MAX21100 Low-Power, Ultra-Accurate 6+3 DoF IMU

General Description

The MAX21100 is a monolithic 3-axis gyroscope plus 3-axis accelerometer Inertial Measurement Unit (IMU) with integrated 9-axis sensor fusion using proprietary Motion Merging Engine (MME) for handset and tablet applications, game controllers, motion remote controls, and other consumer devices.

The MAX21100 is the industry's most accurate 6+3 DoF inertial measurement unit available in a 3mm x 3mm x 0.83mm package and capable of working with a supply voltage as low as 1.71V.

The MAX21100 can interface an external magnetometer through a dedicated I²C master.

The internal Motion Merging Engine (MME) can be flexibly configured to get the most suitable accuracy power trade-off.

The MAX21100 is available in a 16-lead plastic land grid array (LGA) package and can operate within a temperature range of -40°C to +85°C.

Applications

- Motion Control with HMI (Human-Machine Interface)
- GPS and Inertial Navigation Systems
- Appliances and Robotics
- Motion-Based Game Controllers
- Motion-Based 3D Mice and 3D Remote Controls
- Health and Sports Monitoring
- Optical/Electronic Image Stabilization

Features and Benefits

- Fully Integrated, Low Power, Motion Merging Engine Performs Accurate 9DoF Sensor Fusion Using Ultra-Fast, Low Power (50µA) Maxim Proprietary Algorithm Providing:
  - Quaternion Output
  - Gravity and Heading Output
- High Output Data Rate (ODR) for Accelerometer (Up to 2kHz) and Gyroscope (Up to 8kHz)
- Four Selectable Full Scales for Gyroscope (250/500/1000/2000 dps) and Accelerometer (2/4/8/16 g)
- I²C Standard (100kHz), Fast (400kHz), and High-Speed (3.4MHz) Serial Interface—10MHz SPI Interface
- 128 Bytes (64 x 16 Bits) Embedded FIFO with Multiple FIFO Modes
- Unique 48-Bit Serial Number as Die ID
- 5.65mA in Low-Noise Mode and 3.45mA in Eco Mode with MME Active
- 1.2µA Current Consumption in Power-Down Mode
- 45ms Turn-On Time from Power-Down and 4ms Turn-On Time from Standby Mode
- High Stability Over Temperature and Time: Bias Stability of 4°/hr
- High Shock Survivability (10,000g Shock Tolerant)

Ordering Information ***appears at end of data sheet.***

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Absolute Maximum Ratings

V_{DD} .....-0.3V to +6.0V
V_{DDIO} .....-0.3V to +6.0V
REGD .....-0.3V to min (V_{DD} + 0.3V,+2.2V)
INT1, INT2, SDA_SDI_O, SA0_SDO, SCL_CLK, CS, DSYNC, RSV1, RSV2, RSV3 .....-0.3V to min (V_{DDIO} + 0.3V, 6.0V)
MST_SCL, MST_SDA.....-0.3V to min (V_{DDIO} + 0.3V, 6.0V)
I_{VDD} Continuous Current 100mA
I_{VDDIO} Continuous Current 100mA
Operating Temperature Range..... -40°C to +85°C
Junction Temperature.....+150°C
Storage Temperature Range..... -40°C to +150°C
Lead Temperature (soldering, 10s) .....+260°C

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Drops onto hard surfaces can cause shocks of greater than 10,000g and can exceed the absolute maximum rating of the device. Exercise care in handling to avoid damage.

Package Thermal Characteristics (Note 1)

LGA
Junction-to-Case Thermal Resistance (θ_{JC}).....31.8°C/W
Junction-to-Ambient Thermal Resistance (θ_{JA}) .....160°C/W

Note 1: Package thermal resistances were obtained using the method described in JEDEC specification JESD51-7, using a four-layer board. For detailed information on package thermal considerations, refer to **www.maximintegrated.com/thermal-tutorial**.

Electrical Characteristics (Note 2)

(V_{DD} = V_{DDIO} = 1.8V, T_A = -40°C to +85°C, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
OPERATING CONDITIONS						
Operating Temperature	T		-40	25	+85	°C
V_{DD} Supply	V_{DD}		1.71	1.8	3.6	V
V_{DDIO} (Note 3)	V_{DDIO}		1.71	1.8	3.6	V
CURRENT CONSUMPTION						
IDD—Current Consumption G+A+MME Low-Noise Mode	IDDGAM			5.65	6.5	mA
IDD—Current Consumption G+A Low-Noise Mode	IDDGA			5.6	6.4	mA
IDD—Current Consumption G Low-Noise Mode	IDDG			5.4	6.1	mA
IDD—Current Consumption GEco+A+MME	IDDGEAM	f_{GODR} = 125Hz		3.45	4.1	mA
IDD—Current Consumption GEco +A	IDDGEA	f_{GODR} = 125Hz		3.4	4.0	mA
IDD—Current Consumption G Standby Mode	IDDGS			2.9		mA
IDD—Current Consumption A Low-Noise Mode (Note 4)	IDDA			550	625	µA
IDD—Current Consumption AEco (Note 4)	IDDAE	f_{AODR} = 62.5Hz		25	40	µA
		f_{AODR} = 16.6Hz		10	20	
IDD—Current Consumption Power Down (Note 4)	IDDPD			1.2	10	µA

Mechanical Characteristics (Note 2)

(V_{DD} = V_{DDIO} = 1.8V, T_A = -40°C to +85°C, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
GYROSCOPE							
Full-Scale Range	GFS	User selectable			±250		dps
					±500		
					±1000		
					±2000		
Rate Noise Density at +25°C (Note 5)	GRND	GFS independent	Low-Noise Mode		0.009	0.025	dps/√Hz
			Eco Mode, GODR = 250Hz		0.018		
Lowpass Bandwidth (Low-Noise Mode)	GBWL	User selectable		2		2000	Hz
Highpass Cutoff Frequency (Low-Noise Mode)	GBWH	Enable/disable, user selectable		0.1		100	Hz
Phase Delay at 10Hz (Low-Noise Mode)	GPD	GODR = 8kHz GBWL = 400Hz			3.3		deg
Sensitivity	GSO	GFS = ±250dps			120		digit/dps
		GFS = ±500dps			60		
		GFS = ±1000dps			30		
		GFS = ±2000dps			15		
Sensitivity Error at +25°C	GSE			-2.5	±0.3	+2.5	%
Sensitivity Drift Over Temperature (Note 5)	GSD			-0.05	±0.008	+0.05	%/°C
Zero Rate Level Error at +25°C	GZRLE			-6	±0.5	+6	dps
Zero Rate Level Drift Over Temperature (Note 5)	GZRLD			-0.15	±0.025	+0.15	dps/°C
Angular Random Walk Low-Noise Mode	GARW				0.45		deg/√hr
Bias Stability	GBSTAB				4		deg/hr
Nonlinearity at +25°C (Note 5)	GNL	GFS = ±2000dps Best fit line			0.1	0.4	%FS
Cross Axis	GCA	Absolute (Note 5)		-5	±1	+5	%
		Relative to the accelerometer reference system		-3	±1	+3	
Linear Acceleration Effect at +25°C (Note 5)	GLAE	1g static applied		-0.2	±0.05	+0.2	dps/g
Output Data Rate	GODR	User selectable, Low-Noise Mode		3.9		8000	Hz
		User selectable, Eco Mode		31.25		250	

Mechanical Characteristics (continued) (Note 2)

(V_{DD} = V_{DDIO} = 1.8V, T_A = -40°C to +85°C, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
ODR Accuracy (Note 6)	GODRE			-10		+10	%
Startup Time from Power Down	GSTPD				45	90	ms
Startup Time from Standby	GSTS	8kHz GODR 400Hz GBWL			4		ms
Self-Test Output	GSELF	X, Z axis		10	25	50	%GFS
		Y axis		-50	-25	-10	
ACCELEROMETER							
Full-Scale Range	AFS	User selectable			±2		g
					±4		
					±8		
					±16		
Noise Density at +25°C (Note 5)	AND	AFS = ±2g	Low-Noise Mode		140	260	µg/√Hz
			Eco Mode AODR = 250Hz		800		
Output Data Rate	AODR	User-selectable Low-Noise Mode		31.25		2000	Hz
		User-selectable Eco Mode		0.98		250	
ODR Accuracy	AODRE			-10		+10	%
Lowpass Bandwidth	ABWL	User-selectable Low-Noise Mode		AODR/48		300	Hz
		User-selectable Eco Mode		AODR/48		AODR/2	
Highpass Cutoff Frequency Low-Noise Mode	ABWH	Enable/disable, user-selectable bandwidth		AODR/400		AODR/50	Hz
Sensitivity	ASO	AFS = ±2g			15		digit/mg
		AFS = ±4g			7.5		
		AFS = ±8g			3.75		
		AFS = ±16g			1.875		
Sensitivity Error at 25°C	ASE	AFS = ±2g		-2.5	±0.38	+2.5	%
Sensitivity Drift Over Temperature (Note 5)	ASD	AFS = ±2g		-0.028	±0.007	+0.028	%/°C
Zero g Level Error at +25°C (Note 7)	AZGLE	AFS = ±2g, X,Y axes		-120	±20	+120	mg
		AFS = ±2g, Z axis		-180	±35	+180	
Zero g Level Drift Over Temperature (Note 5)	AZGLD	AFS = ±2g, X, Y axes		-1.7	±0.5	+1.7	mg/°C
		AFS = ±2g, Z axis		-3.3	±0.8	+3.3	
Non Linearity at +25°C (Note 5)	ANL	AFS = ±2g, best fit line			0.5	1.2	%FS
Cross Axis (Note 5)	ACA	Absolute		-5	±1	+5	%

Mechanical Characteristics (continued) (Note 2)

(V_{DD} = V_{DDIO} = 1.8V, T_A = -40°C to +85°C, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Self-Test Output (Note 4)	ASELF	X,Y axis	80	300	800	mg
		Z axis	60	240	600	
TEMPERATURE SENSOR						
Sensitivity	TSS	8 bit		1		digit/°C
		16 bit		256		digit/°C
Sensitivity Error (Note 5)	TSSE		-7	±3	+7	%
Output at +25°C	TSO	8 bit		25		digit
		16 bit		6400		
Bandwidth	TSBW			4		Hz

Interface Specifications (Note 2)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
ESD PROTECTION						
Human Body Model	HBM				2000	V
Charged Device Model	CDM				500	V
IOs DC SPECIFICATIONS (Note 5)						
Input Threshold Low	V_{IL}				0.3 x V_{DDIO}	V
Input Threshold High	V_{IH}		0.7 x V_{DDIO}			V
Hysteresis of Schmitt Trigger Input	V_{HYS}		0.05 x V_{DDIO}			V
Input Leakage Current	I_{LK}		-1		+1	µA
I^2C Master bypass Resistance	R_{BYP}				45	Ω
I^2C Internal Pullup Resistance (Note 8)	R_{I2CPU}		4.5		10	kΩ
SPI SLAVE TIMING VALUES (Note 9)						
CLK Frequency	f_{C_CLK}				10	MHz
CS Setup Time	t_{SU_CS}		10			ns
CS Hold Time	t_{H_CS}		12			ns
SDI Input Setup Time	t_{SU_SI}		5			ns
SDI Input Hold Time	t_{H_SI}		10			ns
CLK Fall to SDO Valid Output Time	t_{V_SDO}				35	ns
SDO Output Hold Time	t_{H_SO}		10			ns
I^2C TIMING VALUES (Note 5)						
SCL Clock Frequency	f_{SCL}	Standard mode	0		100	kHz
		Fast mode	0		400	

