

Magnetic Products

GETTING STABLE OUTPUT FROM HMR3000 COMPASS MODULE

AN-208

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Compass applications are invariably in dynamic environments and the need for filters is inevitable. Since the environments differ from one application to another, an adjustable filter will be more appropriate than a fixed, universal filter. Hence, we have provided user configurable filters and this application note describes how to use the built-in filters of the Honeywell's Digital Compass Module, HMR3000, to get stable heading readings for your application.

The output of the compass may be unstable due to a variety of reasons, and when such an output is integrated to drive a display or used in a feedback control loop such as in auto-pilot systems, the results may be less than desirable; therefore, it is important to have the ability to filter the output which would lead to successful integration of the product with optimal performance.

Heading instability can result from magnetic field fluctuations in the vicinity of the compass and tilt fluctuations of the platform to which the compass is mounted.

Magnetic field fluctuations come from electrical activity in ac or dc current carriers near the compass, or from periodic or random motion of any magnetic material such as machinery, actuators, etc. Any vibration of the platform, motion, acceleration, deceleration or random vibrations can cause the liquid in the tilt sensor to be in a dynamic state leading to noisy tilt output as well as unstable heading output.

To overcome this problem, the HMR3000 is equipped with two kinds of filters (see below) the user may adjust to suit the application needs. First there is an IIR-type filter that operates on each of the five raw sensor digital outputs. The second is a non-linear filter which operates only on the heading data.

In the *Continuous* mode (Run mode) operation of HMR3000, a set of fresh raw sensor values is available at every 72.7 ms or at 13.75 Hz rate, and is the input to these digital filters. The output message rate of the HMR3000 can be different from the data rate of 13.75Hz; however, the effect of filter action is independent of the output message and its rate selected, since filtering acts on the raw sensor data input at 13.75 Hz.

Any filtering will result in a time lag between the heading values reported by HMR3000 and the actual (or instantaneous) heading. It is important to find a balance between

the amount of smoothing applied and the time lag associated with it per your application requirements.

IIR Filter Implementation

The filtering action of the IIR filter is controlled by the adjustable time constant, TC1. This filter acts on all five sensor measurements. Characteristic of the IIR filter to a step function change in the input is illustrated in Figure 1.

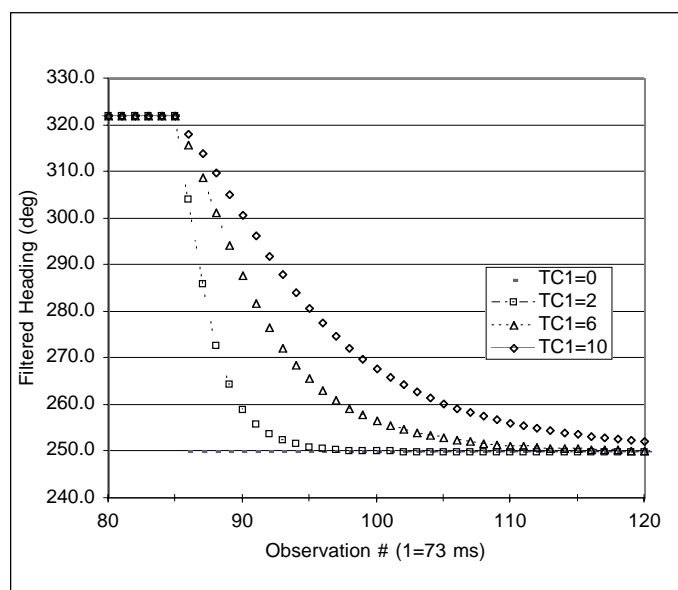


Figure 1. Effect of IIR filter on a step function change in heading for different filter constants.

