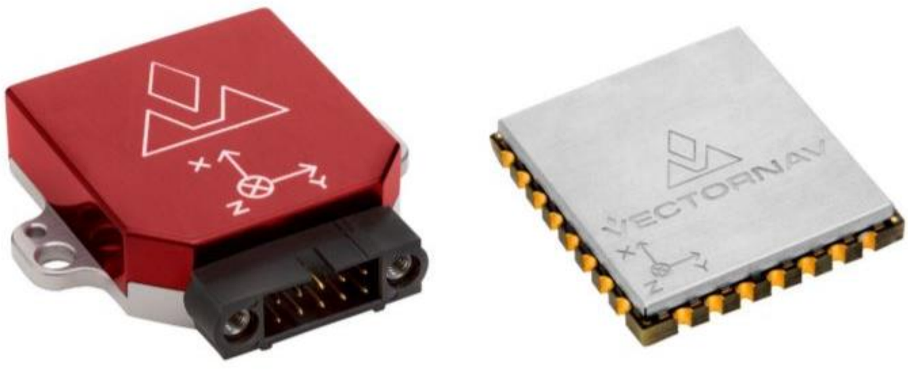
EECE 5554 Robotics Sensing and Navigation LAB 3

IMU Data Analysis by: Arvinder Singh



Description

Analysis of IMU data (Orientation, Magnetic Field, Gyro and Acceleration) for 2 cases-

1) Time series for 15 Minutes data
2) Alan Variance for 5 hours of data

The data is collected in the basement of West Village F.

15 Minutes Data Analysis

The IMU data obtained is plotted for Orientation (X, Y, Z), Gyro (X, Y, Z), Acceleration (X, Y, Z) and Magnetic Field (X, Y. Z) using matplotlib. Pandas is used to convert the rosbag data into a data frame. The custom message has orientation in quaternions which are then converted back into roll, pitch and yaw (Degree), and then plotted against time. The mean and standard deviation are also calculated for all the time series.

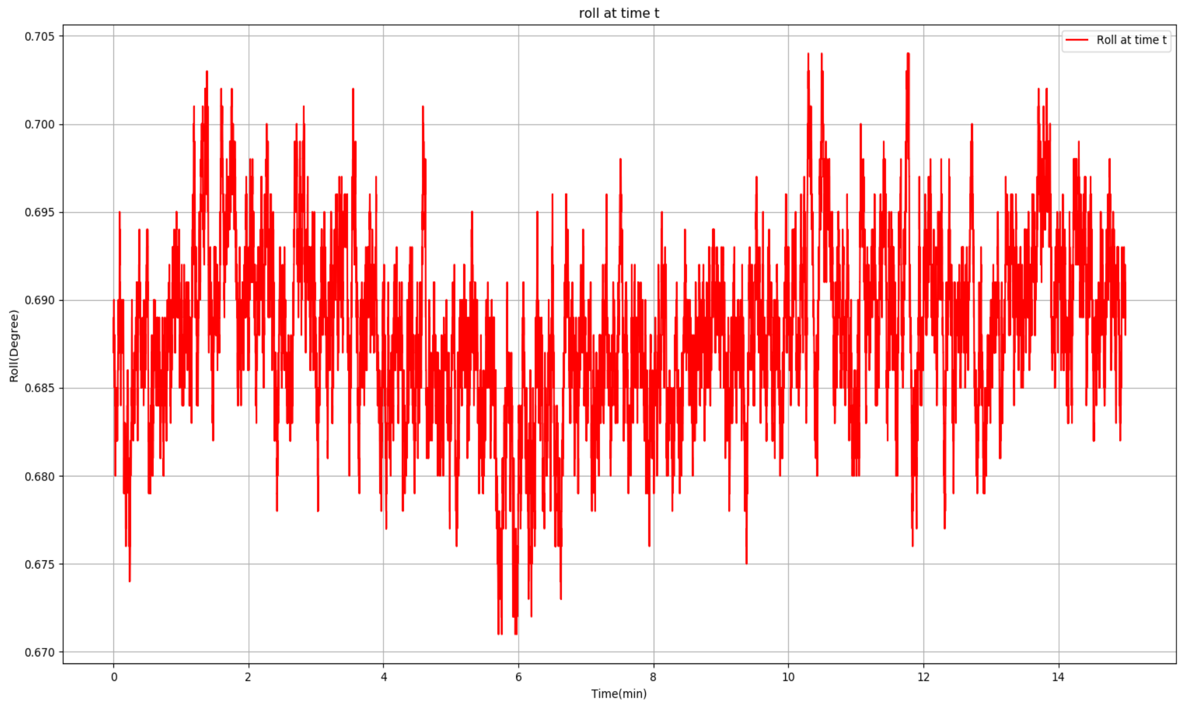
Orientation:

1. **Roll:** Below is the Mean and standard deviation for Roll data

```
Roll Mean = 0.6882026230965835 degree
```

```
Roll Std. Deviation = 0.00491528385237544 degree
```

