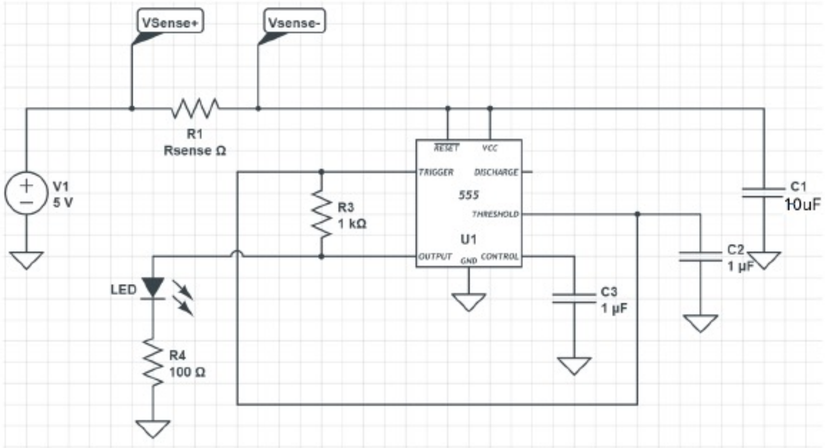
Lab 18 finding

Sepideh Mohammadi
ECEN 5730
PCB DESIGN

Measuring Inrush Current and Steady-State Current

Overview Of the Circuit and Goal:

To learn how to measure **inrush current** and **steady-state current** in an electronic circuit.
To understand how to use a **sense resistor** and **oscilloscope** for current measurement.
To observe how capacitor size affects inrush current.

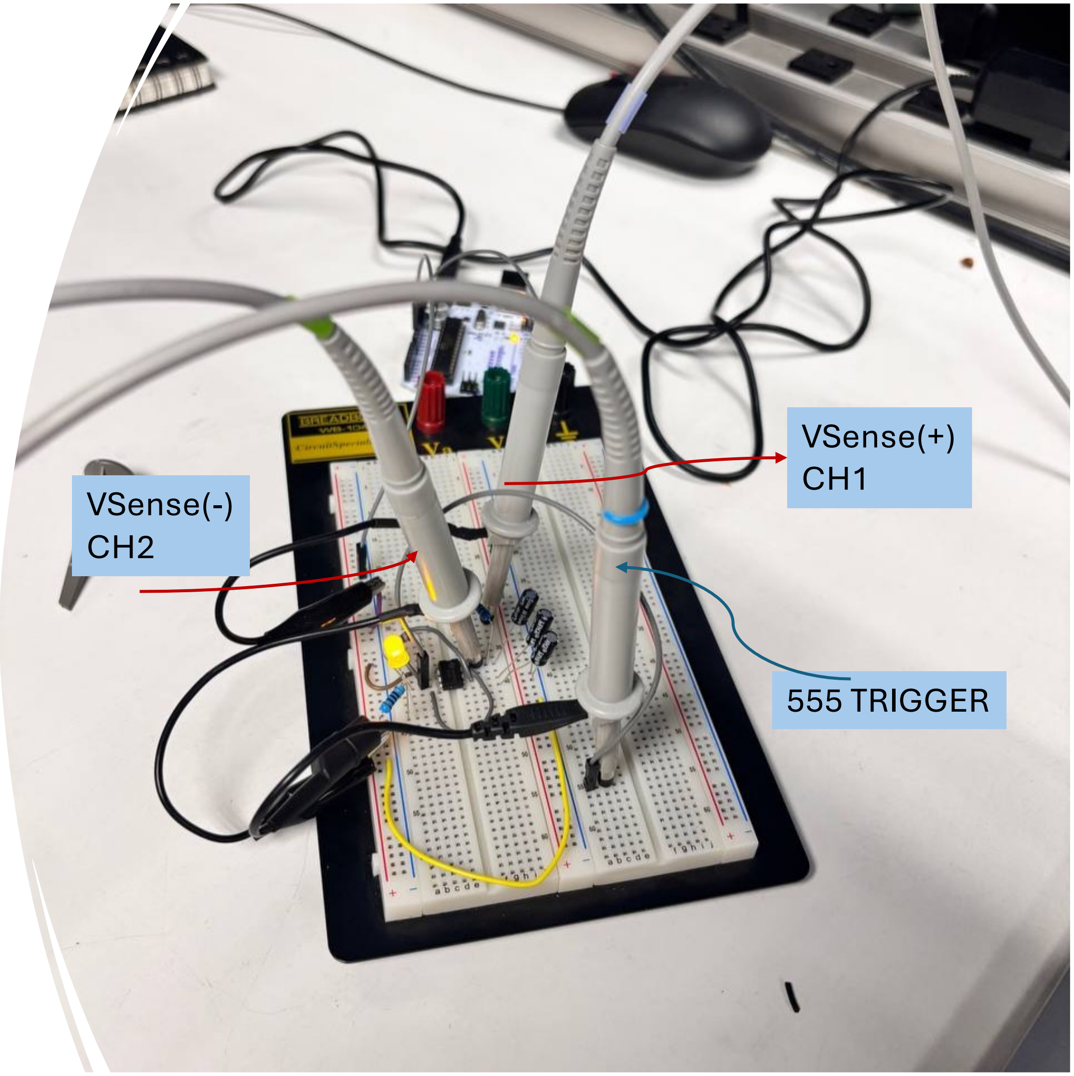


- **Experimental Setup**
  - **Components:**
  - 555 Timer IC circuit with LED load
  - 5 V supply (Arduino 5 V rail)
  - Sense resistor = 1Ω
  - Three 10× oscilloscope probes

