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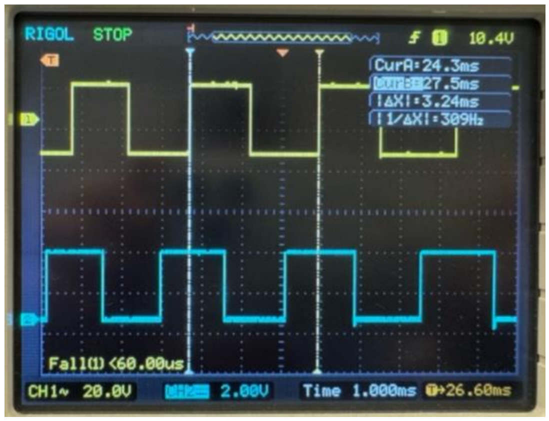
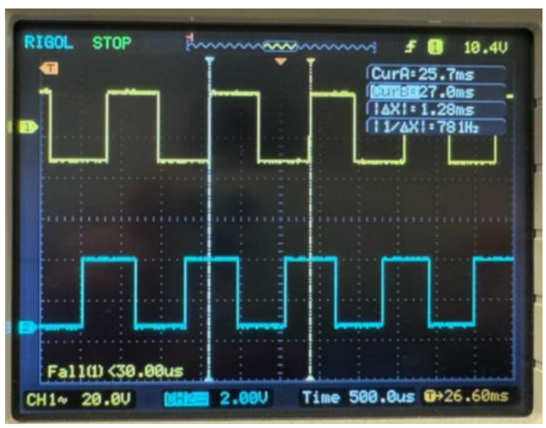
ECE1188 Cyberphys
Dr. Dickerson
Due: 4/5/24

Lab 5 – Sensor Interfacing and Control Systems

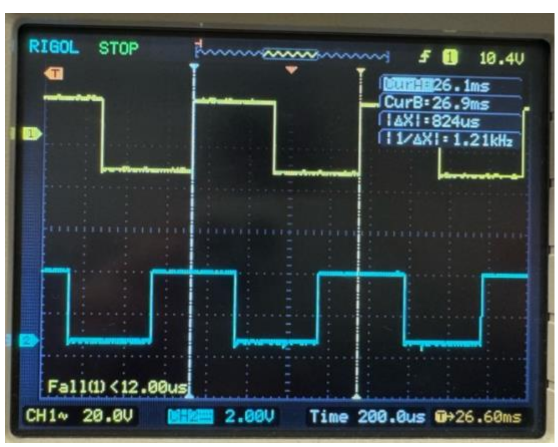
1. **PWM scope measurements**
   a. 25%



   b. 50%



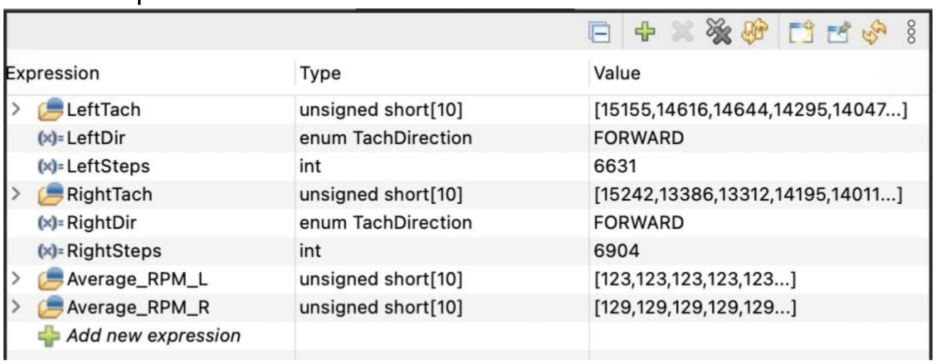
   c. 75%



d. Period
   i. $T_{25\%} = 3.24ms$
   ii. $T_{50\%} = 1.28ms$
   iii. $T_{75\%} = 0.82ms$

