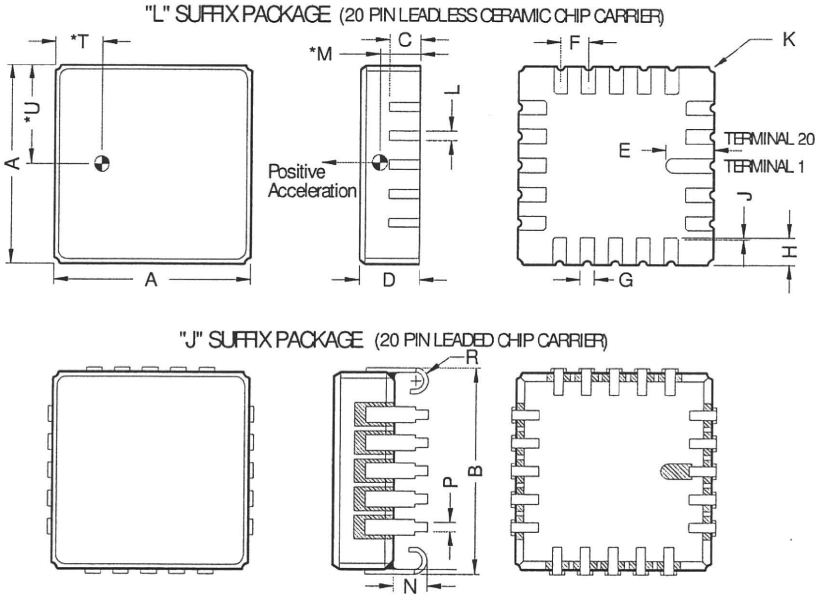
BIAS STABILITY CONSIDERATIONS

Bias temperature hysteresis can be minimized by temperature cycling your model 1221 accelerometer after it has been soldered to your circuit board. If possible, the assembled device should be exposed to ten cycles from -40 to +85°C minimum (-55 to +125°C recommended). The orientation to the Earth's gravitational field during temperature cycling should preferably be in the same orientation as it will be in the final application. The accelerometer does not need to have power applied during this temperature cycling.

PACKAGE DIMENSIONS



DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.342	0.358	8.69	9.09
B	0.346	0.378	8.79	9.60
C	0.055 TYP		1.40 TYP	
D	0.095	0.115	2.41	2.92
E	0.085 TYP		2.16 TYP	
F	0.050 BSC		1.27 BSC	
G	0.025 TYP		0.64 TYP	
H	0.050 TYP		1.27 TYP	
J	0.004 x 45°		0.10 x 45°	
K	0.010 RTYP		0.25 RTYP	
L	0.016 TYP		0.41 TYP	
* M	0.048 TYP		1.23 TYP	
N	0.050	0.070	1.27	1.78
P	0.017 TYP		0.43 TYP	
R	0.023 RTYP		0.58 RTYP	
* T	0.085 TYP		2.16 TYP	
* U	0.175 TYP		4.45 TYP	

NOTES: 1. * DIMENSIONS 'M', 'T' & 'U' LOCATE ACCELERATION SENSING ELEMENT'S CENTER OF MASS.
2. LID IS ELECTRICALLY TIED TO TERMINAL 19 (GND).
3. CONTROLLING DIMENSION: INCH.
4. TERMINALS ARE PLATED WITH 60 MICRO-INCHES MIN GOLD OVER 80 MICRO-INCHES MIN NICKEL. (THIS PLATING SPECIFICATION DOES NOT APPLY TO THE METALLIZED PIN-1 IDENTIFIER MARK ON THE BOTTOM OF THE J-LEAD VERSION OF THE PACKAGE).
5. PACKAGE: 90% MINIMUM ALUMINA (BLACK), LID: SOLDER SEALED KOVAR.

SOLDERING RECOMMENDATIONS:

RoHS Compliance: The model 1221 does not contain elemental lead and is RoHS compliant.

WARNING: If no-lead solder is to be used to attach the device, we do not recommend the use of reflow soldering methods such as vapor phase, solder wave or hot plate. These methods impart too much heat for too long of a period of time and may cause excessive bias shifts. For no-lead soldering, we only recommend the manual "Solder Iron Attach" method (listed on the next page of this data sheet). We also do not recommend the use of ultrasonic bath cleaners because these models contain internal gold wires that are thermo sonically bonded.

Reflow of Sn62 or Sn63 type solder using a hotplate is the preferred method for assembling the model 1221 surface mount accelerometer to your Printed circuit board. Hand soldering using a fine tipped soldering iron is possible but difficult without a steady hand and some form of visual magnification due to the small size of the connections. When using the hand solder iron method, it's best to purchase the J-Leaded version (1221J) for easier visual

inspection of the finished solder joints.

Pre-Tinning of Accelerometer Leads is Recommended: To prevent gold migration embrittlement of the solder joints, it is best to pre-tin the accelerometer leads. We recommend tinning one lead at a time, to prevent excessive heating of the accelerometer, using a fine-tipped solder iron and solder wire. The solder bath method of pre-tinning is not recommended due to the high degree of heat the interior of the device gets subjected to which may cause permanent shifts in the bias and/or scale factor.

Hotplate Attach Method using Solder Paste or Solder Wire: Apply solder to the circuit board's pads using Sn62 or Sn63 solder paste or pre-tin the pads using solder and a fine tipped soldering iron. If pre-tinning with an iron, apply flux to the tinned pads prior to placing the components. Place the accelerometer in its proper position onto the pasted or tinned pads then place the entire assembly onto a hotplate that has been pre-heated to 250°C. Leave on hotplate only long enough for the solder to flow on all pads **(DO NOT OVERHEAT!)**

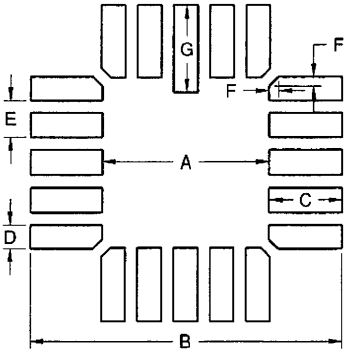
Solder Iron Attach Method using Solder Paste: Apply solder paste to the circuit board's pads where the accelerometer will be attached. Place the accelerometer in its proper position onto the pasted pads. Press gently on the top of the accelerometer with an appropriate tool to keep it from moving and heat one of the corner pads, then an opposite corner pad with the soldering iron. Make sure the accelerometer is positioned so all 20 of its connections are centered on the board's pads. Once the two opposite corner pads are soldered, the part is secure to the board and you can work your way around soldering the remaining 18 connections. Allow the accelerometer to cool in between soldering each pin to prevent overheating.

