

# **IST8210S**

# **Magnetic Angle Sensor**

# **Datasheet**

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## 1. General Description

IST8210S is a digital magnetic angle sensor that employs anisotropic magnetoresistance (AMR) to detect the orientation of a magnetic field. It is an integrated chip with magnetic sensors and a control ASIC with 14-bit ADC output in  $1.6 \times 1.6 \times 1.2 \text{ mm}^3$ , 12-pin BGA package. IST8210S provides an I<sup>2</sup>C digital output with fast mode up to 400 kHz. In order to calculate absolute angles within 180 degrees, two sinusoidal output signals (Sin(2 $\theta$ ) and Cos(2 $\theta$ )) are generated to reflect the angle  $\theta$  between the sensor and direction of magnetic field. IST8210S operates in the saturation region and therefore has a high tolerance for process and temperature variations of magnet as well as PCB mounting alignment errors. Both end-of-shaft and side-shaft mounting configurations are supported. iSentek dynamic calibration algorithms are provided for users to obtain an angle error of 0.25°.

### Features

- I<sup>2</sup>C digital output with fast mode of 400 kHz.
- 14-bit resolution for absolute 180° angle detection
- 0.25° angle error with iSentek dynamic calibration algorithm
- Low current consumption of 1.3 mA
- Low suspend current consumption of 2.5  $\mu$ A
- 1000 Hz output data rate
- Operating Temperature: -40 to 85 °C
- $1.6 \times 1.6 \times 1.2 \text{ mm}^3$ , 12-pin BGA package
- RoHS, HF and TSCA compliant

### Advantages

- Non-contact and wear-free angle measurement
- Insensitive to dust, water, oil, or other contamination
- Excellent robustness against shocks and vibrations
- Constant sensitivity at an operation field higher than 320 G
- High sensitivity
- Negligible hysteresis effect

### Applications

- Angle measurement for general purposes (180° absolute)
- Incremental or absolute position detections for linear or rotational motion
- Rotational speed measurements
- Motor communication
- Industrial robotics
- Valve controllers
- Power tools

