RS2110

2-Axis MEMS Accelerometer

(Preliminary)

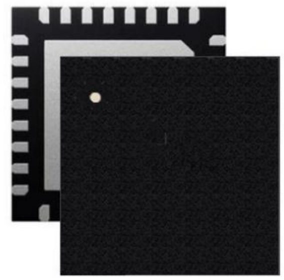
1. FEATURES

- Range： ±2g to ±16g
- Digital output： SPI/I^2C interface supported
- High resolution： 14 bits
- Bandwidth： 4 kHz
- Low noise： 50 μg/√Hz typical for x- and y-axes
- Operating temperature range： -40°C to +125°C
- Package： 5mm × 5mm × 1.2 mm QFN32

2. APPLICATIONS

- High-precision vibration measurement

3. OUTLINE



4. GENERAL DESCRIPTION

RS2110 adopts automotive-grade MEMS and ASIC processes, is compatible with mainstream devices, and has the excellent characteristics which is well suited for high-precision vibration measurement applications.

5. FUNCTIONAL BLOCK DIAGRAM

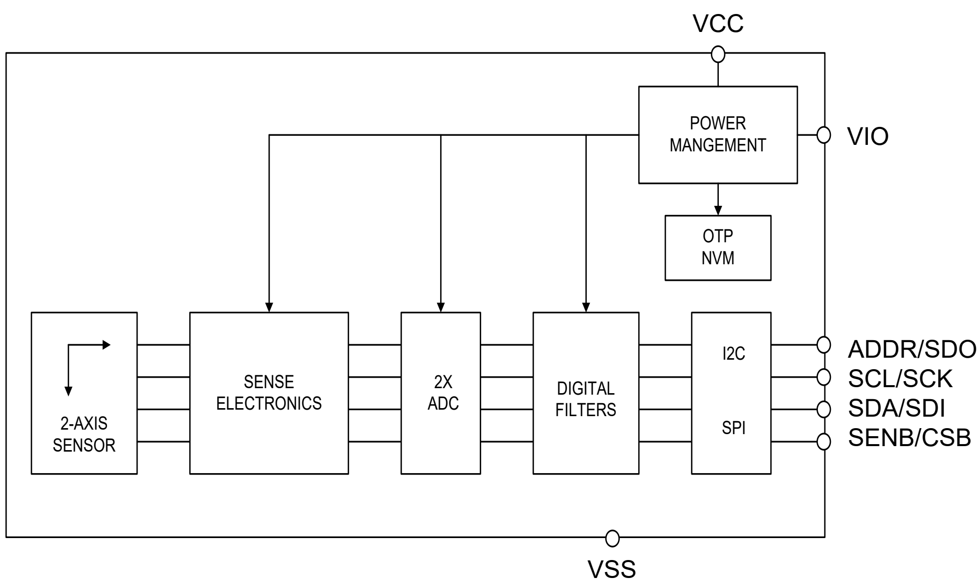


Figure 1. Functional Block Diagram

6. ABSOLUTE MAXIMUM RATINGS

Table 1.

Parameter	Rating
Mechanical Shock （Any Axis, Unpowered）	±4000 g (0.5 ms half sine)
Mechanical Shock （Any Axis, Powered）	±2000 g (0.5 ms half sine)
Supply Voltage	-0.3V to +4V
ESD (HBM)	2000 V
Latch-up Current	100 mA
Storage Temperature Range	-55℃ to +150℃
Operating Temperature Range	-40℃ to +125℃

7. SPECIFICATIONS

TA = 25 °C, VCC = 3.3 V, unless otherwise specified.

Table 2. Accelerometer Specifications Part 1

Parameter	Comments	Value	Unit
Full-scale Range		±2/±4/±6/±8/±16	g
Nonlinearity	Percentage of full-scale range	±1	% FSR
Cross Axis Sensitivity		±3	%
Sensitivity (@±16g FSR) Sensitivity (@±16g FSR) Sensitivity (@±16g FSR) Sensitivity (@±16g FSR) Sensitivity Change Due to Temperature X- and Y-Axes		4096 2048 1024 512 ±2.5	LSB/g LSB/g LSB/g LSB/g %
Resolution		14	Bits
Initial 0 g Output Deviation		<±200	mg
Frequency Response Cutoff (–3 dB) Frequency	User selectable Filters only	1.5 3 4(default)	kHz
Noise		50	μg/√Hz

