UAV Workshop

Quadrotor Control

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Quad-Copter Movement

Yaw Rotation

Each of the rotors on the quad-copter produces both thrust and torque. Given that the front-left and rear-right motors both rotate counter-clockwise and the other two rotate clockwise, the net aerodynamic torque will be zero.

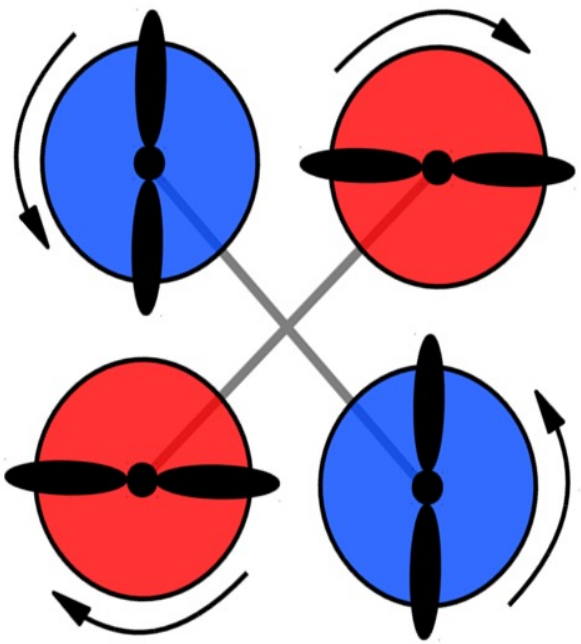
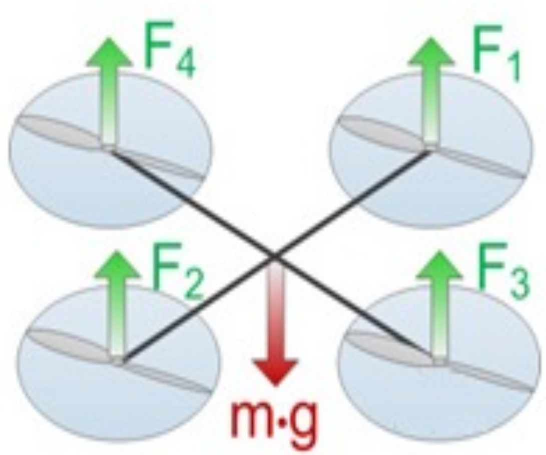


Figure 1: Torque patterns and related motion.

Hovering

For hovering a balance of forces is needed. If we want the quad-copter to hover, SUM(Fi) must be equal m•g. To move the quad-copter climb/decline the speed of every motor is increased/decreased .

SUM(Fi) > m•g <=> climb
SUM(Fi) = m•g <=> hover
SUM(Fi) < m•g <=> decline



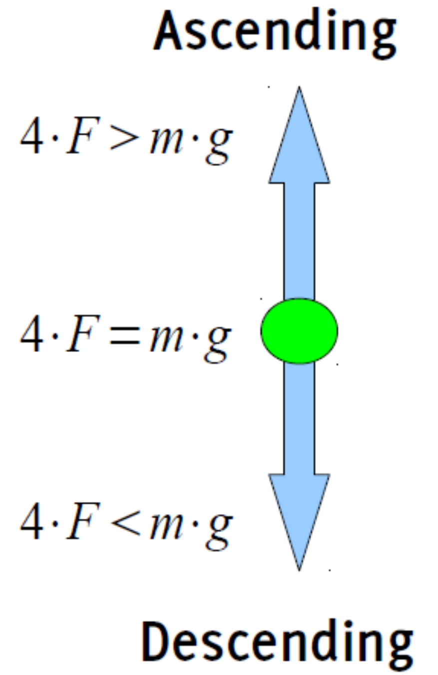


Figure 8: Balance of power while hovering.

Tilting

Now let us take a look on what is happening when we tilt the quad-copter. For simplification only two of the four rotors are shown. We see that the force is divided in two different parts. FL1 and FL2 are the part of the force used to lift the quad-copter. FT1 and FT2 represents the part used for the translation. It is obvious that the lift part becomes smaller with increasing ϕ.

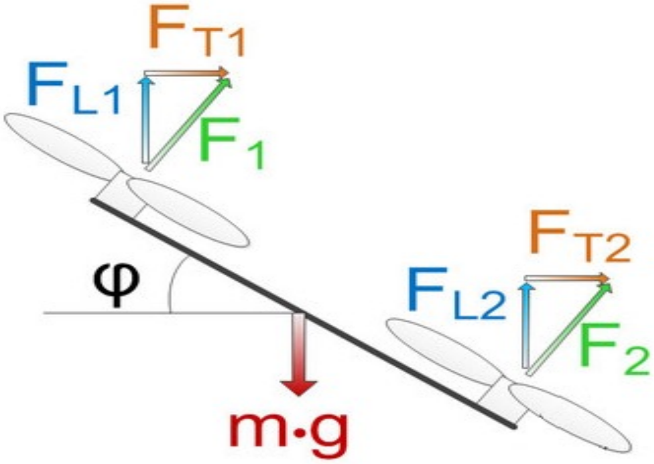


Figure 9: Force distribution for tilting.

