Table of Contents

```matlab
close all; clear; clc;

% Storing Data
data{1,1} = readmatrix('2024_10_04_001_RWHEEL_1');
data{2,1} = readmatrix('2024_10_04_001_RWHEEL_i01_f01_t60s');
data{3,1} = readmatrix('2024_10_04_001_RWHEEL_I01'); %f=1
data{4,1} = readmatrix('2024_10_04_001_RWHEEL_I1_f01_t60s');
data{5,1} = readmatrix('2024_10_04_001_RWHEEL_I1_f08_60s');

%Preallocation
time = cell(5,1);
controlGyro = cell(5,1);
bus = cell(5,1);
coefficients = cell(5,1);
xFit = cell(5,1);
yFit = cell(5,1);
b = cell(5,1);
calibrated = cell(5,1);
CalibratedError = cell(5,1);
rawError = cell(5,1);
posTrue = cell(5,1);
gyroPos = cell(5,1);
posError = cell(5,1);


% Title string vector for the later plots
titles = ["Test Example","Current = 0.1 A, Frequency = 0.1 Hz","Current = 0.1
 A, Frequency = 1 Hz","Current = 1 A, Frequency = 0.1 Hz","Current = 1 A,
 Frequency = 0.8 Hz"];
for i = 1:5

    % Seperate data into columns, do some conversions
    time{i} = data{i}(2 :end,1);
    t = ones(length(time{i}),1);
    time{i} = time{i}(:,1)-time{i}(1,1).*t;
    controlGyro{i} = data{i}(2: end,2); %rad/s
    bus{i} = data{i}(2: end,3).*pi/30; %rad/s
```

a) Time history of measurements

```matlab
% Subplot Graphs
%     figure()
```

```
%       subplot(2,1,1)
%       plot(time{i},bus{i},'Linewidth',1)
%       title('Bus angular velocity (Encoder Measurement)')
%       grid minor;
%       xlabel('Time (s)');
%       ylabel('Angular Velocity (rad/s)')
%
%       subplot(2,1,2)
%       plot(time{i},controlGyro{i},'Linewidth',1)
%       title('Control Gyro Angular Velocity');
%       grid minor;
%       xlabel('Time (s)');
%       ylabel('Angular Velocity (rad/s)')
%       sgtitle(sprintf(titles(i)));

% Plot with the graphs overlaid
    figure()
    hold on;
    plot(time{i},bus{i},'linewidth',1);
    plot(time{i},-controlGyro{i},'LineWidth',1)
    grid on;
    xlabel("Time (s)");
    ylabel("Component Angular Velocity (rad/s)")
    legend("Bus","Reaction Wheel");
    title(sprintf('Comparison of Reaction Wheel and Bus Angular Velocity for
 %s',titles(i)))
```
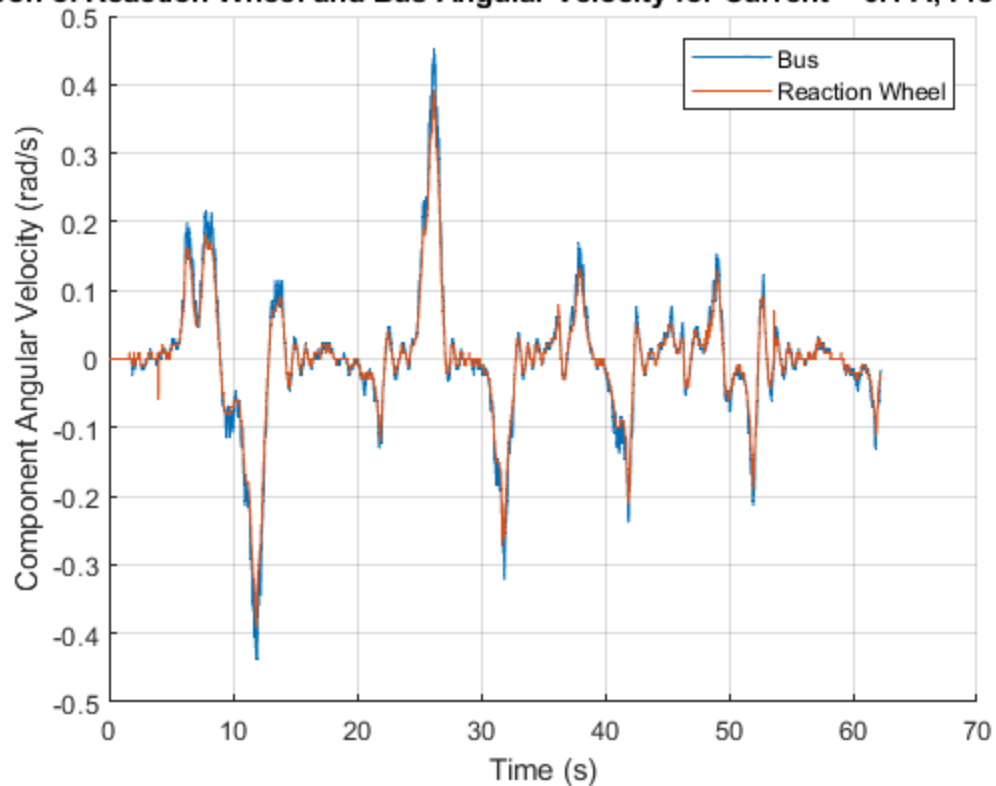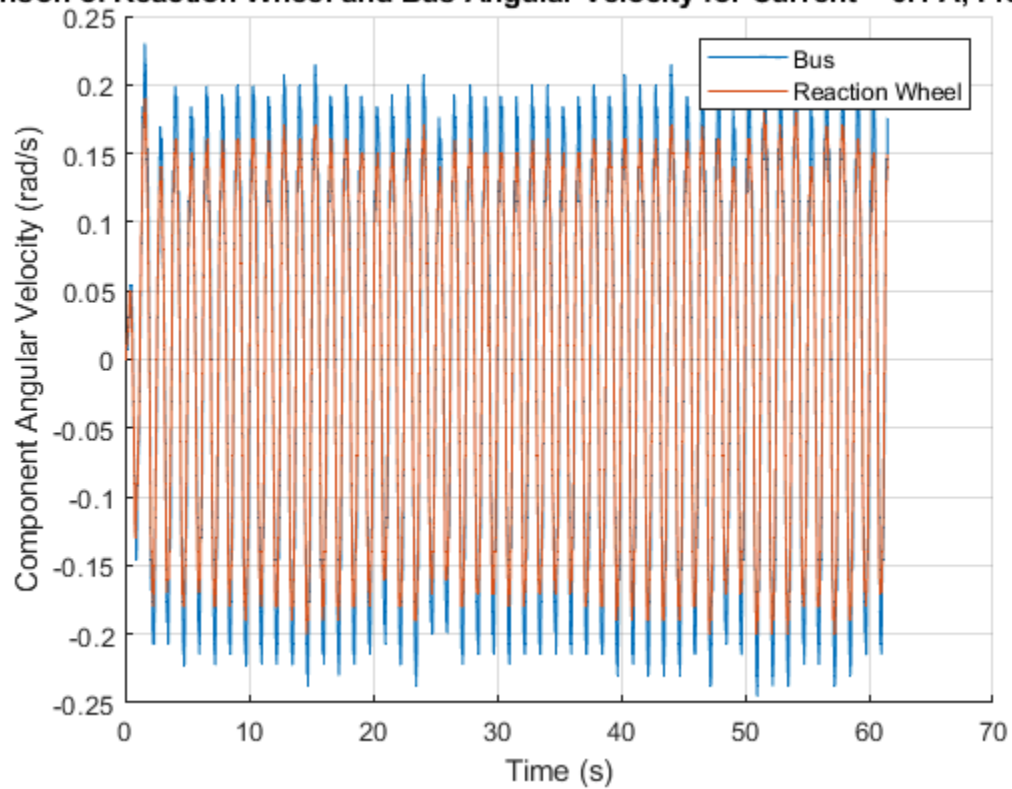