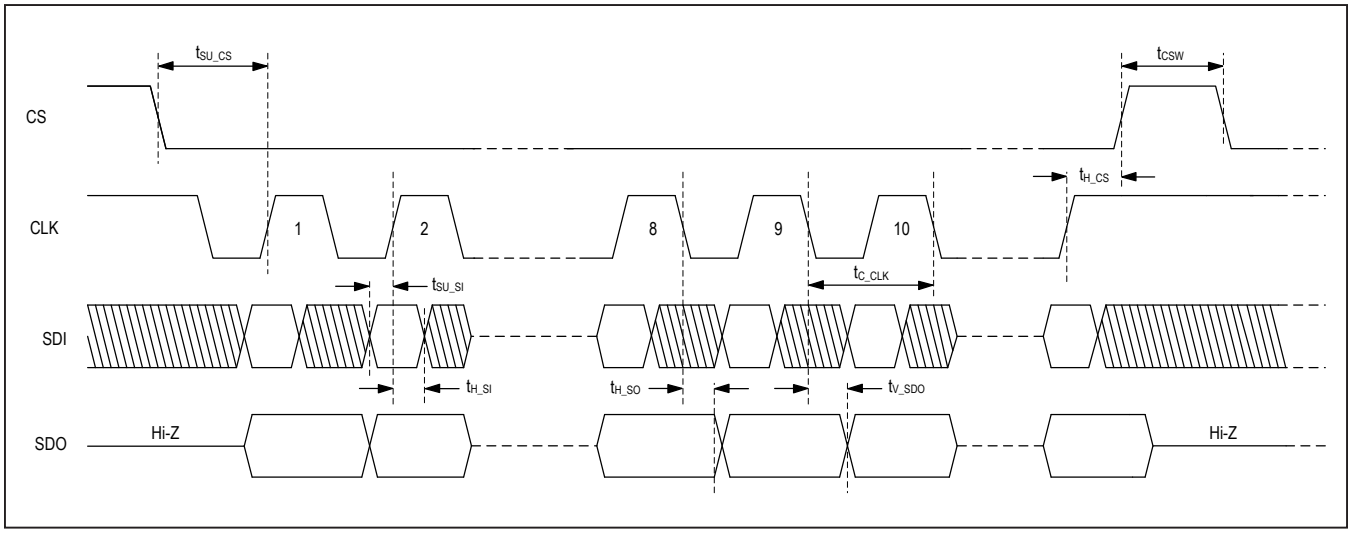
Interface Specifications (continued) (Note 2)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Hold Time (Repeated) START Condition	$t_{HD;STA}$	Standard mode	4			µs
		Fast mode	0.6			
Low Period of SCL Clock	t_{LOW}	Standard mode	4.7			µs
		Fast mode	1.3			
High Period of SCL Clock	t_{HIGH}	Standard mode	4.0			µs
		Fast mode	0.6			
Setup Time for a Repeated START Condition	$t_{SU;STA}$	Standard mode	4.7			µs
		Fast mode	0.6			
Data Hold Time	$t_{HD;DAT}$	Standard mode	0			µs
		Fast mode	0			
Data Setup Time	$t_{SU;DAT}$	Standard mode	250			ns
		Fast mode	100			
Setup Time for STOP Condition	$t_{SU;STO}$	Standard mode	4.0			µs
		Fast mode	0.6			
Bus Free Time Between a STOP and a START Condition	t_{BUF}	Standard mode	4.7			µs
		Fast mode	1.3			
Data Valid Time	$t_{VD;DAT}$	Standard mode			3.45	µs
		Fast mode			0.9	
Data Valid Acknowledge Time	$t_{VD;ACK}$	Standard mode			3.45	µs
		Fast mode			0.9	
I²C TIMING VALUES (High-Speed Mode, Note 5)						
SCLH Clock Frequency	f_{SCLH}	HS mode			3.4	MHz
Setup Time for A REPEATED START Condition	$t_{SU;STA}$	HS mode	160			ns
Hold Time (Repeated) START Condition	$t_{HD;STA}$	HS mode	160			ns
Low Period of SCL Clock	t_{LOW}	HS mode	160			ns
High Period of SCL Clock	t_{HIGH}	HS mode	90			ns
Data Setup Time	$t_{SU;DAT}$	HS mode	10			ns
Data Hold Time	$t_{HD;DAT}$	HS mode	0			ns

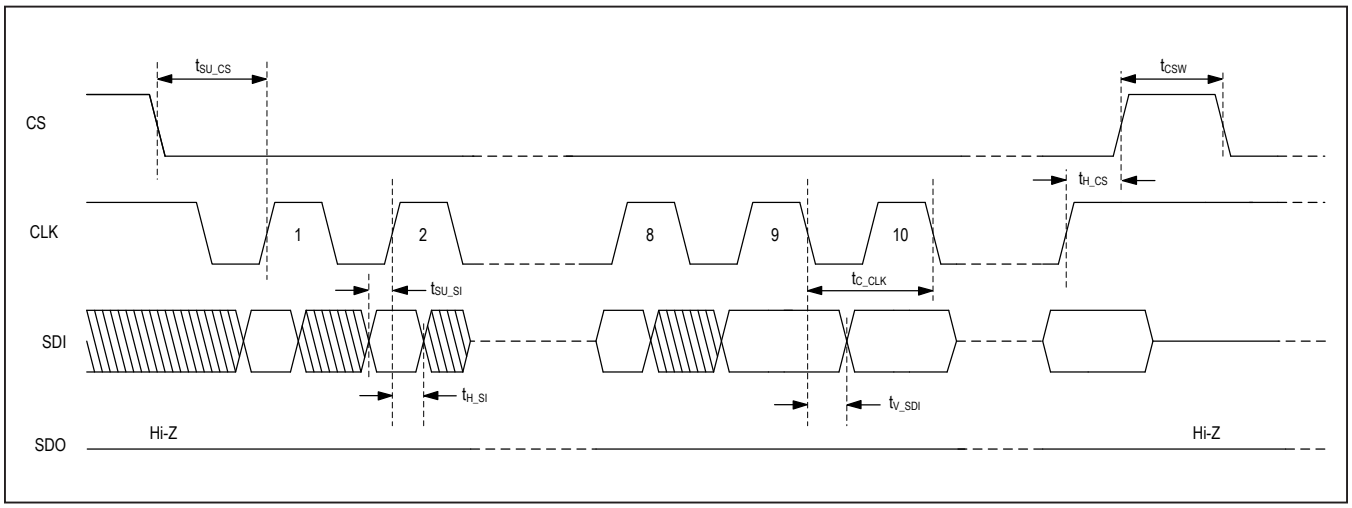
Note 2: Limits are 100% tested at T_A = +25°C. Limits over the operating temperature range and relevant supply voltage range are guaranteed by design and characterization.
Note 3: V_{DDIO} must be lower or equal than V_{DD} supply.
Note 4: Values at T_A = +25°C.
Note 5: Min max based on characterization results.
Note 6: ODR real value can be calculated through proper register readout with 1.5% accuracy.
Note 7: Values after MSL3 preconditioning and 3 reflow cycles.
Note 8: Pullup resistances are user selectable.
Note 9: 10pF load on SPI lines. Min Max based on characterization results.

