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# ME333 – Class 19 Homework

**28.4.1**

1. I will use the SPI4 SPI channel. This uses the NU32 pins F4, F5, B14, and B8.
2. I will use the ADC input AN0, which is pin B0.
3. I will use a digital I/O peripheral for the direction bit. More specifically, I will use pin RD6. I will use the output compare peripheral to generate the PWM. OC1, which is pin D0, will be used.
4. I will use Timer 4 to implement the 200 Hz position-control ISR and Timer 2 for the 5 kHz current-control ISR. The 200 Hz ISR will have a priority level of 4 and the 5 kHz ISR will have a priority level of 5. A higher priority level was chosen for the current-control ISR because it occurs more frequently. It is the inner control loop and should occur more frequently / quickly, and should thus be able to interrupt the outer motion control loop ISR.
5.

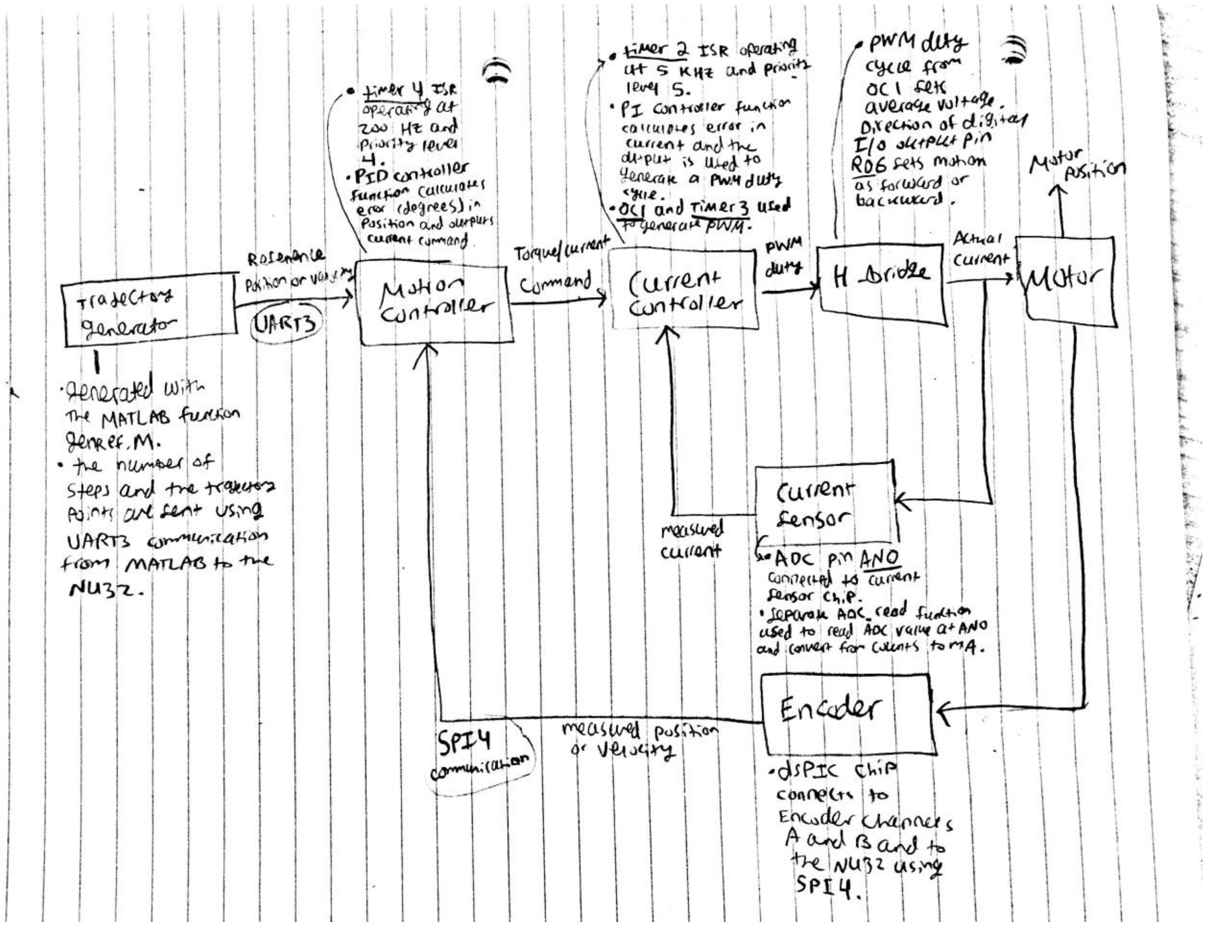


Figure 1. Annotated motor control block diagram.

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6.

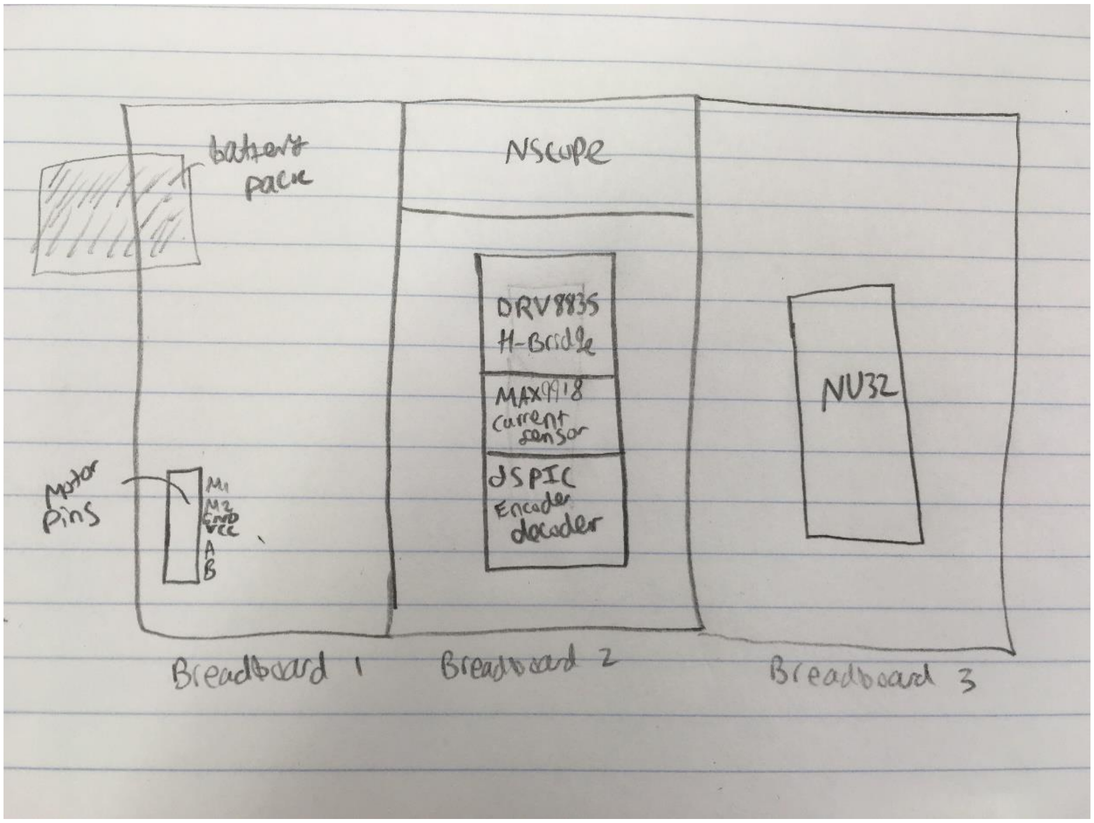


Figure 2. Rough sketch of the layout of the circuit boards.

