

## LIS3DH 3-Axis Accelerometer with ADC (#29020)

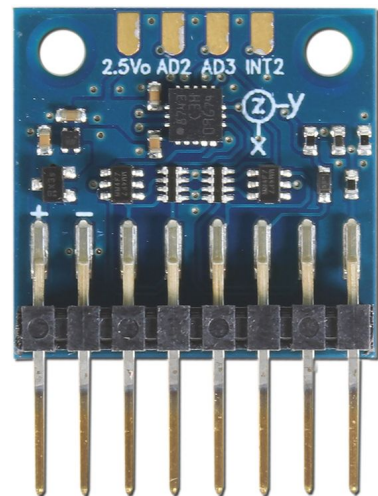
The LIS3DH is an ultra-low power, high performance, three-axis linear accelerometer. It features user-selectable scales up to 16g, an embedded temperature sensor, 10-bit ADC and a standard digital I<sup>2</sup>C/SPI serial interface.

Parallax Inc. places the LIS3DH on a compact 20x21 mm PCB with an 8-pin straight header. The I/O connections operate at the same voltage supplied to the VIN pin for compatibility with both 3.3 V and 5 V microcontrollers. The Parallax module includes a low-noise 2.5 V regulator which matches the LIS3DH factory calibration voltage for the highest possible accuracy.

This LIS3DH module is supported by Propeller C libraries as well as dedicated BlocklyProp blocks for easy visual programming.

### Features

- High-performance, three-axis linear accelerometer
- Factory calibrated with 2.5 V low-noise regulator
- User-selectable full scales of 2 g, 4 g, 8 g, 16 g
- User-selectable axis resolution of 8, 10 or 12-bit
- Output data rates from 1 Hz to 5.3 kHz
- 2 interrupt generators for free-fall and motion detection
- Embedded selectable 8 or 10-bit temperature sensor
- Sensor ultra-low-power mode consumption down to 2  $\mu$ A
- Hardware supports I<sup>2</sup>C, SPI 3-wire, & SPI 4-wire interfaces
- Two modules can be used on the same I<sup>2</sup>C bus
- Over-voltage, reverse polarity, and signal contention protection of all signal pins
- VIN / GND reverse polarity protection
- Compatible with 3.3 V and 5 V microcontrollers
- Breadboard-friendly 8-pin header, plus 2 mounting holes



## Application Ideas

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

## Key Specifications

- Power requirements: +3 VDC to +5 VDC; maximum 1 mA
- Operating modes: High-resolution, normal mode or low-power
- Typical current consumption at VIN = 3.3 VDC, 50 Hz Output Data Rate (ODR): 761  $\mu$ A
- Measurement ranges:  $\pm 2$  g,  $\pm 4$  g,  $\pm 8$  g,  $\pm 16$  g
- Measurement sensitivity: 1 to 192 mg/digit, depending on selected mode
- Zero-g level offset accuracy:  $\pm 40$ mg
- Zero-g level change vs temperature:  $\pm 0.5^\circ$  mg/C
- Temperature: range -40 to +85  $^\circ$ C; sensitivity 0.01%/ $^\circ$ C, typical 8-bit resolution 1 digit/ $^\circ$ C
- 32-level FIFO for each of the three output channels: X, Y, and Z
- Communication: I<sup>2</sup>C (100 or 400 kHz) or SPI (3 and 4 wire, up to 10 MHz)
- Operating temperature: -40 to +185  $^\circ$ F (-40 to +85  $^\circ$ C),
- Form factor: 8-pin male header with 0.1" spacing
- PCB dimensions: 20 x 21 mm
- Mounting holes: Two holes suitable for #3 UNC (M2.5) hardware

## Getting Started

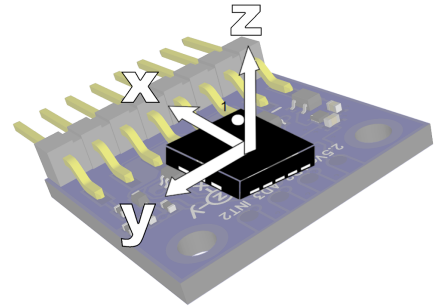
The LIS3DH 3-Axis Accelerometer with ADC module functions as a peripheral device on an I<sup>2</sup>C or SPI bus hosted by your microcontroller. See the [Connection Diagrams](#) and [Code Examples](#) sections below.