Position Control

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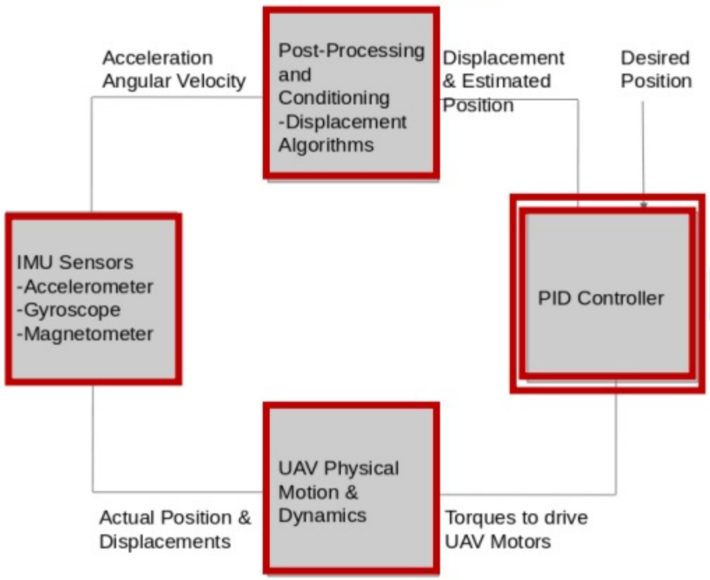
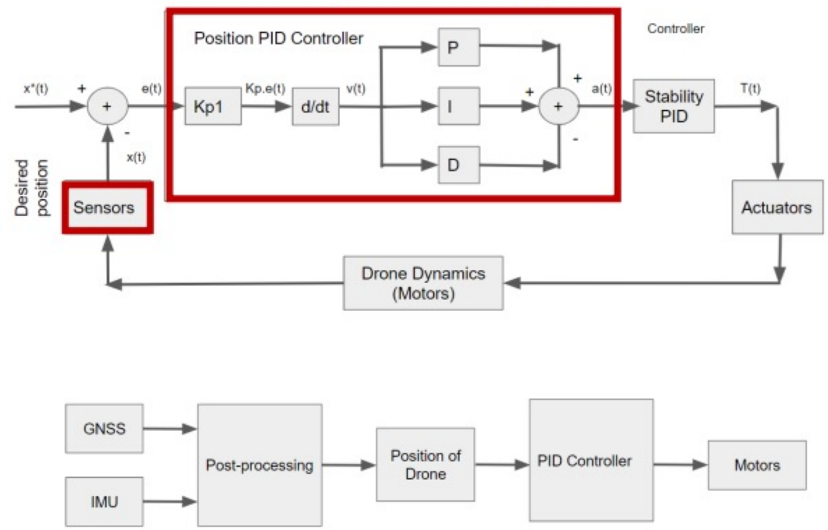
Conceptual Design



