**Tri-rotor open loop response**

* If alpha (tilt) angle = 0 (and roll = pitch = 0), w required to hover (constant z) = sqrt(82994) = 288 rad/sec

**Results without drag force (k\_d = 0): Drag force has some minor effects on torques, which have been ignored for the time being to be able to interpret the results in a better and relatively easier manner**

* w1 = w2 = w3 = 289, a1 = a2 = a3 = 0

Chart, line chart

Description automatically generated

A picture containing line chart

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Chart, line chart

Description automatically generated

As expected, the UAV hovers at its initial position, there is a small vertical velocity which is due the motor rpm being slightly higher than sqrt(82994). There is now force/torque acting in x and y directions

* w1 = w2 = w3 = 290, a1 = a2 = a3 = {0.2 if t<1; 0 if t>= 1}

Chart, histogram

Description automatically generated

For t < 1, z decreases slightly since there is a non-zero tilt angle due to which a component of the propeller force is utilized in translational motion. The x and y components of velocities are very unstable.

Chart

Description automatically generated

Till t = 1, angular velocity in z direction (effecting yaw) and y direction (effecting pitch) increase, w\_x is relatively constant.

Chart

Description automatically generated

The yaw profile is very unstable, and understandably so due to the coupled nature of dynamics. If we disable yaw in the scope, better view of roll and pitch can be seen.

Chart, line chart

Description automatically generated

After 1 sec, the UAV’s altitude gradually starts increasing.

* a1 = a2 = a3 = 0, w1 = w2 = w3 are given by: Background pattern

  Description automatically generated with low confidence

Chart, line chart

Description automatically generated

V\_z rises between t = 4 and t = 8, after that it continues to decrease. It should be noted that making w = 289 again wouldn’t make v\_z = 0, it will just make dv\_z/dt = 0. Thus, if the UAV needs to rise to a certain altitude and then stay there for future time, it should increase its w above 289 for some time, then decrease it till the desired height is achieved, and then w should be made equal to 289.

A picture containing chart

Description automatically generated

Angular velocities are 0 since there is no tilt.

A picture containing chart

Description automatically generated

Chart, line chart

Description automatically generated

z starts rising after 4 secs, after 8 secs, its still rising since only acceleration is negative but velocity is still positive, it appears to reach a peak after 20 secs, after which it will start decreasing.

* w1 = w2 = w3 = 300, a1 = a2 = a3 are given by: Background pattern

  Description automatically generated

Chart, line chart

Description automatically generated

Chart

Description automatically generated

Chart

Description automatically generated

Chart, line chart

Description automatically generated

The exact nature of results is a bit difficult to explain for each time instant. However, one can get a reasonable idea about the complexity of the input-output nature of the system by just looking at the last plot – although we make the tilt angles = 0.1 for 2 secs from 2 secs and then apply the “inverse” of that (-0.1 for t = 2 secs from 6 secs), the output doesn’t restore to its initial value and becomes unstable.