IST8309
3D Magnetometer with Programmable Switch

Datasheet

Table of Contents

1. General Description

iSentek IST8309 is a 3D digital linear hall sensor to measure magnetic flux intensity. It is an IC device that contains magnetic sensors and control ASIC with a 16-bit ADC output. IST8309 provides an I^2C digital output with a fast mode up to 400 kHz. Wide dynamic range operation, high resolution, and compact form factor features make it the best candidate for smartphone, wearable, and IoT devices.

Features

- Single-chip 3-axis linear hall sensor with digital output
- 3-axis programmable magnetic switch function
- INTB pin for event notification (magnetic switch, DRDY, overflow)
- Compact form factor, 1.29 x 0.99 x 0.53 mm^3, 5-pin WLCSP-BGA package
- Operating supply voltage: VDD: 1.7V~3.6V, VID:1.2V~VDD
- I^2C bus supports fast mode up to 400 kHz
- Two selectable slave addresses
- The high dynamic range of a maximum of ±30 mT
- High resolution of maximum of 2.5 μT/LSB
- Absolute 360° angle output
- The high output data rate of maximum of 1 kHz
- Operation temperature -30 - 85 °C
- Built-in oscillator for internal clock source
- Power-on reset circuit
- RoHS, HF and TSCA compliant

