NAVMAN

Jupiter GPS receiver module

# Gyro application note

 

## Contents



## Figure



## Table



 

# Gyros for use with Navman DR GPS receivers

## General information

Navman's Dead-Reckoning (DR) GPS receivers provide precision navigation solutions even in areas where GPS signals are totally blocked, such as tunnels or covered parking areas. To achieve this, they make use of inexpensive gyros (angular rate sensors) mounted so that they provide information about the vehicle's directional changes (heading).

Gyros have been available for many years, but the older style mechanical spinning gyros have now been superseded by two new technology classes—optical gyros and piezoelectric gyros.

Fibre Optic Gyros (FOGs) are more expensive than the piezoelectric designs, but FOGs are less sensitive to temperature and vibration. FOGs work by splitting a polarised and modulated laser light beam such that the two light beams travel through a coil of fibre-optic cable in opposite directions. When the beams have completed their normal respective paths, they recombine to produce an interference pattern. Since they both travel the same distance, as long as there is no movement of the coil, they will cancel exactly. In the event that the coil was rotated in one direction, one of the beams would have to travel a different distance and so the beams would no longer cancel. In such a case, the output of the detector will be proportional to the rate of rotation. The phase modulation of the light beam allows the direction of rotation to be distinguished.

*Note: for additional information on fibre-optic gyros, visit KVH Industries web site at: http://www.kvh.com.*

Piezoelectric gyros make use of technology similar to that of miniature tuning forks used in low frequency oscillators for watches and clocks. Figure 1 shows a block diagram depicting the fork construction for this device. There are four piezo devices attached to the fork. Two of the piezo devices are used to generate vibration of the fork and two are used for detection of rotation. The delta from one side of the fork to the other is used to determine direction and amount of rotation.

The piezoelectric gyro represents one of the most economical design solutions for use with the Navman DR GPS receiver in automotive applications. The algorithm used in the Navman receiver has been optimised for use with this type of gyro.

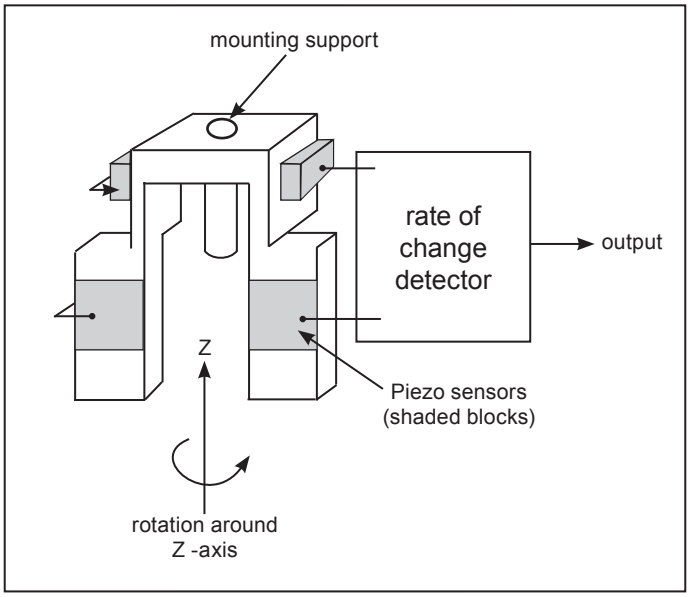


**Figure 1 - Piezoelectric gyro construction**

 

## Gyro operational requirements

Table 1 details the requirements a selected gyro must meet. It is important to ensure that the rate gyro signals have the following operational characteristics:

- range: 0 to 5 V
- output (with no gyro rotation): 2.5 V
- clockwise rotation of the gyro causes the output voltage to increase
- maximum voltage deviation due to rotation should occur with a turning rate of 90 deg/s or less
- change in output voltage is proportional to the rate of rotation.

