# Ten Degrees of Freedom MEMS Inertial Sensor with Dynamic Orientation Outputs

Silicon Anomaly

# ADIS16480

This anomaly list describes the known bugs, anomalies, and workarounds for the ADIS16480.

Analog Devices, Inc., is committed, through future silicon revisions, to continuously improve silicon functionality. Analog Devices tries to ensure that these future silicon revisions remain compatible with your present software/systems by implementing the recommended workarounds outlined here.

## FUNCTIONALITY ISSUES

**Table 1. Incorrect Scale Factors for the x_DELTANG_OUT Registers and the x_DELTANG_LOW Registers [er001]**

| | |
|---|---|
| **Background** | The ADIS16480 provides delta angle registers, which contain sample-to-sample angle displacement estimates for all three axes. The x_DELTANG_OUT registers provide the upper 16 bits, and the x_DELTANG_LOW registers provide the lower 16 bits. The x_DELTANG_OUT registers typically provide a scale factor of 720 ÷ $2^{15}$ degrees per LSB, and the x_DELTANG_LOW registers provide additional resolution (720 ÷ $2^{31}$ degrees per LSB). |
| **Issue** | On units that have Firmware Revision 2.01 (or earlier), the delta angle registers do not have the same scale factors as those listed in the ADIS16480 data sheet. For these units, the scale factors are 274 ÷ $2^{15}$ degrees per LSB for x_DELTANG_OUT and 274 ÷ $2^{31}$ degrees per LSB for x_DELTANG_LOW. |
| **Workaround** | Use 274 ÷ $2^{15}$ degrees per LSB for the x_DELTANG_OUT scale factor and 274 ÷ $2^{31}$ degrees per LSB for the x_DELTANG_LOW scale factor. Use the FIRM_REV register to determine the firmware revision of a unit. For example, FIRM_REV = 0x0201 equates to a Firmware Revision 2.01. |
| **Related Issues** | None. |

**Table 2. Incorrect Scale Factors for the x_DELTVEL_OUT Registers and the x_DELTVEL_LOW Registers [er002]**

| | |
|---|---|
| **Background** | The ADIS16480 provides delta velocity registers, which contain sample-to-sample velocity estimates for all three axes. The x_DELTVEL_OUT registers provide the upper 16 bits, and the x_DELTVEL_LOW registers provide the lower 16 bits. The x_DELTVEL_OUT registers typically provide a scale factor of 200 ÷ $2^{15}$ m/sec per LSB, and the x_DELTVEL_LOW registers provide additional resolution (200 ÷ $2^{31}$ m/sec per LSB). The ADIS16480 (Rev. A) data sheet incorrectly documents these scale factors as 160 ÷ $2^{15}$ and 160 ÷ $2^{31}$, respectively; these errors are being addressed in Rev. B of the data sheet. |
| **Issue** | On units that have Firmware Revision 2.01 (or earlier), the delta velocity registers do not have the same scale factors as those listed in the ADIS16480 data sheet. For these units, the scale factors are 97.65 ÷ $2^{15}$ m/sec per LSB for x_DELTVEL_OUT and 97.65 ÷ $2^{31}$ m/sec per LSB for x_DELTVEL_LOW. |
| **Workaround** | Use 97.65 ÷ $2^{15}$ m/sec per LSB for the x_DELTVEL_OUT scale factor and 97.65 ÷ $2^{31}$ m/sec per LSB for the x_DELTVEL_LOW scale factor. Use the FIRM_REV register to determine the firmware revision of a unit. For example, FIRM_REV = 0x0201 equates to a Firmware Revision 2.01. |
| **Related Issues** | None. |

**Table 3. Inaccurate TEMP_OUT Readings [er003]**

| | |
|---|---|
| **Background** | The TEMP_OUT register provides the internal temperature measurement, which serves as an input to the inertial calibration outputs and also provides a variable that enables users to monitor relative temperature changes inside the unit. |
| **Issue** | On units that have Firmware Revision 2.01 (or earlier), the TEMP_OUT bias error is −10°C, and the scale factor is approximately 5% lower than the scale factor reflected in the ADIS16480 data sheet. |
| **Workaround** | Use devices that have Firmware Revision 2.02 or later to benefit from the improvement in the TEMP_OUT accuracy. For specific, in-application accuracy, users may want to consider their own calibration process because attachment, airflow, and other mechanical variables can affect the TEMP_OUT relationship with ambient temperature conditions. Use the FIRM_REV register to determine the firmware revision of a unit. For example, FIRM_REV = 0x0201 equates to a FirmwareRevision 2.01. |
| **Related Issues** | None. |




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**Table 4. Incorrect Output Data String After Writing to the FNCTIO_CTRL Register [er004]**

| | |
|---|---|
| **Background** | The FNCTIO_CTRL register provides user configuration control for the digital I/O pins, and the TEMP_OUT register provides the internal temperature measurement, which serves as an input to the inertial calibration outputs. |
| **Issue** | On units that have Firmware Revision 2.01 (or earlier), a write to the FNCTIO_CTRL register causes the TEMP_OUT variable to contain an incorrect value for 120 samples. Because this is an input to the calibration function for the gyroscopes and accelerometers, this issue causes the appearance of a discrete bias change between Sample 120 and Sample 121. |
| **Workaround** | When using units that have Firmware Revision 2.01 (or earlier), ignore the first 120 samples of the output registers after writing to the FNCTIO_CTRL register. Use the FIRM_REV register to determine the firmware revision of a unit. For example, FIRM_REV = 0x0201 equates to a firmware revision of 2.01. |
| **Related Issues** | None. |