Time-Series graph for Roll data

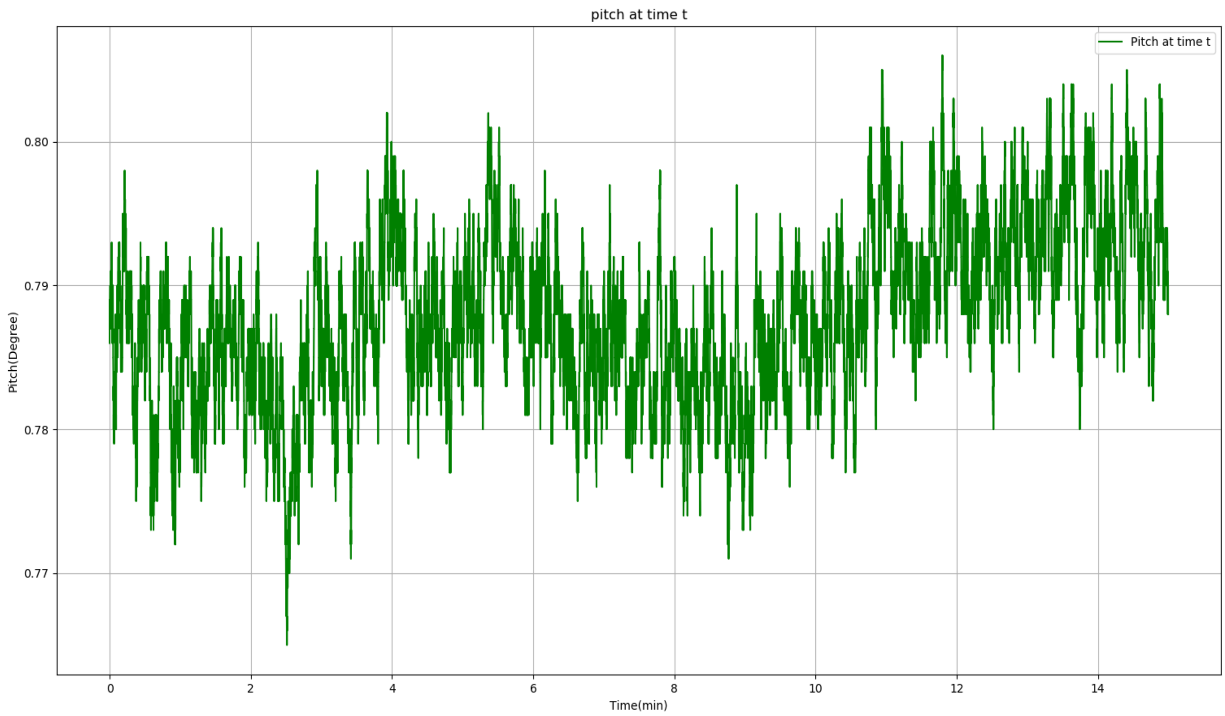


2. **Pitch:** Below is the Mean and standard deviation for Pitch data

Pitch Mean = 0.7877599477603577 degree

Pitch Std. Deviation = 0.005820589935678012 degree

Time-Series graph for Pitch data

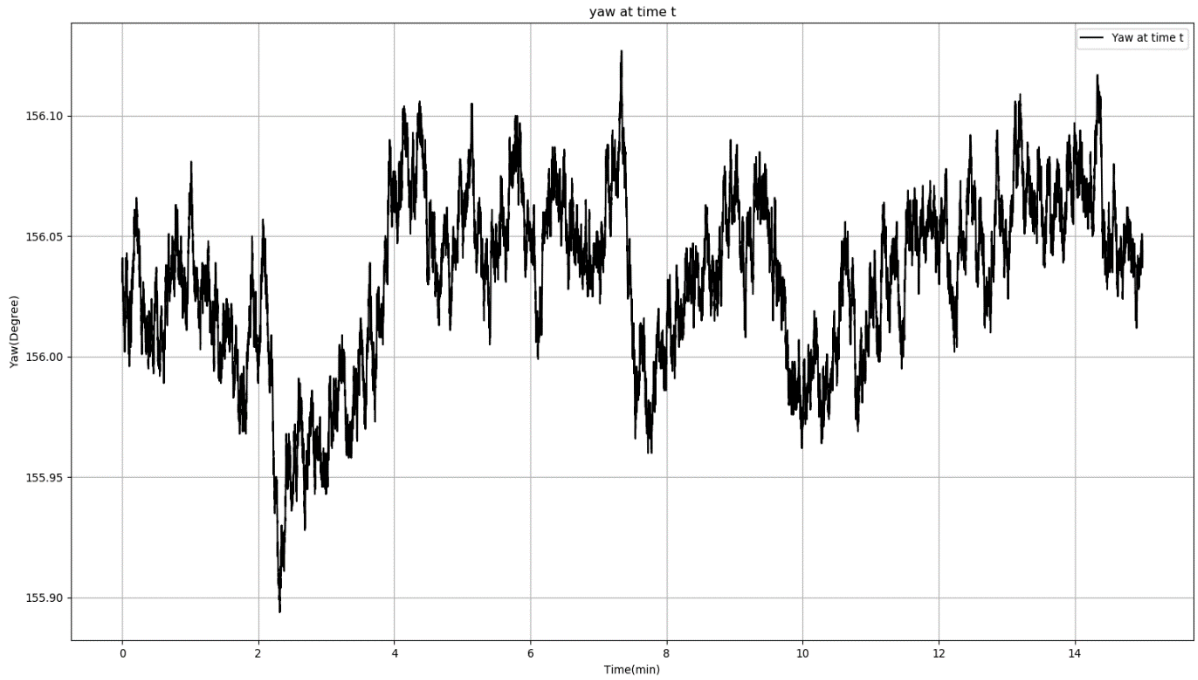


3. **Yaw:** Below is the Mean and standard deviation for Yaw data

```
Yaw Mean =  156.03229001333779 degree
```

```
Yaw Std. Deviation =  0.03591195785997525 degree
```

Time-Series graph for Yaw data



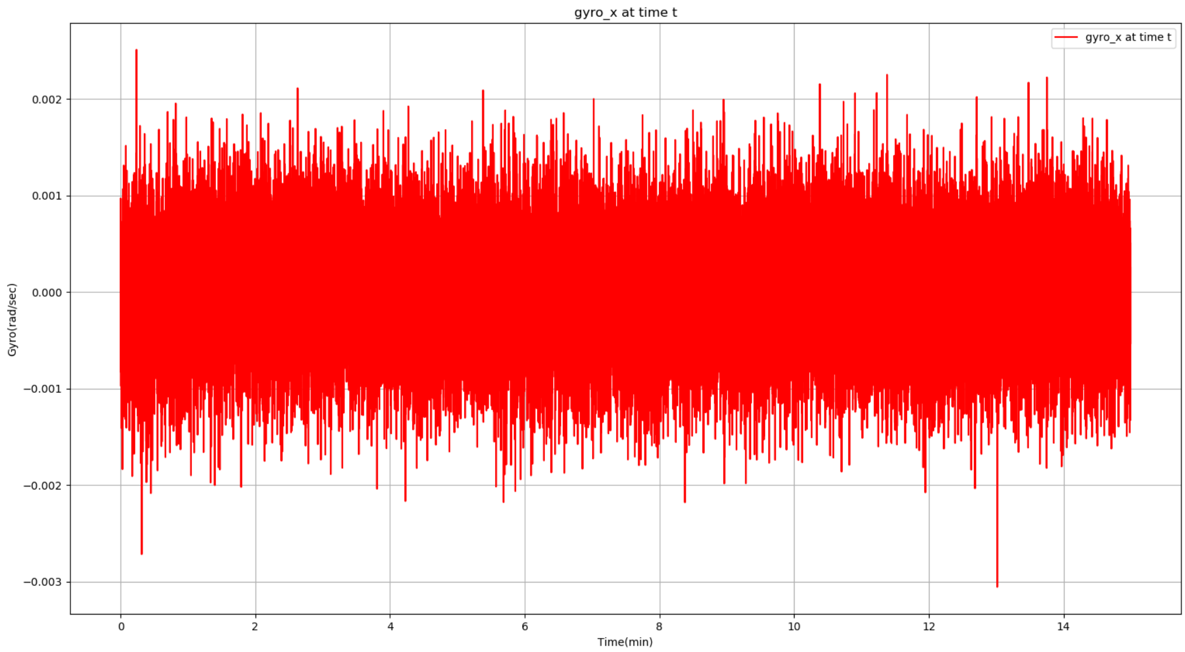
<u>**Gyro:**</u>

1. <u>**Gyro X:**</u> Below is the Mean and standard deviation for Gyro X data

```
Gyro X Mean = -3.2916527731466146e-07 rad/sec
```

```
Gyro X Std. Deviation = 0.0005794148743791399 rad/sec
```

