

The Importance of the Gyroscope Sensor in the Devices, Especially in the Plane

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ABSTRACT

Objective: The secret to producing high-precision tension for connection with a proposed gyroscope (CMGs) in spaceships is the fast speed regulation of gyroscope servo systems. Nevertheless, disturbances, particularly dynamic balancing disturbances that have the exact wavelength as the high-speed rotor, may severely reduce the system stability of gimbal robotic manipulators. Using a dynamic balanced machine to number of key factors the rotor imbalance in built CMGs is quite challenging. In order to calculate the dynamic instability of the rotor built in the CMG, a gimbal disturbances investigator is proposed in this study. **Method:** First, a third-order nonlinear system is created to characterize the behaviors of the disturbances in the gimbal servo system. In this system, the other problems and the rotational dynamic balancing torque along the gimbal axis are treated as being periodic and bounded, respectively. Using the complete disruption as a virtual observation, the gimbal disturbances observer is then created for the second dynamical system. Since the simulated measure is produced from the inverse kinematics of the stabilizer servo system, only observations of gimbal rotation and three-phase flux may be used to indirectly determine the knowledge of the rotating dynamic imbalance. **Results:** Results from semi-physical experiments show how well the observer works when a CMG simulator is used. **Novelty:** In order to calculate the dynamic instability of the rotor built in the CMG, a gimbal disturbances investigator is proposed in this study.

INTRODUCTION

Connection with a proposed gyros (CMGs) have been utilized extensively in spaceship attitude control as a type of axial velocity exchange actuator because of their outstanding qualities in straightforward form, huge torque, and precision [1,2]. As seen in fig. 1, a CMG typically comprises of an increased rotor with a lot of rotational motion and one or multiple quality gimbals.

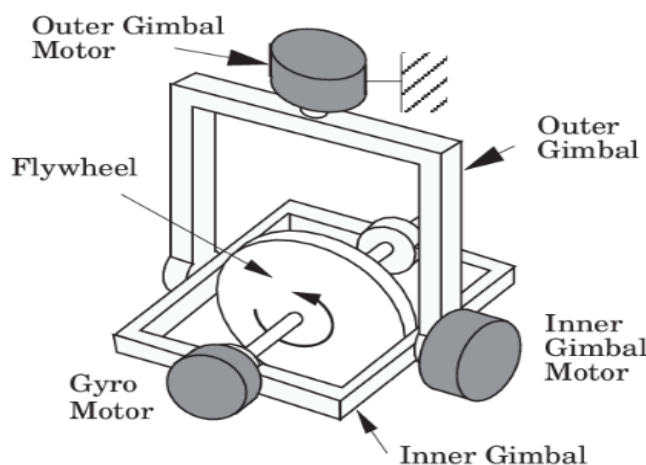


Figure 1. Control moment gyros (CMGs)

Gimbal motions powered by gimbal position control can rotate the rotor in accordance with torque directions. Gyroscopic tension will be developed to regulate spacecraft attitude as a result of changes in the rotor's momentum's direction. The command precision of the servo gyroscope systems needs to be high enough as shown in fig2 in addition to create powerful motor to meet requirements for starship flight control with high stability and accuracy.

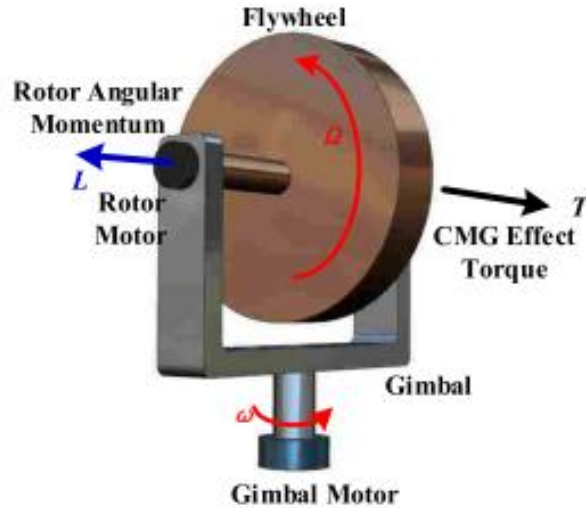


Figure 2. Gimbal servo systems cause the rotor to revolve in tandem with gimbal motions.