The LIS3DH sensor is supplied factory calibrated for highest accuracy axis readings when operated at 2.5 V. The Parallax module includes an onboard low-noise 2.5 V LDO regulator to power the sensor, so further calibration is not required by the user. Any time the device is

turned on, the factory calibration values are automatically downloaded into the sensor registers.

## Module Orientation and Operation

The image shows the 3 directions of travel that are detected by the accelerometer. Data is sampled according to a user configured rate, from 1 Hz to 5.3 kHz.



The directional data is typically added to an internal 3-channel x 32-level FIFO buffer which can be read by an I<sup>2</sup>C or SPI connected device. The LIS3DH sensor can also be configured to signal an interrupt (INT1/INT2) when certain events occur, such as motion, tap detection and free-fall.

The typical use of the FIFO buffer allows power saving for the system. The host processor does not need to continuously poll data from the sensor, but it can wake up only when needed and burst-read data out from the FIFO. However, there are various operation modes available to the user; Bypass mode, FIFO mode, Stream mode and Stream-to-FIFO mode. Refer to the LIS3DH datasheet for full information; download from the 29020 product page at [parallax.com](http://parallax.com).

## Connection Diagrams

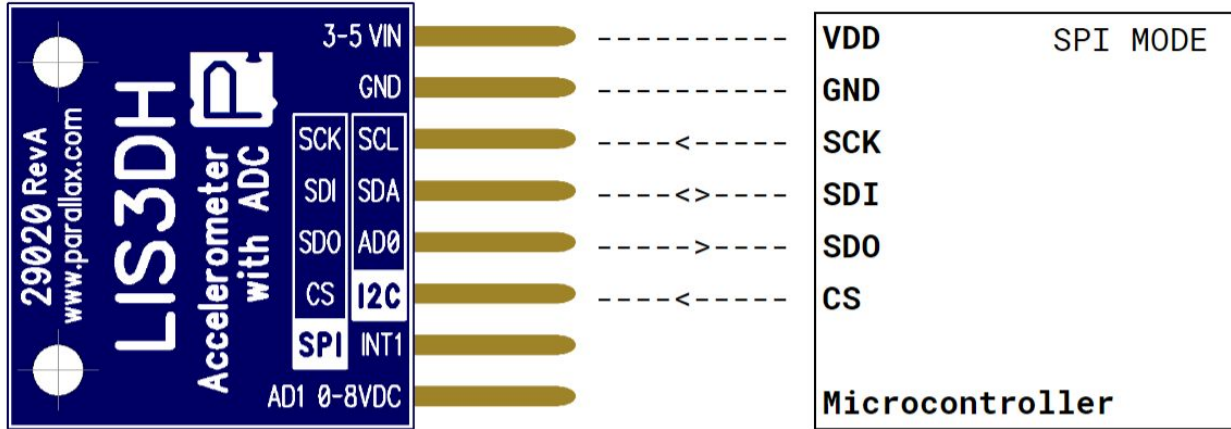
Connection diagrams are supplied below for I<sup>2</sup>C and SPI 3-wire or 4-wire operation. The LIS3DH 3-Axis Accelerometer with ADC module is compatible with both 3.3 V and 5 V microcontrollers. The LIS3DH module power (VIN) pin also sets the required logic level voltage. So, typically the module VIN connects to the same power supply used by the microcontroller. The LIS3DH module GND pin must always be connected to the same GND used by the microcontroller. See the [Pin Descriptions](#) section for more information.