Applications

Magnetometer for external magnetic detection

Displacement detection

Foldable device angle detection

Angle sensor application

Joystick and gaming controller

2. Block Diagram, Package Dimensions, Magnetic Field Direction, Pin Configurations, and Application Circuit

2.1. Block Diagram

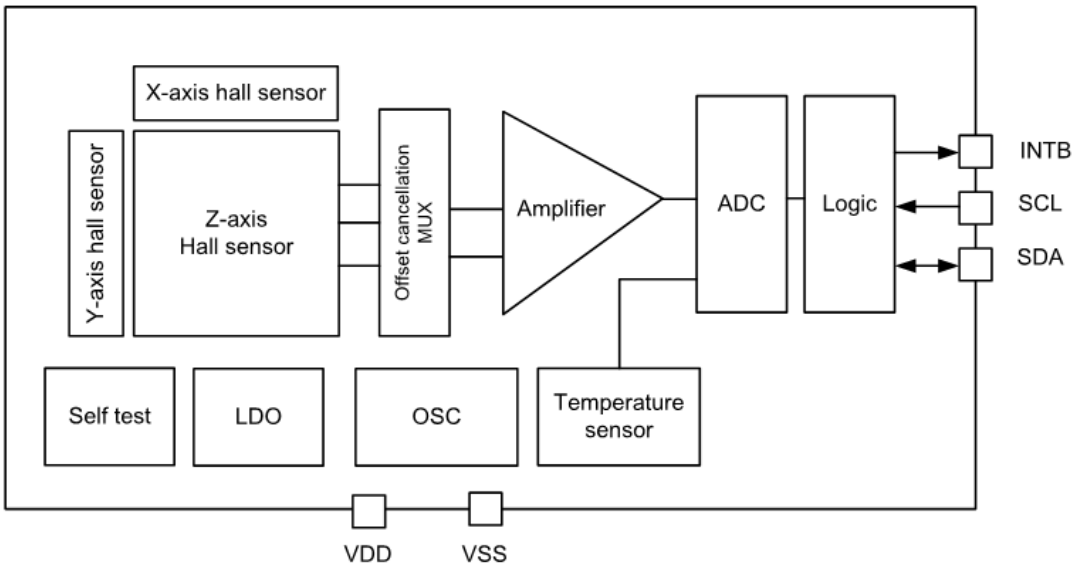


Figure 1. Block Diagram

2.2. Package Dimensions

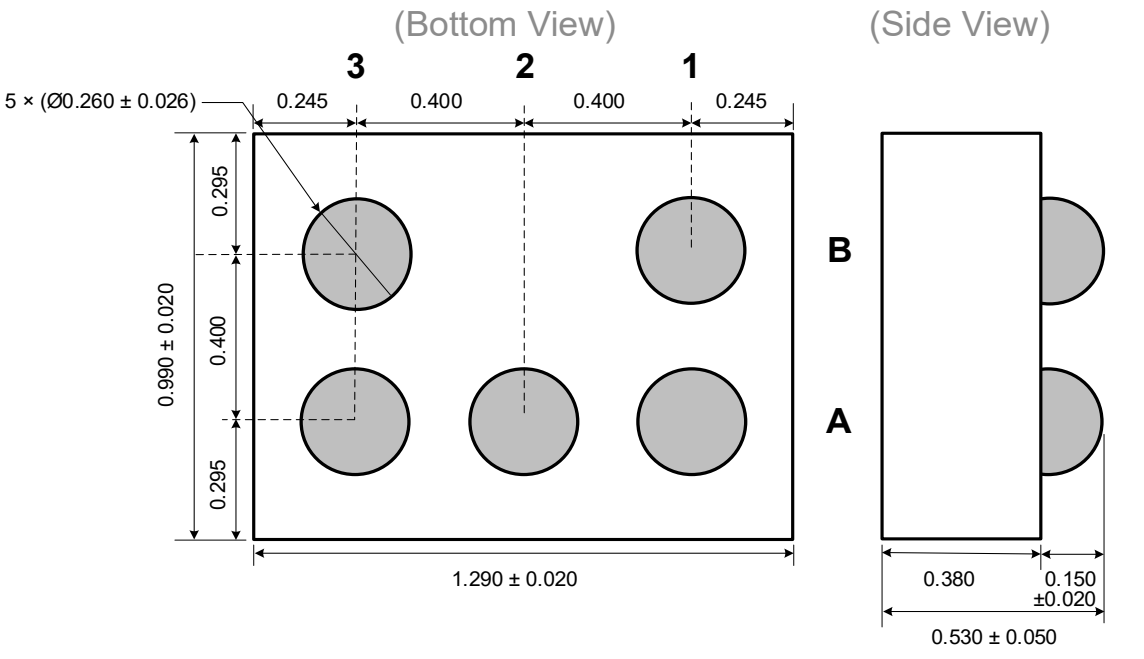


Figure 2. Package Dimensions

2.3. Location of Hall Sensing Elements

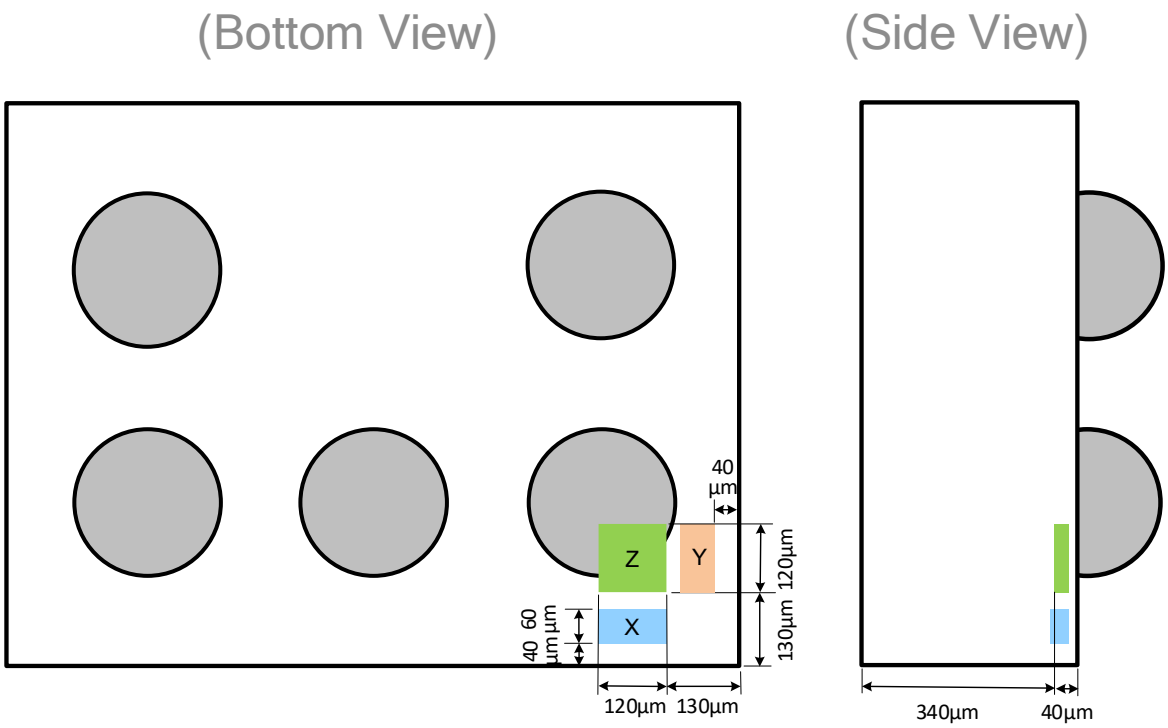


Figure 3. Sensing Element Positions

2.4. Marking

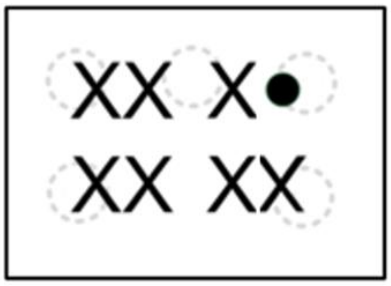
Date code $X_1X_2X_3$●

Product code $X_4X_5X_6X_7$

X_1: Year

X_2X_3: Week

$X_4X_5X_6X_7$: Product code



IST8309 TOP View

