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Ten Degrees of Freedom Inertial Sensor with Dynamic Orientation Outputs

Data Sheet **ADIS16480**

FEATURES

Dynamic angle outputs
- **Quaternion, Euler, rotation matrix**
- **0.1° (pitch, roll) and 0.3° (yaw) static accuracy**

Triaxial, digital gyroscope, ±450°/sec dynamic range
- **±0.05° orthogonal alignment error**
- **6°/hr in-run bias stability**
- **0.3°/√hr angular random walk**
- **0.01% nonlinearity**

Triaxial, digital accelerometer, ±10 *g*
Triaxial, delta angle and delta velocity outputs
Triaxial, digital magnetometer, ±2.5 gauss
Digital pressure sensor, 300 mbar to 1100 mbar
Adaptive extended Kalman filter
- **Automatic covariance computation**
- **Programmable reference reorientation**
- **Programmable sensor disturbance levels**
- **Configurable event-driven controls**

Factory-calibrated sensitivity, bias, and axial alignment
- **Calibration temperature range: −40°C to +85°C**

SPI-compatible serial interface
Programmable operation and control
- **4 FIR filter banks, 120 configurable taps**
- **Digital I/O: data-ready alarm indicator, external clock**
- **Optional external sample clock input: up to 2.4 kHz**
- **Single-command self-test**

Single-supply operation: 3.0 V to 3.6 V
2000 *g* shock survivability

APPLICATIONS

Platform stabilization, control, and pointing
Navigation
Instrumentation
Robotics

GENERAL DESCRIPTION

The ADIS16480 *i*Sensor® device is a complete inertial system that includes a triaxial gyroscope, a triaxial accelerometer, triaxial magnetometer, pressure sensor, and an extended Kalman filter (EKF) for dynamic orientation sensing. Each inertial sensor in the ADIS16480 combines industry-leading *i*MEMS® technology with signal conditioning that optimizes dynamic performance. The factory calibration characterizes each sensor for sensitivity, bias, alignment, and linear acceleration (gyroscope bias). As a result, each sensor has its own dynamic compensation formulas that provide accurate sensor measurements. The sensors are further correlated and processed in the extended Kalman filter, which provides both automatic adaptive filtering, as well as user-programmable tuning. Thus, in addition to the IMU outputs, the device provides stable quaternion, Euler, and rotation matrix outputs in the local navigation frame.

The ADIS16480 provides a simple, cost-effective method for integrating accurate, multiaxis inertial sensing into industrial systems, especially when compared with the complexity and investment associated with discrete designs. All necessary motion testing and calibration are part of the production process at the factory, greatly reducing system integration time. Tight orthogonal alignment simplifies inertial frame alignment in navigation systems. The SPI and register structure provide a simple interface for data collection and configuration control.

The ADIS16480 uses the same footprint and connector system as the ADIS16488 and the ADIS16488A, which greatly simplifies the upgrade process. It comes in a module that is approximately 47 mm × 44 mm × 14 mm and has a standard connector interface. The ADIS16480 provides an operating temperature range of −40°C to +105°C.

FUNCTIONAL BLOCK DIAGRAM

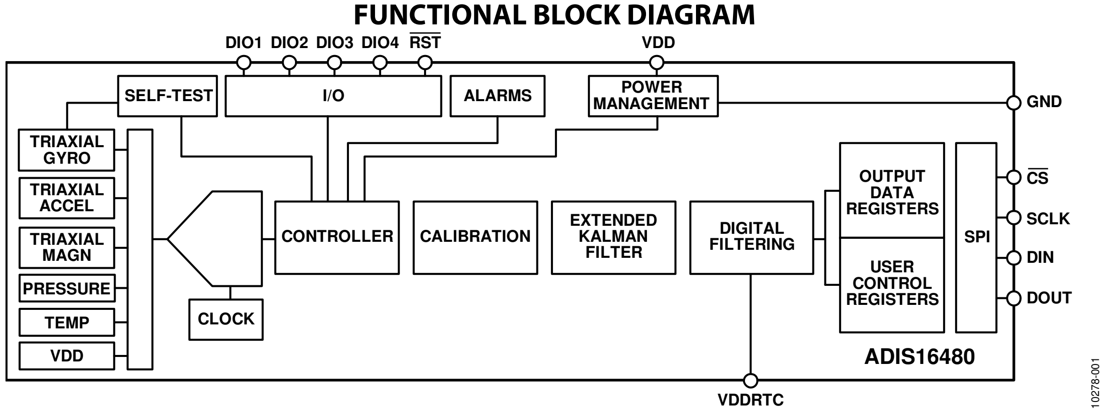

Figure 1.

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Last Content Update: 02/23/2017

COMPARABLE PARTS

View a parametric search of comparable parts.

EVALUATION KITS

- Breakout Board for the ADIS1613x, ADIS1637x, ADIS1648x and ADIS1649x
- EVAL-ADIS Evaluation System

DOCUMENTATION

Application Notes

- AN-1157: Tuning the Extended Kalman Filter in the ADIS16480
- AN-1295: Mechanical Design Tips for ADIS16375, ADIS16480, ADIS16485, and ADIS16488

Data Sheet

- ADIS16480: Anomaly Data Sheet
- ADIS16480: Ten Degrees of Freedom Inertial Sensor with Dynamic Orientation Outputs Data Sheet

User Guides

- ADIS1648x Evaluation on the EVAL-ADIS System

SOFTWARE AND SYSTEMS REQUIREMENTS

- ADIS16480 IIO Inertial Measurement Unit Linux Driver
- IMU Evaluation Software for the EVAL-ADISx Platforms
- USB Driver File for EVAL-ADISx Platforms (v2.2.95.68, 3/9/2016)

REFERENCE MATERIALS

Press

- 10-DoF MEMS IMU Incorporates Sensor Fusion Algorithm for Exceptionally Precise Orientation Sensing in Industrial, Defense and Avionics Applications

Technical Articles

- INS Faceoff: MEMS vs FOGs, InsideGNSS, July/Aug 2012
- MS-2432 The Battle Between MEMS and FOGs for Precision Guidance
- MS-2694: Enabling Next-Generation Avionics Systems

DESIGN RESOURCES

- ADIS16480 Material Declaration
- PCN-PDN Information
- Quality And Reliability
- Symbols and Footprints

DISCUSSIONS

View all ADIS16480 EngineerZone Discussions.

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TABLE OF CONTENTS

REVISION HISTORY

10/2016—Rev. E to Rev. F

6/2015—Rev. D to Rev. E

2/2015—Rev. C to Rev. D

4/2014—Rev. B to Rev. C

1/2014—Rev. A to Rev. B

2/2013—Rev. 0 to Rev. A

5/2012—Revision 0: Initial Version

SPECIFICATIONS

T_A = 25°C, VDD = 3.3 V, angular rate = 0°/sec, dynamic range = ±450°/sec ± 1 *g*, 300 mbar to 1100 mbar, unless otherwise noted.

Table 1.

Parameter	Test Conditions/Comments	Min	Typ	Max	Unit
ANGLE OUTPUTS					
Euler Dynamic Range	Yaw and roll (Euler)			±180	Degrees
	Pitch (Euler)			±90	Degrees
	Rotation matrix, quaternion			±180	Degree
Sensitivity			0.0055		Degrees/LSB
Static Accuracy[1]	Pitch and roll		0.1		Degrees
	Yaw		0.3		Degrees
Dynamic Accuracy[1]	Pitch and roll		0.3		Degrees
	Yaw		0.5		Degrees
GYROSCOPES					
Dynamic Range		±450		±480	°/sec
Sensitivity	x_GYRO_OUT and x_GYRO_LOW (32-bit)		3.052×10^{-7}		°/sec/LSB
Repeatability[2]	$-40°C \leq T_A \leq +85°C$			±1	%
Sensitivity Temperature Coefficient	$-40°C \leq T_A \leq +85°C$, 1 σ		±35		ppm/°C
Misalignment	Axis to axis		±0.05		Degrees
	Axis to frame (package)		±1.0		Degrees
Nonlinearity	Best-fit straight line, FS = 450°/sec		0.01		% of FS
Initial Bias Error			±0.2		°/sec
In-Run Bias Stability	1 σ		6.25		°/hr
Angular Random Walk	1 σ		0.3		°/√hr
Bias Temperature Coefficient	$-40°C \leq T_A \leq +85°C$, 1 σ		±0.0025		°/sec/°C
Linear Acceleration Effect on Bias	Any axis, 1 σ (CONFIG[7] = 1)		0.009		°/sec/*g*
Output Noise	No filtering		0.16		°/sec rms
Rate Noise Density	f = 25 Hz, no filtering		0.0066		°/sec/√Hz rms
3 dB Bandwidth			330		Hz
Sensor Resonant Frequency			18		kHz
ACCELEROMETERS	Each axis				
Dynamic Range		±10			*g*
Sensitivity	x_ACCL_OUT and x_ACCL_LOW (32-bit)		1.221×10^{-8}		*g*/LSB
Repeatability	$-40°C \leq T_A \leq +85°C$			±0.5	%
Sensitivity Temperature Coefficient	$-40°C \leq T_A \leq +85°C$, 1 σ		±25		ppm/°C
Misalignment	Axis to axis		±0.035		Degrees
	Axis to frame (package)		±1.0		Degrees
Nonlinearity	Best-fit straight line, ±10 *g*		0.1		% of FS
Bias Repeatability[3]	$-40°C \leq T_A \leq +85°C$, 1 σ		±16		m*g*
In-Run Bias Stability	1 σ		0.1		m*g*
Velocity Random Walk	1 σ		0.029		m/sec/√hr
Bias Temperature Coefficient	$-40°C \leq T_A \leq +85°C$		±0.1		m*g*/°C
Output Noise	No filtering		1.5		m*g* rms
Noise Density	f = 25 Hz, no filtering		0.067		m*g*/√Hz rms
3 dB Bandwidth			330		Hz
Sensor Resonant Frequency			5.5		kHz