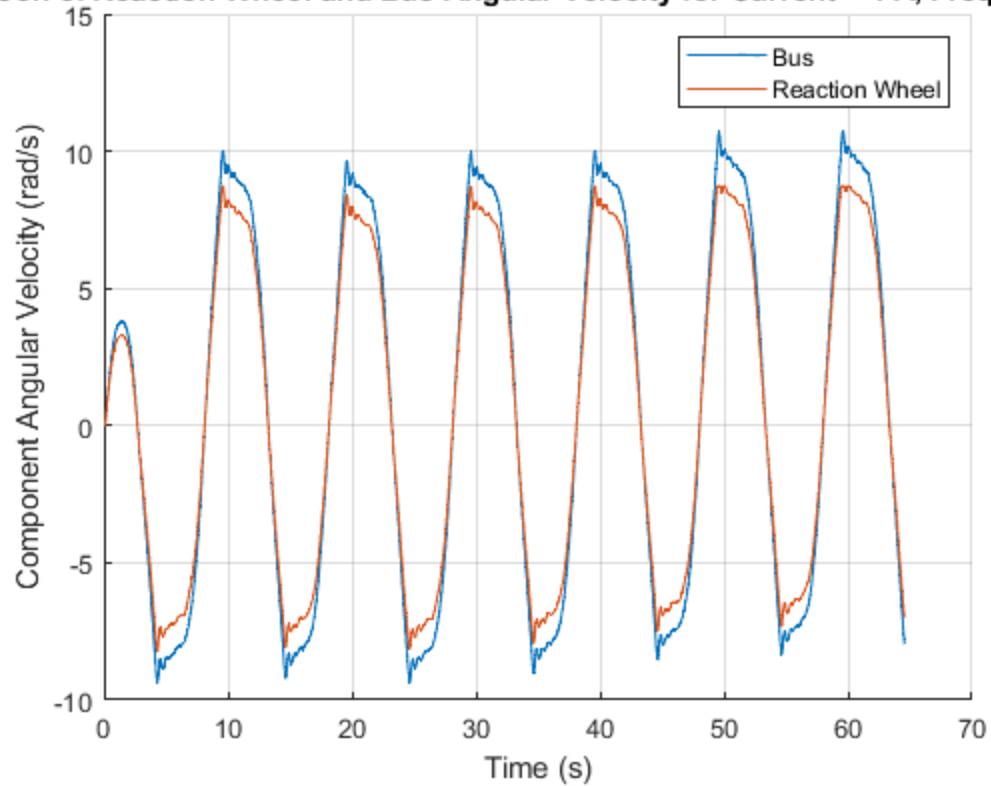Comparison of Reaction Wheel and Bus Angular Velocity for Test Example
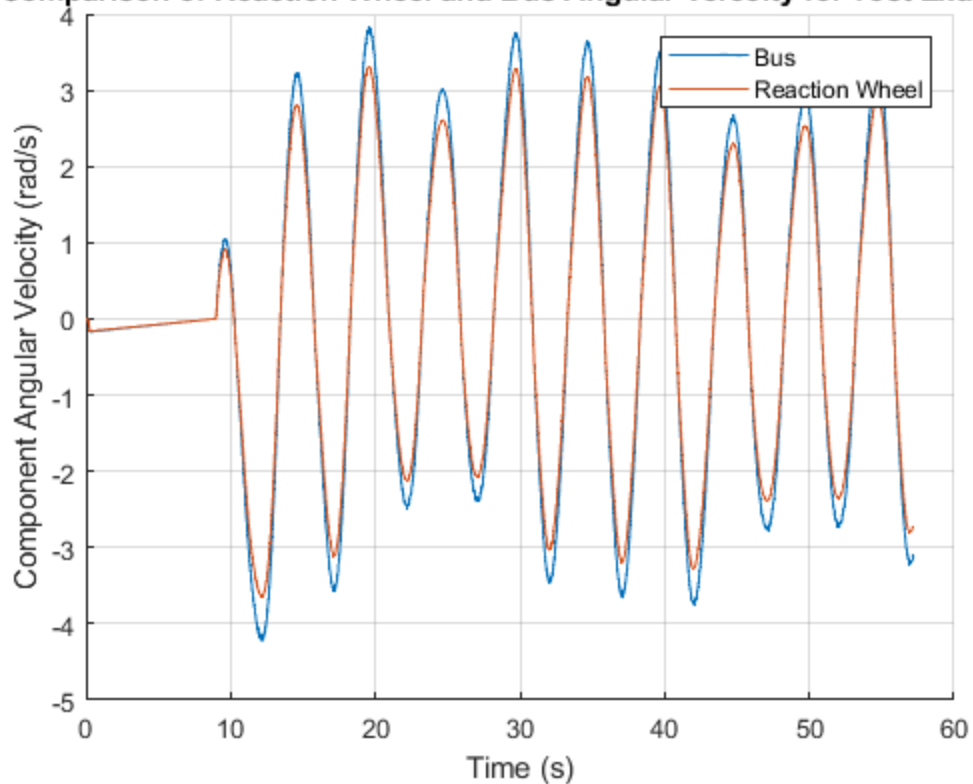
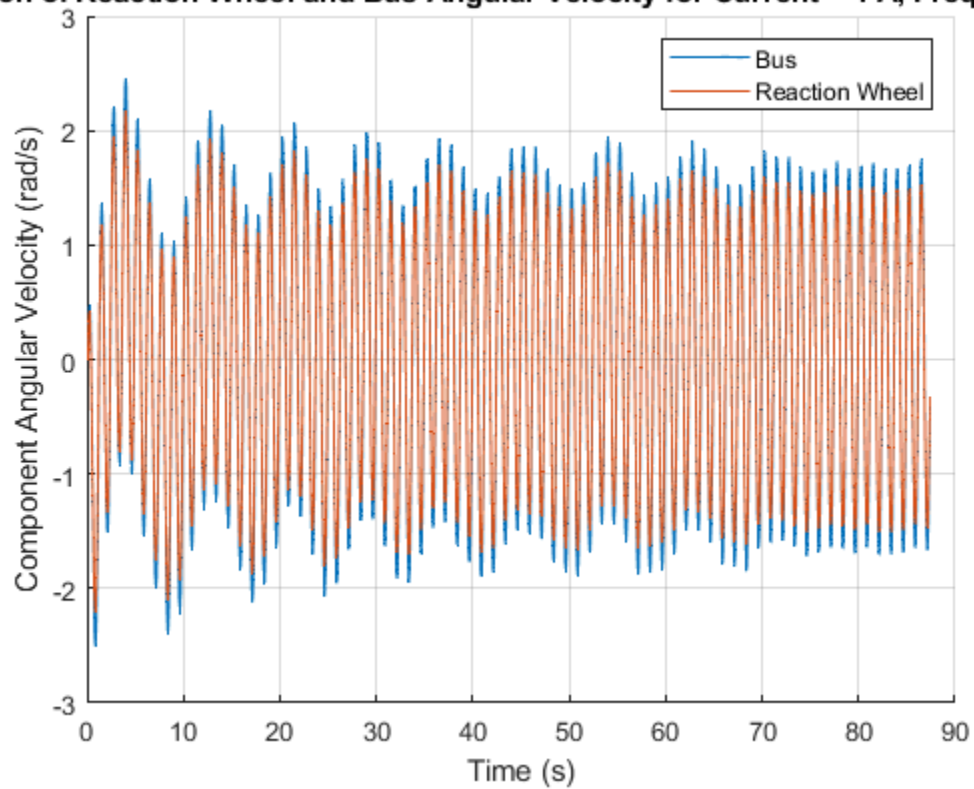Comparison of Reaction Wheel and Bus Angular Velocity for Current = 0.1 A, Frequency

Comparison of Reaction Wheel and Bus Angular Velocity for Current = 0.1 A, Frequency

Comparison of Reaction Wheel and Bus Angular Velocity for Current = 1 A, Frequency

Comparison of Reaction Wheel and Bus Angular Velocity for Current = 1 A, Frequency

b) Time history of angular rate measurement error

Error from encoder figure(); subplot(2,1,1); hold on; scatter(bus{i},controlGyro{i},'Marker','.'); grid minor; title('Encoder Measurement vs Gyro measurement, Uncalibrated'); xlabel("Encoder Rate (rad/s)"); ylabel("Gyro Rate Measurement (rad/s)");

```
    % Calculating the line of best fit of the correlation
    coefficients{i} = polyfit(bus{i}, controlGyro{i}, 1);
    % Create a new x axis with exactly 1000 points
    xFit{i} = linspace(min(bus{i}), max(bus{i}), 1000);
    % Get the estimated yFit value for each of those 1000 new x locations.
    yFit{i} = polyval(coefficients{i} , xFit{i});

    % Correlation best fit plot
%    plot(xFit{i},yFit{i},'r--','Linewidth',1.5);
%    yline(coefficients{i}(2),'linewidth',1)
%    xlabel('Encoder Measurement (rad/s)');
%    ylabel('Calibrated Gyro Measurement (Rad/s)');
%    legend("Data",'Correlation','Bias b')

    % Calibrating data using coeffients from best fit
    b{i} = coefficients{i}(2)*ones(length(time{i}),1);
    calibrated{i} = 1/coefficients{i}(1)*(controlGyro{i}-b{i});

    % Correlation of calibrated data
%    subplot(2,1,2);
%    scatter(bus{i},calibrated{i},'Marker','.');
%    grid minor;
%    xlabel('Encoder Rate Measurement (rad/s)')
%    ylabel('Calibrated Gyro Rate (rad/s)')
%    title('Calibrated Data')
%
%    sgtitle(sprintf('Encoder Gyro Measurement Correlation for
 %s',titles(i)))


%    figure()
%    hold on;
%    plot(time{i},bus{i},'linewidth',1);
%    plot(time{i},calibrated{i},'LineWidth',1);
%    grid on;
%    xlabel("Time (s)");
%    ylabel("Component Angular Velocity (rad/s)")
%    legend("Bus","Reaction Wheel");
%    title(sprintf('Comparison of Calibrated Reaction Wheel and Bus Angular
 Velocity for %s',titles(i)))
```

