
```

clear;
clc;
Ixx = 0.0032;
Iyy = 0.0032;
Izz = 0.0055;
m = 0.5;
kt = 0.01691;
l = 0.17;
g = 9.81;

p = sym('p');
q = sym('q');
r = sym('r');
phi = sym('phi')
theta = sym('theta')
psi = sym('psi')
x = sym('x')
y = sym('y')
z = sym('z')
xd = sym('x_dot')
yd = sym('y_dot')
zd = sym('z_dot')
f1 = sym('f_1')
f2 = sym('f_2')
f3 = sym('f_3')
f4 = sym('f_4')

sympref('FloatingPointOutput',true);
X = [x; y; z; xd; yd; zd; phi; theta; psi; p; q; r];
U = [f1; f2; f3; f4];

Rot = [cos(theta)*cos(psi), cos(theta)*sin(psi), -sin(theta);...
        sin(theta)*sin(phi)*cos(psi)-cos(phi)*sin(psi),
        sin(theta)*sin(phi)*sin(psi)+cos(phi)*cos(psi), sin(phi)*cos(theta);...
        sin(phi)*sin(psi)+cos(phi)*sin(theta)*cos(psi),
        sin(theta)*sin(psi)*cos(phi)-sin(phi)*sin(psi), cos(theta)*cos(phi)]
Trot = [1, tan(theta)*sin(phi), tan(theta)*cos(phi);...
        0, cos(phi), - sin(phi); ...
        0, sin(phi)/cos(theta), cos(phi)/cos(theta)];
% Translational Equations
ins1 = (Rot*[0; 0; f1+f2+f3+f4] + [0; 0; -m*g])/m;
ins2 = (Trot*[p; q; r]);
ins3 = [((1/sqrt(2))*(f1+f3-f2-f4)*l/Ixx) - ((Izz-Iyy)*q*r/Ixx);...
        ((1/sqrt(2))*(f3+f4-f1-f2)*l/Iyy) + ((Izz-Ixx)*p*r/Iyy);...
        kt*(f1+f4-f2-f3)/Izz];
F = [xd; yd; zd;...
     ins1(1); ins1(2); ins1(3);...
     ins2(1); ins2(2); ins2(3);...
     ins3(1); ins3(2); ins3(3)]

```

```
A = jacobian(F, X)
B = jacobian(F, U)
```

```
phi =
```

```
phi
```

```
theta =
```

```
theta
```

```
psi =
```

```
psi
```

```
x =
```

```
x
```

```
y =
```

```
y
```

```
z =
```

```
z
```

```
xd =
```

```
x_dot
```

```
yd =
```

```
y_dot
```

```
zd =
```

```
z_dot
```

```
f1 =
```

```
f_1
```

$f_2 =$

f_2

$f_3 =$

f_3

$f_4 =$

f_4

$Rot =$

[
cos(psi)*cos(theta),
cos(theta)*sin(psi), -sin(theta)]
[cos(psi)*sin(phi)*sin(theta) - cos(phi)*sin(psi), cos(phi)*cos(psi) +
sin(phi)*sin(psi)*sin(theta), cos(theta)*sin(phi)]
[sin(phi)*sin(psi) + cos(phi)*cos(psi)*sin(theta),
cos(phi)*sin(psi)*sin(theta) - sin(phi)*sin(psi), cos(phi)*cos(theta)]

$F =$

x_dot
y_dot
z_dot
-2*sin(theta)*(f_1 + f_2 + f_3 + f_4)
2*cos(theta)*sin(phi)*(f_1 + f_2 + f_3 + f_4)
2*cos(phi)*cos(theta)*(f_1 + f_2 + f_3 + f_4) - 9.8100
p + r*cos(phi)*tan(theta) + q*sin(phi)*tan(theta)
q*cos(phi) - r*sin(phi)
(r*cos(phi))/cos(theta) + (q*sin(phi))/cos(theta)
37.5650*f_1 - 37.5650*f_2 + 37.5650*f_3 - 37.5650*f_4 - 0.7188*q*r
37.5650*f_3 - 37.5650*f_2 - 37.5650*f_1 + 37.5650*f_4 + 0.7188*p*r
3.0745*f_1 - 3.0745*f_2 - 3.0745*f_3 + 3.0745*f_4

$A =$

[0, 0, 0, 1, 0, 0, 0, 0, 0,
0, 0, 0, 0, 1, 0, 0, 0, 0,
0, 0, 0, 0, 0, 1, 0, 0, 0,
0, 0, 0, 0, 0, 0, 1, 0, 0,
0, 0, 0, 0, 0, 0, 0, 1, 0,
0, 0, 0, 0, 0, 0, 0, 0, 1]

```

[0, 0, 0, 0, 0, 0, 0,
                                0,
                                -2*cos(theta)*(f_1 + f_2 + f_3 + f_4), 0,
0,                                0,                                0]
[0, 0, 0, 0, 0, 0, 0,
                                2*cos(phi)*cos(theta)*(f_1 + f_2 + f_3 + f_4),
                                -2*sin(phi)*sin(theta)*(f_1 + f_2 + f_3 + f_4), 0,
0,                                0,                                0]
[0, 0, 0, 0, 0, 0, 0,
                                -2*cos(theta)*sin(phi)*(f_1 + f_2 + f_3 + f_4),
                                -2*cos(phi)*sin(theta)*(f_1 + f_2 + f_3 + f_4), 0,
0,                                0,                                0]
[0, 0, 0, 0, 0, 0, 0,
                                q*cos(phi)*tan(theta) - r*sin(phi)*tan(theta),
                                r*cos(phi)*(tan(theta)^2 + 1) + q*sin(phi)*(tan(theta)^2 + 1), 0,
1, sin(phi)*tan(theta), cos(phi)*tan(theta)]
[0, 0, 0, 0, 0, 0, 0,
                                - r*cos(phi) - q*sin(phi),
                                0, 0,
0,                                cos(phi),                                -sin(phi)]
[0, 0, 0, 0, 0, 0, 0, (q*cos(phi))/cos(theta) - (r*sin(phi))/cos(theta),
                                (r*cos(phi)*sin(theta))/cos(theta)^2 + (q*sin(phi)*sin(theta))/cos(theta)^2,
0,                                0, sin(phi)/cos(theta), cos(phi)/cos(theta)]
[0, 0, 0, 0, 0, 0, 0,
                                0,
                                0, 0,
0,                                -0.7188*r,                                -0.7188*q]
[0, 0, 0, 0, 0, 0, 0,
                                0,
                                0, 0,
0.7188*r,                                0,                                0.7188*p]
[0, 0, 0, 0, 0, 0, 0,
                                0,
                                0, 0,
0,                                0,                                0]

```

B =

```

[                                0,                                0,                                0,
0]
[                                0,                                0,                                0,
0]
[                                0,                                0,                                0,
0]
[ -2*sin(theta), -2*sin(theta), -2*sin(theta),
-2*sin(theta)]
[2*cos(theta)*sin(phi), 2*cos(theta)*sin(phi), 2*cos(theta)*sin(phi),
2*cos(theta)*sin(phi)]
[2*cos(phi)*cos(theta), 2*cos(phi)*cos(theta), 2*cos(phi)*cos(theta),
2*cos(phi)*cos(theta)]
[                                0,                                0,                                0,
0]
[                                0,                                0,                                0,
0]
[                                0,                                0,                                0,
0]
[ 37.5650, -37.5650, 37.5650,
-37.5650]
[ -37.5650, -37.5650, 37.5650,
37.5650]

```

[3.0745, -3.0745, -3.0745,
 3.0745]

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