2.5. Magnetic Field Direction

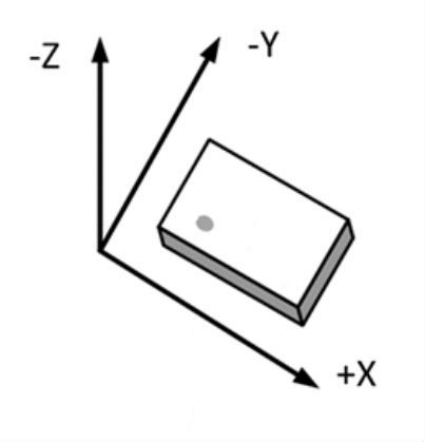
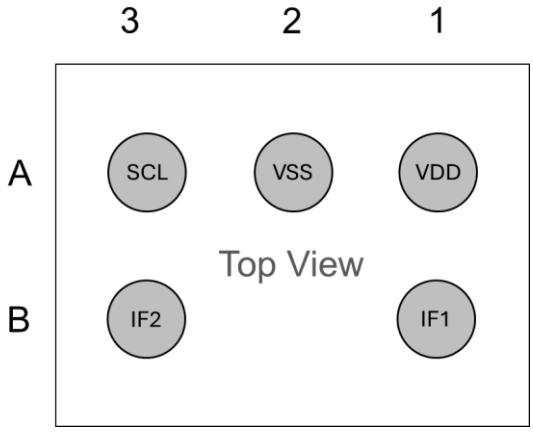


Figure 4. Magnetic Field Direction

2.6. Pin Configurations and Application Circuit



Case 1. Slave Address = 0x18

	Symbol	Function name	Type	Function
A1	VDD	VDD	Power	Power supply
A2	VSS	VSS	Power	Ground
A3	SCL	SCL	Input	I^2C clock
B1	IF1	INTB	Output	Open-drain interrupt output
B3	IF2	SDA	I/O	I^2C data

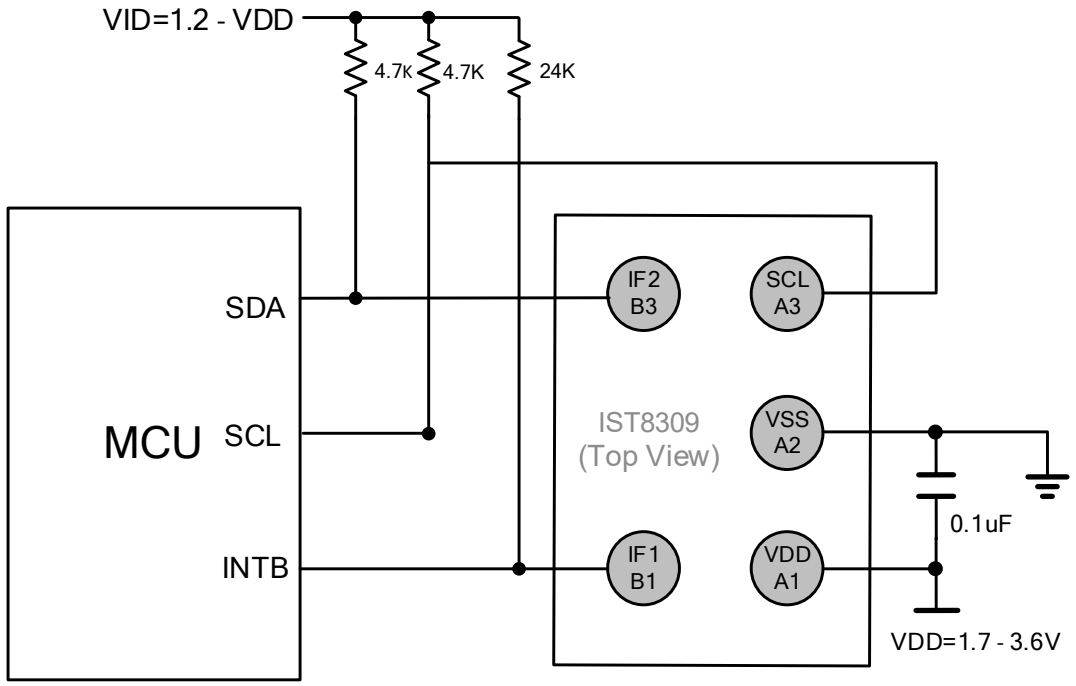


Figure 5. Application Circuit

Note:

1. *VID must be powered up no later than VDD.*
2. ***Resistor Selection:*** *A 24 kΩ resistor is recommended. Alternatives ranging from 16 kΩ to 100 kΩ may be used, depending on customer preference and design requirements. Higher resistance values are beneficial for power saving.*