Solder Iron Attach Method using Solder Wire: Solder pre-tin two opposite corner pads on the circuit board where the accelerometer will be attached. Place the accelerometer in its proper position onto the board. Press gently on the top of the accelerometer and heat one of the corner pads that was tinned and the part will drop down through the solder and seat on the board. Do the same at the opposite corner pad that was tinned. Make sure the accelerometer is positioned so all 20 of its connections are centered on the board's pads. Once the two opposite corner pads are soldered, the part is secure to the board and you can work your way around soldering the remaining 18 connections. Allow the accelerometer to cool in between soldering each pin to prevent overheating.

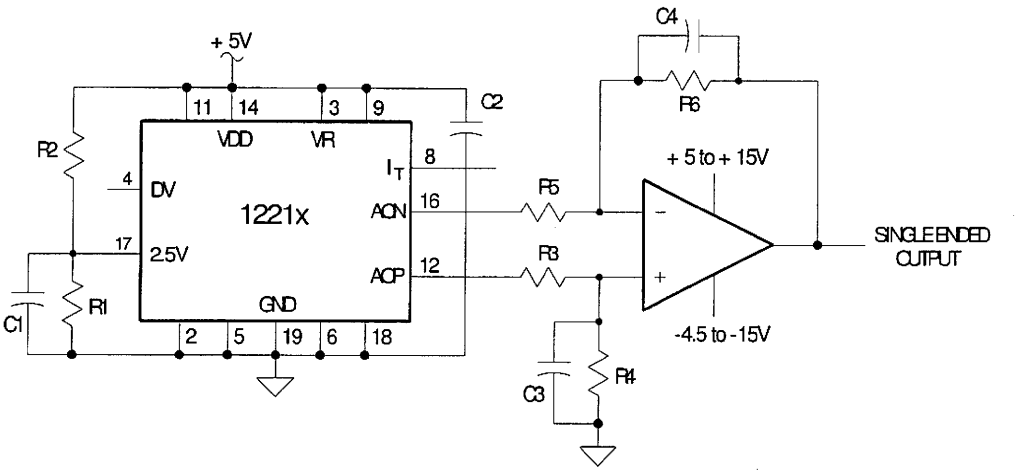
LCC & JLCC Solder Contact Plating Information: The plating composition and thickness for the solder pads and castellations on the "L" suffix (LCC) package are 60 to 225 micro-inches thick of gold (Au) over 80 to 350 micro-inches thick of nickel (Ni) over a minimum of 5 micro-inches thick of moly-manganese or tungsten refractory material. The leads for the "J" suffix (JLCC) package are made of an Iron-Nickel sealing alloy and have the same gold over nickel plating thicknesses as for the LCC pads.

Recommended Solder Pad Pattern: The recommended solder pad size and shape for both the LCC and J-LCC packages is shown in the diagram and table below. These dimensions are recommendations only and may or may not be optimum for your particular soldering process.

DIM	inch	mm
A	.230	5.84
B	.430	10.92
C	.100	2.54
D	.033	0.84
E	.050	1.27
F	.013	0.33
G	.120	3.05



OPTIONAL: ADDING A SINGLE ENDED OUTPUT



R1 = R2 = 5.00K ±0.5% for precision 2.50V ref.	R3, R4, R5 & R6 = 20kΩ to 50kΩ R3 = R5 to within 0.1% for common mode rejection R4 = R6 to within 0.1% for common mode rejection R4 / R3 ratio accurate to within 0.1% for gain control R6 / R5 ratio accurate to within 0.1% for gain control
C1 = C2 (See below for value calculation)	

To achieve the highest resolution and lowest noise performance from your model 1221 accelerometer module, it should be connected to your voltage measurement instrument in a differential configuration using both the **AOP** and **AON** output signals. If your measurement instrument lacks differential input capability or you desire to use a differential input capable instrument in single ended mode, then the circuit above can be used to preserve the low noise performance of the model 1221 while using a single ended type connection.

This circuit converts the ± 4 Volt differential output of the model 1221 accelerometer, centered at +2.5 Volts, to a single ended output centered about ground (0.0 Volts). It provides the advantage of low common mode noise by preventing the accelerometer's ground current from causing an error in the voltage reading.

The op-amp should be located as close as possible to your voltage monitoring equipment so that the majority of the signal path is differential. Any noise present along the differential path will affect both wires to the same degree and the op-amp will reject this noise because it is a common mode signal. The op-amp type is not critical; a µA741 or ¼ of a LM124 can be used. Both plus and minus supplies are needed for the op-amp to accommodate the positive and negative swings of the single ended output. The same +5V supply can be used for both the op-amp and the 1221 or a higher voltage positive supply can be used for the op-amp if you need a larger single ended output swing.

For this design, always set $R_4 = R_6$, $R_3 = R_5$ and $C_3 = C_4$. The gain of the circuit is then determined by the ratio R_4/R_3. When $R_4 = R_3 = R_6 = R_5$, the gain equals 1 and the output swing will be ± 4 Volts single ended with respect to ground. To obtain a ± 5 Volt single ended output, set $R_4/R_3 = R_6/R_5 = 5/4 = 1.25$. The single ended output of the op-amp will be centered at ground if R_4 and C_3 are tied to ground; using some other fixed voltage for this reference will shift the output. The value of the optional capacitors C_3 and C_4 ($C_3 = C_4$) can be selected to roll off the frequency response to the frequency range of interest. The cutoff frequency f_0 (-3 dB frequency) for this single order low pass filter is given by:

$$f_0 = \frac{1}{2\pi R_4 C_3}$$

LIS331DLH

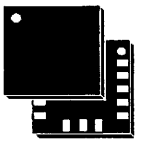
MEMS digital output motion sensor
ultra low-power high performance 3-axes "nano" accelerometer

