Contents

Gyro and Accelerometer Calibration

This is sort of a misnomer since the gyro drifts over time and you don't need to calibration the accelerometers. Any calibration of the gyro is good for only a short while so a complimentary filter is used to combine the gyro (which is good for rate change) and acceleration data (which is good for steady state measurements).

The first step is to find the scale factor. The MPU6050 is configured by the s_block for a rate of 250°/second. The MPU_6050 wrapper scales this to a 16-bit integer implying 32768 ADC counts over the measurement range. Combining these values gives a scale factor as follows:

$$Rate, \frac{radians}{sec} = \left(\frac{ADC\ Count}{32768}\right)\left(\frac{250°}{sec}\right)\left(\frac{\pi\ radians}{180\ °}\right) \approx 0.0001332$$

Figure 1 shows the Simulink model used to generate the data.

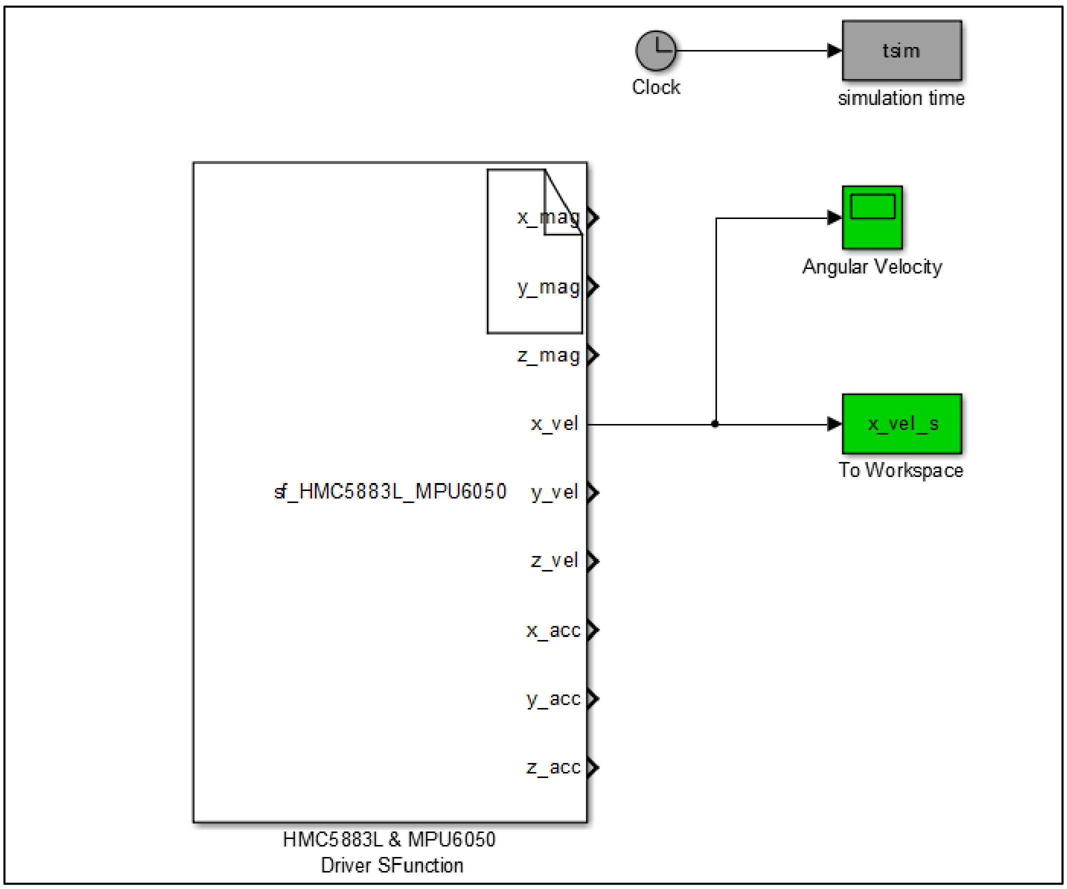

Figure 1 - Simulink model used to measure gyro bias.