Parameter	Test Conditions/Comments	Min	Typ	Max	Unit
MAGNETOMETER					
Dynamic Range		±2.5			gauss
Sensitivity			0.1		mgauss/LSB
Initial Sensitivity Tolerance				±2	%
Sensitivity Temperature Coefficient	1 σ		275		ppm/°C
Misalignment	Axis to axis		0.25		Degrees
	Axis to frame (package)		0.5		Degrees
Nonlinearity	Best fit straight line		0.5		% of FS
Initial Bias Error	0 gauss stimulus		±15		mgauss
Bias Temperature Coefficient	$-40°C \leq T_A \leq +85°C$, 1 σ		0.3		mgauss/°C
Output Noise	No filtering		0.45		mgauss
Noise Density	f = 25 Hz, no filtering		0.054		mgauss/√Hz
3 dB Bandwidth			330		Hz
BAROMETER					
Pressure Range		300		1100	mbar
	Extended	10		1200	mbar
Sensitivity	BAROM_OUT and BAROM_LOW (32-bit)		6.1×10^{-7}		mbar/LSB
Error with Supply			0.04		%/V
Total Error			4.5		mbar
Relative Error[4]	−40°C to +85°C		2.5		mbar
Nonlinearity[5]	Best fit straight line, FS = 1100 mbar		0.1		% of FS
	−40°C to +85°C		0.2		% of FS
Linear-*g* Sensitivity	±1 *g*, 1 σ		0.005		mbar/*g*
Noise			0.025		mbar rms
TEMPERATURE SENSOR					
Scale Factor	Output = 0x0000 at 25°C (±5°C)		0.00565		°C/LSB
LOGIC INPUTS[6]					
Input High Voltage, V_{IH}		2.0			V
Input Low Voltage, V_{IL}				0.8	V
$\overline{CS}$ Wake-Up Pulse Width		20			µs
Logic 1 Input Current, I_{IH}	V_{IH} = 3.3 V			10	µA
Logic 0 Input Current, I_{IL}	V_{IL} = 0 V				
All Pins Except $\overline{RST}$				10	µA
$\overline{RST}$ Pin			0.33		mA
Input Capacitance, C_{IN}			10		pF
DIGITAL OUTPUTS					
Output High Voltage, V_{OH}	I_{SOURCE} = 0.5 mA	2.4			V
Output Low Voltage, V_{OL}	I_{SINK} = 2.0 mA			0.4	V
FLASH MEMORY	Endurance[7]	100,000			Cycles
Data Retention[8]	T_J = 85°C	20			Years
FUNCTIONAL TIMES[9]	Time until inertial sensor data is available				
Power-On Start-Up Time			400 ± 160		ms
Reset Recovery Time[10]	Initiated by $\overline{RST}$ or GLOB_CMD[7] = 1		400 ± 160		ms
Sleep Mode Recovery Time			700		µs
Flash Memory Update Time			1.1	6.8	sec
Flash Memory Test Time			53		ms
Automatic Self-Test Time	Using internal clock, 100 SPS		12		ms
CONVERSION RATE			2.46		kSPS
Initial Clock Accuracy			0.02		%
Temperature Coefficient			40		ppm/°C
Sync Input Clock[11]		0.7		2.4	kHz

Parameter	Test Conditions/Comments	Min	Typ	Max	Unit
POWER SUPPLY, VDD	Operating voltage range	3.0		3.6	V
Power Supply Current[12]	Normal mode, VDD = 3.3 V, μ ± σ		254		mA
	Sleep mode, VDD = 3.3 V		12.2		mA
	Power-down mode, VDD = 3.3 V		45		μA
POWER SUPPLY, VDDRTC	Operating voltage range	3.0		3.6	V
Real-Time Clock Supply Current	Normal mode, VDDRTC = 3.3 V		13		μA

[1] Accuracy specifications assume calibration of accelerometers and magnetometers to address sensor drift and local influences on magnetic fields.
[2] The repeatability specifications represent analytical projections that are based off of the following drift contributions and conditions: temperature hysteresis (−40°C to +85°C), electronics drift (High-Temperature Operating Life test: +110°C, 500 hours), drift from temperature cycling (JESD22, Method A104-C, Method N, 500 cycles, −40°C to +85°C), rate random walk (10 year projection), and broadband noise.
[3] Bias repeatability describes a long-term behavior, over a variety of conditions. Short-term repeatability is related to the in-run bias stability and noise density specifications.
[4] The relative error assumes that the initial error, at 25°C, is corrected in the end application.
[5] Specification assumes a full scale (FS) of 1000 mbar.
[6] The digital I/O signals use a 3.3 V system.
[7] Endurance is qualified as per JEDEC Standard 22, Method A117, and measured at −40°C, +25°C, +85°C, and +125°C.
[8] The data retention specification assumes a junction temperature (T_J) of 85°C as per JEDEC Standard 22, Method A117. Data retention lifetime decreases with T_J.
[9] These times do not include thermal settling, internal filter response times, or EKF start-up times (~825 ms), which may affect overall accuracy, with respect to time.
[10] The $\overline{RST}$ line must be in a low state for at least 10 μs to assure a proper reset initiation and recovery.
[11] The device functions at clock rates below 0.7 kHz, but at reduced performance levels.
[12] Supply current transients can reach 600 mA during start-up and reset recovery.

TIMING SPECIFICATIONS

T_A = 25°C, VDD = 3.3 V, unless otherwise noted.

Table 2.

Parameter	Description	Normal Mode Min[1]	Typ	Max[1]	Unit
f_{SCLK}	Serial clock	0.01		15	MHz
t_{STALL}[2]	Stall period between data	2			µs
t_{CLS}	Serial clock low period	31			ns
t_{CHS}	Serial clock high period	31			ns
$t_{\overline{CS}}$	Chip select to clock edge	32			ns
t_{DAV}	DOUT valid after SCLK edge			10	ns
t_{DSU}	DIN setup time before SCLK rising edge	2			ns
t_{DHD}	DIN hold time after SCLK rising edge	2			ns
t_{DR}, t_{DF}	DOUT rise/fall times, ≤100 pF loading		3	8	ns
t_{DSOE}	$\overline{CS}$ assertion to data out active	0		11	ns
t_{HD}	SCLK edge to data out invalid	0			ns
t_{SFS}	Last SCLK edge to $\overline{CS}$ deassertion	32			ns
t_{DSHI}	$\overline{CS}$ deassertion to data out high impedance	0		9	ns
t_1	Input sync pulse width	5			µs
t_2	Input sync to data invalid		635		µs
t_3	Input sync period	417			µs

[1] Guaranteed by design and characterization, but not tested in production.
[2] See Table 3 for exceptions to the stall time rating.

Table 3 Register Specific Stall Times

Register	Function	Minimum Stall Time (µs)
FNCTIO_CTRL	Configure DIOx functions	60
FLTR_BNK0	Enable/select FIR filter banks	320
FLTR_BNK1	Enable/select FIR filter banks	320
NULL_CFG	Configure autonull bias function	10
GLOB_CMD[1]	Self-test	12,000
GLOB_CMD[2]	Memory test	50,000
GLOB_CMD[3]	Flash memory update	375,000
GLOB_CMD[6]	Flash memory test	75,000
GLOB_CMD[7]	Software reset	12,000

Timing Diagrams

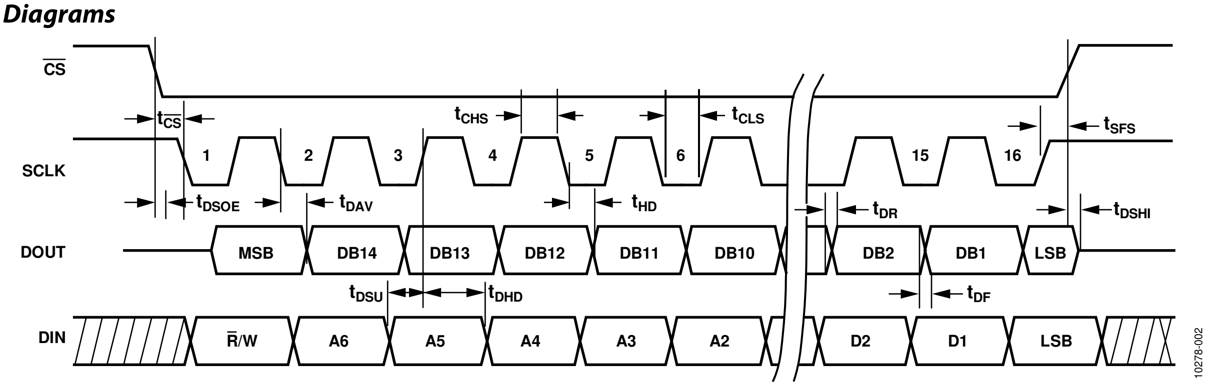


Figure 2. SPI Timing and Sequence

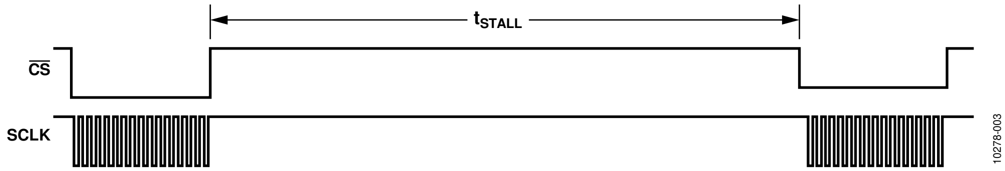


Figure 3. Stall Time and Data Rate

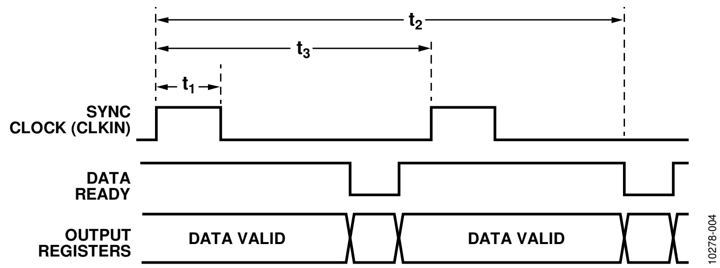


Figure 4. Input Clock Timing Diagram

ABSOLUTE MAXIMUM RATINGS

Table 4.

Parameter	Rating
Acceleration	
Any Axis, Unpowered	2000 *g*
Any Axis, Powered	2000 *g*
VDD to GND	−0.3 V to +3.6 V
Digital Input Voltage to GND	−0.3 V to VDD + 0.2 V
Digital Output Voltage to GND	−0.3 V to VDD + 0.2 V
Operating Temperature Range	−40°C to +105°C
Storage Temperature Range	−65°C to +150°C[1]
Barometric Pressure	2 bar

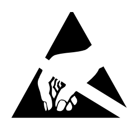
[1] Extended exposure to temperatures that are lower than −40°C or higher than +105°C can adversely affect the accuracy of the factory calibration.

Stresses at or above those listed under Absolute Maximum Ratings may cause permanent damage to the product. This is a stress rating only; functional operation of the product at these or any other conditions above those indicated in the operational section of this specification is not implied. Operation beyond the maximum operating conditions for extended periods may affect product reliability.

Table 5. Package Characteristics

Package Type	θ_{JA}	θ_{JC}	Device Weight
24-Lead Module (ML-24-6)	22.8°C/W	10.1°C/W	48 g

ESD CAUTION



ESD (electrostatic discharge) sensitive device. Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.