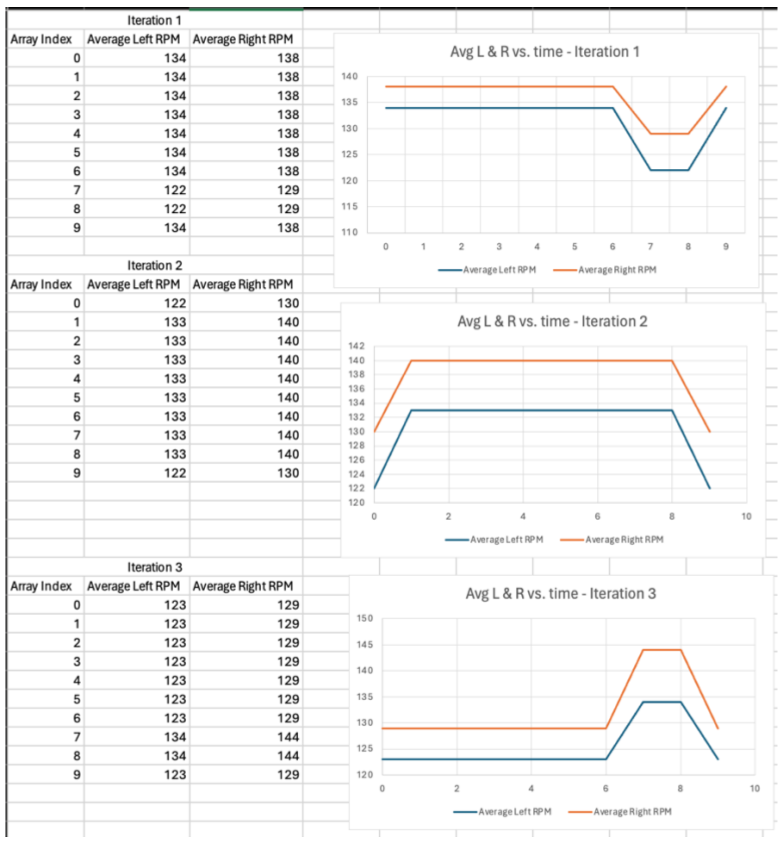
2. Tachometer (Demo)

a. CCS expressions



Expression	Type	Value
LeftTach	unsigned short[10]	[15155,14616,14644,14295,14047...]
LeftDir	enum TachDirection	FORWARD
LeftSteps	int	6631
RightTach	unsigned short[10]	[15242,13386,13312,14195,14011...]
RightDir	enum TachDirection	FORWARD
RightSteps	int	6904
Average_RPM_L	unsigned short[10]	[123,123,123,123,123...]
Average_RPM_R	unsigned short[10]	[129,129,129,129,129...]
Add new expression		

b. Excel Pics



Iteration 1

Array Index	Average Left RPM	Average Right RPM
0	134	138
1	134	138
2	134	138
3	134	138
4	134	138
5	134	138
6	134	138
7	122	129
8	122	129
9	134	138

Iteration 2

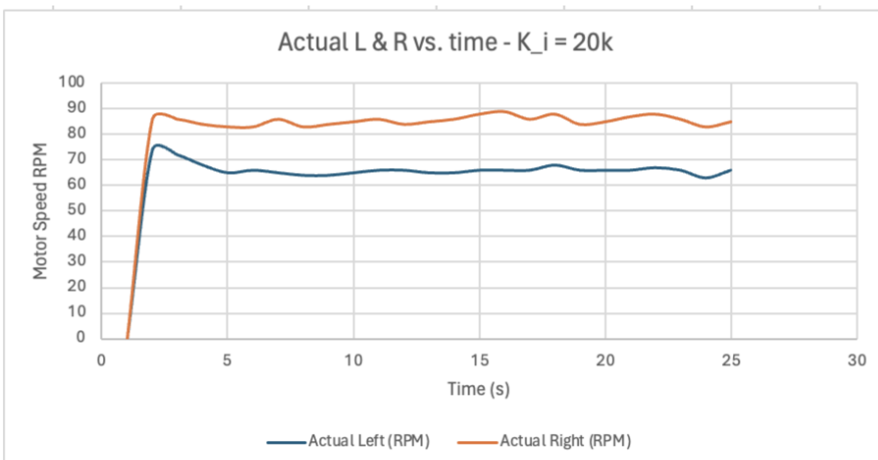
Array Index	Average Left RPM	Average Right RPM
0	122	130
1	133	140
2	133	140
3	133	140
4	133	140
5	133	140
6	133	140
7	133	140
8	133	140
9	122	130