Data was acquired for 10 seconds while the MinSeg was at rest on a desk. Figure 2 shows the data and resulting bias value of -358.4 found by averaging the instantaneous values. This value will be used in subsequent steps.

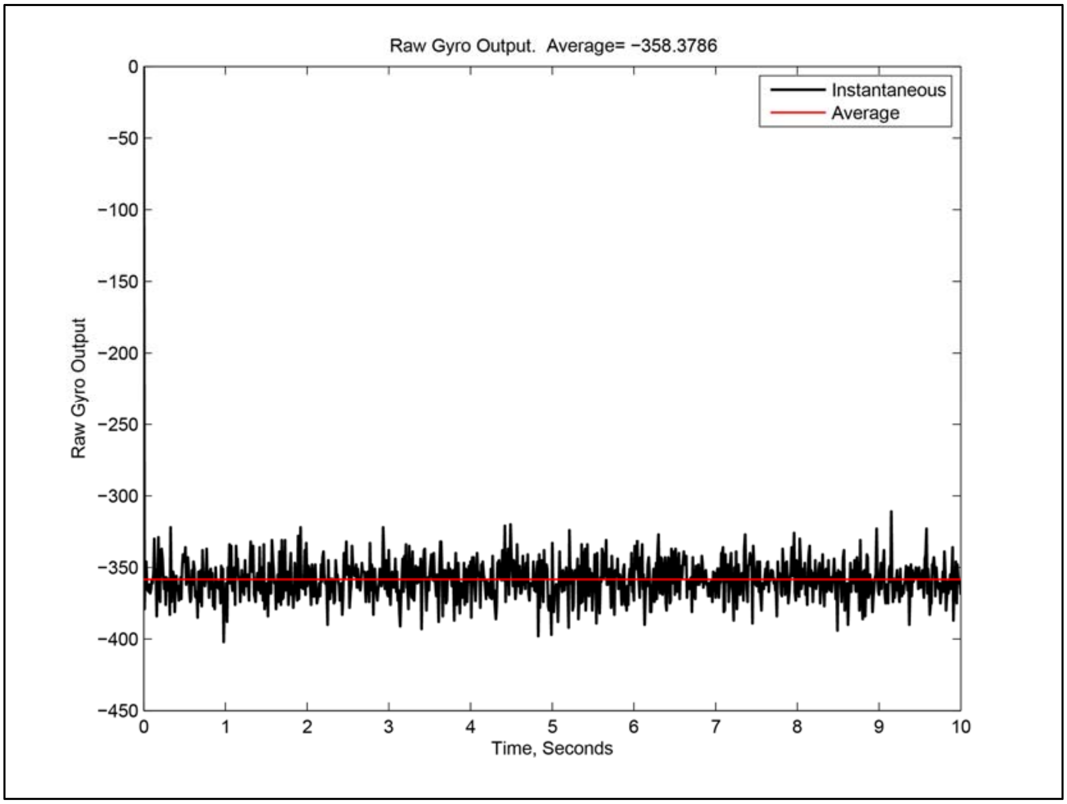

Figure 2 - Gyroscope instantaneous and average raw values.

The next step is to build the complimentary filter and establish biases for the accelerometers. The complimentary filter averages the acceleration and integrated gyro values. Figure 3 shows the complete angle measurement system and Figure 4 shows the complimentary Simulink models used for this test.