SPI Timing

4-Wire SPI Mode

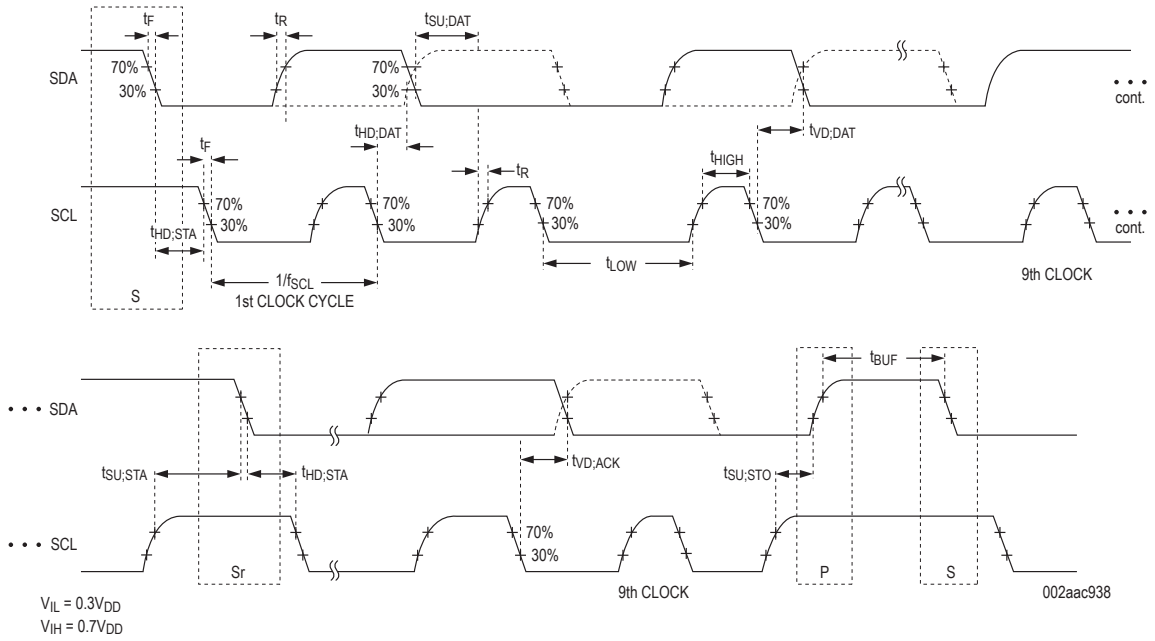


3-Wire SPI Mode

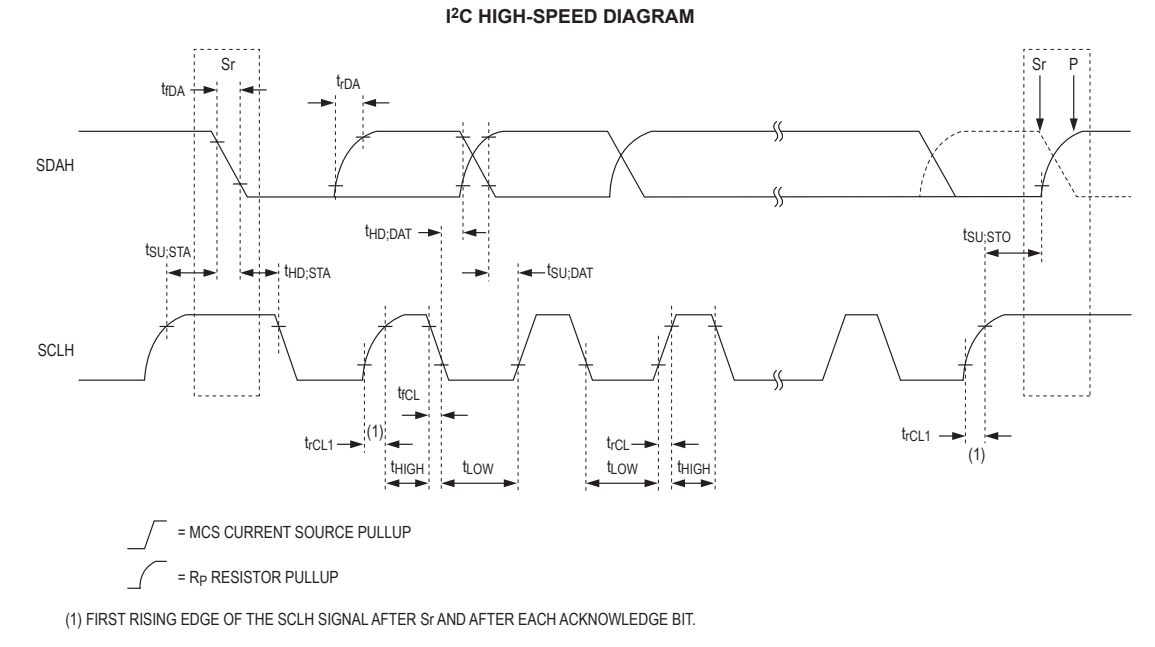


I²C Timing

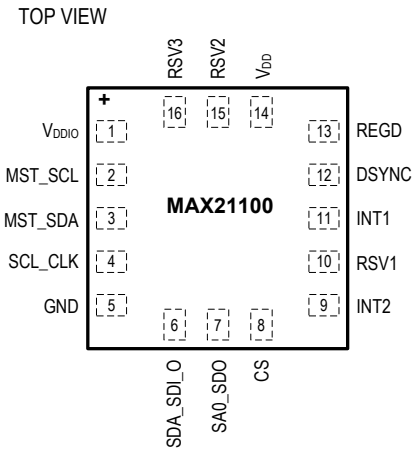
Standard/Fast Mode I²C Bus Timing



High-Speed Mode I²C Bus Timing



Pin Configuration

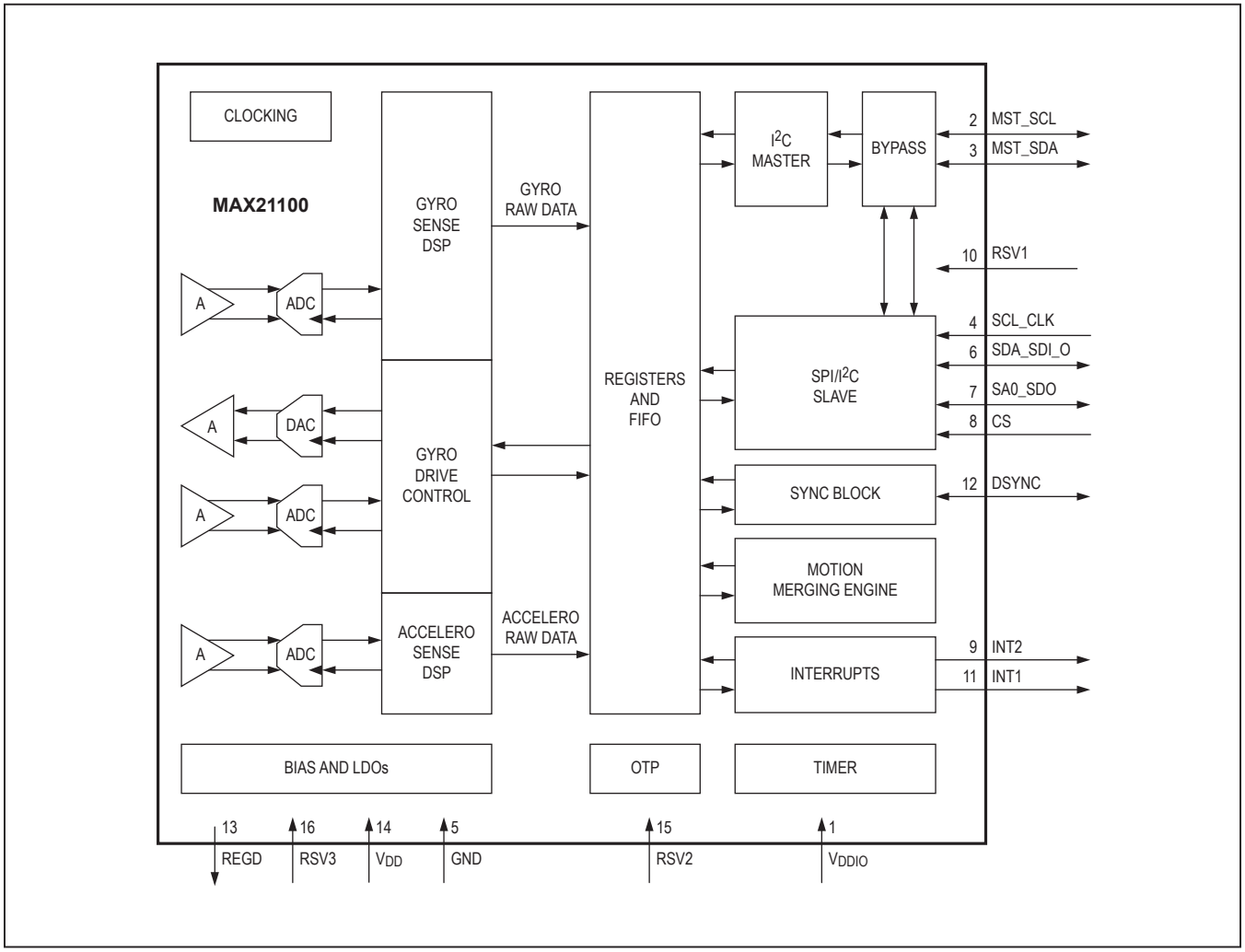


(3mm x 3mm x 0.83mm)
16-LEAD LGA

Pin Description

PIN	NAME	FUNCTION
1	V_{DDIO}	Interface and Interrupt Pad Supply Voltage
2	MST_SCL	I²C Master Serial Clock. User-selectable 6kΩ internal pullup.
3	MST_SDA	I²C Master Serial Data. User selectable 6kΩ internal pullup.
4	SCL_CLK	SPI and I2C Slave Clock. When in I²C mode, the IO has selectable antispike filter and delay to ensure correct hold time.
5	GND	Power-Supply Ground.
6	SDA_SDI_O	SPI In/Out Pin and I²C Slave Serial Data. When in I²C mode, the IO has selectable antispike filter and delay to ensure correct hold time.
7	SA0_SDO	SPI Serial Data Out and I²C Slave Address LSB
8	CS	SPI Chip Select/Serial Interface Selection
9	INT2	Second Interrupt Line
10	RSV1	Reserved. Must be connected to GND.
11	INT1	First Interrupt Line
12	DSYNC	Data Syncronization Pin. Is used to: Dynamically change the MAX21100 power mode. Synchronize data with external clock (e.g., GPS/camera) with various options. Synchronize data with an external event.
13	REGD	Internal regulator output 2.2V max. A 100nF capacitor has to be connected to this pin for ensuring proper device operation
14	V_{DD}	Analog Power Supply. Bypass to GND with a 0.1µF capacitor and one 10µF.
15	RSV2	Reserved. Must be tied to V_{DD} in the application.
16	RSV3	Reserved. Leave unconnected.

Functional Diagram



Detailed Description

The MAX21100 is a low-power, low voltage, small package 6-axis inertial measurement unit able to provide unprecedented accuracy and stability over temperature and time.

The MAX21100 integrates a 3-axis gyroscope and 3-axis linear accelerometer in a 3mm x 3mm x 0.83mm package capable of working with a supply voltage as low as 1.71V.

It includes a sensing element and an IC interface capable of providing the measured angular rate and acceleration to the external world through a digital interface (I^2C/SPI).

The IC interface includes an I^2C master dedicated to the data collection of an external magnetometer. This data can be fused together with the gyroscope and accelerometer data through an embedded ultra-low power 9DoF motion merging engine.

All sensors and fusion data can be stored into a 128 bytes fully configurable embedded FIFO.

The DSYNC functionality allows for sensor synchronization with an external trigger with external source (e.g., GPS/Camera).

The MAX21100 features a wide selection of dynamically selectable power modes that allows the user to optimize the system power consumption based on the application needs.

The MAX21100 has a full scale of ±250/±500/±1000/±2000 dps for gyroscope and ±2/±4/±8/±16g for accelerometer. It is capable of measuring angular rates and accelerations with a user-selectable bandwidth.

The MAX21100 is available in a 3mm x 3mm x 0.83mm 16-lead plastic land grid array (LGA) package and can operate within a temperature range of -40°C to +85°C.

Definitions

Power supply [V]: This parameter defines the operating DC power-supply voltage range of the 6DoF inertial measurement unit. Although it is always a good practice to keep V_{DD} clean with minimum ripple, unlike most of the competitors, who require an ultra-low noise, low-dropout regulator to power the device, the MAX21100 can not only operate at 1.71V, but that supply can also be provided by a switching regulator to minimize the system power consumption.

Current consumption in Low-Noise Mode [mA]: This parameter defines the typical current consumption when the 6DoF inertial measurement unit is operating with the lowest noise for both the accelerometer and gyroscope.

Current consumption in Eco Mode [mA]: This parameter defines the current consumption when the 6DoF inertial measurement unit is in Eco Mode. Whilst in Eco Mode, the MAX21100 significantly reduces the power consumption, but increases the noise.

Current consumption in Power-Down Mode [µA]: This parameter defines the current consumption when the 6DoF inertial measurement unit is powered down. In this mode, both the mechanical sensing structure and reading chain are turned off. Users can configure the control register through the I^2C/SPI interface for this mode. Full access to the control registers through the I^2C/SPI interfaces is also guaranteed in Power-Down Mode.

Gyroscope full-scale range [dps]: This parameter defines the measurement range of the gyroscope in degrees per second (dps). When the applied angular rate is beyond the full-scale range, the gyroscope output becomes saturated.

Zero-rate level [dps]: This parameter defines the DC device output when there is no external angular rate applied to the gyroscope.

Gyroscope sensitivity [digit/dps]: Sensitivity is the relationship between LSb and dps. It can be used to convert a digital gyroscope's measurement from digits to angular rate.

Zero-rate level change vs. temperature [dps/°C]: This parameter defines the zero-rate level change in dps/°C over the operating temperature range.

Gyroscope sensitivity change vs. temperature [%/°C]: This parameter defines the gyroscope sensitivity change as a percentage (%) over the operating temperature range specified in the data sheet.

Gyroscope nonlinearity [% FS]: This parameter defines the maximum absolute difference between the gyroscope output and the best-fit straight line as a percentage of the gyroscope full-scale (GFS) range.

Gyroscope bandwidth [Hz]: This parameter defines the frequency of the angular rate signal from DC to the built-in bandwidth (GBWL) that the gyroscope can measure. A dedicated register can be used to select the gyroscope bandwidth.

Rate noise density [dps/√Hz]: This parameter defines the square root of the equivalent noise power density of the gyroscope angular rate.

Accelerometer full-scale range [g]: This parameter defines the measurement range of the accelerometer in g. When the applied acceleration is beyond the full-scale range, the accelerometer output becomes saturated.

Zero-g level [mg]: This parameter defines the DC device output when there is no external acceleration applied to the accelerometer.

Accelerometer sensitivity [digit/g]: Sensitivity is the relationship between LSb and g. It can be used to convert a digital acceleration measurement from digits to g.

Zero-g level change vs. Temperature [mg/°C]: This parameter defines the zero-g level change in mg/°C over the operating temperature range.

Accelerometer Sensitivity change vs. temperature [%/°C]: This parameter defines the accelerometer sensitivity change as a percentage (%) over the operating temperature range specified in the data sheet.

Accelerometer nonlinearity [% FS]: This parameter defines the maximum absolute difference between the accelerometer output and the best-fit straight line as a percentage of the full-scale (FS) range.

Accelerometer bandwidth [Hz]: This parameter defines the frequency of the acceleration signal from DC to the built-in bandwidth (ABWL) that the accelerometer can measure. A dedicated register can be used to select the accelerometer bandwidth.

Accelerometer noise density [µg/√Hz]: This parameter defines the square root of the equivalent noise power density of accelerometer linear acceleration.

MAX21100 Architecture

The MAX21100 comprises the following key blocks and functions:

- 3-axis MEMS gyroscope sensor with 16-bit ADCs and signal conditioning
- 3-axis MEMS accelerometer sensor with 16-bit ADCs and signal conditioning
- Motion Merging Engine (MME)
- Slave I2C and SPI serial communications interfaces
- Master I2C
- Interrupt generators
- Digital output temperature sensor
- Power management enabling different power modes
- Sensor data registers
- FIFO
- Data synchronization block
- Self-test functionality

Three-Axis MEMS Gyroscope with 16-Bit ADCs and Signal Conditioning

The MAX21100 includes MEMS gyroscope that detects rotations around the X, Y, and Z axes through the related IC interface. When the gyroscope rotates around any of the sensing axes, the Coriolis Force determines a displacement in the MEMS structure, which is detected as a capacitive variation. The resulting signal is then processed by the 16-bit ADC to produce a digital output proportional to the angular rate. The gyro full-scale range can be digitally programmed at ±250, ±500, ±1000 or ±2000 dps.

Three-Axis MEMS Accelerometer Sensor with 16-Bit ADCs and Signal Conditioning

The MAX21100 includes a MEMS accelerometer that detects linear accelerations along the X, Y, and Z axes. The acceleration applied to one of the sensing axes causes a displacement of the MEMS structure which is detected as a capacitive variation. The signal is then converted in the digital domain by 16-bit ADC and is available to the user as a digital output proportional to the applied acceleration. The accelerometer full-scale range can be digitally programmed at ±2, ±4, ±8 or ±16 g.

Motion Merging Engine (MME)

The MME takes the gyroscope, accelerometer, and external magnetometer raw data as inputs and provides the device orientation information as output.

The orientation information is represented using the quaternion or gravity-and-heading representations and features the gyroscope quick responsiveness and the low frequency accuracy given by the accelerometer and magnetometer.

When the gyroscope information is not available (i.e., gyro is turned off), the absolute orientation information is still available. This is commonly called e-Compass or Soft Gyro mode and features good accuracy, but slow response.

The MME can be also used to generate the quaternion with the sole integration of the gyroscope data without fusion operations with either the accelerometer or the magnetometer.

The MME outputs are available for direct register read and for FIFO storage, together with raw data outputs.

Slave I²C and SPI Serial Communications Interfaces

The registers embedded inside the MAX21100 can be accessed through both the slave I²C and SPI serial interfaces. The latter can be SW configured to operate either in 3-wire or 4-wire interface mode.

The serial interfaces are mapped onto the same pins. To select/exploit the I²C interface, CS line must be tied high (i.e., connected to V_{DDIO}).

I²C Interface

I²C is a two-wire interface comprised of the signals serial data (SDA) and serial clock (SCL). In general, the lines are open-drain and bidirectional. In a generalized I²C interface implementation, attached devices can be a master or a slave. The master device puts the slave address on the bus, and the slave device with the matching address acknowledges the master.

The MAX21100 operates as a slave device when communicating to the system processor, which thus acts as the master. SDA and SCL lines typically need pull-up resistors to VDDIO. The maximum bus speed is 3.4MHz (I2C HS); this reduces the amount of time the system processor is kept busy in supporting the exchange of data.

The slave address of the MAX21100 is b101100X, which is 7 bits long. The LSb of the 7-bit address is determined by the logic level on pin SA0. This allows two MAX21100s to be connected on the same I²C bus.

When used in this configuration, the address of one of the two devices should be b1011000 (pin SA0_SD0 is set to logic low) and the address of the other should be b1011001 (pin SA0_SD0 is set to logic-high).

SPI Interface

The MAX21100 SPI can operate up to 10MHz, in both 3-wires (half duplex) and 4-wires mode (full duplex).

It is recommended to set the I2C_OFF bit at address 0x16 if the MAX21100 is used together with other SPI devices to avoid the possibility to switch inadvertently into I²C mode when traffic is detected with the CS un-asserted.

The MAX21100 operates as an SPI slave device.Both the read register and write register commands are completed in 16 clock pulses, or in multiples of 8 in case of multiple read/write bytes. Bit duration is the time between two falling edges of CLK.

The first bit (bit 0) starts at the first falling edge of CLK after the falling edge of CS while the last bit (bit 15, bit 23, etc.) starts at the last falling edge of CLK just before the rising edge of CS.

Bit 0: RW bit. When 0, the data DI(7:0) is written to the device. When 1, the data DO(7:0) from the device is read. In the latter case, the chip drives SDO at the start of bit 8.

Bit 1: MS bit. Depending on the configuration of IF_PARITY this bit may either be used to operate in multi-addressing standard mode or to check the parity with the register address.

Table 1. Digital Interface Pin Description

NAME	DESCRIPTION
CS	SPI enable and I2C/SPI mode selection (1: I²C mode, 0: SPI enabled)
SCL/CLK	SPI and I²C clock. When in I²C mode, the IO has selectable anti-spike filter and delay to ensure correct hold time.
SDA/SDI/SDO	SPI in/out pin and I²C serial data. When in I²C mode, the IO has selectable antispike filter and delay to ensure correct hold time.
SDO/SA0	SPI serial data out or I²C slave address LSb

Table 2. I²C Address

I²C BASE ADDRESS	SA0/SDO PIN	R/W BIT	RESULTING ADDRESS
0x2C (6 bit)	0	0	0xB0
0x2C	0	1	0xB1
0x2C	1	0	0xB2
0x2C	1	1	0xB3

If used as a MS bit, when 1, the address remains unchanged in multiple read/write commands, whilst when 0, the address is auto-incremented in multiple read/write commands.