**Table 5. Incorrect Offset and Scale Correction Order [er005]**

| | |
|---|---|
| **Background** | Each accelerometer and gyroscope has unique user configurable offset and scale correction registers. For instance, on the x-axis gyroscope, the XG_BIAS_HIGH and XG_BIAS_LOW registers combine to provide the 32-bit, twos complement bias (offset) correction factor, and the X_GYRO_SCALE register provides the scale correction function. The proper order of applying these correction factors is bias correction first and scale correction second. |
| **Issue** | On units that have Firmware Revision 2.01 (or earlier), the order of application is reversed, and the ADIS16480 applies the scale correction value first, followed by the offset value. |
| **Workaround** | When using units that have firmware Revision 2.01 or earlier, if this function is part of the system-level calibration processes, note this difference. Use the FIRM_REV register to determine the firmware revision of a unit. For example, FIRM_REV = 0x0201 equates to a Firmware Revision 2.01. |
| **Related Issues** | None. |

**Table 6. Factory Restore Command in GLOB_CMD Not Working Properly [er006]**

| | |
|---|---|
| **Background** | GLOB_CMD[6] provides a factory restore function that enables users to reset all user configurable calibration registers to 0x0000 (factory default). To activate this function, turn to Page 3 by setting DIN = 0x8003, and then set GLOB_CMD[6] = 1 by writing the following two 16-bit commands to the DIN line: 0x8240 and 0x8300. |
| **Issue** | On units that have Firmware Revision 2.03 (or earlier), setting GLOB_CMD[6] = 1 does not reset all calibration registers. |
| **Workaround** | When using units that have Firmware Revision 2.03 (or earlier), write 0x0000 to each individual calibration register. Use the FIRM_REV register to determine the firmware revision of a unit. For example, FIRM_REV = 0x0203 equates to a Firmware Revision 2.03. |
| **Related Issues** | None. |

**Table 7. EKF Setting Time and Accuracy Affected by Accidental Writes to Hidden Register [er007]**

| | |
|---|---|
| **Background** | In the ADIS16480 data sheet, Address 0x0E on Page 3 is a reserved location. Although this location contains a valid user register for other products in this same family, it is not accessible through the serial peripheral interface (SPI) for users. |
| **Issue** | On units that have Firmware Revision 2.04 and earlier, this location is not write protected and can influence the extended Kalman filter (EKF) operation. |
| **Workaround** | On Page 3, write 0x04 to Address 0x0E and write 0x07 to Address 0x0F to restore proper EKF settling and operation. Note that the factory default is 0x070A for all devices that have Firmware Revision 2.04 and earlier. If this setting is providing proper service for a particular application, there is no need to change it. Ensure that this location does not experience any other write commands. The impact of moving from 0x070A to 0x0704 is that the EKF settling time is reduced from ~26 sec to ~416 ms. |
| **Related Issues** | None. |

**Table 8. Magnetometer Calibration Equation Updates [er008]**

| | |
|---|---|
| **Background** | The ADIS16480 offers a 3 × 3 soft iron correction matrix and a 3 × 1 hard iron correction array for users who implement these types of correction processes into their systems and processes. Each of these correction factors has a user programmable register location that contains their specific values. |
| **Issue** | The manner in which these factors apply to the magnetometer data has changed. On units that have Firmware Revision 2.02 and earlier, these correction factors apply to the magnetometer data using the following formula: $$\begin{bmatrix} M_{XC} \\ M_{YC} \\ M_{ZC} \end{bmatrix} = \begin{bmatrix} 1+S_{11} & S_{12} & S_{13} \\ S_{21} & 1+S_{22} & S_{23} \\ S_{31} & S_{32} & 1+S_{33} \end{bmatrix} \times \begin{bmatrix} M_X \\ M_Y \\ M_Z \end{bmatrix} + \begin{bmatrix} H_X \\ H_Y \\ H_Z \end{bmatrix}$$ On units that have Firmware Revision 2.03 and later, these correction factors apply to the magnetometer data using the following formula: $$\begin{bmatrix} M_{XC} \\ M_{YC} \\ M_{ZC} \end{bmatrix} = \begin{bmatrix} 1+S_{11} & S_{12} & S_{13} \\ S_{21} & 1+S_{22} & S_{23} \\ S_{31} & S_{32} & 1+S_{33} \end{bmatrix} \times \left( \begin{bmatrix} M_X \\ M_Y \\ M_Z \end{bmatrix} + \begin{bmatrix} H_X \\ H_Y \\ H_Z \end{bmatrix} \right)$$ This difference is associated with Revision B of the ADIS16480 data sheet. |
| **Workaround** | For those who use this function and want to maintain long term consistency, use external processing to apply these correction factors to the magnetometer data produced by ADIS16480 units that have Firmware Revision 2.02 or earlier. |
| **Related Issues** | None. |

## ANOMALY STATUS

**Table 9. ADIS16480 Functionality Issues Status**

| Reference Number | Description | Status | Date Code |
|---|---|---|---|
| er001 | Incorrect scale factors for the x_DELTANG_OUT registers and the x_DELTANG_LOW registers | Fixed | 1226 |
| er002 | Incorrect scale factors for the x_DELTVEL_OUT registers and the x_DELTVEL_LOW registers | Fixed | 1226 |
| er003 | Inaccurate TEMP_OUT readings | Fixed | 1226 |
| er004 | Incorrect output data string after writing to the FNCTIO_CTRL register | Fixed | 1226 |
| er005 | Incorrect offset and scale correction order | Fixed | 1226 |
| er006 | Factory restore command in GLOB_CMD not working properly | Fixed | 1314 |
| er007 | EKF setting time and accuracy affected by accidental writes to hidden register | Open | |
| er008 | Magnetometer calibration equation updates | Open | |

## NOTES

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