Case 2. Slave Address = 0x19

	Symbol	Function name	Type	Function
A1	VDD	VDD	Power	Power supply
A2	VSS	VSS	Power	Ground
A3	SCL	SCL	Input	I^2C clock
B1	IF1	SDA	I/O	I^2C data
B3	IF2	INTB	Output	Open-drain interrupt output

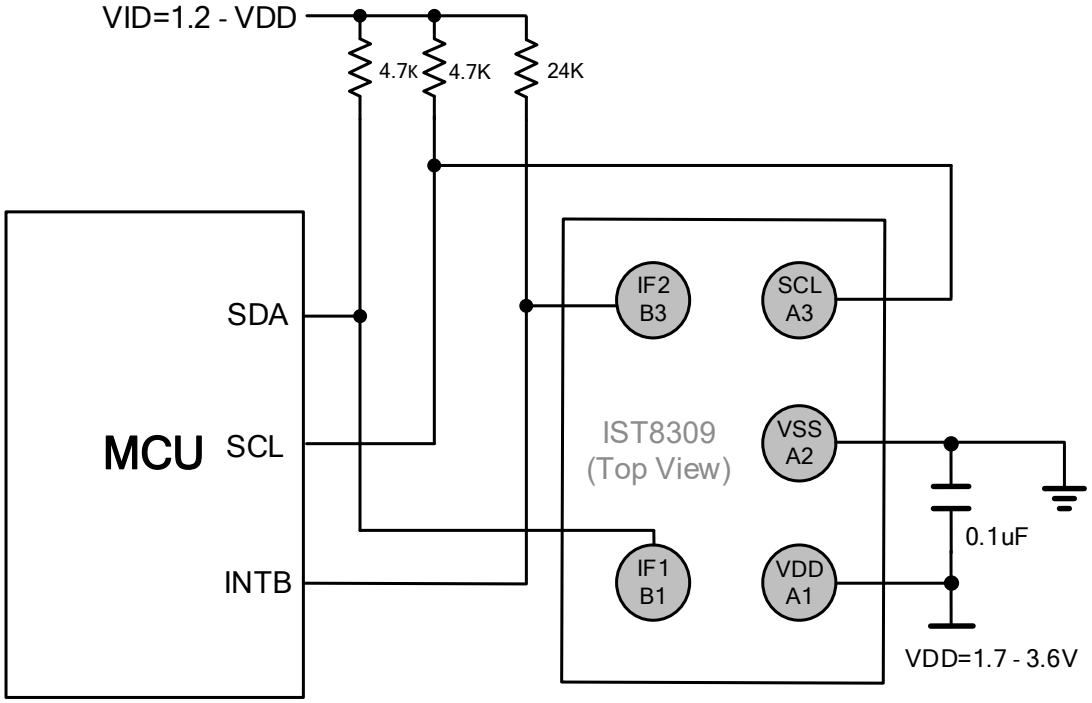


Figure 6. Application Circuit

Note:

1. *VID must be powered up no later than VDD.*
2. ***Resistor Selection:*** *A 24 kΩ resistor is recommended. Alternatives ranging from 16 kΩ to 100 kΩ may be used, depending on customer preference and design requirements. Higher resistance values are beneficial for power saving.*