Table 2. Accelerometer Specifications Part 2

Parameter	Test Conditions/ Comments	Value	Unit
Self Test Positive Output Change X- and Y-Axes Negative Output Change X- and Y-Axes	 DC self test magnitude DC self test magnitude	 6.6 -6.6	 g g
Operating Voltage		3.3	V
Regulated Input/Output Voltage		1.8	V
Supply Current		3	mA
Turn On Time		200	µs

Table 3. SPI interface characteristics

Parameter	Symbol	Min	Max	Unit
SPI Clock Period	t_{sck}	100	1000	ns
SPI Frequency	f_{sck}	1	10	MHz
CSB Setup Time	t_{sucsb}	20		ns
CSB Hold Time	t_{hcsb}	20		ns
SDI Setup Time	t_{susdi}	20		ns
SDI Sold Time	t_{hsdi}	20		ns
SDO Valid Time	t_{vdsdo}		30	ns
SDO Hold Time	t_{hsdo}	20		ns
SDO Disable Time	t_{dissdo}		10	ns

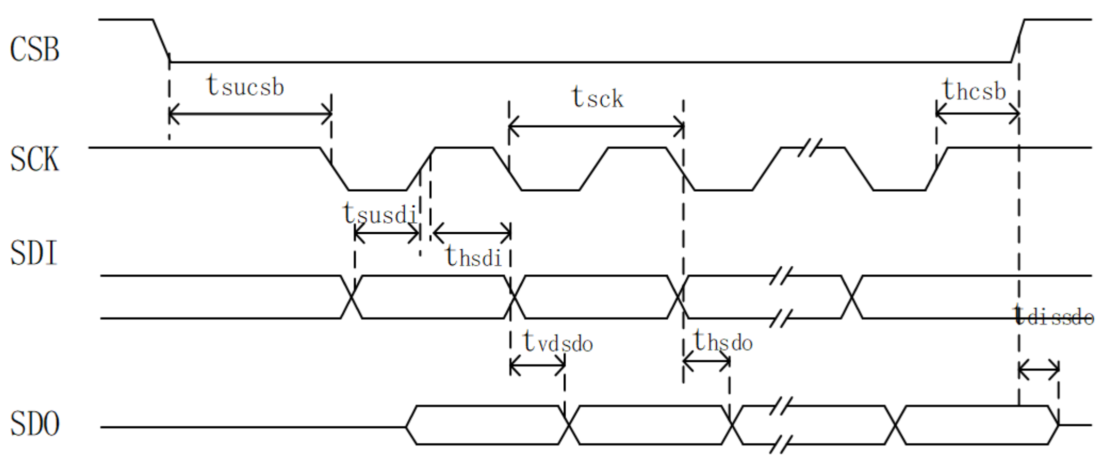


Figure 2. SPI Timming Diagram

Table 3. I²C interface characteristics

Parameter	Symbol	Min	Max	Unit
I²C Frequency	f_{sck}		1	MHz
I²C Clock Low Time	t_{low}	0.5		µs
I²C Clock High Time	t_{high}	0.5		µs
SDA Data Setup Time	t_{sudat}	150		ns
SDA Data Hold Time	t_{hdat}	0	1	µs
Repeat Start Condition Setup Time	t_{sursta}	0.5		µs
Start Condition Hold Time	t_{hsta}	0.5		µs
Stop Condition Setup Time	t_{susp}	0.5		µs