Features

- Wide supply voltage, 2.16 V to 3.6 V
- Low voltage compatible IOs, 1.8 V
- Ultra low-power mode consumption down to 10 µA
- ±2*g*/±4*g*/±8*g* dynamically selectable full-scale
- I^2C/SPI digital output interface
- 16 bit data output
- 2 independent programmable interrupt generators for free-fall and motion detection
- Sleep to wake-up function
- 6D orientation detection
- Embedded self-test
- 10000 *g* high shock survivability
- ECOPACK® RoHS and "Green" compliant (see *Section 8*)

Applications

- Motion activated functions
- Free-fall detection
- Intelligent power saving for handheld devices
- Pedometer
- Display orientation
- Gaming and virtual reality input devices
- Impact recognition and logging
- Vibration monitoring and compensation



LGA 16 (3x3x1 mm)

Description

The LIS331DLH is an ultra low-power high performance three axes linear accelerometer belonging to the "nano" family, with digital I^2C/SPI serial interface standard output.

The device features ultra low-power operational modes that allow advanced power saving and smart sleep to wake-up functions.

The LIS331DLH has dynamically user selectable full scales of ±2*g*/±4*g*/±8*g* and it is capable of measuring accelerations with output data rates from 0.5 Hz to 1 kHz.

The self-test capability allows the user to check the functioning of the sensor in the final application.

The device may be configured to generate interrupt signal by inertial wake-up/free-fall events as well as by the position of the device itself. Thresholds and timing of interrupt generators are programmable by the end user on the fly.

The LIS331DLH is available in small thin plastic land grid array package (LGA) and it is guaranteed to operate over an extended temperature range from -40 °C to +85 °C.

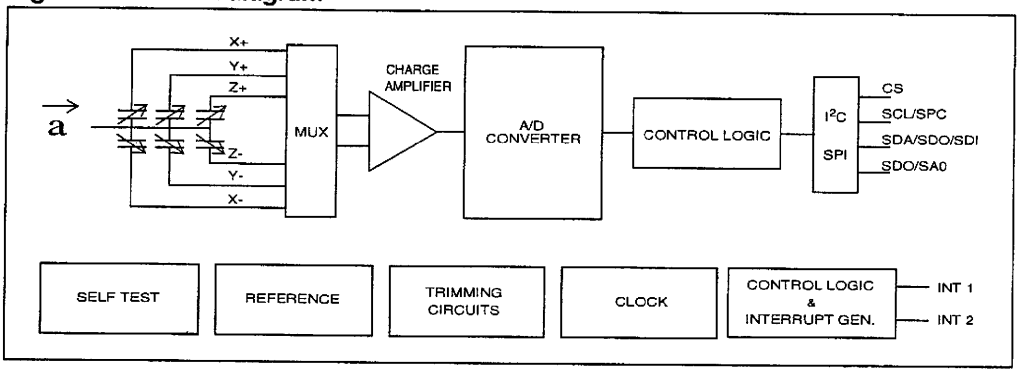
Table 1. Device summary

Order codes	Temperature range [° C]	Package	Packaging
LIS331DLH	-40 to +85	LGA 16	Tray
LIS331DLHTR	-40 to +85	LGA 16	Tape and reel

1 Block diagram and pin description

1.1 Block diagram

Figure 1. Block diagram



1.2 Pin description

Figure 2. Pin connection

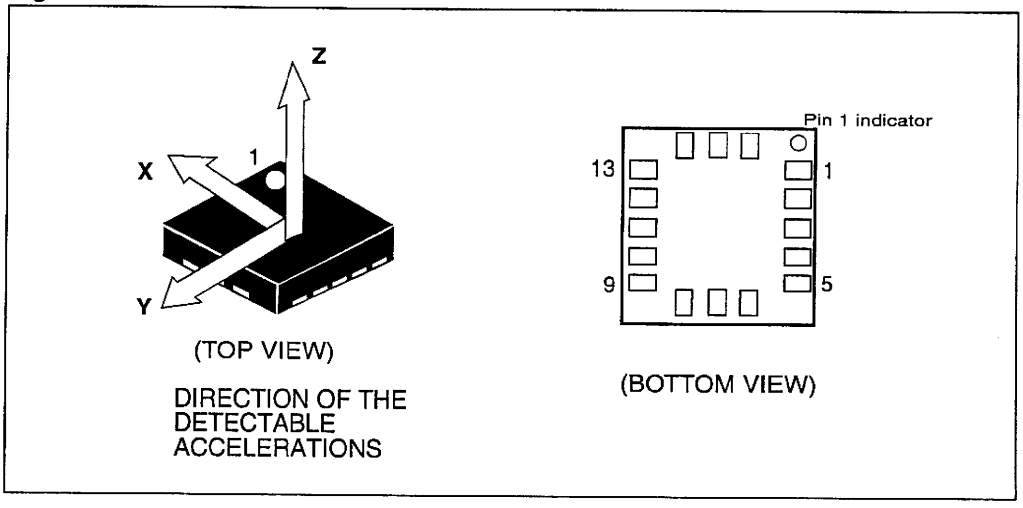


Table 2. Pin description

Pin#	Name	Function
1	Vdd_IO	Power supply for I/O pins
2	NC	Not connected
3	NC	Not connected
4	SCL SPC	I^2C serial clock (SCL) SPI serial port clock (SPC)
5	GND	0V supply
6	SDA SDI SDO	I^2C serial data (SDA) SPI serial data input (SDI) 3-wire interface serial data output (SDO)
7	SDO SA0	SPI serial data output (SDO) I^2C less significant bit of the device address (SA0)
8	CS	SPI enable I^2C/SPI mode selection (1: I^2C mode; 0: SPI enabled)
9	INT 2	Inertial interrupt 2
10	Reserved	Connect to GND
11	INT 1	Inertial interrupt 1
12	GND	0 V supply
13	GND	0 V supply
14	Vdd	Power supply
15	Reserved	Connect to Vdd
16	GND	0 V supply

LIS331DLH

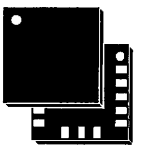
MEMS digital output motion sensor ultra low-power high performance 3-axes "nano" accelerometer

Features

- Wide supply voltage, 2.16 V to 3.6 V
- Low voltage compatible IOs, 1.8 V
- Ultra low-power mode consumption down to 10 µA
- ±2*g*/±4*g*/±8*g* dynamically selectable full-scale
- I^2C/SPI digital output interface
- 16 bit data output
- 2 independent programmable interrupt generators for free-fall and motion detection
- Sleep to wake-up function
- 6D orientation detection
- Embedded self-test
- 10000 *g* high shock survivability
- ECOPACK® RoHS and "Green" compliant (see *Section 8*)

Applications

- Motion activated functions
- Free-fall detection
- Intelligent power saving for handheld devices
- Pedometer
- Display orientation
- Gaming and virtual reality input devices
- Impact recognition and logging
- Vibration monitoring and compensation



LGA 16 (3x3x1 mm)

Description

The LIS331DLH is an ultra low-power high performance three axes linear accelerometer belonging to the "nano" family, with digital I^2C/SPI serial interface standard output.

