be very substantial, so a higher-value resistor is needed to view low current amounts, but the higher the value of the resistor, the less the maximum tolerable current will be. Out of the resistors we had, the lowest was 1.5 ohm. This would be a good amount to measure the current, without sinking too much current and taking too much power from the circuit.

To measure the voltage on the resistor, we used two 10x probes, one on the high side and one on the low side.

5 Measurements

5.1 Steady state

We expect to see a square wave current draw, with the highest current when the LEDs are on.

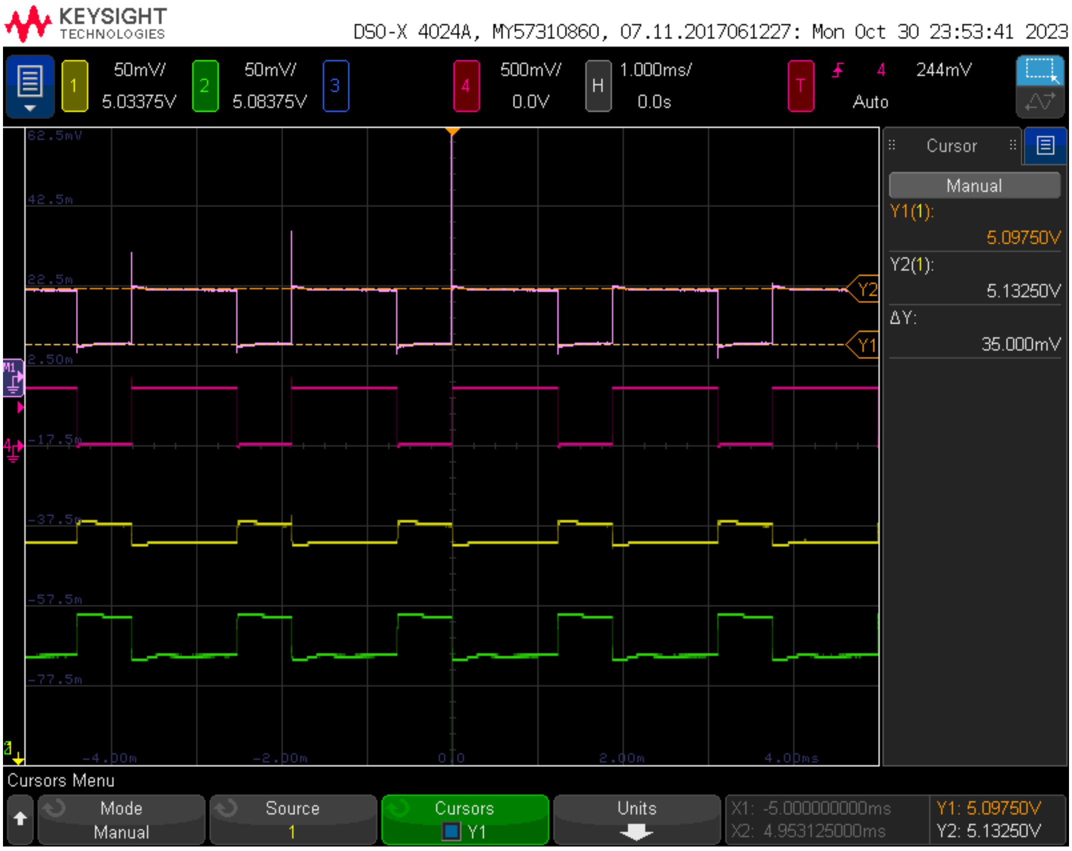

Figure 2: Plot of steady state measurements

In this graph, the green and yellow traces are the high and low sides of the sense resistor respectively. The red trace is the 555 timer output, which we are using to trigger the scope, and the pink trace is a math function, green - yellow. This gives the voltage across the sense resistor, and we can use that to find the current with ohms law.

We see in the graph the current ranges from 5mv to 22mv. (the cursors are inaccurate). We see the current is highest when the LED's are on with a current of around 20mA.

5.2 Inrush Current

We want to measure the inrush current in the circuit. With the circuit in a steady state, the capacitors are completely uncharged and will demand a very high current. This current can be magnitudes higher than the normal operating current. We expect the current to be around 1-3 Amps of current.

In order to measure the transient event, we need to trigger the scope once and nothing more. To do this we can trigger on the input voltage. When the voltage rises to 1v, it will trigger the scope. However it will not re-trigger as the normal operating voltage never dips down to 1v, leaving us with the event.

Figure 3: Plot of inrush measurements

In this graph, the green and yellow traces are the low and high sides of the sense resistor respectively. The pink trace is a math function, yellow - green. This leaves us the voltage across the resistor.

We see there is a very large inrush spike, creating around 4v across the sense resistor! (cursors are accurate). This is an enormous current. This current is around 2.6A! This is around 100 times more current than the steady state. We can see why inrush current is so important to design with in mind. Very high currents can damage sensitive components and even damage the power supply.

One interesting thing that happened was the lab bench power supplies have built-in inrush current arrestors. We couldn't get a big spike when turning on and off the lab bench power supplies, but when we left them on and touched the wires together, we saw a massive current spike.

5.3 Key Learnings

- The inrush current can be significantly higher than the steady-state current, especially when capacitors are charging.
- Selecting the appropriate value for the sense resistor is crucial for obtaining accurate measurements.
- Two single-ended scope probes can be used to measure the voltage difference across the sense resistor.
- Triggering the oscilloscope when measuring inrush current is essential to capture the transient event effectively.
- Designing with inrush current in mind is a must

5.4 Conclusion

In this lab, we successfully measured the inrush current and steady-state current draw of a circuit using a sense resistor and an oscilloscope. We observed that inrush current can be substantial during power-on due to capacitor charging, while steady-state current represents normal operation. Careful selection of the sense resistor value is necessary to avoid affecting circuit operation negatively. Triggering the oscilloscope for inrush current measurements allowed us to capture the transient event accurately.

This lab provides insights into the importance of understanding and measuring current in circuits. It also highlights the significance of selecting appropriate components with current rush in mind. Overall, it enhances our knowledge of circuit behavior during power-up and normal operation, which can be crucial for designing and troubleshooting electronic systems.