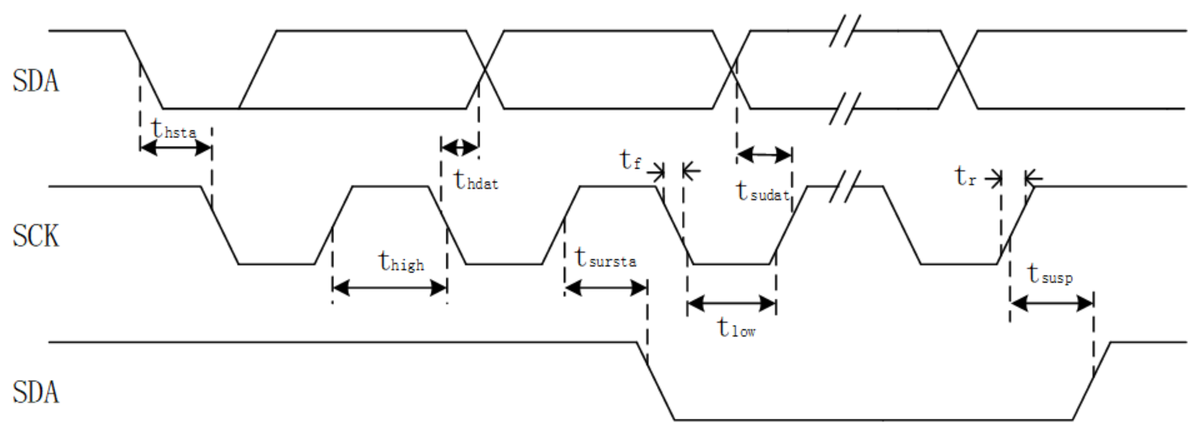


Figure 3. I²C Timming Diagram

8. PIN CONFIGURATION AND FUNCTION DESCRIPTIONS

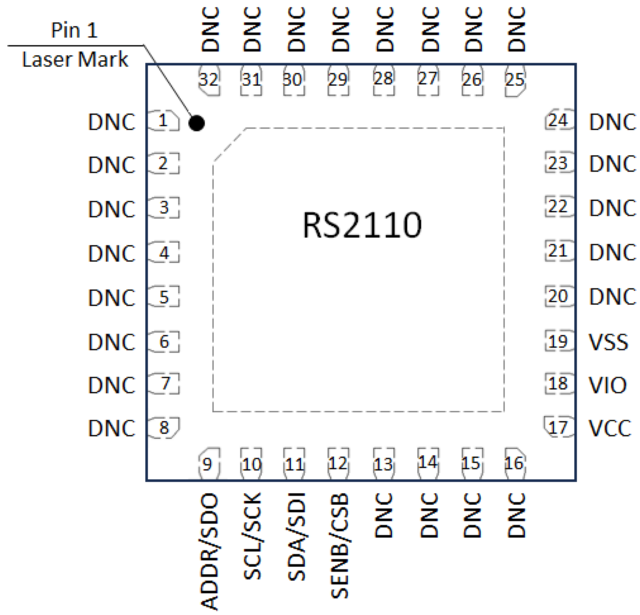


Figure 4. Pin Configuration

Table 4.

Pin No.	Mnemonic	Description
1~8	DNC	Do not connect. Do not connect these pins.
9	ADDR/SDO	I²C Address Select, serial data output in SPI.
10	SCL/SCK	I²C Serial Clock, serial clock in SPI.
11	SDA/SDI	I²C Serial Data, serial data input in SPI.
12	SENB/CSB	SPI Chip Select.
13~16	DNC	Do not connect. Do not connect these pins.
17	VCC	Supply Voltage.
18	VDD/VIO	Internal Regulator Output Voltage. Use this pin for the I²C high reference.
19	VSS	Reference Voltage. Connect this pin to ground.
20~32	DNC	Do not connect. Do not connect these pins.
	EP	Exposed Pad. The exposed pad must be connected to ground.

9. USING SELF TEST

The sensor self test is a diagnostic test. In this test, the sensor proof mass is deflected by an electrostatic force, thereby creating a measurable output change. For a self test routine to be evaluated properly, the change in output must be measured before and after applying the self test force. If this change is within the specified values shown in Table 2, it is considered successful. The RS2110 features positive and negative self test routines.

The RS2110 features a flexible self test routine to evaluate the condition of the sensors. Self test can be activated in following modes:

- Positive self test mode. In this mode, a positive dc excitation is applied to the sensor along the desired axis. This excitation is approximately 6.6 g for the x- and y-axes, plus any excitation from the environment.
- Negative self test mode. In this mode, a negative dc excitation is applied to the sensor along the desired axis. This excitation is approximately −6.6 g for the x- and y-axes, plus any excitation from the environment.

When first powering on the RS2110, the user must use the positive and negative dc self test to achieve an accurate understanding of device health. Each axis is capable of controlling its self test independently of the other axes, resulting in many combinations of self test settings. These settings are configured in the X_ST and Y_ST registers and the corresponding EN_ST_X and ST_ POL_ X bits.