The device features ultra low-power operational modes that allow advanced power saving and smart sleep to wake-up functions.

The LIS331DLH has dynamically user selectable full scales of ±2*g*/±4*g*/±8*g* and it is capable of measuring accelerations with output data rates from 0.5 Hz to 1 kHz.

The self-test capability allows the user to check the functioning of the sensor in the final application.

The device may be configured to generate interrupt signal by inertial wake-up/free-fall events as well as by the position of the device itself. Thresholds and timing of interrupt generators are programmable by the end user on the fly.

The LIS331DLH is available in small thin plastic land grid array package (LGA) and it is guaranteed to operate over an extended temperature range from -40 °C to +85 °C.

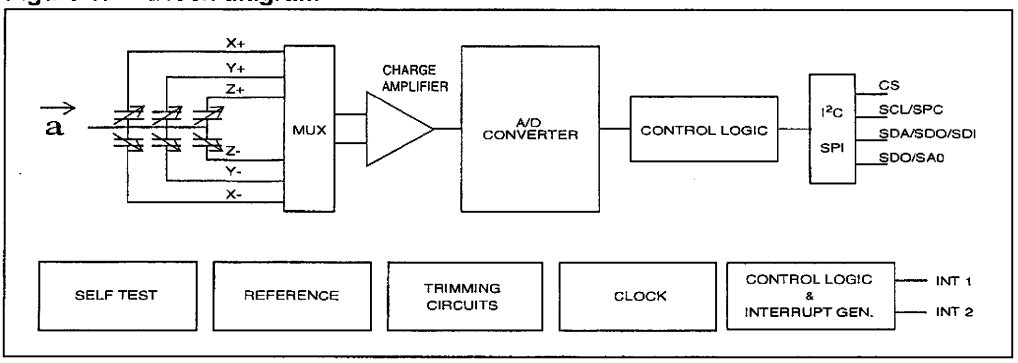
Table 1. Device summary

Order codes	Temperature range [°C]	Package	Packaging
LIS331DLH	-40 to +85	LGA 16	Tray
LIS331DLHTR	-40 to +85	LGA 16	Tape and reel

1 Block diagram and pin description

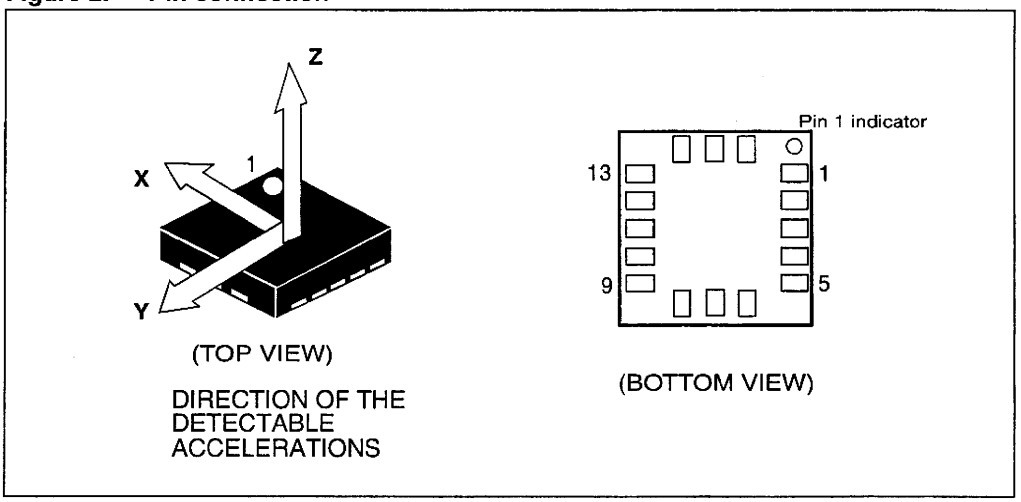
1.1 Block diagram

Figure 1. Block diagram



1.2 Pin description

Figure 2. Pin connection



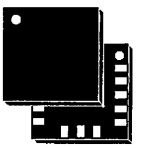
LIS331HH

MEMS digital output motion sensor ultra low-power high full-scale 3-axes "nano" accelerometer

Preliminary data

Features

- Wide supply voltage, 2.16 V to 3.6 V
- Low voltage compatible IOs, 1.8 V
- Ultra low-current mode consumption down to 10 µA
- ±6*g*/±12*g*/±24*g* dynamically selectable full-scale
- I^2C/SPI digital output interface
- 16 bit data output
- 2 independent programmable interrupt engines
- Sleep to wake-up function
- 6D orientation detection
- Embedded self-test
- 10000 *g* high shock survivability
- ECOPACK® RoHS and "Green" compliant (see *Section 8*)



LGA16 (3x3x1 mm)

Applications

- Pedometer
- Gaming and virtual reality input devices
- Motion activated functions
- Impact recognition and logging
- Intelligent power saving for handheld devices
- Vibration monitoring and compensation

Description

The LIS331HH is an ultra low-power high performance high full-scale three axes linear accelerometer belonging to the "nano" family, with digital I^2C/SPI serial interface standard output.

The device features ultra low-power operational modes that allow advanced power saving and smart sleep to wake-up functions.

The LIS331HH has dynamically user selectable full scales of ±6*g*/±12*g*/±24*g* and it is capable of measuring accelerations with output data rates from 0.5 Hz to 1 kHz. The self-test capability allows the user to check the functioning of the sensor in the final application.