Yet there are numerous problems with gimbal servo systems, including resistance, torque jerk, the disturbances torque resulting from rotor imbalance [4], etc. Particularly the dynamical imbalance disturbance, all these disturbances have the potential to considerably worsen the system stability of gimbal servo systems. Increased control of gimbal drive system has been severely hampered by the amplitude, which is equivalent to the square of both the rotor's angular speed and has the same incidence as the rotor [5, 6]. This is because the rotor's high speed causes severe disturbances with frequency higher and larger amplitude. Thus, it is essential to gather data on rotational dynamics imbalances before developing the gyroscope servo systems for Group consisting as shown in fig 3.

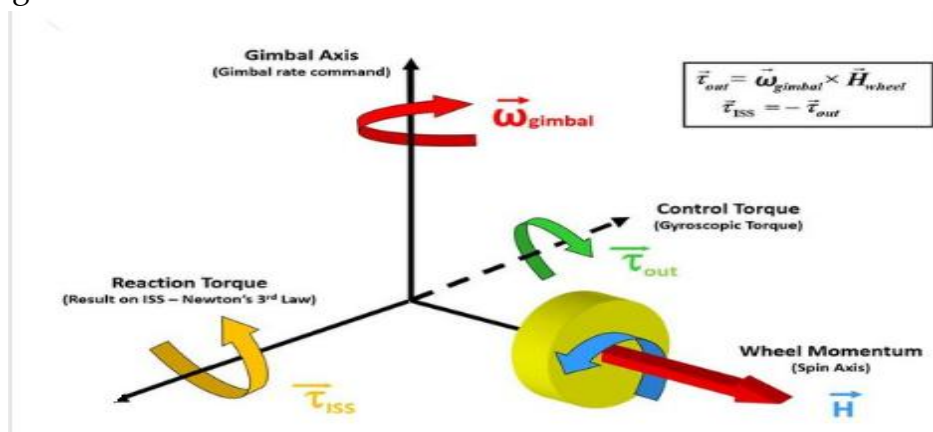


Figure 3. Dyskinesia disorders of imbalance having a frequency that is the same and a loudness that is equal all the way there of both the rotor's Angle of rotation

Due to asymmetrical mass redistribution and production flaws, the rotor's relationship to the rotational axis is out of balance, which leads to rotors mass imbalance [7,8]. The centroid of the rotor is offset from its rotating axis, which causes static imbalance. Dynamic imbalance is caused by the major axis of inertia's mismatch with the rotor's spinning axis. Dynamic and static imbalance can, respectively, provide peripheral centrifugal forces as well as torque when the rotor spins around the spindle axis [9,10]. The dynamic mismatch, not the static one, is the main problem impacting gimbal servo systems because only the servo's tension can rotate the gimbal. The dynamic instability for a freely rotor can be established using established techniques, and it can subsequently be corrected with mechanisms by adding or removing corrective masses [11]. After dynamic balancing, the rotor still has some leftover imbalance because of the limitations of device applications [12]. Also, after the rotor is mounted on the mechanical bearing, an assembly failure could modify the dynamic imbalance. Field dynamic balancing approaches can be utilized without dismantling to gain information on the dynamics unbalance for the completed rotor [13,14]. Due to the impact of both the gimbal movements, these strategies are ineffective for the constructed CMGs. Several research findings have been published in literatures for the assessment and reduction of the remaining mass balance of magnetically hung rotors mounted in the apparatus [15]. In one work [16], a composite control approach was suggested in order to achieve precise suspending of a permanent magnetic balance (AMB) system after a disturbance monitor was created to estimate the associated disruptions, including imbalances. Another study designed a repeating disturbance observer-based controller specifically to reject the disturbance brought on by an AMB system's rotor mass imbalance. According to a different study, vibrations were controlled following disturbance compensation for microwave actuators by applying disturbed models and state observations to predict lumped disturbance, including balance. Yet in order to get these results, observations of the rotor deflections were used, which are only possible with magnetized suspended rotors compared to mechanical ones. Moreover, it is impossible to isolate the imbalance disturbance from the estimated overall disturbance. In this research, a gimbal disruption observer is presented to monitor the kinetic imbalance for completed rotors in CMGs. The gimbal servo system's vibrant imbalance disturbance and other disturbances are described by this observer, which is built for a third-order system. The total disturbance is considered to be a virtual measurement while designing the observer, and it can be done by utilizing the range of variables of the gyroscope servo system. The static imbalance disturbance can be identified by employing the gimbal disturbance observer.