- Automatic applications

## 2. Block Diagram, Output Signal, Package Dimension and Pin

### Descriptions

#### 2.1. Block Diagram

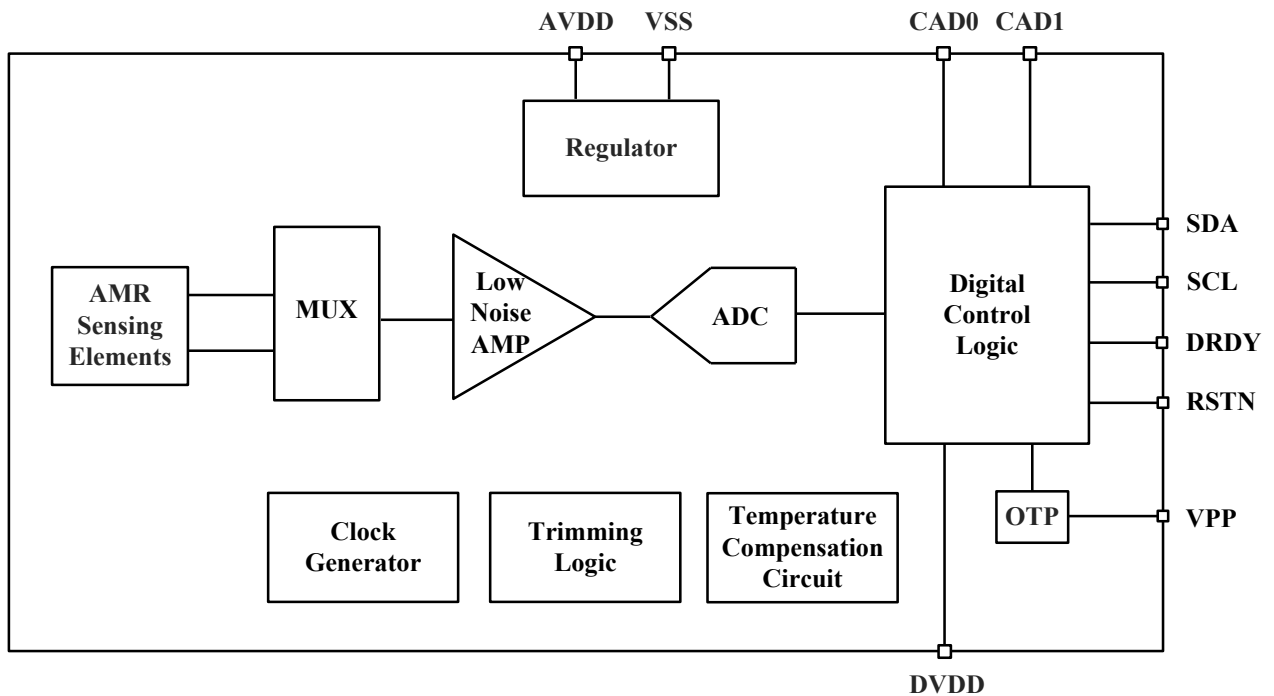


Figure 1. Block Diagram.

#### 2.2. Output Signal

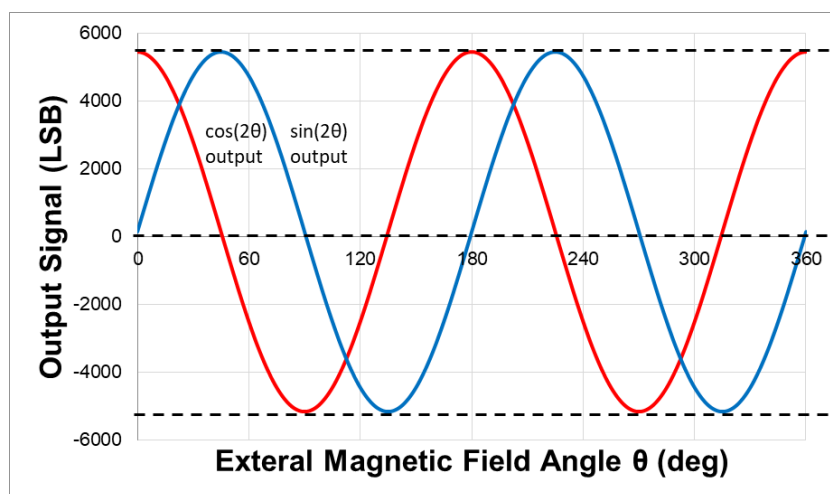
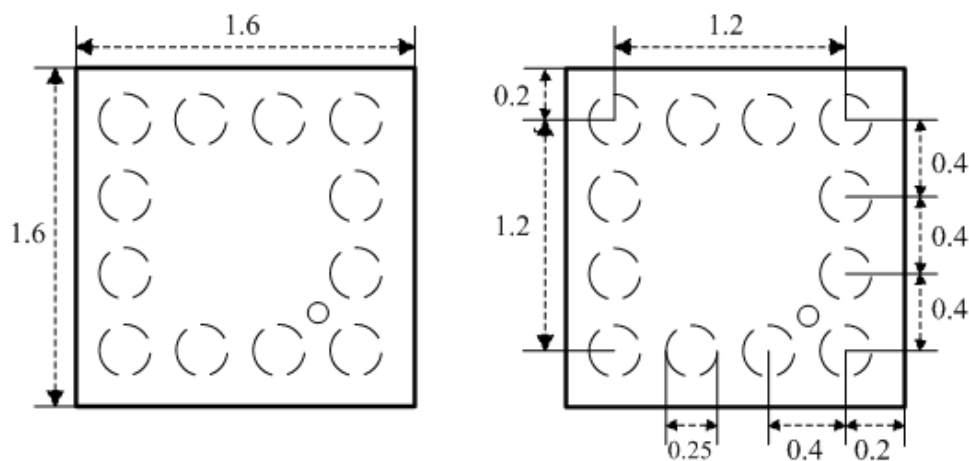


Figure 2. Sensor output as a function of angle  $\theta$

## 2.3. Package Dimensions

IST8210S BGA Top View (Looking Through)



IST8210S BGA Side View



Unit: mm

Tolerance:  $\pm 0.1$  mm

Figure 3. Package dimensions.