c) Time history of angular position error

```
    % Calculating the Error in Measurement
    CalibratedError{i} = abs(bus{i})-abs(calibrated{i});
```

```matlab
    rawError{i} = abs(controlGyro{i}) - abs(bus{i});

    meanErrorRaw(i) = mean(rawError{i});
    meanErrorCalibrated(i) = mean(CalibratedError{i});

    figure();
    hold on
    subplot(2,1,1);
    scatter(time{i}, rawError{i},'marker','.')
    title('Measurement Error vs. Time')
    yline(meanErrorRaw(i),'Linewidth',1)
    xlabel('Time (s)');
    ylabel('Error (rad/s)');
    grid minor;
    legend('','Mean Error','location','southwest')
    hold off;

    subplot(2,1,2);
    hold on;
    scatter(time{i}, CalibratedError{i},'marker','.')
    title('Calibrated Data Error vs. Time')
    yline(meanErrorCalibrated(i),'Linewidth',1)
    xlabel('Time (s)');
    ylabel('Error (rad/s)');
    grid minor;
    legend('','Mean Error','location','southwest')
    sgtitle(sprintf('Time History of Angular Rate Error (measured vs.
calibrated) for %s',titles(i)))
    hold off;
```
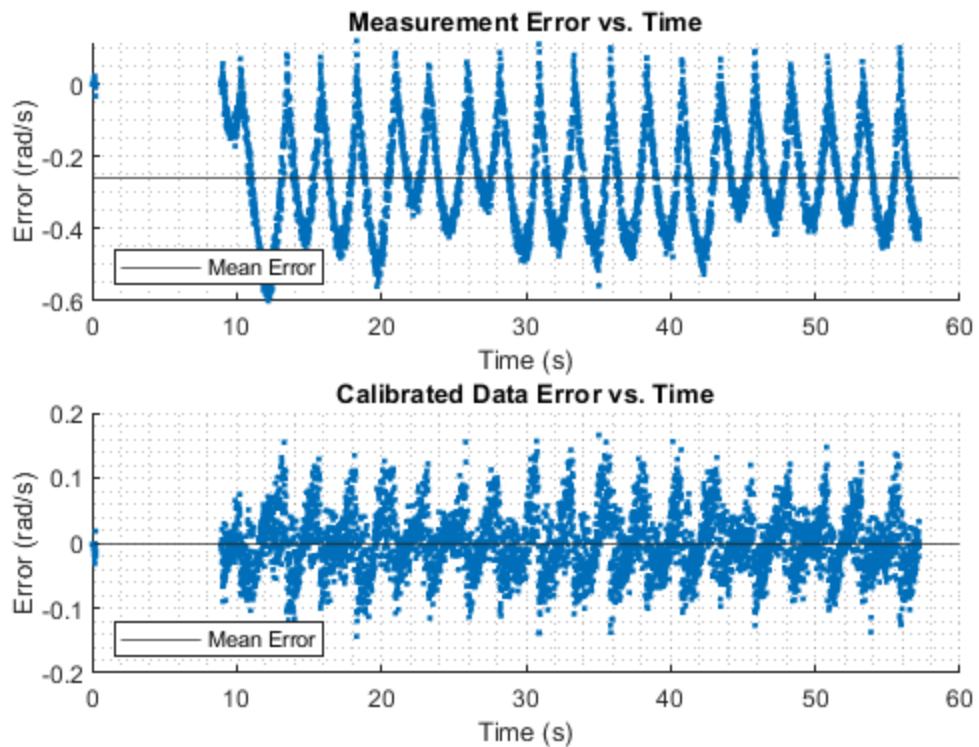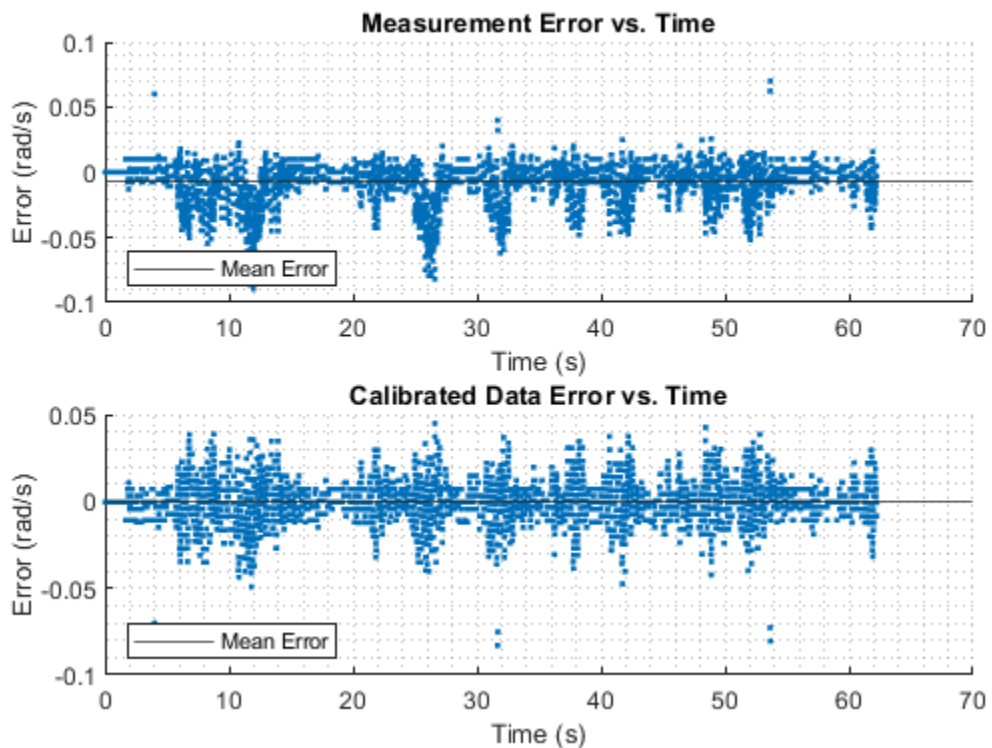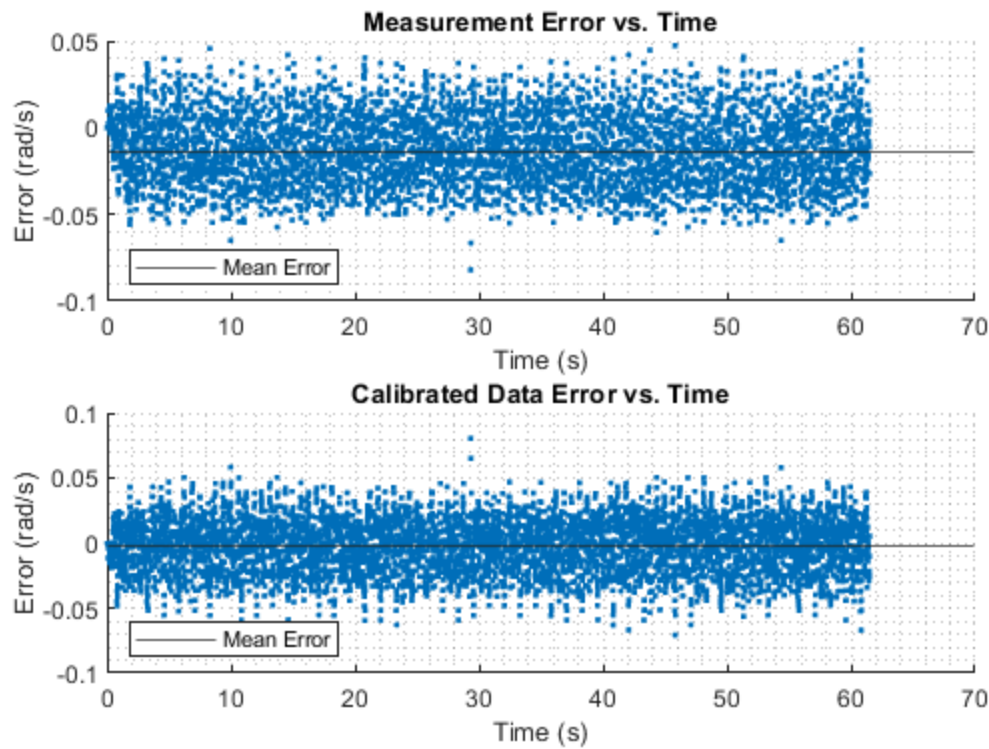
Measurement Error vs. Time

