LIS352AX

MEMS inertial sensor
3-axis - ±2g absolute analog output accelerometer

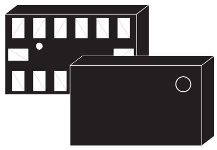
Preliminary Data

Features

- Absolute 0-g level and sensitivity
- Very high stability over temperature
- 3 acceleration channels plus multiplexed analog output
- Factory trimmed device sensitivity and 0-g level
- Power-down mode
- Embedded self test
- 10000g high shock survivability
- ECOPACK® RoHS and “Green” compliant (see *Section 5*)

Applications

- Free-fall detection for data protection
- Mobile and battery operated terminals
- Gaming and virtual reality input devices
- Antitheft systems and inertial navigation



LGA14 (3x5x0.9mm)

Description

The LIS352AX is the new small size, low-power three-axis linear accelerometer that includes a sensing element and an IC interface able to provide an absolute analog signal to the external world.

The IC interface is manufactured using a CMOS process that allows high level of integration to design a dedicated circuit which is trimmed to better match the sensing element characteristics.

The LIS352AX has a full scale of ±2g and it is capable of measuring accelerations over a maximum bandwidth of 2.0 kHz. The device bandwidth may be reduced by using external capacitances.
The self-test capability allows the user to check the functioning of the system.

An embedded multiplexer allows to redirect the analog outputs onto a single pin for operation with a single channel A/D converter.

ST is already in the field with several hundreds million sensors with excellent acceptance from the market in terms of quality, reliability and performance.

The LIS352AX is provided in plastic land grid array (LGA) package.
Several years ago ST pioneered successfully the usage of this package for accelerometers. Today ST has the widest manufacturing capability and strongest expertise in the world for production of sensor in plastic LGA package.

Table 1. Device summary

Order codes	Temperature range, °C	Package	Packing
LIS352AX	-40°C to +85°C	LGA-14	Tray
LIS352AXTR	-40°C to +85°C	LGA-14	Tape and reel (16mm, pitch 0.8mm)

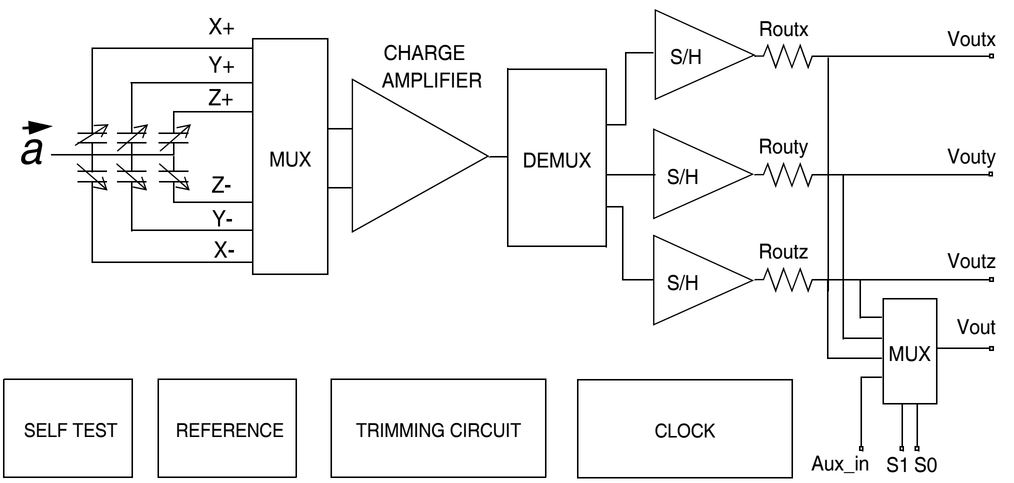
This is preliminary information on a new product now in development or undergoing evaluation. Details are subject to change without notice.