## SPI Operation

Use of SPI communication is configured by pulling the CS line low. The serial interface can be operated in 3-wire or 4-wire mode. The SPI communication protocol is the same for both modes.

- **In 3-wire mode:** CS (chip select), SCK (serial clock), SDI (data input/output). In this mode, SDO is not used and should be left unconnected or driven high. This mode is supported by Propeller C libraries and BlocklyProp blocks.

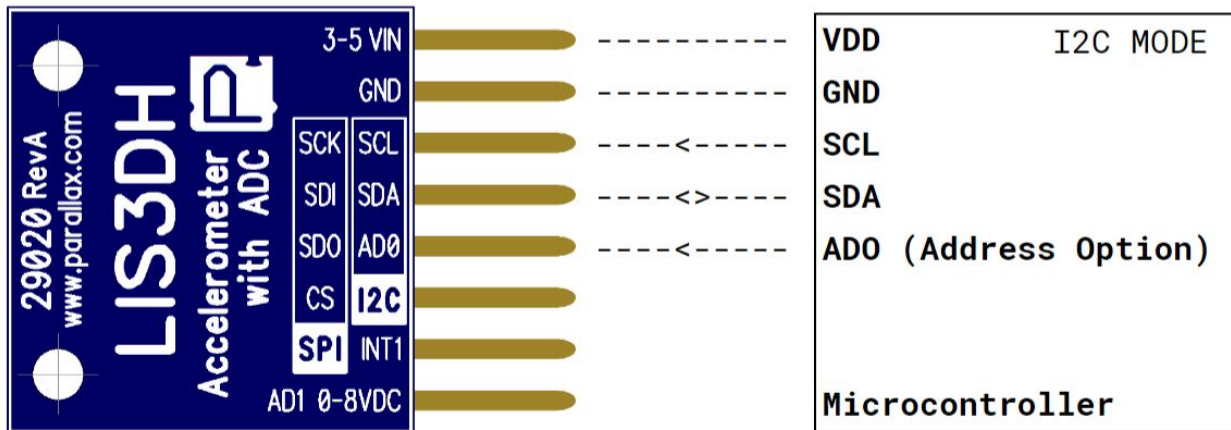
- **In 4-wire mode:** CS (chip select), SCK (serial clock), SDI (data input), SDO (data output). This mode is supported by Propeller C libraries.



### I<sup>2</sup>C Operation

I<sup>2</sup>C operation requires two signals: the serial clock line (SCL) and serial data line (SDA). The bidirectional SDA is used to send and receive data on the I<sup>2</sup>C bus. Up to two sensors can be used on the same I<sup>2</sup>C bus.

The default I<sup>2</sup>C address is 0x19. Pull the AD0 pin low to change that module's I<sup>2</sup>C address to 0x18. Note that the CS pin must be left unconnected or driven high for I<sup>2</sup>C mode.



## Resources & Code Examples

The LIS3DH sensor is supported by BlocklyProp Solo visual programming using a 3-wire SPI bus with blocks for "LIS3DH" available under the Sensor category. A Propeller C library and example

code are included in the Propeller C Learn folder 2/03/2020 or later. The sensor is also compatible with Arduino or Raspberry Pi hardware. Look for code downloads and additional resources links at the sensor's product page; search "29020" at [www.parallax.com](http://www.parallax.com).

Full details about the I<sup>2</sup>C and SPI communication protocols, and sensor specifications, are available from the LIS3DH manufacturer's datasheet. Please refer to the datasheet, code samples and other manufacturer resources for detailed explanations and configurations.

