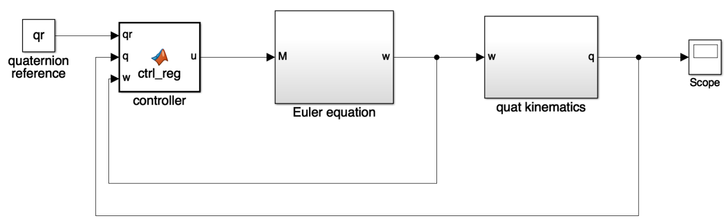
Nonlinear control and aerospace applications - Lab session 7

Exercise 1

A satellite with inertia matrix $\mathbf{J} = \mathrm{diag}(10\,000, 9\,000, 12\,000)\,\mathrm{kg\,m^2}$ is traveling on an Earth orbit. The satellite attitude is relative to a suitable orbital frame. Suppose that orbit non-inertial effects, gravity gradient moment, third body gravity, atmosphere drag and solar radiation can be neglected.
The satellite initial quaternion and angular velocity are the following:

$$\mathfrak{q}(0) = (0.6853, 0.6953, 0.1531, 0.1531), \quad \boldsymbol{\omega}(0) = (0.53, 0.53, 0.053)\,\mathrm{rad/s}.$$

1. For this satellite, implement in Simulink the block diagram shown in the figure.
2. Design an attitude controller finalized to bring the satellite attitude to the (constant) identity quaternion.
3. Change the controller parameters to analize the trade-off between convergence time and command activity.



Exercise 2

Consider the WMAP application discussed in Lecture LS05, where a satellite travels on an orbit around the Earth-Sun L2 Lagrange point, with the goal of mapping the cosmic radiation.

1. For this satellite, implement in Simulink the block diagrams shown in the figures, where the second one is a suitable reference generator. Assume an input saturation $u_i \in [-10, 10]\,\mathrm{Nm}$, $\quad i = 1, 2, 3$.
2. Design an attitude controller finalized to track the Euler angles and rates indicated in Lecture LS05.
   (a) First, suppose a zero disturbance.
   (b) Next, add a disturbance to the input (a sinusoidal signal with amplitude $0.005\,\mathrm{Nm}$ and frequency $0.1\,\mathrm{rad/s}$ for each input component).
   (c) Finally, to reproduce a realistic situation where the inertia matrix is not perfectly known, change the values of the inertia matrix used for control design (e.g., a 5% or 10% change on all entries).