Overview of circuit after placing the components

- **Key idea:**
  When power is first applied, capacitors charge quickly, this causes a **large, short current spike** called *inrush current*.
- Formula:
- $I = \frac{V_{sense}}{R_{sense}}$

- **Setup notes:**
- Resistor placed **in series** with the power line.
- Both probes measure voltage on each side of the resistor.
- Scope math function used: **CH1 – CH2 = V across resistor**.



Output Signal of 555 Timer Circuit

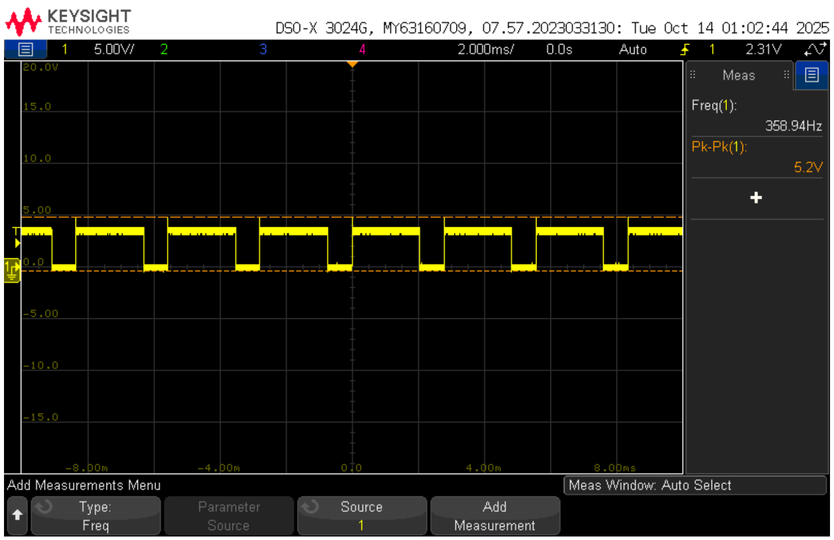


Figure 1

The output of the 555-timer circuit was measured on Channel 1. The waveform shows a periodic square wave with a frequency of approximately 360 Hz and a peak-to-peak voltage of 5.2 V.

The waveform of the steady-state

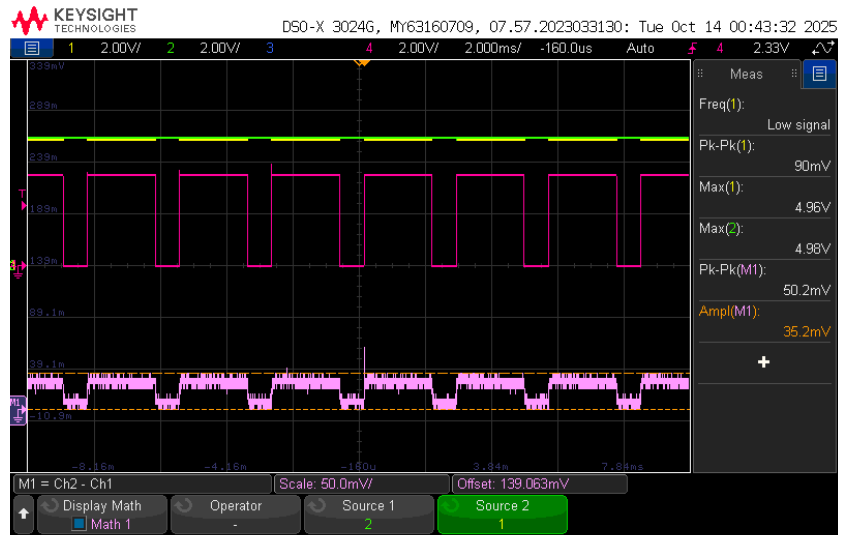


Figure 2

The waveform shows the steady-state voltage across a 1Ω current-sense resistor measured using the oscilloscope Math function (CH1 – CH2). The measured amplitude of ~35 mV corresponds to a current of approximately 3.5 mA.