**28.4.7**

1. $R_3 = 330\ \Omega$
2. $R_{motor} = 13.95\ \Omega$, as measured in the previous homework. $V = 5.95$ V, as measured with a voltmeter. Thus, $\boldsymbol{I_{max}} = \frac{\boldsymbol{2V}}{\boldsymbol{R_{motor}}} = \boldsymbol{0.853\ A}$.
3. $V_{max} = 0.0128$ V.
4. $\frac{R_2}{R_1} = 127.9 \approx 128.0$. Choose $\boldsymbol{R_2 = 1.33\ M\Omega}$ **and** $\boldsymbol{R_1 = 10\ k\Omega}$.
5. $RC \approx 0.0008$ seconds. Choose $\boldsymbol{C = 0.1\ \mu F}$**, making** $\boldsymbol{R \approx 10\ k\Omega}$ to get a cutoff frequency of $f_c = 159.15\ Hz$.
6.

| R0 (Ω) | Expected $I$ (mA) | Measured $I$ (mA) | Sensor (V) | ADC (counts) |
|---|---|---|---|---|
| 10 (to RS+) | 595 | 440 | 2.6 | 830 |
| 20 (to RS+) | 297.5 | 270 | 2.2 | 675 |
| 40 (to RS+) | 148.75 | 130 | 1.95 | 594 |
| Open circuit | 0 | 0 | 1.7 | 507 |
| 40 (to RS-) | -148.75 | -130 | 1.4 | 420 |
| 20 (to RS-) | -297.5 | -250 | 1.05 | 339 |
| 10 (to RS-) | -595 | -460 | 0.7 | 192 |

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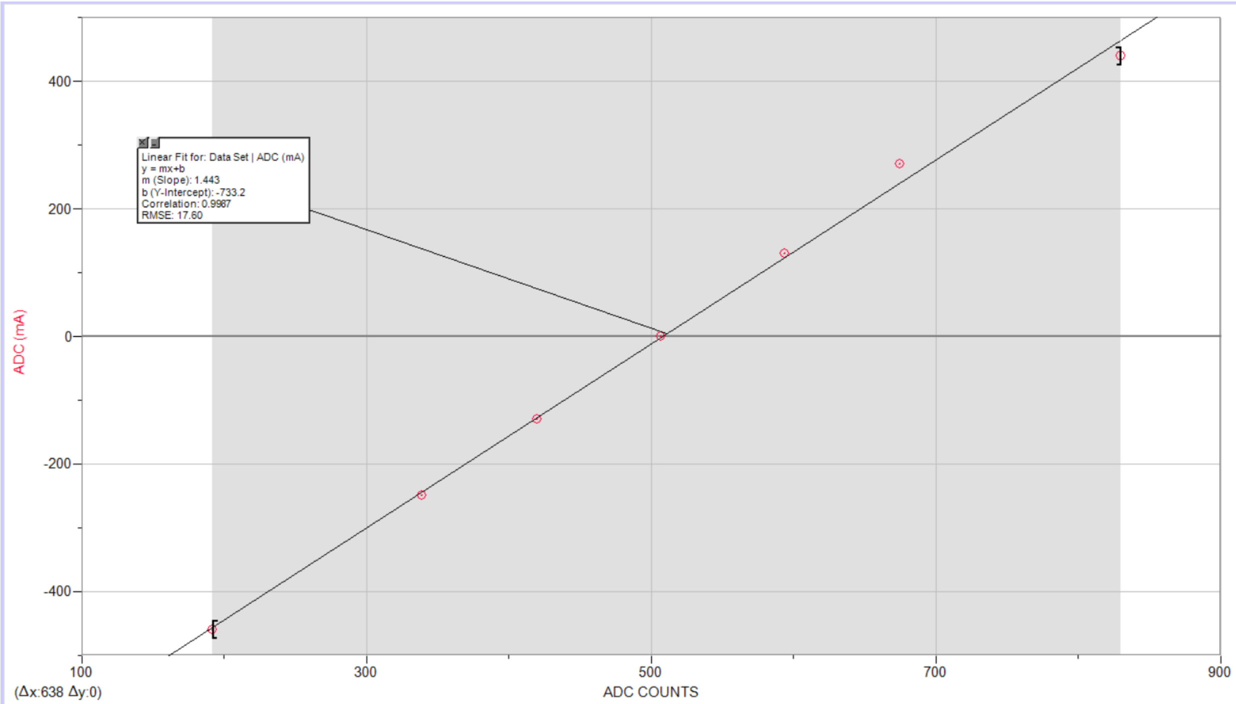
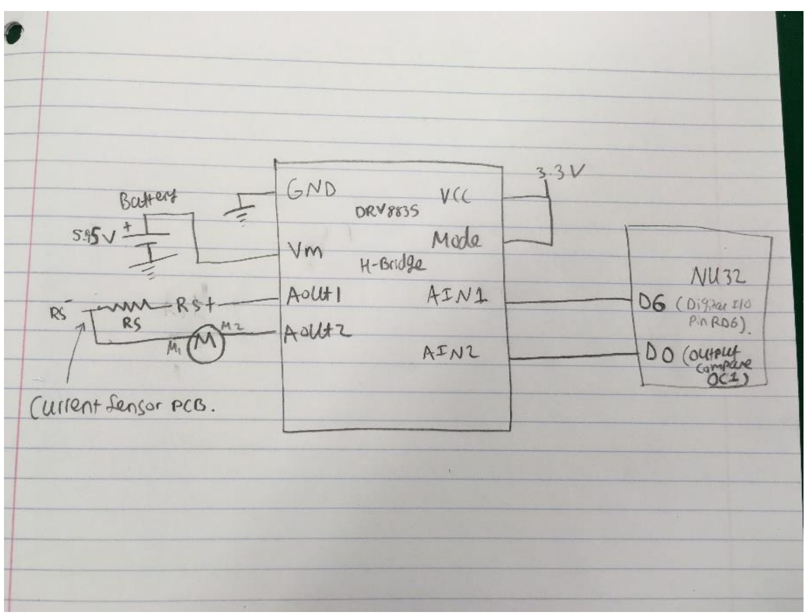
**28.4.8**