## 2.4. Application Circuit and Pin Description

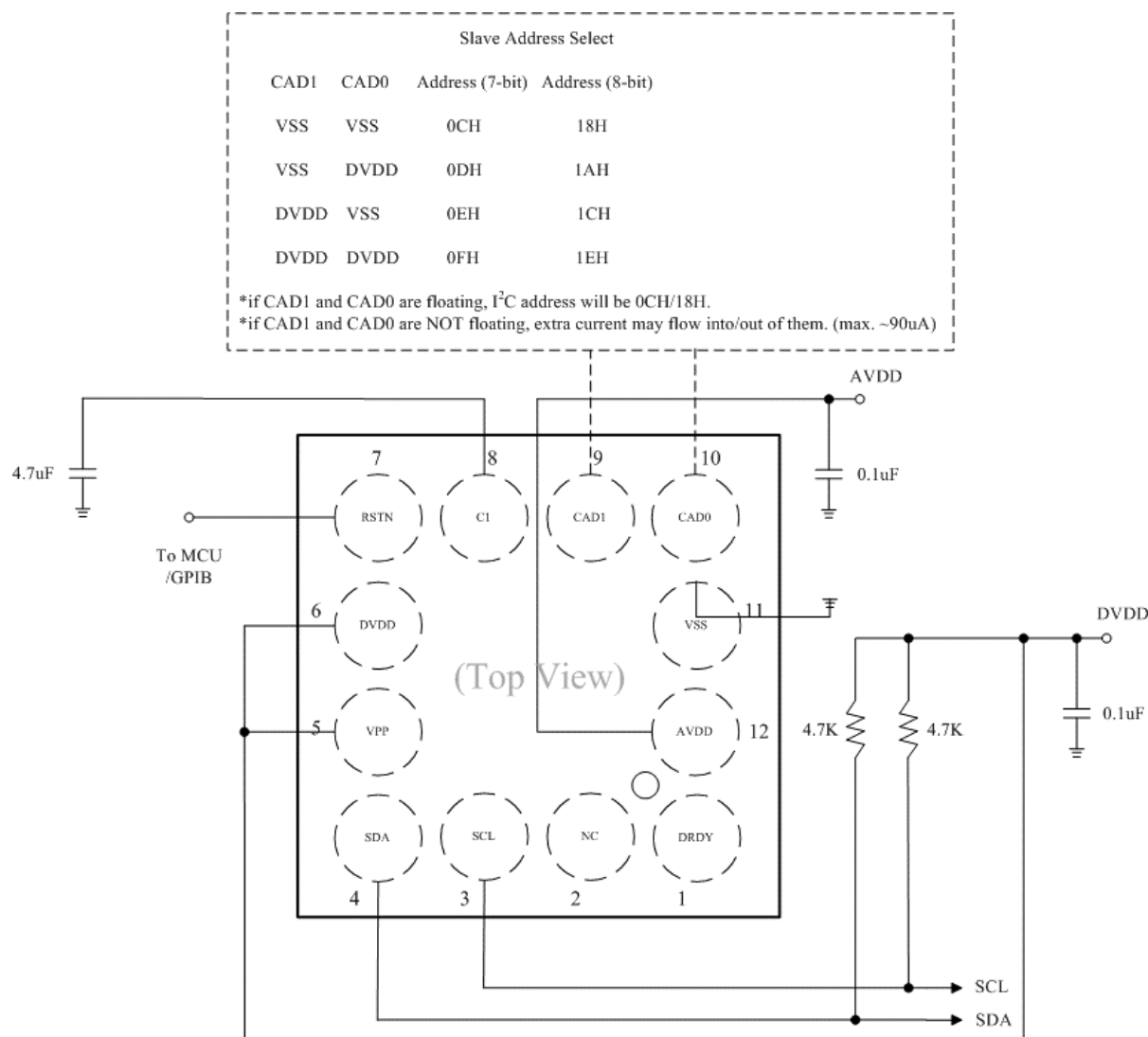


Figure 4. 12-pin BGA Package Application Circuit

Pin <sup>*1</sup>	Name	Function
1	DRDY	Data ready
2	NC	Not use
3	SCL	I <sup>2</sup> C serial clock
4	SDA	I <sup>2</sup> C serial data
5	VPP	Test pin, connect to DVDD or keep floating <sup>*2</sup>
6	DVDD	Digital supply voltage, 1.72 – 3.6 V
7	RSTN	Reset pin, resets registers by setting it to “Low”. Internally pulled to “High” for floating connection. MCU connection is suggested (but not necessary).
8	C1	Set/Reset function
9	CAD1	I <sup>2</sup> C slave address select, internally pulled to “high” by default
10	CAD0	I <sup>2</sup> C slave address select, internally pulled to “low” by default
11	VSS	GND
12	AVDD	Analog supply voltage, 2.4 – 3.6 V

<sup>\*1</sup> Please refer to Figure 4. on page 6.

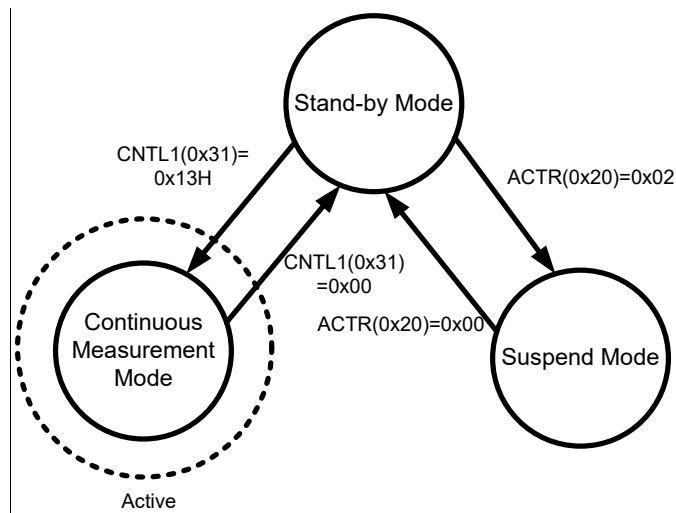
<sup>\*2</sup> Please keep CAD1 floating if VPP is floating.

## 3. Operational Modes and Functional Descriptions

### 3.1. Operation modes

IST8210S has following operation modes:

- (1) Standby Mode
- (2) Suspend Mode
- (3) Continuous Measurement Mode



#### 3.1.1. Standby Mode

The initial mode (after power on) of IST8210S is Standby Mode. In Standby Mode, all internal circuits are off (except oscillator and regulator) and all registers are accessible. The latest state of data saved in Read/Write registers is maintained. Registers can be reset by soft reset or hard reset (through RSTN pin).

#### 3.1.2. Suspend Mode

When Suspend Mode is set through ACTR(0x20), all circuits except I<sup>2</sup>C related are turned off. This is a mode with ultra-low power consumption of 2.5  $\mu$ A, Users are advised to use this mode when the system does not require IST8210S data. Users must first enter Standby Mode before using other modes.

#### 3.1.3. Continuous Measurement Mode

When Continuous Measurement Mode is set, the sensor is measured periodically at preset frequency (~ 1.3 kHz). The measured data is stored in Output Data Registers. Output Data Registers will be updated at the preset frequency with or without being read.