The gyro should be mounted so its sensitive axis is as near vertical as practical. Deviations from the vertical will reduce sensitivity for heading changes in the horizontal direction. Experiments have shown that acceptable performance can be achieved with mounting deviations of several degrees, but a better performance is achieved when the gyro is mounted closer to vertical.

Contact Navman for suggested rate gyro sources.

## Gyro installation precautions

The customer may install the gyro in the vehicle at any convenient location but must observe the following precautions:

- install the gyro where it is protected from the outside weather elements
- do not locate the gyro near heat radiating objects such as power transistors or other automotive heat generating devices
- do not install the gyro in a location where extreme vehicle vibration could transfer to the device
- do not mount more than one gyro on a plate where mutual interference from one gyro to the other could occur
- install the interface cable in such a way that vibration of the cable is not transmitted to the gyro
- reverse voltage or excessive voltage over 5 V may destroy the gyro.
- install the gyro such that the Z-axis is vertical (refer to Figure 1)
- for installations where electrical noise coupling may occur with the cable that connects the gyro to the receiver, shielded cable or additional power supply filtering may be required at the gyro

## Calibration process

Gyro calibration is a 2-step process, bias determination and scale-factor determination:

1) bias determination (zero point determination), which takes place while the vehicle is stopped

Bias determination is accomplished by placing the vehicle in a fixed (stationary) position while the GPS receiver locks on to satellites and goes into navigation mode. This part of the calibration process can be done at any time, at initial start up once the GPS receiver has reached navigation status, or later by bringing the vehicle to a stop and allowing the gyro and receiver to become synchronised. Scale factor determination process is performed next to complete calibration.

2) scale-factor determination.

Scale factor determination requires the vehicle to be in motion and a turn to be executed. Normally 2 turns are executed, one left and one right. Alternatively a full circle is driven in both directions to improve calibration from the beginning.

Generally, it is best to travel for several seconds in a straight path to calibrate the heading from the GPS, then execute a turn, then continue navigating along another straight path for a few seconds to give a good change in heading. This process will allow the GPS receiver to calibrate the turning rate output of the gyro, determine the actual heading change, and relate the two by a scale factor.

Since piezoelectric gyros are imprecise devices whose bias and scale factors are subject to change, calibration is constantly updated as the vehicle navigates in GPS mode (or combined mode). This tightly coupled configuration of the gyro with the receiver's hardware and software is a unique feature of the Navman DR GPS receiver design.

 

| Characteristic | Symbol | Condition | Minimum | Typical | Maximum | Units |
|---|---|---|---|---|---|---|
| Supply voltage | Vcc | | +4.75 | 5.0 | +5.25 | VDC |
| Output voltage | Vout | @rate limits | >0.0 | | 5.0 | VDC |
| Operating temp | | | –40 | +23 | +85 | °C |
| Start up time | | | | | 1 | s |
| Angular velocity** | | | –100<br>–60 | | +100<br>+60 | deg/s |
| Resolution | | | | 0.05 | | deg/s |
| CW/CCW assymmetry | | | | | 0.1 | deg/s |
| Bias* | $\omega_o$ | Angular rate = 0 deg/s<br>Temp = 23°C | –1 | 0 | +1 | deg/s |
| Bias change due to temp variation | | Angular rate = 0 deg/s | | | ±0.30 | (deg/s)/°C |
| Bias noise | | Constant temp (1 min) | | | <±0.25 | deg/s |
| Scale factor* | SF | Temp = 23°C | –0.10 | 0 | +0.10 | |
| Scale factor change due to temp variation | | | | | ±0.001 | 1/°C |
| Scale factor noise | | Constant temp (1 min) | | | <±0.0005 | |
| Response | | | | | ±100 | deg/s$^2$ |
| Linearity | | | | | ±0.5 | % full scale |

* Bias and scale factor are defined as: $\omega_{measured} = \omega_{true}(1+SF) + \omega_o$
** Dynamic ranges for particular gyros can vary within the limits specified

**Table 1. Gyro requirements**