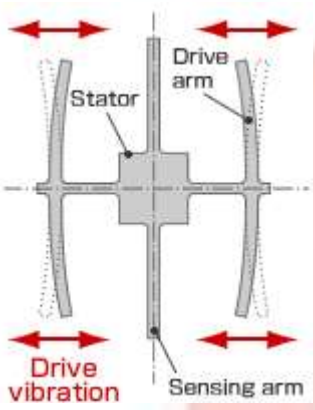
GYRO SENSOR

(* references: https://learn.sparkfun.com/tutorials/gyroscope/how-a-gyro-works, http://www.pieter-jan.com/node/7)

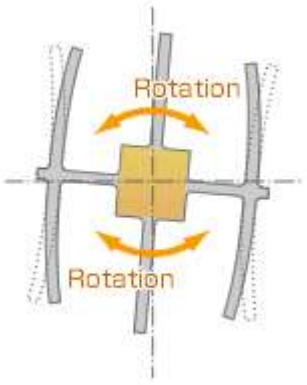
What is a gyro sensor?

Gyro sensors, also known as angular rate sensors or angular velocity sensors are devices that sense angular velocity. They can sense rotational motion and hence sense changes in orientation.

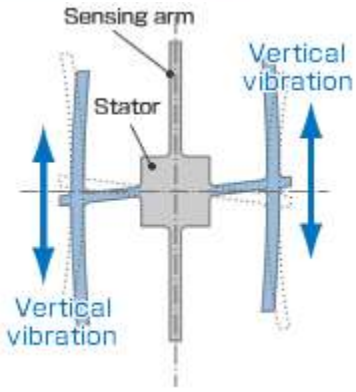
How does a gyro sensor work?



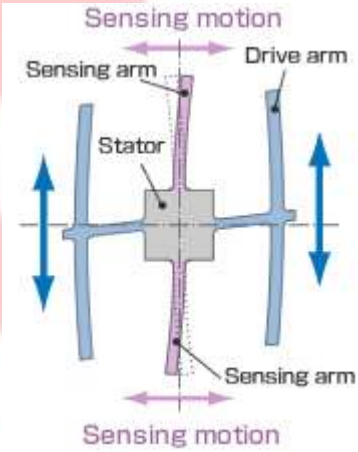
1. Normally, a drive arm vibrates in a certain direction



2. Direction of rotation



3. When the gyro is rotated, the Coriolis force acts on the drive arms, producing vertical vibrations



4. The stationary part bends due to vertical drive arm vibration, producing a sensing motion in the sensing arms

arms produces a potential difference from which angular velocity is sensed. The angular velocity is converted to, and output as, an electrical signal

(Image courtesy: http://www5.epsondevice.com/en/information/technical_info/gyro/)

What does the gyro sensor measure? Does the raw data needs further changes before calculating tilt angle?

Gyroscope sensor does not measure angular orientation as such, it measures angular velocity (the rate of change in orientation angle). The raw data needs certain calculations for estimating the orientation. Multiply the raw data with the scale factor corresponding to the sensitivity you have chosen. Scale factor corresponding to different available sensitivity (as per the datasheet) are given below. Note that you should multiply the raw data with the scale factor in dps/digit.

- 250 dps : 8.75 mdps/digit
- 500 dps : 17.50 mdps/digit
- 2000 dps : 70 mdps/digit

How to find orientation or tilt angle using gyro sensor?

We can obtain the tilt angle by integrating the measured angular velocity as per the equation below:

$\omega = d\theta / dt$ $\theta = \int \omega \, dt$ $\theta = \int$ scaled gyro data dt

However, we can't take perfectly continuous integral and we have to take the sum of finite number of samples. So, ω dt gives the angle it has rotated in dt time and summing this value to itself in a loop (the loop repeats itself in dt time) can give us the total angle of rotation of the sensor.

angle of rotation = ω (scaled gyro data) *dt (in sec) + angle of rotation

What is offset and why should we calculate the offset? How can we calculate the offset?

When gyro is not rotating, it returns a value which is termed as offset. To know the rate of rotation one has to subtract the offset from the value the gyro returns. Suppose the offset of the sensor is 580 and the value it returns is 670 then the sensor is turning clockwise with about 90(670 - 580) degrees a second. But the gyro is like any other sensor- a bit noisy; in reality the rotation could also be 89 or 91 degrees.

The offset is different for every sensor and can change due to external factors as well. For this reason, it is important to determine the offset of your gyro before you can use it. This is not so hard to do. You just take the value the sensor returns when it is motionless, this is the offset. But, as said before, there is some noise in gyro readings. To eliminate this noise when finding the offset you shouldn't rely on just one reading. You should take the average of a lot of readings, say 500 readings, to get a good offset. As the refresh rate of the gyro is 333 readings a second this will take almost two seconds.

What is drift and why do we need to consider this concept?

The gyro returns integer values, but in reality the rate of rotation is not an integer, it could well be 5.23 degrees a second. The gyro sensor rounds off the gyro readings when it converts them from an analog signal to a digital integer value. This means that there is a small error in every reading you get from the gyro. Hence while finding the tilt angle, we keep on integrating this error, thereby increasing the error. This is termed as drift. The gyro sensor provides accurate data about changing orientation in the short term, but the necessary integration causes the results to drift over longer time scales. So we cannot rely on only gyro sensor to find our tilt angle.