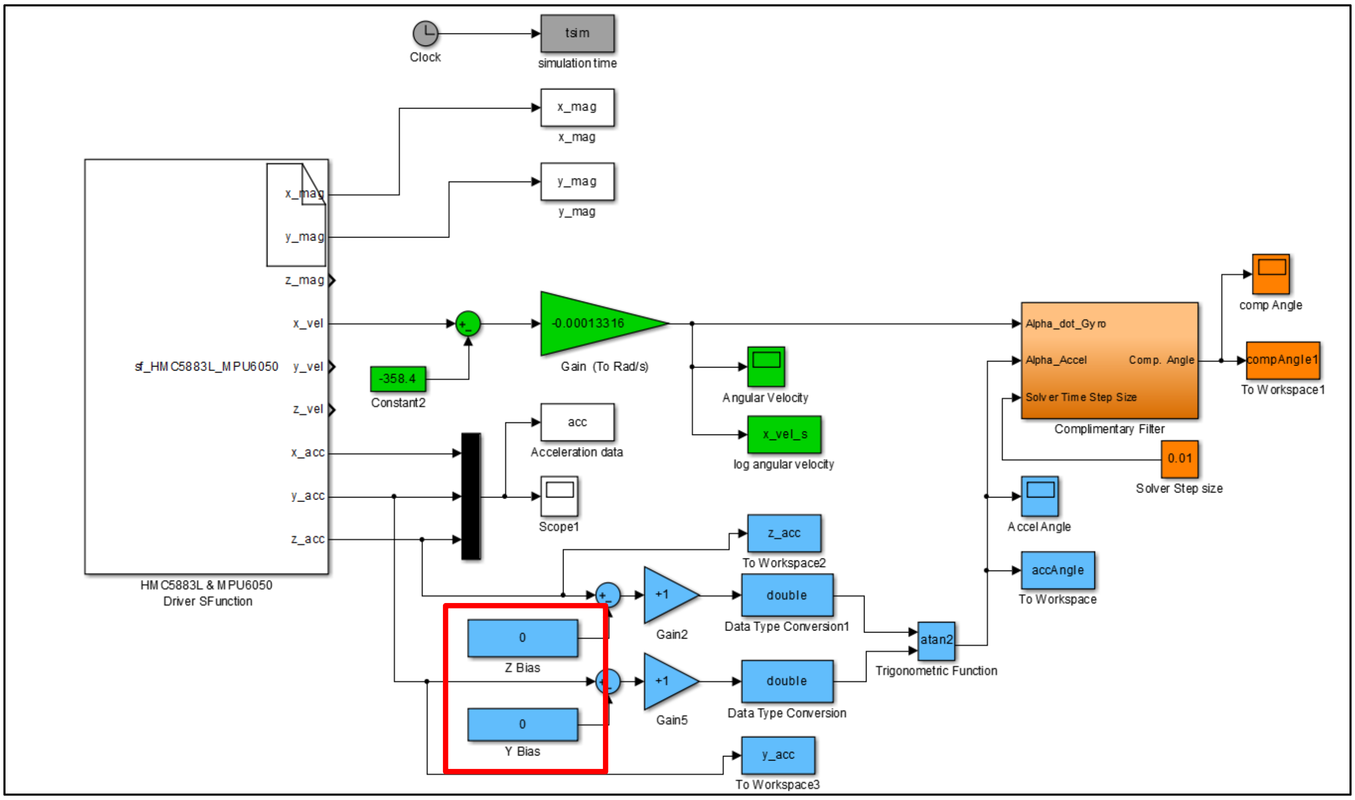

Figure 3 - Angle measurement system Simulink model.

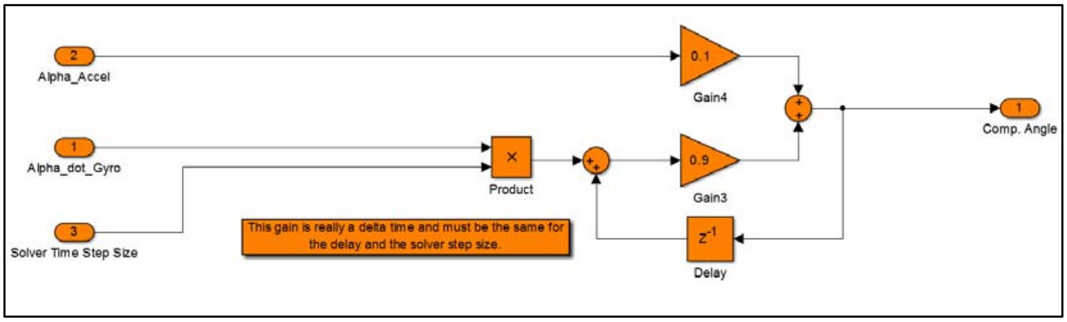

Figure 4 - Complimentary filter Simulink model.