The device contains 2 indipendent interrupt engines able to recognize dedicated inertial events.
Thresholds and timing of interrupt generators are programmable by the end user on the fly.

The LIS331HH is available in small thin plastic land grid array package (LGA) and it is guaranteed to operate over an extended temperature range from -40 °C to +85 °C.

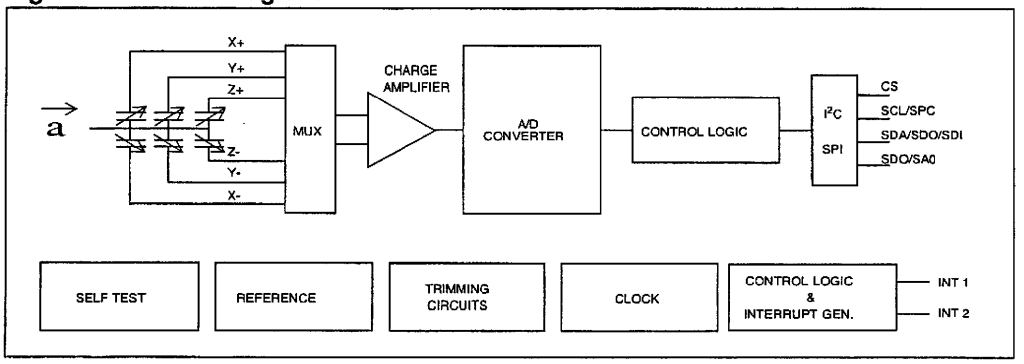
Table 1. Device summary

Order codes	Temperature range [° C]	Package	Packaging
LIS331HH	-40 to +85	LGA16	Tray
LIS331HHTR	-40 to +85	LGA16	Tape and reel

1 Block diagram and pin description

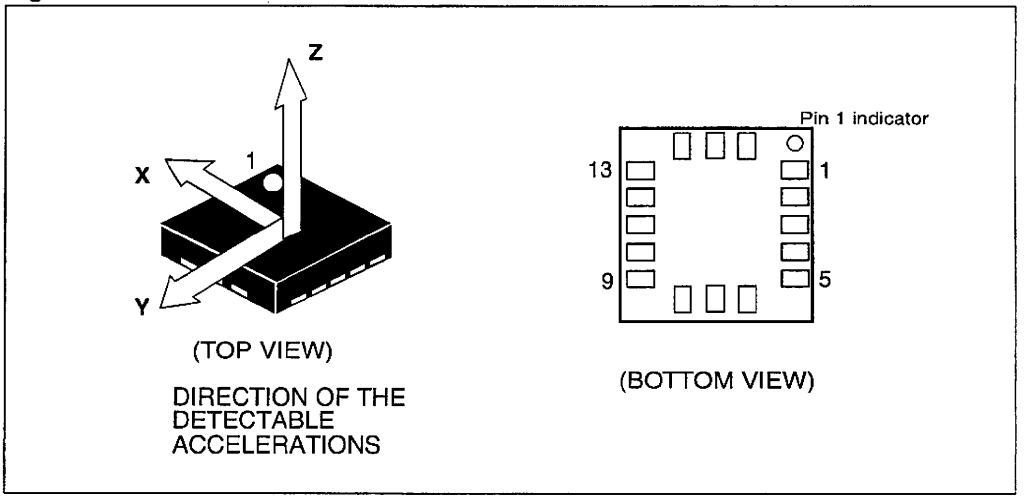
1.1 Block diagram

Figure 1. Block diagram



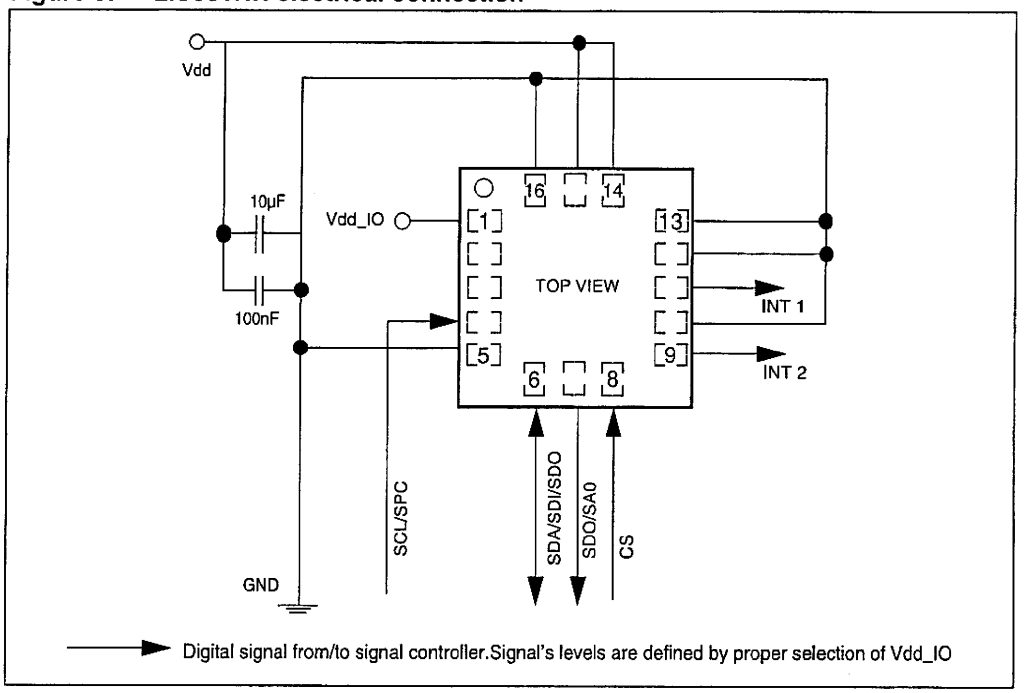
1.2 Pin description

Figure 2. Pin connection



4 Application hints

Figure 5. LIS331HH electrical connection



The device core is supplied through Vdd line while the I/O pads are supplied through Vdd_IO line. Power supply decoupling capacitors (100 nF ceramic, 10 µF Aluminum) should be placed as near as possible to the pin 14 of the device (common design practice).

