Electrical, Computer & Energy Engineering
UNIVERSITY OF COLORADO BOULDER

ESM Lab Grading Report

Course Number: 2
Module: 4: Lab 2 on Motor Voltage and Current Measurement

Lab Report Date _10/11/2021_____

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Each Section of this Lab Report Counts for 20 points. Points will be allocated as follows:
20 points: section fully meets requirements of this rubric
15 points: section mostly meets requirements of this rubric
10 points: section meets roughly half the requirements of this rubric
5 points: section does not meet requirements, but shows a weak attempt
0 points: section blank

Goal: The purpose of this lab is to learn how to measure the speed of a brushed DC motor without using external sensors. We will briefly interrupt the power to the motor, and look at the voltage generated across the terminals of the motor, and then reapply power to the motor before it can lose much speed.

Background: Measuring rotary position or speed is a common application. You can use hall switches and optical rotary encoders to directly measure the speed of DC motor. You can also measure the speed by measuring its back EMF voltage, which effectively subtracts from the voltage applied to the motor. The back EMF is proportional to the speed of the motor, with the constant of proportionality K_e measured in volts per thousand RPM. The torque constant K_t relates torque to motor current It is measured in N-m per amp.

The power FET is used to control a large current from a smaller current available from a PSoC pin. The n-channel MOSFET works in the following way. It's a 3-terminal device with a drain, gate and source. The gate to source voltage controls the resistance between the drain and the source. The current from the drain to the source can be much larger than the current than the GPIO pin can source or sink. We use the GPIO pin to control the voltage at the gate. The impedance at the gate is quite high, so the GPIO pin can control this voltage. When the gate to source voltage exceeds a few volts, the transistor turns on and the drain to source resistance becomes very low. When the gate to source voltage goes to zero, then the drain to source resistance becomes very high. Thus, the device acts as a nearly perfect switch.

The power FET will be turned on and off at a high rate of speed, which allows us to temporarily turn the power to the motor on and off. The motor current rises

when the PET is turned on, and the motor speeds up. At first, the back EMF is low, but it rises as the motor speeds up. The current sags as the motor speeds up and back EMF increases. Eventually, at equilibrium, there is just enough current in the motor to overcome friction and the speed stabilizes.

(A) Functional demonstration of your circuit to our TA. In this exercise, you schedule an appointment with your TA to show that your hardware functions as designed. For the Closed Loop C Motor Control lab, this will involve the following steps:

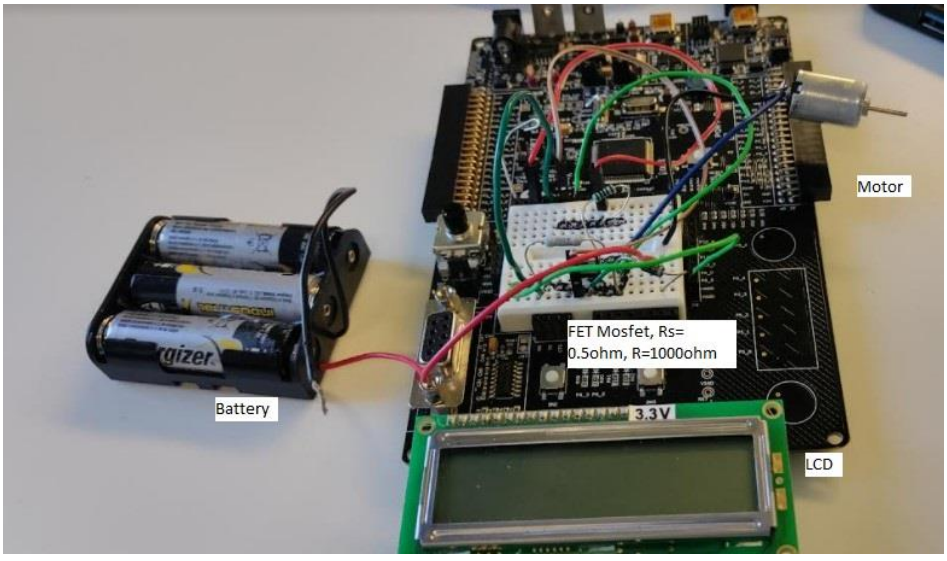
1. Show that all hardware is in place, and that your PSoC software can read the motor current, motor voltage and FET gate drive.
2. Alter the speed of the motor by allowing the motor to free spin or hold the motor shaft with your fingers. You should display the speed of the motor on the LCD in units of RPM.

