F-16 Capstone

Sensor Noise Analysis

5/10/2021

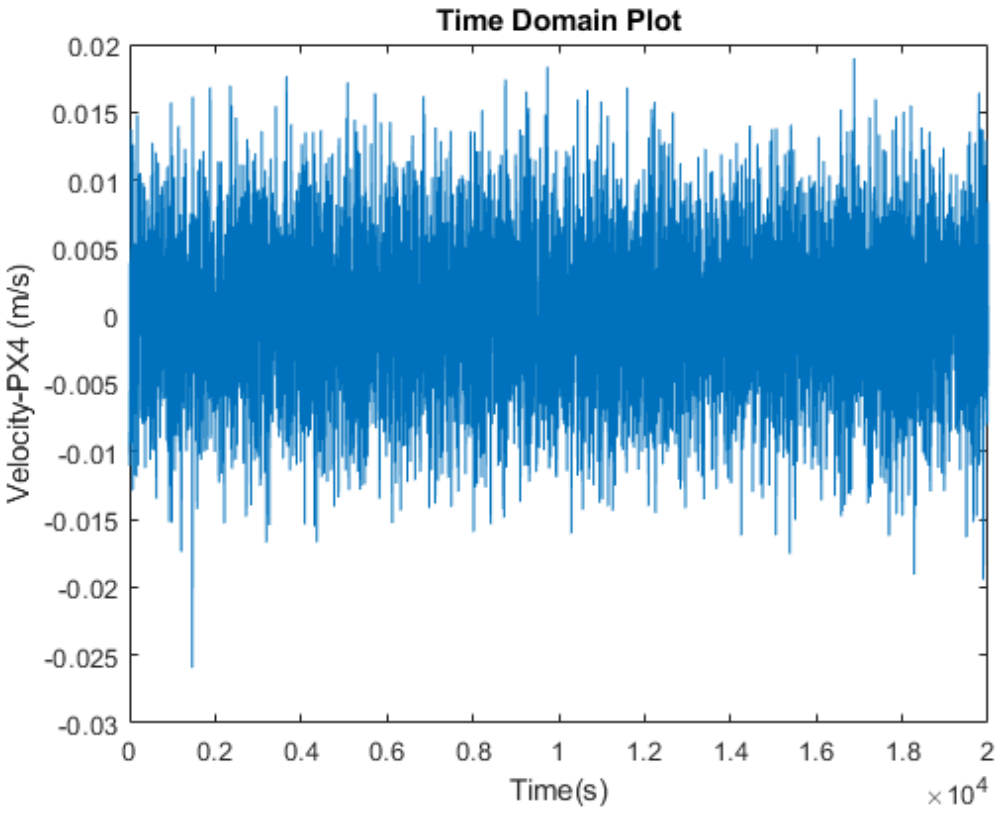
TABLE OF CONTENTS

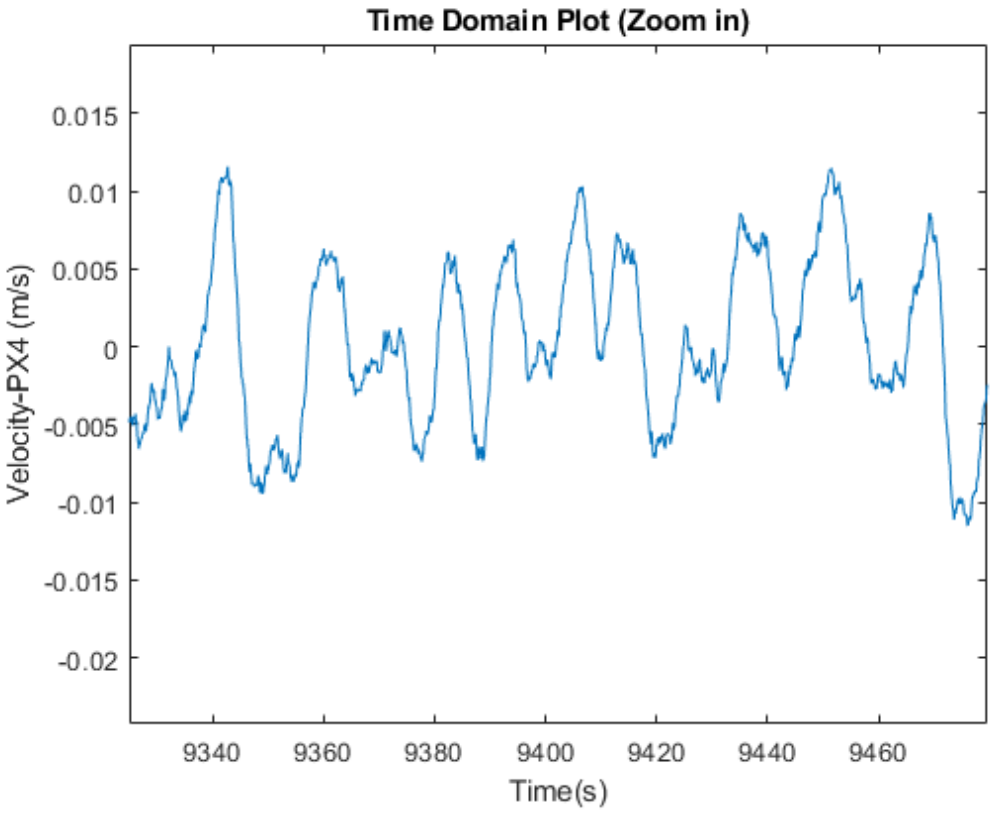
1. IMU in PX4

1.1 Velocity (PX4)

Sample frequency: 10 Hz

a. Time Domain Plot

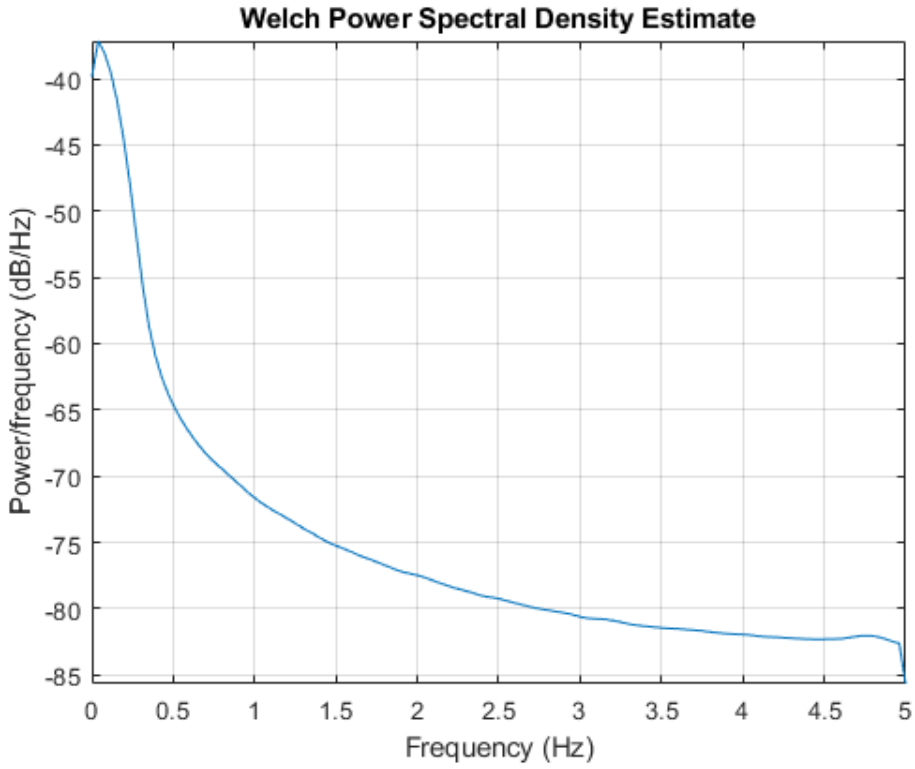




b. Mean Value and Standard Deviation

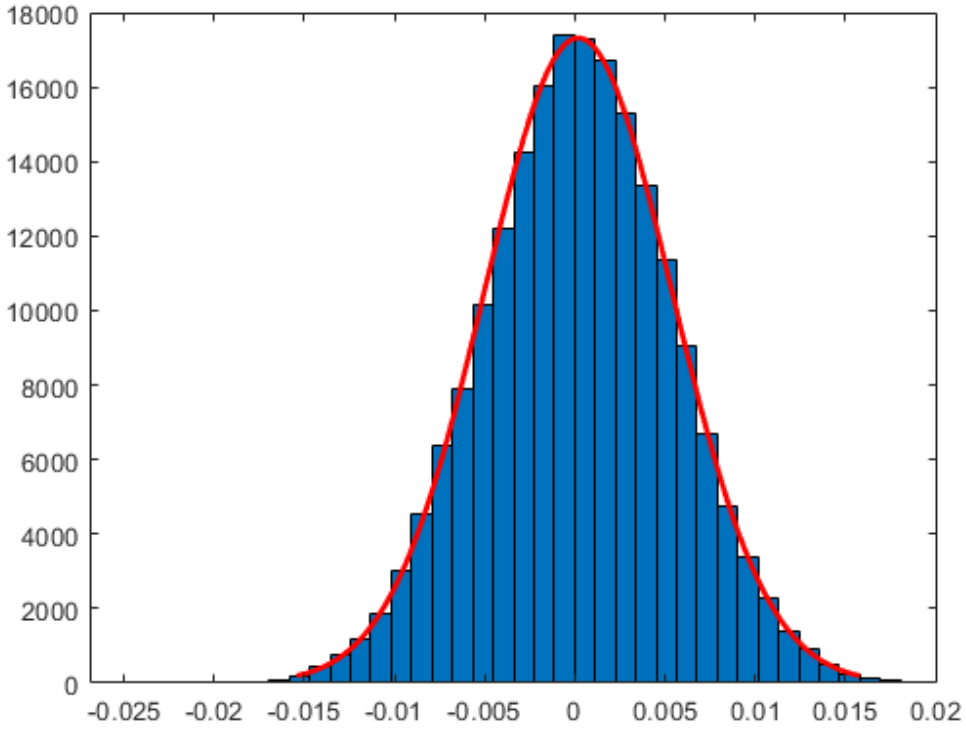
	Value
Mean Value	$-1.87*10^{-4}$ m/s
Standard Deviation	0.0054 m/s