All the voltage and ground supplies must be present at the same time to have proper behavior of the IC (refer to *Figure 5*). It is possible to remove Vdd maintaining Vdd_IO without blocking the communication bus, in this condition the measurement chain is powered off.

The functionality of the device and the measured acceleration data is selectable and accessible through the I^2C or SPI interfaces.When using the I^2C, CS must be tied high.

The functions, the threshold and the timing of the two interrupt pins (INT 1 and INT 2) can be completely programmed by the user through the I^2C/SPI interface.

4.1 Soldering information

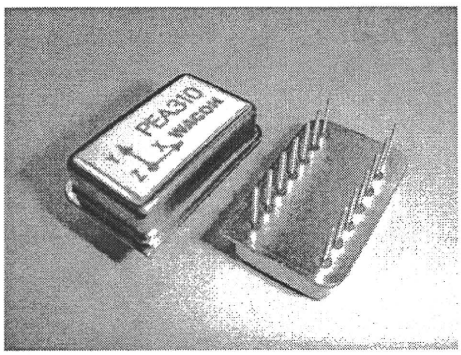
The LGA package is compliant with the ECOPACK®, RoHS and "Green" standard.
It is qualified for soldering heat resistance according to JEDEC J-STD-020C.

Leave "Pin 1 Indicator" unconnected during soldering.

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

圧電型3軸加速度センサ（アンプ内蔵型）

PEA シリーズ



ワコーが提供する PEA シリーズは、検出素子に圧電セラミックを使用した3軸加速度センサです。センサに対してあらゆる方向から加えられた加速度 A に対し、3軸方向の加速度成分（Ax,Ay,Az）を出力します。
この信号から、加速度の大きさと方向を求めることができます。

センサの構造は1つの素子で同時に3軸方向の加速度を検出可能となるように工夫されております。そのため小型軽量で低価格なセンサが実現できました。
また、出力はオペアンプ出力ですので、取り扱いが大変容易です。

車両、ロボット、工作機械、ゲームなど幅広い分野にご利用頂けます。

特徴

◆3軸加速度を同時に検出

加速度 A の3軸方向の加速度成分（Ax,Ay,Az）に分離して出力

◆小型軽量

1つの素子で3軸加速度が検出可能なため、小型軽量

◆広いダイナミックレンジ

0.5～500（PEA304）、1000（PEA320）、2000Hz（PEA350）の周波数領域で安定に測定が可能

用途

◆車両

エアーバッグ・システム/振動計測・制御/シャシー・コントロール

◆ロボット・工作機械

異常振動検出/アーム制御

◆民生

歩数計/ゲーム用インプット・デバイス/地震計(感震計)/防犯用感振器　　etc.

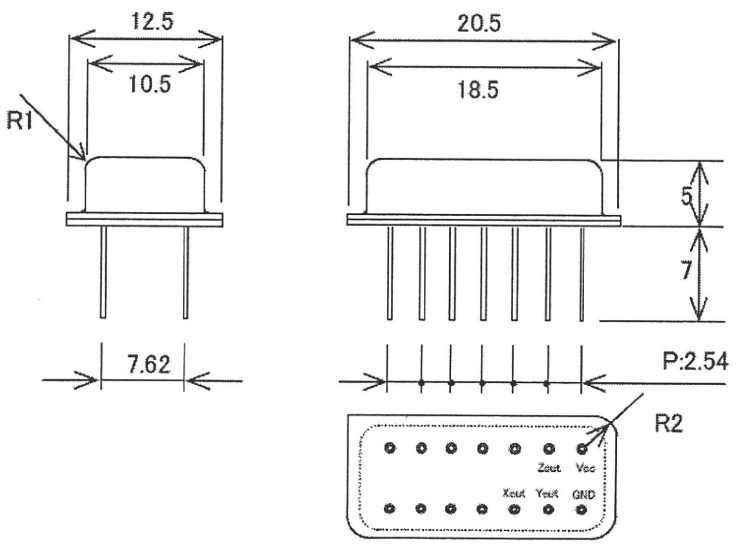
■主な仕様

<typical>

項目	製品名			単位
	PEA304	PEA320	PEA350	
検出軸	3軸(X,Y,Z)			
定格加速度	±4	±20	±50	G
検出感度	500	±100	40	mV/G
応答周波数	0.5～500	0.5～1000	0.5～2000	Hz
直線性	±2			%FS 以下
零点出力	2.5±0.2			V
他軸感度	5			%FS 以下
駆動電圧	5			V
消費電流	0.5			mA 以下
動作温度	-40～85			℃
保存温度	-40～100			℃
サイズ	20.5×12.5×5.0			mm

[注]仕様は断り無く変更することがあります。

■外形寸法 (mm)



株式会社ワコー　大宮事業所
〒330-0854 さいたま市大宮区桜木町 4-241-2 第 2 山崎ビル 6F
TEL 048-641-9995　　FAX048-641-9996

富山事業所
〒933-0816 富山県高岡市二塚 322-5 高岡テクノドーム内 203 号室
TEL0766-29-2370　　FAX0766-29-2371

販売会社 株式会社ワコー販売
〒101-0032 東京都千代田区岩本町 3-9-15 フォロス岩本町ビル 5F
TEL 03-3861-2513　　FAX 03-3861-2514

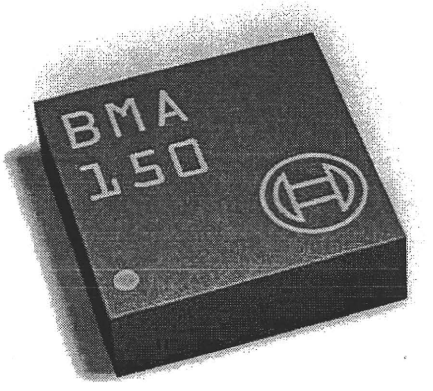
URL http://www.wacoh.co.jp

BMA150
Digital, triaxial acceleration sensor

Data sheet

Bosch Sensortec

BOSCH
Invented for life



BMA150 Data sheet

Order code(s)	0 273 141 028 (non-halogen-free) and 0 273 141 043 (halogen-free)
Package type	12-pin LGA
Data sheet version	1.5
Release date	29 May 2008
Notes	Specifications are subject to change without notice. Product photos and pictures are for illustration purposes only and may differ from the real product's appearance.