If you are an on-campus student, then show your circuit to one of our TA's during office hours.

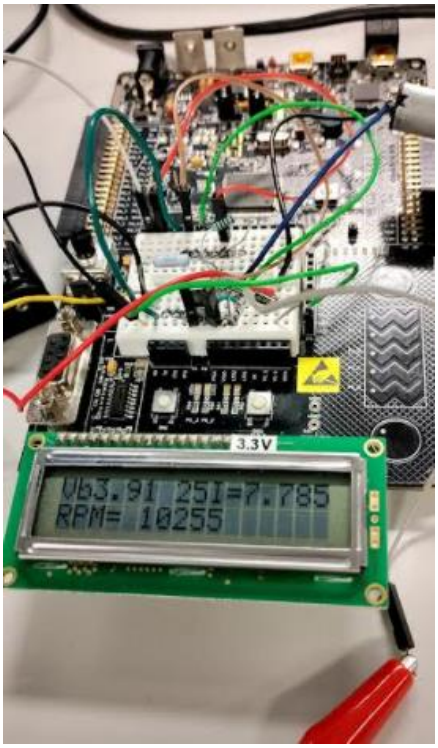
If you are a distance learning student, make an online appointment with your TA to demonstrate your work via Zoom meeting or other Web-based meeting tool. You can use the camera on your laptop PC or suitable plug-in webcam (Logitech etc.) to demonstrate a working circuit.

(B) Place photos here of your hardware setup, including PSoC board, connections to Oscilloscope or nScope, wiring, LCD Display, components. Label all components.

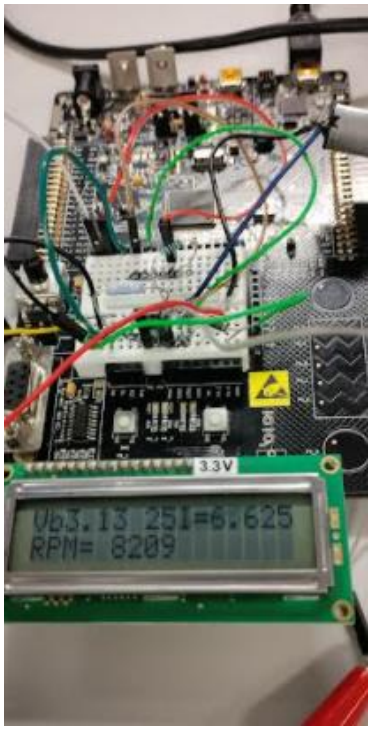
Sample photo is shown here. (Make sure to delete the sample and place your own photos here).