Time-Series graph for Gyro X data

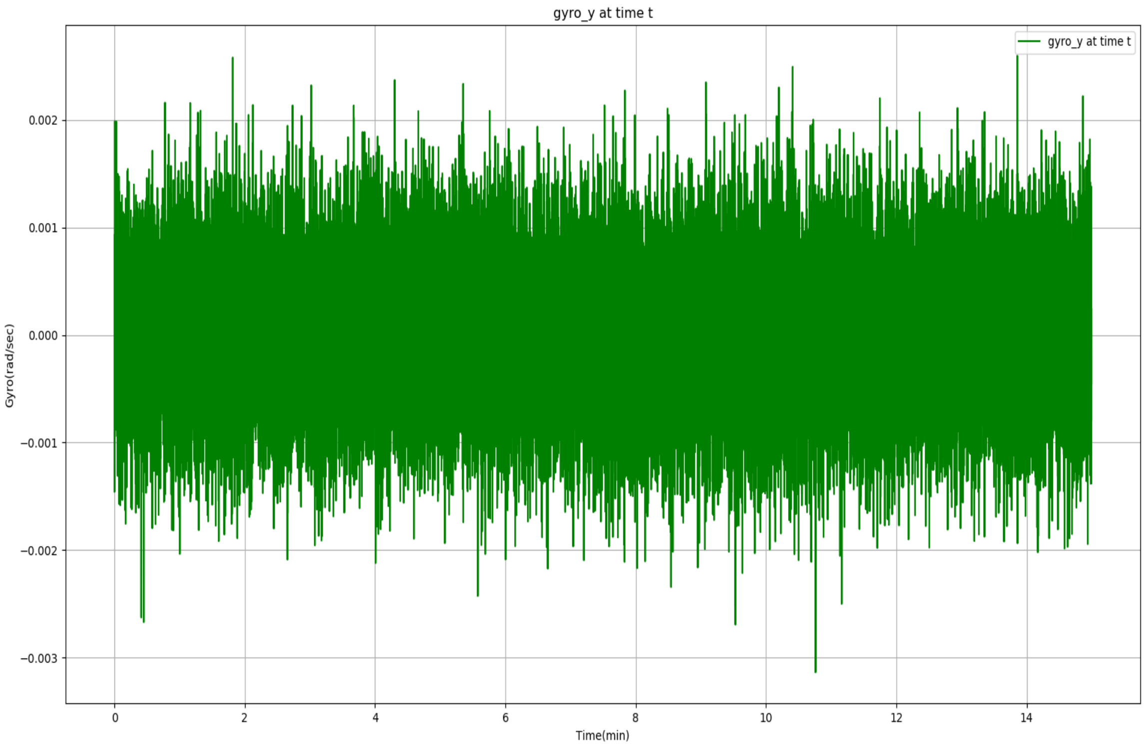


2. **<u>Gyro Y:</u>** Below is the Mean and standard deviation for Gyro Y data:

```
Gyro Y Mean =  1.429484828276092e-05 rad/sec
```

```
Gyro Y Std. Deviation =  0.0006302742721299171 rad/sec
```

Time-Series graph for Gyro Y data

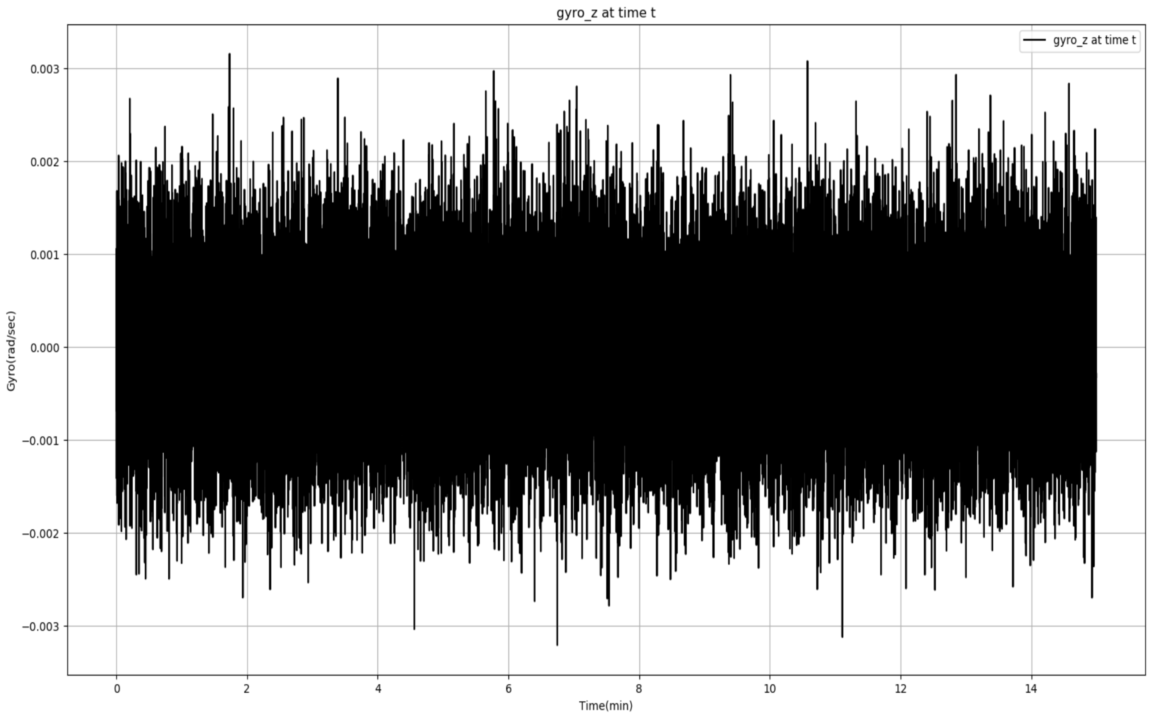


3. **<u>Gyro Z:</u>** Below is the Mean and standard deviation for Gyro Z data:

```
Gyro Z Mean =  -8.670417917083474e-06 rad/sec
```

```
Gyro Z Std. Deviation =  0.0007641305582428205 rad/sec
```

Time-Series graph for Gyro Z data



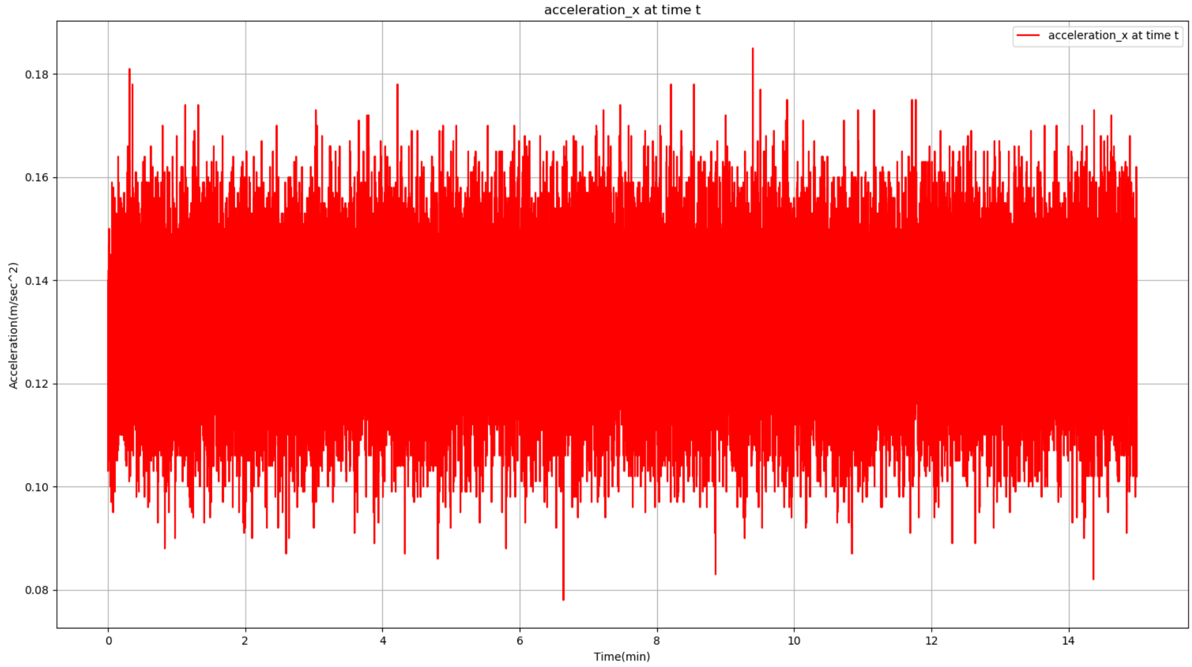
<u>Acceleration:</u>

1. **<u>Acceleration X:</u>** Below is the Mean and standard deviation for 1. Acceleration X data:

```
Acceleration X Mean = 0.13134742136267646 m/sec^2
```

```
Acceleration X Std. Deviation = 0.012537978751851668 m/sec^2
```