6. The line equation is $ADC\ (mA) = 1.443\ (ADC\ COUNTS) - 733.2$. Plot of measured current versus ADC counts:




**28.4.9**

**8.** Circuit diagram showing all connections of the H-bridge to the NU32, motor, and current sensor:



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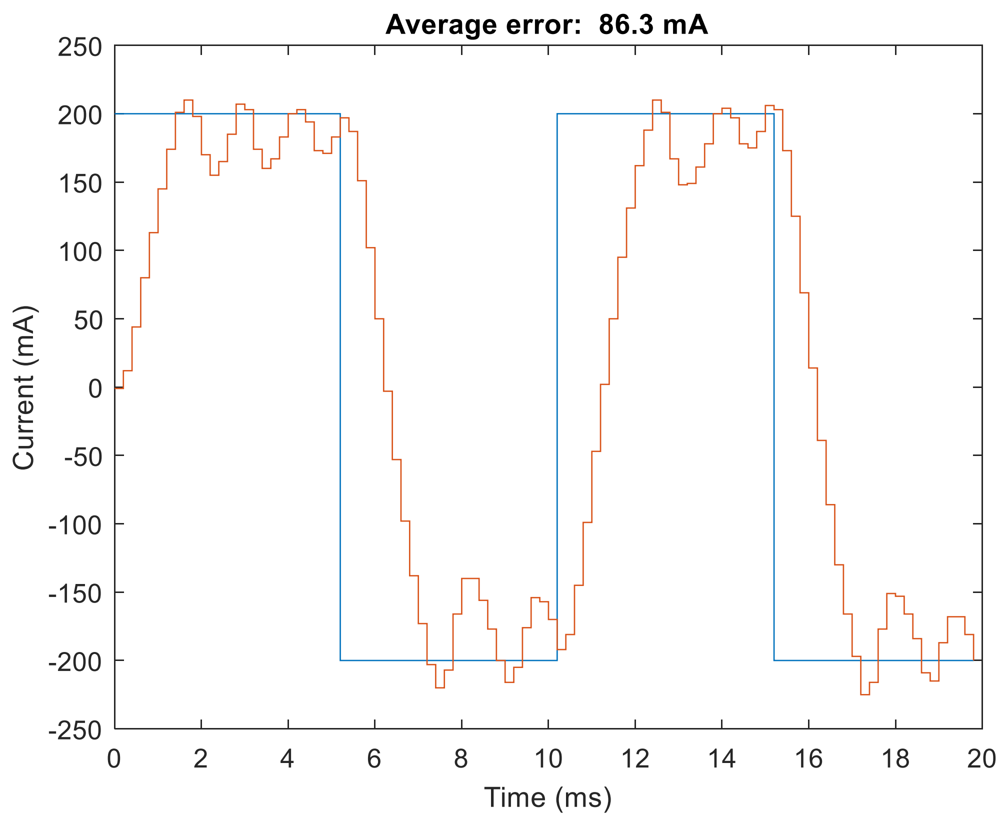
**28.4.10:**