System Design



Determine Position

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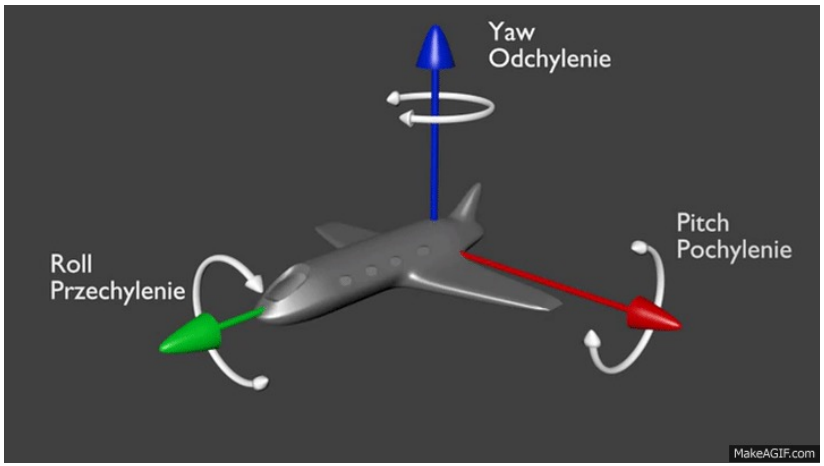
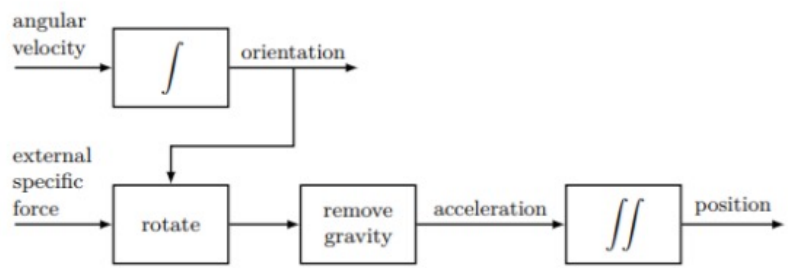
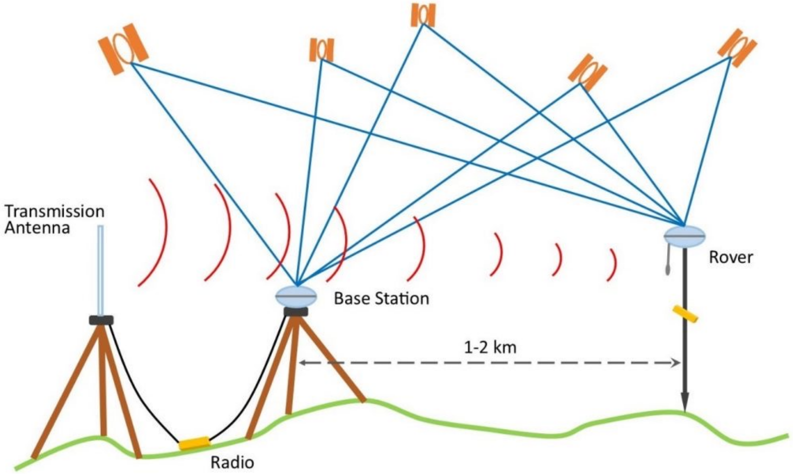
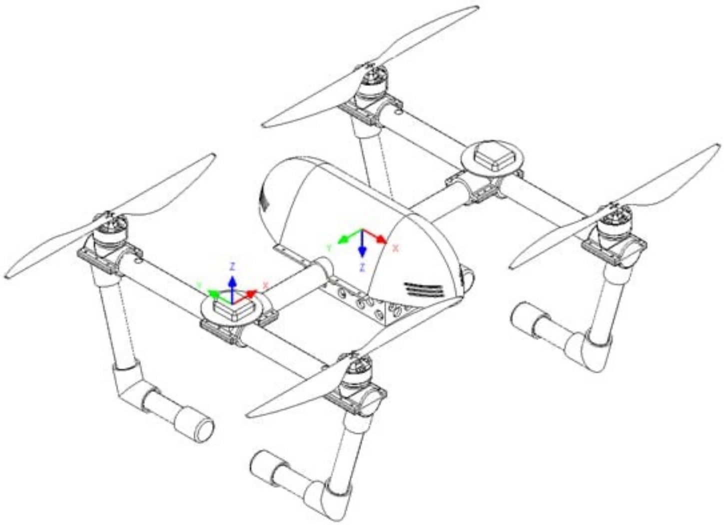