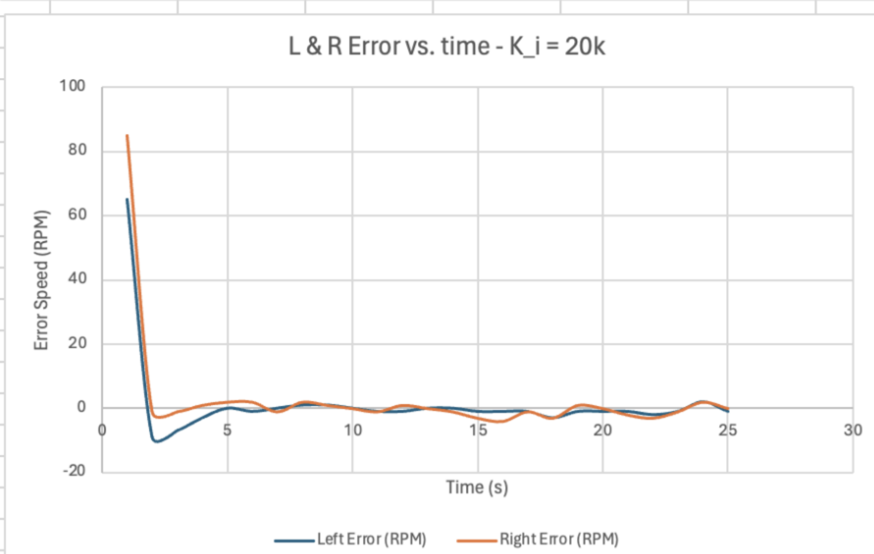
Iteration 3

Array Index	Average Left RPM	Average Right RPM
0	123	129
1	123	129
2	123	129
3	123	129
4	123	129
5	123	129
6	123	129
7	134	144
8	134	144
9	123	129

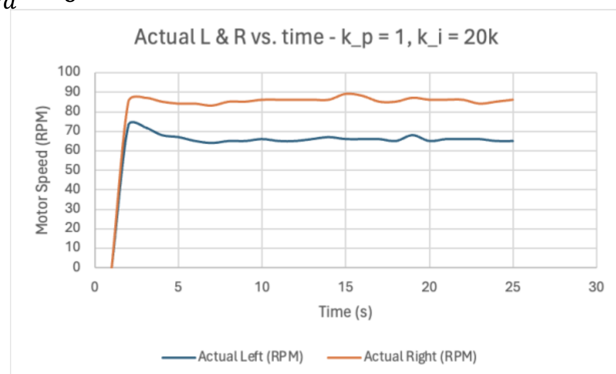
c. I took 3 iterations of this data set because the initial one looked very odd to me. The most obvious observation is that both motors speed up and slowdown in unison, but the right motor is always slightly faster (orange). There is also almost a periodic trend in motor RPM as the 3 iterations produce a full picture. This could be due to the motor using the tachometer measurements to inherently reduce the error from the user defined PWM value.

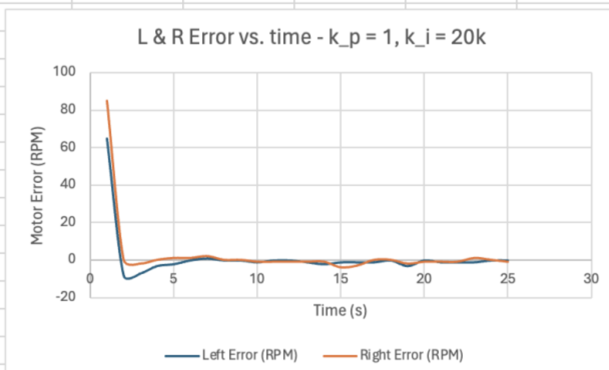
3. **Integrator control**
    a. After changing the RPM values, I noticed that both motors had the same "actual RPM" value which could mean a couple different things. After parsing through the code, I noticed that both motor speeds and errors are independent of each other. Knowing this, a possible reason to account for this observation is that with the gain set extremely small, the motor with more measured error (right motor) is in fact accelerating faster over time.
    b. From $k_i = 1$ to $k_i = 100$ both remaining errors were decreasing very slow. I went up 2 more magnitudes to $k_i = 10000$ and the error was diminished in about 10 seconds. I tried 1 and 2 higher magnitudes, but the gain was so high that the calculated RPM adjustment would still put the motor in a high error state. It would get confused and either drive the motor extremely hard or not at all.
    c. I tried gain values in steps of 5,000 from 5,000 to 40,000. In the 30 – 40k range the motors seemed to oscillate both in sound and data. 20,000 seemed to be quick but also not have too much overshoot. I used this gain value for my data collection.