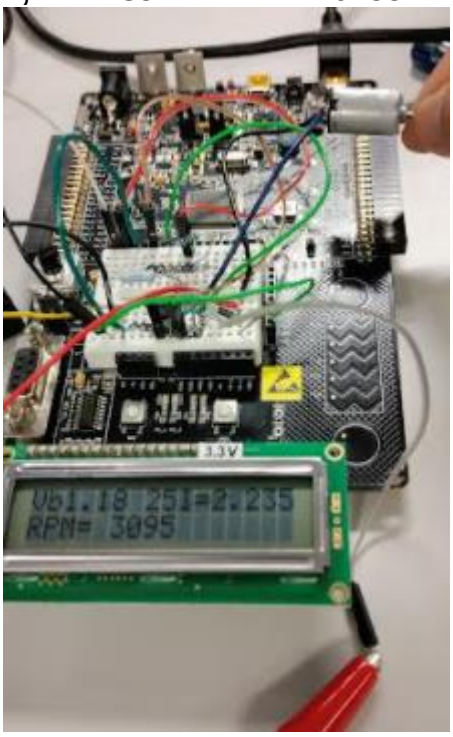
Hardware Setup



No Load RPM and back EMF Vb = 3.91 V, I= 7.785mA RPM= 10255



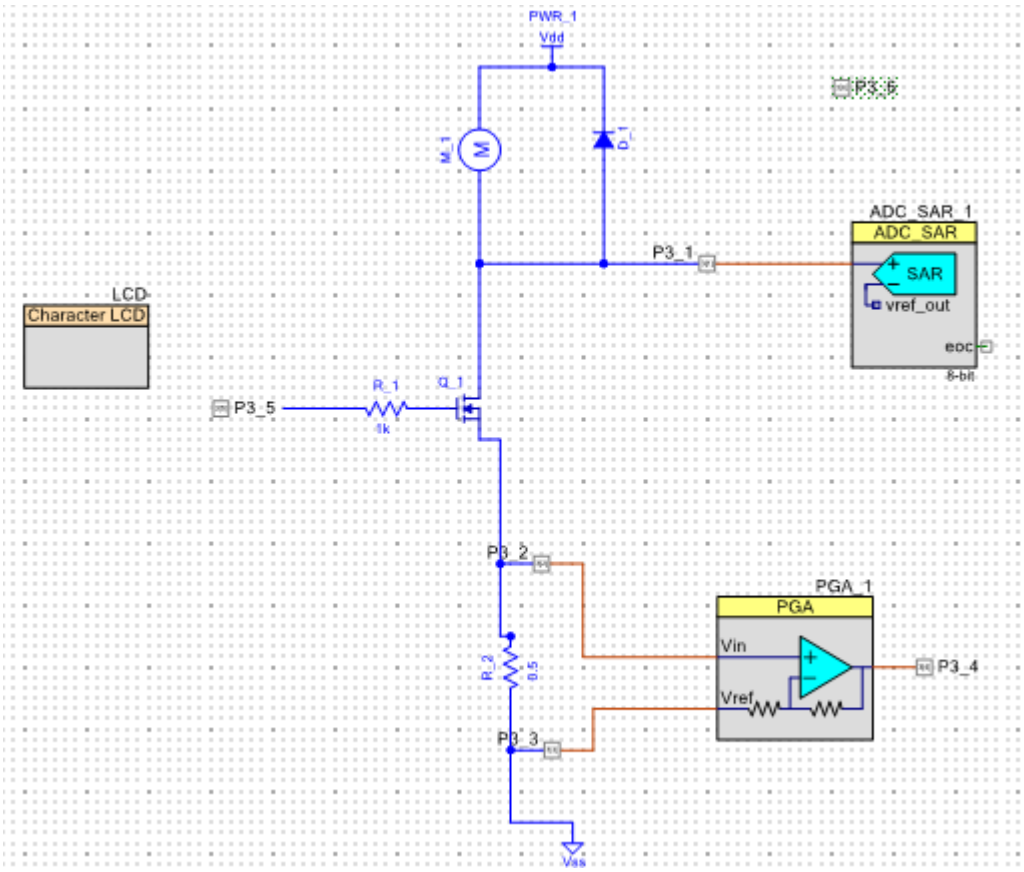
Partial Load and Back Emf
Vb= 3.13 I= 6.625mA
RPM = 8209



Partial load and back emf
Vb = 1.18 V, I= 2.235mA
RPM=3095

(C) Place complete PSoC schematic here. This schematic must include internal components from the PSoC board (amplifier, MUX, etc.), as well as external components (power diode, motor, n-channel power FET, etc.).