RESEARCH METHOD

Theory

Motion at an angle. The simple replacements (bold variables are vectors) can frequently be made to the calculations for translational to yield the fundamental equations for angular motion:

Linear variables	Angular variables
Force, F	Torque, τ^{\rightarrow}
Mass, m	Moment of Inertia, I
Velocity, v	Angular velocity, ω^{\rightarrow}
Momentum, p	Angular Momentum, L
Acceleration, a	Angular acceleration, a

NB. The analogy should not be taken too literally; for instance, I is not a regular part of the body, unlike mass, because its value changes on the direction around which it's measured.

Thus Newton's Law

$$\vec{F} = \frac{d\vec{p}}{dt} = \frac{d(m\vec{v})}{dt} = m\vec{a}, \text{ becomes } \vec{\tau} = \frac{d\vec{L}}{dt} = \frac{d(I\vec{\omega})}{dt} = I\vec{\alpha}.$$

We can therefore observe that the torque (τ) applied to a wind turbine rotor (L) leads to an alteration in that linear velocity using the following relationship:

$$\vec{\tau} = \frac{d\vec{L}}{dt} \longrightarrow \textcircled{1}$$

where τ^{\rightarrow} is the applied torque; $\vec{L} = I\vec{\omega}$ is the angular momentum, ω^{\rightarrow} is the angular velocity of rotation of the body and I is a body's inertia period relative to its axis of revolution. (i.e., about the

$\vec{\omega}$ axis). If this τ^{\rightarrow} The axis of the application of tension is L (i.e., perpendicular to the direction of $\vec{\omega}$)

then from equation (1), L not only changes in direction but also in magnitude. Before continuing, ask a demonstration to confirm that you do not understanding why this is the case. This shift in L 's course

(and thus also of $\vec{\omega}$) precession, which manifests as a revolution of the L vector's direction through having room a loans for small angular velocity of $\bar{\Omega}p$. Then it might be demonstrated that as in fig4 :

$$\vec{\tau} = \Omega_p \times \vec{L} \longrightarrow \textcircled{2}$$

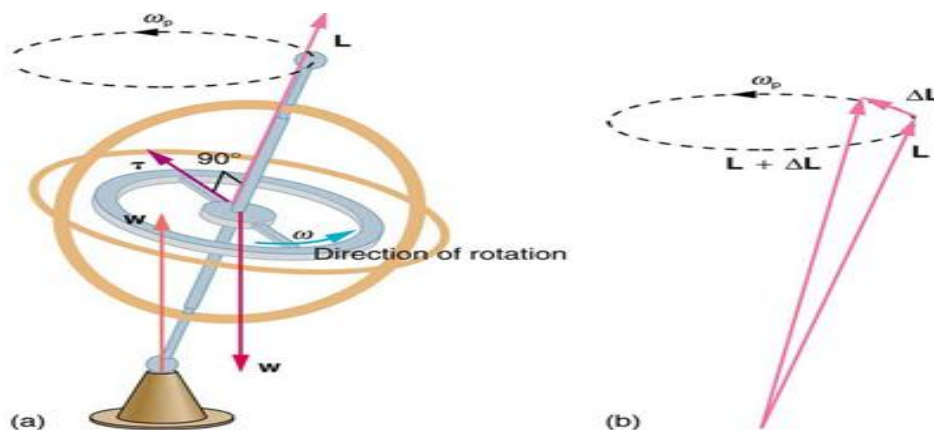


Figure 4. (a.b)

The mass of the rotating gyroscope and the strength of the stand's support are the forces acting on it in figure (a). These forces produce a diagonal torque on the accelerometer, which results in a horizontal shift in angular velocity L .

In figure (b), the addition of L and L creates a new centrifugal momentum that has the same amplitude but a different path, preventing the gyroscope from toppling over.