BMA150
Digital, triaxial ±2g/±4g/±8g acceleration sensor

Key features

•	Three-axis accelerometer	
•	Temperature output	
•	Small package	LGA package Footprint 3mm x 3mm, height 0.90mm
•	Digital interface	SPI (4-wire, 3-wire), I²C, interrupt pin
•	Programmable functionality	g-range ±2g/±4g/±8g, bandwidth 25-1500Hz, internal acceleration evaluation for interrupt trigger also enabling stand-alone capability (without use of microcontroller), self-test
•	Ultra-low power ASIC	Low current consumption, short wake-up time, advanced features for system power management
•	Eco-friendly	RoHS compliant, Lead(Pb)-free Halogen-free (part number 0 273 141 043 only)

Typical applications

- HDD protection
- Menu scrolling, tap sensing function
- Gaming
- Pedometer/step-counting
- Drop detection for warranty logging
- Display profile switching
- Advanced system power management for mobile applications
- Shock detection

General description

The BMA150 is a triaxial, low-g acceleration sensor IC with digital output for consumer market applications. It allows measurements of acceleration in perpendicular axes as well as absolute temperature measurement.

An evaluation circuitry converts the output of a three-channel micromechanical acceleration-sensing structure that works according to the differential capacitance principle.

Package and interface have been defined to match a multitude of hardware requirements. Since the sensor IC has small footprint and flat package it is attractive for mobile applications. The sensor IC can be programmed to optimize functionality, performance and power consumption in customer specific applications.

The BMA150 senses tilt, motion and shock vibration in cell phones, handhelds, computer peripherals, man-machine interfaces, virtual reality features and game controllers.

The BMA150 is the LGA package version of the SMB380 triaxial acceleration sensor which is available in a 3mm x 3mm x 0.9mm QFN package.

1. Specification

If not stated otherwise, the given values are maximum values over lifetime and full performance temperature/voltage range in the normal operation mode.

Table 1: Operating range, output signal and mechanical specifications of BMA150

Parameter	Symbol	Condition	Min	Typ	Max	Units
OPERATING RANGE						
Acceleration range	g_{FS2g}	Switchable via serial digital interface	-2		2	g
	g_{FS4g}		-4		4	g
	g_{FS8g}		-8		8	g
Supply voltage analogue	V_{DD}		2.4		3.6	V
Supply voltage for digital I/O	V_{DDIO}	$V_{DDIO} \leq V_{DD}$	1.62		3.6	V
Supply current in normal mode	I_{DD}	Digital and analog		200	290	µA
Supply current in stand-by mode *	I_{DDsbm}	Digital and analog		1	2	µA
Operating temperature	T_A		-40		+85	°C
ACCELERATION OUTPUT SIGNAL						
Acceleration output resolution		Format: 2's complement			10	Bit
Sensitivity	S_{2g}	g-range ±2g	246	256	266	LSB/g
	S_{4g}	g-range ±4g	122 **	128	134 **	LSB/g
	S_{8g}	g-range ±8g	61 **	64	67 **	LSB/g
Zero-g offset	Off	T_A=25°C, calibrated	-60		60	mg
Zero-g offset	Off	T_A=25°C , over lifetime ***	-150		150	mg
Zero-g offset temperature drift		Over T_A		1		mg/K
Power supply rejection ratio	PSRR	Over V_{DD}			0.2	LSB/V

* For more details on the BMA150's current consumption during wake-up mode, please refer to chapter 7.2 & 7.3
** Values here are given as indications for reference only
*** The offset can deviate from the original calibration mainly due to stress effects during soldering depending on the soldering process. For many applications it is beneficial to re-calibrate the offset after PCB assembly (see application note ANA016 "In-line offset re-calibration").

Parameter	Symbol	Condition	Min	Typ	Max	Units
Bandwidth	bw	2nd order analog filter		1500		Hz
		Digital filter *		25, 50, 100, 190, 375, 750		Hz
Acceleration data refresh rate (all axes)	f_rate		2700	3000	3300	Hz
Nonlinearity	NL	Best fit straight line	-0.5		0.5	%FS
Output noise	n_{rms}	Rms		0.5		mg/√Hz
TEMPERATURE SENSOR IC						
Sensitivity	S_T	Preliminary data	0.475	0.5	0.525	K/LSB
Temperature measurement range	T_S		-30		97.5	°C
Temperature offset	Off_T	Calibrated at 30°C		1		K
MECHANICAL CHARACTERISTICS						
Cross axis sensitivity	$\overline{S}$	Relative contribution between 3 axes			2	%
POWERING UP CHARACTERISTICS						
Wake-up time	t_{wu}	From stand-by		1	1.5	ms
Start-up time	t_{su}	From power-off		3		ms

* Please refer to chapter 3.1.3 for more detailed explanations

BMA220
Digital, triaxial acceleration sensor

Bosch Sensortec

BOSCH
Invented for life

General description

The BMA220 is an ultra small triaxial, low-g acceleration sensor with digital interfaces, aiming for low-power consumer market applications.
The BMA220 allows measurement of accelerations in 3 perpendicular axes and thus senses tilt, motion, shock and vibration in cell phones, handhelds, computer peripherals, man-machine interfaces, virtual reality features and game controllers.

BMA220 target applications

- Display profile switching (e.g. portrait/landscape)
- Tap sensing function
- Menu scrolling
- Gaming
- Advanced power management for mobile devices
- Shock detection

Sensor operation

With its size of only 2 mm x 2 mm the BMA220 represents a new generation of digital acceleration sensors. The BMA220 integrates a multitude of features that facilitates its use especially in the area of motion detection applications, such as device orientation detection, gaming, HMI and menu browser control.