The complimentary filter weighs both the gyros and accelerometers. The gyro bias has been established previously. Accelerometer biases were determined by suspending the model upside down (making it a regular pendulum) and allowing it to swing by its axles. The bias values for the accelerometer were temporarily set to zero (This is what is shown in Figure 3 inside the red box). In addition the gains were set to +1 to avoid the transition from –pi to pi engendered by the tan2 function. The accelerometers outputs are measured, then corrected to inverted pendulum configuration. Figure 5 shows the resulting data.

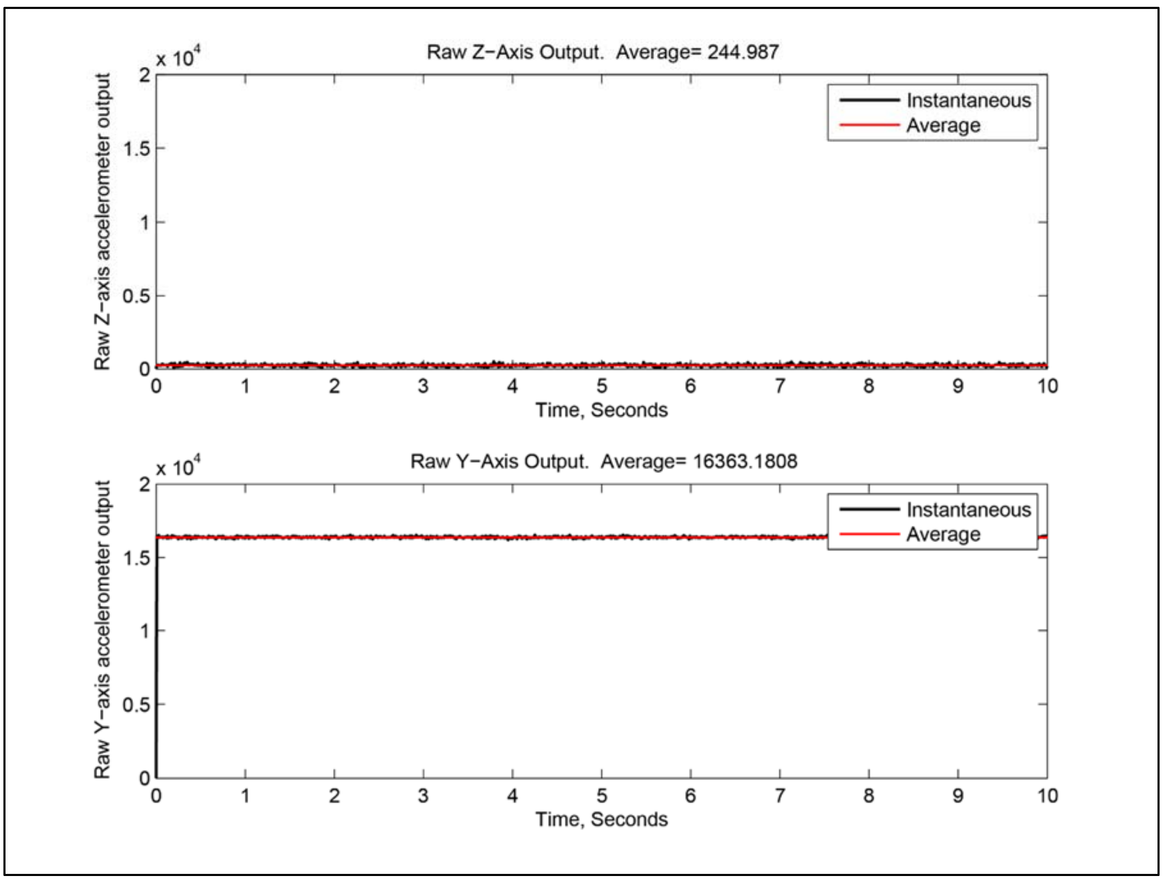

Figure 5 - Accelerometer bias correction.