Case 3. Dual IST8309

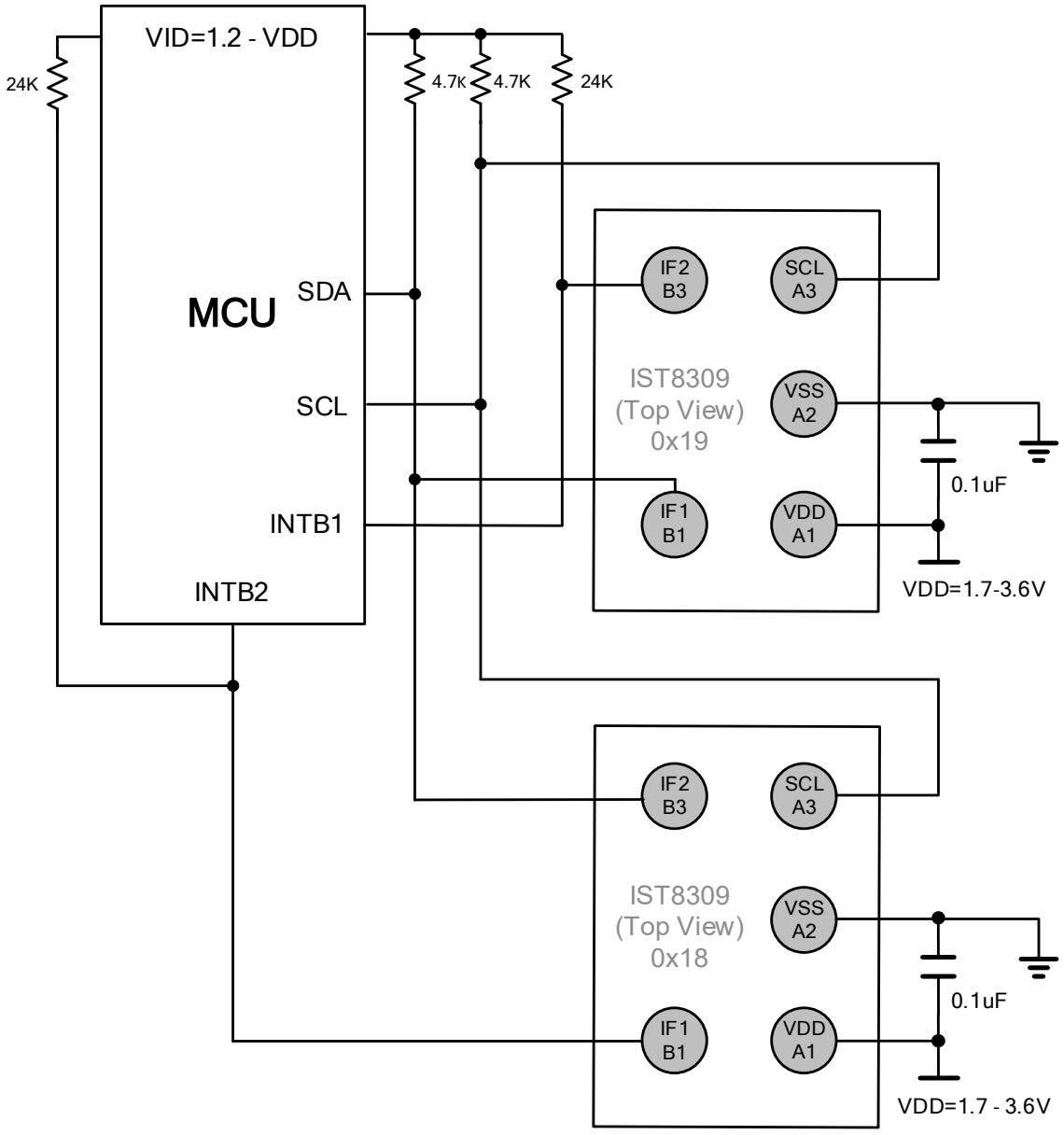


Figure 7. Application Circuit

Note:

1. *VID must be powered up no later than VDD.*
2. ***Resistor Selection:*** *A 24 kΩ resistor is recommended. Alternatives ranging from 16 kΩ to 100 kΩ may be used, depending on customer preference and design requirements. Higher resistance values are beneficial for power saving.*

2.7. Slave Address Detection

1. The slave address, either **0x18** or **0x19**, is determined by the pull-up resistors of SDA, SCL, and INT.
2. Pull-up resistor **MUST** be:

- 4.7 kΩ on **SDA** and **SCL**.
- 24 kΩ on **INT**

3. The I²C **"SDA"** and interrupt **"INT"** schematics are **different** between 0x18 and 0x19.

- When the slave address is set to **0x18**:

"SDA" will be **IF2** (B3 Pin)

"INT" will be **IF1** (B1 Pin)

- When the slave address is set to **0x19**:

"SDA" will be **IF1** (B1 Pin)

"INT" will be **IF2** (B3 Pin)

2.8. MCU and Platform Baseband Application

1. External pull-up resistors on SDA, SCL, and INT are required.
2. Disconnect any internal pull-up resistors within the MCU or Platform Baseband.
3. Set the GPIO mode connected to the INT to either FLOATING MODE or INPUT MODE at power-on
4. Set the mode of I²C IO for SDA and SCL to OPEN DRAIN MODE.

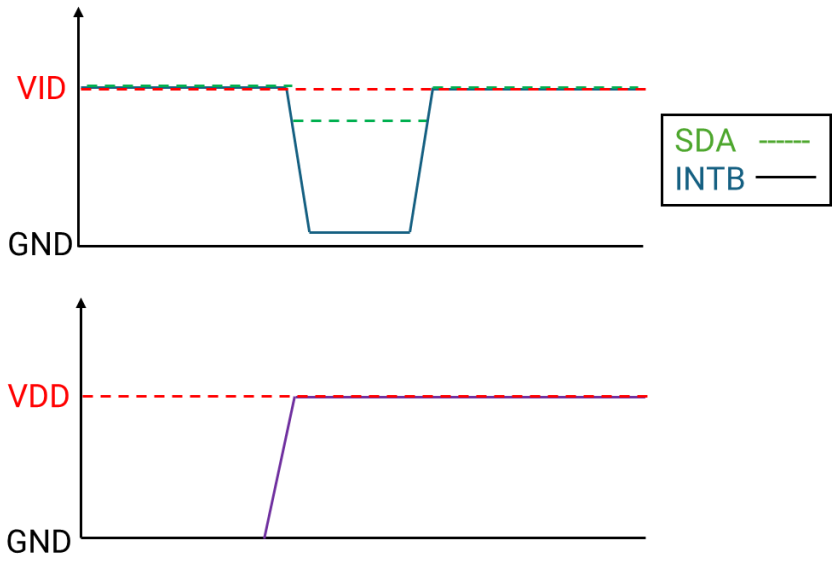
DO NOT ACCESS SDA, SCL, AND INT WHILE POWER-ON