Contents

1 Block diagram and pin description

1.1 Block diagram

Figure 1. Block diagram



1.2 Pin description

Figure 2. Pin connection

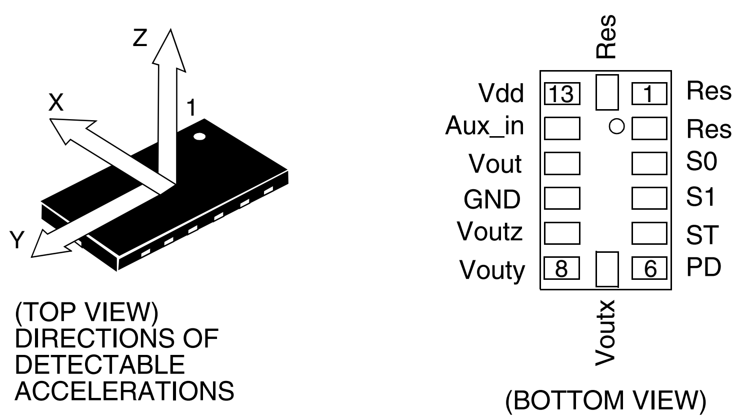


Table 2. Pin description

Pin #	Pin name	Function
1	Reserved	Connect to GND
2	Reserved	Connect to Vdd
3	S0	Mux selector 0 (connect to Vdd or to GND)
4	S1	Mux selector 1 (connect to Vdd or to GND)
5	ST	Self Test (logic 0: normal mode; logic 1: Self-test)
6	PD	Power Down (logic 0: normal mode; logic 1: Power-Down mode)
7	Voutx	Output Voltage X channel
8	Vouty	Output Voltage Y channel
9	Voutz	Output Voltage Z channel
10	GND	0V supply
11	Vout	Multiplexer output
12	Aux_in	Auxiliary input
13	Vdd	Power supply
14	Reserved	Connect to Vdd

2 Mechanical and electrical specifications

2.1 Mechanical characteristics

@ T = 25 °C unless otherwise noted

Table 3. Mechanical characteristics (1)

Symbol	Parameter	Test condition	Min.	Typ.(2)	Max.	Unit
Ar	Acceleration range(3)			±2.0		g
So	Sensitivity(4)		0.363 - 5%	0.363	0.363 + 5%	V/g
SoDr	Sensitivity change vs. Temperature	Delta from +25°C		±0.01		%/°C
Voff	Zero-g level(4)	T = 25°C	1.25 - 6%	1.25	1.25 + 6%	V
OffDr	Zero-g level change Vs Temperature	Delta from +25°C		±0.3		mg/°C
NL	Non linearity(5)	Best fit straight line		±0.5		% FS
CrossAx	Cross-axis(6)			±2		%
An	Acceleration noise density	Vdd=3.3V		100		$\mu g/\sqrt{Hz}$
Vt	Self test output voltage change(7)	T = 25°C X axis		+210		mV
		T = 25°C Y axis		+210		mV
		T = 25°C Z axis		+290		mV
Fres	Sensing element resonant frequency(8)	X, Y, Z axis	2.0			kHz
Top	Operating temperature range		-40		+85	°C
Wh	Product Weight			30		mgram

1. Product is factory calibrated at 3.3 V
2. Typical specifications are not guaranteed
3. Guaranteed by wafer level test and measurement of initial offset and sensitivity
4. Zero-g level and sensitivity are not ratiometric to supply voltage
5. Guaranteed by design
6. Contribution to the measuring output of an inclination/acceleration along any perpendicular axis
7. “Self test output voltage change” is defined as $Vout_{(Vst=Logic1)}-Vout_{(Vst=Logic0)}$
8. Minimum resonance frequency Fres=2.0 kHz. Sensor bandwidth=1/(2*π*32 kΩ*Cload), with Cload>2.5 nF

2.2 Electrical characteristics

@ T = 25°C unless otherwise noted

Table 4. Electrical characteristics [1]