The mapping of all possible settings of these bits and the resultant self test force is shown in Table 4.

Table 5. Self Test Settings Combinations

EN_ST_X	ST_ POL_ X	Self Test Force
0	0	Self test is disabled
0	1	Self test is disabled
1	0	Positive self test
1	1	Negative self test

When a self test force is exerted along any axis, the value returned from the sensor is additive with any external force applied to the accelerometer.

For simplicity, assume all axes receive the same input. The resultant measurement returned from the RS2110 after applying self test is the sine wave added to the self test excitation.

Be sure to account for gravity in self test measurements.

Taking an accurate self test measurement involves a few steps. For the two dc self test modes, the following routine must be followed to accurately assess the results of self test:

1. Ensure all self test functionality is disabled. That is, set the X_ST and Y_ST registers (Address 0x5E) to 0x00.
2. Read acceleration data for the x-axis. It is recommended to take an average of 25 ms to reduce the influence of noise in the measurement.
3. Deactivate self test by asserting the X_ST bit and wait for the output to transition to the maximum value.
4. Read acceleration data again for 25 ms.
5. Subtract the data collected in Step 2 from the data collected in Step 4 to determine the magnitude of the positive self test delta (STΔ).
6. Deactivate the ST_ POL_ X bit, and wait for the output to transition to the minimum value.
7. Read acceleration data again for 25 ms.
8. Subtract the data collected in Step 2 from the data collected in Step 7 to determine the magnitude of the negative self test delta (STΔ).
9. Compare the positive and negative STΔ magnitudes to the limits in Table 2. If both magnitudes are within the minimum and maximum specifications, the device passed the self test. Otherwise, the device failed and must be flagged for further investigation.
10. Repeat Step 1 to Step 9 for the y-axis, sequentially.

Self test must be activated one channel at a time, meaning that Step 1 to Step 9 must be repeated for the x-, y-axis channels, sequentially.

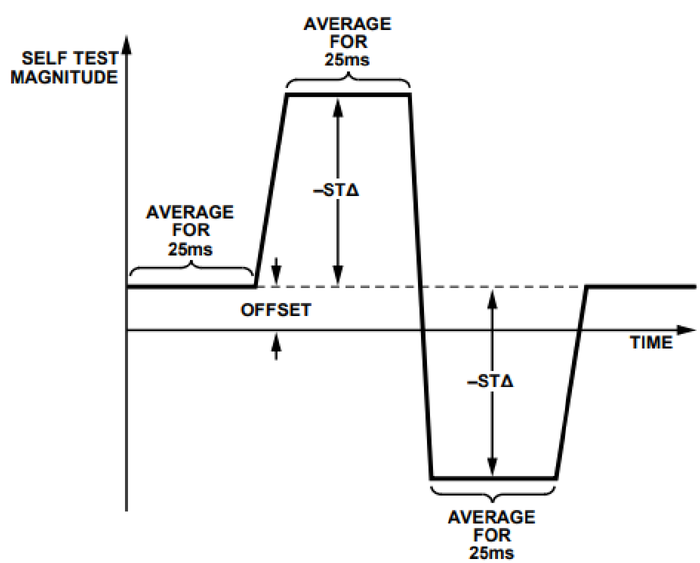


Figure 5. DC Self Test Measurement

10. SERIAL COMMUNICATIONS

The RS2110 communicates via both 4-wire SPI and 2-wire I^{2}C digital communication interfaces.

SPI INTERFACE

Wire the RS2110 for SPI communication as shown in the connection diagram in Figure 6.