Calibrated Data Error vs. Time

Measurement Error vs. Time

Calibrated Data Error vs. Time

of Angular Rate Error (measured vs. calibrated) for Current = 0.1 A, Freq

Measurement Error vs. Time

Calibrated Data Error vs. Time

of Angular Rate Error (measured vs. calibrated) for Current = 1 A, Freque

Measurement Error vs. Time
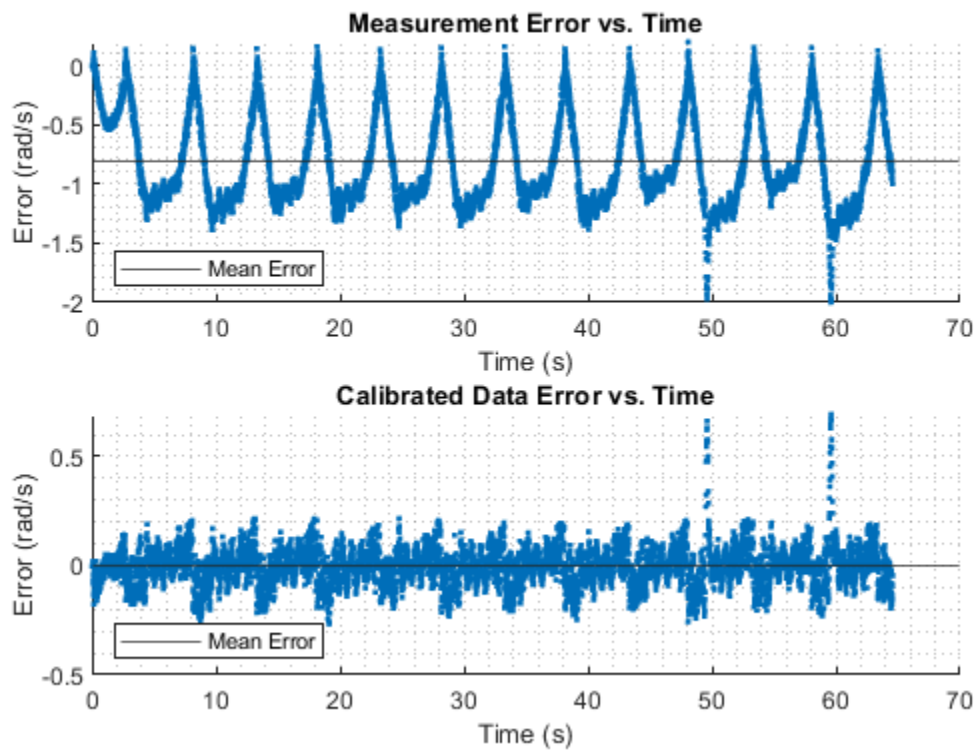
Calibrated Data Error vs. Time
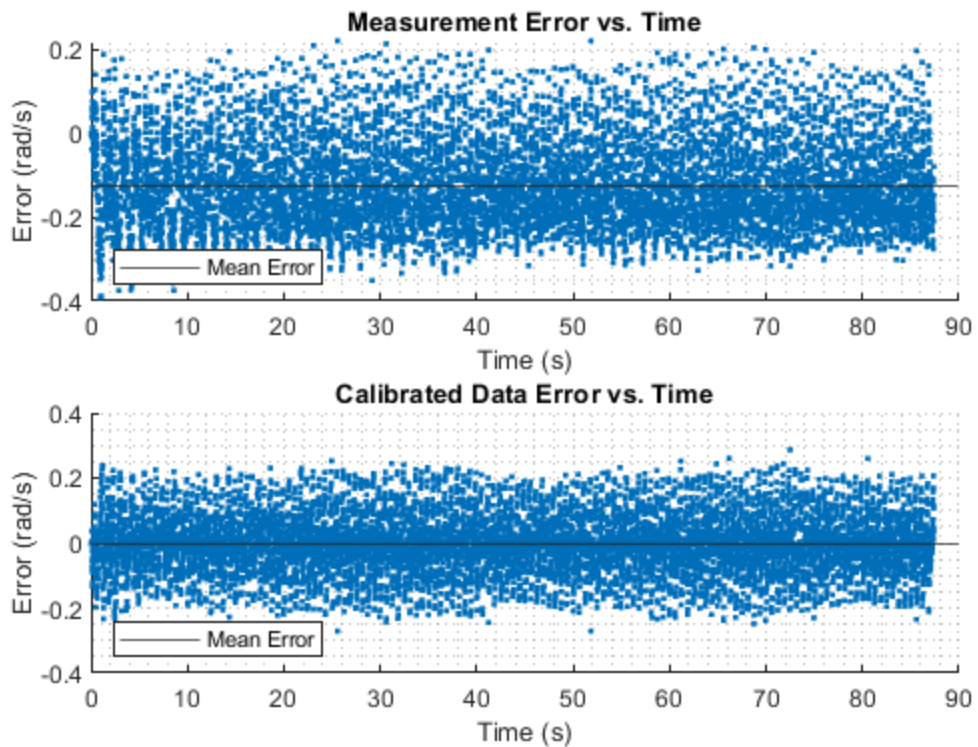
d) Time history of angular position error

```matlab
deltaT = time{i}(2)-time{i}(1);
intBus = deltaT*bus{i};
intGyro = deltaT*controlGyro{i};

for j = 1:length(time{i})
    posTrue{i}(j,1) = sum(intBus([1,j]));
    gyroPos{i}(j,1) = sum(intGyro([1,j]));

end

%    figure()
%    subplot(3,1,1);
%    plot(time{i},posTrue{i},'Linewidth',1);
%    grid minor;
%    xlabel('Time (s)');
%    ylabel('Angular Position (rad)');
%    title('Angular Position from Encoder');
%
%    subplot(3,1,2);
%    plot(time{i},gyroPos{i},'Linewidth',1);
%    grid minor;
%    xlabel('Time (s)');
%    ylabel('Angular Position (rad)');
```

```matlab
%     title('Angular Position from Gyro');
%
%     sgtitle(sprintf('Time History of Angular Position Error %s',titles(i)));