PIN CONFIGURATION AND FUNCTION DESCRIPTIONS

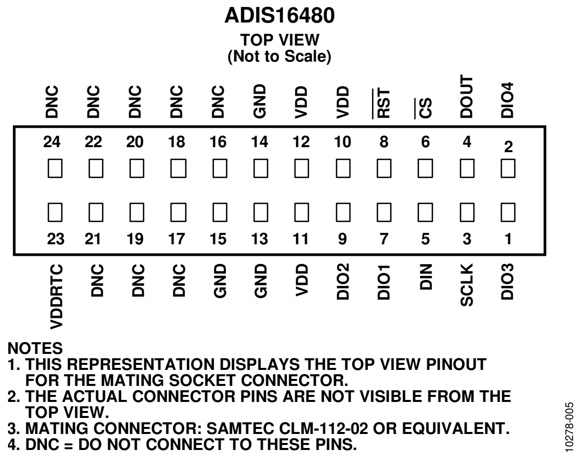


Figure 5. Mating Connector Pin Assignments

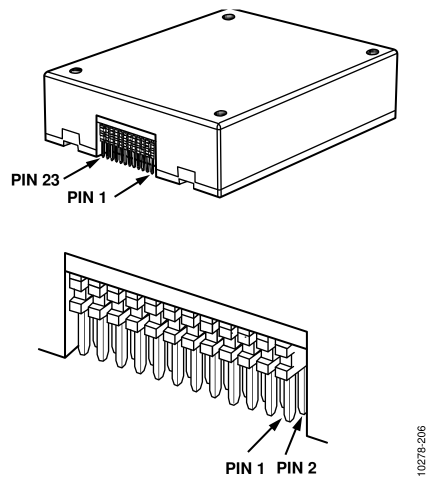


Figure 6. Axial Orientation (Top Side Facing Up)

Table 6. Pin Function Descriptions

Pin No.	Mnemonic	Type	Description
1	DIO3	Input/output	Configurable Digital Input/Output.
2	DIO4	Input/output	Configurable Digital Input/Output.
3	SCLK	Input	SPI Serial Clock.
4	DOUT	Output	SPI Data Output. Clocks output on SCLK falling edge.
5	DIN	Input	SPI Data Input. Clocks input on SCLK rising edge.
6	$\overline{CS}$	Input	SPI Chip Select.
7	DIO1	Input/output	Configurable Digital Input/Output.
8	$\overline{RST}$	Input	Reset.
9	DIO2	Input/output	Configurable Digital Input/Output.
10, 11, 12	VDD	Supply	Power Supply.
13, 14, 15	GND	Supply	Power Ground.
16 to 22, 24	DNC	Not applicable	Do Not Connect. Do not connect to these pins.
23	VDDRTC	Supply	Real-Time Clock Power Supply.

TYPICAL PERFORMANCE CHARACTERISTICS

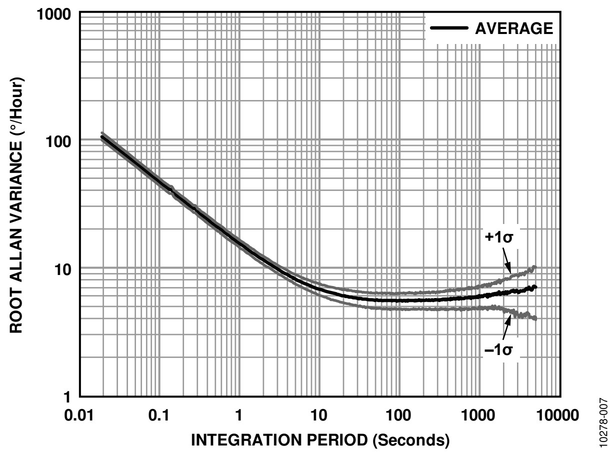


Figure 7. Gyroscope Allan Variance, 25°C

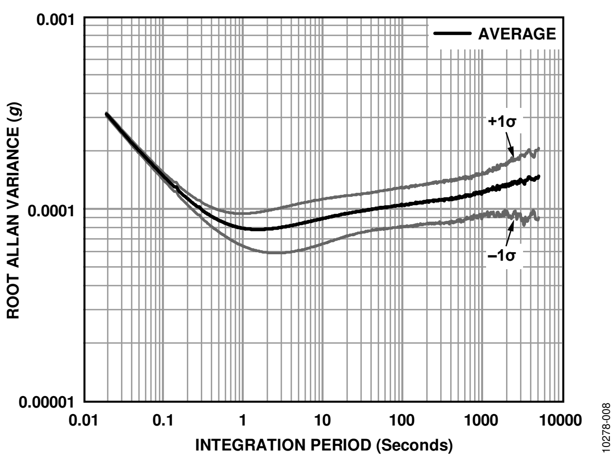


Figure 8. Accelerometer Allan Variance, 25°C

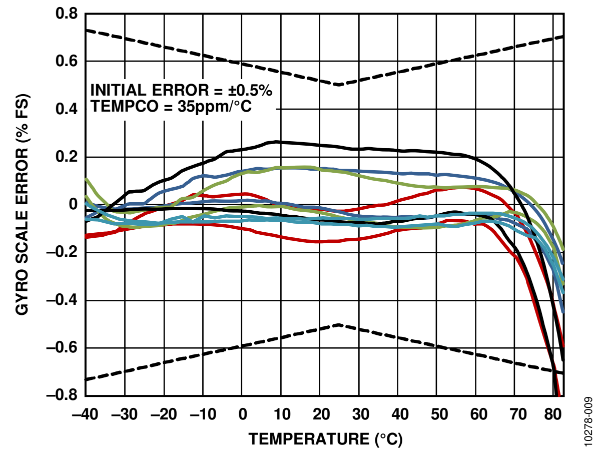


Figure 9. Gyroscope Scale (Sensitivity) Error and Hysteresis vs. Temperature

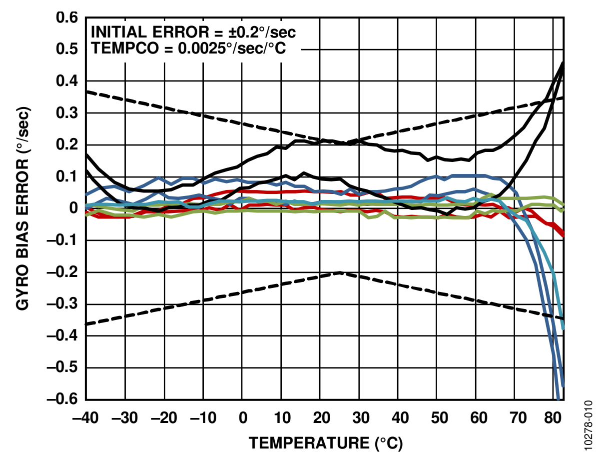


Figure 10. Gyroscope Bias Error and Hysteresis vs. Temperature

BASIC OPERATION

The ADIS16480 is an autonomous sensor system that starts up on its own when it has a valid power supply. After running through its initialization process, it begins sampling, processing, and loading calibrated sensor data into the output registers, which are accessible using the SPI port. The SPI port typically connects to a compatible port on an embedded processor, using the connection diagram in Figure 11. The four SPI signals facilitate synchronous, serial data communication. Connect $\overline{\text{RST}}$ (see Table 6) to VDD or leave it open for normal operation. The factory default configuration provides users with a data-ready signal on the DIO2 pin, which pulses high when new data is available in the output data registers.

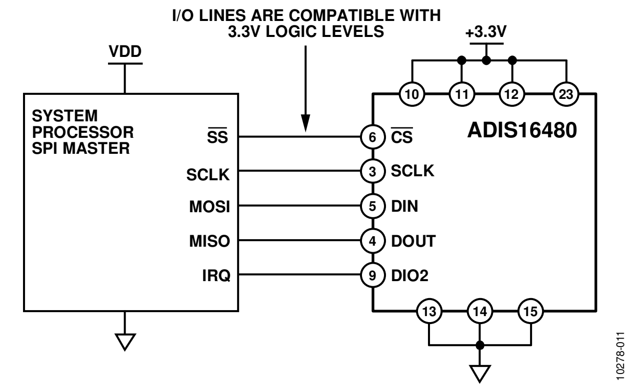


Figure 11. Electrical Connection Diagram

Table 7. Generic Master Processor Pin Names and Functions

Mnemonic	Function
$\overline{\text{SS}}$	Slave select
IRQ	Interrupt request
MOSI	Master output, slave input
MISO	Master input, slave output
SCLK	Serial clock

Embedded processors typically use control registers to configure their serial ports for communicating with SPI slave devices such as the ADIS16480. Table 8 provides a list of settings, which describe the SPI protocol of the ADIS16480. The initialization routine of the master processor typically establishes these settings using firmware commands to write them into its serial control registers.

Table 8. Generic Master Processor SPI Settings

Processor Setting	Description
Master	The ADIS16480 operates as a slave
SCLK ≤ 15 MHz	Maximum serial clock rate
SPI Mode 3	CPOL = 1 (polarity), and CPHA = 1 (phase)
MSB-First Mode	Bit sequence
16-Bit Mode	Shift register/data length

REGISTER STRUCTURE

The register structure and SPI port provide a bridge between the sensor processing system and an external, master processor. It contains both output data and control registers. The output data registers include the latest sensor data, a real-time clock, error flags, alarm flags, and identification data. The control registers include sample rate, filtering, input/output, alarms, calibration, EKF tuning, and diagnostic configuration options. All communication between the ADIS16480 and an external processor involves either reading or writing to one of the user registers.

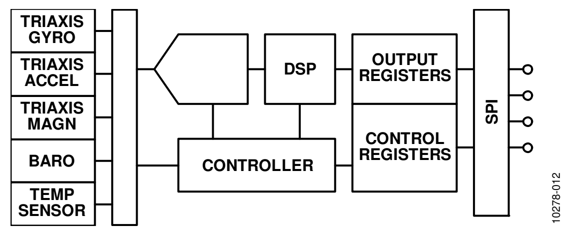


Figure 12. Basic Operation

The register structure uses a paged addressing scheme that is composed of 13 pages, with each one containing 64 register locations. Each register is 16 bits wide, with each byte having its own unique address within the memory map of that page. The SPI port has access to one page at a time, using the bit sequence in Figure 17. Select the page to activate for SPI access by writing its code to the PAGE_ID register. Read the PAGE_ID register to determine which page is currently active. Table 9 displays the PAGE_ID contents for each page, along with their basic functions. The PAGE_ID register is located at Address 0x00 on every page.

Table 9. User Register Page Assignments

Page	PAGE_ID	Function
0	0x00	Output data, clock, identification
1	0x01	Reserved
2	0x02	Calibration
3	0x03	Control: sample rate, filtering, I/O, alarms
4	0x04	Serial number
5	0x05	FIR Filter Bank A Coefficient 0 to Coefficient 59
6	0x06	FIR Filter Bank A, Coefficient 60 to Coefficient 119
7	0x07	FIR Filter Bank B, Coefficient 0 to Coefficient 59
8	0x08	FIR Filter Bank B, Coefficient 60 to Coefficient 119
9	0x09	FIR Filter Bank C, Coefficient 0 to Coefficient 59
10	0x0A	FIR Filter Bank C, Coefficient 60 to Coefficient 119
11	0x0B	FIR Filter Bank D, Coefficient 0 to Coefficient 59
12	0x0C	FIR Filter Bank D, Coefficient 60 to Coefficient 119

SPI COMMUNICATION

The SPI port supports full duplex communication, as shown in Figure 17, which enables external processors to write to DIN while reading DOUT, if the previous command was a read request. Figure 17 provides a guideline for the bit coding on both DIN and DOUT.

DEVICE CONFIGURATION

The SPI provides write access to the control registers, one byte at a time, using the bit assignments shown in Figure 17. Each register has 16 bits, where Bits[7:0] represent the lower address (listed in Table 10) and Bits[15:8] represent the upper address. Write to the lower byte of a register first, followed by a write to its upper byte. The only register that changes with a single write to its lower byte is the PAGE_ID register. For a write command, the first bit in the DIN sequence is set to 1. Address Bits[A6:A0] represent the target address, and Data Command Bits[DC7:DC0] represent the data being written to the location. Figure 13 provides an example of writing 0x03 to Address 0x00 (PAGE_ID [7:0]), using DIN = 0x8003. This write command activates the control page for SPI access.