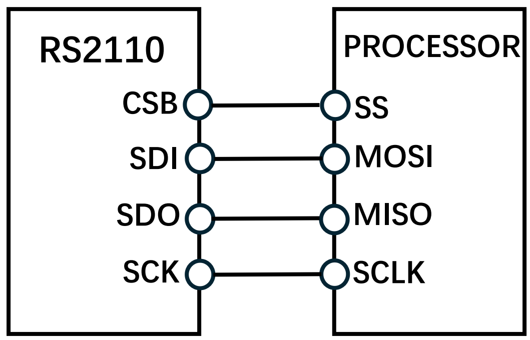


Figure 6. 4-Wire SPI Connection

I^{2}C INTERFACE

The I^{2}C interface of RS2110 is a slave bus. There are two signals associated with the I^{2}C bus: the serial clock SCL and serial data SDA. The SDA is a bi-directional line used to send or receive data from the interface. Both lines must be connected to VDDIO through external pull-up resistors.
The default I^{2}C address of RS2110 is 0b1010011. It is used if the ADDR pin is pulled to ’GND’. The alternative address 0b0011101 is selected by pulling ADDR to ’VDDIO’.
The I^{2}C bus is implemented with both fast mode (400 kHz) and standard mode.
Data transfer with acknowledge is mandatory. The transmitter must release the SDA line during the acknowledge pulse. The receiver then must pull the SDA line ’low’ so it remains low during the high period of the acknowledge clock pulse. A receiver which has been addressed is obliged to generate an acknowledge after each byte of data received.
The transaction begins with a start (ST) condition generated by master, followed by 7 bits slave address (SAD) and 1 read/write bit, then the master sends the one byte register address (RAD). If it is a read operation, a repeated start (SR) condition must be issued after the register address byte. If it is a write operation, the master will transmit data which will be written into the register addressed by register address byte. The slave sends out slave acknowledge condition (ACK) after the slave address issued by master matches its slave address, and after master sends out register address and receives data byte written by master. The master must assert master acknowledge condition (MACK) after receives data from slave.
Data are transferred in byte format with MSB sent out first. The number of bytes transferred is unlimited until no master acknowledge (MNACK) condition asserted by master for read operation, or when master issues stop condition for write operation.

