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Lab 18 Report: Inrush Current

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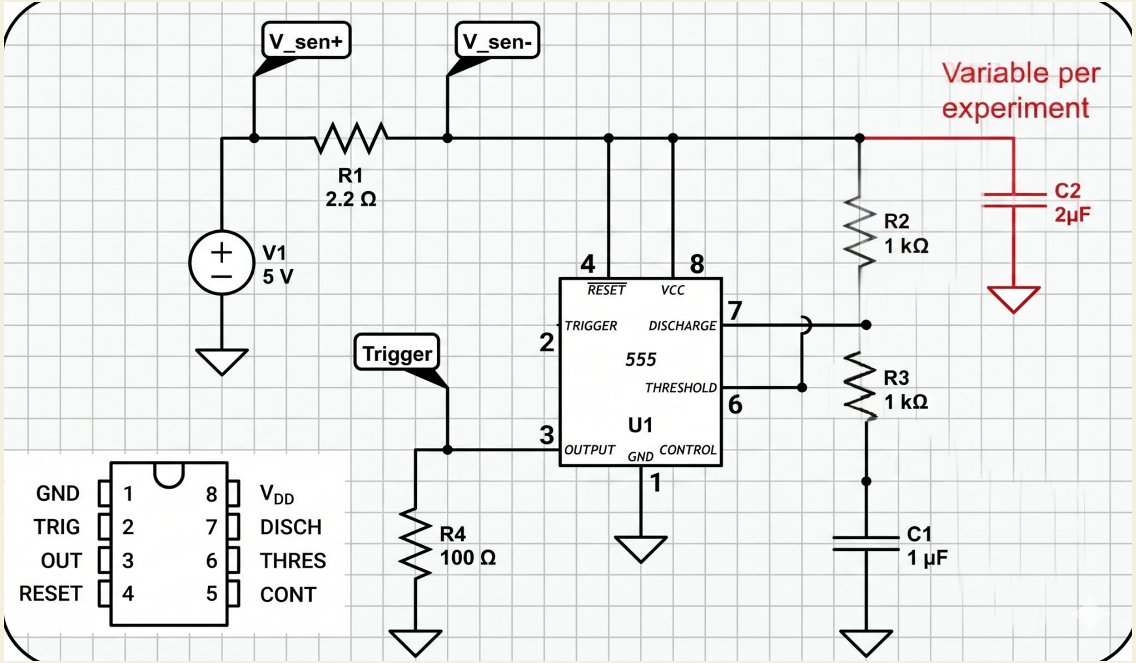
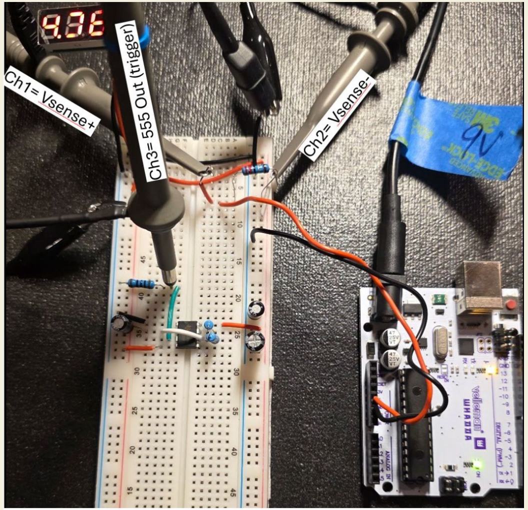
Purpose

Shown on the right is the circuit schematic we followed for this lab. The purpose of this circuit is to create a repeating transient load using a rapidly switching 555 timer circuit. This creates continuous inrush events that can be seen by the oscilloscope. In this setup we use 3 probes, one to trigger on the output of the timer and the other two measuring the voltage across R1, the sense resistor. This allows us to do differential probing across the resistor and find the current coming from the main supply.