%
    posError{i} = gyroPos{i} + posTrue{i};
%     subplot(3,1,3);
%     plot(time{i},posError{i},'Linewidth',1)
%     grid minor;
%     xlabel('Time (s)');
%     ylabel ('Angular Error (rad)')
%     title('Position Error')

    figure()
    subplot(2,1,1);
    plot(time{i},posTrue{i},'Linewidth',1);
    grid minor;
    xlabel('Time (s)');
    ylabel('Angular Position (rad)');
    title('Angular Position from Encoder');

    subplot(2,1,2);
    plot(time{i},gyroPos{i},'Linewidth',1);
    grid minor;
    xlabel('Time (s)');
    ylabel('Angular Position (rad)');
    title('Angular Position from Gyro');
    sgtitle()
    sgtitle(sprintf('Time History of Angular Position %s',titles(i)));


    figure()
    plot(time{i},posError{i},'Linewidth',1)
    grid minor;
    xlabel('Time (s)');
    ylabel ('Angular Error (rad)')
    title('Position Error')


ans =

     []
```
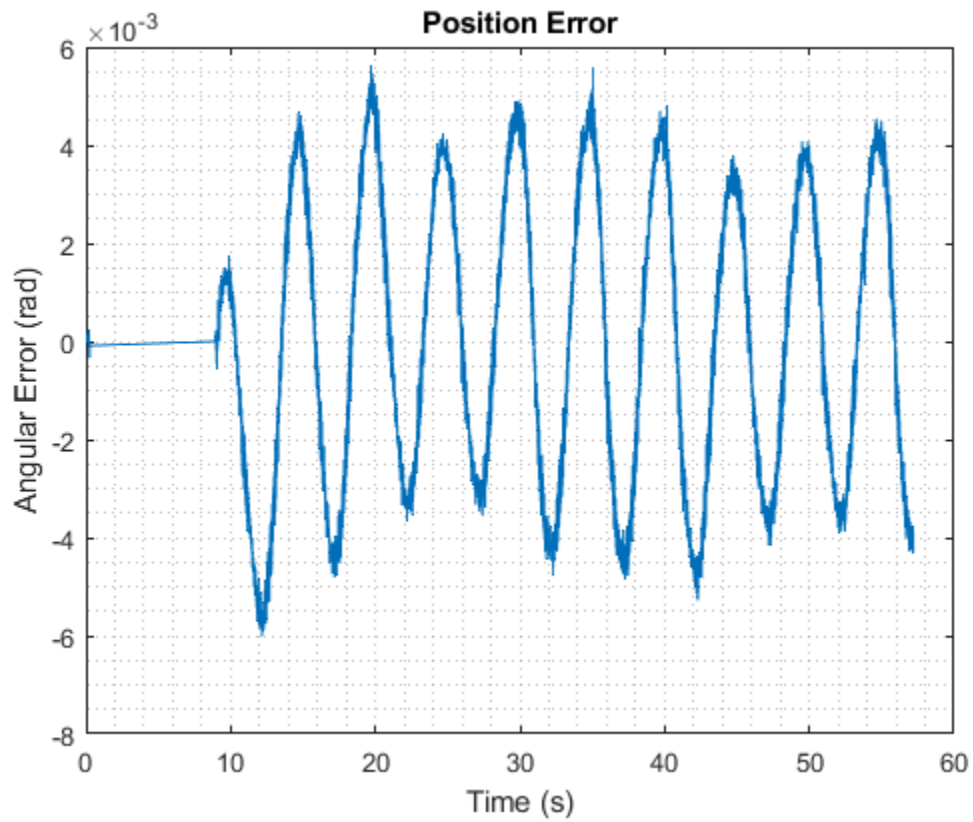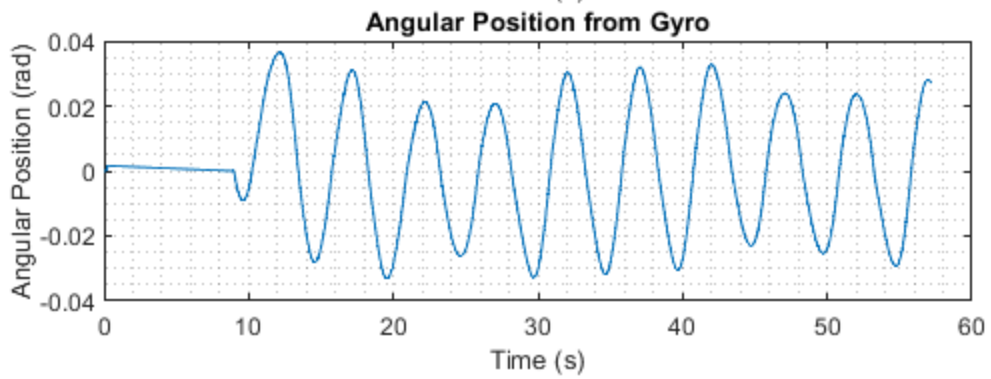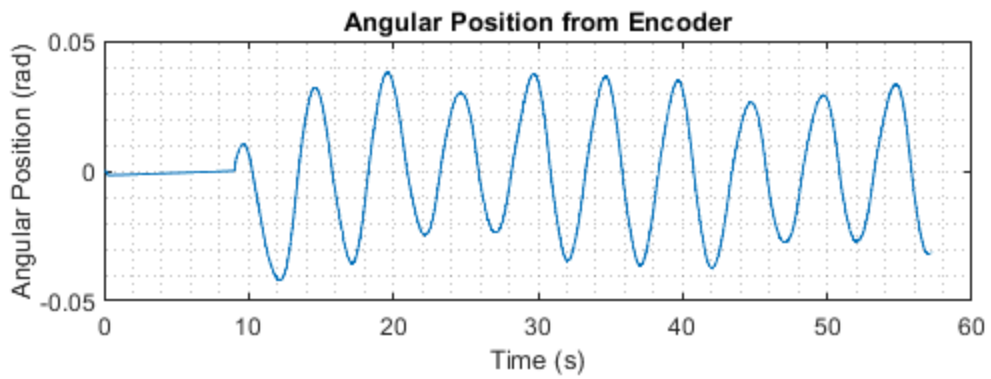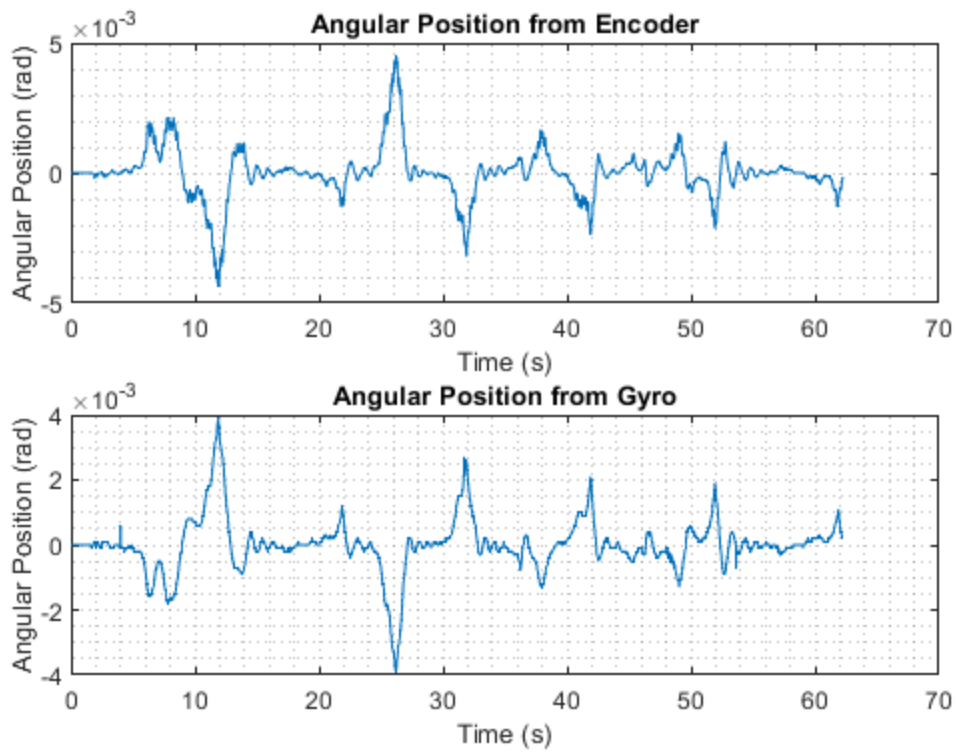
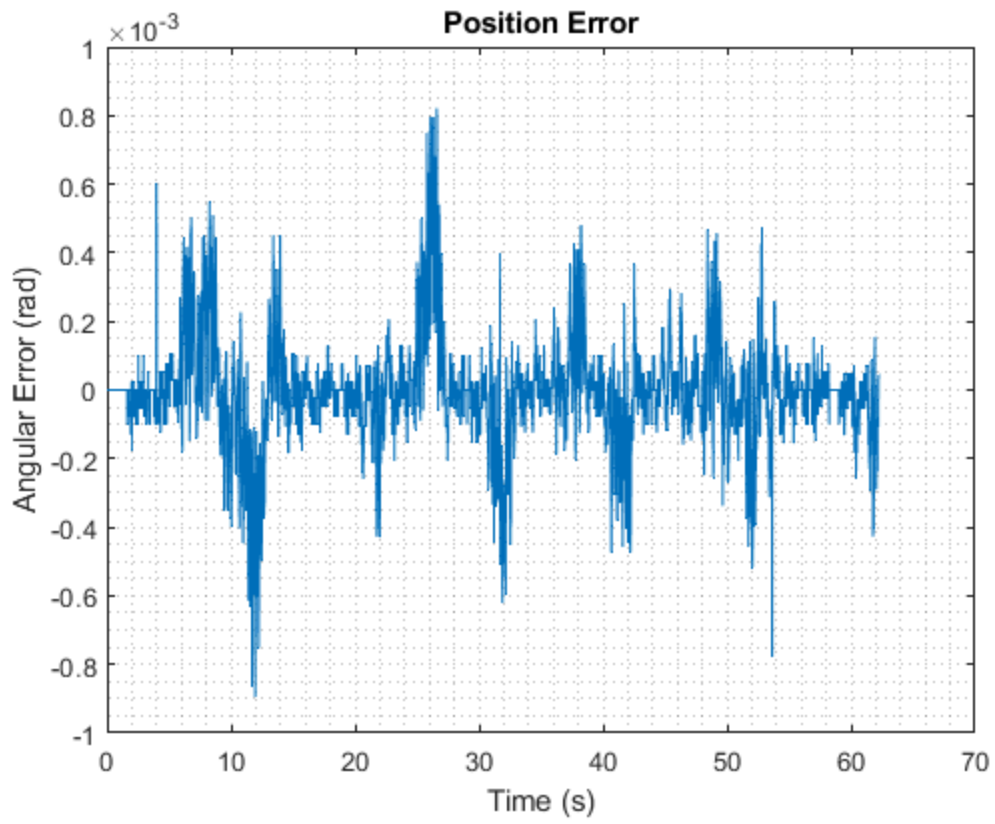# Time History of Angular Position Test Example

