Practical PCB Design and Manufacture

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

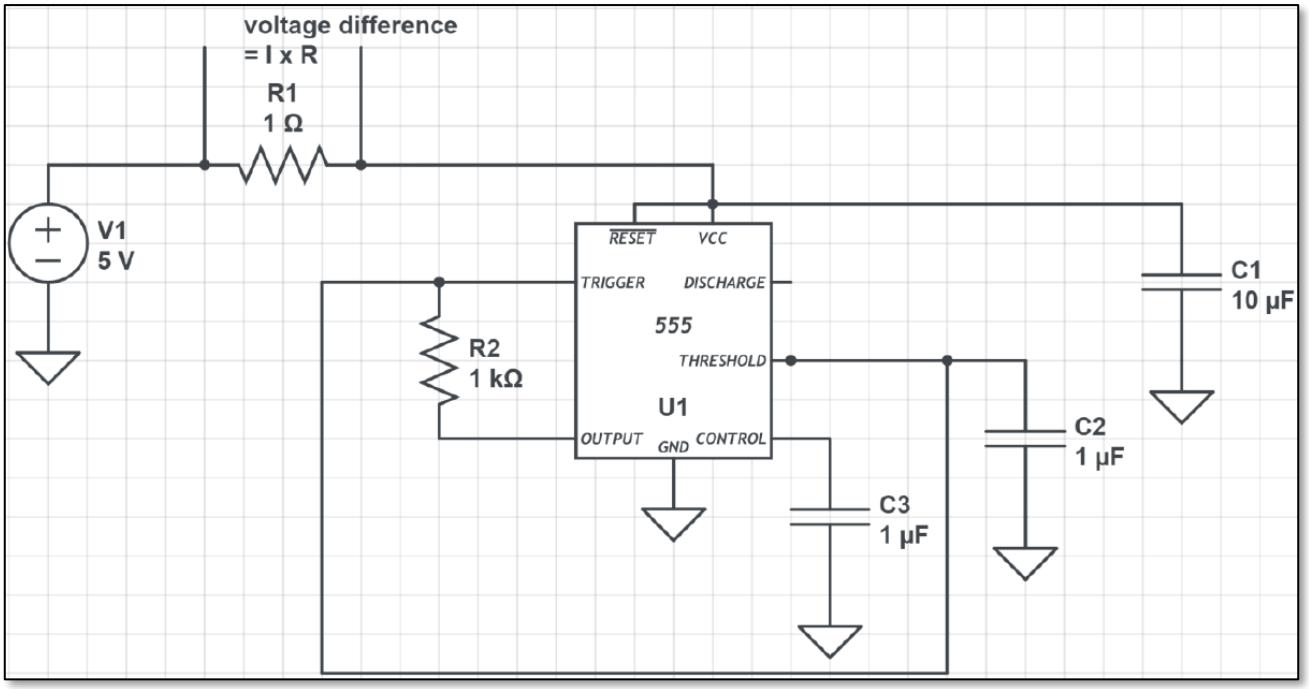
Objective / Purpose of the Lab:

- The aim of this lab is to master a method for measuring the inrush and steady-state currents of a board, utilizing a sense resistor in series with the power rail to translate current into a voltage observable by a scope. The focus is on overcoming the challenge of detecting minute voltage differentials across the sense resistor, not referenced to ground. The lab will predominantly demonstrate the use of two single-ended scope probes, while also introducing alternative measurement techniques using an AD2 scope and an AD623 instrumentation amplifier for further exploration.

Component Listing:

- Solderless Bread Board
- Arduino UNO
- NE555DR Slow Timer
- Connecting Wires
- Oscilloscope (With 10x Probes)
- Digital Multimeter
- Capacitors
- Resistors

Board Connections Sketch:



Scope Shots with Analysis:

Fig – 1: Averaging Mode

Fig – 2: Normal Mode

The above images show the inrush current when probes are connected between the high end and low end of the 1Ω resistor. The measurements have been taken in the averaging mode and the normal mode of the oscilloscope.

Principle of Current Sense Resistor:

A current sense resistor, also known as a shunt resistor, is a device used to measure the amount of current flowing in a circuit. It operates on the principle of Ohm's Law, which states that the current through a conductor between two points is directly proportional to the voltage across the two points and inversely proportional to the resistance between them (I = V/R).