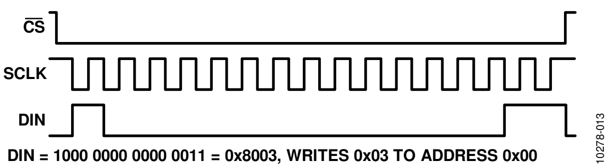


Figure 13. SPI Sequence for Activating the Control Page (DIN = 0x8003)

Dual Memory Structure

Writing configuration data to a control register updates its SRAM contents, which are volatile. After optimizing each relevant control register setting in a system, use the manual flash update command, which is located in GLOB_CMD[3] on Page 3 of the register map. Activate the manual flash update command by turning to Page 3 (DIN = 0x8003) and setting GLOB_CMD[3] = 1 (DIN = 0x8208, then DIN = 0x8300). For a flash memory update, make sure that the power supply is within specification for the entire processing time (see Table 1). Table 10 provides a memory map for all of the user registers, which includes a column of flash backup information. A yes in this column indicates that a register has a mirror location in flash and, when backed up properly, automatically restores itself during startup or after a reset. Figure 14 provides a diagram of the dual memory structure used to manage operation and store critical user settings.

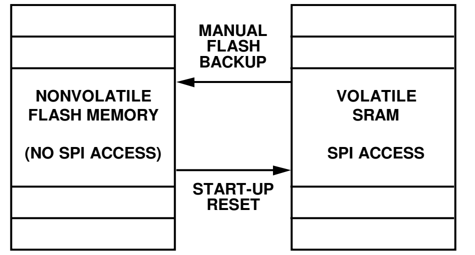


Figure 14. SRAM and Flash Memory Diagram

READING SENSOR DATA

The ADIS16480 automatically starts up and activates Page 0 for data register access. Write 0x00 to the PAGE_ID register (DIN = 0x8000) to activate Page 0 for data access after accessing any other page. A single register read requires two 16-bit SPI cycles. The first cycle requests the contents of a register using the bit assignments in Figure 17, and then the register contents follow DOUT during the second sequence. The first bit in a DIN command is zero, followed by either the upper or lower address for the register. The last eight bits are don't care, but the SPI requires the full set of 16 SCLKs to receive the request. Figure 15 includes two register reads in succession, which starts with DIN = 0x1A00 to request the contents of the Z_GYRO_OUT register and follows with 0x1800 to request the contents of the Z_GYRO_LOW register.

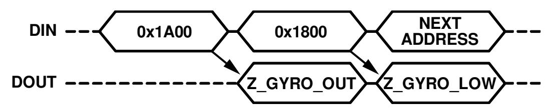


Figure 15. SPI Read Example

Figure 16 provides an example of the four SPI signals when reading PROD_ID in a repeating pattern. This is a good pattern to use for troubleshooting the SPI interface setup and communications because the contents of PROD_ID are predefined and stable.

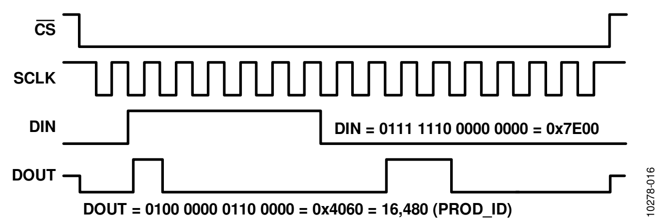


Figure 16. SPI Read Example, Second 16-Bit Sequence

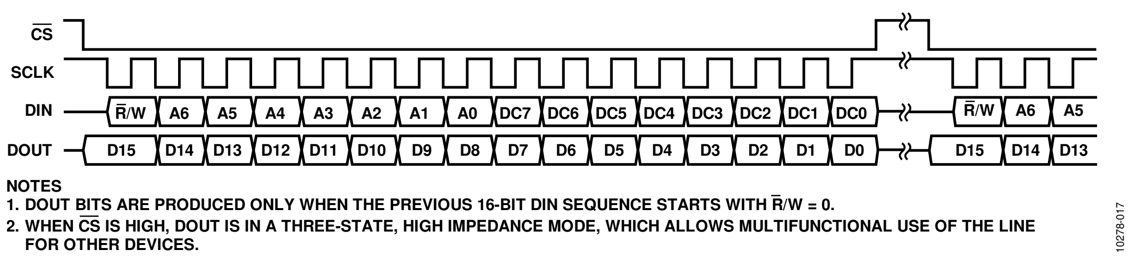


Figure 17. SPI Communication Bit Sequence

USER REGISTERS

Table 10. User Register Memory Map (N/A = Not Applicable)

Name	R/W	Flash	PAGE_ID	Address	Default	Register Description	Format
PAGE_ID	R/W	No	0x00	0x00	0x00	Page identifier	N/A
Reserved	N/A	N/A	0x00	0x02 to 0x04	N/A	Reserved	N/A
SEQ_CNT	R	No	0x00	0x06	N/A	Sequence counter	Table 69
SYS_E_FLAG	R	No	0x00	0x08	0x0000	Output, system error flags	Table 60
DIAG_STS	R	No	0x00	0x0A	0x0000	Output, self-test error flags	Table 61
ALM_STS	R	No	0x00	0x0C	0x0000	Output, alarm error flags	Table 62
TEMP_OUT	R	No	0x00	0x0E	N/A	Output, temperature	Table 58
X_GYRO_LOW	R	No	0x00	0x10	N/A	Output, x-axis gyroscope, low word	Table 15
X_GYRO_OUT	R	No	0x00	0x12	N/A	Output, x-axis gyroscope, high word	Table 11
Y_GYRO_LOW	R	No	0x00	0x14	N/A	Output, y-axis gyroscope, low word	Table 16
Y_GYRO_OUT	R	No	0x00	0x16	N/A	Output, y-axis gyroscope, high word	Table 12
Z_GYRO_LOW	R	No	0x00	0x18	N/A	Output, z-axis gyroscope, low word	Table 17
Z_GYRO_OUT	R	No	0x00	0x1A	N/A	Output, z-axis gyroscope, high word	Table 13
X_ACCL_LOW	R	No	0x00	0x1C	N/A	Output, x-axis accelerometer, low word	Table 22
X_ACCL_OUT	R	No	0x00	0x1E	N/A	Output, x-axis accelerometer, high word	Table 18
Y_ACCL_LOW	R	No	0x00	0x20	N/A	Output, y-axis accelerometer, low word	Table 23
Y_ACCL_OUT	R	No	0x00	0x22	N/A	Output, y-axis accelerometer, high word	Table 19
Z_ACCL_LOW	R	No	0x00	0x24	N/A	Output, z-axis accelerometer, low word	Table 24
Z_ACCL_OUT	R	No	0x00	0x26	N/A	Output, z-axis accelerometer, high word	Table 20
X_MAGN_OUT	R	No	0x00	0x28	N/A	Output, x-axis magnetometer, high word	Table 39
Y_MAGN_OUT	R	No	0x00	0x2A	N/A	Output, y-axis magnetometer, high word	Table 40
Z_MAGN_OUT	R	No	0x00	0x2C	N/A	Output, z-axis magnetometer, high word	Table 41
BAROM_LOW	R	No	0x00	0x2E	N/A	Output, barometer, low word	Table 57
BAROM_OUT	R	No	0x00	0x30	N/A	Output, barometer, high word	Table 55
Reserved	N/A	N/A	0x00	0x32 to 0x3E	N/A	Reserved	N/A
X_DELTANG_LOW	R	No	0x00	0x40	N/A	Output, x-axis delta angle, low word	Table 29
X_DELTANG_OUT	R	No	0x00	0x42	N/A	Output, x-axis delta angle, high word	Table 25
Y_DELTANG_LOW	R	No	0x00	0x44	N/A	Output, y-axis delta angle, low word	Table 30
Y_DELTANG_OUT	R	No	0x00	0x46	N/A	Output, y-axis delta angle, high word	Table 26
Z_DELTANG_LOW	R	No	0x00	0x48	N/A	Output, z-axis delta angle, low word	Table 31
Z_DELTANG_OUT	R	No	0x00	0x4A	N/A	Output, z-axis delta angle, high word	Table 27
X_DELTVEL_LOW	R	No	0x00	0x4C	N/A	Output, x-axis delta velocity, low word	Table 36
X_DELTVEL_OUT	R	No	0x00	0x4E	N/A	Output, x-axis delta velocity, high word	Table 32
Y_DELTVEL_LOW	R	No	0x00	0x50	N/A	Output, y-axis delta velocity, low word	Table 37
Y_DELTVEL_OUT	R	No	0x00	0x52	N/A	Output, y-axis delta velocity, high word	Table 33
Z_DELTVEL_LOW	R	No	0x00	0x54	N/A	Output, z-axis delta velocity, low word	Table 38
Z_DELTVEL_OUT	R	No	0x00	0x56	N/A	Output, z-axis delta velocity, high word	Table 34
Reserved	N/A	N/A	0x00	0x58	N/A	Reserved	N/A
Q0_C11_OUT	R/W	Yes	0x00	0x60	N/A	Quaternion, q0 or rotation matrix, C11	Table 43
Q1_C12_OUT	R/W	Yes	0x00	0x62	N/A	Quaternion, q1 or rotation matrix, C12	Table 44
Q2_C13_OUT	R/W	Yes	0x00	0x64	N/A	Quaternion, q2 or rotation matrix, C13	Table 45
Q3_C21_OUT	R/W	Yes	0x00	0x66	N/A	Quaternion, q3 or rotation matrix, C21	Table 46
C22_OUT	R/W	Yes	0x00	0x68	N/A	Rotation matrix, C22	Table 47
ROLL_C23_OUT	R/W	Yes	0x00	0x6A	N/A	Euler angle, roll axis, or rotation matrix, C23	Table 48
PITCH_C31_OUT	R/W	Yes	0x00	0x6C	N/A	Euler angle, pitch axis, or rotation matrix, C31	Table 49
YAW_C32_OUT	R/W	Yes	0x00	0x6E	N/A	Euler angle, yaw axis, or rotation matrix, C32	Table 50
C33_OUT	R/W	Yes	0x00	0x70	N/A	Rotation matrix, C33	Table 51
Reserved	N/A	N/A	0x00	0x72 to 0x76	N/A	Reserved	N/A