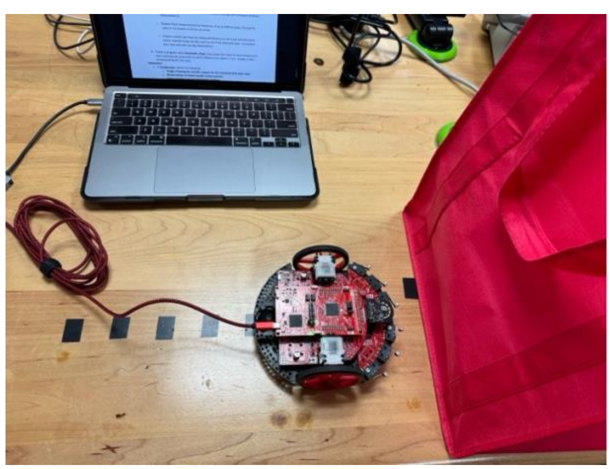


4. **PID control**
   a. I found that using the derivative term added no extra benefit to reducing the transient response of the system as I tried values from 0.1 to 100. The proportional term also acts very similarly to the integrator term as there is a relationship between the gains: $k_p = \frac{k_i}{1024}$. My benchmark of testing was to keep the majority of error data between ± 2 RPM.
   b. Gain Values
      i. $k_p = 1$
      ii. $k_i = 20000$
      iii. $k_d = 0$





5. **Distance Sensor**
   a. Set up

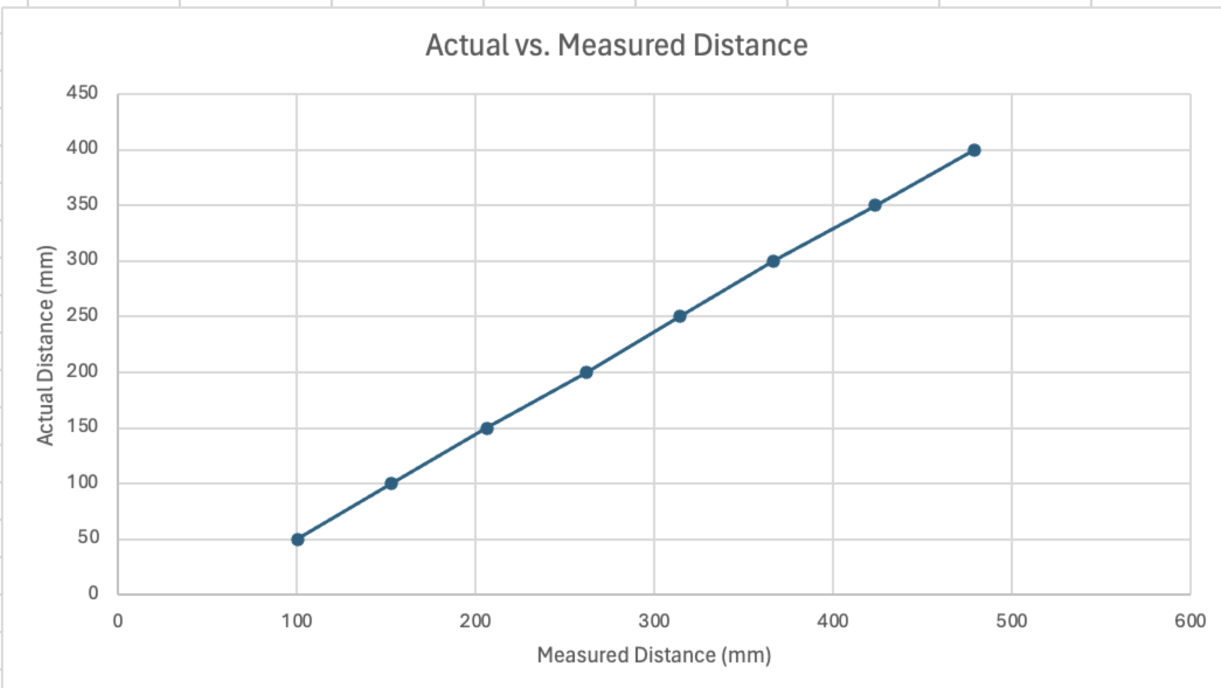


b. Data collection

i. CAVEAT: During this test, you can see I use a cheap bag as my object-to-be-sensed. I was curious why my measurements were 50mm consistently off. When I got home, I tried using a real wall, and got more accurate results. I didn't have enough time to update this section, hopefully this is acceptable!

			Center Distance Sensor Reading					
Itreration	50mm	100mm	150mm	200mm	250mm	300mm	350mm	400mm
1	103	150	212	260	318	364	425	481
2	91	150	208	264	313	365	427	483
3	99	156	202	255	314	366	419	478
4	105	150	206	266	316	370	420	480
5	104	156	202	264	309	368	426	473
Average	100.4	152.4	206	261.8	314	366.6	423.4	479

Actual Distance (mm)	Measured Distance (mm)
50	100.4
100	152.4
150	206
200	261.8
250	314
300	366.6
350	423.4
400	479



6. Auto stop

https://youtube.com/shorts/A3ubl4A44-s?si=_b6IQ8kSC54_gBIl