Bit 2–7: Address AD(5:0). This is the address field of the indexed register.

Bit 8–15: Data DI(7:0) (write mode). This is the data that is written to the device (MSb first).

Bit 8–15: Data DO(7:0) (read mode). This is the data that is read from the device (MSb first).

SPI Half- and Full-Duplex Operation

The MAX21100 can be programmed to operate in half-duplex (a bidirectional data pin) or full-duplex (one data-in and one data-out pin) mode. The SPI master sets a register bit called SPI_3_WIRE into I2C_CFG (0x16) to 0 for full-duplex, and 1 for half-duplex operation. Full duplex is the power-on default.

Full-Duplex Operation

The MAX21100 is put into full-duplex mode at power-up. When the SPI master clears the SPI_3_WIRE bit, the SPI interface uses separate data pins, SDI and SDO, to transfer data. Because of the separate data pins, bits can be simultaneously clocked into and out of the MAX21100. The MAX21100 makes use of this feature by clocking out 8 output data bits as the command byte is clocked in.

Reading from the SPI Slave Interface (SDO)

The SPI master reads data from the MAX21100 slave interface using the following steps:

1) When CS is high, the MAX21100 is unselected and three-states the SDO output.
2) After driving SCL_CLK to its inactive state, the SPI master selects the MAX21100 by driving CS low.
3) The SPI master clocks the command byte into the MAX21100. The SPI read command is performed with 16 clock pulses. Multiple byte read command is performed adding blocks of 8 clock pulses at the previous one.

   Bit 0: READ bit. The value is 1.

   Bit 1: MS bit. When 1, do not increment address, when 0, increment address in multiple reading.

   Bit 2–7: Address AD(5:0). This is the address field of the indexed register.

   Bit 8–15: Data DO(7:0) (read mode). This is the data that is read from the device (MSb first).

   Bit 16–... : Data DO(...-8). Further data in multiple byte reading. After 16 clock cycles, the master can drive CS high to deselect the MAX21100, causing it to tristate its SDO output. The falling edge of the clock puts the MSB of the next data byte in the sequence on the SDO output.
4) By keeping CS low, the master clocks register data bytes out of the MAX21100 by continuing to supply SCL_CLK pulses (burst mode). The master terminates the transfer by driving CS high. The master must ensure that SCL_CLK is in its inactive state at the beginning of the next access (when it drives CS low).

Writing to the SPI Slave Interface (SDI)

The SPI master writes data to the MAX21100 slave interface through the following steps:

1) The SPI master sets the clock to its inactive state. While CS is high, the master can drive the SDI input.
2) The SPI master selects the MAX21100 by driving CS low
3) The SPI master clocks the command byte into the MAX21100. The SPI Write command is performed with 16 clock pulses. Multiple byte write command is performed adding blocks of 8 clock pulses at the previous one.

   Bit 0: WRITE bit. The value is 0.

   Bit 1: MS bit. When 1, do not increment address, when 0, increment address in multiple writing.

   Bit 2–7: address AD(5:0). This is the address field of the indexed register.

   Bit 8–15: Data DI(7:0) (write mode). This is the data that is written inside the device (MSb first).

   Bit 16–... : data DI(...-8). Further data in multiple byte writing.
4) By keeping CS low, the master clocks data bytes into the MAX21100 by continuing to supply SCL_CLK pulses (burst mode). The master terminates the transfer by driving CS high. The master must ensure that SCL_CLK is inactive at the beginning of the next access (when it drives CS low).

Half-Duplex Operation

When the SPI master sets SPI_3_WIRE = 1, the MAX21100 is put into half-duplex mode. In half-duplex mode, the MAX21100 tri-states its SDO pin and makes the SDI pin bidirectional, saving a pin in the SPI interface. The SDO pin can be left unconnected in half-duplex operation. The SPI master accesses a MAX21100 register as follows: the SPI master sets the clock to its inactive state. While CS is high, the master can drive the SDI pin to any value.

1) The SPI master selects the MAX21100 by driving CS low and placing the first data bit (MSB) to write on the SDI input.
2) The SPI master turns on its output driver and clocks the command byte into the MAX21100. The SPI read command is performed with 16 clock pulses:

   Bit 0: READ bit. The value is 1.

   Bit 1: MS bit. When 1, do not increment address, when 0, increment address in multiple reading.

   Bit 2-7: address AD(5:0). This is the address field of the indexed register.

   Bit 8-15: data DO(7:0) (read mode). This is the data that is read from the device (MSb first).

   Multiple read command is also available in 3-wire mode.

Master I²C

The master interface allows:

- Readout of the external magnetic sensor at selectable sub multiples of the accelerometer ODR
- Shadowing the AppProcessor read/write commands
- Bypass mode: electrical bypass

The master interface pads are supplied at V_{DDIO}.

Interrupt Generators

The MAX21100 offers two completely independent interrupt generators, to ease the SW management of the interrupt generated. For instance, one line could be used to signal a DATA_READY event whilst the other line might be used, for instance, to notify the completion of the internal start-up sequence.

Interrupt functionality can be configured through the Interrupt Configuration registers. Configurable items include the INT pin level and duration, the clearing method as well as the required triggers for the interrupts.

The interrupt status can be read from the Interrupt Status registers.

The event that has generated an interrupt is available in both forms: latched and unlatched.

Interrupt sources may be enabled/ disabled and cleared individually. The list of possible interrupt sources includes the following conditions: DATA_READY, FIFO_EMPTY, FIFO_THRESHOLD, FIFO_OVERRUN, OTP_DOWNLOAD, DSYNC.

The interrupt generation can also be configured as latched, unlatched or timed, with programmable length.

When configured as latched, the interrupt can be cleared by reading the corresponding status register (clear-on-read) or by writing an appropriate mask to the status register (clear-on-write).

Digital-Output Temperature Sensor

An digital output temperature sensor is used to measure the MAX21100 die temperature. The readings from the ADC can be accessed from the Sensor Data registers.

The temperature data is split over 2 bytes. For faster and less accurate reading, accessing the MSB allows to read the temperature data as an absolute value expressed in

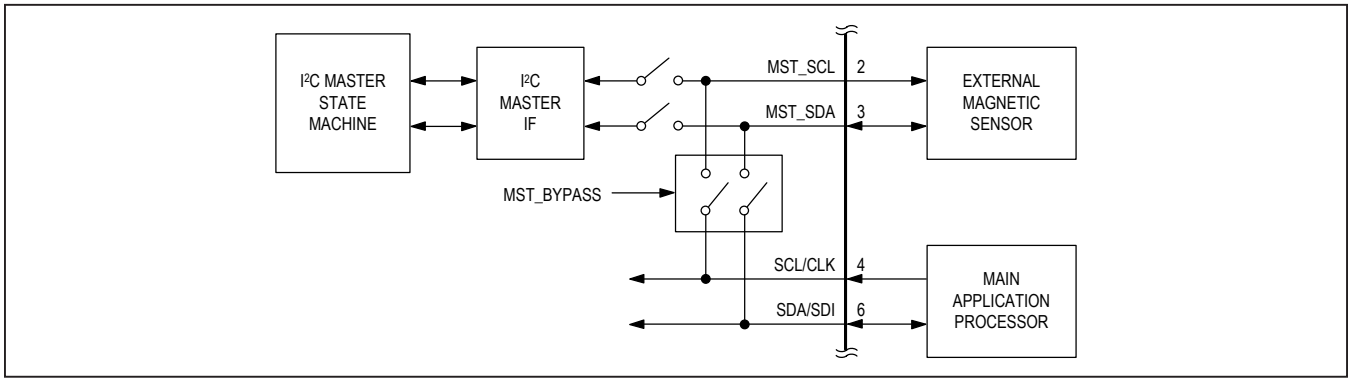


Figure 1. Master I²C

Celsius degrees. By reading the LSB, the accuracy is greatly increased, up to 256 digit/°C.

Power Modes

The MAX21100 features nine different power modes, allowing selecting the appropriate tradeoff between power consumption, noise level, accuracy and turn-on time.

The transition between different power modes can be controlled with the software by explicitly setting a power mode in the Configuration register, or by enabling the automatic power mode transition based on the DSYNC pin.

Gyro Low-Noise Mode

In Gyro Low-Noise Mode, only the gyro is switched on and it is operational with minimum noise level.

Gyro Eco Mode

In this power mode, only the gyro is switched on and it is operating in Eco Mode. The Eco Mode allows to reduce power consumption with the same sensor accuracy at the price of a higher rate noise density.

This unique MAX21100 feature can be activated for the gyro with four different ODR: 31.25Hz, 62.5Hz, 125Hz, and 250Hz.

Gyro Standby Mode

To reduce power consumption and have a shorter turn-on time, the IC features a standby mode for the gyro. In standby mode, the MAX21100 gyro does not generate data because a significant portion of the signal processing resources is turned off to save power. Still, this mode enables a much quicker turn-on time.

Acc Low-Noise Mode

In Acc Low-Noise mode, only the accelerometer is switched on. It is operational with minimum noise level.

Acc Eco Mode

In this Power Mode, only the accelerometer is switched on and it is operating in Eco Mode. The Eco Mode allows to reduce power consumption with the same sensor accuracy at the price of a higher accelerometer noise density.

This feature can be activated for accelerometer with nine ODR: being 0.98Hz, 1.95Hz, 3.9Hz, 7.8Hz 15.625Hz, 31.25Hz, 62.5Hz, 125Hz, and 250Hz.

Power-Down Mode

In Power-Down Mode, the IC is configured to minimize the power consumption. In Power-Down Mode, registers can still be read and written, but neither sensor can generate new data. Compared to Standby Mode, it takes longer to activate the IC and start collecting data from the sensors.

Sensor Data Output Registers

The sensor data registers contain the latest gyroscope, accelerometer, magnetometer, quaternions (or gravity & heading) and temperature measurement data.

They are read-only registers and are accessed through the serial interface. Data from these registers can be read at anytime. However, the interrupt function can be used to determine when new data is available.

Table 3. Power Modes

NAME	DESCRIPTION
Gyro Low-Noise	Only gyroscope is switched on and it is operational with maximum performances.
Gyro Eco	Only gyroscope is switched on and operates to reduce the average current consumption.
Gyro Standby	The gyroscope is in Standby Mode, the current consumption is reduced by 50%, with a shorter turn-on time
Acc Low-Noise	Only accelerometer is switched on and it is operational with maximum performances.
Acc Eco	Only accelerometer is switched on and operates to reduce the average current consumption.
Gyro Low-Noise Mode + Acc Low-Noise Mode	Acc and gyro are both switched on in Low-Noise Mode.
Gyro Eco + Acc Low-Noise Mode	Acc is in low-noise mode, while the gyro is Eco Mode.
Gyro Standby + Acc Low-Noise Mode	Acc is in low-noise mode, while the gyro is Standby Mode.
Power-Down	This is the minimum power consumption mode, at the price of a longer turn-on time.

FIFO

The MAX21100 embeds a 128-bytes data FIFO. The user can flexibly select the set of axis data to be stored in FIFO.This allows a power saving at system level as the host processor does not need to continuously poll data from the sensor, but it can wake up only when needed and burst the significant data out from the FIFO.

The FIFO buffer can work according to four main modes: off, normal, interrupt, and snapshot.

When configured in snapshot mode, it offers the ideal mechanism to capture the data following an external interrupt event.

Both normal and interrupt modes can be optionally configured to operate in overrun mode, depending on whether, in case of buffer under-run, newer or older data are accepted to be lost.

Various FIFO status flags can be enabled to generate interrupt events on INT1/INT2 pin.

FIFO Off Mode

In this mode, the FIFO is turned off; data are stored only in the data registers and no data are available from the FIFO if read.

When the FIFO is turned off, there are essentially two options to use the device: synchronous and asynchronous reading through the data registers.

Synchronous Reading

In this mode, the processor reads the data set (e.g., 6 bytes for a 3 axes configuration) generated by the MAX21100 every time that DATA_READY is set. The processor must read once and only once the data set in order to avoid data inconsistencies.

Benefits of using this approach include the perfect reconstruction of the signals coming the MAX21100 with the minimum data traffic.

Asynchronous Reading

In this mode, the processor reads the data generated by the MAX21100 regardless the status of the DATA_READY flag. To minimize the error caused by different samples being read a different number of times, the access frequency to be used must be much higher than the selected ODR. This approach normally requires a much higher BW.

FIFO Normal Mode

Overrun = false

- FIFO is turned on.
- FIFO is filled with the data at the selected output data rate (ODR).
- When FIFO is full, an interrupt can be generated.
- When FIFO is full, all the new incoming data is discharged. Reading only a subset of the data already stored into the FIFO keeps locked the possibility for new data to be written.
- Only if all the data are read, the FIFO restarts saving data.
- If communication speed is high, data loss can be prevented.
- To prevent a FIFO-full condition, the required condition is to complete the reading of the data set before the next DATA_READY occurs.
- If this condition is not guaranteed, data can be lost.