5. The startup sequence should be completed within 1 ms after power-on before beginning any I²C communication operations.

2.9. Startup Sequence and Voltage Requirements

(1) VID is applied before VDD

The power-up of VDD triggers the address detection mechanism. During this process, SDA remains high relative to INTB until the detection is completed.

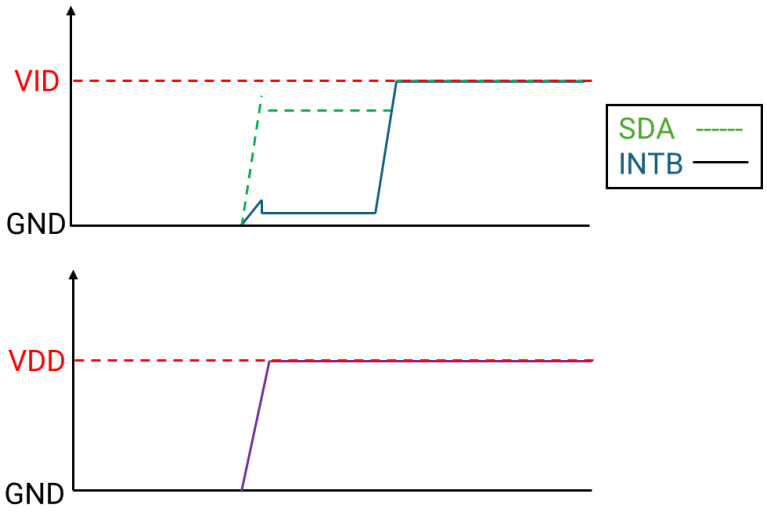


Notes:

- VID voltage must be less than or equal to VDD voltage.
- SDA, SCL, and INTB must all operate at the same VID voltage.

(2) VDD and VID Applied Simultaneously

The power-up of VDD triggers the address detection mechanism. During this process, SDA remains high relative to INTB until the detection is completed.



Notes:

- VID voltage must be less than or equal to VDD voltage.
- SDA, SCL, and INTB must all operate at the same VID voltage.

3. Operational Modes and Functional Descriptions

3.1. Operation Modes

IST8309 has the following operation modes:

(1) Standby mode

(2) Single measurement mode

(3) Continuous measurement mode

(4) Self-test mode

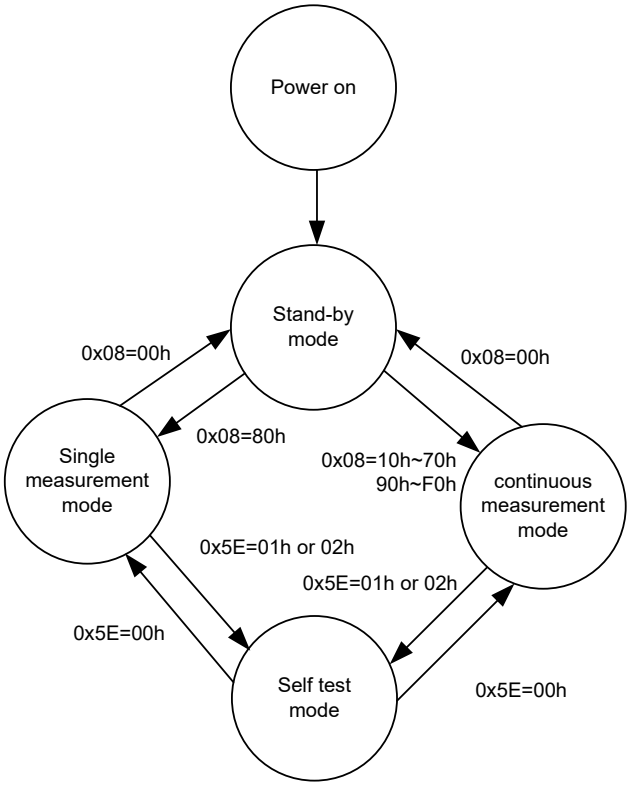


Figure 8. Operation Modes

3.1.1. Standby Mode

The initial model of the IST8309 (after power on) is Standby Mode. In Standby Mode, internal circuits are deactivated (except the oscillator and regulator). In Standby Mode, you can access all registers. The latest state of data saved in Read/Write registers is maintained. A soft reset can be used to reset registers.

