

# ANC

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## Attitude

### Model

$$\dot{\mathbf{q}} = \frac{1}{2} \mathbf{q} \otimes \begin{pmatrix} 0 \\ \vec{\omega} \end{pmatrix} \quad (1)$$

$$\dot{\vec{\omega}} = \Gamma_n \vec{n} + \Gamma_u \vec{u} - I^{-1} (\vec{\omega} \times I \vec{\omega}) \quad (2)$$

$$\dot{\vec{n}} = k_2 (k_1 \vec{u} - \vec{n}) \quad (3)$$

There are 10 system states:

$$\mathbf{x} = (q_0 \quad q_1 \quad q_2 \quad q_3 \quad \omega_x \quad \omega_y \quad \omega_z \quad n_x \quad n_y \quad n_z)^T \in \mathbb{R}^{10 \times 1}$$

- $\mathbf{q}$  is the orientation of the drone, expressed as a unit quaternion.
- $\omega$  is the angular velocity of the drone.
- $\mathbf{n}$  is the speed of the torque motors.

The input to the system is the control signal to the three torque motors:

$$\mathbf{u} = (u_x \quad u_y \quad u_z)^T \in \mathbb{R}^{3 \times 1}$$

The output (measurements) of the system are the orientation and the angular velocity:

$$\mathbf{y} = (q_0 \quad q_1 \quad q_2 \quad q_3 \quad \omega_x \quad \omega_y \quad \omega_z)^T \in \mathbb{R}^{7 \times 1}$$

$\Gamma_n$  and  $\Gamma_u$  are first order approximations of the motor torque in function of the motor speed and control signal.

### Linearisation

### Controller

Linear Quadratic Regulator

$$Q = \begin{pmatrix} 1.4e+02 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1.4e+02 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 2.4e+02 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0.15 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0.15 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0.041 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1e-10 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1e-10 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1e-10 \end{pmatrix}$$

$$R = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

### Bias rejection

$$\begin{pmatrix} x_{k+1} \\ d_{k+1} \end{pmatrix} = \begin{pmatrix} A & 0 \\ 0 & I_6 \end{pmatrix} \begin{pmatrix} x_k \\ d_k \end{pmatrix} + \begin{pmatrix} B \\ 0 \end{pmatrix} u_k + \begin{pmatrix} I_9 & B & 0 \\ 0 & 0 & I_6 \end{pmatrix} \begin{pmatrix} \delta_x \\ \delta_u \\ \delta_d \end{pmatrix}$$