Symbol	Parameter	Test condition	Min.	Typ.[2]	Max.	Unit
Vdd	Supply voltage		2.16	3.3	3.6	V
Idd	Supply current	Mean value PD pin connected to GND		0.3		mA
IddPdn	Supply current in power-down mode	PD pin connected to Vdd		1		µA
Vst	Self test input	Logic 0 level	0		0.2*Vdd	V
		Logic 1 level	0.8*Vdd		Vdd	V
Vs0	S0 input	Logic 0 level	0		0.2*Vdd	V
		Logic 1 level	0.8*Vdd		Vdd	V
Vs1	S1 input	Logic 0 level	0		0.2*Vdd	V
		Logic 1 level	0.8*Vdd		Vdd	V
Rout	Output impedance of Voutx, Vouty, Voutz			32		kΩ
Cload	Capacitive load drive for Voutx, Vouty, Voutz[3]		2.5			nF
Rmux	Series resistance of multiplexer input vs. Vout			1		kΩ
Cloadmux	Capacitive load drive for multiplexed output Vout			10		pF
Ton	Turn-on time at exit from Power-down mode	Cload in µF		160*Cload+0.3		ms

1. Product is factory calibrated at 3.3 V
2. Typical specifications are not guaranteed
3. Minimum resonance frequency Fres=2.0 kHz. Device bandwidth=1/(2*π*32 kΩ*Cload), with Cload>2.5 nF

2.3 Absolute maximum ratings

Stresses above those listed as “Absolute maximum ratings” may cause permanent damage to the device. This is a stress rating only and functional operation of the device under these conditions is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.

Table 5. Absolute maximum ratings

Symbol	Ratings	Maximum value	Unit
Vdd	Supply voltage	-0.3 to 6	V
Vin	Input voltage on any control pin (PD, ST, S0, S1)	-0.3 to Vdd +0.3	V
V_{Aux_in}	Aux_in input voltage	-0.3 to Vdd +0.3	V
A_{POW}	Acceleration (any axis, powered, Vdd=3.3V)	3000g for 0.5 ms	
		10000g for 0.1 ms	
A_{UNP}	Acceleration (any axis, not powered)	3000g for 0.5 ms	
		10000g for 0.1 ms	
T_{STG}	Storage temperature range	-40 to +125	°C

This is a mechanical shock sensitive device, improper handling can cause permanent damages to the part

This is an ESD sensitive device, improper handling can cause permanent damages to the part

2.4 Terminology

Sensitivity describes the gain of the sensor and can be determined by applying 1g acceleration to it. As the sensor can measure DC accelerations this can be done easily by pointing the axis of interest towards the center of the Earth, note the output value, rotate the sensor by 180 degrees (point to the sky) and note the output value again thus applying ±1g acceleration to the sensor. Subtracting the larger output value from the smaller one, and dividing the result by 2, will give the actual sensitivity of the sensor. This value changes very little over temperature (see Sensitivity change vs. temperature) and also very little over time. The Sensitivity tolerance describes the range of Sensitivities of a large population of sensors.

Zero-g level describes the actual output signal if there is no acceleration present. A sensor in a steady state on a horizontal surface will measure 0g in X axis and 0g in Y axis whereas the Z axis will measure ±1g. A deviation from ideal 0-g level (1250mV in this case) is called Zero-g offset. Offset of precise MEMS sensors is to some extend a result of stress to the sensor and therefore the offset can slightly change after mounting the sensor onto a printed circuit board or exposing it to extensive mechanical stress. Offset changes little over temperature - see “Zero-g level change vs. temperature” - the Zero-g level of an individual sensor is very stable over lifetime. The Zero-g level tolerance describes the range of Zero-g levels of a population of sensors.

Self test allows to test the mechanical and electrical part of the sensor, allowing the seismic mass to be moved by means of an electrostatic test-force. The self test function is off when the ST pin is connected to GND. When the ST pin is tied at Vdd an actuation force is applied to the sensor, simulating a definite input acceleration. In this case the sensor outputs will exhibit a voltage change in their DC levels. When ST is activated, the device output level is given by the algebraic sum of the signals produced by the acceleration acting on the sensor and by the electrostatic test-force. If the output signals change within the amplitude specified inside *Table 3*, then the sensor is working properly and the parameters of the interface chip are within the defined specification.