3.1.2. Single Measurement Mode

In Single Measurement Mode, measured data are recorded in data registers before IST8309 automatically transitions into Standby Mode. On transition to Standby Mode, CNTL1 [7:4] turns

to “0000”. Simultaneously, the DRDY bit in the STAT1 register turns to “1”. This is defined as “Data ready”. When any of the measurement data registers are read, the DRDY bit turns to “0”. For the next measurement, the user needs to set CNTL1 [7:4] to “1000” again.

3.1.3. Continuous Measurement Mode

When the Continuous Measurement Mode is set, the sensor is measured periodically at preset frequencies. The measured data is stored in Output Data Registers. When the next measurement time comes, IST8309 automatically starts to measure again, and the Output Data Registers will be updated.

3.1.4. Self-Test Mode

Self-test mode is utilized to ensure that the magnetic sensor is functioning normally.
When this mode is enabled (0x5E = 0x01 or 0x02), the internal coil is activated to generate a standard magnetic field for testing the magnetic sensing functionality. Users will receive two sets of sensing data for each axis when (0x5E = 0x01) and (0x5E = 0x02) are configured. After calculating the absolute value of the difference between these two data (for each axis), we can determine that the sensor is functioning properly if the result is approximately 1 Gauss.

3.2. IST8309 Read Process

(1) Read STAT1 register:
-Polling STAT1 register
-DRDY: indicates whether or not the hall sensor data is ready
0: no data ready
1: data ready
-DOR: indicates whether any data was skipped prior to the current data in Continuous Measurement Mode
0: no skipped data
1: data skipped
(2) Read XYZ Data (2's complement):
Read register 0x11 ~ 0x16 for X, Y, and Z-axis data. When data reading starts, the DRDY bit and DOR bit turn to “0”.
(3) Read Angle Data:
Read register 0x19, 0x1A for angle data. When data reading starts, the DRDY bit and DOR bit turn to “0”. [Angle = ((0x1A data) x 256 + (0x19 data)) x (1/128) = 0° ~ 359.99°]

4. Electrical Specifications

4.1. Absolute Maximum Ratings

Parameter	Symbol	Limits	Unit
Storage Temperature	TCG	-40 to +125	°C
Power Supply Voltage	VDD	-0.3 to +4.0	V
Electrostatic Discharge Voltage*[1]	VESD_HBM	-2000 to 2000	V
Electrostatic Discharge Voltage*[2]	VESD_CDM	-1000 to 1000	V
Reflow Classification	JESD22-A113 with 260°C Peak Temperature		

If the device is used in conditions exceeding these limits, it may malfunction permanently. Performance cannot be assured when these limits are exceeded.

1. Human Body Model (HBM)
2. Charge Device Model (CDM)

4.2. Recommended Operating Conditions

Parameter	Symbol	Min.	Typ.	Max.	Unit
Operating Temperature	TA	-30		+85	°C
Power Supply Voltage	VDD	1.7	3.3	3.6	V

4.3. Electrical Specifications

Operating conditions: TA = +25 ℃; VDD = 3.3 V.

Parameter	Symbol	Pin	Conditions	Min.	Typ.	Max.	Unit
Current Consumption	IDD	VDD	10 Hz sampling		50		μA
Standby Consumption	CUP	VDD	Standby mode		2		μA
Input current	IAN	SCL, IF1, IF2	GND or VDD	-10		10	μA
Input Low Voltage	VIL	SCL, IF1, IF2		-0.3		0.42	V
Input High Voltage	VIA	SCL, IF1, IF2		0.89		VDD	V
Output Low Voltage	VOL	IF1, IF2				0.3	V
Hysteresis Input	VHS	SCL, IF1, IF2		0.2			V

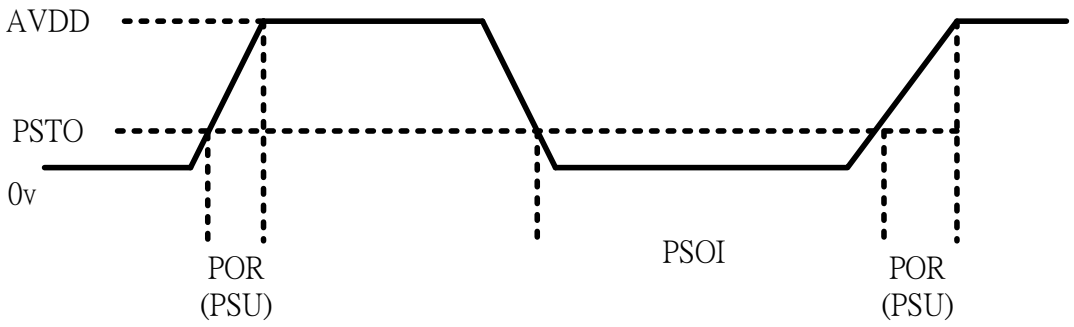
4.4. Magnetic Sensor Specifications

Operating conditions: TA = +25 ℃; VDD = 3.3 V.