Name	R/W	Flash	PAGE_ID	Address	Default	Register Description	Format
TIME_MS_OUT	R	Yes	0x00	0x78	N/A	Factory configuration time: minutes/seconds	Table 157
TIME_DH_OUT	R	Yes	0x00	0x7A	N/A	Factory configuration date/time: day/hour	Table 158
TIME_YM_OUT	R	Yes	0x00	0x7C	N/A	Factory configuration date: year/month	Table 159
PROD_ID	R	Yes	0x00	0x7E	0x4060	Output, product identification (16,480)	Table 66
Reserved	N/A	N/A	0x01	0x00 to 0x7E	N/A	Reserved	N/A
PAGE_ID	R/W	No	0x02	0x00	0x00	Page identifier	N/A
Reserved	N/A	N/A	0x02	0x02	N/A	Reserved	N/A
X_GYRO_SCALE	R/W	Yes	0x02	0x04	0x0000	Calibration, scale, x-axis gyroscope	Table 104
Y_GYRO_SCALE	R/W	Yes	0x02	0x06	0x0000	Calibration, scale, y-axis gyroscope	Table 105
Z_GYRO_SCALE	R/W	Yes	0x02	0x08	0x0000	Calibration, scale, z-axis gyroscope	Table 106
X_ACCL_SCALE	R/W	Yes	0x02	0x0A	0x0000	Calibration, scale, x-axis accelerometer	Table 114
Y_ACCL_SCALE	R/W	Yes	0x02	0x0C	0x0000	Calibration, scale, y-axis accelerometer	Table 115
Z_ACCL_SCALE	R/W	Yes	0x02	0x0E	0x0000	Calibration, scale, z-axis accelerometer	Table 116
XG_BIAS_LOW	R/W	Yes	0x02	0x10	0x0000	Calibration, offset, gyroscope, x-axis, low word	Table 101
XG_BIAS_HIGH	R/W	Yes	0x02	0x12	0x0000	Calibration, offset, gyroscope, x-axis, high word	Table 98
YG_BIAS_LOW	R/W	Yes	0x02	0x14	0x0000	Calibration, offset, gyroscope, y-axis, low word	Table 102
YG_BIAS_HIGH	R/W	Yes	0x02	0x16	0x0000	Calibration, offset, gyroscope, y-axis, high word	Table 99
ZG_BIAS_LOW	R/W	Yes	0x02	0x18	0x0000	Calibration, offset, gyroscope, z-axis, low word	Table 103
ZG_BIAS_HIGH	R/W	Yes	0x02	0x1A	0x0000	Calibration, offset, gyroscope, z-axis, high word	Table 100
XA_BIAS_LOW	R/W	Yes	0x02	0x1C	0x0000	Calibration, offset, accelerometer, x-axis, low word	Table 111
XA_BIAS_HIGH	R/W	Yes	0x02	0x1E	0x0000	Calibration, offset, accelerometer, x-axis, high word	Table 108
YA_BIAS_LOW	R/W	Yes	0x02	0x20	0x0000	Calibration, offset, accelerometer, y-axis, low word	Table 112
YA_BIAS_HIGH	R/W	Yes	0x02	0x22	0x0000	Calibration, offset, accelerometer, y-axis, high word	Table 109
ZA_BIAS_LOW	R/W	Yes	0x02	0x24	0x0000	Calibration, offset, accelerometer, z-axis, low word	Table 113
ZA_BIAS_HIGH	R/W	Yes	0x02	0x26	0x0000	Calibration, offset, accelerometer, z-axis, high word	Table 110
HARD_IRON_X	R/W	Yes	0x02	0x28	0x0000	Calibration, hard iron, magnetometer, x-axis	Table 117
HARD_IRON_Y	R/W	Yes	0x02	0x2A	0x0000	Calibration, hard iron, magnetometer, y-axis	Table 118
HARD_IRON_Z	R/W	Yes	0x02	0x2C	0x0000	Calibration, hard iron, magnetometer, z-axis	Table 119
SOFT_IRON_S11	R/W	Yes	0x02	0x2E	0x0000	Calibration, soft iron, magnetometer, S11	Table 121
SOFT_IRON_S12	R/W	Yes	0x02	0x30	0x0000	Calibration, soft iron, magnetometer, S12	Table 122
SOFT_IRON_S13	R/W	Yes	0x02	0x32	0x0000	Calibration, soft iron, magnetometer, S13	Table 123
SOFT_IRON_S21	R/W	Yes	0x02	0x34	0x0000	Calibration, soft iron, magnetometer, S21	Table 124
SOFT_IRON_S22	R/W	Yes	0x02	0x36	0x0000	Calibration, soft iron, magnetometer, S22	Table 125
SOFT_IRON_S23	R/W	Yes	0x02	0x38	0x0000	Calibration, soft iron, magnetometer, S23	Table 126
SOFT_IRON_S31	R/W	Yes	0x02	0x3A	0x0000	Calibration, soft iron, magnetometer, S31	Table 127
SOFT_IRON_S32	R/W	Yes	0x02	0x3C	0x0000	Calibration, soft iron, magnetometer, S32	Table 128
SOFT_IRON_S33	R/W	Yes	0x02	0x3E	0x0000	Calibration, soft iron, magnetometer, S33	Table 129
BR_BIAS_LOW	R/W	Yes	0x02	0x40	0x0000	Calibration, offset, barometer, low word	Table 132
BR_BIAS_HIGH	R/W	Yes	0x02	0x42	0x0000	Calibration, offset, barometer, high word	Table 131
Reserved	N/A	N/A	0x02	0x44 to 0x60	N/A	Reserved	N/A
REFMTX_R11	R/W	Yes	0x02	0x62	0x7FFF	Reference transformation matrix, R11	Table 85
REFMTX_R12	R/W	Yes	0x02	0x64	0x0000	Reference transformation matrix, R12	Table 86
REFMTX_R13	R/W	Yes	0x02	0x66	0x0000	Reference transformation matrix, R13	Table 87
REFMTX_R21	R/W	Yes	0x02	0x68	0x0000	Reference transformation matrix, R21	Table 88
REFMTX_R22	R/W	Yes	0x02	0x6A	0x7FFF	Reference transformation matrix, R22	Table 89
REFMTX_R23	R/W	Yes	0x02	0x6C	0x0000	Reference transformation matrix, R23	Table 90
REFMTX_R31	R/W	Yes	0x02	0x6E	0x0000	Reference transformation matrix, R31	Table 91
REFMTX_R32	R/W	Yes	0x02	0x70	0x0000	Reference transformation matrix, R32	Table 92
REFMTX_R33	R/W	Yes	0x02	0x72	0x7FFF	Reference transformation matrix, R33	Table 93
USER_SCR_1	R/W	Yes	0x02	0x74	0x0000	User Scratch Register 1	Table 153
USER_SCR_2	R/W	Yes	0x02	0x76	0x0000	User Scratch Register 2	Table 154
USER_SCR_3	R/W	Yes	0x02	0x78	0x0000	User Scratch Register 3	Table 155
USER_SCR_4	R/W	Yes	0x02	0x7A	0x0000	User Scratch Register 4	Table 156

Name	R/W	Flash	PAGE_ID	Address	Default	Register Description	Format
FLSHCNT_LOW	R	Yes	0x02	0x7C	N/A	Diagnostic, flash memory count, low word	Table 148
FLSHCNT_HIGH	R	Yes	0x02	0x7E	N/A	Diagnostic, flash memory count, high word	Table 149
PAGE_ID	R/W	No	0x03	0x00	0x0000	Page identifier	N/A
GLOB_CMD	W	No	0x03	0x02	N/A	Control, global commands	Table 147
Reserved	N/A	N/A	0x03	0x04	N/A	Reserved	N/A
FNCTIO_CTRL	R/W	Yes	0x03	0x06	0x000D	Control, I/O pins, functional definitions	Table 150
GPIO_CTRL	R/W	Yes	0x03	0x08	0x00X0[1]	Control, I/O pins, general purpose	Table 151
CONFIG	R/W	Yes	0x03	0x0A	0x00C0	Control, clock, and miscellaneous correction	Table 107
DEC_RATE	R/W	Yes	0x03	0x0C	0x0000	Control, output sample rate decimation	Table 68
Reserved	N/A	N/A	0x03	0x0E	N/A	Reserved	N/A
SLP_CNT	R/W	No	0x03	0x10	N/A	Control, power-down/sleep mode	Table 152
Reserved	N/A	N/A	0x03	0x12 to 0x14	N/A	Reserved	N/A
FILTR_BNK_0	R/W	Yes	0x03	0x16	0x0000	Filter selection	Table 70
FILTR_BNK_1	R/W	Yes	0x03	0x18	0x0000	Filter selection	Table 71
Reserved	N/A	N/A	0x03	0x1A to 0x1E	N/A	Reserved	N/A
ALM_CNFG_0	R/W	Yes	0x03	0x20	0x0000	Alarm configuration	Table 143
ALM_CNFG_1	R/W	Yes	0x03	0x22	0x0000	Alarm configuration	Table 144
ALM_CNFG_2	R/W	Yes	0x03	0x24	0x0000	Alarm configuration	Table 145
Reserved	N/A	N/A	0x03	0x26	N/A	Reserved	N/A
XG_ALM_MAGN	R/W	Yes	0x03	0x28	0x0000	Alarm, x-axis gyroscope threshold setting	Table 133
YG_ALM_MAGN	R/W	Yes	0x03	0x2A	0x0000	Alarm, y-axis gyroscope threshold setting	Table 134
ZG_ALM_MAGN	R/W	Yes	0x03	0x2C	0x0000	Alarm, z-axis gyroscope threshold setting	Table 135
XA_ALM_MAGN	R/W	Yes	0x03	0x2E	0x0000	Alarm, x-axis accelerometer threshold	Table 136
YA_ALM_MAGN	R/W	Yes	0x03	0x30	0x0000	Alarm, y-axis accelerometer threshold	Table 137
ZA_ALM_MAGN	R/W	Yes	0x03	0x32	0x0000	Alarm, z-axis accelerometer threshold	Table 138
XM_ALM_MAGN	R/W	Yes	0x03	0x34	0x0000	Alarm, x-axis magnetometer threshold	Table 139
YM_ALM_MAGN	R/W	Yes	0x03	0x36	0x0000	Alarm, y-axis magnetometer threshold	Table 140
ZM_ALM_MAGN	R/W	Yes	0x03	0x38	0x0000	Alarm, z-axis magnetometer threshold	Table 141
BR_ALM_MAGN	R/W	Yes	0x03	0x3A	0x0000	Alarm, barometer threshold setting	Table 142
Reserved	N/A	N/A	0x03	0x3C to 0x4E	N/A	Reserved	N/A
EKF_CNFG	R/W	Yes	0x03	0x50	0x0200	Extended Kalman filter configuration	Table 95
Reserved	N/A	N/A	0x03	0x52	N/A	Reserved	N/A
DECLN_ANGL	R/W	Yes	0x03	0x54	0x0000	Declination angle	Table 94
ACC_DISTB_THR	R/W	Yes	0x03	0x56	0x0020	Accelerometer disturbance threshold	Table 96
MAG_DISTB_THR	R/W	Yes	0x03	0x58	0x0030	Magnetometer disturbance threshold	Table 97
Reserved	N/A	N/A	0x03	0x5A to 0x5E	N/A	Reserved	N/A
QCVR_NOIS_LWR	R/W	Yes	0x03	0x60	0xC5AC	Process covariance, gyroscope noise, lower word	Table 78
QCVR_NOIS_UPR	R/W	Yes	0x03	0x62	0x3727	Process covariance, gyroscope noise, upper word	Table 77
QCVR_RRW_LWR	R/W	Yes	0x03	0x64	0xE6FF	Process covariance, gyroscope RRW, lower word	Table 80
QCVR_RRW_UPR	R/W	Yes	0x03	0x66	0x2E5B	Process covariance, gyroscope RRW, upper word	Table 79
Reserved	N/A	N/A	0x03	0x68 to 0x6A	N/A	Reserved	N/A
RCVR_ACC_LWR	R/W	Yes	0x03	0x6C	0x705F	Measurement covariance, accelerometer, upper	Table 82
RCVR_ACC_UPR	R/W	Yes	0x03	0x6E	0x3189	Measurement covariance, accelerometer, lower	Table 81
RCVR_MAG_LWR	R/W	Yes	0x03	0x70	0xCC77	Measurement covariance, magnetometer, upper	Table 84
RCVR_MAG_UPR	R/W	Yes	0x03	0x72	0x32AB	Measurement covariance, magnetometer, lower	Table 83
Reserved	N/A	N/A	0x03	0x74 to 0x76	N/A	Reserved	N/A
FIRM_REV	R	Yes	0x03	0x78	N/A	Firmware revision	Table 63
FIRM_DM	R	Yes	0x03	0x7A	N/A	Firmware programming date: day/month	Table 64
FIRM_Y	R	Yes	0x03	0x7C	N/A	Firmware programming date: year	Table 65
Reserved	N/A	N/A	0x03	0x7E	N/A	Reserved	N/A
Reserved	N/A	N/A	0x04	0x00 to 0x18	N/A	Reserved	N/A
SERIAL_NUM	R	Yes	0x04	0x20	N/A	Serial number	Table 67
Reserved	N/A	N/A	0x04	0x22 to 0x7F	N/A	Reserved	N/A