Sensors for Position



GPS



IMU

Filtering/Smoothing

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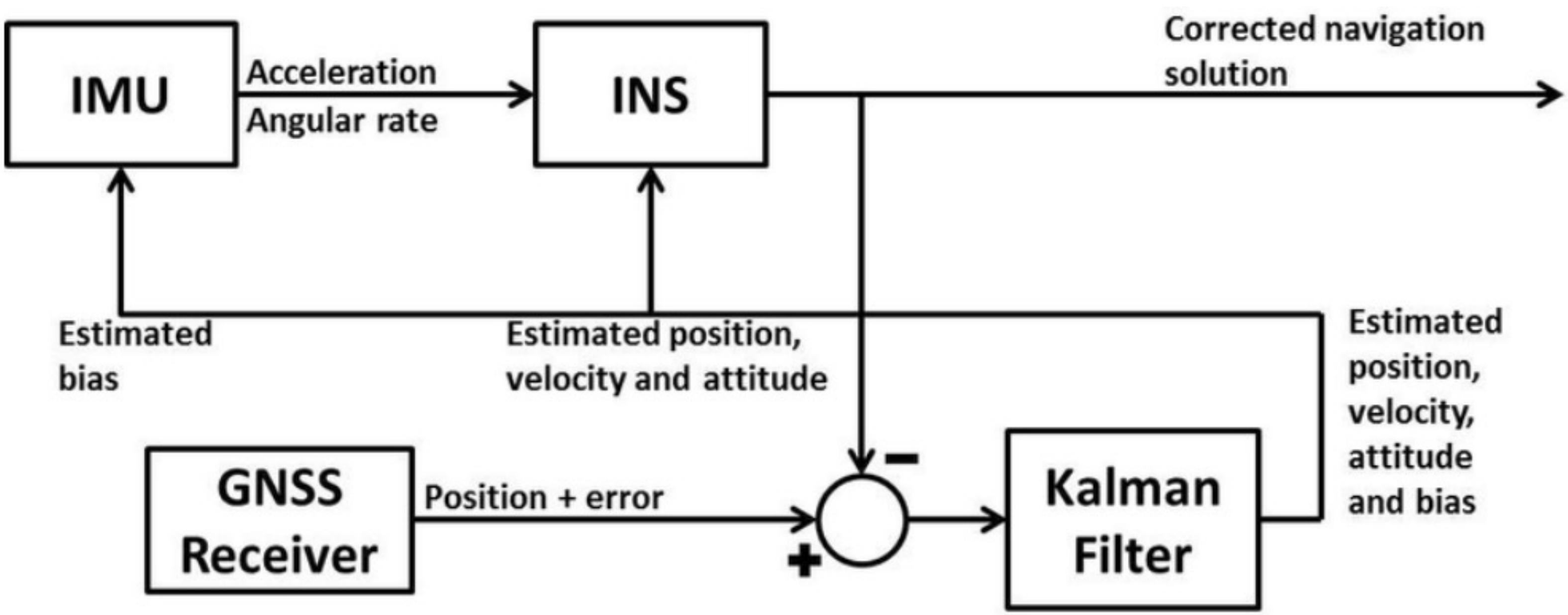
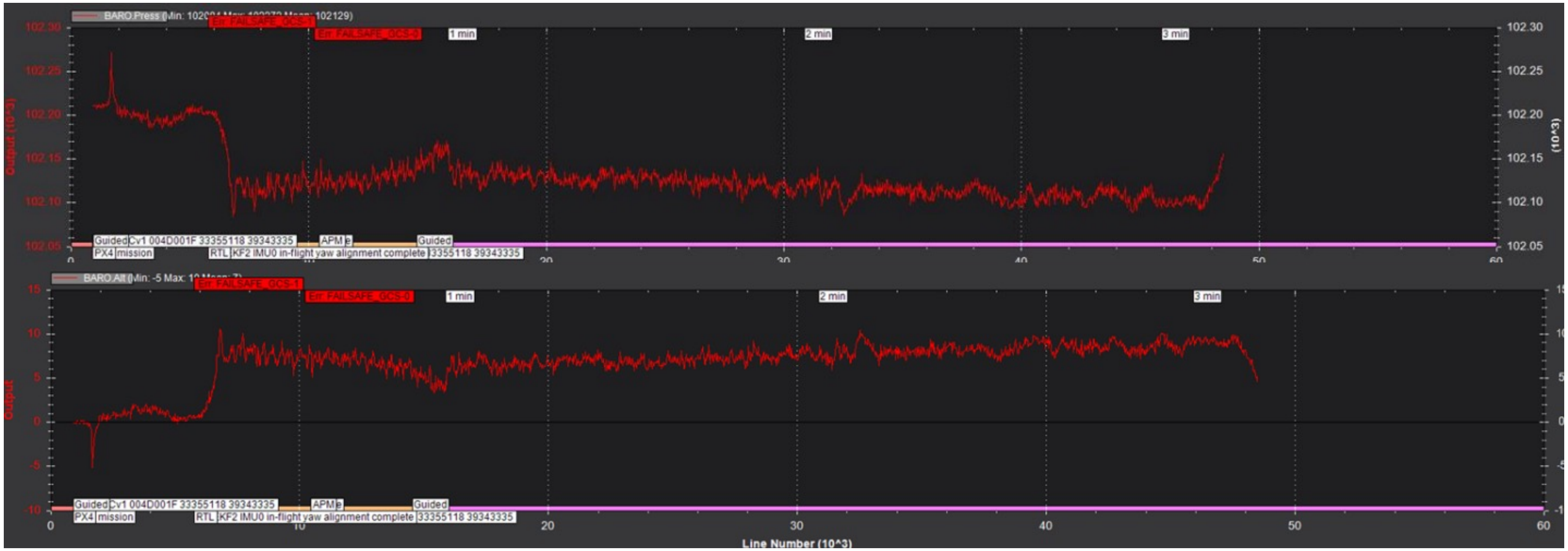
Extended Kalman Filtering (EKF)



EKF Altitude



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EFK - Attitude - Gyroscope + Compass