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
Dynamic Range	DR		±26 ±180[*1]	±30 ±210[*1]	±35 ±245[*1]	mT
Resolution	RES	16-bit setting	2.17 ±13.1[*1]	2.5 17.5[*1]	2.94 ±22.9[*1]	uT/LSB
Zero-Field Offset	BOF		-1	0	1	mT

[*1] ***High Dynamic Range Mode:*** *Guaranteed by design; not subject to testing.*

4.5. Power-On Reset (POR) Specifications



PSTO: Power Supply Turn Off voltage
PSOI: Power Supply Turn Off Interval
POR: Power On Reset
PSU: Power Supply Rise Time[*1]

PSTO: max=0.1volt
PSOI: min=30ms
POR: max:1ms

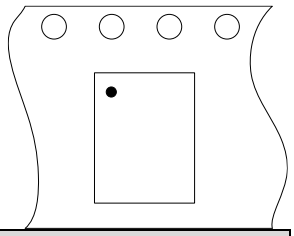
[*1] *The power on reset time is equal to the power supply rise time (max:1ms).*

When the POR circuit detects an increase in VDD value, it resets all internal circuits and initializes all registers. After being reset, IST8309 transits to Standby Mode.

5. Packing Information

Reel tape with round hole facing up, with Pin 1 positioned at the top left.
Moisture Sensitivity Level (MSL): 1

6. Ordering Information



Order Number	Package Type	Packaging	Temperature Range	Marking Information
IST8309	WLCSP – 5 pins	Tape and Reel: 5k pieces per reel	-30 to +85°C	$X_1X_2X_3$● $X_4X_5X_6X_7$ X_1: Year X_2X_3: Week $X_4X_5X_6X_7$: Product code

For further information about iSentek's Magnetic Sensors, please send an email to sales@isentek.com visit our website at www.isentek.com.

7. Legal disclaimer

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7.3. Disclaimer Regarding Changes

iSentek reserves the right to modify the contents of this datasheet, including specifications

and descriptions, at any time and without prior notice. This document supersedes all previously issued information.

Revision History

Revision Version	Date	Description
1.3	August 18th, 2022	Initial release
1.4	February 06th, 2023	Added environmental statement (Page 3); modify power-on time = 1ms (Page 15).
1.5	March 8th, 2023	
1.6	March 31th, 2023	Modified operating temperature from 85°C to 125°C (Page 10)
1.7	July 25th, 2023	Updated 5.1.1. Section (Page 16)
1.8	March 15th, 2024	Modified register 0x59 settings (Page 21, 26); Modified reserved bits in the registers based on register description; changed default from 0 to "by OTP," included 0x05, 0x0C, 0x0D, 0x4E, 0x59
1.9	June 3rd, 2024	Modified default register values (originally marked as "by OTP", now filled with the actual programmed values); Modified pin location (Page 8)
2.0	July 18th, 2024	Edited the features (Page 3); edited the slave address and INTB function (Page 6 & 8); added the time information of startup (Page 10); added the angle range (Page 13); edited the standby current consumption (Page 14); edited the dynamic range value, resolution & create the Value of Zero-Field Offset (Page 15); edited the slave address (Page 16); deleted the Register of Angle_Zero_L and Angle_Zero_H & added the of channel disable information (Page 17). Edited the description of Move_A (0x03) (Page 18); edited Angle Option (0x05) default value (Page 19); edited STAT1 (0x10) description (Page 20). Edited the Default Value of OSRCNTL_Z (0x4E) and OSRC NTL_XY (0x59) (Page 25)
2.1	August 28th, 2024	Added note in Case 1 (Page 6), Case 2 (Page 7), Case 3 (page 8) 1. VID must be powered up no later than VDD. 2. Resistor Selection: A 24 kΩ resistor is recommended. Alternatives ranging from 16 kΩ to 100 kΩ may be used, depending on customer preference and design requirements. Higher resistance values are beneficial for power saving.
2.2	September 27th, 2024	Modified the solder ball dimension in figure 2 (Page 4)
2.3	November 8th, 2024	Added packing information (Page 27); added moisture sensitivity level (MSL): 1 (Page 27)
2.4	March 25th, 2025	Edited figure 2 (Page 4), figure 3 (Page 5); edited setting for 1 KHz ODR (Page 21)