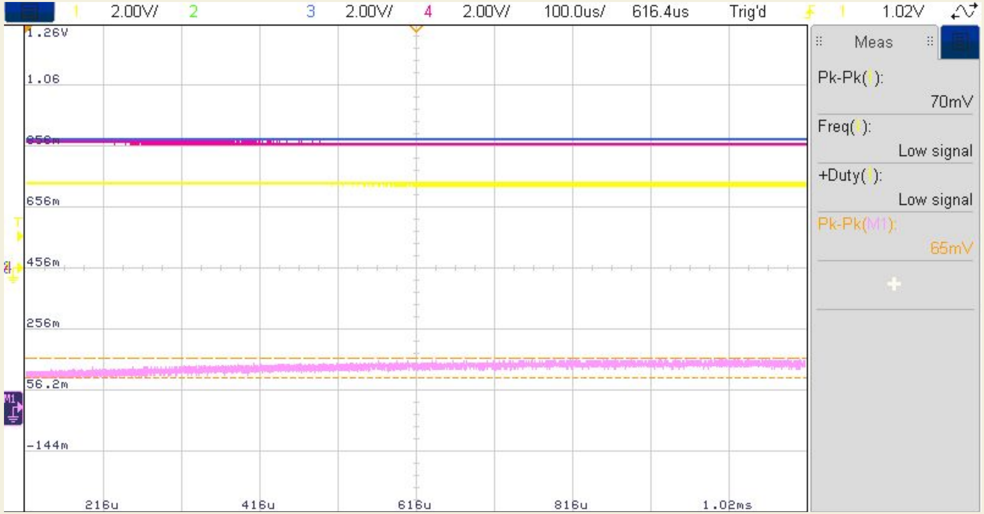


Circuit and Steady-State Current



The solderless breadboard version of the circuit is pictured on the left. In order to measure the steady-state current of the circuit we must trigger on the output of the 555 timer and wait until the voltage across the sense resistor stabilizes. The output voltage of the timer was 3.2V which gives us an expected current of 32 mA.

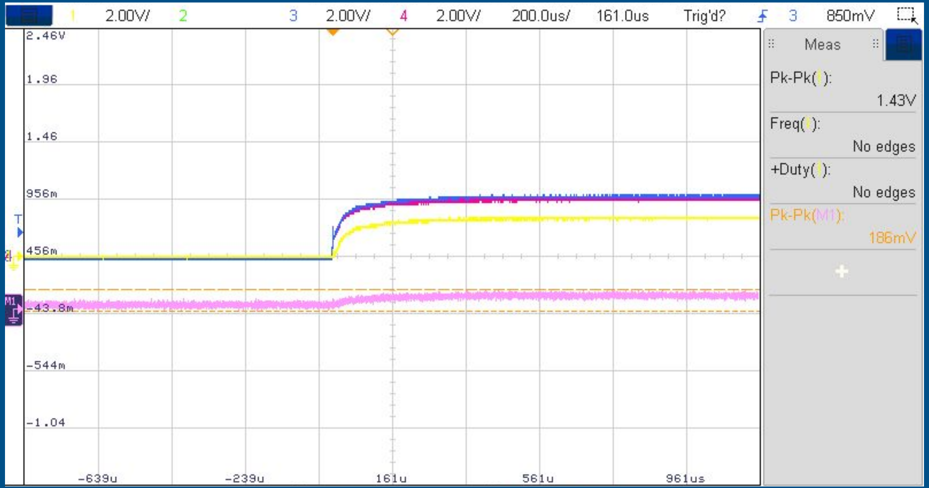
On the right we have the voltage across the sense resistor once it reaches a stable value. We can calculate the steady-state current to be 29.55 mA (65 mV / 2.2 Ohms).