c. Power Spectral Density Plot



It can be seen from the Time domain plot that the vibration frequency of the velocity data measured by PX4 is about f=2.5/20s=0.125Hz. It is exactly the frequency of the vertex in the PSD Plot

d. Distribution Histogram

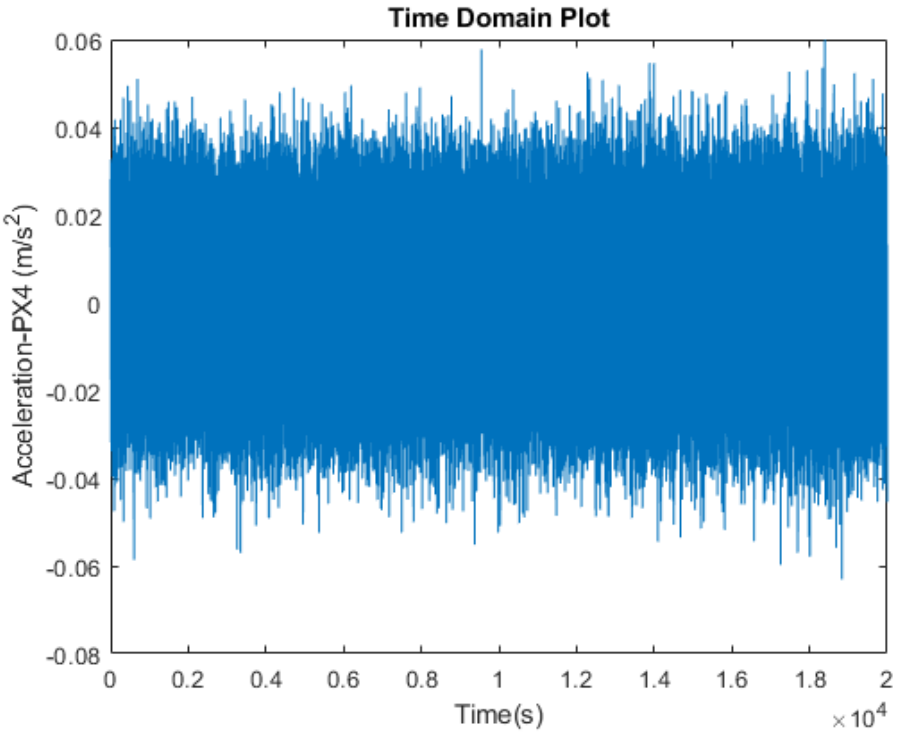


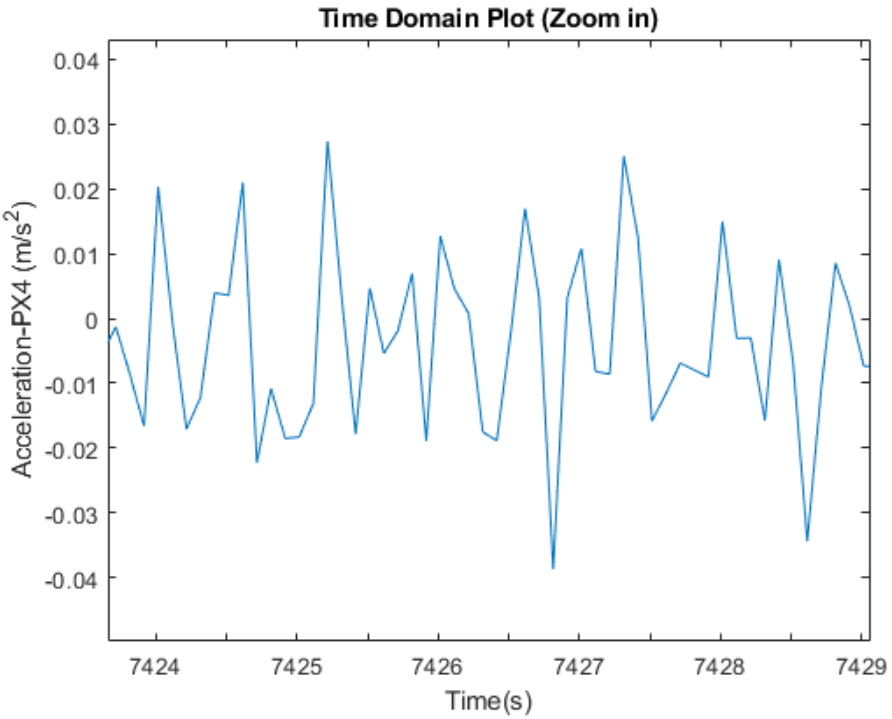
It can be seen from the distribution histogram that the data conforms to the normal distribution