Overrun = true

- FIFO is turned on.
- FIFO is filled with the data at the selected ODR.
- When FIFO is full, an interrupt can be generated.
- When FIFO is full, the oldest data is overwritten with the new ones.
- If communication speed is high, data integrity can be preserved.
- In order to prevent a FIFO_WR_FULL condition, the required condition is to complete the reading of the data set before the next DATA_READY occurs.
- If this condition is not guaranteed, data can be overwritten.

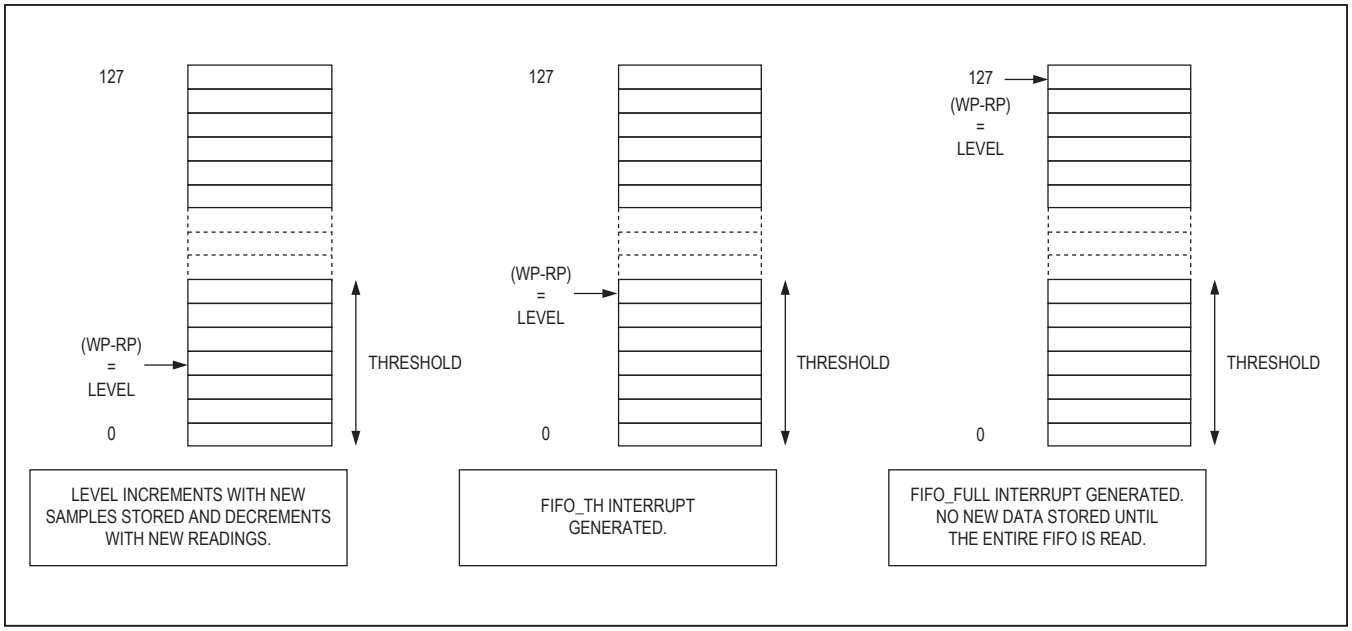


Figure 2. FIFO Normal mode, Overrun = False

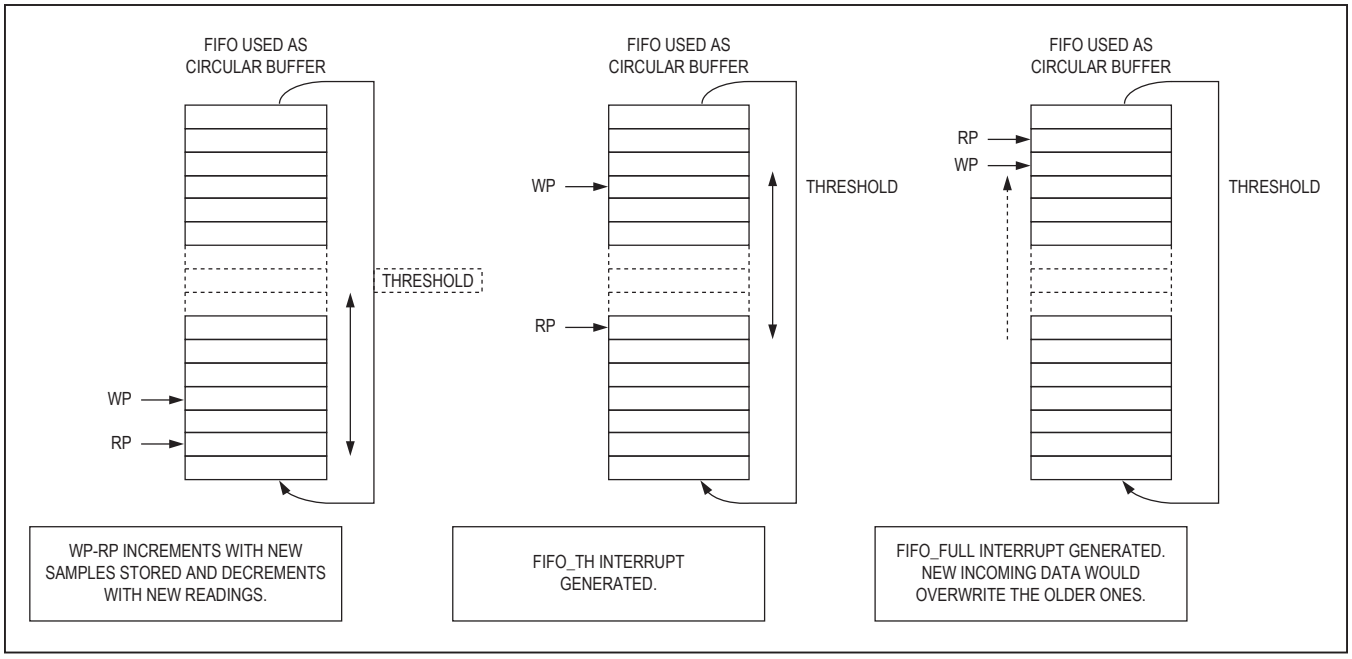


Figure 3. FIFO Normal Mode, Overrun = True

Interrupt Mode

Overrun = false

- FIFO is initially disabled. Data are stored only in the data registers.
- When an interrupt (either INT_OR or INT_AND) is generated, the FIFO is turned on automatically. It stores the data at the selected ODR.
- When FIFO is full, all the new incoming data is discharged. Reading only a subset of the data already stored into the FIFO keeps locked the possibility for new data to be written.
- Only if all the data are read the FIFO restarts saving data when a new event is generated.

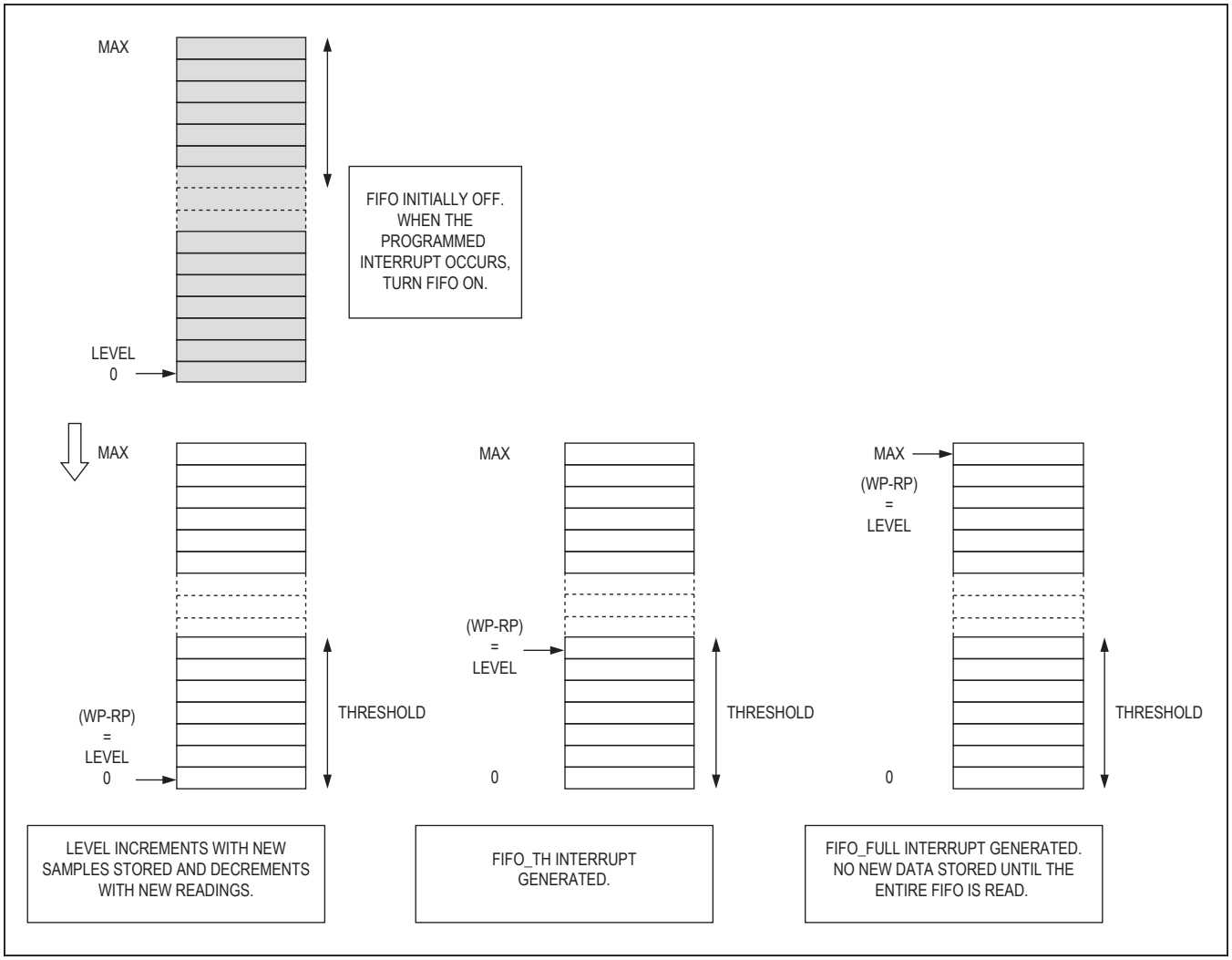


Figure 4. FIFO Interrupt Mode, Overrun = False

Overrun = true

- FIFO is initially disabled. Data are stored only in the data registers.
- When an interrupt (either INT_OR or INT_AND) is generated, the FIFO is turned on automatically. It stores the data at the selected ODR.
- When FIFO is full, an interrupt can be generated.
- When FIFO is full, the oldest data is overwritten with the new ones.
- If communication speed is high, data integrity can be preserved.
- In order to prevent a FIFO_WR_FULL condition, the required condition is to complete the reading of the data set before the next DATA_READY occurs.
- If this condition is not guaranteed, data can be overwritten.

