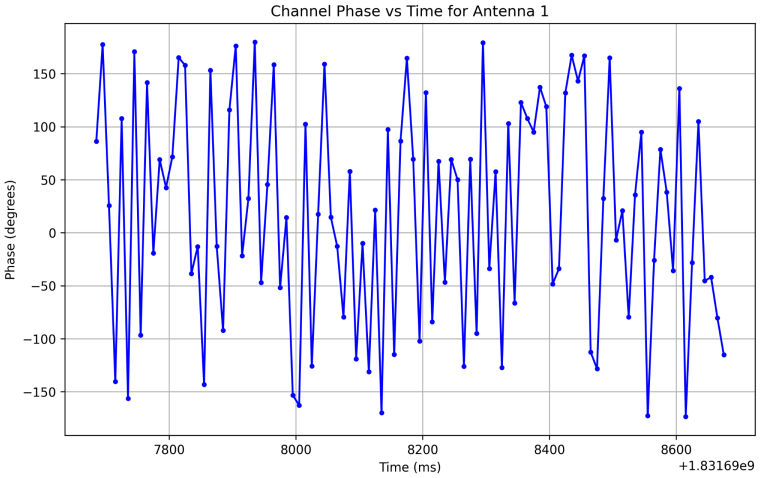
Team members: Jian-Fong Yu, Yanxin Jiang

1. Wireless Channels

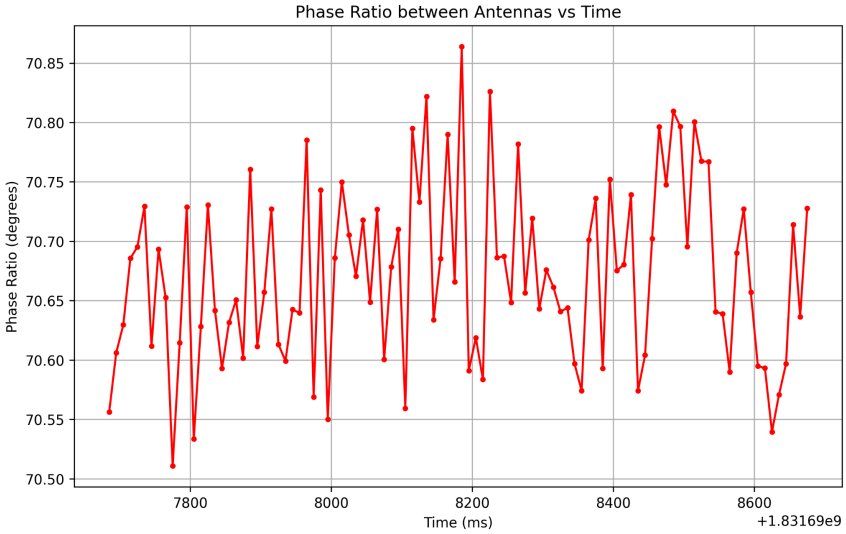
i. Plot the phase of the channel measured on antenna 1 with respect to time. Include the plot in your solution.



ii. You will observe that the channel phase does not remain constant. Why do the channel measurements change even though the receiver and the transmitter are static?

Ans. The channel phase change may be due to CFO, multipath effect, hardware offset, and other noise and interference. Frequency mismatch between transmitter and receiver may lead to the time-varying phase drift. For a multipath effect, even a small environmental change or reflection would lead to the phase change. Hardware offset without the accurate calibration could also lead to the phase inconsistency. Noise and interference in the environment could introduce phase variation.

iii. Plot the phase of the ratio of the channel measured on antenna 1 to the channel measured on antenna 2 for each packet, with time on the x-axis. Include the plot in your solution.



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iv. Does the phase remain constant (almost) for the ratio of the channels? If yes, why? If no, why not?

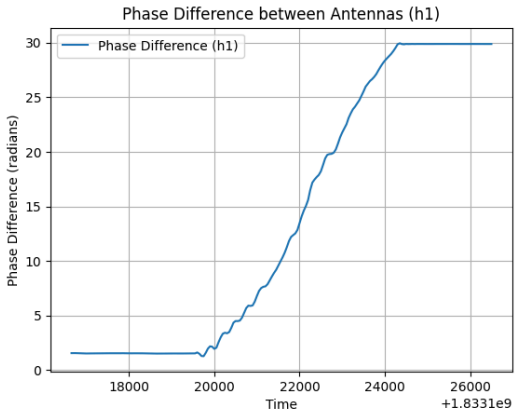
Ans. Yes, the phase remains constant for the ratio of the channels. This is because the two antennas are static. That is to say, the CFO, multipath effect, and other environment factors to these two antennas are identical, which results in the constant ratio for these two channels.

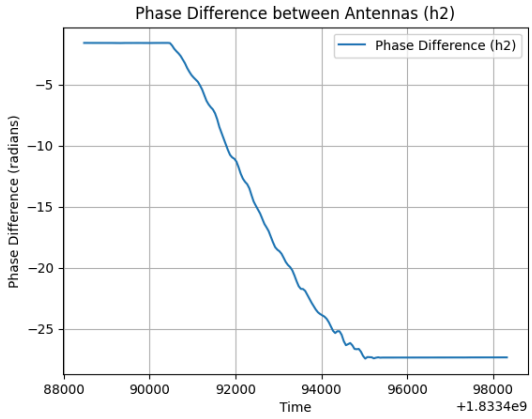
2. Let's move the antenna!

Ans. In order to determine the Roomba's motion direction based on channel measurements, we calculated the phase difference between the two antennas by using np.unwrap(np.angle(h1[:, 0] / h1[:, 1])).

Then, we use the phase difference to determine the direction that the Roomba moves. As the Roomba moves, this phase difference changes over time. If the Roomba moves from left to right, the phase at antenna 1 will change before the phase at antenna 2, causing the phase difference to increase over time. On the other hand, if the Roomba moves from right to left, the phase difference will decrease over time.

In the end, we plotted the phase differences between these two antennas. As you can see, the phase difference in h1 is increasing over time, while the phase difference in h2 is decreasing over time. That is to say, the Tx in h1 is moving from left to right, and the Tx in h2 is moving from right to left.





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3. Antenna Arrays