Name	R/W	Flash	PAGE_ID	Address	Default	Register Description	Format
PAGE_ID	R/W	No	0x05	0x00	0x0000	Page identifier	N/A
FIR_COEF_Axxx	R/W	Yes	0x05	0x02 to 0x7E	N/A	FIR Filter Bank A, Coefficients 0 through 59	Table 72
PAGE_ID	R/W	No	0x06	0x00	0x0000	Page identifier	N/A
FIR_COEF_Axxx	R/W	Yes	0x06	0x02 to 0x7E	N/A	FIR Filter Bank A, Coefficients 60 through 119	Table 72
PAGE_ID	R/W	No	0x07	0x00	0x0000	Page identifier	N/A
FIR_COEF_Bxxx	R/W	Yes	0x07	0x02 to 0x7E	N/A	FIR Filter Bank B, Coefficients 0 through 59	Table 73
PAGE_ID	R/W	No	0x08	0x00	0x0000	Page identifier	N/A
FIR_COEF_Bxxx	R/W	Yes	0x08	0x02 to 0x7E	N/A	FIR Filter Bank B, Coefficients 60 through 119	Table 73
PAGE_ID	R/W	No	0x09	0x00	0x0000	Page identifier	N/A
FIR_COEF_Cxxx	R/W	Yes	0x09	0x02 to 0x7E	N/A	FIR Filter Bank C, Coefficients 0 through 59	Table 74
PAGE_ID	R/W	No	0x0A	0x00	0x0000	Page identifier	N/A
FIR_COEF_Cxxx	R/W	Yes	0x0A	0x02 to 0x7E	N/A	FIR Filter Bank C, Coefficients 60 through 119	Table 74
PAGE_ID	R/W	No	0x0B	0x00	0x0000	Page identifier	N/A
FIR_COEF_Dxxx	R/W	Yes	0x0B	0x02 to 0x7E	N/A	FIR Filter Bank D, Coefficients 0 through 59	Table 75
PAGE_ID	R/W	No	0x0C	0x00	0x0000	Page identifier	N/A
FIR_COEF_Dxxx	R/W	Yes	0x0C	0x02 to 0x7E	N/A	FIR Filter Bank D, Coefficients 60 through 119	Table 75

[1] The GPIO_CTRL[7:4] bits reflect the logic levels on the DIOx lines and do not have a default setting.

OUTPUT DATA REGISTERS

After the ADIS16480 completes its start-up process, the PAGE_ID register contains 0x0000, which sets Page 0 as the active page for SPI access. Page 0 contains the output data, real-time clock, status, and product identification registers.

INERTIAL SENSOR DATA FORMAT

The gyroscope, accelerometer, delta angle, delta velocity, and barometer output data registers use a 32-bit, twos complement format. Each output uses two registers to support this resolution. Figure 18 provides an example of how each register contributes to each inertial measurement. In this case, X_GYRO_OUT is the most significant word (upper 16 bits), and X_GYRO_LOW is the least significant word (lower 16 bits), which captures the bit growth associated with the final averaging/decimation register. When using the maximum sample rate (DEC_RATE = 0x0000, the x_xxxx_LOW registers are not active.

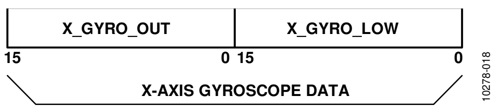


Figure 18. Gyroscope Output Format Example, DEC_RATE > 0

The arrows in Figure 19 describe the direction of the motion, which produces a positive output response in each sensor output register. The accelerometers respond to both dynamic and static forces associated with acceleration, including gravity. When lying perfectly flat, as shown in Figure 19, the z-axis accelerometer output is 1 *g*, and the x and y accelerometers are 0 *g*. EKF_CNFG[3] (see Table 95) provides a selection for gyroscope, accelerometer, and magnetometer data orientation, between the body frame and the local navigation frame. When EKF_CNFG[3] = 0 (default), the accelerometer and magnetometer data displays in the local navigation frame.

ROTATION RATE (GYROSCOPE)

The registers that use the x_GYRO_OUT format are the primary registers for the gyroscope measurements (see Table 11, Table 12, and Table 13). When processing data from these registers, use a 16-bit, twos complement data format. Table 14 provides x_GYRO_OUT digital coding examples.

Table 11. X_GYRO_OUT (Page 0, Base Address = 0x12)

Bits	Description
[15:0]	X-axis gyroscope data; twos complement, ±450°/sec range, 0°/sec = 0x0000, 1 LSB = 0.02°/sec

Table 12. Y_GYRO_OUT (Page 0, Base Address = 0x16)

Bits	Description
[15:0]	Y-axis gyroscope data; twos complement, ±450°/sec range, 0°/sec = 0x0000, 1 LSB = 0.02°/sec

Table 13. Z_GYRO_OUT (Page 0, Base Address = 0x1A)

Bits	Description
[15:0]	Z-axis gyroscope data; twos complement, ±450°/sec range, 0°/sec = 0x0000, 1 LSB = 0.02°/sec

Table 14. x_GYRO_OUT Data Format Examples

Rotation Rate	Decimal	Hex	Binary
+450°/sec	+22,500	0x57E4	0101 0111 1110 0100
+0.04/sec	+2	0x0002	0000 0000 0000 0010
+0.02°/sec	+1	0x0001	0000 0000 0000 0001
0°/sec	0	0x0000	0000 0000 0000 0000
−0.02°/sec	−1	0xFFFF	1111 1111 1111 1111
−0.04°/sec	−2	0xFFFE	1111 1111 1111 1110
−450°/sec	−22,500	0xA81C	1010 1000 0001 1100

The MSB in x_GYRO_LOW has a weight of 0.01°/sec, and each subsequent bit has ½ the weight of the previous one.

Table 15. X_GYRO_LOW (Page 0, Base Address = 0x10)

Bits	Description
[15:0]	X-axis gyroscope data; additional resolution bits

Table 16. Y_GYRO_LOW (Page 0, Base Address = 0x14)

Bits	Description
[15:0]	Y-axis gyroscope data; additional resolution bits

Table 17. Z_GYRO_LOW (Page 0, Base Address = 0x18)

Bits	Description
[15:0]	Z-axis gyroscope data; additional resolution bits

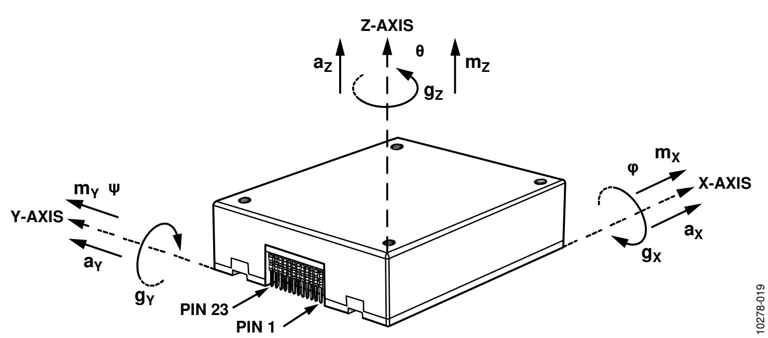


Figure 19. Inertial Sensor Direction Reference Diagram

ACCELERATION

The registers that use the x_ACCL_OUT format are the primary registers for the accelerometer measurements (see Table 18, Table 19, and Table 20). When processing data from these registers, use a 16-bit, twos complement data format. Table 21 provides x_ACCL_OUT digital coding examples.

Table 18. X_ACCL_OUT (Page 0, Base Address = 0x1E)

Bits	Description
[15:0]	X-axis accelerometer data; twos complement, ±10 *g* range, 0 *g* = 0x0000, 1 LSB = 0.8 m*g*

Table 19. Y_ACCL_OUT (Page 0, Base Address = 0x22)

Bits	Description
[15:0]	Y-axis accelerometer data; twos complement, ±10 *g* range, 0 *g* = 0x0000, 1 LSB = 0.8 m*g*

Table 20. Z_ACCL_OUT (Page 0, Base Address = 0x26)

Bits	Description
[15:0]	Z-axis accelerometer data; twos complement, ±10 *g* range, 0 *g* = 0x0000, 1 LSB = 0.8 m*g*

Table 21. x_ACCL_OUT Data Format Examples

Acceleration	Decimal	Hex	Binary
+10 *g*	+12,500	0x30D4	0011 0000 1101 0100
+1.6 m*g*	+2	0x0002	0000 0000 0000 0010
+0.8 m*g*	+1	0x0001	0000 0000 0000 0001
0 m*g*	0	0x0000	0000 0000 0000 0000
−0.8 m*g*	−1	0xFFFF	1111 1111 1111 1111
−1.6 m*g*	−2	0xFFFE	1111 1111 1111 1110
−10 *g*	−12,500	0xCF2C	1100 1111 0010 1100

The MSB in x_ACCL_LOW has a weight of 0.4 m*g*, and each subsequent bit has ½ the weight of the previous one.

Table 22. X_ACCL_LOW (Page 0, Base Address = 0x1C)

Bits	Description
[15:0]	X-axis accelerometer data; additional resolution bits

Table 23. Y_ACCL_LOW (Page 0, Base Address = 0x20)

Bits	Description
[15:0]	Y-axis accelerometer data; additional resolution bits

Table 24. Z_ACCL_LOW (Page 0, Base Address = 0x24)

Bits	Description
[15:0]	Z-axis accelerometer data; additional resolution bits

DELTA ANGLES

The x_DELTANG_OUT registers are the primary output registers for the delta angle calculations. When processing data from these registers, use a 16-bit, twos complement data format (see Table 25, Table 26, and Table 27). Table 28 provides x_DELTANG_OUT digital coding examples.

The delta angle outputs represent an integration of the gyroscope measurements and use the following formula for all three axes (x-axis displayed):

$$\Delta\theta_{x,nD} = \frac{1}{2f_S} \times \sum_{d=0}^{D-1} \left(\omega_{x,nD+d} + \omega_{x,nD+d-1}\right)$$

where:
ω_x is the x-axis rate of rotation (gyroscope).
f_S is the sample rate.
n is the sample time prior to the decimation filter.
D is the decimation rate (DEC_RATE + 1).