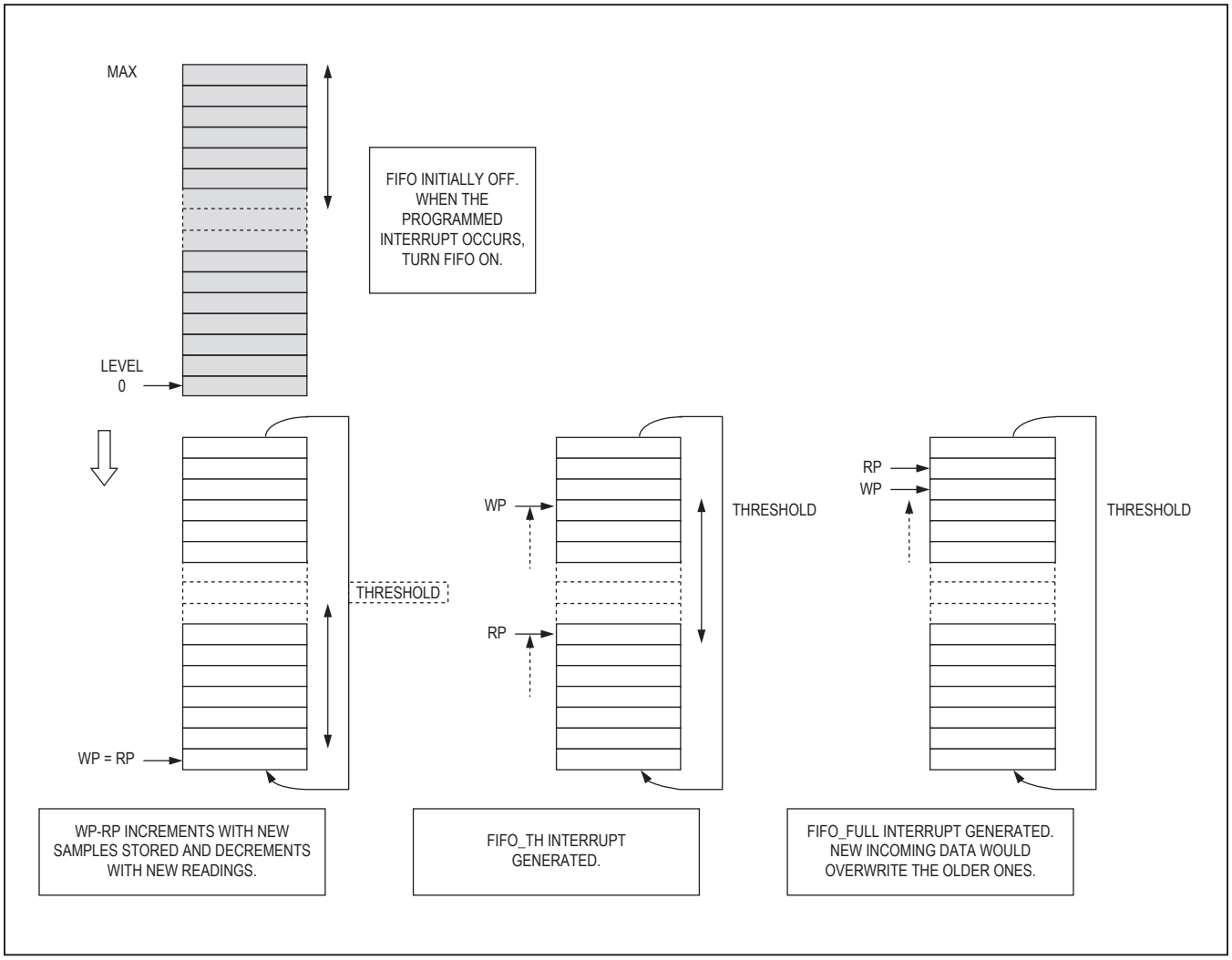


Figure 5. FIFO Interrupt Mode, Overrun = True

Snapshot Mode

- FIFO is initially in normal mode with overrun enabled.
- When an interrupt (either INT_OR or INT_AND) is generated, the FIFO switches automatically to not-overrun mode. It stores the data at the selected ODR until the FIFO becomes full.
- When FIFO is full, an interrupt can be generated.
- When FIFO is full, all the new incoming data is discharged. Reading only a subset of the data already stored into the FIFO keeps locked the possibility for new data to be written.
- Only if all the data are read the FIFO restarts saving data in overrun mode.

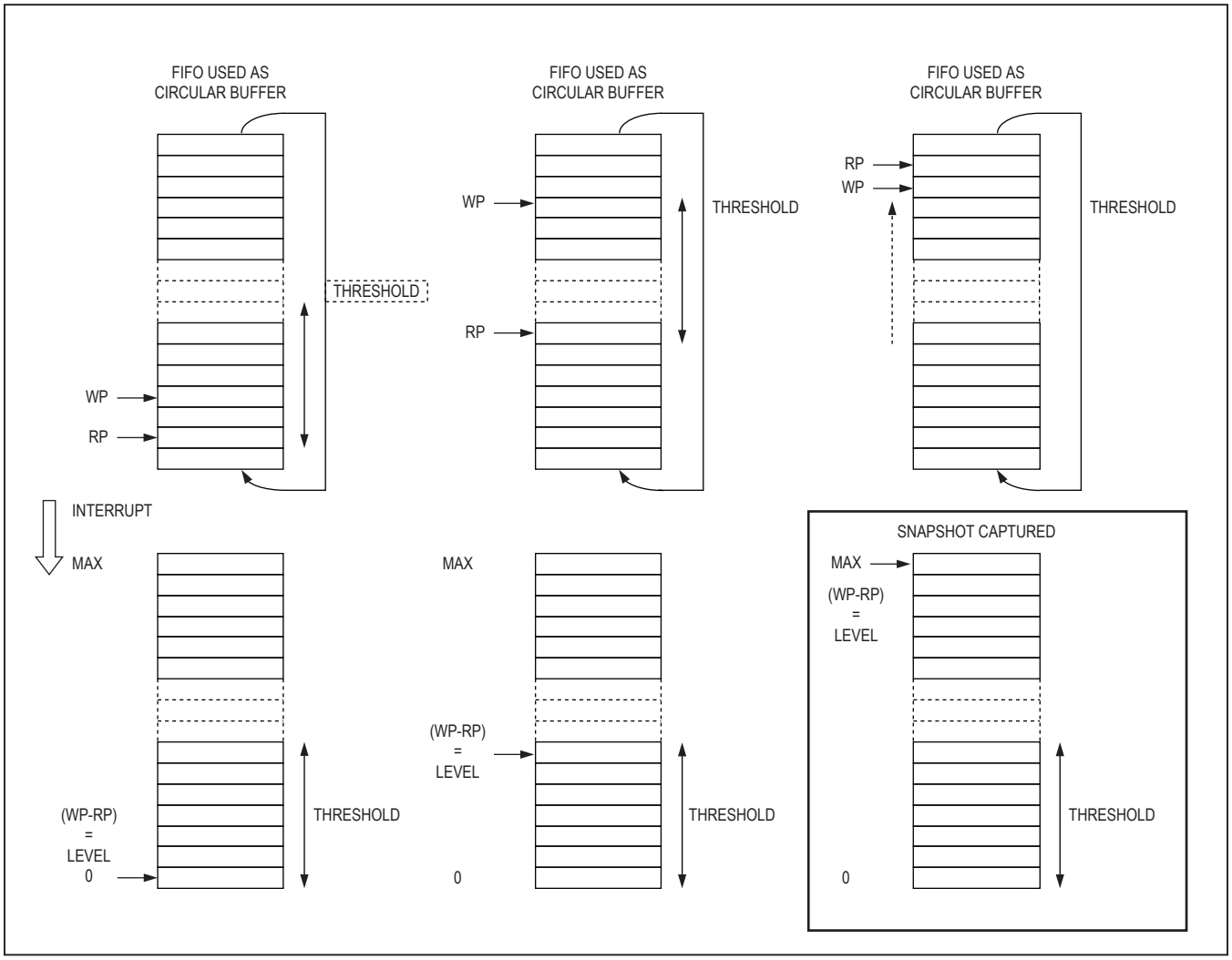


Figure 6. FIFO Snapshot Mode

Data Synchronization

The MAX21100 has a pin named DSYNC whose purpose is to enable a number of synchronization options.

Wake-Up Feature

The DSYNC pin can be used to switch the MAX21100 between two power modes according to the PWR_SEL and PWR_MODE settings in POWER_CFG (0x00) register. This feature can be used to control the power mode of the MAX21100 using an external controlling device, whether it is a microprocessor, another sensor or a different kind of device.

DSYNC can be configured to active either High or Low and on either edge or level.

This feature is controlled by a specific bit in the DSYNC_CFG register.

Data Capture Feature

Another way to use the DSYNC pin is as Data Capture trigger. The MAX21100 can be configured to stop filling FIFO with data until a given edge occur on DSYNC. Once the programmed active edge occurs, the MAX21100 collects in FIFO as many data as specified in the DSYNC_CNT register.

DSYNC Mapping on Data

DSYNC can be optionally mapped onto the LSb of the sensor data, to perform a sort of a-posteriori synchronization. The mapping occurs on every enabled axis of the sensors (gyroscope, accelerometer, magnetometer, and temperature sensor). This feature is controlled by specific bits in the DSYNC_CFG register.

DSYNC Interrupt Generation

The DSYNC pin can be used as an interrupt source to determine a different kind of data synchronization based on the software management performed by an external processor.

The DSYNC-based wake-up, data capture, data mapping, and interrupt generation features can be combined together.

Self-Test

The embedded self-test for MAX21100 gyroscope and accelerometer is an additional key feature that allows the part to be tested during final product assembly without requiring physical device movement.

Gyroscope

This gyroscope embedded self-test feature can be used to verify if the gyroscope is working properly without physically rotating the device. That may be used either before or after it is assembled on a PCB. If the gyroscope's outputs are within the specified self-test values in the data sheet, then the gyroscope is working properly.

Accelerometer

The accelerometer embedded self-test feature is used to verify the sensor functionality without physically moving the device. When this feature is enabled, an electrostatic test force is applied to the mechanical sensing element and causes the moving part to move away from its original position, emulating a definite input acceleration. In this case the sensor outputs exhibit a change in their DC levels which is related to the selected full scale through the device sensitivity. The output in this self-test mode is then compared with the output data of the device when the self-test is disabled. If the absolute value of the output difference is within the minimum and maximum range of the preselected full scale range, the accelerometer is working properly.

Unique Serial Number

Each MAX21100 device is uniquely identified by 48 bits that can be used to track the history of the sample, including manufacturing, assembly, and testing information.

Revision ID

The MAX21100 has a register used to identify the revision ID of the device and to identify the specific part number. Even though different part numbers may share the same WHO_AM_I value, they would still be identified by means of different Revision ID values.

Register File

The register file is organized per banks. On the Common Bank are mapped addresses from 0x20 to 0x3F and these registers are always available. It is possible to map on addresses 0x00 to 0x1F three different user banks by properly programming address 0x22. The purpose of this structure is to limit the management of the register map addresses in the 0x00 to 0x3F range even though the number of physical registers is in excess of 64.

Common Bank

The common is the bank whose locations are always available regardless the register bank selection.

This bank contains all the registers most commonly used, including data registers and the FIFO data.

Table 4. Common Bank

NAME	REGISTER ADDRESS	TYPE	DEFAULT VALUE	COMMENT
WHO_AM_I	0x20	R	1011 0010	Device ID
REVISION_ID	0x21	R	Variable	Revision ID Register
BANK_SELECT	0x22	R/W	0000 0000	Register Bank Selection
SYSTEM_STATUS	0x23	R	Data	System Status Register
GYRO_X_H	0x24	R	Data	Bits [15:8] of X measurement, Gyro
GYRO_X_L	0x25	R	Data	Bits [07:0] of X measurement, Gyro
GYRO_Y_H	0x26	R	Data	Bits [15:8] of Y measurement, Gyro
GYRO_Y_L	0x27	R	Data	Bits [07:0] of Y measurement, Gyro
GYRO_Z_H	0x28	R	Data	Bits [15:8] of Z measurement, Gyro
GYRO_Z_L	0x29	R	Data	Bits [07:0] of Z measurement, Gyro
ACC_X_H	0x2A	R	Data	Bits [15:8] of X measurement, Accel.
ACC_X_L	0x2B	R	Data	Bits [07:0] of X measurement, Accel.
ACC_Y_H	0x2C	R	Data	Bits [15:8] of Y measurement, Accel.
ACC_Y_L	0x2D	R	Data	Bits [07:0] of Y measurement, Accel.
ACC_Z_H	0x2E	R	Data	Bits [15:8] of Z measurement, Accel.
ACC_Z_L	0x2F	R	Data	Bits [07:0] of Z measurement, Accel.
MAG_X_H	0x30	R	Data	Bits [15:8] of X measurement, Mag.
MAG_X_L	0x31	R	Data	Bits [07:0] of X measurement, Mag.
MAG_Y_H	0x32	R	Data	Bits [15:8] of Y measurement, Mag.
MAG_Y_L	0x33	R	Data	Bits [07:0] of Y measurement, Mag.
MAG_Z_H	0x34	R	Data	Bits [15:8] of Z measurement, Mag.
MAG_Z_L	0x35	R	Data	Bits [07:0] of Z measurement, Mag.
TEMP_H	0x36	R	Data	Bits [15:8] of T measurement
TEMP_L	0x37	R	Data	Bits [07:0] of T measurement
RFU	0x38	R	0000 0000	
RFU	0x39	R	0000 0000	
RFU	0x3A	R	0000 0000	
RFU	0x3B	R	0000 0000	
FIFO_COUNT	0x3C	R	0000 0000	Available number of FIFO samples for data set
FIFO_STATUS	0x3D	R	0000 0000	FIFO Status Flags
FIFO_DATA	0x3E	R	Data	FIFO Data, to be read in burst mode
RST_REG	0x3F	W & Reset	0000 0000	Reset Register

User Bank 0

User bank 0 is the register used to configure most of the features of the MAX21100, with the exception of the interrupts, which are part of the user bank 1.

