

Laboratory Exercise 3

Learning Quadcopter Flight Dynamics

Answer to Task 1: Estimating k

Selecting a sine wave signal as input, tests were conducted on three systems, and the results are as follows.

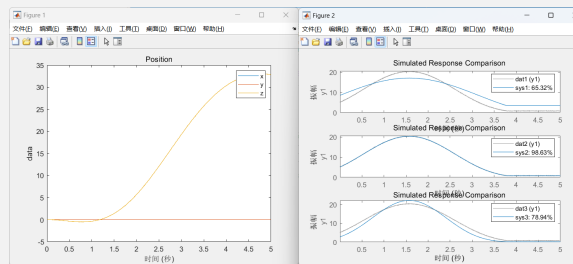


Figure 1: Task1 plot

Estimate k based on the simulation results, and the results are as follows.

```
k_est =

    2.2004e-08

k =

    2.2000e-08
```

Figure 2: Task1 result

```
1 %%
2 Omega.in.time = (0:inner.h:10)';
3 % 500 < Omega.in.signals.values < 2500
4 %Omega.in.signals.values = 1000*ones(length(Omega.in.time),1)*ones(1,4) %You will ...
   need to change ones to something better, HINT linspace
5 Omega.in.signals.values = 1250*(sin(Omega.in.time)+1)*ones(1,4)
6 %Omega.in.signals.values = zeros(length(Omega.in.time),1)*ones(1,4)
7
8
9 k_est = sys2.kp * m
```

Answer to Task 2: Estimating I3 and b

It's not possible to solve for both b and I_3 simultaneously because if both b and i_3 are unknowns, the system of equations has no solution.

Use $I(3)$ and the result of simulation to estimate b , the plots are shown as follows.

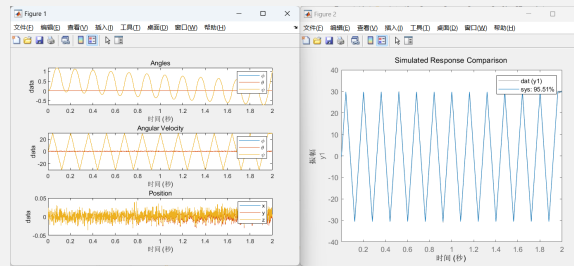


Figure 3: Task2 plot

The estimation of b is shown as follow.

```
b_est =  
  
1.9947e-09  
  
true_b =  
  
2.0000e-09
```

Figure 4: Task2 b result

```
1 %%  
2 c = 5 %TODO change  
3 %Omega1 = TODO, calculate as a function of c  
4 Omega1 = sqrt((m*g)/(2*k*(c^2+1)));  
5 Omega2 = c*Omega1;  
6 Omega = [Omega1 Omega2 Omega1 Omega2];  
7 Omega.in.time = (0:inner.h:2)';  
8 nbr.samples = length(Omega.in.time);  
9 Omega.in.signals.values = zeros(nbr.samples,4);  
10 segments = 25; %TODO change to something better  
11 segment.size = floor(nbr.samples/segments)  
12 switch.time = [floor(segment.size/2):segment.size:nbr.samples, nbr.samples]  
13  
14 u=-2*Omega1^2+2*Omega2^2;  
15 % b_est = abs((max(Psidot)-min(Psidot))/(2/segments)/u*I(3))  
16 b_est =sys.kp *I(3)
```

Answer to Task 3: Estimating I_1 and I_2

Construct a suitable iddata object and choose a suitable model structure. The simulation results are shown as follows.