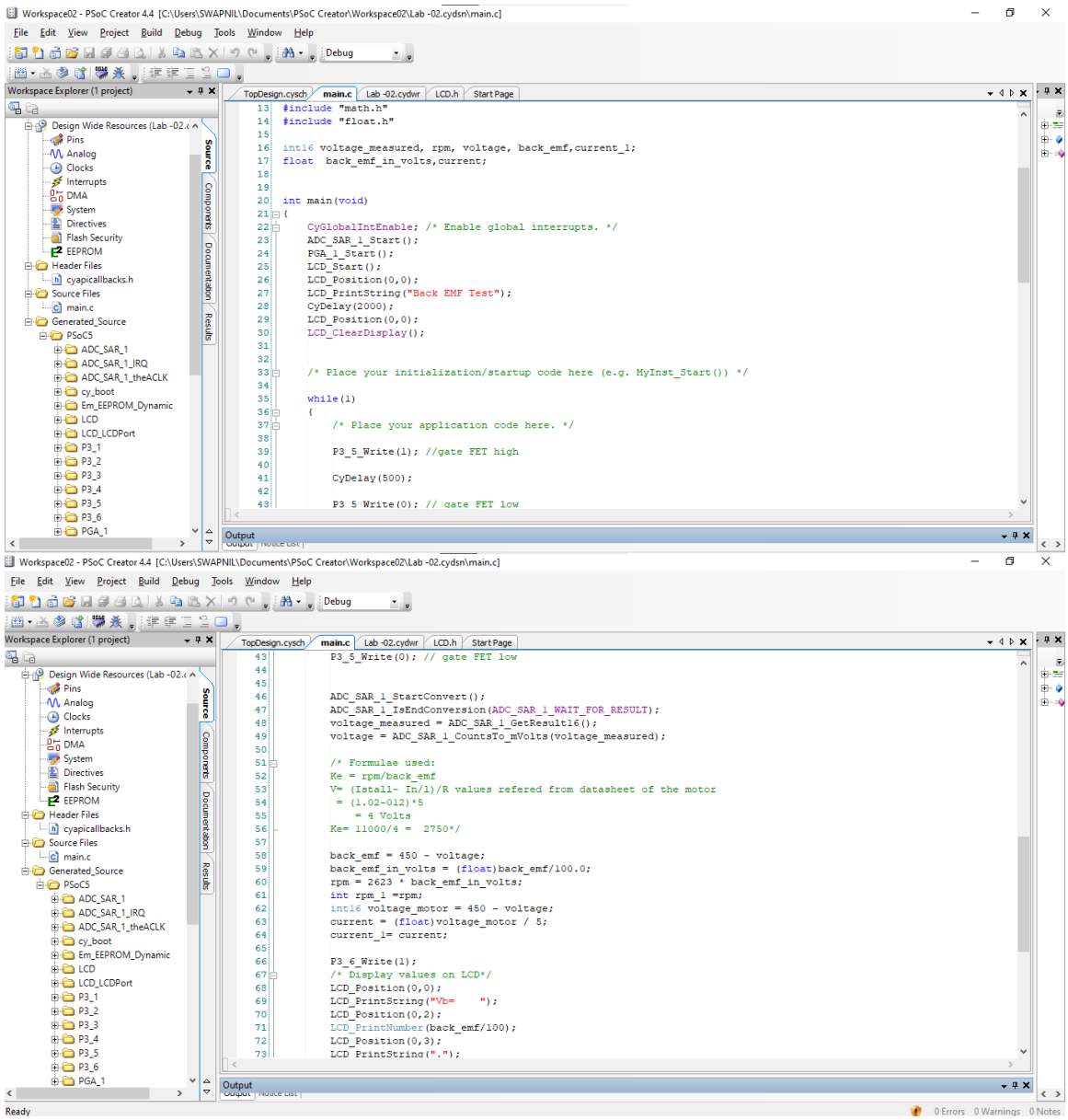
Sample schematic is shown here. (Make sure to delete the sample and place your own schematic here).