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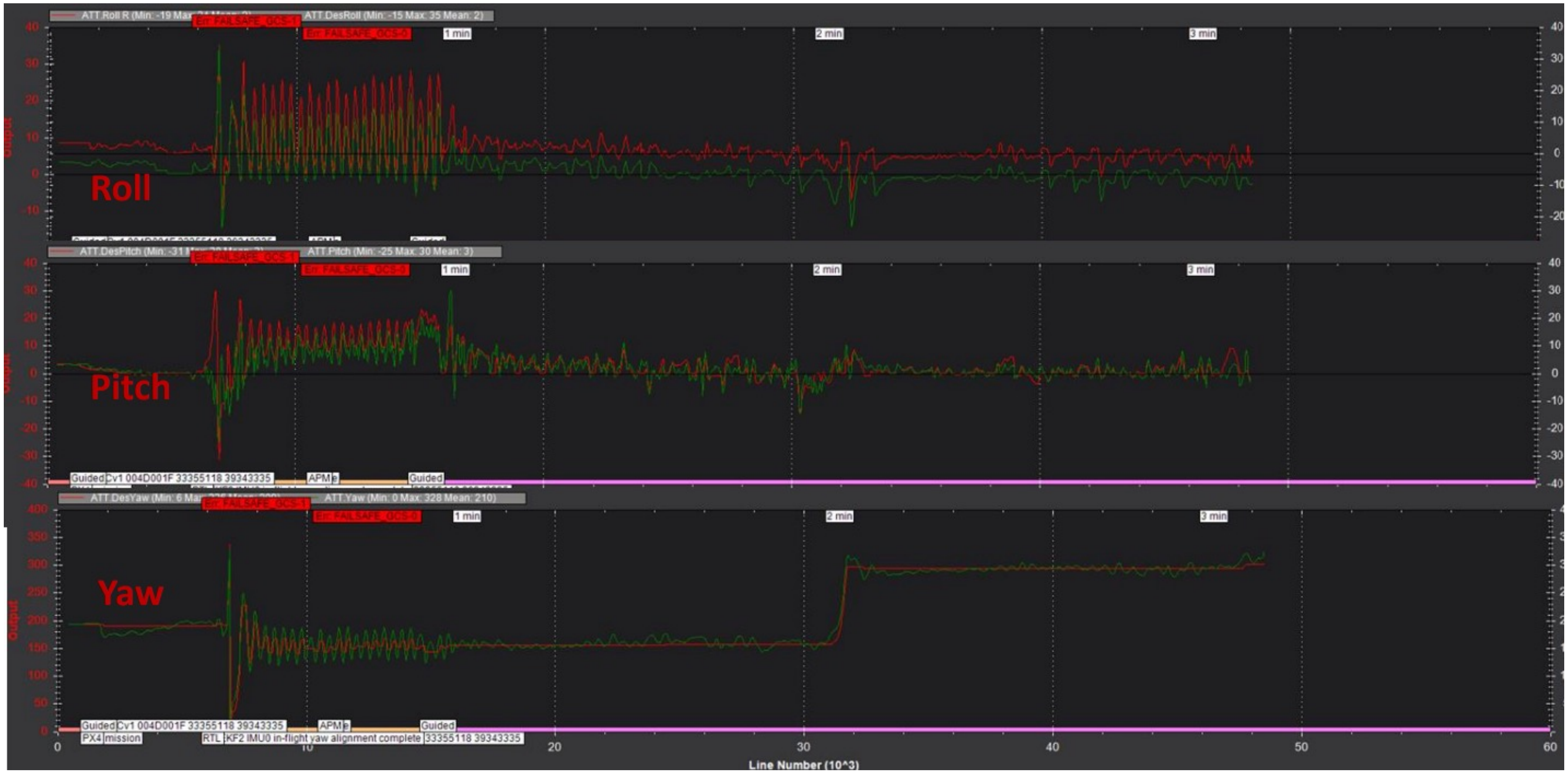

