University of Colorado Boulder

Electrical and Computer Engineering

ECEN3730 Practical PCB Design Manufacture

LABORATORY REPORT

Lab 22: SBB Version of Board 4 measurements

Student Name: Mathias Labuszewski

Submission Date : 12/2/2023

1 Introduction

This lab focuses on constructing a solderless breadboard version of board 4, a measurement system designed for characterizing voltage sources and voltage regulator modules. The board measures Thevenin voltage and Thevenin resistance as functions of output current. The setup involves building an electronic load to draw controlled current and measure voltage drop on the VRM under various load conditions.

2 Objectives

1. Validate system functionality by introducing a known resistor as a preliminary test.
2. Choose a sense resistor and duty cycle based on the desired current range.
3. Address power consumption considerations through duty cycle management.
4. Measure Thevenin voltage, Thevenin resistance, and loaded voltage.

3 SSB Board

The board used for this lab is a prototype version of our board 4. The board is based on this schematic.

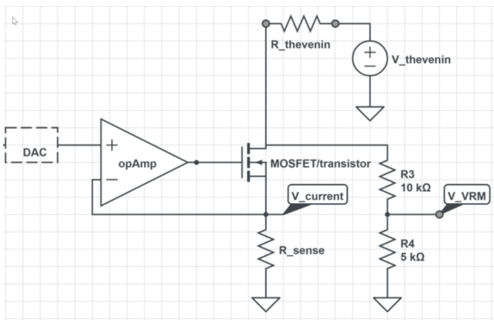

Figure 1: Schematic of Board 4

The circuit uses 4 main components. A DAC and ADC, MOSFET, and an opamp. The DAC and ADC are controlled by the microcontroller attached to the circuit via I2C. The purpose of the DAC is to control the MOSFET and pulse the VRM to measure its current and voltage. The ADC will be used to measure the current and the voltage of the VRM. We have a sense resistor that is measured and will give the current via the known voltage and resistance. The voltage is measured via a voltage divider. The ADC has a maximum voltage 5v it can measure, so to be able to measure more VRM's we add a voltage divider.

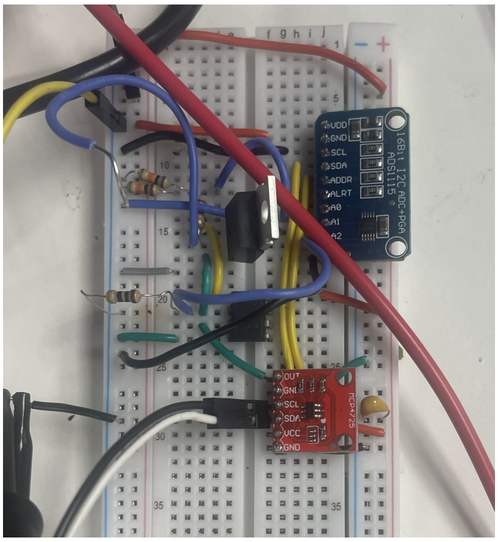

Figure 2: SSB of Board 4

4 Methodology

4.1 Verifying functionality

- To verify functionality we need to measure some of the key points in the circuit and place a known test load and check the given resistance.

4.2 Measuring Circuit

We can take a few measurements to verify the circuits working. First I measured the gate voltage of the MOSFET so I know current should be flowing thru the resistor.

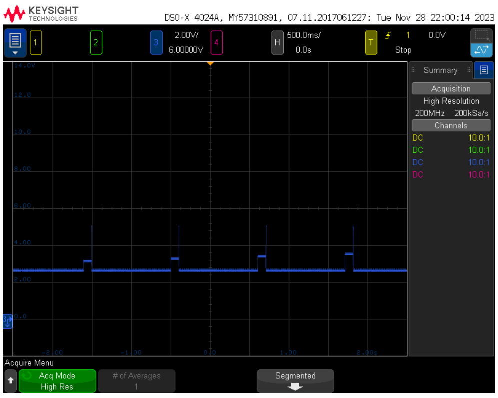

Figure 3: Gate Voltage of Board 4

We can see the gate is getting voltage in periods, which means out DAC and OPAMP will work. Next, I measured the voltage of the VRM and the voltage across the current sensor. Blue - Gate Green - VRM V Yellow - V sense

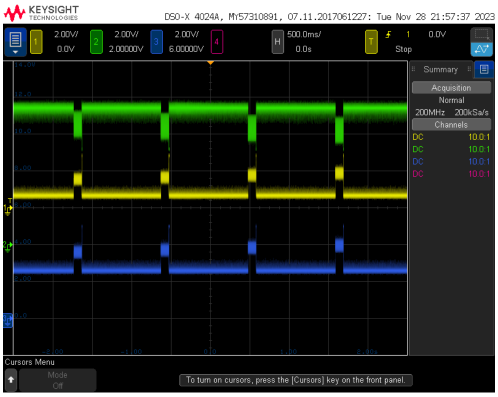

Figure 4: Gate, VRM, and Sense voltage of Board 4

We can see when the gate of the MOSFET is getting voltage, the VRM voltage drops a bit, and the sense voltage increases. This means the circuit is working properly. The last thing to do is to check the overall functionality.