When using the internal sample clock, f_S is equal to 2,460 SPS. When using the external clock option, f_S is equal to the frequency of the external clock, which is limited to a minimum of 2 kHz, in order to prevent overflow in the x_DELTANG_xxx registers at high rotation rates. See Table 68 and Figure 20 for more information on the DEC_RATE register (decimation filter).

Table 25. X_DELTANG_OUT (Page 0, Base Address = 0x42)

Bits	Description
[15:0]	X-axis delta angle data; twos complement, ±720° range, 0° = 0x0000, 1 LSB = 720°/2^{15} = ~0.022°

Table 26. Y_DELTANG_OUT (Page 0, Base Address = 0x46)

Bits	Description
[15:0]	Y-axis delta angle data; twos complement, ±720° range, 0° = 0x0000, 1 LSB = 720°/2^{15} = ~0.022°

Table 27. Z_DELTANG_OUT (Page 0, Base Address = 0x4A)

Bits	Description
[15:0]	Z-axis delta angle data; twos complement, ±720° range, 0° = 0x0000, 1 LSB = 720°/2^{15} = ~0.022°

Table 28. x_DELTANG_OUT Data Format Examples

Angle (°)	Decimal	Hex	Binary
$+720 \times (2^{15} - 1)/2^{15}$	+32,767	0x7FFF	0111 1111 1111 1111
$+1440/2^{15}$	+2	0x0002	0000 0000 0000 0010
$+720/2^{15}$	+1	0x0001	0000 0000 0000 0001
0	0	0x0000	0000 0000 0000 0000
$-720/2^{15}$	−1	0xFFFF	1111 1111 1111 1111
$-1440/2^{15}$	−2	0xFFFE	1111 1111 1111 1110
−720	−32,768	0x8000	1000 0000 0000 0000

The x_DELTANG_LOW registers (see Table 29, Table 30, and Table 31) provide additional resolution bits for the delta angle and combine with the x_DELTANG_OUT registers to provide a 32-bit, twos complement number. The MSBs in the x_DELTANG_LOW registers have a weight of ~0.011° (720°/2^{16}), and each subsequent bit carries a weight of ½ of the previous one.

Table 29. X_DELTANG_LOW (Page 0, Base Address = 0x40)

Bits	Description
[15:0]	X-axis delta angle data; additional resolution bits

Table 30. Y_DELTANG_LOW (Page 0, Base Address = 0x44)

Bits	Description
[15:0]	Y-axis delta angle data; additional resolution bits

Table 31. Z_DELTANG_LOW (Page 0, Base Address = 0x48)

Bits	Description
[15:0]	Z-axis delta angle data; additional resolution bits

DELTA VELOCITY

The registers that use the x_DELTVEL_OUT format are the primary registers for the delta velocity calculations. When processing data from these registers, use a 16-bit, twos complement data format (see Table 32, Table 33, and Table 34). Table 35 provides x_DELTVEL_OUT digital coding examples.

The delta velocity outputs represent an integration of the accelerometer measurements and use the following formula for all three axes (x-axis displayed):

$$\Delta V_{x,nD} = \frac{1}{2 f_S} \times \sum_{d=0}^{D-1} \left(a_{x,nD+d} + a_{x,nD+d-1} \right)$$

where:
a_x is the x-axis linear acceleration.
f_S is the sample rate.
n is the sample time prior to the decimation filter.
D is the decimation rate (DEC_RATE + 1).

When using the internal sample clock, f_S is equal to 2,460 SPS. When using the external clock option, f_S is equal to the frequency of the external clock, which is limited to a minimum of 2 kHz, in order to prevent overflow in the x_DELTVEL_xxx registers at high rotation rates. See Table 68 and Figure 20 for more information on the DEC_RATE register (decimation filter).

Table 32. X_DELTVEL_OUT (Page 0, Base Address = 0x4E)

Bits	Description
[15:0]	X-axis delta velocity data; twos complement, ±200 m/sec range, 0 m/sec = 0x0000 1 LSB = 200 m/sec ÷ (2^{15} − 1) = ~6.104 mm/sec

Table 33. Y_DELTVEL_OUT (Page 0, Base Address = 0x52)

Bits	Description
[15:0]	Y-axis delta velocity data; twos complement, ±200 m/sec range, 0 m/sec = 0x0000 1 LSB = 200 m/sec ÷ (2^{15} − 1) = ~6.104 mm/sec

Table 34. Z_DELTVEL_OUT (Page 0, Base Address = 0x56)

Bits	Description
[15:0]	Z-axis delta velocity data; twos complement, ±200 m/sec range, 0 m/sec = 0x0000 1 LSB = 200 m/sec ÷ (2^{15} − 1) = ~6.104 mm/sec

Table 35. x_DELTVEL_OUT, Data Format Examples

Velocity (m/sec)	Decimal	Hex	Binary
+200 × (2^{15} − 1)/2^{15}	+32,767	0x7FFF	0111 1111 1111 1111
+400/2^{15}	+2	0x0002	0000 0000 0000 0010
+200/2^{15}	+1	0x0001	0000 0000 0000 0001
0	0	0x0000	0000 0000 0000 0000
−200/2^{15}	−1	0xFFFF	1111 1111 1111 1111
−400/2^{15}	−2	0xFFFE	1111 1111 1111 1110
−200	−32,768	0x8000	1000 0000 0000 0000

The x_DELTVEL_LOW registers (see Table 36, Table 37, and Table 38) provide additional resolution bits for the delta velocity and combine with the x_DELTVEL_OUT registers to provide a 32-bit, twos complement number. The MSBs in the x_DELTVEL_LOW registers have a weight of ~3.052 mm/sec (200 m/sec ÷ 2^{16}), and each subsequent bit carries a weight of ½ of the previous one.

Table 36. X_DELTVEL_LOW (Page 0, Base Address = 0x4C)

Bits	Description
[15:0]	X-axis delta velocity data; additional resolution bits

Table 37. Y_DELTVEL_LOW (Page 0, Base Address = 0x50)

Bits	Description
[15:0]	Y-axis delta velocity data; additional resolution bits

Table 38. Z_DELTVEL_LOW (Page 0, Base Address = 0x54)

Bits	Description
[15:0]	Z-axis delta velocity data; additional resolution bits

MAGNETOMETERS

The registers that use the x_MAGN_OUT format are the primary registers for the magnetometer measurements. When processing data from these registers, use a 16-bit, twos complement data format. Table 39, Table 40, and Table 41 provide each register numerical format, and Table 42 provides x_MAGN_OUT digital coding examples.

Table 39. X_MAGN_OUT (Page 0, Base Address = 0x28)

Bits	Description
[15:0]	X-axis magnetometer data; twos complement, ±3.2767 gauss range, 0 gauss = 0x0000, 1 LSB = 0.1 mgauss

Table 40. Y_MAGN_OUT (Page 0, Base Address = 0x2A)

Bits	Description
[15:0]	Y-axis magnetometer data; twos complement, ±3.2767 gauss range, 0 gauss = 0x0000, 1 LSB = 0.1 mgauss

Table 41. Z_MAGN_OUT (Page 0, Base Address = 0x2C)

Bits	Description
[15:0]	Z-axis magnetometer data; twos complement, ±3.2767 gauss range, 0 gauss = 0x0000, 1 LSB = 0.1 mgauss

Table 42. x_MAGN_OUT Data Format Examples

Magnetic Field	Decimal	Hex	Binary
+3.2767 gauss	+32,767	0x7FFF	0111 1111 1111 1111
+0.2 mgauss	+2	0x0002	0000 0000 0000 0010
+0.1 mgauss	+1	0x0001	0000 0000 0000 0001
0 gauss	0	0x0000	0000 0000 0000 0000
−0.1 mgauss	−1	0xFFFF	1111 1111 1111 1111
−0.2 mgauss	−2	0xFFFE	1111 1111 1111 1110
−3.2768 gauss	−32,768	0x8000	1000 0000 0000 0000

ROLL, PITCH, YAW ANGLES

The EKF_CNFG (Table 95) register contains two bits, which define the output format of the angle estimates. The first one is EKF_CNFG[4], which selects the output format. When EKF_CNFG[4] = 0; the output data is in the format of a quaternion vector (see Table 43 through Table 46) and Euler angles (see Table 48 through Table 50). When EKF_CNFG[4] = 1, the output data is in the form of a rotation matrix (see Table 43 through Table 51).

Initial Conditions

During start-up, reset recovery, sleep mode recovery, and power-down recovery, the ADIS16480 uses the inertial sensor outputs to estimate bias and a number of critical initial states that are critical for stable operation and accurate angle estimates. To assure convergence and accuracy, only initiate start-up or reset commands when the platform of the ADIS16480 is not in motion and the magnetic environment is free of interference.

Quaternion

This four-element hypercomplex number defines the attitude of the body frame, relative to that of the navigation frame. The Qx_Cxx_OUT registers (See Table 43 through Table 46) contain the value for each element (q0, q1, q2, q4). The element, q0, is the scalar part of the quaternion and represents the magnitude of the rotation. The vector portion of the quaternion is defined by $(q1, q2, q3)^T$, which identifies the axis about which the rotation takes place, in adjusting the body frame to that of the navigation frame. When the orientation is in its reference position, q0 is equal to one and q1, q2, and q3 are equal to zero. These registers update at the same data rate as the gyroscopes and accelerometers.

Euler Angles

The Euler angle names are yaw (ψ), pitch (θ), and roll (φ). See Figure 19 for the axial association of these angles. These three elements represent the most intuitive way of describing orientation angles. The process of translating body frame data to the navigation frame can be broken down into three successive translations. These translations follow as the yaw rotation about the z-axis, followed by the pitch rotation about the y-axis, and finally the roll rotation about the x-axis. Reverse this sequence to resolve a reverse rotation. Difficulties in this process arise due to the singularities that occur whenever the pitch approaches ±90° thus making the roll indistinguishable from the yaw. For applications that may approach these limits, the quaternion or rotation matrix output may be more appropriate. When the ADIS16480 is in its reference position, all three Euler angles are equal to zero. The update rate for these variables is the same as the gyroscopes and accelerometers.

Rotation Matrix Data

The rotation matrix defines the attitude of the body frame relative to that of the navigation frame. The Cxx_OUT registers (see Table 43 through Table 51) define each element in this 3 × 3 matrix. Each element is the product of the unit vectors that describe the axes of the two frames, which in turn, are equal to the cosines of the angles between the axes. When the ADIS16480 is in its reference position, the rotation matrix are equal to a 3 × 3 identify matrix.