<https://www.st.com/en/mems-and-sensors/lis3dh.html>

# Pin Descriptions

## SIP Header Pins

Pin		Type	Function
VIN		Power	The module will operate between 3 V and 5 V DC. The VIN voltage also sets the logic-high level voltage for the signal pins.
GND		Ground	Common Ground (0 V supply) must be shared with microcontroller host
SPI	I2C		Signal Pins
SCK	SCL	In	SPI & I <sup>2</sup> C serial clock
SDI	SDA	In / Out	SPI serial data input (SPI 4-wire mode) SPI serial data input/output (SPI 3-wire mode) I <sup>2</sup> C serial data input/output
SDO	AD0	In / Out	SPI serial data output (SPI 4-wire mode only) I <sup>2</sup> C device address selection (when CS is high)*: 1: I <sup>2</sup> C address 0x19 (default) 0: I <sup>2</sup> C address 0x18
CS		In	I <sup>2</sup> C/SPI mode selection** 1: I <sup>2</sup> C communication enabled (default) 0: SPI communication mode / I <sup>2</sup> C disabled
Feature Pins			
INT1		Out	Inertial interrupt 1 Default: push-pull output forced to GND
AD1 0-8VDC		In	Analog-to-digital converter input 1 Resolution: User selectable 8 or 10-bit Input includes a voltage divider Input range: 0-7800mV DC (± 200mV)

\* I<sup>2</sup>C device address can be changed during operation

\*\* Power-cycle required after changing mode from SPI to I<sup>2</sup>C

## Signal Pins

Each of the four LIS3DH signal pins (SCK/SCL, SDI/SDA, SDO, CS) is protected by a level-shifting circuit, used to translate the internal I/O voltage of the LIS3DH to the voltage used by the master device (microcontroller). The level shifter has built-in pull-up resistors to each supply rail so it can be driven by open drain outputs for I<sup>2</sup>C, or can be driven low/high for SPI protocol.

This protection means that there is no need for any external interfacing circuitry to operate the Parallax LIS3DH 3-Axis Accelerometer with ADC module with 3.3 V or 5 V logic level microcontrollers.

## Feature Pins

### INT1

The function, threshold and timing of the INT1 interrupt pin can be programmed by the user through the I<sup>2</sup>C/SPI interface. By default INT1 is a push-pull output driven low, and can be set to open-drain mode if preferred. INT1 includes a level shifter and protections against short-circuit and reverse-polarity power. When the INT1 output is high, the voltage level will be the same as VIN.

### AD1 0-8VDC

The LIS3DH has an auxiliary 3-channel ADC which reads 900-1700 mV  $\pm$ 100 mV inputs. Resolution is user selectable between 8 or 10 bit. The AD1 pin of the Parallax module includes a voltage divider which converts an input voltage range of 0-7800 mV DC ( $\pm$ 200 mV) to the correct levels for the sensor. The upper limit of 8 VDC allows the typical battery pack or supply voltage used in Parallax robots and projects to be monitored.

## Optional Feature Pads

Pad	Type	Function
2.5Vo	Out	Power output from 2.5 V LDO regulator Maximum current: 200 mA
AD2	In	Analog-to-digital converter input 2 Resolution: User selectable 8-bit or 10-bit Input range: 900 mVDC to 1700 mVDC ( $\pm$ 100 mV) <b>Do not exceed 2.5 V on this pin</b> Default: input high impedance
AD3	In	Analog-to-digital converter input 3 Resolution: User selectable 8 or 10-bit Input range: 900 mVDC to 1700 mVDC ( $\pm$ 100 mV) <b>Do not exceed 2.5 V on this pin</b> Default: input high impedance AD3 user selectable as internal temperature sensor function
INT2	Out	Inertial interrupt 2 Default: push-pull output forced to GND No level shifting or protection. VOH = 2.5 V

The optional feature pads across the top of the module between the mounting holes provide user access directly to sensor features which are not available on the SIP header.



**NO SIGNAL CONDITIONING!** The signals at these pads do not include any conditioning or protective components. Refer to the sensor's manufacturer datasheet and Parallax module schematic before use; download from the 29020 product page at [www.parallax.com](http://www.parallax.com). Proceed at your own risk!

### **2.5Vo**

The on-board 2.5V LDO regulator output is connected directly to this pad. This power output is recommended only for logic level use, and not to exceed 200 mA load. Apply standard good practices when using this output as connecting an external circuit here may interfere with the sensitivity and accuracy of the LIS3DH sensor.