Table 6. I²C Single Byte Write

Master	ST	SAD+W		RADR		DATA		SP
Slave			ACK		ACK		ACK	

Table 7. I²C Single Byte Read

Master	ST	SAD+W		RADR		RS	SAD+R			MNACK	SP
Slave			ACK		ACK			ACK	DATA		

Table 8. I²C Multiple Byte Write

Master	ST	SAD+W		RADR		DATA		DATA		SP
Slave			ACK		ACK		ACK		ACK	

Table 9. I²C Multiple Byte Read

Master	ST	SAD+W		RADR		RS	SAD+R			MACK		MNACK	SP
Slave			ACK		ACK			ACK	DATA		DATA		

11. AXES OF ACCELERATION SENSITIVITY

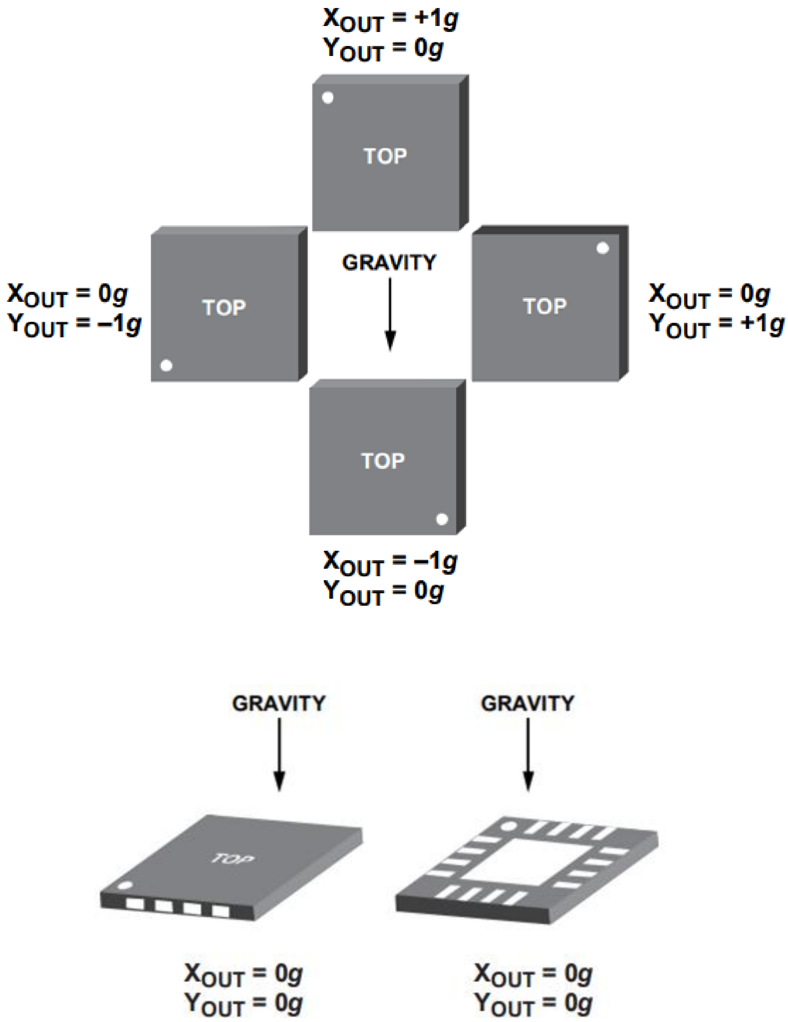


Figure 7. Output Response vs. Orientation to Gravity

12. PACKAGE DIMENSIONS

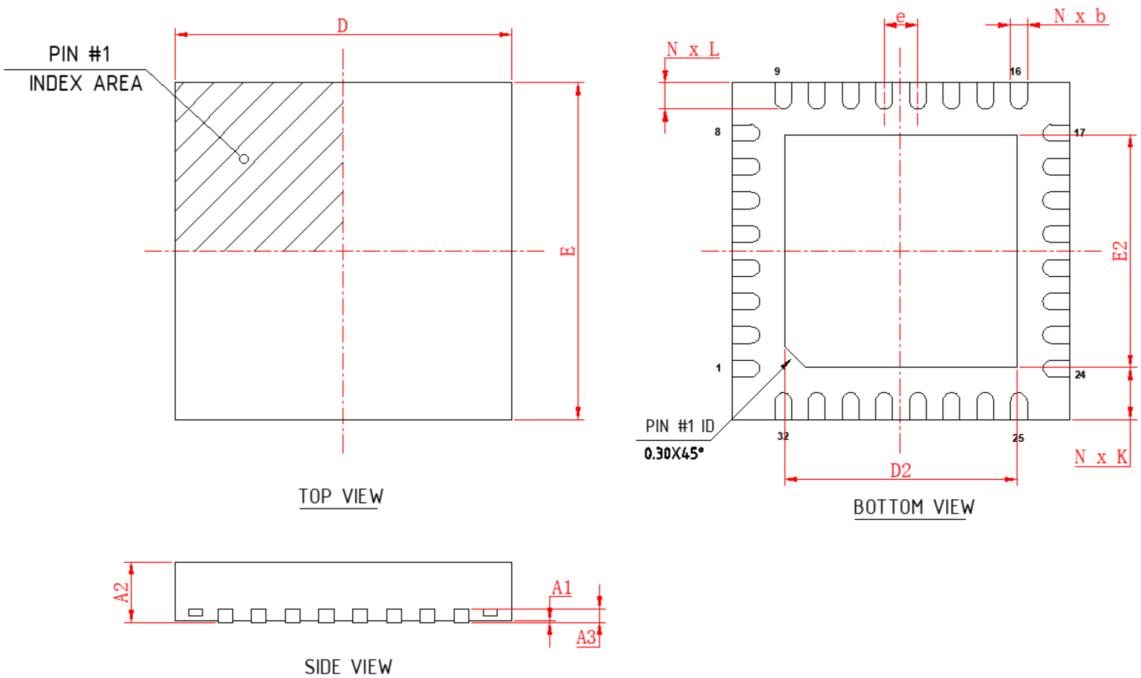


Figure 8. 32-Lead Frame Chip Scale Package

Table 10

Symbol	Min	Mid	Max
A1	0.00	0.02	0.05
A2	1.1	1.2	1.3
A3		0.20 REF	
b	0.18	0.25	0.30
D	4.95	5.00	5.05
E	4.95	5.00	5.05
e		0.50BSC	
D2	3.30	3.45	3.55
E2	3.30	3.45	3.55
K		0.20 REF	
L	0.30	0.40	0.50
N		32	

Note:

1. All dimensions are in mm.
2. The dimension is influenced by the molding film. Since it is impossible to predict the local film stretch condition, the values here should be considered as “Target” only.