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# Study on Fiber Optic Gyroscope

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*Abstract*:-- **A ring laser gyroscope (RLG) consists of a ring laser having two independent counter-propagating resonant modes over the same path; the difference in the frequencies is used to detect rotation. It operates on the principle of the Sagnac effect which shifts the nulls of the internal standing wave pattern in response to angular rotation. Interference between the counter-propagating beams, observed externally, results in motion of the standing wave pattern, and thus indicates rotation.**

## I. INTRODUCTION

The term navigation represents the information needed in air, land, space and in ocean regarding the position and direction. The word „navigation" is originates Sanskrit word „Navgathi" which indicates „to move or direct". The techniques for navigation include locating the position, compared to know the locations, the direction and the distance travelled. Development of radio, radar, inertial and satellite navigation systems occurred in the modern phase.

Usually the navigation systems are used for determining position, velocity and direction relative to some reference co-ordinate frame. All navigation systems include requirement of choosing a reference co-ordinate frame as the common aspect. In a three- dimensional system, all these frames are orthogonal and also right handed. Another important orthogonal frame of reference is known as Earth Central Inertial (ECI). The term „inertial frame refers to a frame that is non-inertial and non-accelerating in inertial space.

An inertial navigation is a navigation aid that uses a computer, motion sensors and rotation sensors to continuously calculate via dead reckoning the position, orientation and velocity of a moving object without the need for external references. It is used on vehicles such as ships, aircrafts, submarines, guided missiles and spacecraft. By processing signals from such device tracking of position and orientation of a device is possible.

### *1.1 Gyroscope*

A gyroscope is a device for measuring or maintaining orientation, based on principles of angular momentum. The applications of gyroscopes include inertial navigation systems where magnetic compasses would not work or with low precision. Due to high precision of gyroscopes, they are used in gyro the odolites to maintain direction in tunnel mining.

In the past, the basic approach in designing a gyroscope includes a spinning mass mounted on stable element, so that gyroscope was fixed in inertial space and through use of gimbals isolated from the vehicle motion. With advent of lase, a physical mechanism is developed to allow laser to sense rotation. The rotation sensing is possible in the frame of lase, which allows the device to be measured directly to the vehicle and avoiding the need of gimbals. In this type, laser was introduced within a closed contour for the cavity. This is described as a ring laser gyro or simply, RLG. It works on the principle of Sagnac effect.

### *1.2 Sagnac Effect*

In a Sagnac interferometer, two oppositely directed beams, i.e. clockwise (CW) and counter (CCW), arising from same source propagate inside the interferometer along same closed path . At its output, the CW and CCW waves interfere to produce a fringe pattern which shifts if a rotation is applied along an axis perpendicular to the plane of beam path. The two CW and CCW beams undergo a relative phase difference proportional to the rotation rate Ω. With respect to inertial space, the two counter- propagating light waves take different times to complete a trip around a rotating closed path. Thus difference in optical path occurs which is indicated by the fringe pattern due to interference of two beams.

### *1.3RingLaser Gyroscope*

Ring Laser Gyroscope is a gyroscope in which Sagnac effect is used to measure the angular rate. During any movement of the aircraft, or on other vehicle it is mounted on, the angular rate is measured by determining the frequency shift in the beams. The RLG became the first optical device for inertial guidance use. Even though currently RLG remains very large and heavy, they are proven to have more accuracy than traditional rotating

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mechanical gyroscope. Ring laser gyroscopes contain optical elements such as He-Ne laser light, having wavelength 632.8 nm, which was split into two different but identical optical paths set by mirrors and combined to produce an interference pattern.

## II. WORKING OF RLG

The RLG combines functions of optical frequency generation and rotation sensing into a laser oscillator within a ring shaped cavity [12]. The ring laser gyroscope consists of a solid block, either square or triangular, of glass ceramic material into which a lasing medium is introduced as shown in fig.1. The electrodes provide gain for the lasing medium. The lasing medium is generally a Helium- Neon mixture due to its short coherent length and refractive index nearly 1.0. This generates two independent beams in opposite directions around the cavity. For the optical path to support lasing there must be an integral number of wavelengths, around the path and oscillation will occur at that frequency „f", which meets this requirement. The cavity size is adjusted to support oscillation at frequencies optimal to the lasing media. This difference in frequency between the two travelling waves is called beat frequency, Δf.

Δf where, A is area of ring cavity, L is path length of laser light, λ is wavelength of light in lasing medium and Ω is angular rate of rotation. The ratio 4A/Lλ is known as scale factor of gyro. Beat frequency is directly proportional to rate of rotation Ω. = 4AΩ/Lλ where, A is area of ring cavity, L is path length of laser light, λ is wavelength of light in lasing medium and Ω is angular rate of rotation. The ratio 4A/Lλ is known as scale factor of gyro. Beat frequency is directly proportional to rate of rotation Ω.

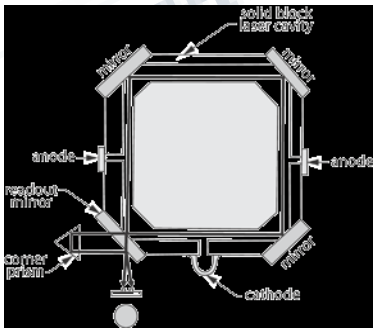


***Fig.1: Ring laser gyroscope***

The output of ring laser gyroscope is developed by use of a combining prism which produces two nearly collinear beams interfering to create fringe patterns sensed by the photo detectors. The number of beats during a time interval is directly proportional to the rotation rate and the direction of fringe movement indicate the rotational direction.

## III. ADVANTAGES OF LRG

The RLG provides digital output linear with angular rotation. It has high sensitivity and stability. The reaction time to respond to rotation rate is quick. The ring laser gyroscopes are insensitive to acceleration and immune to environmental effects.

## IV. LIMITATIONS

The existing cavity geometries and precision mirrors required for RLG construction and the necessity of assembly under stringent clean room conditions increase its cost. The size and weight of RLG are other limiting factors. The main limitation of RLG rotation sensing is due to its lock-in effect.

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