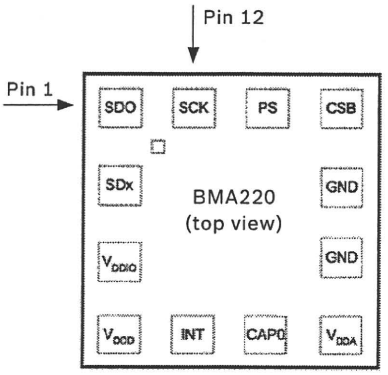
Key features BMA220
▶ User programmable g-range and bandwidth
▶ Low-power consumption
▶ SPI (3-wire/4-wire) and I²C interface
▶ User programmable interrupt engine
▶ Ultra-low-power auto-wake-up mode
▶ Self-test capability
▶ Ultra small package
▶ RoHS compliant, halogen-free

The BMA220 is highly configurable in order to give the designer full flexibility when integrating the sensor into his system. All features can be set by software via the digital interface. This implies also that even once a hardware platform with the BMA220 exists, it can be modified by software in order to expand the capabilities and use cases.

As already introduced with the successful BMA150 and SMB380 digital acceleration sensors, also for the BMA220 the g-ranges, bandwidths and interrupt parameters can be user programmed via the serial digital interface. Here the user can choose between I²C and SPI (3-wire/4-wire) interface modes.

Technical data preliminary	BMA220
Sensitivity axes	x/y/z
Measurement range	±2g, ±4g, ±8g, ±16g (switchable via SPI/I²C)
Sensitivity (calibrated)	2g: 16LSB/g 4g: 8LSB/g 8g: 4LSB/g 16g: 2LSB/g
Resolution	6bit ⇨62.5mg (±2g range)
Nonlinearity	±2% FS
Zero-g offset	±100mg
Bandwidth	1kHz ... 32Hz (switchable via SPI/I²C)
Digital input/output	SPI & I²C, interrupt pin
Supply voltage	1.8V
I/O supply voltage	1.62V ... 3.6V
Temperature range	-20°C ... +70°C
LGA package	2 mm x 2 mm x 0.98 mm

BMA220 Pin configuration (top view)



Pin No.	Name	Function
1	SDO	SPI serial data output
2	SDx	I²C/SPI serial data in/out (SDI, SDA, SDO)
3	V_{DDIO}	I/O supply voltage (1.62...3.6V)
4	V_{DDD}	Digital supply voltage (1.8V)
5	INT	Interrupt output
6	DNC	Do not connect!
7	V_{DDA}	Analog supply voltage(1.8V)
8	GND	Shared ground
9	GND	Shared ground
10	CSB	SPI chip select
11	PS	I²C/SPI select pin
12	SCK	SCL (I²C serial clock) SCK (SPI serial clock)

One of the key elements of the BMA220 is the intelligent interrupt engine that gives the hard- and software designer full control. Various motion detection scenarios can be identified by the BMA220 and signaled to the system via a simple interrupt pin.

By using the digital serial interface, the exact details of the motion event that triggered the interrupt can be read-out.

Following motion detection use case scenarios are supported by the interrupt engine:

- Any-motion (slope) detection
- Tap sensing
- Orientation change recognition
- Low-g/high-g detection
- Data-ready
- Self-wake-up

The interrupts can be conveniently configured by the user and thus perfectly support the integration of the BMA220 into the user's system environment.

Another important feature of the BMA220 acceleration sensor is the power management module. This module allows for optimizing the sensor's power consumption in-line with the specific user requirements. Thus, it is not necessary to operate the sensor at full power for all application scenarios all the time. For some use cases the power consumption drastically shrinks to just a fraction of what would be required in full performance mode.

Moreover this feature of the BMA220 allows for an intelligent system power management and thus significant reduction of the whole system's power consumption. In particular, this helps increasing battery life-time of any kind of mobile device.

In the unique "dedicated I/O" modes the BMA220 can be operated as a stand-alone device without requiring a µController.

Headquarters
Bosch Sensortec GmbH

Gerhard-Kindler-Strasse 8
72770 Reutlingen · Germany
Telephone +49 7121 3535 900
Fax +49 7121 3535 909
contact@bosch-sensortec.com
www.bosch-sensortec.com

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分担研究報告書

JIS B 7761-1の規格に準拠した国内外の計測器および計測ソフトの調査に関する研究

研究分担者　石松一真　独立行政法人労働安全衛生総合研究所　研究員

研究要旨：本研究では、国内外でいまだ開発がなされていない、作業現場において容易に工具振動の大きさ(周波数補正振動加速度実効値の 3 軸合成値)が測定できる安価な機器を３年間で研究開発する事が目的である。この分担研究では、国内外の JIS B 7761-1 の規格に準拠した国内外で市販されている手腕振動計測器の調査及び手腕振動実現の為の計測ソフトの検討に関する研究を行った。国内外メーカーから市販されている手腕振動測定装置にも 2 種類のものが考えられていることが明らかになった。手腕振動計測装置の価格は 100 万円前後の非常に高価な機器であることが明らかになった。また、汎用計測装置に至っては、数百万円の金額であることも明らかになった。振動工具管理責任者が、毎日、作業の前後に手持振動工具の振動工具の振動値の管理には、現在市販されている手腕振動計測装置では、高価で容易に使用することが出来ない事が明らかになった。今回の調査から、今回の研究テーマである作業現場において容易に振動の大きさを測定できる機器の開発に関する研究の必要性を明らかにする事が出来た。手腕振動計測装置の基本システムを駆動するための計測ソフトの基本的な考え方を明らかにすることができた。

A．研究目的

本研究の目的は、作業現場において容易に工具振動の大きさを測定できる安価な機器の開発である。平成21年7月10日に厚生労働省より発出された振動の新指針では、振動の大きさ(周波数補正振動加速度実効値の３軸合成値)及び振動のばく露時間で規定される１日８時間の等価振動加速度実効値である日振動ばく露量A(8)の考え方を取り入れ、日振動ばく露限界値及び日振動ばく露対策値に基づく
作業管理等を推進しているが、海外においては、振動リスクを、実作業の観察、振動の予想される大きさに関する情報、振動の大きさの測定によって評価するとされている。また、振動の大きさは、点検・整備、作業の状況によって変化すると考えられることから、作業現場においての工具の振動計測が必要である。この計測には、現在市販されている人体振動計などでも可能であるが、市販されてきている人体振動計の価格は100万円前後の非常に高価な機器である。このような現状から、事業者に対し一律に振動測定を求めるのは困難な状況である。

本研究では、国内外でいまだ開発がなされていない、作業現場において容易に工具振動の大きさ(周波数補正振動加速度実効値の3軸合成値)が測定できる安価な機器を３年間で