### **AD2**

ADC channel 2 is user selectable between 8 or 10 bit, and reads 900-1700 mV  $\pm$ 100 mV input. If unused can be left floating, or connected to 2.5Vo or GND. Do not exceed 2.5V on this pin.

### **AD3**

ADC channel 3 is user selectable between 8 or 10 bit, and reads 900-1700 mV  $\pm$ 100 mV input. If unused can be left floating, or connected to 2.5 Vo or GND. Do not exceed 2.5 V on this pin.

Channel AD3 is special because it can be configured to read an internal temperature sensor in the LIS3DH chip, rather than the signal connected to the AD3 input pad. Refer to the LIS3DH sensor datasheet v2 for details, section 3.7 "Auxiliary ADC and temperature sensor."

### **INT2**

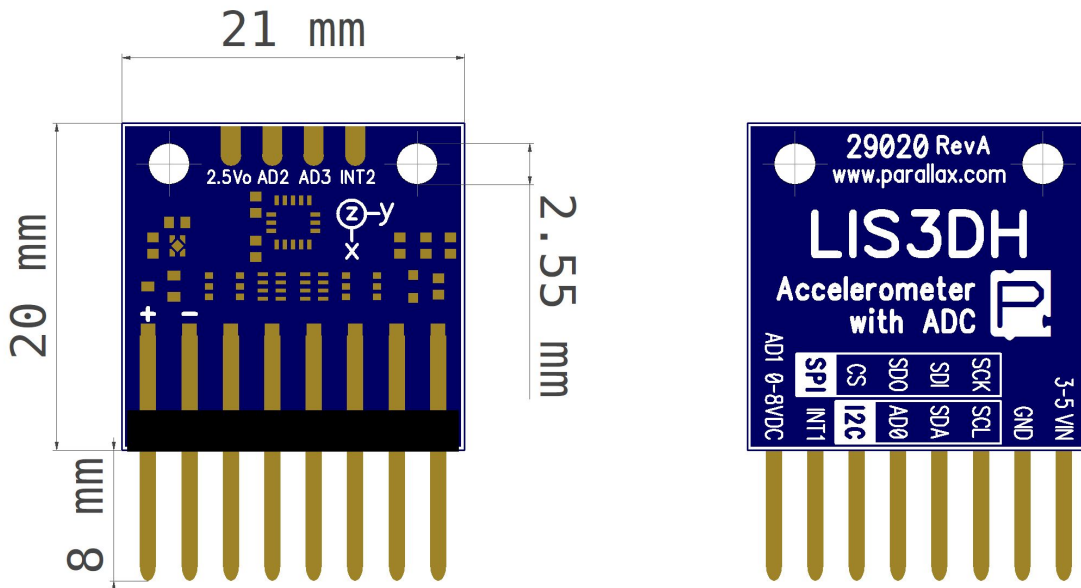
The function, threshold and timing of INT2 can be programmed by the user through the I<sup>2</sup>C/SPI interface. By default INT2 is a push-pull output and driven low.



## Absolute maximum ratings

Symbol	Ratings	Maximum value	Unit
VIN	Supply voltage	-0.3 to 5.5	V
VIN_IO	Input voltage on SIP header pins: CS, SCL/SPC, SDA/SDI/SDO, SDO/AD0, INT1	-0.3 to 5.5	V
VIN_AD1	Input voltage on SIP header AD1 pin	-0.3 to 10	V
VOUT_2.5Vo	Output current from 2.5Vo pad	200	mA
VIN_PADS	Input voltage on option pads: AD2, AD3, INT2	-0.3 to 2.8	V
ACC	Acceleration, any axis	3000 g for 0.5 ms	
		10000 g for 0.2 ms	
T <sub>OP</sub>	Operating temperature range	-40 to +85	°C
T <sub>STG</sub>	Storage temperature range	-40 to +125	°C

## PCB Dimensions



## Revision History

Version 1.0: original release.