Non-Linear Heading Filter Implementation

This filter acts only on the heading output and is controlled by two user-selectable parameters L and S. It can be tuned to apply a large amount of filtering to small variations and little or no filtering for large changes in compass heading output. The behavior of this non-linear filter can be qualitatively explained as below. The value of the parameter L selects a *noise threshold* for the filter. Small values of L will limit the filtering action to small changes in heading. Increasing the value of L will cause the filter to treat larger heading changes as *noise*. For a given L value the value of S parameter will determine the amount of smoothing applied to the *noisy* heading data. The smaller the S value the greater the smoothing and vice versa. In a particular

application one would want to select the smallest value possible for the L parameter and the largest possible value for S. We have treated the effects of the parameters S and L to be independent of each other for the purpose of the above discussion. However, the filter action is a combined result of the values S and L chosen. The exact implementation of the filter is as follows;

Algorithm for the Non-Linear Heading Filter

Assume CH = current heading
 SH = smoothed output
 L = tuned setting (integer > 0, 0 = disable)
 S = tuned setting (0 < fraction < 1, 0 = disable, max = 0.999985)

Calculate $D = CH - SH$ (difference)
 $G = S + S * (D/L)**2$ (saturate G as D/L gets large, $S \leq G \leq 1$)
 $SH = SH + D * G$ (note that SH = CH for G = 1)

These calculations are iterated at the 13.75 Hz rate.

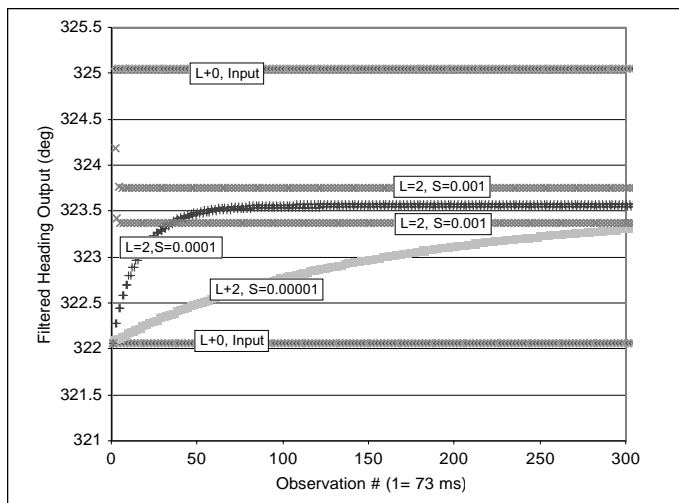


Figure 2. Effect of Non-Linear Heading Filter to an oscillatory heading input.

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Application of the non-linear filter to an input that oscillates between the heading values of 325 and 322 degrees is shown in Figure 2 for several combinations of L value. Response of the filter to several large changes in heading is plotted in Figure 3 for fixed values of L and S. This filter, unlike the IIR filter, does not introduce a time lag to large heading changes.

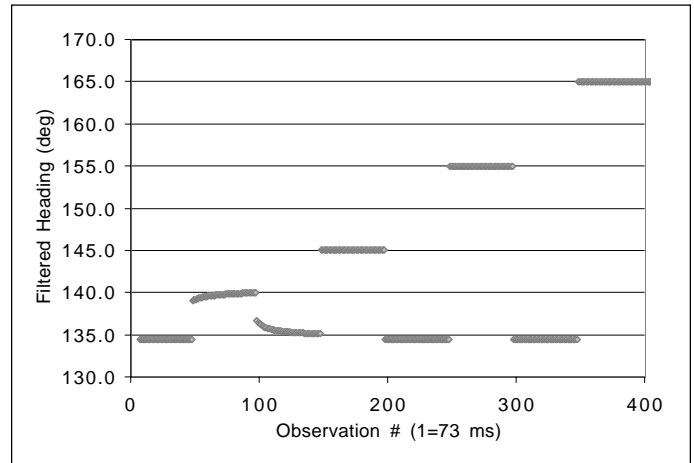


Figure 3. Effect of the Non-Linear Heading Filter on large heading changes.

Using the Simulation Tool

The accompanying Excel spreadsheet simulation (HMR3000 Filters) will allow you to choose the most appropriate filter parameters for the application. The disk labeled *HMR3000 Filter Sim* contains the Excel spreadsheet HMR3000 Filters in the zip format.

1. Install the HMR3000 in the application environment.
2. Tune the parameters as follows:
 $TC1=0$ $TC2=0$ $L=0$
 (See the *HMR3000 User's Manual* on how to set these parameters.)
3. Configure HMR3000 to output CCD message at a rate of 825 sentences per minute.
4. Log or capture data representative of data during normal operation.
5. Cut and paste the data to the Excel spreadsheet (HMR3000 Filters) and experiment with the filter parameters to select appropriate settings for your application requirements.