Stabilize, Roll, Pitch & Yaw PID’s

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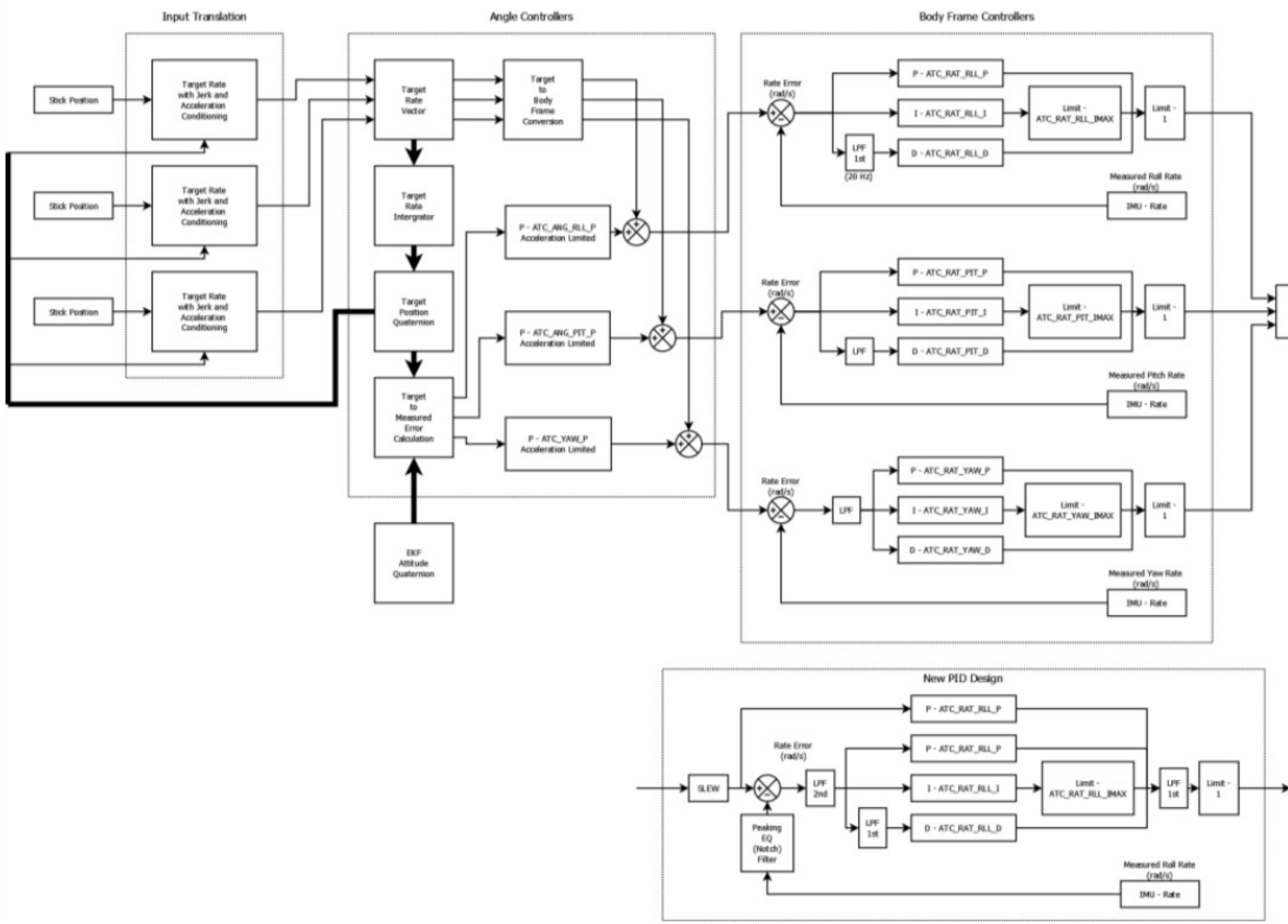