$$y_k = (C \quad I_6) \begin{pmatrix} x_k \\ d_k \end{pmatrix} + Du_k + v$$

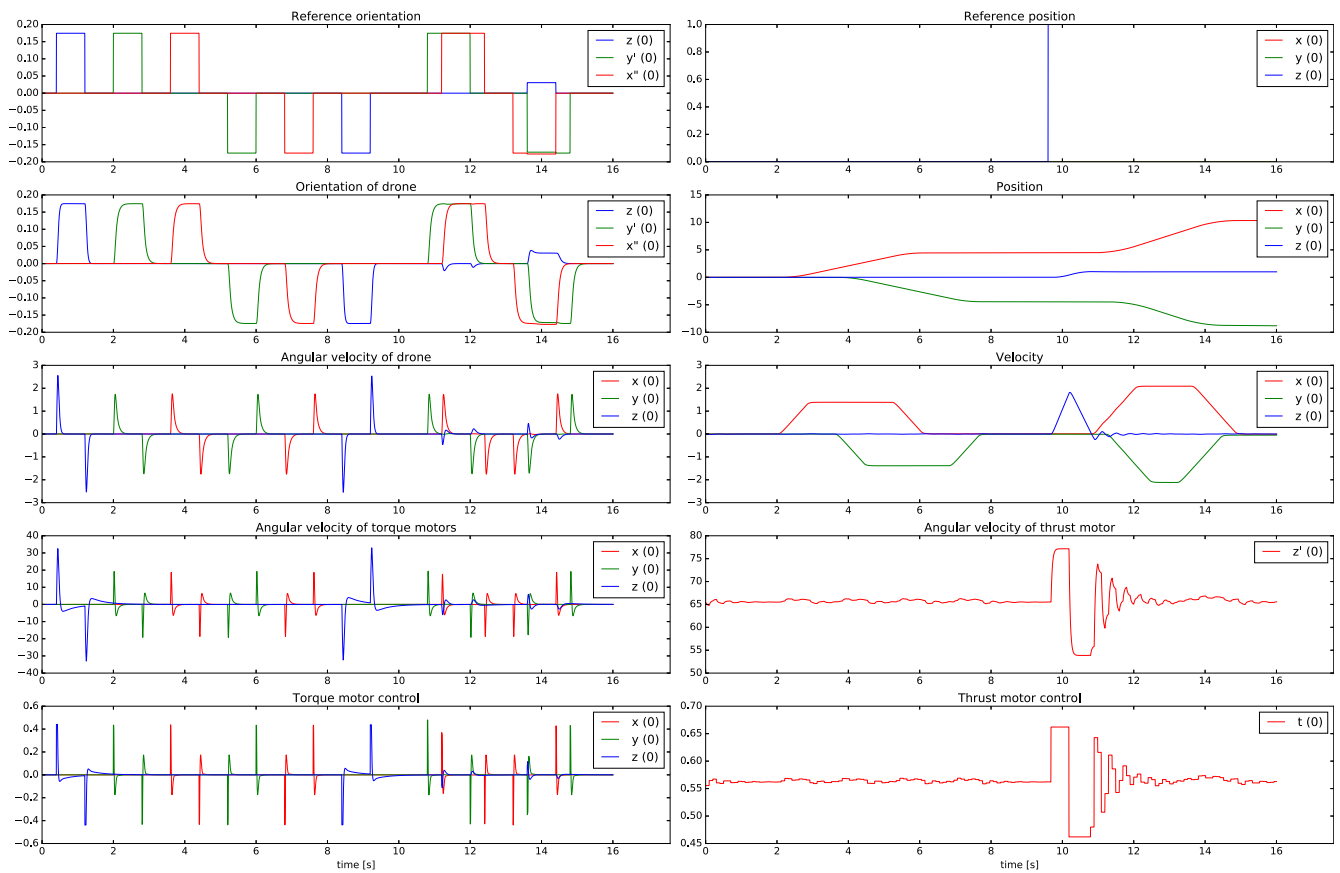
## Vragen

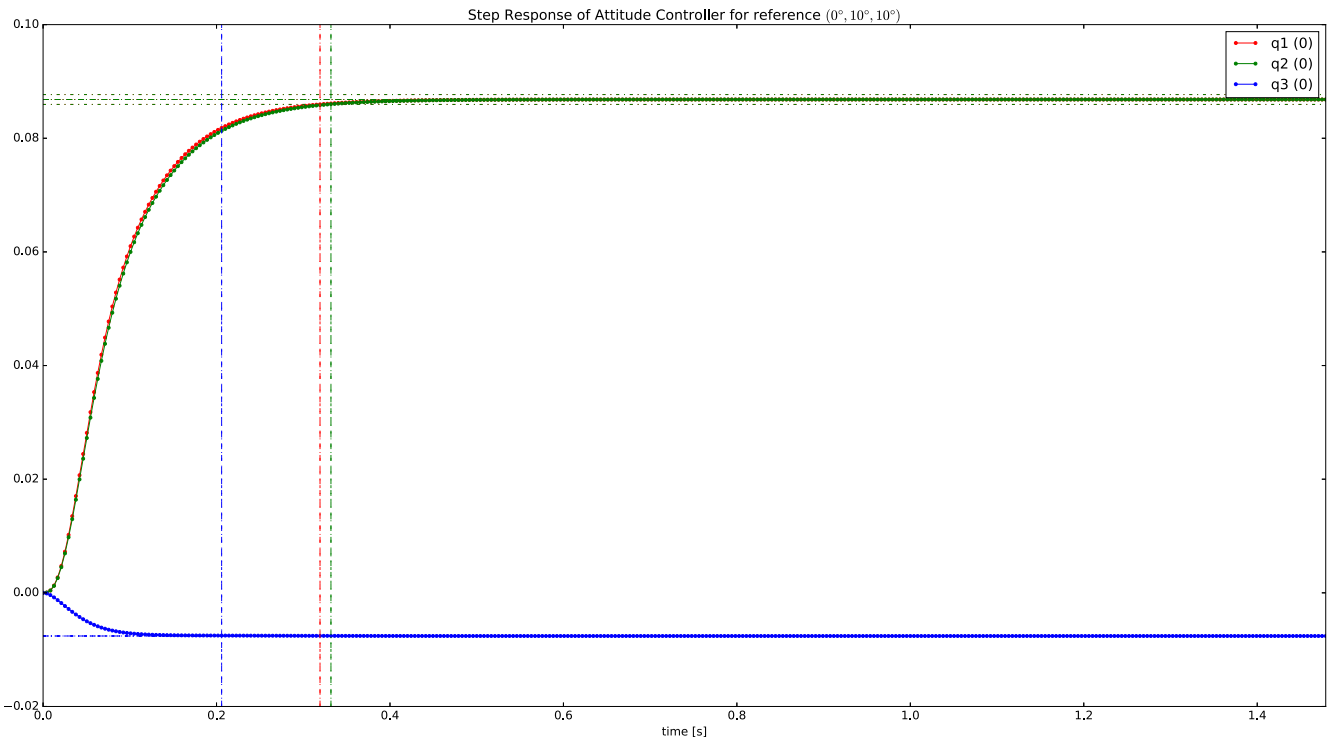
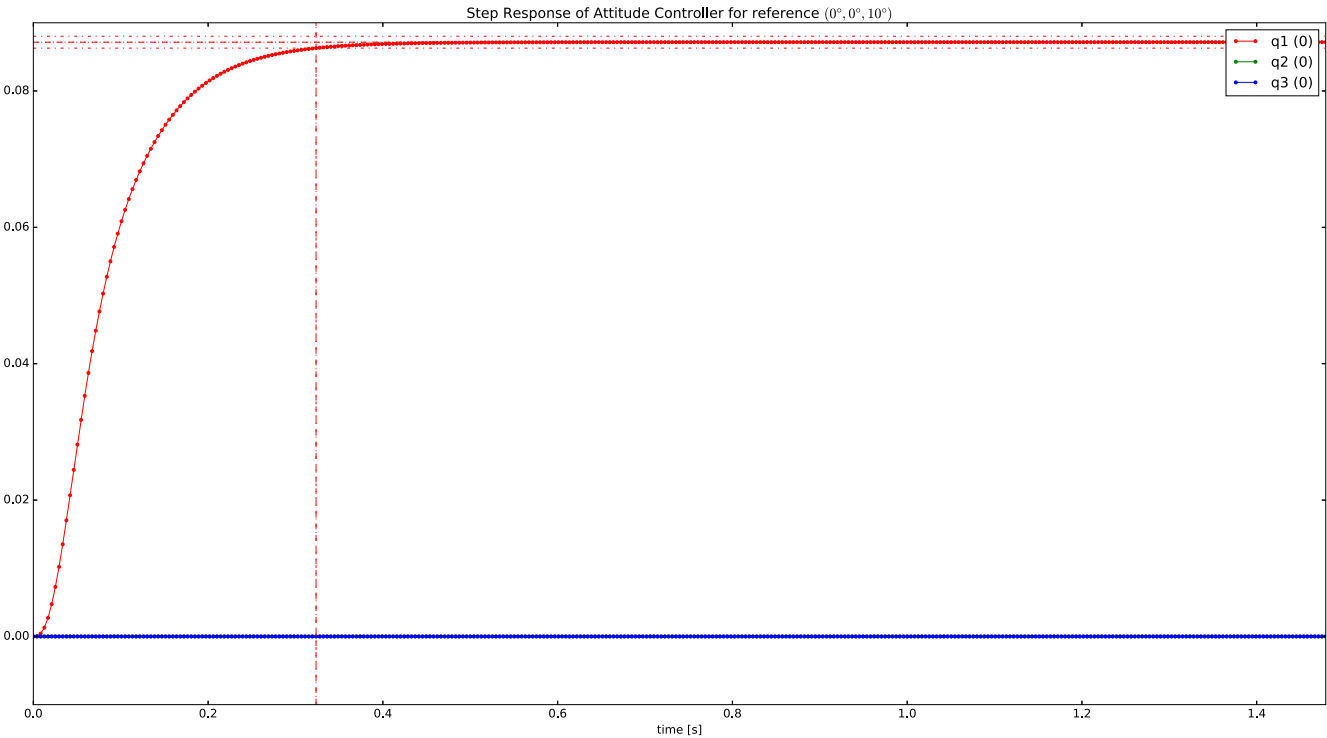
1. Bias rejection attitude controller
2. Integral controller attitude controller
3. Flippen observer als yaw > 90°
4. SSH is traag
5. SSH fingerprint verandert heel de tijd
6. PWM limits: multiple defines

7. Router board bevestigen op de drone
8. Calibratie wanneer thrust geclamped wordt
9. Als de controller wegvalt, moet de drone stoppen!

## To do

1. ✓ Bias rejection attitude controller
2. ✓ Clamp thrust to 80%
3. ✓ Vliegen RC attitude + filmpje
4. ✓ Vliegen met altitude + filmpje
5. ✓ Schema controllers/observers afwerken
6. ✓ Montage GA
7. ✓ Blender animation
8. Keep  $q_0$  positive (slide 135)
9. ✓ Observer reset als thrust 0
10. Mousse IMU
11. When switching from altitude to attitude, gradually change thrust





Model