Output impedance describes the resistor inside the output stage of each channel. This resistor is part of a filter consisting of an external capacitor of at least 2.5 nF and the internal resistor. Due to the resistor level, only small inexpensive external capacitors are needed to generate low corner frequencies. When interfacing with an ADC it is important to use high input impedance input circuitries to avoid measurement errors. Note that the minimum load capacitance forms a corner frequency close to the resonance frequency of the sensor. In general the smallest possible bandwidth for a particular application should be chosen to get the best results.

3 Functionality

The LIS352AX is an ultra compact low-power, analog output three-axis linear accelerometer packaged in a LGA package. The complete device includes a sensing element and an IC interface able to take the information from the sensing element and to provide an analog signal to the external world.

3.1 Sensing element

A proprietary process is used to create a surface micro-machined accelerometer. The technology allows to carry out suspended silicon structures which are attached to the substrate in a few points, called anchors, and are free to move in the direction of the sensed acceleration. To be compatible with the traditional packaging techniques a cap is placed on top of the sensing element to avoid blocking the moving parts during the moulding phase of the plastic encapsulation.

When an acceleration is applied to the sensor the proof mass displaces from its nominal position, causing an imbalance in the capacitive half-bridge. This imbalance is measured using charge integration in response to a voltage pulse applied to the sense capacitor.

At steady state the nominal value of the capacitors are few pF and when an acceleration is applied the maximum variation of the capacitive load is in fF range.

3.2 IC interface

The complete signal processing uses a fully differential structure, while the final stage converts the differential signal into a single-ended one to be compatible with the external world.

The first stage is a low-noise capacitive amplifier that implements a correlated double sampling (CDS) at its output to cancel the offset and the 1/f noise. The produced signal is then sent to three different S&Hs, one for each channel, and made available to the outside.

The device provides an embedded multiplexer to allow the redirection of either the analog output signals Voutx, Vouty, and Voutz or of an auxiliary input signal onto a single pin for operation with a single channel A/D converter.

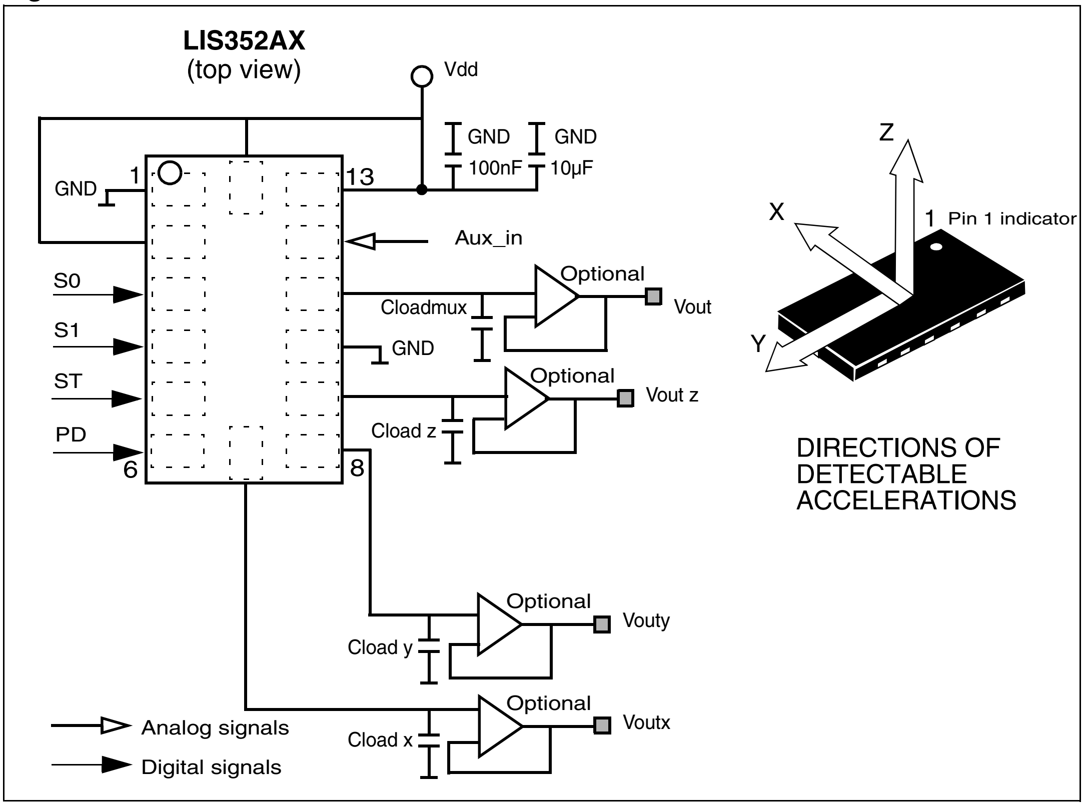
All the analog parameters (output offset voltage and sensitivity) are absolute with respect to the voltage supply. Increasing or decreasing the voltage supply, the sensitivity and the offset will not change. The feature allows the coupling of the sensor with an ADC having a fixed voltage reference independent from Vdd.