Table 43. Q0_C11_OUT (Page 0, Base Address = 0x60)

Bits	Description
[15:0]	Quarterion scalar, q0 or rotation matrix, C11
	Twos complement
	q0 scale factor = 0.000030518/LSB ($1/2^{15}$)
	C11 scale factor = 0.000030518/LSB ($1/2^{15}$)

Table 44. Q1_C12_OUT (Page 0, Base Address = 0x62)

Bits	Description
[15:0]	Quarterion vector, q1; or rotation matrix, C12
	Twos complement
	q1 scale factor = 0.000030518/LSB ($1/2^{15}$)
	C12 scale factor = 0.000030518/LSB ($1/2^{15}$)

Table 45. Q2_C13_OUT (Page 0, Base Address = 0x64)

Bits	Description
[15:0]	Quarterion vector, q2; or rotation matrix, C13
	Twos complement
	q2 scale factor = 0.000030518/LSB ($1/2^{15}$)
	C13 scale factor = 0.000030518/LSB ($1/2^{15}$)

Table 46. Q3_C21_OUT (Page 0, Base Address = 0x66)

Bits	Description
[15:0]	Quarterion vector, q3; or rotation matrix, C21
	Twos complement
	q3 scale factor = 0.000030518/LSB ($1/2^{15}$)
	C21 scale factor = 0.000030518/LSB ($1/2^{15}$)

Table 47. C22_OUT (Page 0, Base Address = 0x68)

Bits	Description
[15:0]	Rotation matrix, C22, twos complement
	C22 scale factor = 0.000030518/LSB ($1/2^{15}$)

Table 48. ROLL_C23_OUT (Page 0, Base Address = 0x6A)

Bits	Description
[15:0]	Euler angle, φ, roll or rotation matrix, C23
	Twos complement, range: ±180° (±π radians)
	Roll angle scale factor = ($180/2^{15}$)°/LSB
	Rotation matrix variable, C23
	Twos complement
	C23 scale factor = 0.000030518/LSB ($1/2^{15}$)

Table 49. PITCH_C31_OUT (Page 0, Base Address = 0x6C)

Bits	Description
[15:0]	Euler angle, θ, pitch or rotation matrix, C31
	Twos complement, range: ±90° (±π/2 radians)
	Pitch angle scale factor = ($180/2^{15}$)°/LSB
	Rotation matrix variable, C31
	Twos complement, 0.000030518/LSB ($1/2^{15}$)

Table 50. YAW_C32_OUT (Page 0, Base Address = 0x6E)

Bits	Description
[15:0]	Euler angle, Ψ, yaw or rotation matrix, C32
	Twos complement, range: ±180° (±π radians)
	Yaw angle scale factor = ($180/2^{15}$)°/LSB
	Rotation matrix variable, C32
	Twos complement, 0.000030518/LSB ($1/2^{15}$)

Table 51. C33_OUT (Page 0, Base Address = 0x70)

Bits	Description
[15:0]	Rotation matrix, C33, twos complement
	C22 scale factor = 0.000030518/LSB ($1/2^{15}$)

Table 52. Rotation Matrix/q1/q2/q3 Data Format Examples

Angle (°)	Decimal	Hex	Binary
$(2^{15} – 1)/2^{15}$	+32,767	0x7FFF	0111 1111 1111 1111
$2/2^{15}$	+2	0x0002	0000 0000 0000 0010
$1/2^{15}$	+1	0x0001	0000 0000 0000 0001
0	0	0x0000	0000 0000 0000 0000
$−1/2^{15}$	−1	0xFFFF	1111 1111 1111 1111
$−2/2^{15}$	−2	0xFFFE	1111 1111 1111 1110
−1	−32,768	0x8000	1000 0000 0000 0000

Table 53. Yaw, Roll, q0 Angle Data Format Examples

Angle (°)	Decimal	Hex	Binary
$+180 \times (2^{15} – 1)/2^{15}$	+32,767	0x7FFF	0111 1111 1111 1111
$+360/2^{15}$	+2	0x0002	0000 0000 0000 0010
$+180/2^{15}$	+1	0x0001	0000 0000 0000 0001
0	0	0x0000	0000 0000 0000 0000
$−180/2^{15}$	−1	0xFFFF	1111 1111 1111 1111
$−360/2^{15}$	−2	0xFFFE	1111 1111 1111 1110
−180	−32,768	0x8000	1000 0000 0000 0000

Table 54. Pitch Angle Data Format Examples

Angle (°)	Decimal	Hex	Binary
$+90 \times (2^{15}–1)/2^{15}$	+16,383	0x3FFF	0011 1111 1110 1111
$+360/2^{15}$	+2	0x0002	0000 0000 0000 0010
$+180/2^{15}$	+1	0x0001	0000 0000 0000 0001
0	0	0x0000	0000 0000 0000 0000
$−180/2^{15}$	−1	0xFFFF	1111 1111 1111 1111
$−360/2^{15}$	−2	0xFFFE	1111 1111 1111 1110
−90	−16,384	0xC000	1100 0000 0000 0000

BAROMETER

The BAROM_OUT register (see Table 55) and BAROM_LOW register (see Table 57) provide access to the barometric pressure data. These two registers combine to provide a 32-bit, twos complement format. Some applications are able to use BAROM_OUT by itself. For cases where the finer resolution available from BAROM_LOW is valuable, combine them in the same manner as the gyroscopes (see Figure 18). When processing data from the BAROM_OUT register alone, use a 16-bit, twos complement data format. Table 55 provides the numerical format in BAROM_OUT, and Table 56 provides digital coding examples.

Table 55. BAROM_OUT (Page 0, Base Address = 0x30)

Bits	Description
[15:0]	Barometric pressure; twos complement, ±1.31 bar range, 0 bar = 0x0000, 40 μbar/LSB

Table 56. BAROM_OUT Data Format Examples

Pressure (bar)	Decimal	Hex	Binary
$+0.00004 \times (2^{15} - 1)$	+32,767	0x7FFF	0111 1111 1111 1111
+0.00008	+2	0x0002	0000 0000 0000 0010
+0.00004	+1	0x0001	0000 0000 0000 0001
0	0	0x0000	0000 0000 0000 0000
−0.00004	−1	0xFFFF	1111 1111 1111 1111
−0.00008	−2	0xFFFE	1111 1111 1111 1110
-0.00004×2^{15}	−32,768	0x8000	1000 0000 0000 0000

The BAROM_LOW register provides additional resolution for the barometric pressure measurement. The MSB has a weight of 20 μbar, and each subsequent bit carries a weight of ½ of the previous one.

Table 57. BAROM_LOW (Page 0, Base Address = 0x2E)

Bits	Description
[15:0]	Barometric pressure; additional resolution bits

INTERNAL TEMPERATURE

The TEMP_OUT register provides an internal temperature measurement that can be useful for observing relative temperature changes inside of the ADIS16480 (see Table 58). Table 59 provides TEMP_OUT digital coding examples. Note that this temperature reflects a higher temperature than ambient, due to self heating.

Table 58. TEMP_OUT (Page 0, Base Address = 0x0E)

Bits	Description
[15:0]	Temperature data; twos complement, 0.00565°C per LSB, 25°C = 0x0000

Table 59. TEMP_OUT Data Format Examples

Temperature (°C)	Decimal	Hex	Binary
+85	+10,619	0x297B	0010 1001 0111 1011
+25 + 0.0113	+2	0x0002	0000 0000 0000 0010
+25 + 0.00565	+1	0x0001	0000 0000 0000 0001
+25	0	0x0000	0000 0000 0000 0000
+25 − 0.00565	−1	0xFFFF	1111 1111 1111 1111
+25 − 0.0113	−2	0xFFFE	1111 1111 1111 1110
−40	−11,504	0xD310	1101 0011 0001 0000

STATUS/ALARM INDICATORS

The SYS_E_FLAG register in Table 60 provides the system error flags and new data bits for the magnetometer and barometer outputs. The new data flags are useful for triggering data collection of the magnetometer and barometer (x_MAGN_OUT and BAROM_xxx registers) because they update at a fixed rate that is not dependent on the DEC_RATE setting. Reading the SYS_E_FLAG register clears all of its error flags and returns each bit to a zero value, with the exception of Bit[7]. If SYS_E_FLAG[7] is high, use the software reset (GLOB_CMD[7], see Table 147) to clear this condition and restore normal operation. If any bit in the SYS_E_FLAG register is associated an error condition that remains after reading this register, this bit automatically returns to an alarm value of 1.

Table 60. SYS_E_FLAG (Page 0, Base Address = 0x08)

Bits	Description (Default = 0x0000)
15	Watch dog timer flag (1 = timed out)
14	Not used
13	EKF divergence (1 = divergence has occurred)
12	Gyroscope saturation
	1 = saturation conditions exists and the gyroscope weighting factors in the EKF have been automatically reduced
	0 = gyroscope measurements within range
11	Magnetometer disturbance
	1 = magnetometer measurements exceed MAG_DISTB_THR levels (see Table 97) and the magnetometer influence in the EKF has been automatically eliminated
	0 = magnetometer measurements are within the specified normal range
10	Linear acceleration
	1 = accelerometer measurements exceed ACC_DISTR_THR levels (see Table 96) and the accelerometer weighting factors in the EKF have been automatically reduced
	0 = accelerometer measurements are within the specified normal range
9	New data flag, barometer (1 = new, unread data)[1]
8	New data flag, magnetometer (1 = new, unread data)[2]
7	Processing overrun (1 = error)
6	Flash memory update, result of GLOB_CMD[3] = 1 (1 = failed update, 0 = update successful)
5	Inertial self-test failure (1 = DIAG_STS ≠ 0x0000)
4	Sensor overrange (1 = at least one sensor overranged)
3	SPI communication error (1 = error condition, when the number of SCLK pulses is not equal to a multiple of 16)
[2:1]	Not used
0	Alarm status flag (1 = ALM_STS ≠ 0x0000)

[1] This flag restores to zero after reading the contents on BAROM_OUT.
[2] This flag restores to zero after reading one x_MAGN_OUT register.

The DIAG_STS register in Table 61 provides the flags for the internal self-test function, which is from GLOB_CMD[1] (see Table 147). Note that the barometer flag, DIAG_STS[11], only updates after start-up and reset operations and that reading DIAG_STS also resets it to 0x0000.

Table 61. DIAG_STS (Page 0, Base Address = 0x0A)

Bits	Description (Default = 0x0000)
[15:12]	Not used
11	Self-test failure, barometer (1 = failed at startup)
10	Self-test failure, z-axis magnetometer (1 = failure)
9	Self-test failure, y-axis magnetometer (1 = failure)
8	Self-test failure, x-axis magnetometer (1 = failure)
[7:6]	Not used
5	Self-test failure, z-axis accelerometer (1 = failure)
4	Self-test failure, y-axis accelerometer (1 = failure)
3	Self-test failure, x-axis accelerometer (1 = failure)
2	Self-test failure, z-axis gyroscope (1 = failure)
1	Self-test failure, y-axis gyroscope (1 = failure)
0	Self-test failure, x-axis gyroscope (1 = failure)

The ALM_STS register in Table 62 provides the alarm bits for the programmable alarm levels of each sensor. Note that reading ALM_STS also resets it to 0x0000.

Table 62. ALM_STS (Page 0, Base Address = 0x0C)

Bits	Description (Default = 0x0000)
[15:12]	Not used
11	Barometer alarm flag (1 = alarm is active)
10	Z-axis magnetometer alarm flag (1 = alarm is active)
9	Y-axis magnetometer alarm flag (1 = alarm is active)
8	X-axis magnetometer alarm flag (1 = alarm is active)
[7:6]	Not used
5	Z-axis accelerometer alarm flag (1 = alarm is active)
4	Y-axis accelerometer alarm flag (1 = alarm is active)
3	X-axis accelerometer alarm flag (1 = alarm is active)
2	Z-axis gyroscope alarm flag (1 = alarm is active)
1	Y-axis gyroscope alarm flag (1 = alarm is active)
0	X-axis gyroscope alarm flag (1 = alarm is active)