1.2 Acceleration (PX4)

Sample frequency: 10 Hz

a. Time Domain Plot

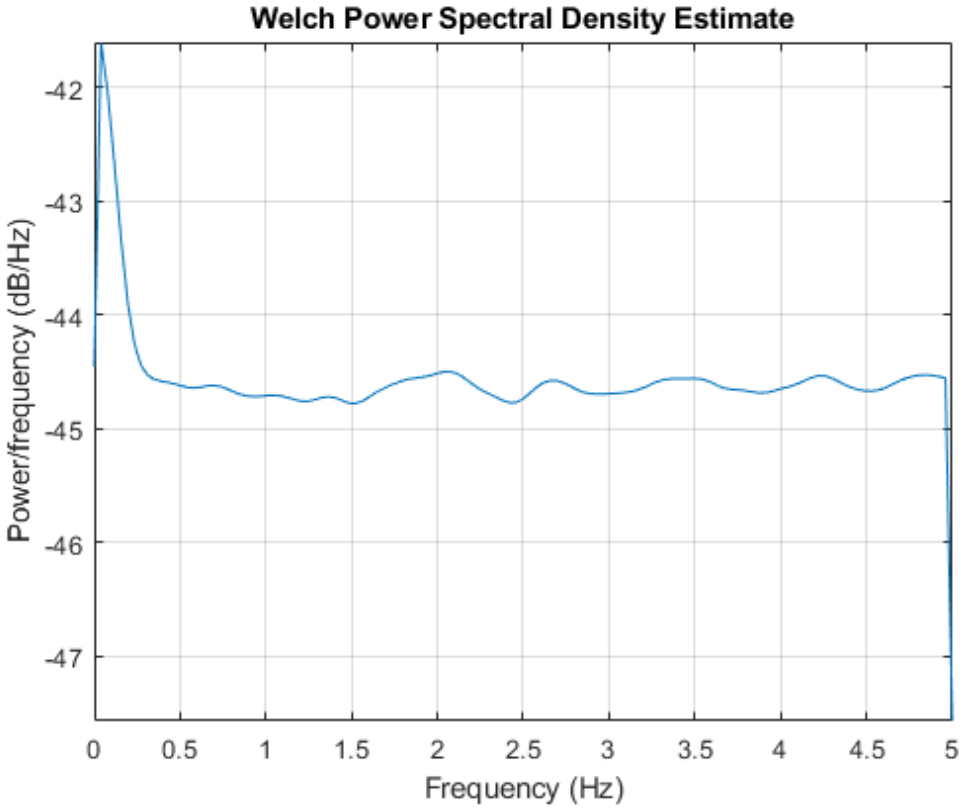




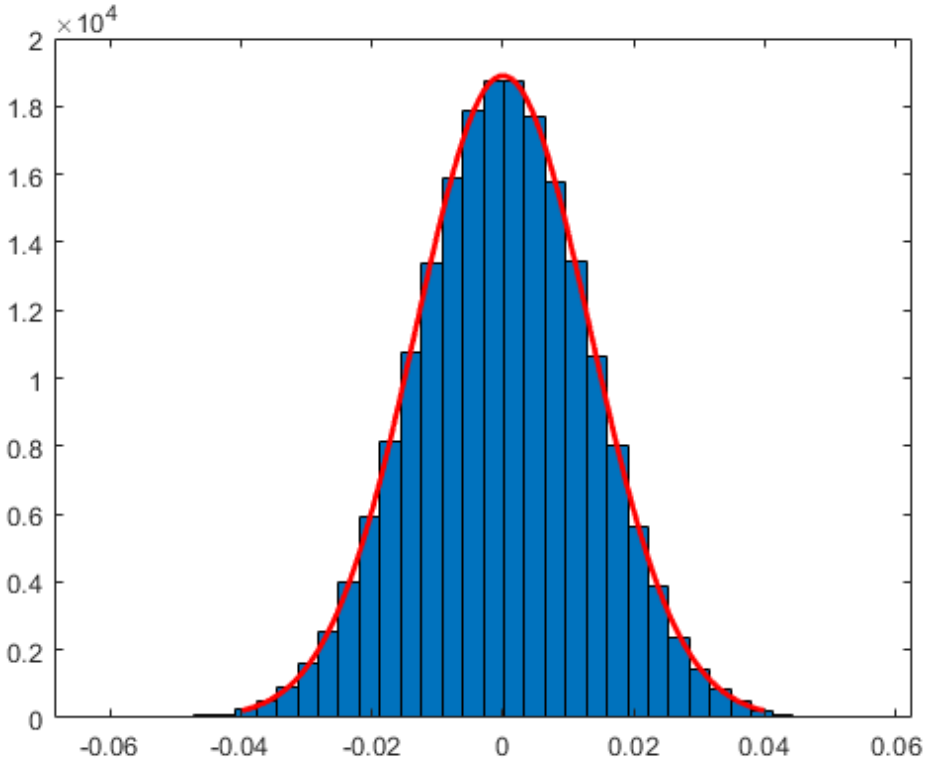
b. Mean Value and Standard Deviation

	Value
Mean Value	$-1.20*10^{-6}$ m/s^2
Standard Deviation	0.0133 m/s^2

c. Power Spectral Density Plot



d. Distribution Histogram

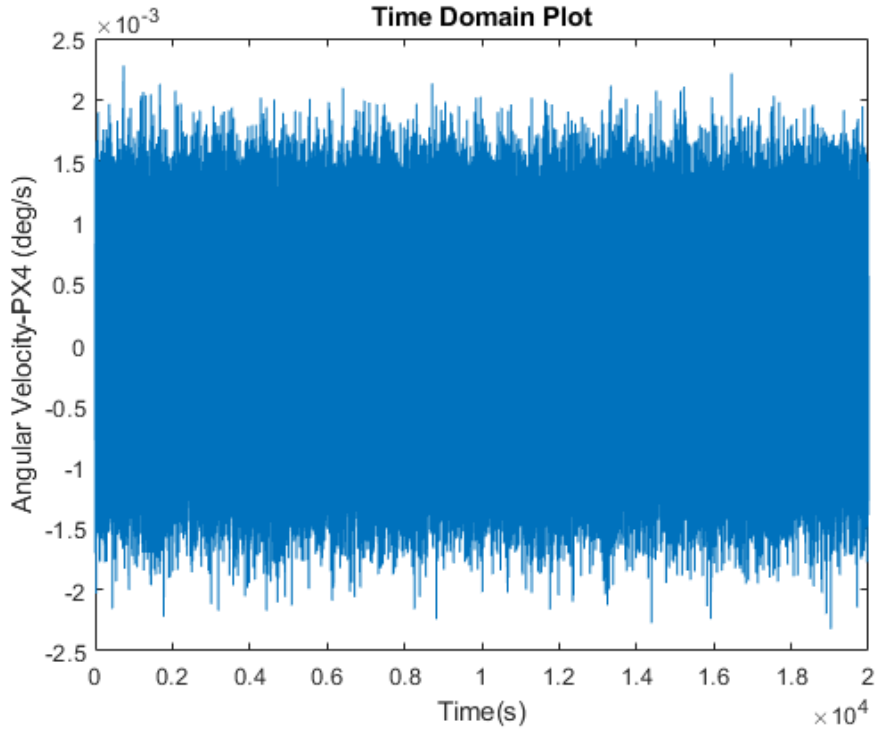


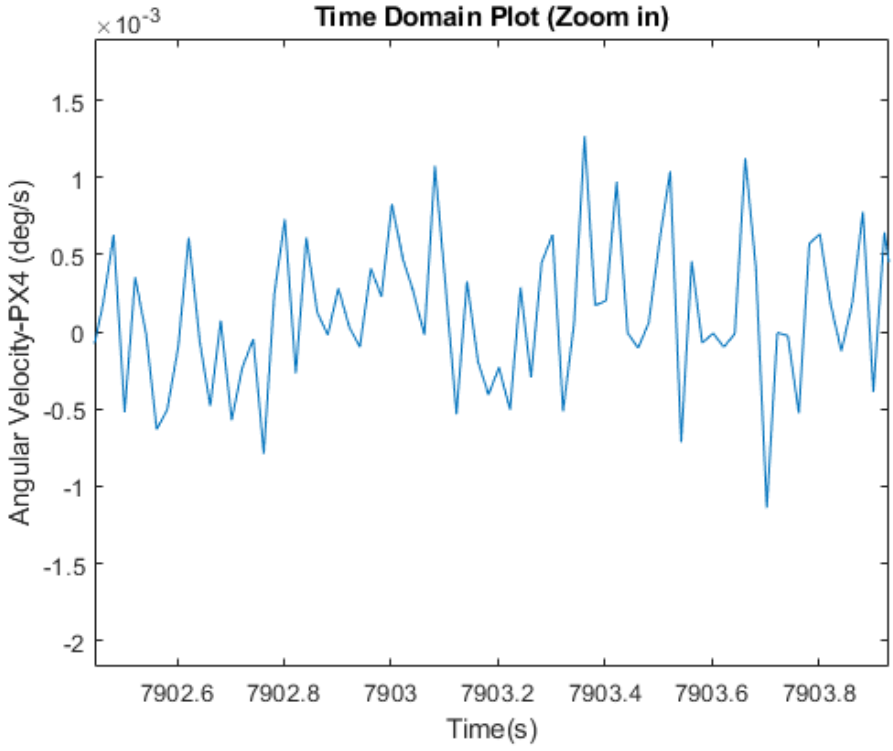
It can be seen from the distribution histogram that the data conforms to the normal distribution