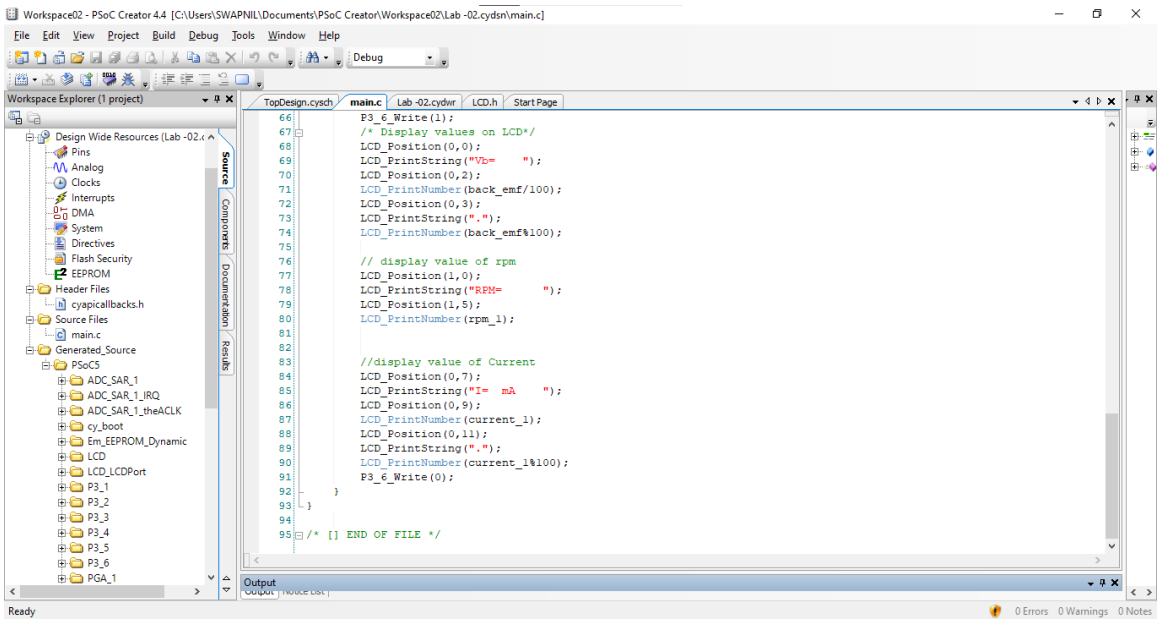


The schematic for the Lab 2

(D) Complete PSoC software. This software must include calls to all internal functions, appropriate comments, and functional code that you included. We will not grade you on the exact syntax and structure, as there are numerous ways to structure the code and still provide the temperature measurement function. Instead, we will grade you on the completeness of the code relative to using the appropriate PSoC functions to gather the necessary data.

Along with this completed file, upload to Canvas a .zip file with the PSoC file main.c. This screen shot from PSoC shows where the file main.c is located in your main screen.



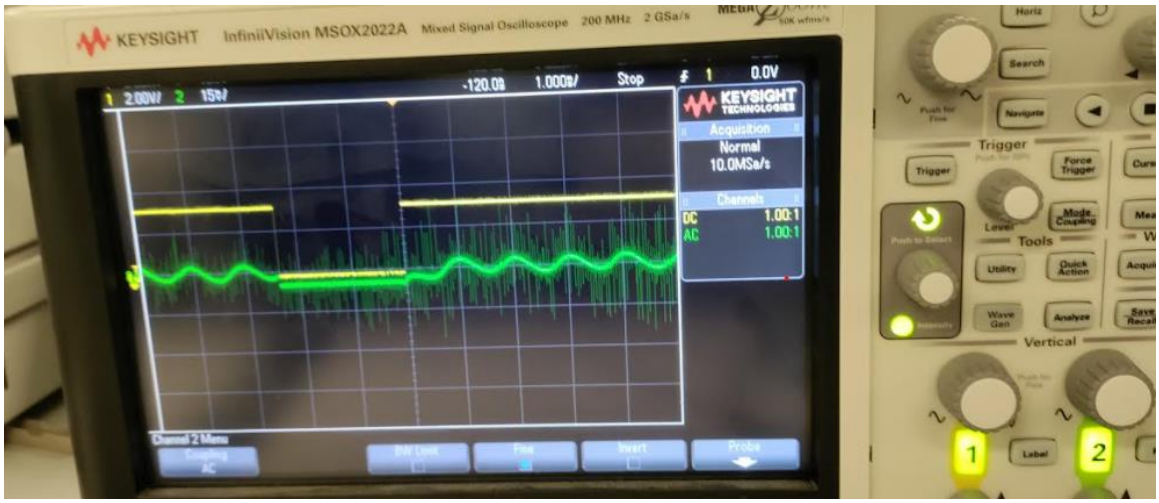


Main.c

E) Place screenshots from your oscilloscope or nScope showing critical loop times or signal outputs. For this lab, you should show plots of the motor current and voltage on one channel, and the FET gate on the other, similar to what is shown in the sample below.

Sample screenshots are shown here. (Make sure to delete the sample and place your own screen shots here).

Back EMF and Gate of FET



Across Rsense and Gate of FET