Running the measurement code, We should see periodic measurements and changes in the measurements according to the code. The code should ramp up the current and do it multiple times to sample as much data is possible.

Figure 5: Gate, VRM, and Sense voltage of Board 4

We can see the overall function of the board is working. The current on the resistor is going up and the voltage drop of the VRM is getting larger.

4.3 Initial Output

To verify the correct output, I connected a test resistance to a DC power bench power supply. The power supply should ideally have 0 Thevenin resistance, but in practice, it is very low. This however is fine, as my test resistance is much larger. Using a 10ohm rest resistance I connected the circuit. The power supply was set in CV mode at 8v with a max current of 2A. The sense resistor I used was a 10ohm. The max current we should see is 0.8A, less than the max current of the DC supply.

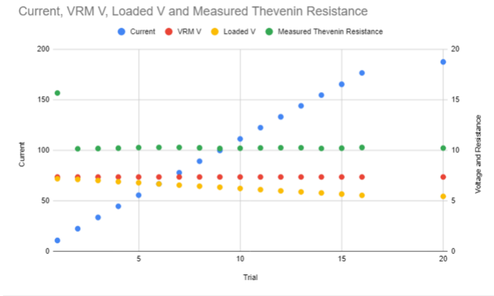

Figure 6: Measurements of Board 4

The plots shows us the current, VRM V, loaded V and measured thevenin resistance. We can see the measured thevenin resistance is 10ohms. This is correct. This means the functionality of the SSB version of board 4 is verified.

4.4 More measurements

4.4.1 Function Generator

Earlier in the year we measured the thevenin internal resistance of a function generator. We can use our board to test. The resistance we obtained was 50 ohms, so the board should reflect that number. To measure, I had to use a 100 ohm resistor and set the function generator to 9v DC. The function generator cannot source very much current.

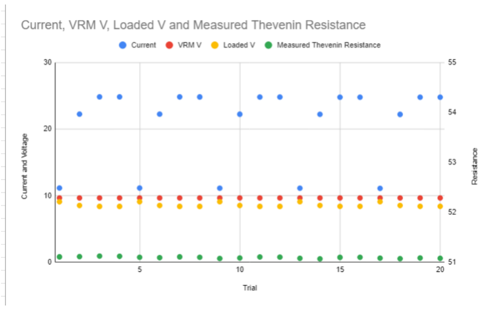

Figure 7: Measurements of Board 4

The calculated thevenin resistance was 51 ohms. This is close, and the 1ohm difference can be explained by tolerances, and/or the resistance of all the interconnects of the circuit. Interestingly we can see the output is not linear. The current rises and then rebounds to a lower value. The function generator is a nonlinear device, and there is lots of complex functionality going on inside it.

4.4.2 5v Rail of Arduino

Measuring the 5v rail can provide insight into the efficiency and reliability of the design. I used a 10ohm resistor.

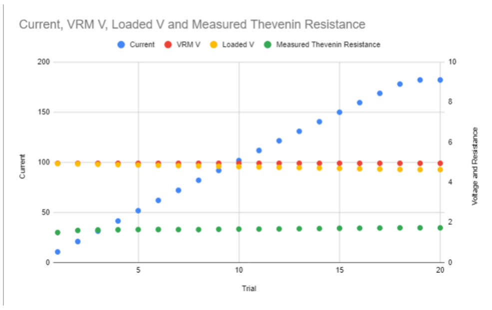

Figure 8: Measurements of Board
4

We can see the thevenin resistance is around 1.65 ohms.

4.5 Importance of Measuring Thevenin Voltage and Resistance

Measuring Thevenin voltage and resistance is important for several reasons:

- Evaluation: The obtained measurements give critical indicators of a VRM's performance under varying load conditions, good for insights into its stability and reliability.
- Predictive Analysis: The data obtained help predictive analysis, helping engineers anticipate how a system will respond to different loads and enabling adjustments for functionality.
- Design Validation: These measurements are fundamental in validating the design of VRMs.
- Troubleshooting: Thevenin measurements provide valuable debugging information. Sudden changes in Thevenin voltage or resistance can signal issues in the connected circuit.
- Short Paths: Use short traces to reduce loop inductance and signal travel time.

4.6 Conclusion

In conclusion, this lab provided an exploration of constructing our board 4, an instrument droid for characterizing voltage sources and VRM's. The solderless breadboard implementation of board 4 allowed for a practical understanding and tool in measuring Thevenin voltage and resistance as functions of output current.