In practical terms, a current sense resistor is placed in series with the load in a circuit. As current flows through the circuit, it also passes through the resistor. Due to its resistance, the resistor creates a small voltage drop across its terminals, which is directly proportional to the current flowing through it. This voltage drop is then measured and used to calculate the actual current in the circuit.

Current sense resistors are designed to have a very low resistance value to minimize their impact on the circuit's overall operation. They are also constructed to handle the power (I^2R) that results from the current flow without overheating. By accurately measuring the voltage drop across the resistor and knowing its resistance, the current through the circuit can be precisely determined, making current sense resistors crucial for monitoring, and controlling electrical systems.

The blue trace shows the output of the 555-timer at 66% duty cycle. The yellow trace is for the higher side of the resistor, and the green trace is for the lower side of the resistor. We are using the MATH functionality on the oscilloscope to calculate the difference between the signals on Channel 1 (yellow trace) and the Channel 2 (green trace). This shows the inrush current difference between the incoming current from the Arduino UNO 5V power supply.

When we trigger the power supply, we get the output as shown in the figure below:

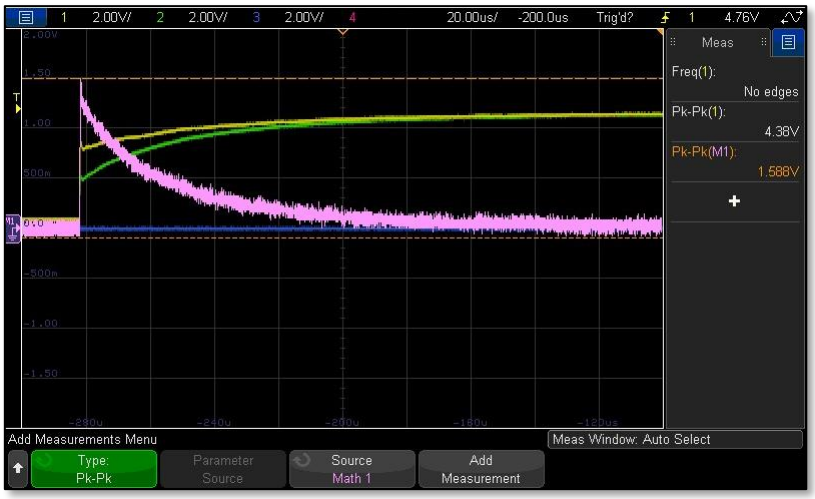


Fig – 3: Inrush Current Measurement

The inrush current measured across the 1Ω resistor is calculated as follows:

I = V/R
Thus I = 1.588V / 1Ω
= 1.588A

The phenomenon of drawing a large amount of current from the power supply initially to charge the input capacitor is referred to as "in-rush current." This inrush current tends to rise as the input capacitance increases. The capacitor reaches its full charge in a brief period, during which this elevated current flows. Therefore, understanding the maximum limit of inrush current is essential when designing a circuit that includes an input filter capacitor.

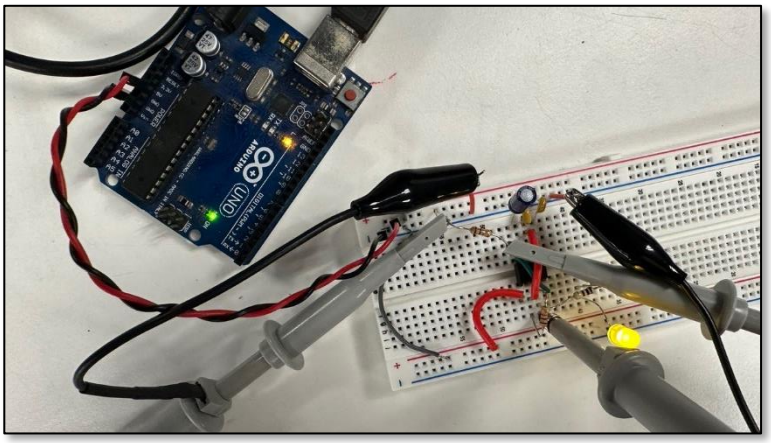


Fig – 4: Board Connections

Conclusion / Inference:

- Inrush current measurement in circuit design involves using a sense resistor in the power rail and is critical for circuits with an input filter capacitor.
- Alternative measurement setups can use two single-ended oscilloscopes with a math function instead of an AD2 scope.
- The chosen sense resistor value must balance between being large enough to detect voltage changes and small enough to keep the voltage low relative to the power rail, with inrush current directly proportional to the decoupling capacitor's value.