### 3.2. DRDY Function

DRDY function is used when the output data is updated. The DRDY pin is used to monitor the data ready output. After reading data from the output register (assume DRP bit is "1", as default setting), DRDY becomes low



## 3.3. IST8210S Read Process

(1) Read STAT register:

- Polling STAT register bit 0
- DRDY: shows if the data is ready or not
  - 0: no data ready
  - 1: data ready
- DOR: shows if any data has been skipped before the current data
  - 0: no skipped data
  - 1: data skipped.

(2) Read Measurement Data:

Read Register 0x11h ~ 0x14h for X and Y-axis data. When data reading starts, DRDY bit and DOR bit turn to "0".

## 4. Electrical and Magnetic Specifications

### 4.1. Absolute Maximum Ratings

Parameter	Symbol	Limits	Unit
Analog Supply Voltage	AVDD	-0.5 to 3.6	V
Digital Supply Voltage	DVDD	-0.5 to 3.6	V
Digital Input Voltage	VIN	-0.3 to VDD + 0.3	V
Electrostatic Discharge <sup>*1</sup>	VESD_HBM	-4000 to 4000	V
Electrostatic Discharge <sup>*2</sup>	VESD_MM	-300 to 300	V
Electrostatic Discharge <sup>*3</sup>	VESD_CDM	-700 to 700	V
Storage Temperature		-40 to 150	°C
Reflow Classification	JEDEC22-A113 with 260°C Peak Temperature		

If the device is used in conditions exceeding these limits, it may be permanently failed. Device's performance cannot be guaranteed when exceeding these limits.

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

## 4.2. Recommended Operating Conditions

Parameter	Symbol	Conditions	Min.	Typ.	Max	Unit
Analog Supply Voltage	AVDD		2.4	3.3	3.6	V
Digital Supply Voltage	DVDD		1.72	1.8	3.6	V
Operating Magnetic Field Strength	H <sub>OP</sub>	At IC's surface (middle), no upper limit.	320			G
Operating temperature	T <sub>OP</sub>		-40		85	°C

## 4.3. General Specifications

(Operating conditions: T<sub>OP</sub> = +25 °C; H<sub>op</sub> = 320 G; AVDD = 2.5 V; DVDD = 1.8 V; unless otherwise specified)

Parameter	Symbol	Conditions	Min.	Typ.	Max	Unit
Operating Current	I <sub>o</sub>	Operating at 1000 Hz		1.30		mA
Suspend Current	I <sub>suspend</sub>			2.5		μA
Resolution	RES			14		Bit
X,Y Output Range					±5300	LSB
Output Data Rate	ODR			1000	1300	Hz
Overall Calibrated Angle error	Δθ <sub>cal</sub>	Full temperature range, with iSentek dynamic calibration algorithm		0.25		Degree
Overall Un-calibrated Angle Error	Δθ <sub>u<sub>cal</sub></sub>	T = 25 °C, without iSentek dynamic calibration algorithm		1		Degree
Output Noise	Noise	RMS value		0.075		Degree
Offset		Without iSentek dynamic calibration algorithm	-115		+115	LSB
Sensitivity Temperature Coefficient	T <sub>sen</sub>	Without iSentek dynamic calibration algorithm		-0.40		%/°C

Offset Temperature Coefficient	$T_{off}$	Without iSentek dynamic calibration algorithm		$\pm 0.015$		Degree/ $^{\circ}\text{C}$
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1.  $T_{sen} = 100 \times \frac{S(T_2) - S(T_1)}{S(T_1) \cdot (T_2 - T_1)}$ , where  $T_1 = -40^{\circ}\text{C}$ , and  $T_2 = 85^{\circ}\text{C}$ .

2.  $T_{OFF} = \frac{O(T_2) - O(T_1)}{(T_2 - T_1)}$ , where  $T_1 = -40^{\circ}\text{C}$ , and  $T_2 = 85^{\circ}\text{C}$ .