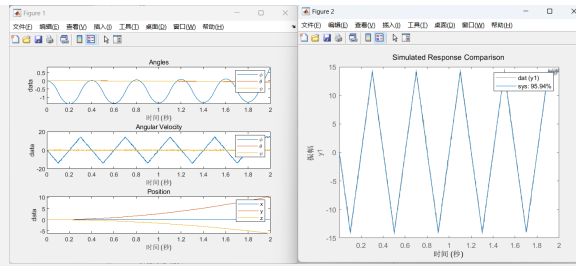


Figure 5: Task3 plot

Estimate $I1(=I2)$ based on the simulation results, and the results are as follows.

```
I1_est =

    1.6624e-05

true_I =

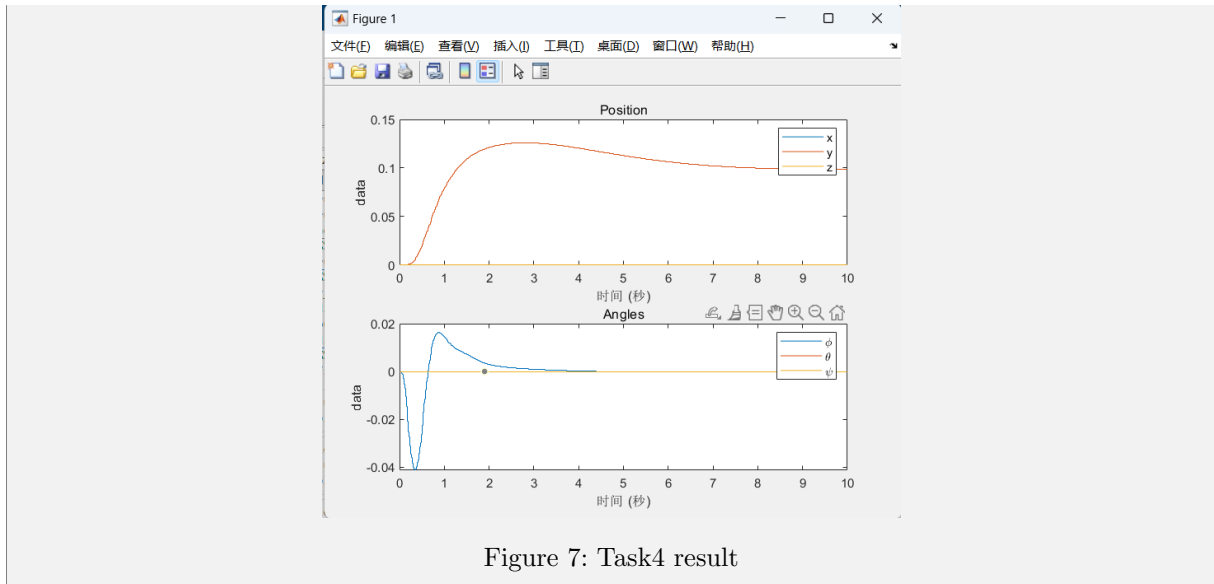
    1.6600e-05
```

Figure 6: Task3 I1/I2 result

```
1 Omega_H = sqrt((m*g)/(4*k)); %TODO
2 c = 1.5; %TODO
3 Omega2 = sqrt((2*(Omega_H^2))/(1+c^2)); %TODO
4 Omega4 = c*Omega2;
5 Omega.in.time = (0:inner.h:2)';
6 nbr_samples = length(Omega.in.time);
7 Omega.in.signals.values = zeros(nbr_samples,4);
8 segments = 10; %TODO
9 segment_size = floor(nbr_samples/segments)
10 switch_time = [floor(segment_size/2):segment_size:nbr_samples, nbr_samples]
11
12 u=-Omega2^2+Omega4^2;
13 I1_est = (k*1)/sys.kp
```

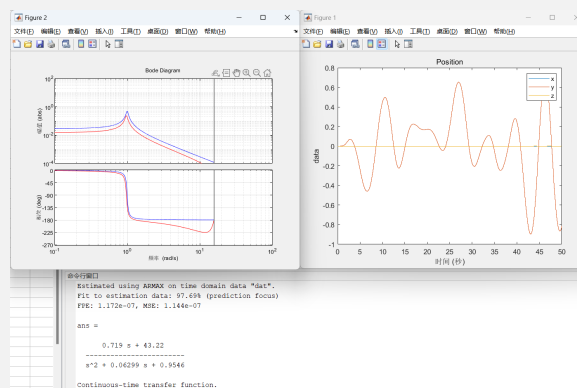
Answer to Task 4: Closing the Loop

Set $y_{ref} = 0.1$, the simulation results are shown as follows.



Answer to Task 5: Estimating a Disturbance Model

Set $R = 12$, the coefficient of the denominator of the simulation result is most approach the 'wind.denum'.



But then I notice that the Bode plot obtained from the simulation is not similar to the original system, especially in the high-frequency region. And the highest degree of the polynomials in the numerator is different. So I set $R = 3$, and get a better result.

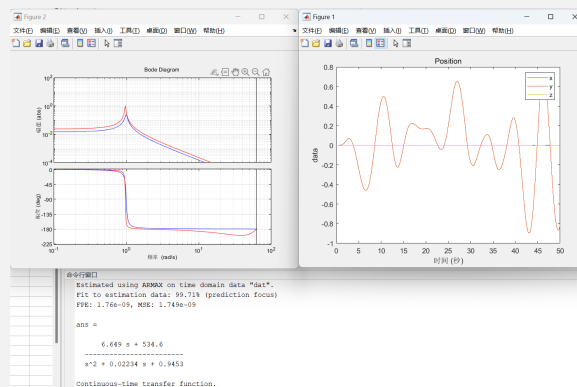


Figure 9: Task5 R=3

Answer to Task 5: Using the Disturbance Model in a control design

Insert $\omega_0 = 1$ and $\epsilon = 0.1$ into design.LQG.m, run the control synthesis and run the simulation.

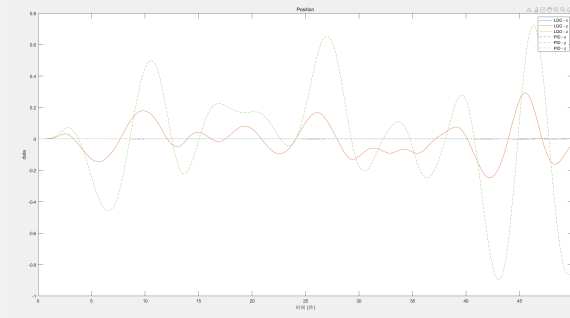


Figure 10: Task6