AE 6210 - Advanced Dynamics I
Computer Aided Design Project

Due Date: Last Day of Class

1. DESCRIPTION

Small, unmanned air vehicles are becoming increasingly prevalent for a variety of missions. These vehicles are maneuverable in complex, small, and dangerous spaces and can be used in intelligence, surveillance, and reconnaissance roles. Unlike larger piloted aircraft, these lightweight aircraft experience wind disturbances that are a significant percentage of the trim flight speed of the vehicle, leading to large perturbations in orientation and angular rates. Reduced sensitivity to atmospheric gusts and turbulence is important for camera pointing, tracking, and other reconnaissance work. In order to reduce orientation perturbations, angular velocity feedback is employed inside the flight control system. Rate gyroscopes are commonly used sensors for measuring angular velocity.

Each team of two students will design a single axis gyroscope specialized to a small unmanned air vehicle which is capable of dynamically measuring the pitch rate of the vehicle. As part of the gyroscope design process, the team will create a dynamic model of the gyroscope device attached to a generic aircraft capable of general 6 degree of freedom motion. A schematic of a typical single axis rate gyroscope is shown below (Figure 1). The dynamic model will subsequently be used to establish gyroscope design properties such as the gyroscope disk speed, disk mass, mount stiffness, mount damping, device placement on the aircraft, and device orientation on the aircraft.

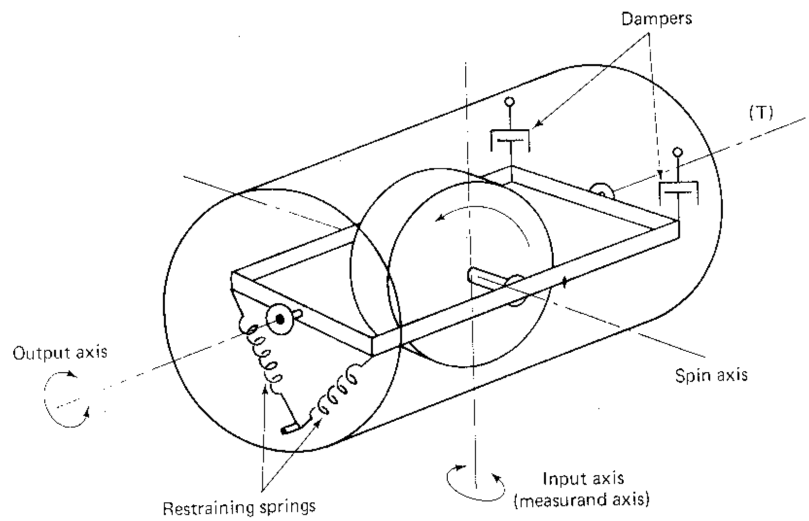

Figure 1 – Schematic of a Rate Gyroscope

The target aircraft for which the pitch rate gyroscope will be specialized is pictured above and is a commercially available radio control aircraft called the Decathlon. The aircraft has a mass of 5.6132 kg, an aerodynamic reference area of 0.6558 m^2, a wing chord of 0.3215 m, and a wing span of 2.04 m. The design trim airspeed is 20 m/sec at a flight path angle of 0.0 deg at a standard altitude of 300 m. An example time history of the 6 degree of freedom states and their time derivatives for this aircraft will be emailed to the teams.

2. REQUIREMENTS

Each group must complete the following items:

a) Develop a single degree of freedom dynamic model of a single axis gyroscope. The rotation angle of the disk support frame and its time derivative should be used as the state variables.
b) Develop a method to insure quality control of the dynamic model. In particular, create a method to ensure the derived equations of motion are correct. Also, create a method to ensure the coding of the equation of motion is correct.
c) Show an example time history of the gyroscope output due to a step change in aircraft pitch attitude. Provide numerical values of all parameters of your model so that your results can be independently regenerated.
d) Conduct parametric trade studies by varying gyroscope disk speed, gyroscope disk mass, gyroscope mounting stiffness, gyroscope mounting damping, etc. Run simulations to assess how the nature of the response is affected. Report your findings.
e) Document your final gyroscope design and present simulation results using the provided aircraft trajectory data.

f) Generate a report including the following sections: Introduction, Model Description, Model Validation, Parametric Design Trade Studies, Final Design, Conclusions, and References. The report length is limited to a total of 10 single sided pages.

3. DESIGN NOTES

Assuming that the designed gyroscope device is substantially smaller and lighter than the parent aircraft, it can be assumed that the gyroscope does not affect the motion of the aircraft. However, the motion of the parent aircraft obviously affects the gyroscope dynamics.