Table 5. User Bank 0

NAME	REGISTER ADDRESS	TYPE	DEFAULT VALUE	COMMENT
POWER_CFG	0x00	RW	0000 0111	Power mode configuration
GYRO_CFG1	0x01	RW	0010 1000	Gyro configuration 1
GYRO_CFG2	0x02	RW	0000 0100	Gyro configuration 2
GYRO_CFG3	0x03	RW	0000 0000	Gyro configuration 3
PWR_ACC_CFG	0x04	RW	1100 0111	Accel. power configuration
ACC_CFG1	0x05	RW	0000 0010	Accel. configuration 1
ACC_CFG2	0x06	RW	0000 0000	Accel. configuration 2
MAG_SLV_CFG	0x07	RW	0000 0110	Magnetometer slave configuration
MAG_SLV_ADD	0x08	RW	0000 0000	Magnetometer slave address
MAG_SLV_REG	0x09	RW	0000 0000	Magnetometer slave register
MAG_MAP_REG	0x0A	RW	0000 0000	Magnetometer mapping register
I2C_MST_ADD	0x0B	RW	0000 0000	I^2C master register address
I2C_MST_DATA	0x0C	RW	0000 0000	I^2C master register data
MAG_OFS_X_MSB	0x0D	RW	0000 0000	Magnetometer offset X, MSB
MAG_OFS_X_LSB	0x0E	RW	0000 0000	Magnetometer offset X, LSB
MAG_OFS_Y_MSB	0x0F	RW	0000 0000	Magnetometer offset Y, MSB
MAG_OFS_Y_LSB	0x10	RW	0000 0000	Magnetometer offset Y, LSB
MAG_OFS_Z_MSB	0x11	RW	0000 0000	Magnetometer offset Z, MSB
MAG_OFS_Z_LSB	0x12	RW	0000 0000	Magnetometer offset Z, LSB
DR_CFG	0x13	RW	0000 0001	Data ready configuration
IO_CFG	0x14	RW	0000 0000	Input/output configuration
I2C_PAD	0x15	RW	0000 0100	PADs configuration
I2C_CFG	0x16	RW	0000 0000	Serial interfaces configuration
FIFO_TH	0x17	RW	0000 0000	FIFO threshold configuration
FIFO_CFG	0x18	RW	0000 0000	FIFO mode configuration
RFU	0x19	R	0000 0000	—
DSYNC_CFG	0x1A	RW	0000 0000	DSYNC configuration
DSYNC_CNT	0x1B	RW	0000 0000	DSYNC counter
ITF_OTP	0x1C	RW	0000 0000	Serial interfaces and OTP control
RFU	0x1D	R	0000 0000	—
RFU	0x1E	R	0000 0000	—
RFU	0x1F	R	0000 0000	—

User Bank 1

User Bank 1 is primarily devoted to the configuration of the interrupts. It also contains the unique serial number.

Table 6. User Bank 1

NAME	REGISTER ADDRESS	TYPE	DEFAULT VALUE	COMMENT
INT_REF_X	0x00	RW	0000 0000	Interrupt reference for X-axis
INT_REF_Y	0x01	RW	0000 0000	Interrupt reference for Y-axis
INT_REF_Z	0x02	RW	0000 0000	Interrupt reference for Z-axis
INT_DEB_X	0x03	RW	0000 0000	Interrupt debounce, X
INT_DEB_Y	0x04	RW	0000 0000	Interrupt debounce, Y
INT_DEB_Z	0x05	RW	0000 0000	Interrupt debounce, Z
INT_MSK_X	0x06	RW	0000 0000	Interrupt mask, X-axis zones
INT_MSK_Y	0x07	RW	0000 0000	Interrupt mask, Y-axis zones
INT_MSK_Z	0x08	RW	0000 0000	Interrupt mask, Z-axis zones
INT_MASK_AO	0x09	RW	0000 0000	Interrupt masks, and/or
INT_CFG1	0x0A	RW	0000 0000	Interrupt configuration 1
INT_CFG2	0x0B	RW	0010 0100	Interrupt configuration 2
INT_TMO	0x0C	RW	0000 0000	Interrupt timeout
INT_STS_UL	0x0D	R	0000 0000	Interrupt sources, unlatched
INT_STS	0x0E	R	0000 0000	Interrupt status register
INT_MSK	0x0F	RW	1000 0010	Interrupt mask register
RFU	0x10	R	0000 0000	—
RFU	0x11	R	0000 0000	—
RFU	0x12	R	0000 0000	—
RFU	0x13	R	0000 0000	—
RFU	0x14	R	0000 0000	—
RFU	0x15	R	0000 0000	—
RFU	0x16	R	0000 0000	—
INT_SRC_SEL	0x17	RW	0011 1100	Interrupt source selection
RFU	0x18	R	0000 0000	—
RFU	0x19	R	0000 0000	—
SERIAL_5	0x1A	R	Variable	Unique serial number, Byte 5
SERIAL_4	0x1B	R	Variable	Unique serial number, Byte 4
SERIAL_3	0x1C	R	Variable	Unique serial number, Byte 3
SERIAL_2	0x1D	R	Variable	Unique serial number, Byte 2
SERIAL_1	0x1E	R	Variable	Unique serial number, Byte 1
SERIAL_0	0x1F	R	Variable	Unique serial number, Byte 0

User Bank 2

User Bank 2 is primarily devoted to the configuration of the interrupts. It also contains the unique serial number.

Table 7. User Bank 2

NAME	REGISTER ADDRESS	TYPE	DEFAULT VALUE	COMMENT
QUAT0_H	0x00	R	0000 0000	MSB of QUATERNION 0
QUAT0_L	0x01	R	0000 0000	LSB of QUATERNION 0
QUAT1_H	0x02	R	0000 0000	MSB of QUATERNION 1
QUAT1_L	0x03	R	0000 0000	LSB of QUATERNION 1
QUAT2_H	0x04	R	0000 0000	MSB of QUATERNION 2
QUAT2_L	0x05	R	0000 0000	LSB of QUATERNION 2
QUAT3_H	0x06	R	0000 0000	MSB of QUATERNION 3
QUAT3_L	0x07	R	0000 0000	LSB of QUATERNION 3
RFU	0x08	R	0000 0000	—
RFU	0x09	R	0000 0000	—
RFU	0x0A	R	0000 0000	—
RFU	0x0B	R	0000 0000	—
RFU	0x0C	R	0000 0000	—
RFU	0x0D	R	0000 0000	—
RFU	0x0E	R	0000 0000	—
RFU	0x0F	R	0000 0000	—
RFU	0x10	R	0000 0000	—
RFU	0x11	R	0000 0000	—
RFU	0x12	R	0000 0000	—
BIAS_GYRO_X_H	0x13	RW	0000 0000	GYRO bias compensation, X-MSB
BIAS_GYRO_X_L	0x14	RW	0000 0000	GYRO bias compensation, X-LSB
BIAS_GYRO_Y_H	0x15	RW	0000 0000	GYRO bias compensation, Y-MSB
BIAS_GYRO_Y_L	0x16	RW	0000 0000	GYRO bias compensation, Y-LSB
BIAS_GYRO_Z_H	0x17	RW	0000 0000	GYRO bias compensation, Z-MSB
BIAS_GYRO_Z_L	0x18	RW	0000 0000	GYRO bias compensation, Z-LSB
BIAS_ACC_X	0x19	RW	0000 0000	ACC bias compensation, X
BIAS_ACC_Y	0x1A	RW	0000 0000	ACC bias compensation, Y
BIAS_ACC_X	0x1B	RW	0000 0000	ACC bias compensation, Z
FUS_CFG0	0x1C	RW	0000 0000	Fusion Engine Configuration register 0
FUS_CFG1	0x1D	RW	0101 1000	Fusion Engine Configuration register 1
RFU	0x1E	R	0000 0000	—
GYRO_ODR_TRIM	0x1F	RW	0111 0000	GYRO ODR correction factor register

Orientation of Axes

Figures 7 and 8 show the orientation of the axes of sensitivity and the polarity of rotation and linear acceleration. Note the pin 1 identifier (●) in the figure.

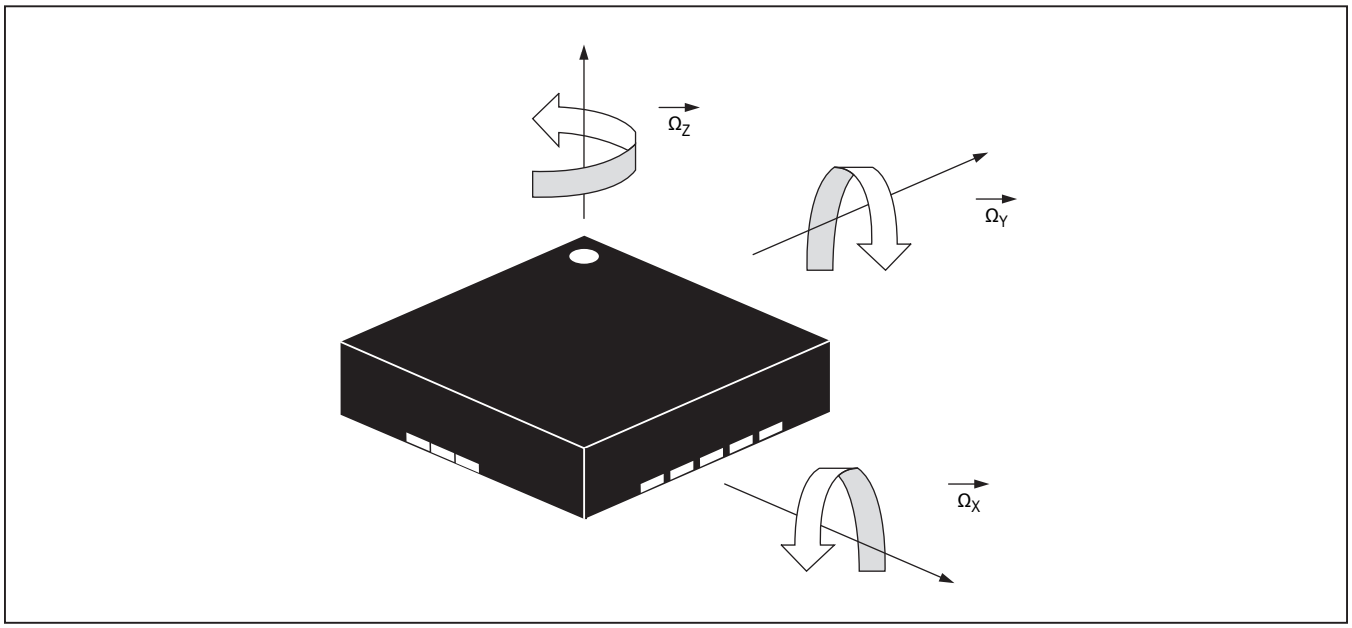


Figure 7. Orientation of Gyro Axes

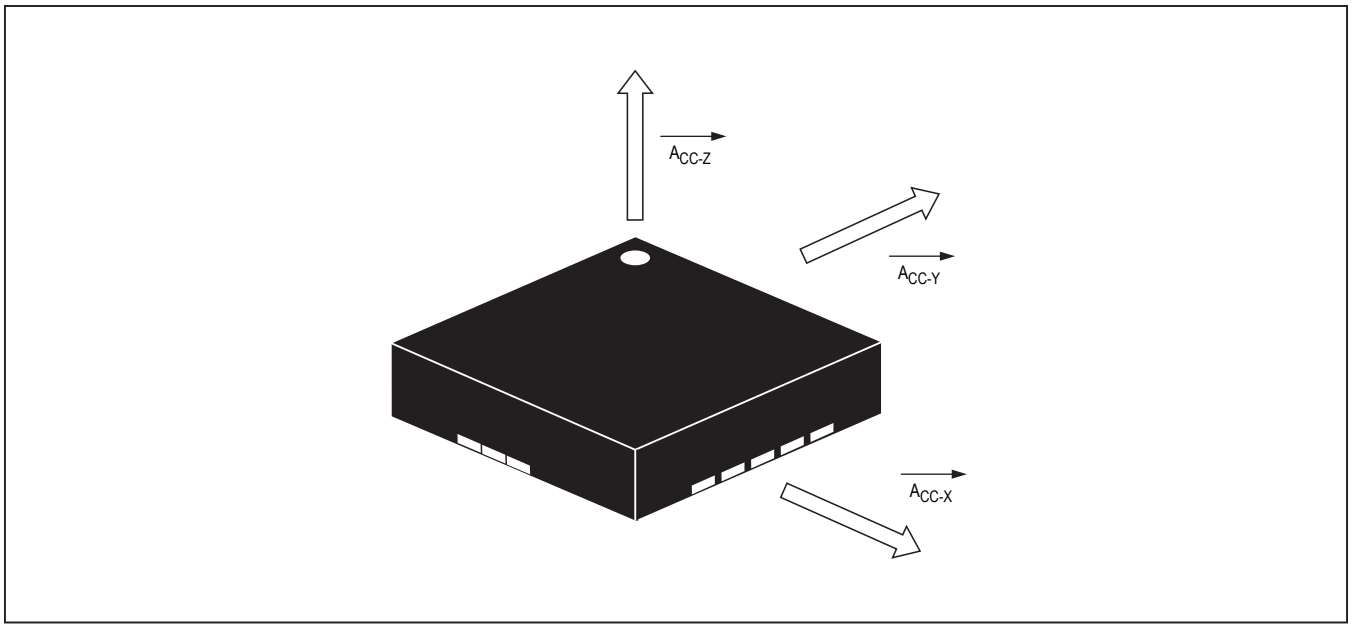


Figure 8. Orientation of Accelerometer Axes

Soldering Information

Visit **www.maximintegrated.com/MAX21100.related** for soldering recommendations.

Application Notes

Bypass V_{DD} and V_{DDIO} to the ground plane with 0.1µF ceramic chip capacitors on each pin as close as possible to the device to minimize parasitic inductance.