Body frame controller

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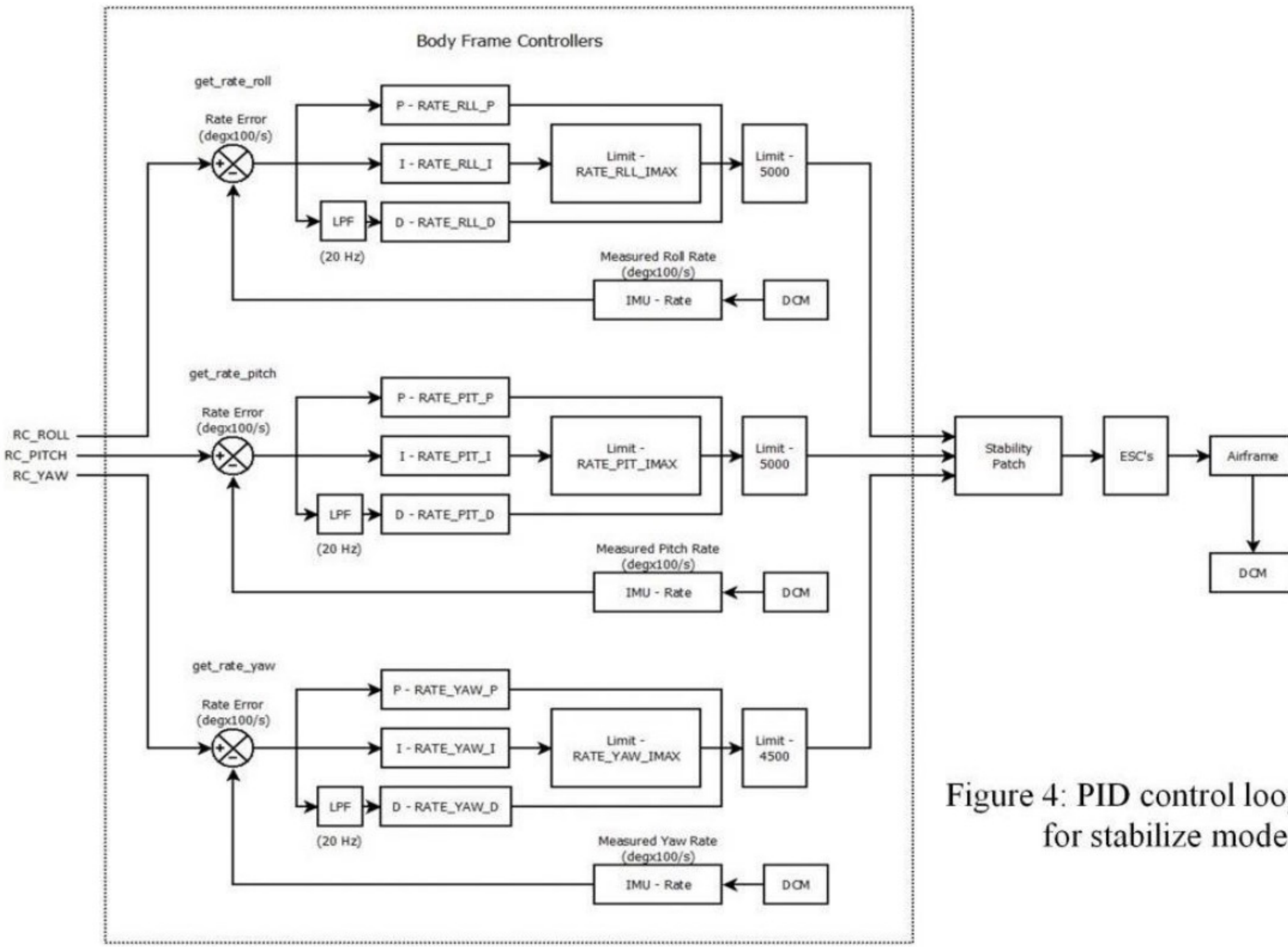
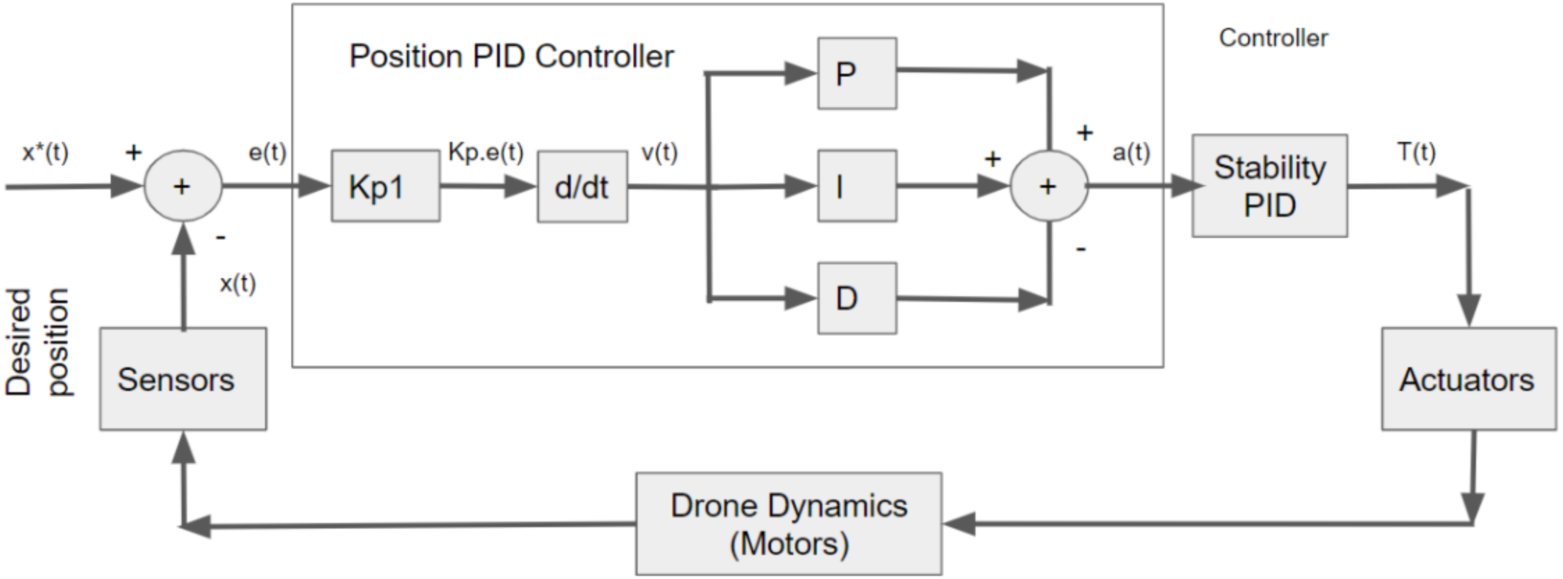