A. Inertial Sensors

A tool that accurately monitors momentum is an accelerator. The coordinate acceleration is not always the proper acceleration as determined by an accelerometer. (rate of change of velocity). Instead, in the standpoint of the accelerator device, it perceives the accelerating connected with the occurrence of weight observed by any analysis . the primary at rest. Due to its weight, an accelerometer at resting on the planet's outermost layer will, for instance, register an acceleration of $g=9.81 \text{ m/s}^2$ straight upwards. Gyroscope in free fall either at rest in space, on the other hand, will register zero. G-force acceleration is another name for the kind of movement that accelerometers can measure. Accelerometers are used in a wide variety of scientific and industrial processes. Elements of inertial coordinate systems for aircraft as well as missiles include highly sensitive accelerometers. In attempting to detect and track movement in spinning machines, accelerometers are utilized. Digital cameras and touch screens both use accelerometers to ensure that pictures on screens have always been presented upright. In order to sense attitude (because the direction of weight changes), coordinate momentum (as long as it produces g-force or a start changing in g-force), acoustic noise, shock, and falling in a resistive medium, there are Accelerometers come in single- and multi-axis types. Currently offered (a case where the proper acceleration changes, since it starts at zero, then increases). Online gaming controller and other compact electronic toys are beginning to incorporate small non accelerometers.

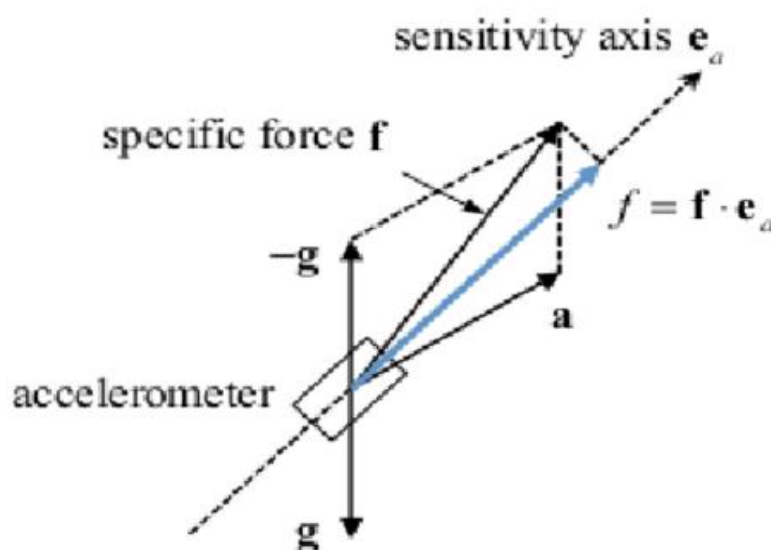


Figure 5. The projected is determined by a single-axis accelerometer.

B. Magnetization

The magnetic field of the planet has a constituent parallel to the surface that constantly faces the electromagnetic north pole and has a strength of between 0.5 and 0.6 gauss. It is downward in the hemisphere. It points vertically at the equator and upward in the southern hemisphere. An inclination angle is the arc that is created by the earth's magnetism and the horizontal plane. Depending on the location, an inclination angle in the magnitude of 20o is regarded as another angle here between global magnetic north and continental north. A 3-axis magnetism detector and a 3-axis gyroscopes are necessary for an electronically compass system that can compensate for tilt. For tilt correction, the accelerometer measures the tilt inclinations of rotation and pitch. Moreover, the magnetic sensor measures the earth's magnetic field before calculating the heading angle in relation to magnetic north. The deflection angle at the existing geographic position should be corrected to the electromagnetic heading if the bearing with respect to north direction is needed. like in fig 6.



Figure 6. Magnetometer and Gyroscope Calibration Method with Level Rotation.

RESULTS AND DISCUSSION

Voltage is applied

Certain airplanes only have electrical, vacuum, or pressure-operated gyros. On other aircraft, the headed and attitude displays are driven by the vacuum or pressure technologies, whereas The electrical infrastructure provides electricity to the turn coordinators. To know that at least one stream of bank details is available in the event that one power source fails, the majority of helicopters have at least one or two power sources. Similar to how a windmill or turbine works, the tension or pressure arrangement spins the gyroscope by pushing an airstream up against the spinning vanes and causing the rotor to spin rapidly. The range of suction or pressure needed for an instrument to operate lies between 4.5 and 5.5 inches of mercury. One generator of pressure for the flatbreads is an impeller drivetrain pump that is installed on the accessories case of the power plant Pump capacity differs across aircraft, according to the amount of gyros. A common vacuum system comprises of a drivetrain vacuum pump, control valves, air

filter, gauges, and tubes required to finish the interconnections. The gauge, which is located in the cockpit of the airplane, displays the system's pressure (Lower than the average vacuum can be expressed in inches of methane). The diesel vacuum pump pulls air into the vacuum system, as seen in Figure 7. To stop foreign objects from entering the suction or pressured system, it initially passes through a filter. The air then travels via.