## 5. IST8210S Technology Overview

### 5.1. AMR Technology

IST8210S is a high-performance anisotropy magnetoresistance (AMR) angle sensor from iSentek. AMR technology contains the following advantages:

- High sensitivity and low noise
- High resolution
- High bandwidth
- Small footprint
- Manufacturing process compatibility
- Excellent robustness
- Radiation resistance

The sensitivity of a sensing element based on AMR technology is approximately 50 to 200 times greater than that of a conventional Hall element. The high sensitivity and resolution enable exceptional performances, including high response speed, high accuracy, low noise, and low power consumption.

### 5.2. Design of IST8210S

IST8210S contains two independent (galvanically isolated) full Wheatstone bridges arranged around the geometric center of the device. Each bridge generates sinusoidal output and solely responds to the direction of the external magnetic field. The output is generated from the resistance change of the AMR resistors as the external magnetic field changes direction. The two bridges form an angle of  $45^{\circ}$ , creating a phase shift in signal, so that the function of the output would be  $\sin(2\theta)$  and  $\cos(2\theta)$ . The signal is provided via I<sup>2</sup>C bus. After arctangent conversion, the absolute angle is obtained.

Unique AMR resistors are the key to the IST8210S's superior linearity and precision. Conventional AMR resistors are typically rectangular with long axis and short axes. The magnetization of the AMR resistors rotates in response to changes in the external magnetic field. Non-uniform shape anisotropy, however, causes a distribution in magnetic polarization with rotation angle, resulting in non-linear output. This issue is effectively resolved by the IST8210S's innovative design, which achieves remarkable precision.

By combining a magnetic measuring scale with an evaluation circuit, IST8210S is able to precisely measure linear and rotary movements. IST8210S angle sensor is designed to be independent of the pole length (pitch) of the magnetic scale, providing maximum design flexibility.

### 5.3. Advantages of IST8210S

IST8210S has many advantages, including:

- High accuracy and resolution
- Outstanding bandwidth and response speed
- Low bridge offset
- Low temperature coefficient of bridge offset
- Negligible magnetic hysteresis
- Non-contact and wear-free detection
- Allowing large working distance
- Insensitive to dust, water, oil, and other contamination
- Excellent robustness against shocks and vibrations
- Low power consumption
- Wide operation temperature range
- Constant sensitivity in extreme operation fields

The great performance of IST8210S provides accurate and instantaneous control of angle, position, travel, and sensitive speed. Even with a simple evaluation circuit, the minimal bridge offset voltage and negligible magnetic hysteresis of the sensor ensure measurement precision. The low temperature coefficient of both bridge offset and sensitivity allows operation across a broad temperature range without significant accuracy loss. The non-contact nature avoids interference from the environment, such as dust, water, oil as well as from operation, such as wearing. IST8210S supports a large working distance, is resistant to shocks and vibrations, and offers flexibility for system integration in addition to excellent robustness. Distinct from conventional Hall angle sensors whose sensitivity is always proportional to the strength of the operation magnetic field, IST8210S has a constant sensitivity at an operation magnetic field that exceeds the suggested value (320 Gauss). This unique feature allows end users to use magnets with a wide range of flux density without

additional tuning of the evaluation circuits, which is usually necessary for Hall-based angle sensors.

## 6. Ordering Information

Order Number	Package Type	Packaging	Marking Information
IST8210S	BGA – 12 pin	Tape and Reel: 3k pieces per reel	X <sub>1</sub> X <sub>2</sub> X <sub>3</sub> 10● X <sub>1</sub> : Last number of the year X <sub>2</sub> X <sub>3</sub> : Week number 10: Product code of IST8210S

For more information on iSentek's magnetic sensors, please send an email to [sales@isentek.com](mailto:sales@isentek.com) or visit our website at [www.isentek.com](http://www.isentek.com).

## 7. Legal disclaimer

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