Angular Position from Encoder

Angular Position from Gyro

Position Error

ans =

   [ ]

Time History of Angular Position Current = 0.1 A, Frequency = 0.1 Hz

Angular Position from Encoder

Angular Position from Gyro

ans =

   [ ]

Time History of Angular Position Current = 0.1 A, Frequency = 1 Hz

Angular Position from Encoder

Angular Position from Gyro

Position Error

```
ans =

    [ ]
```

Time History of Angular Position Current = 1 A, Frequency = 0.1 Hz

Position Error

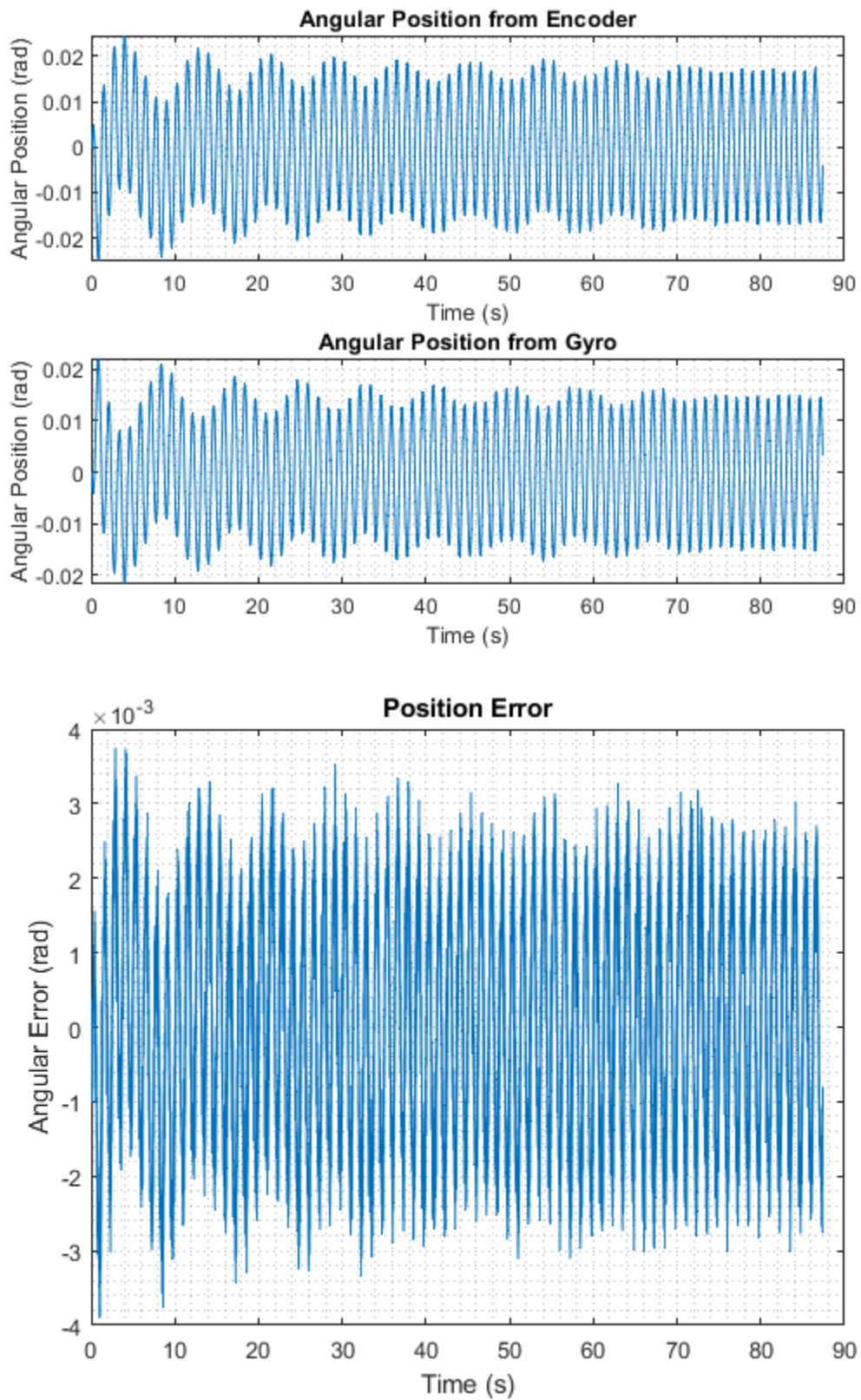_x_-axis: Time (s)
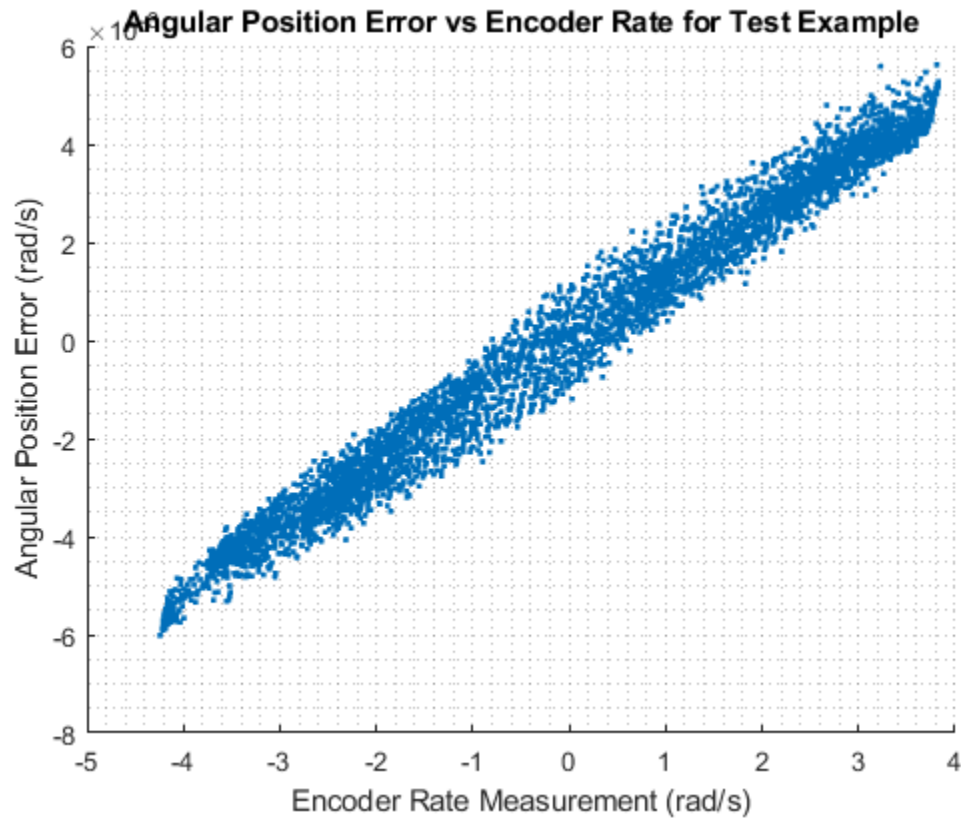_y_-axis: Angular Error (rad)