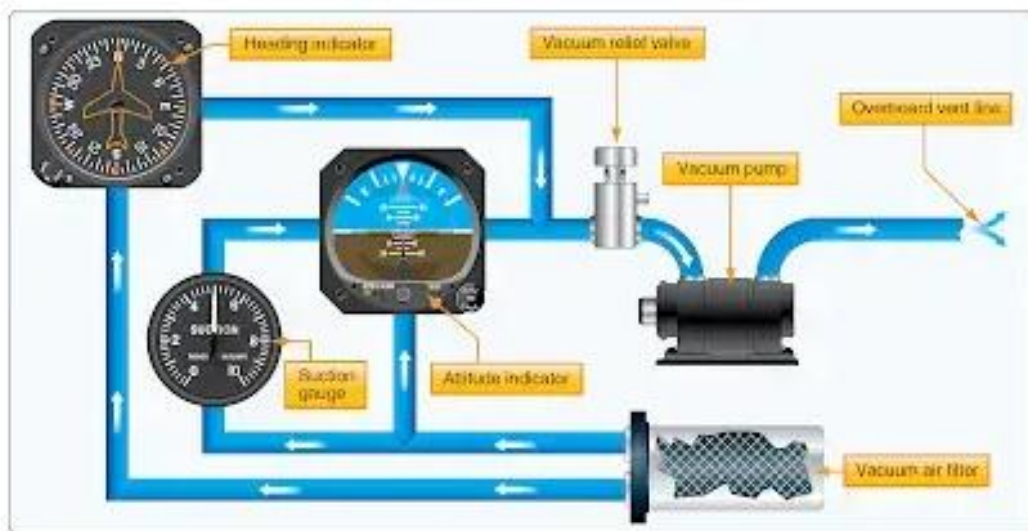


Figure 7. Typical vacuum system.

Is crucial to keep an eye on vacuum pressure throughout flight, since low pressure of suction could make the orientation and heading indications unreliable. The normal range of the vacuum or suction gauge is typically marked. Some airplanes are fitted with just an indicator light that lights when the atmospheric pressure drops just under the permitted limit. When the atmosphere pressure goes below the normal range of operation, the gyro instruments might be unreliable and incorrect. Regularly cross-examining the tools is an excellent habit to establish.

Applications

1. Gyroscope There are numerous uses for sensors. Whilst the optic fibre gyros are utilized in racecars and personal watercraft, ring optical gauges are employed in spacecraft and space shuttles.
2. Vibratory gyroscope sensors serve applications such as radio-controlled helicopters, autonomous systems, camera shake detection in camcorders, stability control power systems for cars, motion sensing in mobile games, etc.
3. Angle sensing, angular velocity perceiving, and control mechanisms are the primary duties of the gyroscope sensor in all applications. By using an optical image way on the basis with a gyroscope sensor, image smearing in cameras can indeed be reduced.
4. Developers are creating a variety of effective and affordable goods by studying their behavior and characteristics, such as a system for gesture-based control of a magic mouse, bidirectional control of a wheelchair, etc.

5. The way we may utilize our movements as directions to control devices is evolving as a result of the creation of several new applications. The market gives the MAX21000, MAX21001, MAX21003, and MAX21100 gyroscope sensors, among others. What smartphone app did you employ to emulate the magnetometer sensor on your mobile?

CONCLUSION

Fundamental Finding : A third-order developed model can effectively characterize overall perturbations in a gyroscope servo system, enabling accurate identification and isolation of rotor dynamic imbalance disturbances from total system disturbances. **Implication :** The use of a third-order gimbal disturbances observer allows indirect measurement of rotational kinetic imbalance using only three-phase wind and gimbal speed readings, improving efficiency and reducing the need for additional sensing components in CMG systems. **Limitation :** The system stability is highly sensitive to disturbances, particularly rotor dynamic imbalance occurring at the same wavelength as the high-speed rotor, which can significantly degrade servo performance. **Future Research :** Further investigation is needed to enhance robustness of the observer under severe disturbance conditions and to validate the approach in more complex or real-world CMG operational environments.

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