Time-Series graph for Acceleration X data

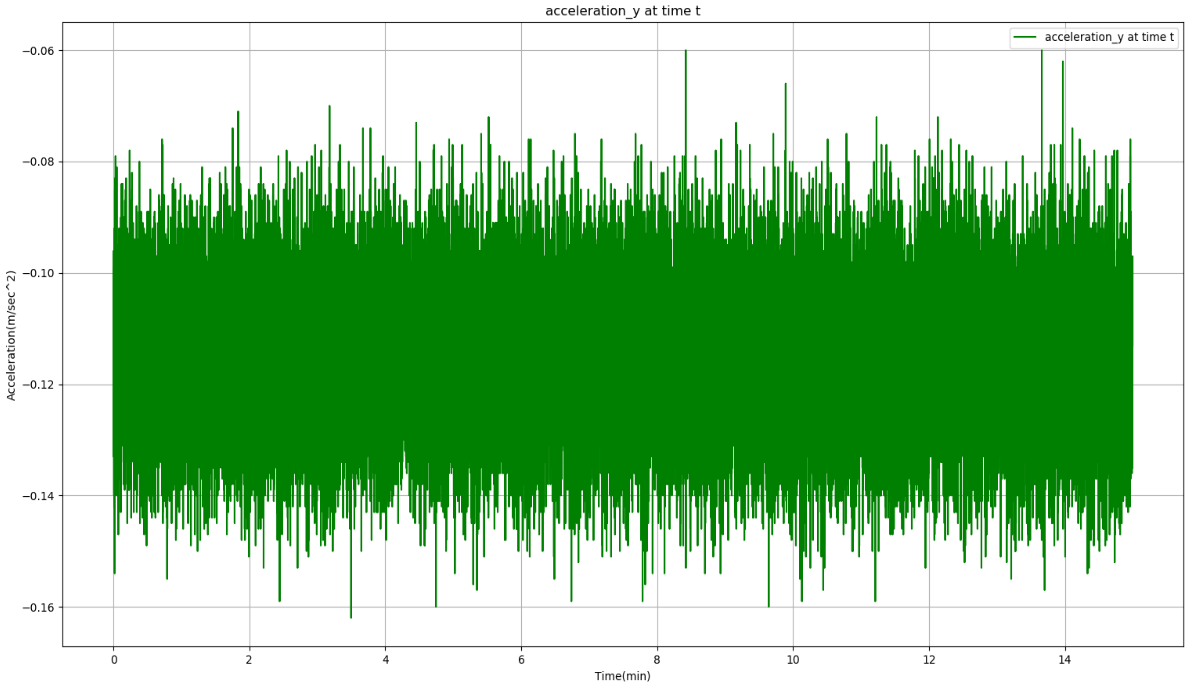


2. **<u>Acceleration Y:</u>** Below is the Mean and standard deviation for 1. Acceleration Y data:

```
Acceleration Y Mean =  -0.1148470045570746 m/sec^2
```

```
Acceleration Y Std. Deviation =  0.012198203370945977 m/sec^2
```

Time-Series graph for Acceleration Y data

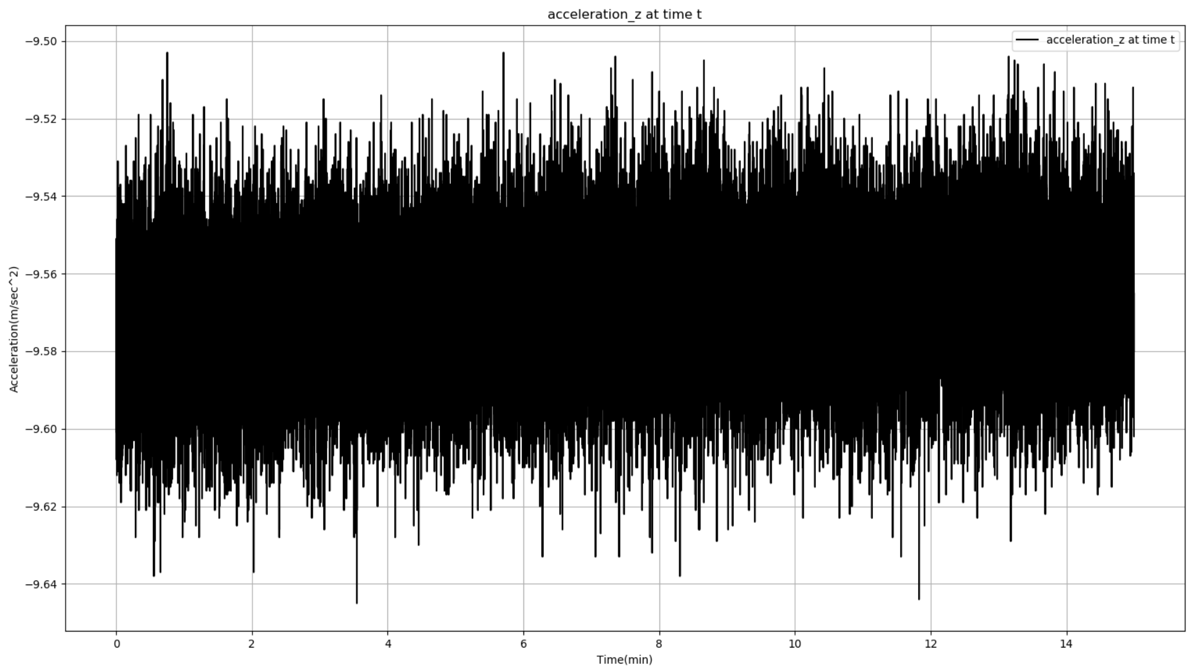


3. **<u>Acceleration Z:</u>** Below is the Mean and standard deviation for Acceleration Z data:

```
Acceleration Z Mean =  -9.568762226297656 m/sec^2
```

```
Acceleration Z Std. Deviation =  0.017530138607317704 m/sec^2
```

Time-Series graph for Acceleration Z data



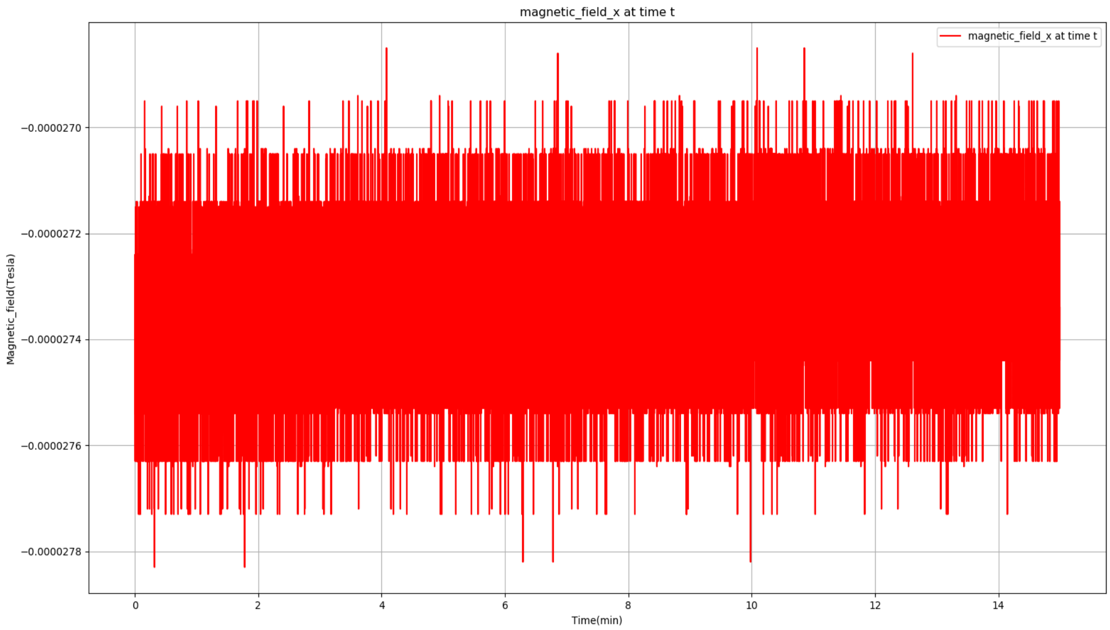
<u>Magnetic Field:</u>

1. **Magnetic Field X**: Below is the Mean and standard deviation for Magnetic Field X data:

```
Magnetic field X Mean = -2.732853645659664e-05 Tesla
```

```
Magnetic field X Std. Deviation = 1.2644098869257612e-07 Tesla
```