ans =

    [ ]
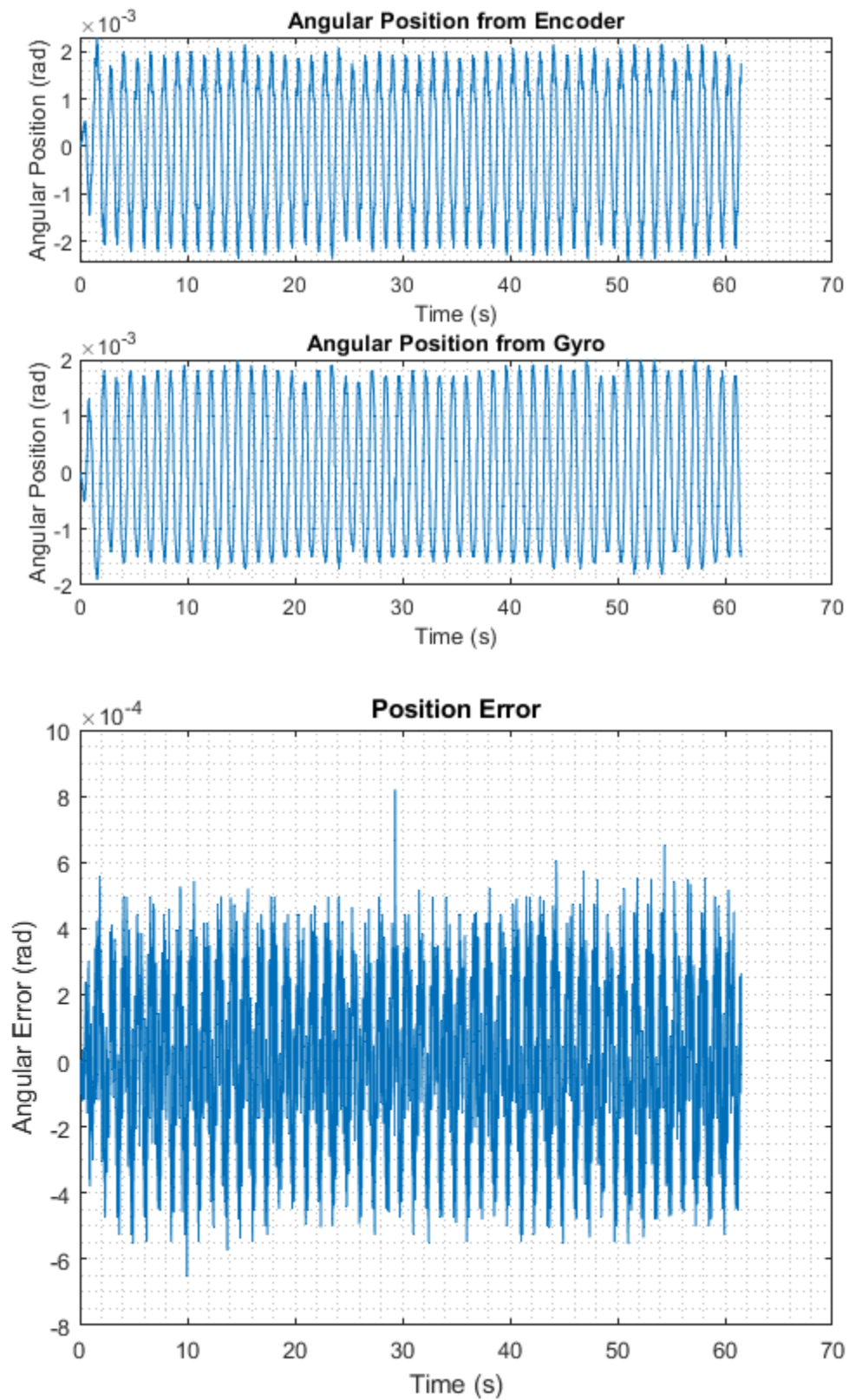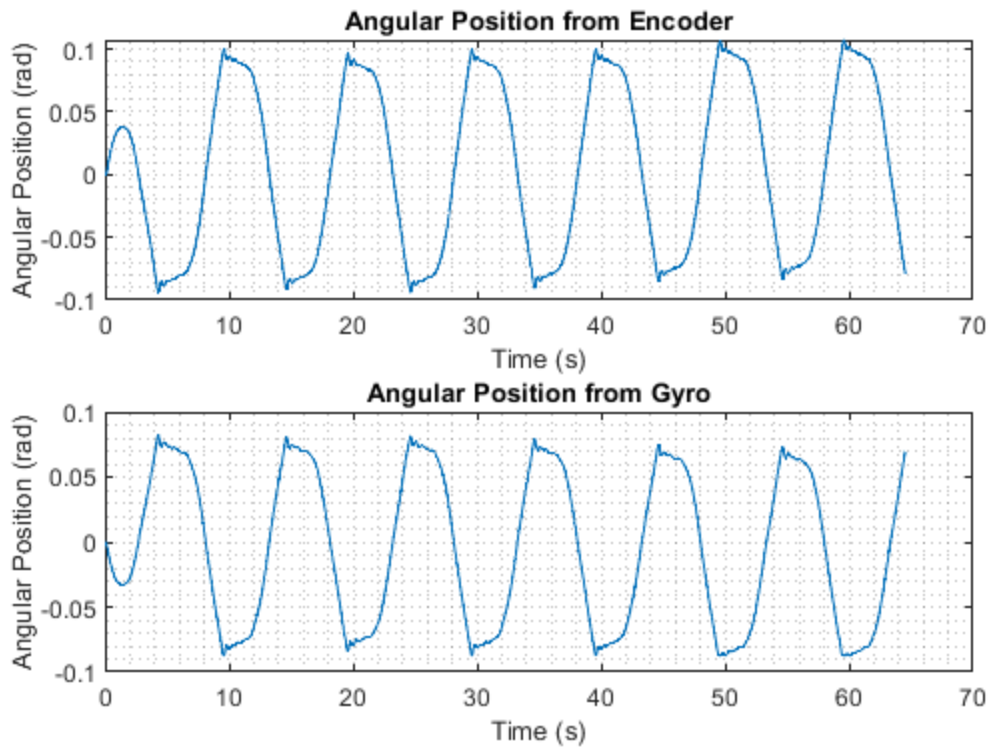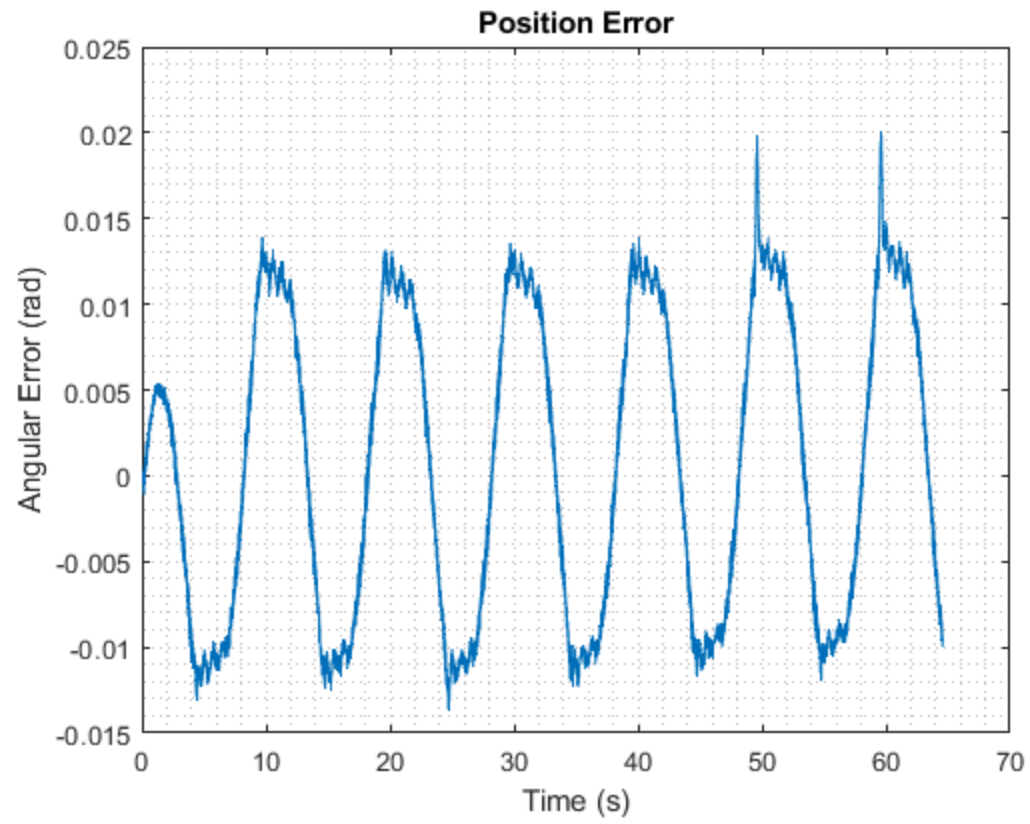
# Time History of Angular Position Current = 1 A, Frequency = 0.8 Hz