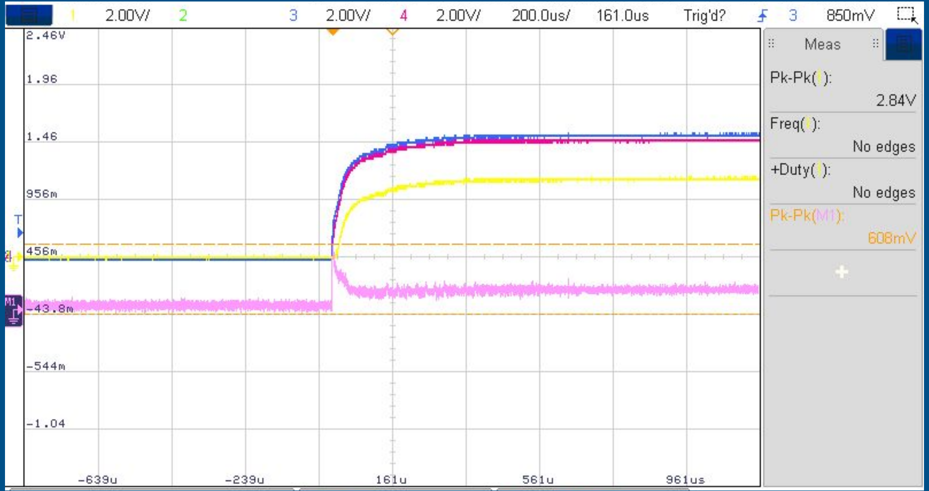


Inrush Current

Inrush current was measured by triggering the scope off the 555 timer output and capturing single measurements to observe the effects of various capacitor values. The capacitors are placed on the power rails and are used for decoupling.

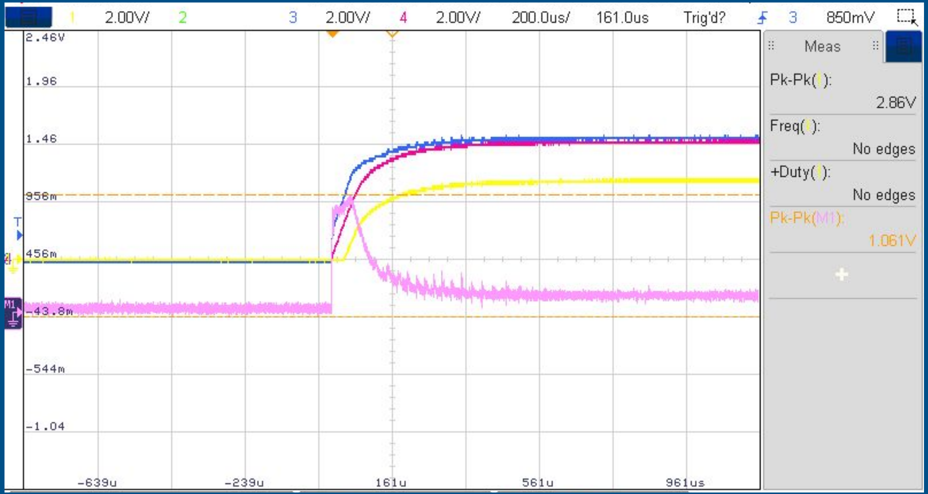
With no capacitor (Top), inrush current was 84.54 mA (186 mV / 2.2 Ohms). With a 1 uF capacitor (Bottom), it was 276.36 mA (608 mV / 2.2 Ohms). The change in capacitance causes quite a large current spike!





Inrush Current Cont.

The top scope measurement is with a 10 uF capacitor and has an inrush current of 482.27 mA (1.061 V / 2.2 Ohms). The bottom measurement uses a 100 uF capacitor and has an inrush current of 801.81 mA (1.764 V / 2.2 Ohms). As capacitance increases the inrush current also increases due to the higher energy requirements. Notice that the change in inrush current with different capacitances is not linear.



Discussion of Results

- Inrush Current Scaling: This relationship is not linear due to time it takes for current to reach its peak is proportional to the $\sqrt{(LC)}$. This square root causes the peak current to scale on a curve. Another factor is higher inductances for larger capacitors due to manufacturer constraints: Higher inducatances resist changes in current. The final factor is maximum current drawn by the circuit. As you get into massive capacitor values, the peak current will stop growing as quickly and will stay under this limit.
- Measuring the steady-state current of the circuit can help us calculate power consumption
- Using decoupling capacitors on our power rails is a useful tool, but it is important to understand how that can result in extremely high inrush currents that can harm certain components
- Different types of power supplies will handle the demands of the circuit differently and it can be very beneficial to include differential probing to see this