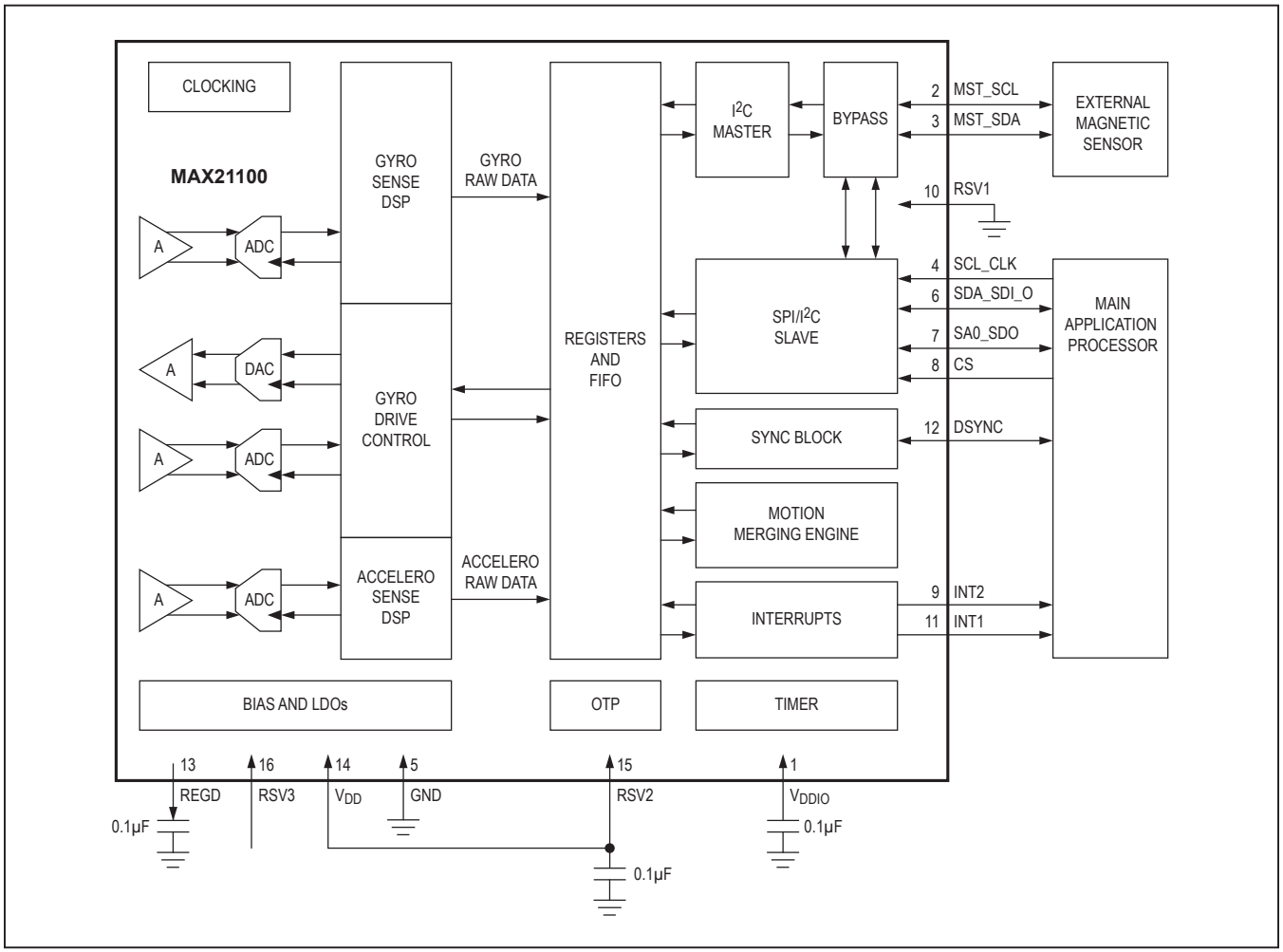
Connect to REGD 100nF ceramic chip capacitor as close as possible to the MAX21100 to minimize parasitic inductance.

Depending on the specific application board, an additional bulk decoupling capacitor to V_{DD} and V_{DDIO} might be needed. For best performance, keep separate V_{DD} and V_{DDIO} power supplies.

Table 8. Bill of Materials for External Components

COMPONENT	LABEL	SPECIFICATION	QUANTITY
V_{DD}/V_{DDIO} Bypass Capacitor	C1	Ceramic, X7R, 0.1µF ±10%, 4V	2
REGD Capacitor	C2	Ceramic, X7R, 100nF ±10%, 2V	1

Typical Application Circuit



Ordering Information

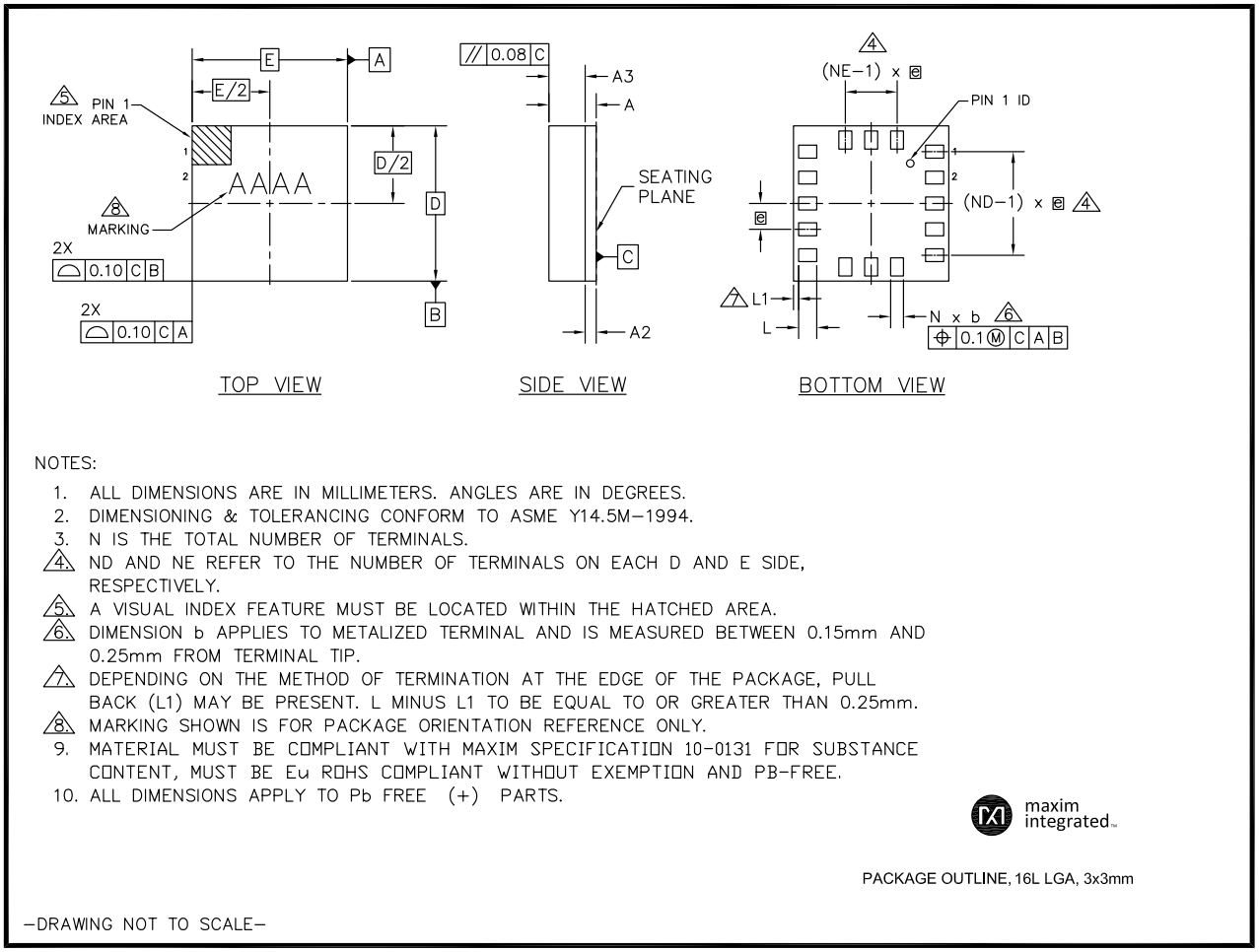
PART	TEMP RANGE	PIN-PACKAGE
MAX21100+	-40°C to +85°C	16 LGA
MAX21100+T	-40°C to +85°C	16 LGA

+Denotes a lead(Pb)-free/RoHS-compliant package.

T = Tape and reel.

Package Information

For the latest package outline information and land patterns (footprints), go to **www.maximintegrated.com/packages**. Note that a "+", "#", or "-" in the package code indicates RoHS status only. Package drawings may show a different suffix character, but the drawing pertains to the package regardless of RoHS status.



Package Information (continued)

For the latest package outline information and land patterns (footprints), go to **www.maximintegrated.com/packages**. Note that a "+", "#", or "-" in the package code indicates RoHS status only. Package drawings may show a different suffix character, but the drawing pertains to the package regardless of RoHS status.

REF.	MIN.	NOM.	MAX.
A	0.78	0.83	0.88
A2		0.13 REF	
A3	0.65	0.70	0.75
ɔ	0.20	0.25	0.30
D		3.00 BSC	
E		3.00 BSC	
e		0.50 BSC	
L	0.275	0.325	0.375
L1	--	--	0.10
N		16	
ND		5	
NE		3	

maxim integrated

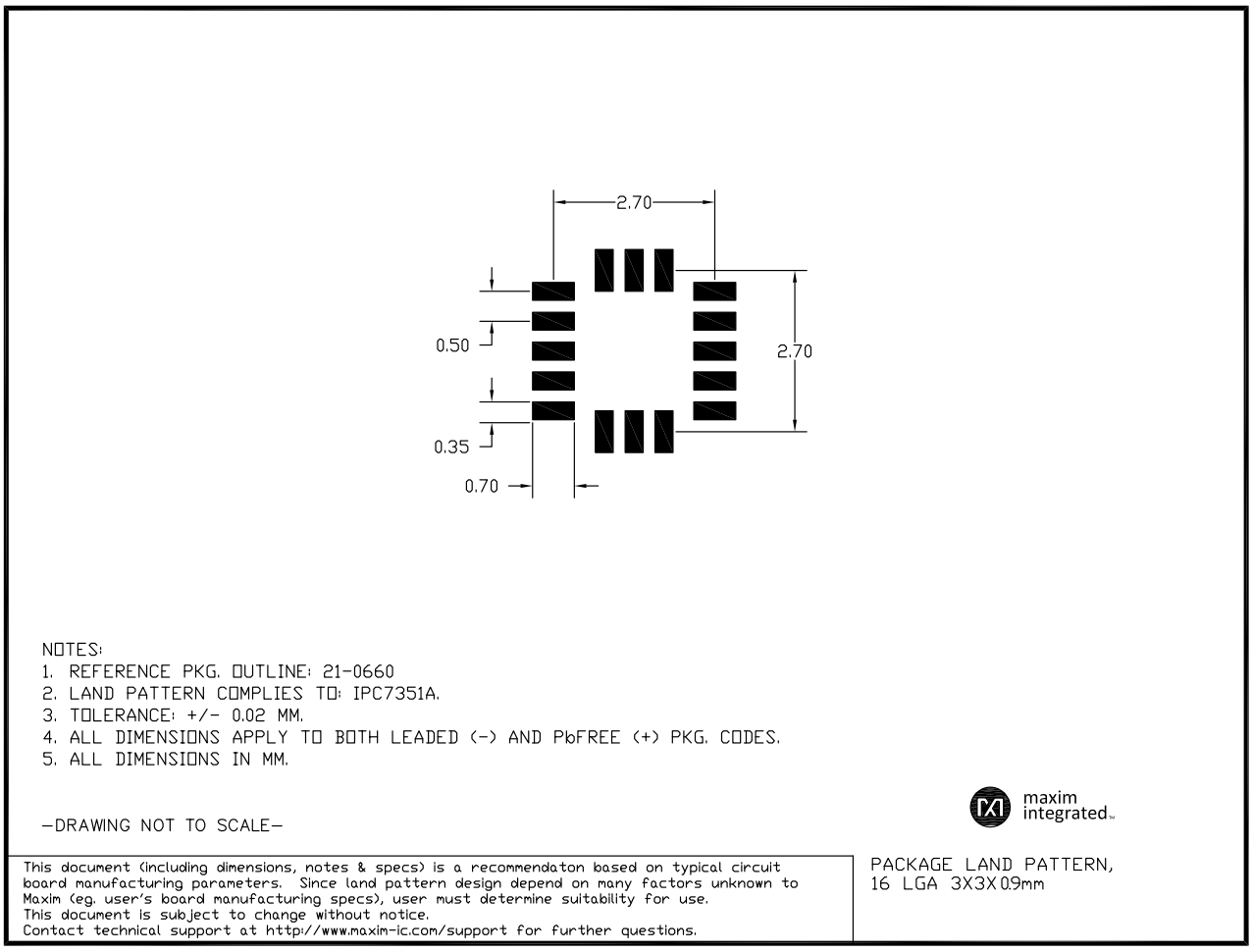
TITLE:
PACKAGE OUTLINE,
16L LGA, 3x3mm

APPROVAL | DOCUMENT CONTROL NO. | REV. H | 2/2

—DRAWING NOT TO SCALE—

Package Information (continued)

For the latest package outline information and land patterns (footprints), go to **www.maximintegrated.com/packages**. Note that a "+", "#", or "-" in the package code indicates RoHS status only. Package drawings may show a different suffix character, but the drawing pertains to the package regardless of RoHS status.



Revision History

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
0	11/13	Initial release	—
1	10/14	Corrected units for sensitivity parameter	3