1.3 Angular Velocity (PX4)

Sample frequency: 50 Hz

a. Time Domain Plot

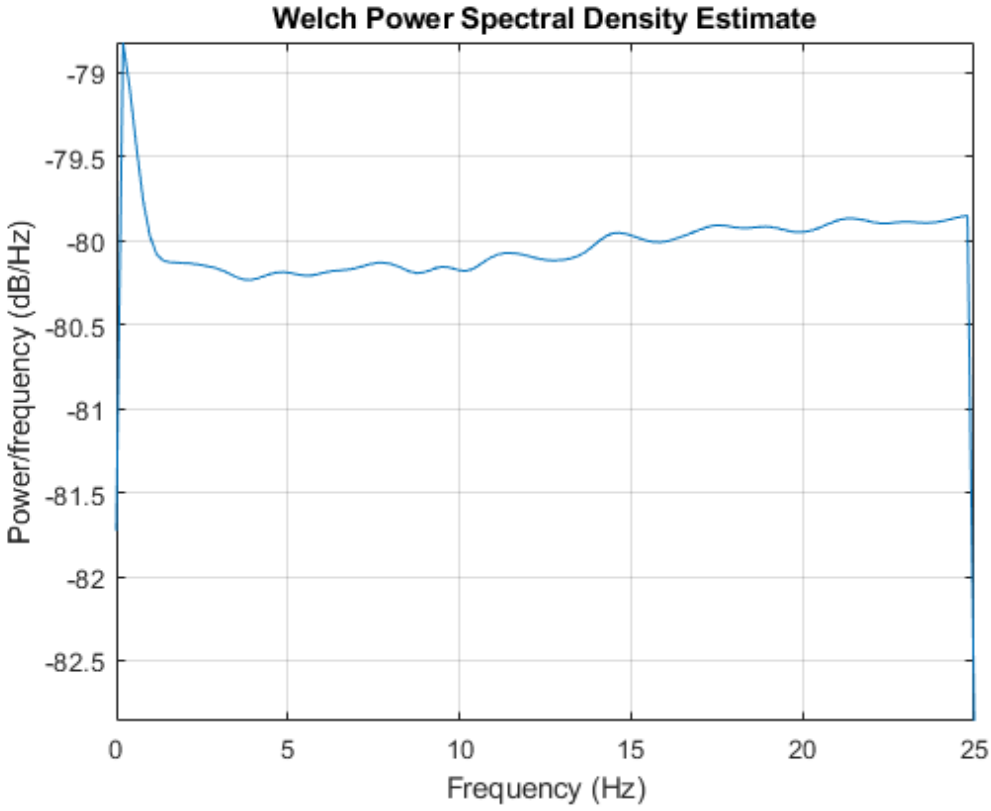




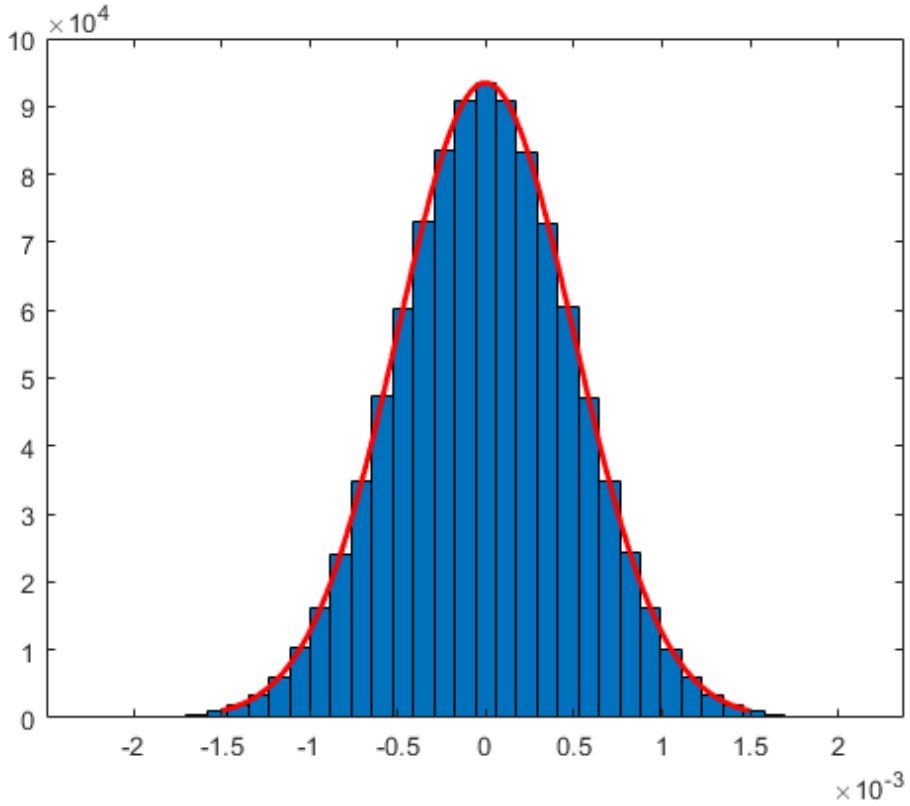
b. Mean Value and Standard Deviation

	Value
Mean Value	$-1.74*10^{-6}$ deg/s
Standard Deviation	$4.99*10^{-4}$ deg/s

c. Power Spectral Density Plot



d. Distribution Histogram



It can be seen from the distribution histogram that the data conforms to the normal distribution

Analyze and Conclusion:

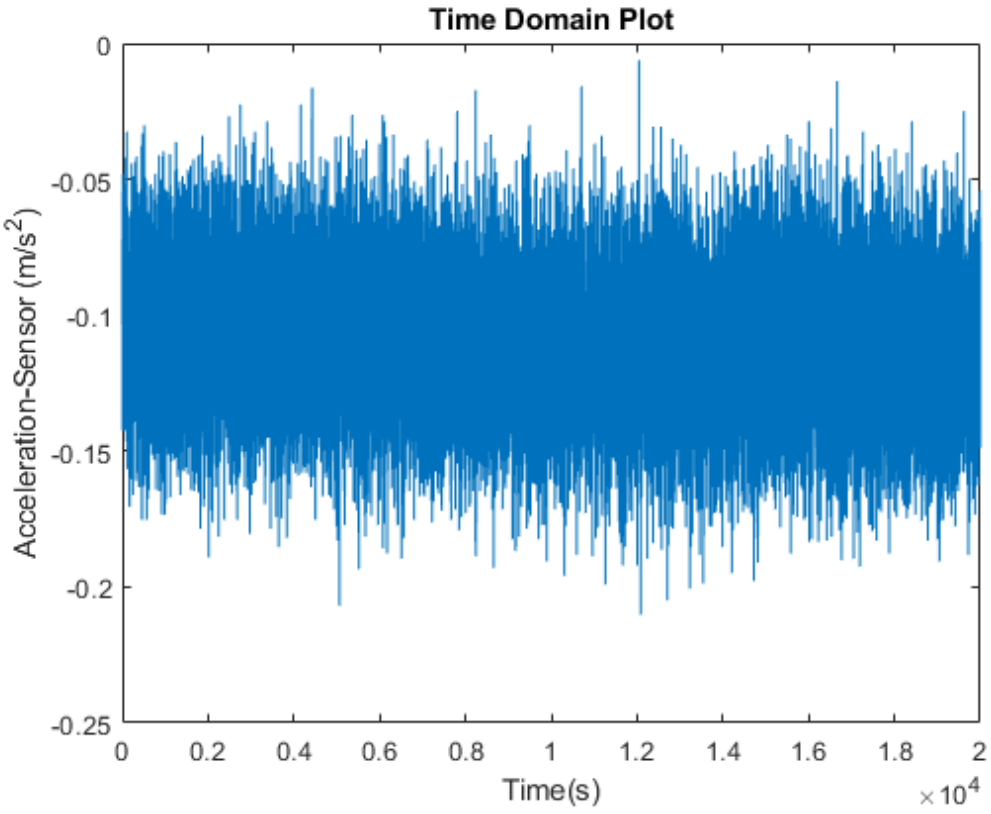
The IMU data measured by PX4 is relatively stable and the error is small, and the error can be ignored in the real flight test. This meets our requirements for the margin of error