Note: *Channel 1 was used for the frequency measurement (Figure 1) and later changed to Channel 4 as the trigger source for the 555 output (Figure 2).*

Inrush Current Measurement During Power-Up Transient

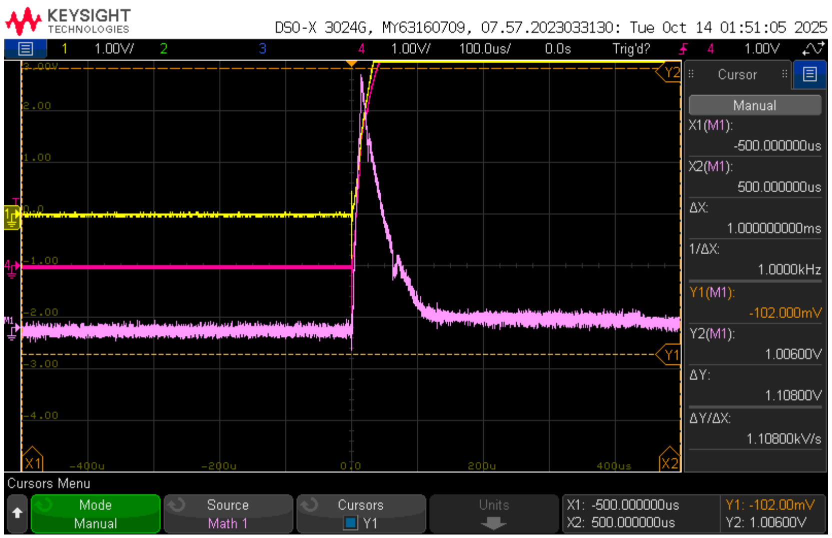


Figure 3: measurements with cursor

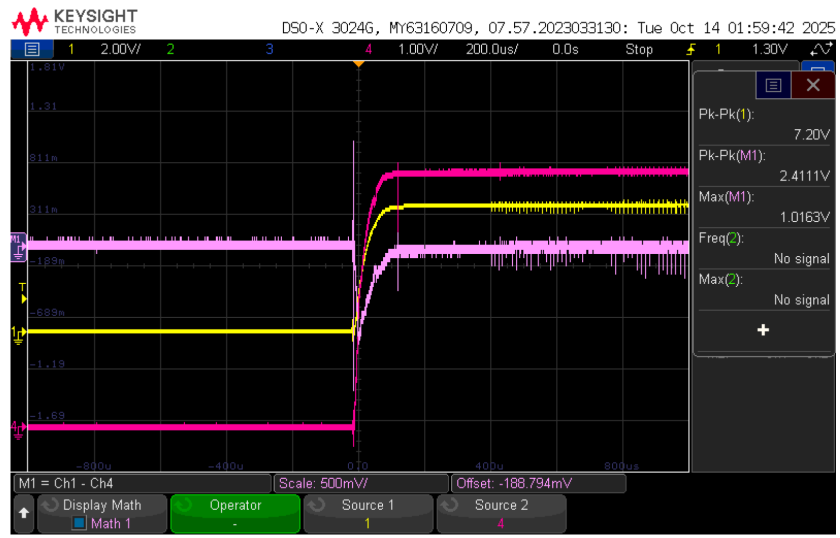


Figure 4: measurements with Meas

The oscilloscope capture shows the voltage difference across the 1 Ω current-sense resistor (pink trace) at the instant the 555-timer circuit is powered on. The sharp transient indicates an inrush current peak of approximately **1.01 V / 1 Ω ≈ 1 A**, followed by a the 10 μF decoupling capacitor charges. The yellow trace represents the supply rail voltage during the event.

Summary

In this experiment, a **555-timer circuit** powered by a **5 V supply** was used to study how current changes when the circuit is first powered on (inrush current) and during normal operation (steady-state current).

A **small sense resistor** (1 Ω) was placed **in series with the power line** to convert current into a measurable voltage.

Two oscilloscope probes were connected, one on each side of the resistor, and the **Math function (CH1 − CH2)** was used to display the voltage difference, which represents the current through the circuit.

First, **Channel 1** measured the **output of the 555 timer** to verify that it was generating a square wave at about **360 Hz** with a **5.2 V peak-to-peak** amplitude. Then the probes were switched to measure the voltage across the sense resistor, giving a **steady-state amplitude of ~35 mV**, which corresponds to **about 3.5 mA** of current during normal operation. (figure 1,2)

To measure **inrush current**, the oscilloscope was set to **Normal trigger mode** so it would capture the short transient that occurs when power is first applied. A large voltage spike was observed across the resistor (around **2.4 V peak**), indicating an **inrush current of about 1.6 A** lasting only a few hundred microseconds as the **10 µF decoupling capacitor** charged.(Figure 3,4)

Overall: The results show that the circuit draws a brief, high-amplitude current when first powered, followed by a small steady-state current during operation. This demonstrates how capacitors on a power rail cause inrush current and why sense resistors and proper triggering are useful for observing these fast transients.

Note:
We use a higher-value capacitor on the power rail to **stabilize voltage and filter noise by storing more charge**, but this also causes a **larger inrush current at startup**; if the capacitor value is too low, the **voltage may fluctuate and the circuit may become unstable during switching or load changes**