LORD TECHNICAL NOTE

3DM-GX3®-45 and 3DM-RQ1™-45

Selecting a Gyroscope Option

Overview

The LORD MicroStrain® 3DM-GX3®-45 Miniature GPS-Aided Inertial Navigation System is normally equipped with gyroscopes that have a ±300 degrees/second measurement range. The 3DM-GX3®-45 may also be optionally equipped with ±50, ±600 and ±1200 degrees/second gyroscopes.

The LORD MicroStrain® 3DM-RQ1™-45 Ruggedized Tactical Grade GPS-Aided Inertial Navigation System is normally equipped with gyroscopes that have a ±300 degrees/second measurement range. The 3DM-RQ1™-45 may also be optionally equipped with ±75, ±150 and ±900 degrees/second gyroscopes.

This technical note discusses what considerations a customer should make when selecting an optional gyroscope. The discussion is in the form of a narrative.

3DM-GX3®-45

Let's use this example: A customer is using a 3DM-GX3®-45 with optional ±1.7*g* accelerometers and ±50 degrees/second gyros. He's driving around in a car and is finding that the device is not reporting data quantities correctly, based on the maneuvers he is performing.

Let's go to the larger questions:

1) What would be the purpose of optioning a 3DM-GX3®-45 with ±1.7*g* accelerometers and ±50 degrees/second gyros and using it in an automotive application?
2) What would be the reasons for applying any of the options to the 3DM-GX3®-45? At what applications would they be targeted?
3) What is the impact on the navigation solution with these various options?
4) What is the logic path to make a sensor options decision?

The performance issue that the customer is experiencing may or may not be related to the dynamic range of the inertial sensors that he's selected. There are plenty of other possibilities, heading input selection being the first one that one should check, but let's answer the questions as if the dynamic range is the issue:

1) What would be the purpose of optioning a 3DM-GX3®-45 with ±1.7*g* accelerometers and ±50 degrees/second gyros and using it in an automotive application?

   The goal of optimizing the dynamic range for a particular application is to reduce the sensor noise and in-run bias stability. In this particular case, we do not think ±1.7*g* accelerometers and ±50 degrees/second gyros are a good choice. The customer has incorrectly assumed that since he will not turn the car faster than ±50 degrees/second and will not accelerate at 2*g*, that this range is appropriate for his application. In practice, the influence of external forces and vibration of the chassis will typically induce dynamics that are beyond the range selected. Over-ranging the sensors is a bad idea, especially in the case of the gyros. We would suspect that the standard ±5*g* accelerometers and ±300 degrees/second gyros would be more appropriate.

2) What would be the reasons for applying any of the options to the 3DM-GX3®-45? At what applications would they be targeted?

   The reasons are stated above and this would be appropriate for an application that had very smooth dynamics, such as a mag-lev train.

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3) What is the impact on the navigation solution with these various options?

With the 3DM-GX3®-45, the default sensor noise values are hard-coded in the device (currently true; future devices may change). The customer has the option to override these defaults; this option was designed for applications that had poorer performance due to random vibration, but can also be used in the case of lower noise (i.e. better performance). If these values are not changed, the customer may not see any benefit to the Kalman filter output (Position/Velocity/Attitude), only an improvement in the scaled inertial values. If the customer chose a higher dynamic range (e.g. ±900 degrees/second) the filter would still function, but the PVA outputs will be noisier as it is trusting the inertial sensors too much.

4) What is the logic path to make a sensor options decision?

In general, lower dynamic range means lower noise and higher dynamic range means higher noise. A customer needs to pick a dynamic range that is appropriate for their application, taking into account all dynamics they will encounter. Once they do this, they select the option closest, but above their need (e.g. if they need ±175 degrees/second and we have options of ±50 and ±300 degrees/second, they need to select the ±300 degrees/second.) Once the choice is made, the white noise is what it is for that dynamic range and they must accept it. If they need the low noise performance of a ±50 degrees/second gyro, but the high dynamic range of a ±1200 degrees/second gyro, they may be out of luck as we can only integrate available sensors.

An example of proper selection of sensors would be an aerospace antenna pointing application. They do not expect dynamics beyond ±50 degrees/second and initially it looked like ±75 degrees/second would be a good option for them, which happens to have very low noise and bias drift. Upon further investigation they realized that the body of the aircraft can flex significantly, enough to potentially over range the sensors. So, they went with ±150 degrees/second, sacrificing some noise and bias performance, but ultimately getting the dynamic range they will need to be successful for their application.

3DM-RQ1™-45

In general, lower dynamic range means lower noise and higher dynamic range means higher noise. A customer needs to pick a dynamic range that is appropriate for their application, taking into account all dynamics they will encounter. Once they do this, they select the option closest, but above their need (e.g. if they need ±600 degrees/second and we have options of ±300 and ±900 degrees/second, they need to select the ±900 degrees/second). Once the choice is made, the white noise is what it is for that dynamic range and they must accept it. If they need the low noise performance of a ±50 degrees/second gyro, but the high dynamic range of a ±1200 degrees/second gyro, they may be out of luck as we can only integrate available sensors.

Here is an example of proper gyro selection in an aerospace antenna pointing application:

The customer does not expect angular rates beyond ±100 degrees/second due to aircraft dynamics and initially it looks like our ±150 degrees/second option (which happens to meet their low noise and bias drift requirements comfortably) will work. Upon further investigation, the customer realizes the body of the aircraft can flex significantly and impose angular rates up to ±250 degrees/second at the sensor mounting location, enough to over-range the ±150 degrees/second sensors. In this case, they should chose the ±300 degrees/second, sacrificing some noise and bias performance, but ultimately getting the dynamic range they will need to be successful for their application.

Support

LORD MicroStrain® support engineers are always available to expand on this subject and support you in any way we can.

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