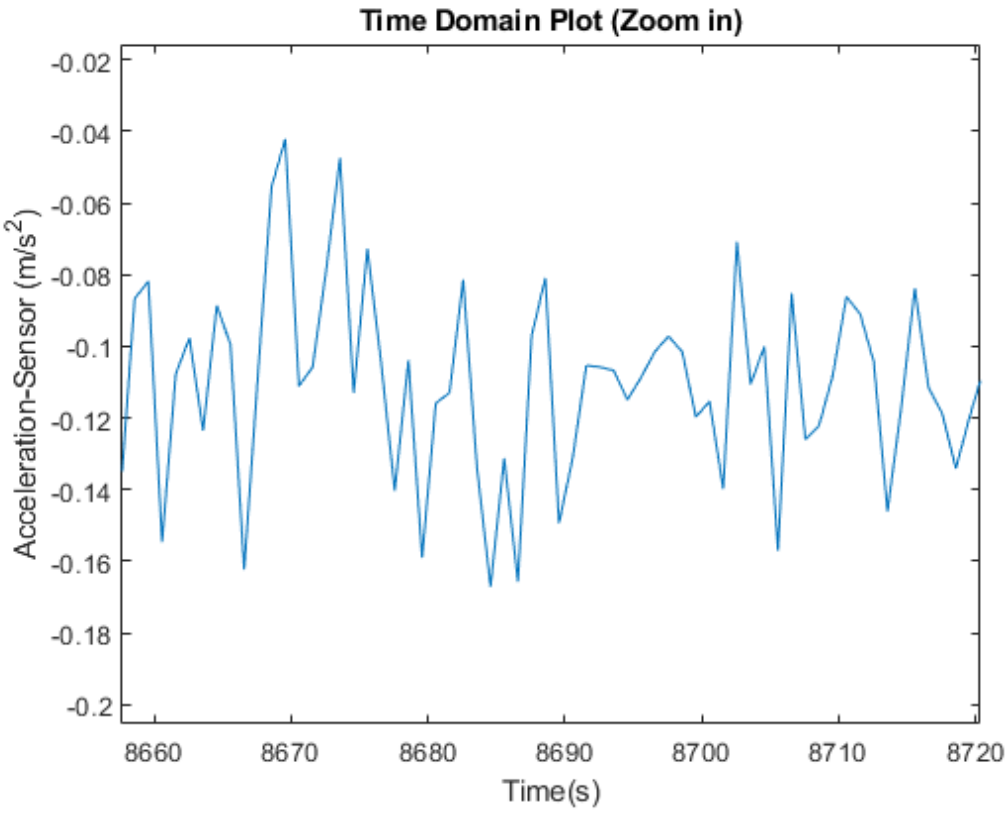
2. IMU Sensor

2.1 Acceleration (Sensor)

Sample frequency: 1 Hz

a. Time Domain Plot

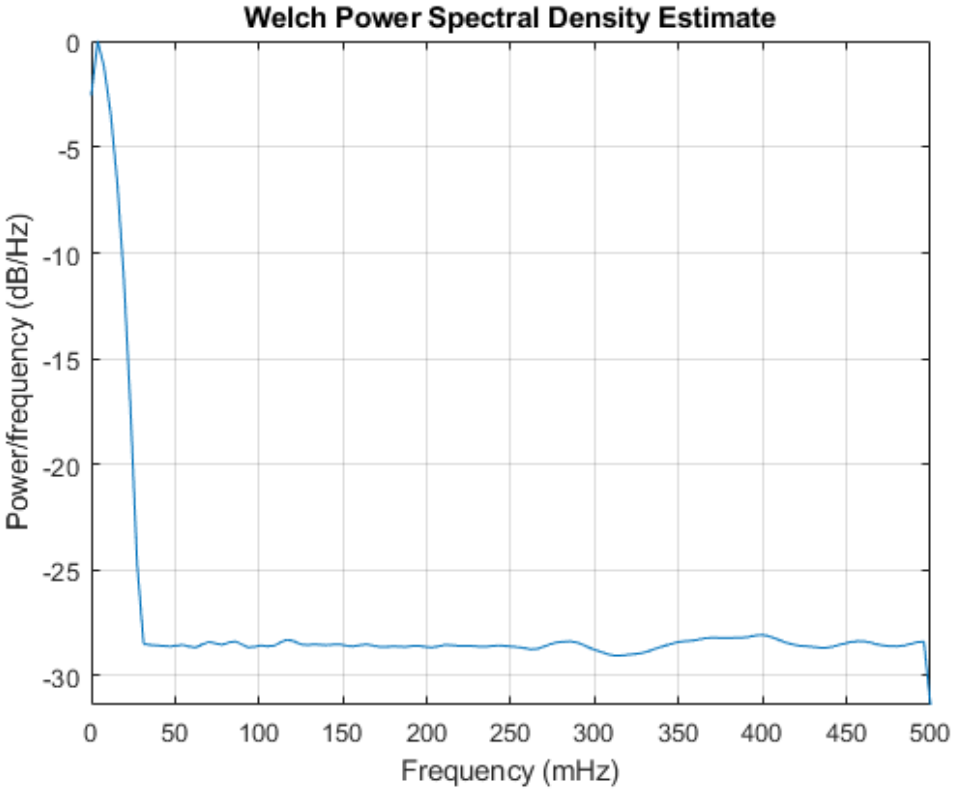




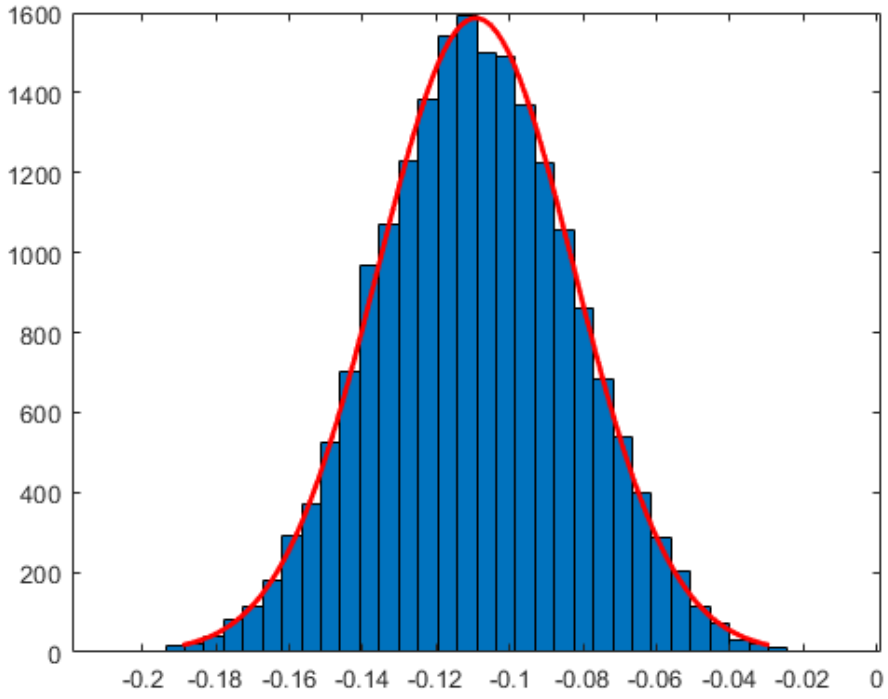
b. Mean Value and Standard Deviation

	Value
Mean Value	-0.109 m/s^2
Standard Deviation	0.0266 m/s^2

c. Power Spectral Density Plot



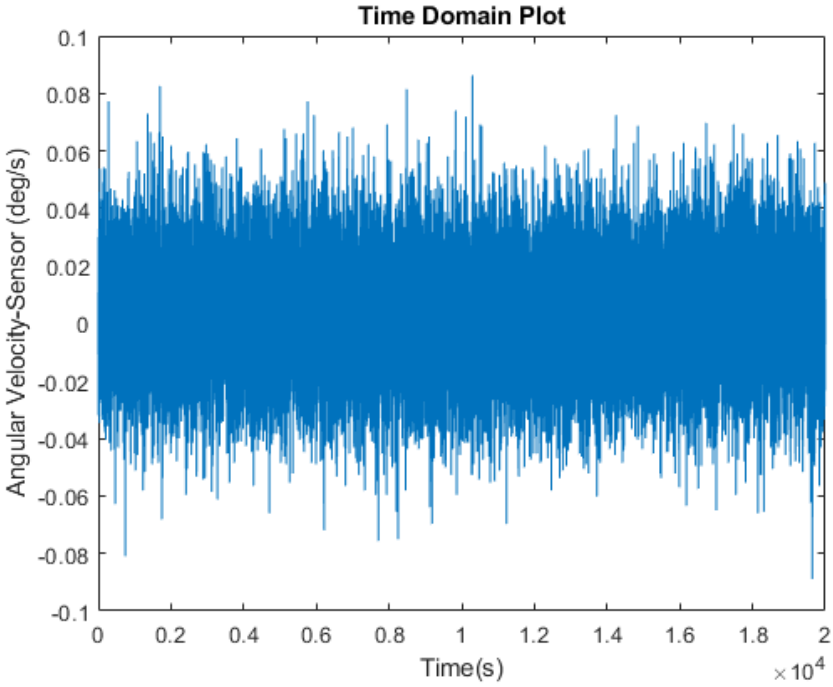
d. Distribution Histogram

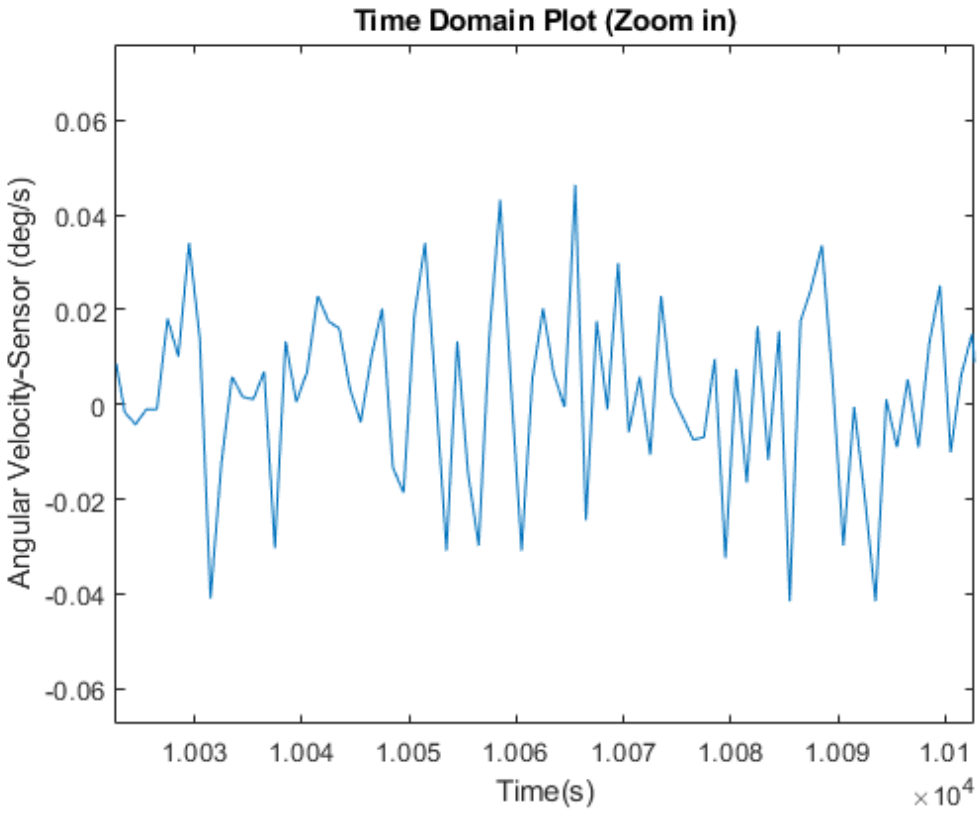


2.2 Angular Velocity (Sensor)

Sample frequency: 1 Hz

a. Time Domain Plot

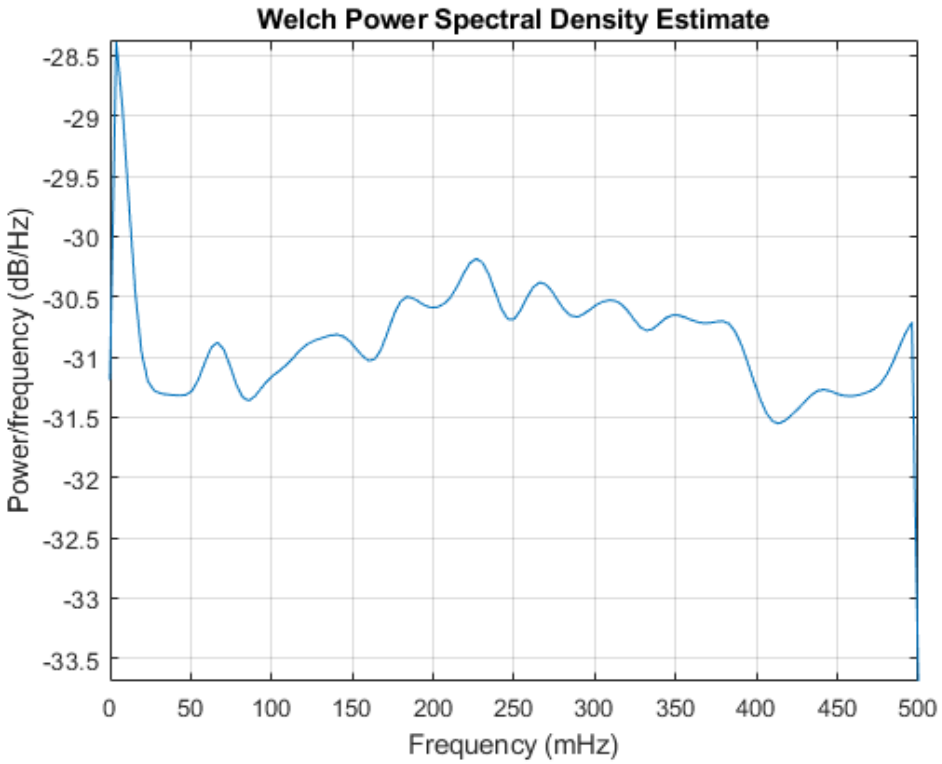




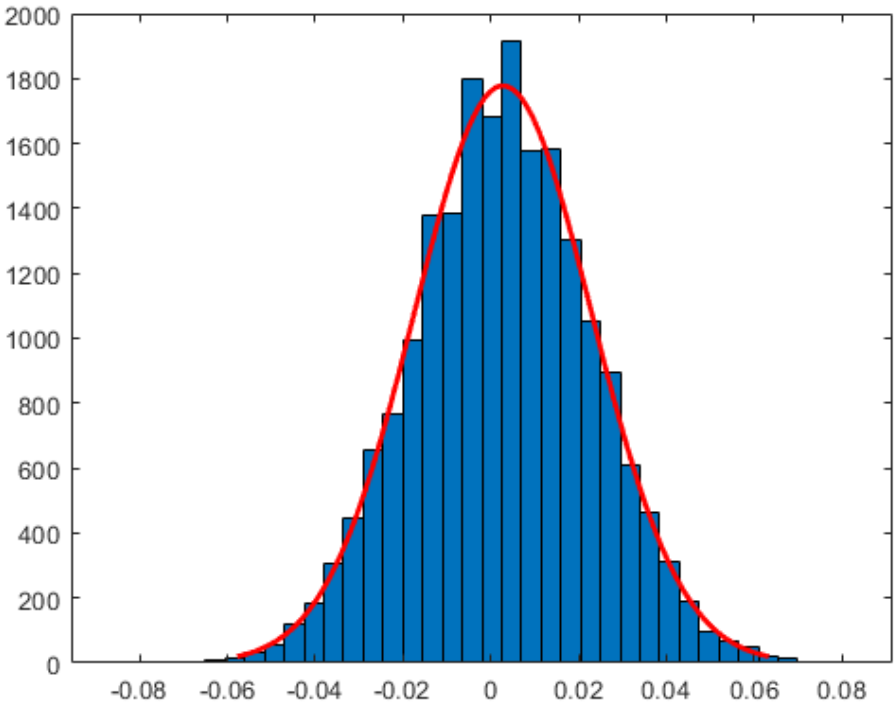