e) Angular Position Error vs encoder rate

```
figure()
scatter(bus{i},posError{i},'marker','.');
grid minor;
title(sprintf('Angular Position Error vs Encoder Rate for %s',titles(i)));
ylabel('Angular Position Error (rad/s)')
xlabel('Encoder Rate Measurement (rad/s)');
```
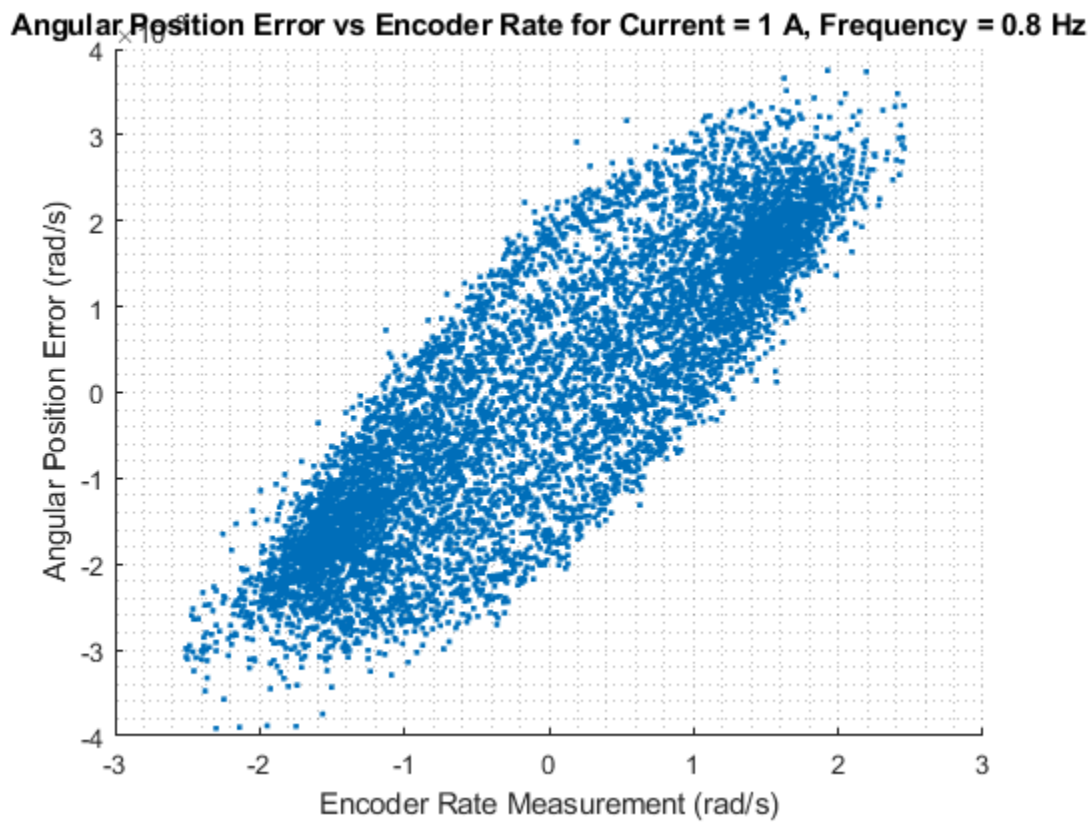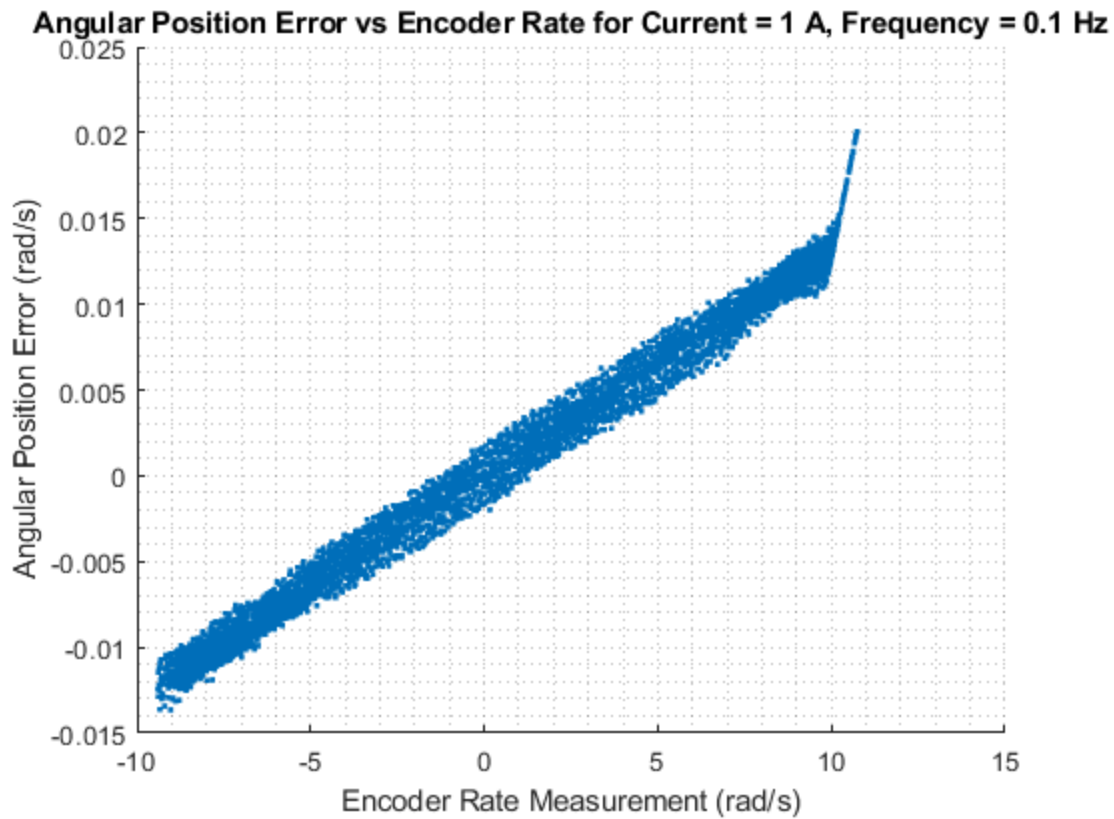
Angular Position Error vs Encoder Rate for Current = 0.1 A, Frequency = 0.1 Hz

Angular Position Error vs Encoder Rate for Current = 0.1 A, Frequency = 1 Hz

Angular Position Error vs Encoder Rate for Current = 1 A, Frequency = 0.1 Hz
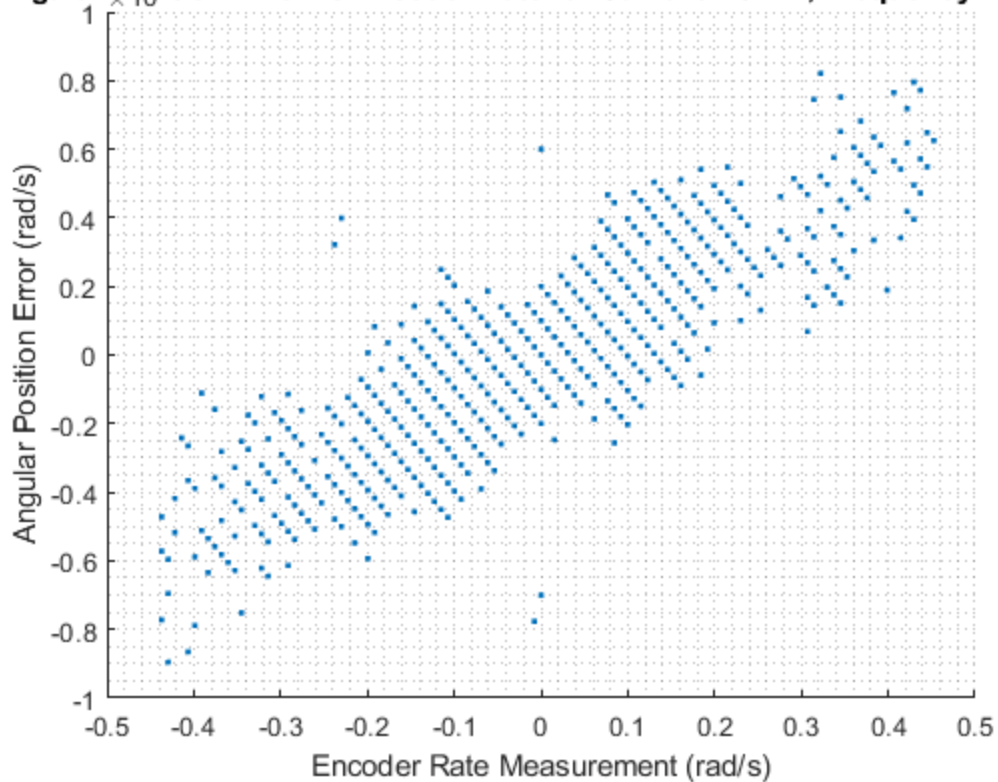
Angular Position Error vs Encoder Rate for Current = 1 A, Frequency = 0.8 Hz
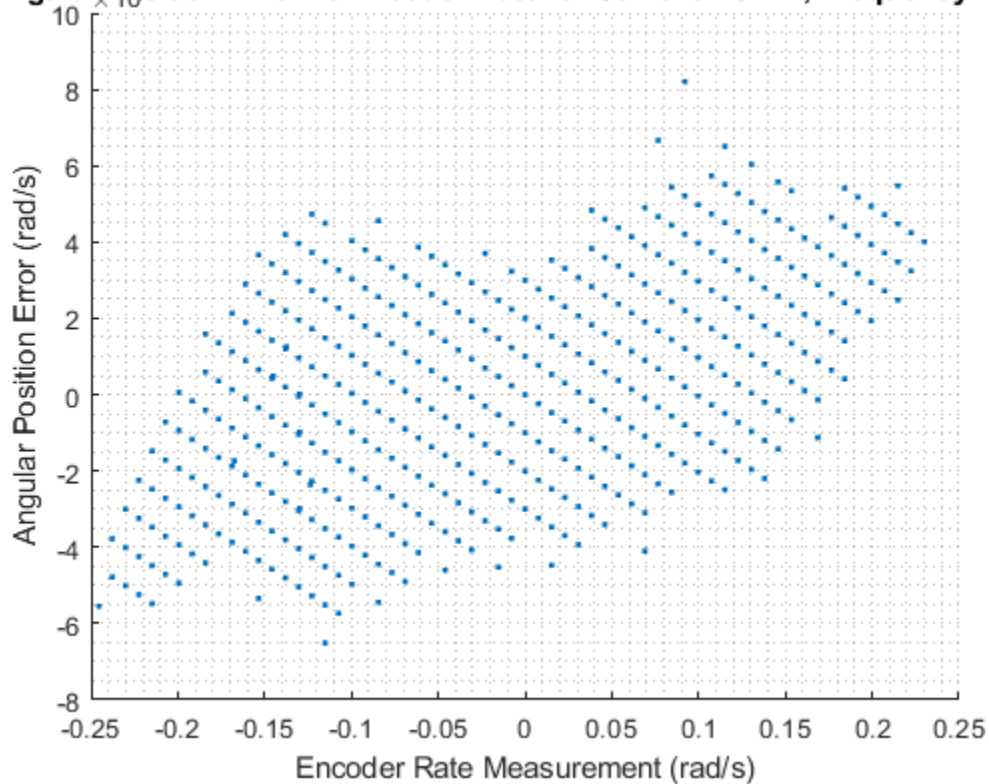
```
end

b_mean = b{1,1}(1,1)+b{2,1}(1,1)+b{3,1}(1,1)+b{4,1}(1,1)+b{5,1}(1,1);

bias = zeros(5,1);
sensitivity = zeros(5,1);
for i = 1:5

    bias(i) = coefficients{i}(2);
    sensitivity(i) = coefficients{i}(1);

end

[devBias,mBias] = std(bias)
[devSens,mSens] = std(sensitivity)


devBias =

    0.0014


mBias =

    0.0013


devSens =

    0.0073


mSens =

   -0.8733
```

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