3.3 Factory calibration

The IC interface is factory calibrated for sensitivity (So) and Zero-g level (Voff).
The trimming values are stored inside the device in a non volatile structure. Any time the device is turned on, the trimming parameters are downloaded into the registers to be employed during the normal operation. This allows the user to employ the device without further calibration.

4 Application hints

Figure 3. LIS352AX electrical connection



Power supply decoupling capacitors (100 nF ceramic or polyester + 10 µF Aluminum) should be placed as near as possible to the device (common design practice).

The LIS352AX allows to band limit Voutx, Vouty and Voutz through the use of external capacitors. The recommended frequency range spans from DC up to 2.0 kHz. Capacitors must be added at output pins to implement low-pass filtering for antialiasing and noise reduction, even if the only multiplexed output (*Vout*) is used. The equation for the cut-off frequency (f_t) of the external filters is:

Equation 1

$$f_t = \frac{1}{2\pi \cdot R_{out} \cdot C_{load}(x,\ y,\ z)}$$

Taking into account that the internal filtering resistor (R_{out}) has a nominal value equal to 32 kΩ, the equation for the external filter cut-off frequency may be simplified as follows:

Equation 2

$$f_t = \frac{5\mu F}{C_{load}(x,\ y,\ z)}[Hz]$$

The tolerance of the internal resistor can vary typically of ±20% within its nominal value of 32 kΩ; thus the cut-off frequency will vary accordingly. A minimum capacitance of 2.5 nF for C_{load}(x, y, z) is required in any case.

An external capacitor can be added to the Vout pin. Values below 10 pF are recommended.

Table 6. Filter capacitor selection, C_{load} (x,y,z)

Cut-off frequency	Capacitor value
1 Hz	5 µF
10 Hz	0.5µF
20 Hz	250nF
50 Hz	100nF
100 Hz	50nF
200 Hz	25nF
500 Hz	10nF

Table 7. MUX I/O table

S1 pin	S0 pin	MUX status
0	0	Vout=Voutx
0	1	Vout=Vouty
1	0	Vout=Voutz
1	1	Vout=Aux_in

4.1 Soldering information

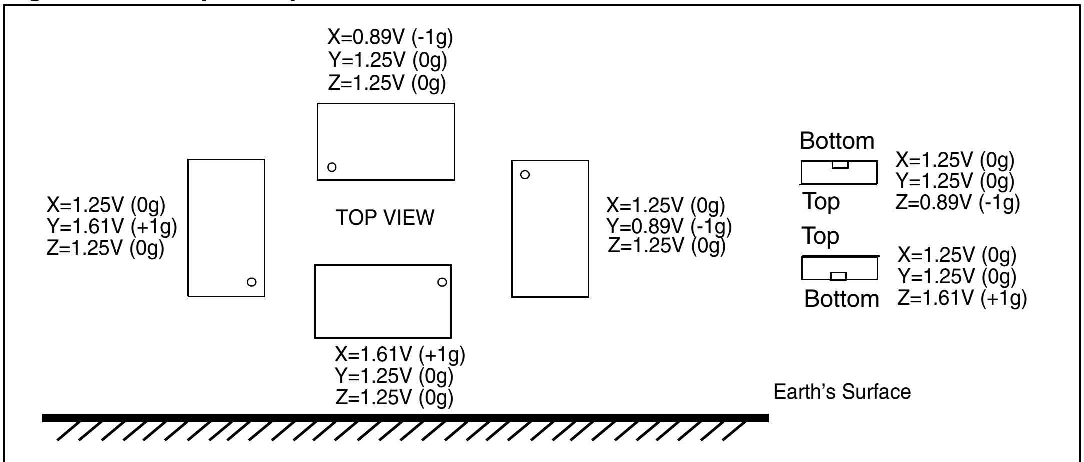
The LGA package is compliant with the ECOPACK®, RoHs and "Green" standard.
It is qualified for soldering heat resistance according to JEDEC J-STD-020C.