b. Mean Value and Standard Deviation

	Value
Mean Value	0.0028 deg/s
Standard Deviation	0.0202 deg/s

c. Power Spectral Density Plot



d. Distribution Histogram



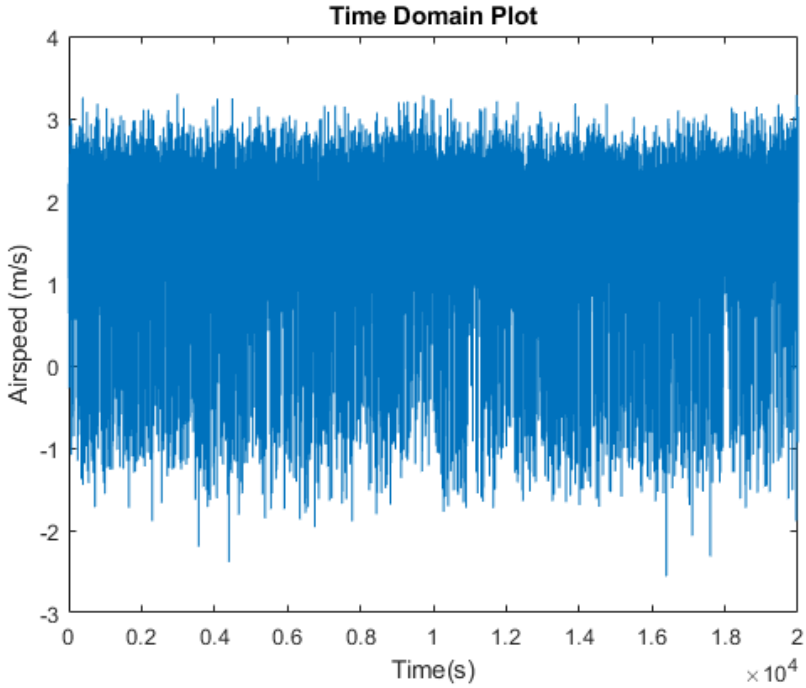
Analyze and Conclusion:

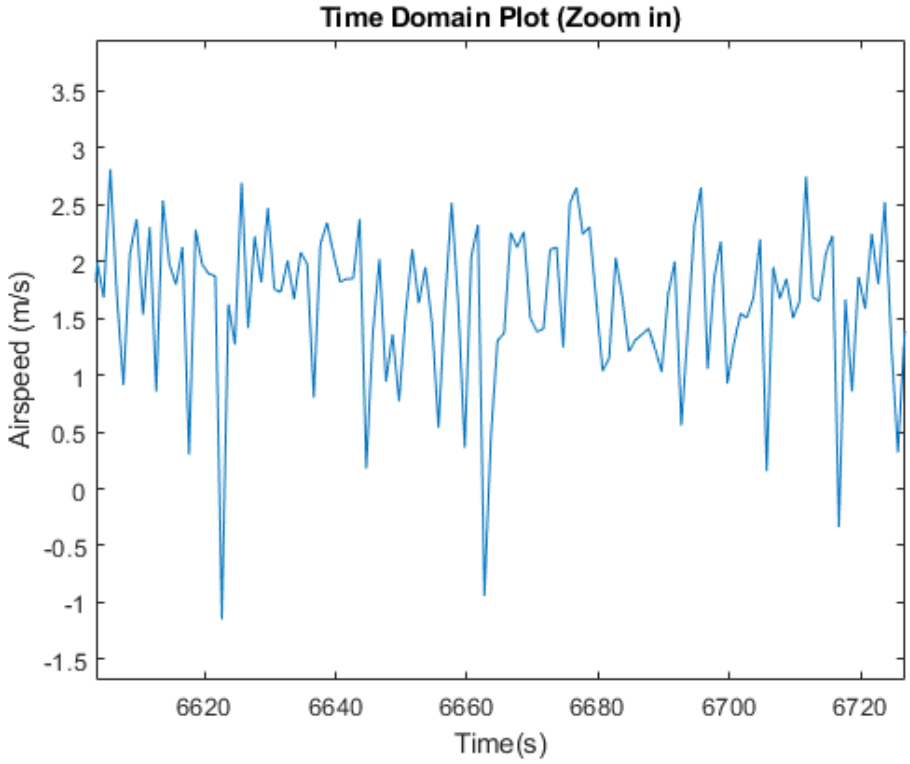
The IMU data measured by sensor (inside GPS) is not very stable. Compared with the IMU data measured by PX4, the error is larger. And the sampling frequency of The IMU data measured by sensor is 1Hz, which is not suitable for analysis. So it is recommended to only use the IMU data measured by the sensor as a reference. Or as a backup in emergency situations.

