Nomenclature

* UAV: unmanned aerial vehicle, any autonomous aircraft
* 6-DOF: six degrees of freedom, full attitude and position states
* 4-DOF: four degrees of freedom, reduced attitude control
* SISO: single-input single-output typical control loop, mostly in frequency domain
* MEMs: Micro-electromechanical systems; accelerometers, gyroscopes and the like
* DIY: Do-it-yourself, in context example hobbyking SK450 kit
* VTOL: vertical take-off/landing aircraft. E.g: helicopter, osprey, quadrotor, bi-rotor
* 3-D: three dimensional vector with components in cartesian X-Y-Z axial directions
* MPC: model predictive control
* QFT: quantative feedback technology
* IMU: inertial measurement unit, either 6-DOF acc/gyro or 9-DOF acc/gyro/mag
* RPM: revolution per minute, typical units for propeller rotational velocity
* BLDC: Brushhless-DC motor, actually 3-phase with ESC operates like DC motor
* KV: Thousand RPM per V applied, rating unit for BLDC motor
* OAT: opposed active tilting, single axis rotation on bi-rotor
* dOAT: dual axis opposed active tilting
* PD: Controller structure proportional to error and error derivative
* PID: Proportional to error, error integral and error derivative
* PSO: Particle swarm optimization, gradient free optimization method
* ITAE: Integral-time absolute error, cost function used to evaluate setpoint tracking
* BEM: Blade-Element momentum theory, calculation of applied thrust from propeller
* FTC: Fault tolerant control (typically compensates for uncertainty/disturbances and incorporates redudency)
* LQR: linear quadratic regulator, control structure
* CMG: control moment gyroscope, satellite actuator

Symbols

* pitch rotation about X axis, rad
* roll rotation about Y axis, rad
* yaw rotation about Z axis, rad
* Euler angle set
* transformed Euler angles in common shared body frame
* attitude quaternion with scalar and vector components
* angular velocity in body frame, rad/s
* translational position in the X axis direction
* translational position in the Y axis direction
* translational height in the Z axis direction
* inertial position, m
* translational velocity in body frame, m/s
* full 6-DOF state for combined attitude and position
* desired state setpoint
* error state, not necessarily subtractive, quaternion errors are multiplicative
* rotational velocity of ith propeller, units RPM or RPS specified
* scalar propeller thrust as a function or rotational speed, from EQ:, N
* actuator plant input matrix, consists of rotational positions for extra actuation servos and each motor module’s propeller speed, in R12
* motor module rotation about X axis, rad
* motor module rotation about Y axis, rad
* input torque, Nm
* attitude controller designed torque input, Nm
* input force, N
* position controller designed force input, N
* generalized virtual control input
* body x rotational inertiain Kgm^2, relative frame in context
* vehicle mass, Kg
* actuator matrix
* body frame origin
* motor module center of rotation
* vector arm length from  origin, m
* body x center of mass
* body x mass
* for rotor body
* for inner ring assembly
* for middle ring assembly
* for net motor module
* for constant body frame
* for net multi-body assembly
* Underline implies vector quantity (column vector)
* \mu subscript denotes control inputs
* Subscripts 1-4 refer to quanities associated with each motor module
* Hat accent an axis quantity
* Lower case axis quanitities are unit vectors in the axial direction
* Upper case axiis quanitites refer to the axis itself
* Bold faced vectors are lumped state variables
* Dot accents denote derivates
* M\_i subscripts imply reference to the i^th motor module’s frame
* F^i refers to the ith reference frame
* **Vec{O}**\_irefers to the origin of motion used for the Ith frame
* **C\_i** is center of mass for the body i

Where possible, typical convention for quanitites and notation has been adhered to.