Figure 4: PID control loop for stabilize mode

PID for Position Control



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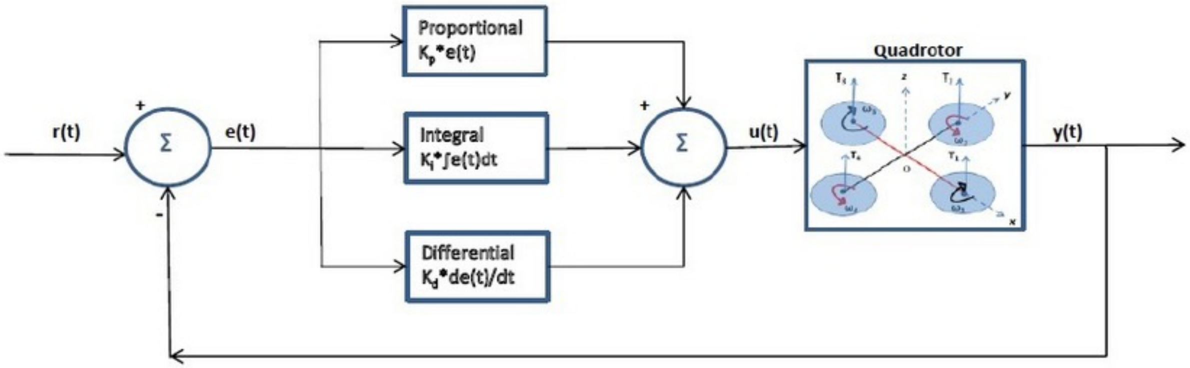
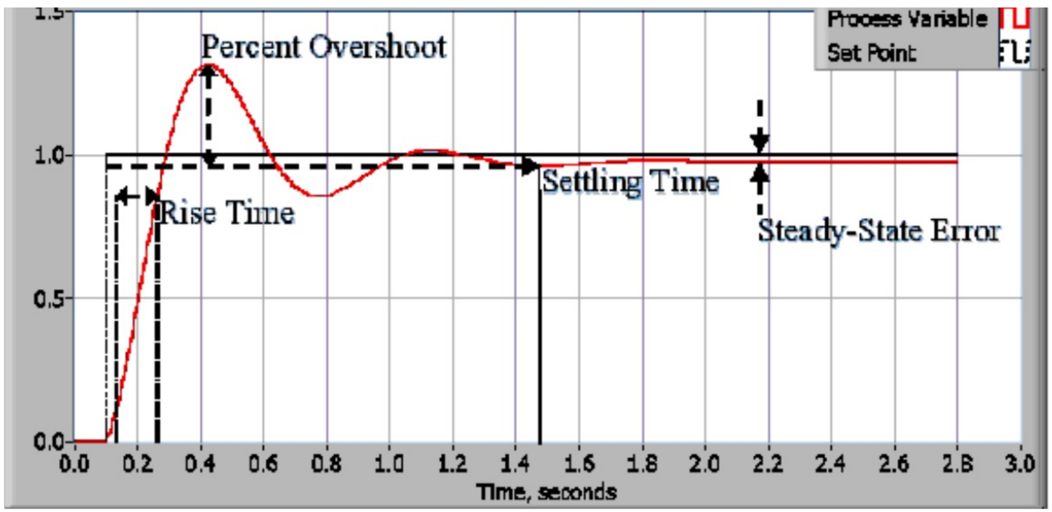
PID for Motor Speed Control





In motor speed control, PID controllers are applied to individual motors to regulate their speed and achieve desired thrust for stabilization and maneuvering.

- **Combining Position and Motor Speed Control:**
  - Both PID controllers work in conjunction to provide complete control over the quadrotor's position and orientation.
  - The position control PID outputs control signals to adjust motor speeds, and the motor speed control PID fine-tunes individual motor speeds.
- **System Stability:**
  - The combined use of PID controllers contributes to the overall stability and responsiveness of the quadrotor, enabling it to accurately follow desired trajectories and respond to external disturbances.
- Proper tuning of PID parameters is crucial for achieving optimal performance in both position and motor speed control.