Time-Series graph for **Magnetic Field X** data

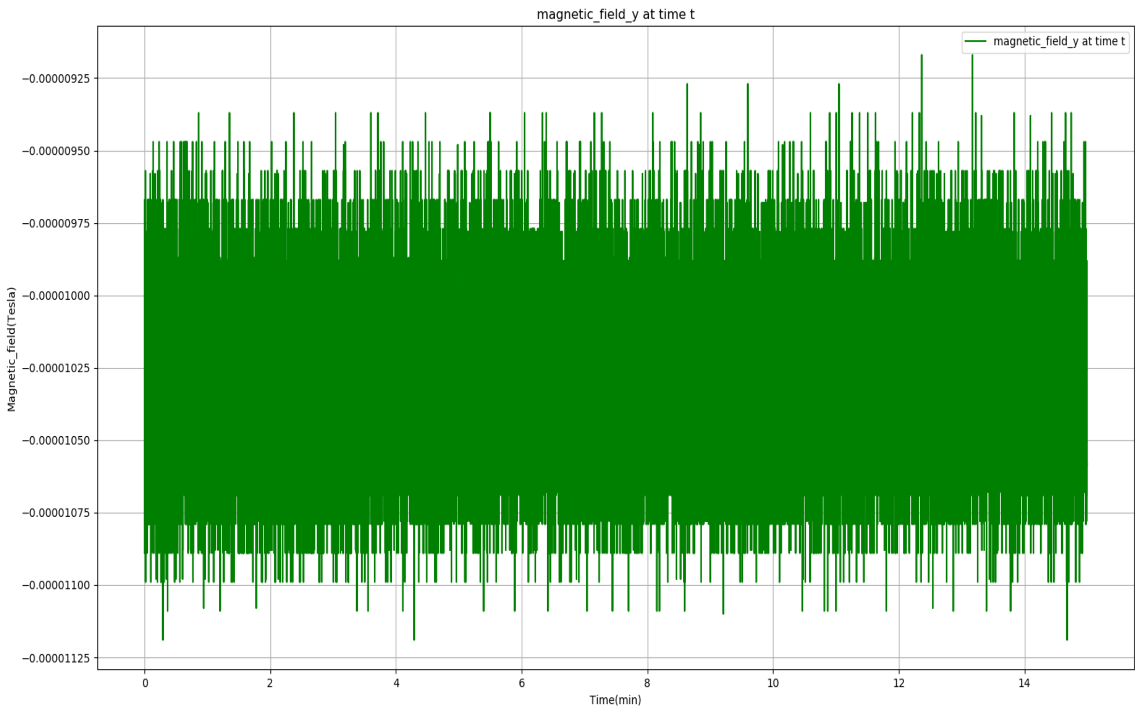


2. **Magnetic Field Y**: Below is the Mean and standard deviation for Magnetic Field Y data:

```
Magnetic field Y Mean =  -1.0333180226742248e-05 Tesla
```

```
Magnetic field Y Std. Deviation =  2.780948729454677e-07 Tesla
```

Time-Series graph for **Magnetic Field Y** data

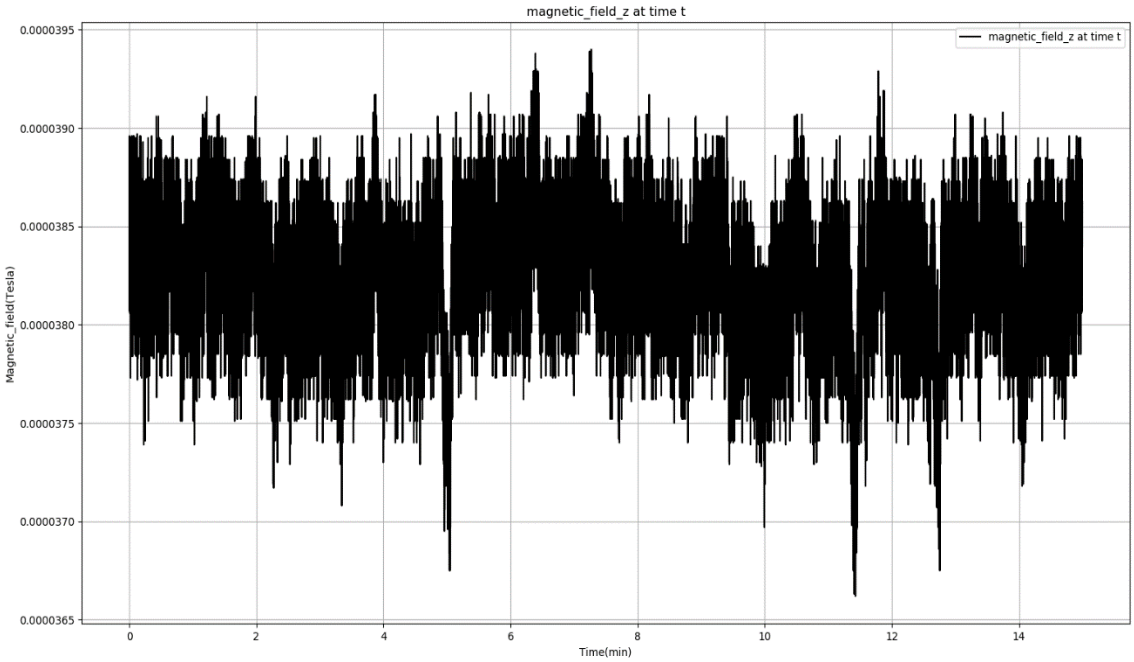


3. **Magnetic Field Z**: Below is the Mean and standard deviation for Magnetic Field Z data:

```
Magnetic field Z Mean =  3.826814465933089e-05 Tesla
```

```
Magnetic field Z Std. Deviation =  3.162990148565433e-07 Tesla
```