The Y-axis should be pointing straight down, experiencing 1 g or 16384 ADC counts. The average is 16363, so the bias is +(16384-16363)= +21. The Z-axis should be exactly 0, so it has a bias of -255. With these biases, and correcting the orientation by switching the +1 values to -1 values, the MinSeg was returned to the inverted pendulum orientation and Z bias and Y bias values were fine tuned to give a zero angle reading when the MinSeg felt balanced. Figure 6 shows the final arrangement of the complimentary filter. Note that the gains are quite a bit different than those calculated in the suspended position. This could be because the MPU6050 is not perfectly parallel to the geometric axis of the MinSeg.

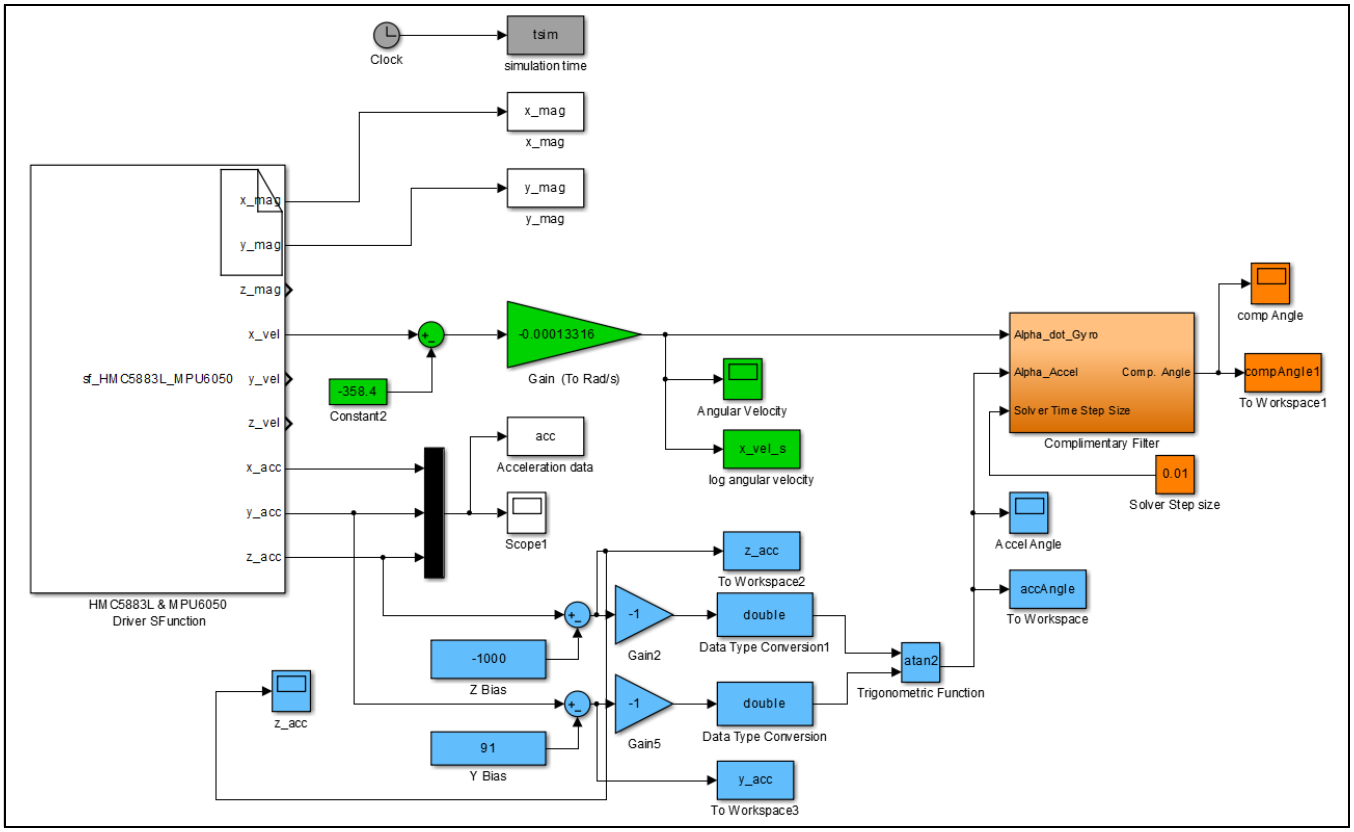

Figure 6 - Final MinSeg complimentary filter arrangement.