Leave "Pin 1 Indicator" unconnected during soldering.

Land pattern and soldering recommendations are available at www.st.com/.

4.2 Output response vs. orientation

Figure 4. Output response vs. orientation



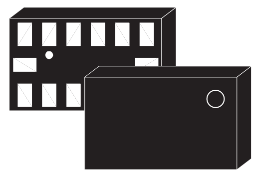
5 Package information

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK® packages, depending on their level of environmental compliance. ECOPACK® specifications, grade definitions and product status are available at: www.st.com. ECOPACK is an ST trademark.

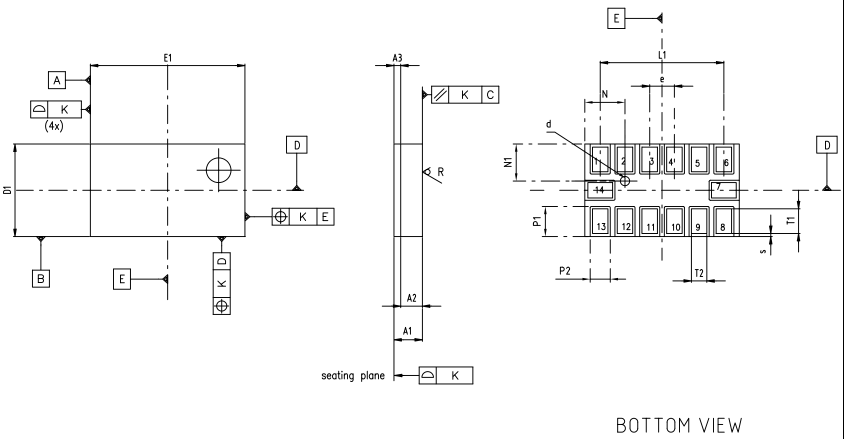
Figure 5. LGA 14: mechanical data and package dimensions

DIM.	mm			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A1		0.920	1.000		0.0362	0.0394
A2			0.700			0.0275
A3	0.180	0.220	0.260	0.0071	0.0087	0.0102
D1	2.850	3.000	3.150	0.1122	0.1181	0.1240
E1	4.850	5.000	5.150	0.1909	0.1968	0.2027
e		0.800			0.0315	
d		0.300			0.0118	
L1		4.000			0.1575	
N		1.360			0.0535	
N1		1.200			0.0472	
P1	0.965	0.975	0.985	0.0380	0.0384	0.0386
P2	0.640	0.650	0.660	0.0252	0.0256	0.0260
T1	0.750	0.800	0.850	0.0295	0.0315	0.0335
T2	0.450	0.500	0.550	0.0177	0.0197	0.0217
R	1.200		1.600	0.0472		0.0630
h		0.150			0.0059	
k		0.050			0.0020	
i		0.100			0.0039	
s		0.100			0.0039	

OUTLINE AND MECHANICAL DATA



LGA14 (3x5x0.92mm) Pitch 0.8mm Land Grid Array Package



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6 Revision history

Table 8. Document revision history

Date	Revision	Changes
26-Mar-2009	1	Initial release

STMicroelectronics group of companies

Australia - Belgium - Brazil - Canada - China - Czech Republic - Finland - France - Germany - Hong Kong - India - Israel - Italy - Japan - Malaysia - Malta - Morocco - Singapore - Spain - Sweden - Switzerland - United Kingdom - United States of America

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