Time-Series graph for **Magnetic Field Z** data



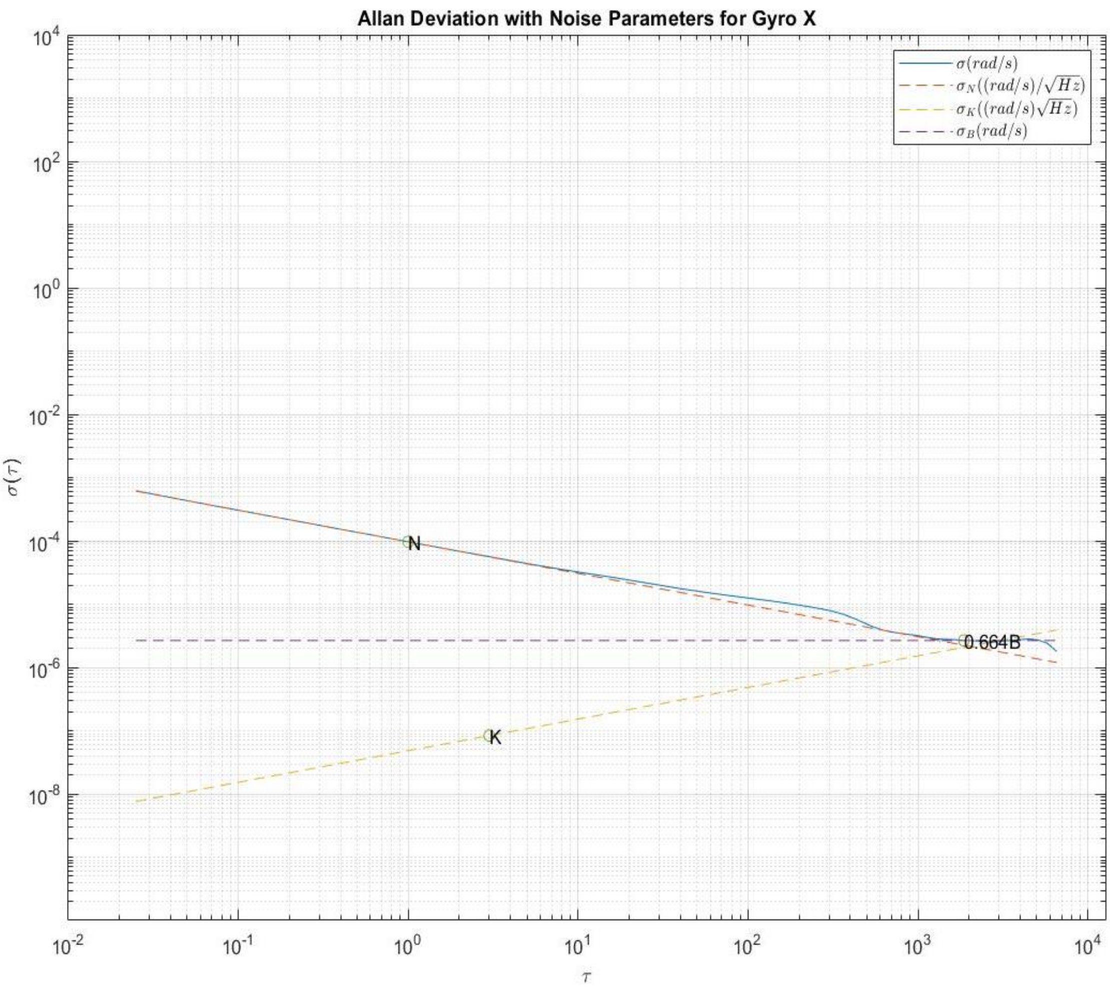
5 Hours Data Allan Variance Analysis

The IMU data obtained is plotted for Gyro (X, Y, Z), and Acceleration (X, Y, Z) using MATLAB.

Gyro:

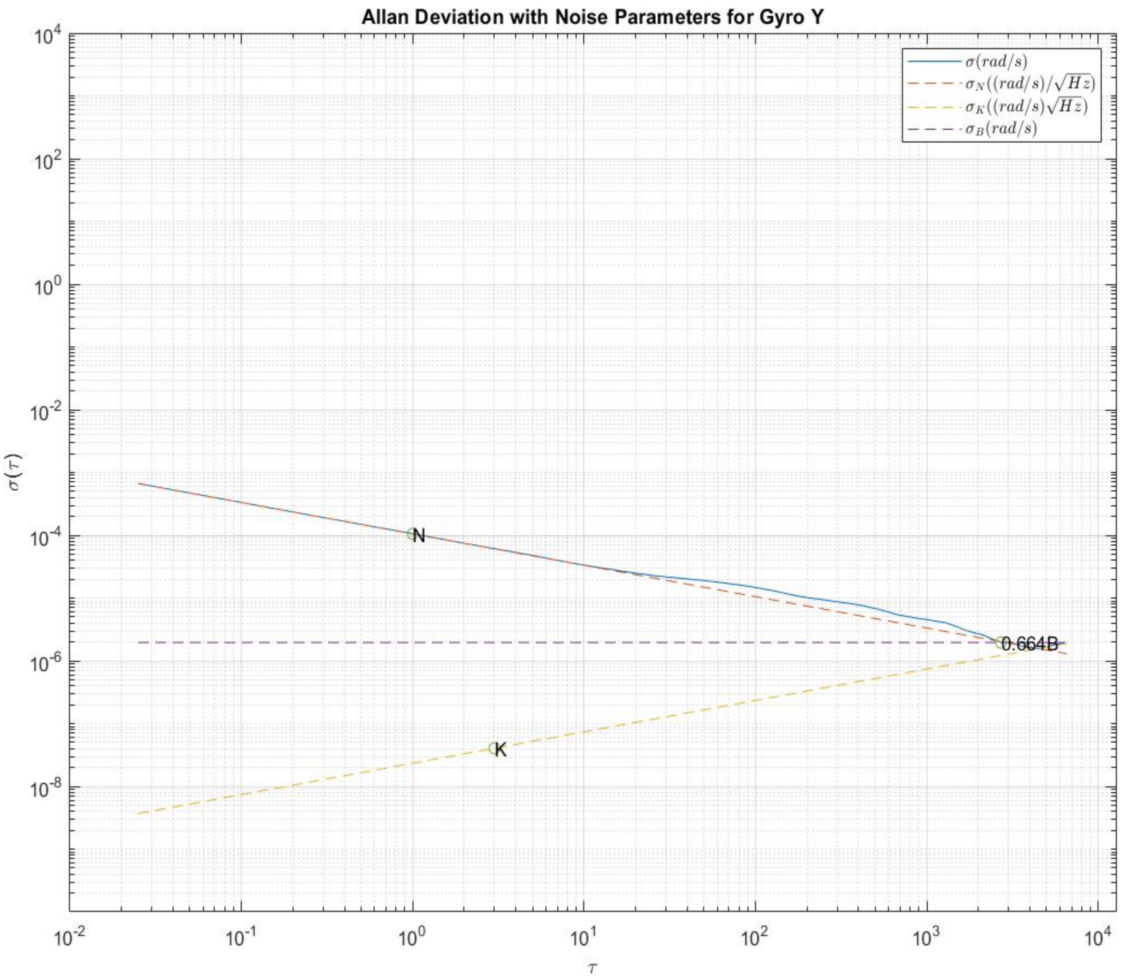
1. **Gyro X:**

```
N =

   9.6677e-05


K =

   8.3419e-08


B =

   4.0031e-06
```



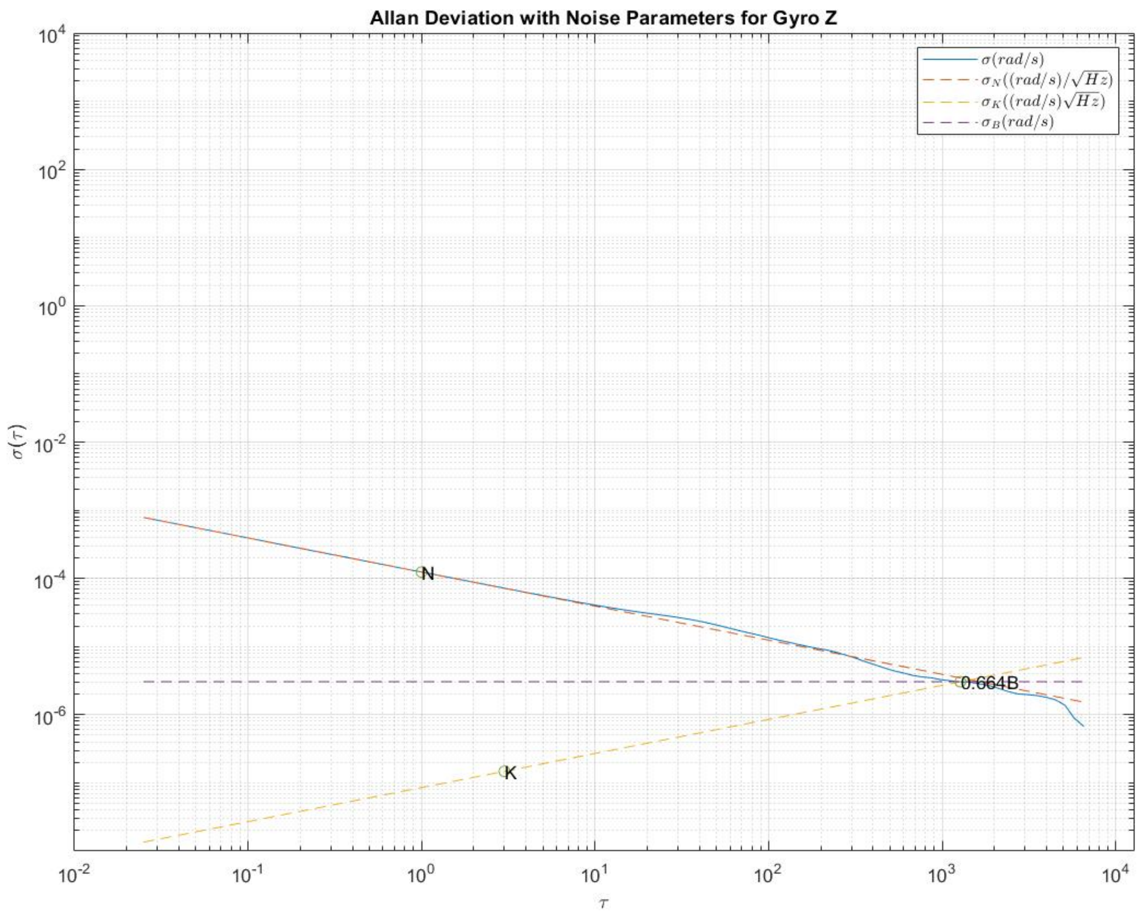
2. Gyro Y:

```
N =

   1.0529e-04


K =

   4.0474e-08


B =

   2.9436e-06
```