3. Airspeed

Sample frequency: 1 Hz

a. Time Domain Plot

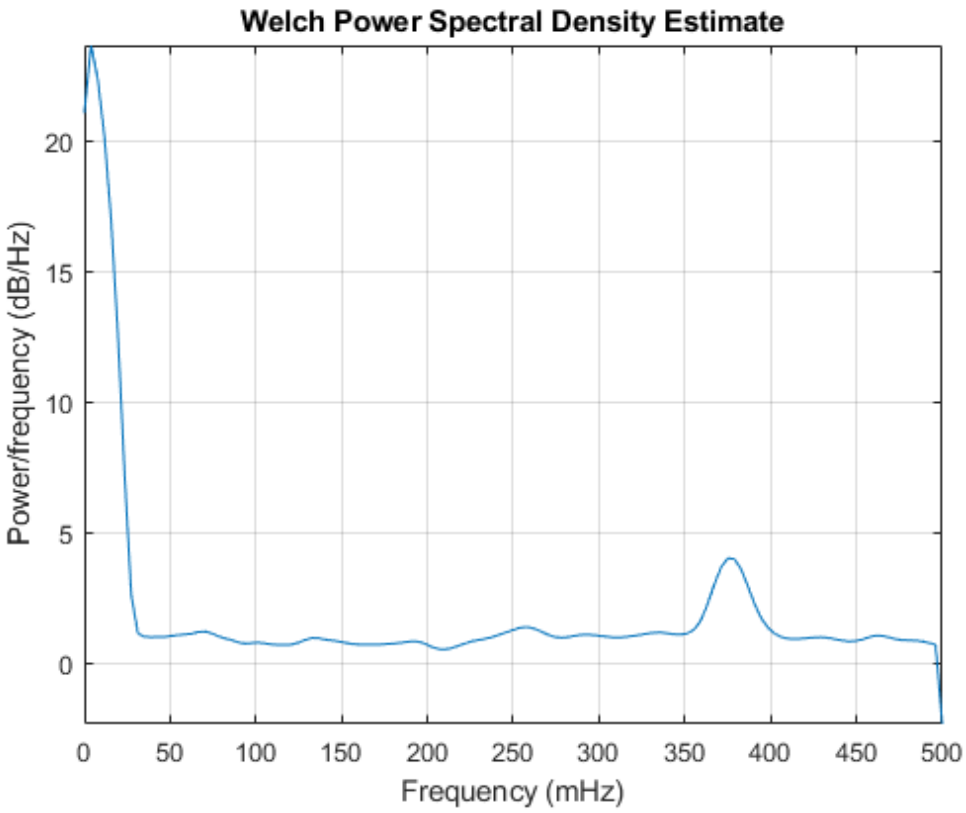




b. Mean Value and Standard Deviation

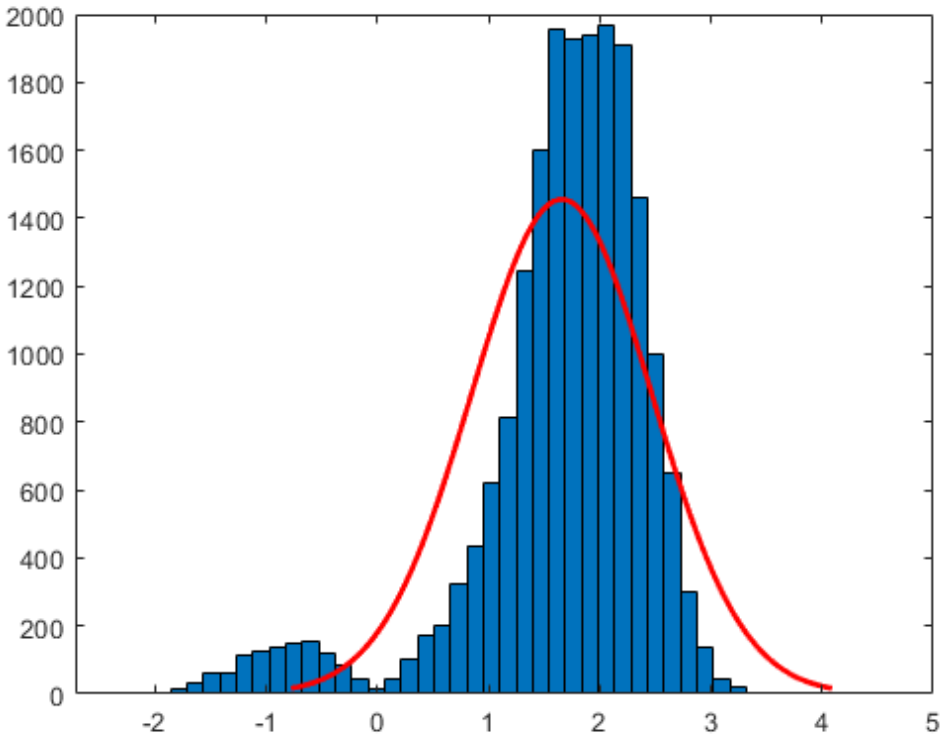
	Value
Mean Value	1.657 m/s
Standard Deviation	0.811 m/s

c. Power Spectral Density Plot



In the PSD plot, there is a higher amplitude when the frequency is about 0.375Hz. It also can be seen from the Time domain plot that the vibration frequency of the velocity data measured by PX4 is about f=7.5/20s=0.375Hz.

d. Distribution Histogram



Analysis and Conclusion

The airspeed sensor is actually a pressure sensor, which calculates the relative airspeed based on the pressure difference after measuring the dynamic air pressure and the static air pressure. In the error analysis, we can calculate the pressure error measured by the pressure sensor at the static state to get the error range in actual flight.

The dynamic air pressure equation is:

$$P=0.5*\rho*v^2$$

Assuming that the air density ρ is 1.225kg/m^3. From the zero-state airspeed Time **Domain** Plot, we can get the maximum airspeed v measured by the airspeed sensor is

about 3.2m/s. Therefore, the maximum error of the pressure difference measured by the pressure sensor can be calculated as: $P_e=0.5*1.225*3.2^2 = 6.272Pa$.

Assuming that the airspeed of the RC model in real flight is 20m/s, then the theoretical dynamic air pressure at that time is $P=0.5*\rho*v^2 =0.5*1.225*20^2= 245Pa$. And the maximum relative error is P_e/P =6.272/245 =2.6%.

This 2.6% error range is reasonable and completely smaller than the 15% error range we require.