**5.** The current controller takes in a current and returns a percent duty cycle. Thus, the control gains have units of percent duty cycle divided by mA.

For the plot below, gains of [Kp, Ki] = [10, 0] were used. The gains have units of $\frac{\%\, duty\ cycle}{mA}$.

**ITEST Plot:**




**28.4.12:**

**5**. Gains of [Kp, Kd, Ki] = [40, 1000, 0] were used for both the step and cubic trajectories. The gains have units of $\frac{mA}{degrees}$. The PID controller takes in an error in degrees and returns a commanded current in mA.

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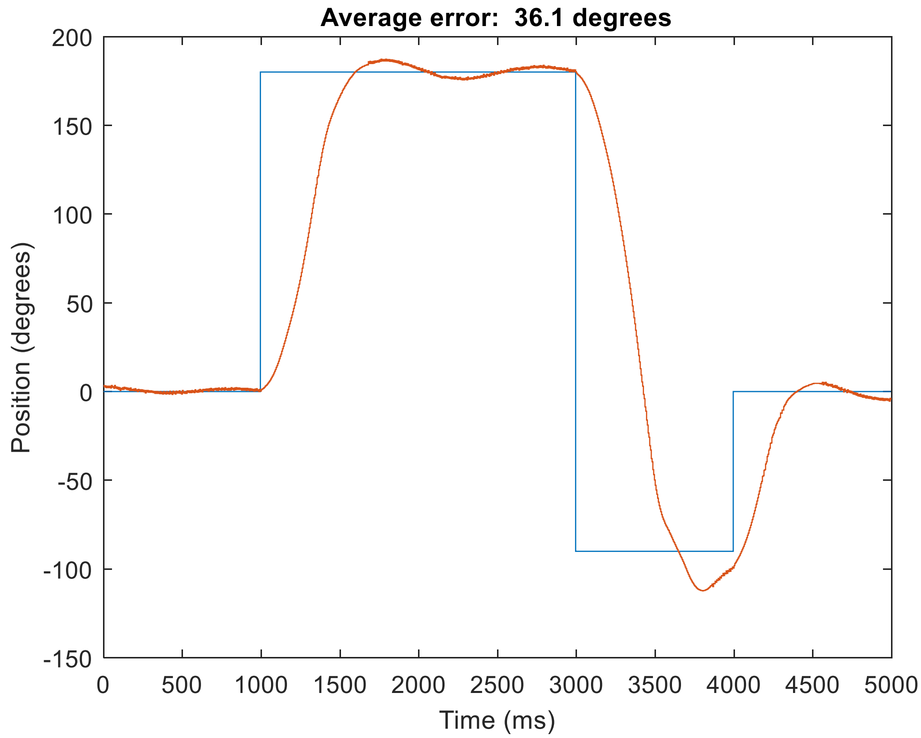
**Step trajectory plot:**




**Cubic trajectory plot:**