3. Gyro Z:

```
N =

   1.2387e-04


K =

   1.4797e-07


B =

   4.5892e-06
```



Gyro Data Analysis:

N = angle random walk coefficient

K = rate random walk coefficient

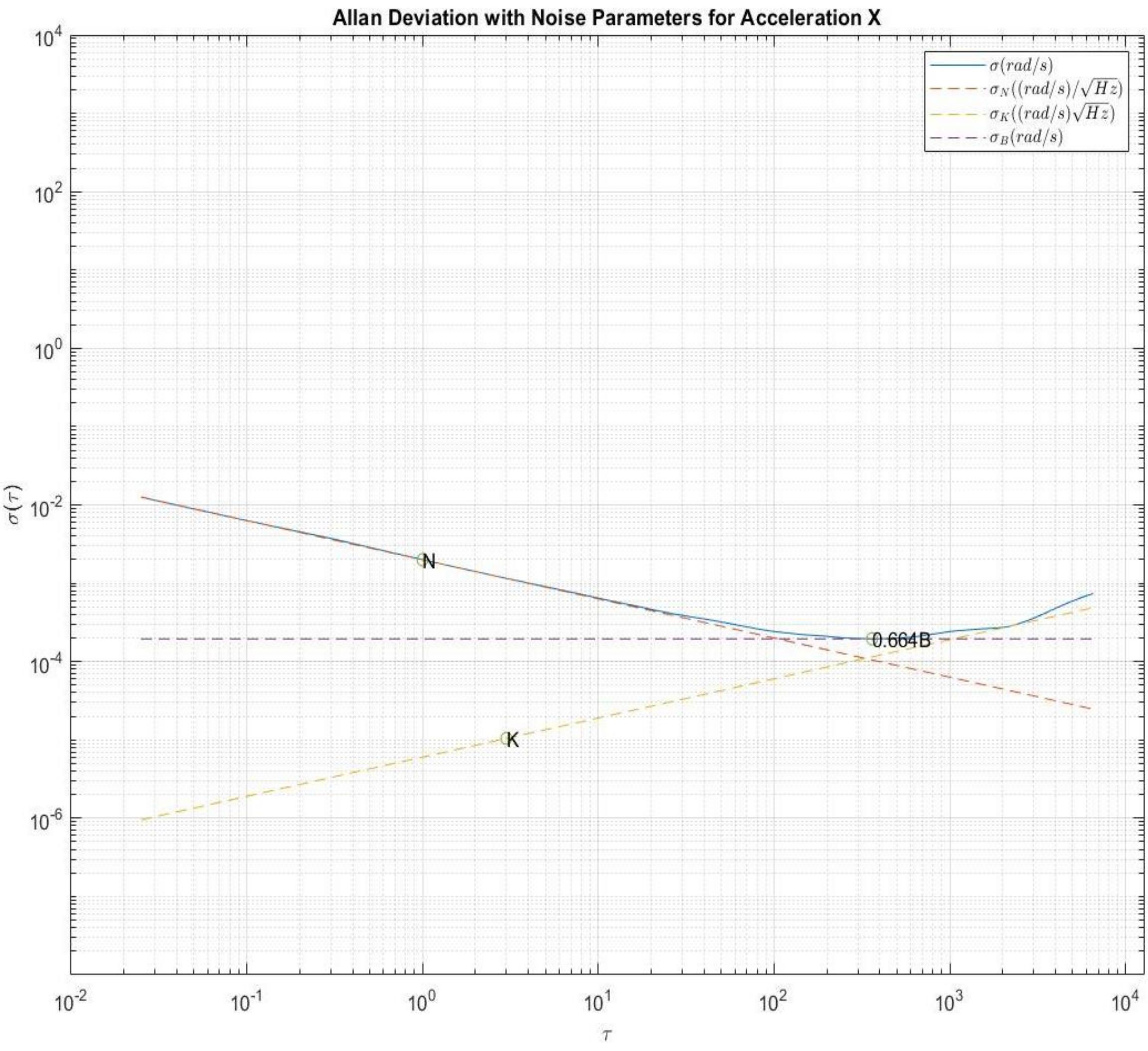
B = bias instability coefficient

The types of error sources present are Angle Random Walk and Bias Instability. The line with a -0.5-slope sigma_N when meets our Allan Variance function sigma denotes the Angle Random Walk error line; this denotes the white noise or the gaussian noise present in our sensor. The +0.5-slope line sigma_K when meets our Allan Variance function sigma denotes the Rate random walk which is not present in our Gyro Data as that is only present in accelerometer data. The line sigma_B is the line with slope 0 which when meets our Allan Variance function sigma denotes the Bias instability present in our sensor. noise density which provides the noise divided by the square root of the sampling rate can be used to measure the noise in our data. By multiplying the noise density (ND) by the square root of the sampling rate (SR), the noise standard deviation (σ) at that rate can be recovered. Overall, the measurements are good and relatable to the measurements given in the Data Sheet of VN-100

Acceleration:

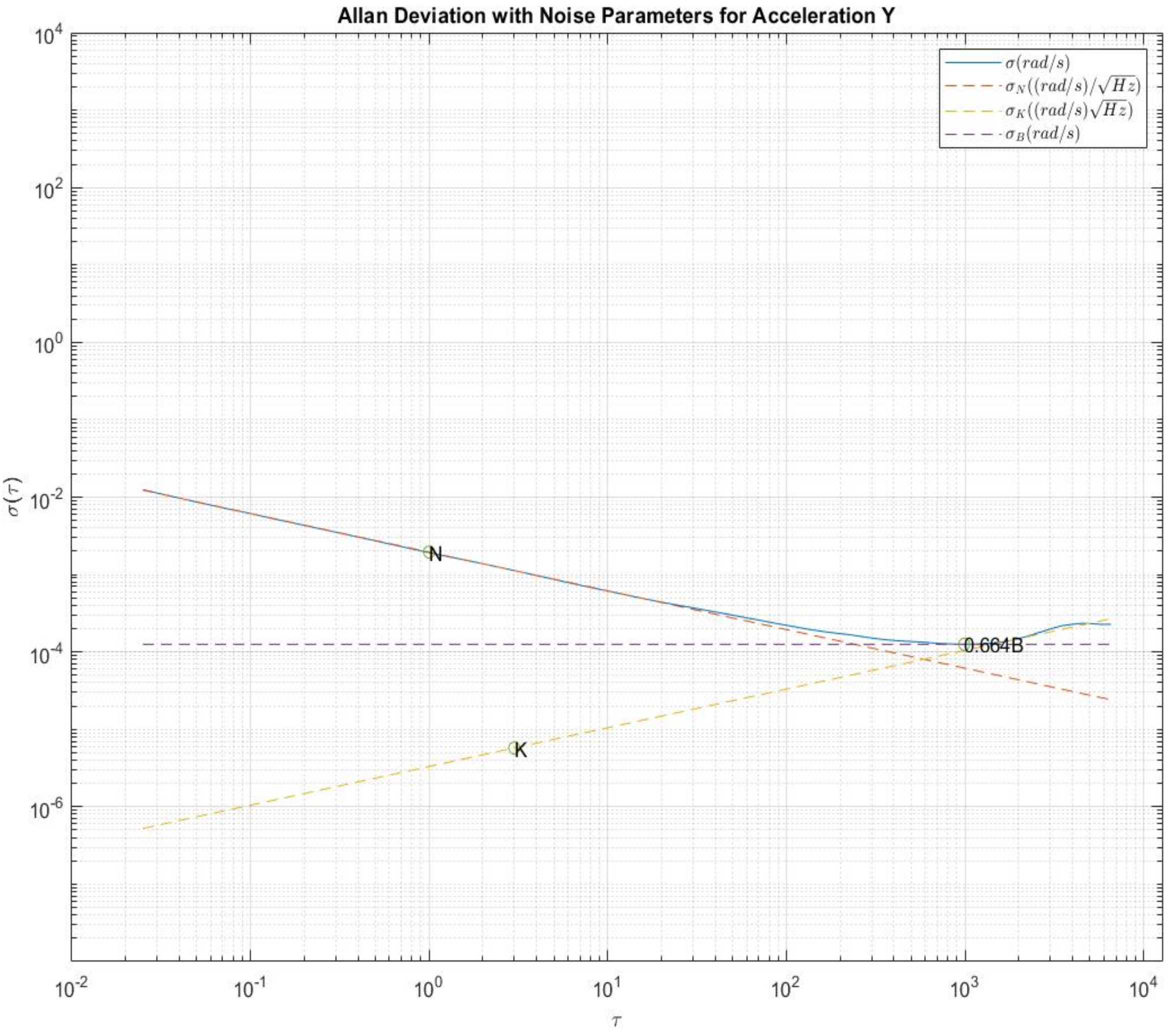
1. Acceleration X:

```
N =

    0.0020


K =

   1.0435e-05


B =

   2.9372e-04
```



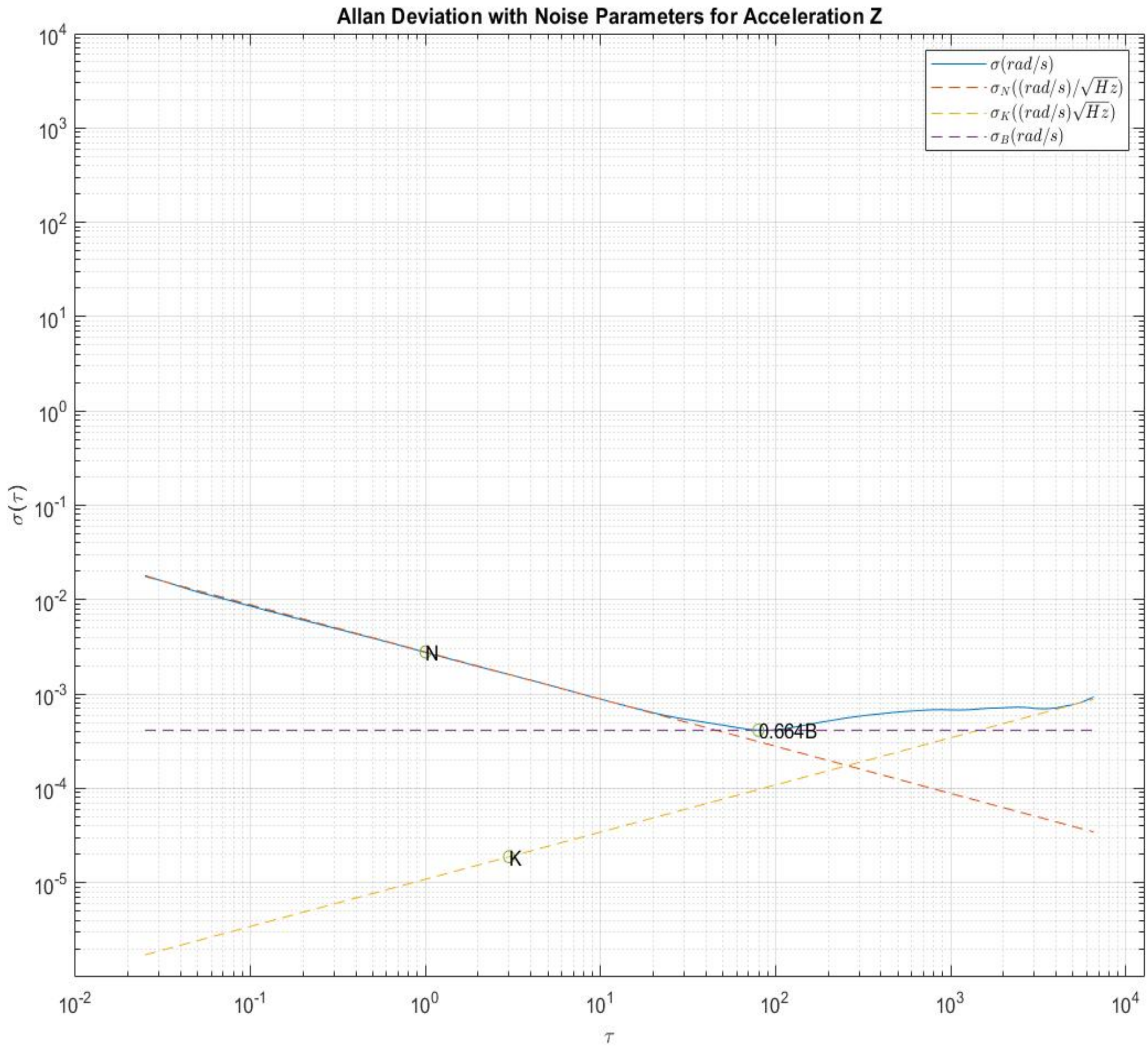
2. Acceleration Y:

```
N =

    0.0019


K =

   5.7459e-06


B =

   1.8939e-04
```



3. Acceleration Z:

```
N =

    0.0028


K =

   1.8832e-05


B =

   6.2184e-04
```



Acceleration Data Analysis:

N = angle random walk coefficient

K = rate random walk coefficient

B = bias instability coefficient

The types of error sources present are Angle Random Walk, Rate random walk and Bias Instability. The line with a -0.5-slope sigma_N when meets our Allan Variance function sigma denotes the Angle Random Walk error; this denotes the white noise or the gaussian noise present in our sensor. Points where the +0.5-slope line sigma_K meets our Allan Variance function sigma denotes the Rate random walk error which is present in our Acceleration Data as that is only present in accelerometer data. The line sigma_B is the line with slope 0 which when meets our Allan Variance function sigma denotes the Bias instability present in our sensor. noise density which provides the noise divided by the square root of the sampling rate can be used to measure the noise in our data. By multiplying the noise density (ND) by the square root of the sampling rate (SR), the noise standard deviation (σ) at that rate can be recovered. Overall, the measurements are good and relatable to the measurements given in the Data Sheet of VN-100