**Measurement Chain**

For our application we make use only of the MPU-9250 sensor pack, which includes a three-axis accelerometer, a three-axis gyroscope and a three-axis magnetometer (the last is not used and was deactivated).

The *measuring object* is the sensor itself (the acceleration and orientation of it). Since it is rigidly mounted on the PCB, we can assume that corresponds to measuring the movement of the whole Sensortag. However, we cannot ignore the soft connection of the Sensortag to the belt and of the belt to the user. This would require adaptation of the fall detection algorithms to many different user/clothing combinations.

The *measured quantities* are: the total resulting acceleration (gravity plus motion); and angular velocity.

The *measurement method* is indirect (see individual sensor description below).

The complete *measurement chain* consists of the sensors themselves, the ADCs built into the MPU-9250, and the number conversion that takes place in the desktop part of the application. Since the signals are transmitted only after the analog to digital conversion takes place, we don’t have to worry about transmission induced errors.

**Accelerometer**:

“The accelerometer uses separate proof masses for each axis. Acceleration along a particular axis induces displacement on the corresponding proof mass, and capacitive sensors detect the displacement differentially. “ The analog value is digitalized by three 16bit sigma-delta ADC (one per axis). The resulting value may be written as:

Where is the real value, is the intrinsic error (3%), is the temperature induced error (0.026%/°C), is the non-linearity error (0.5%), is the initial calibration error (80 mG) and is the noise (8 mG). At room temperature and for the threshold values used by our fall detection algorithm, the above formula can be approximated with:

**Gyroscope**:

The gyroscope’s sensors consist of 3 vibratory MEMS. “When the gyros are rotated about any of the sense axes, the Coriolis Effect causes a vibration that is detected by a capacitive pickoff.” The resulting value may be written as:

Where is the real value, is the intrinsic error (3%), is the temperature induced error (4%), is the non-linearity error (0.1%), is the initial calibration error (5 °/s) and is the noise (0.1 °/s). At room temperature and for the threshold values used by our fall detection algorithm, the above formula can be approximated with:

Reference: MPU-9250 Product Specification, InvenSense, Document Number: PS-MPU-9250A-01, Revision: 1.1, Release Date: 06/20/2016