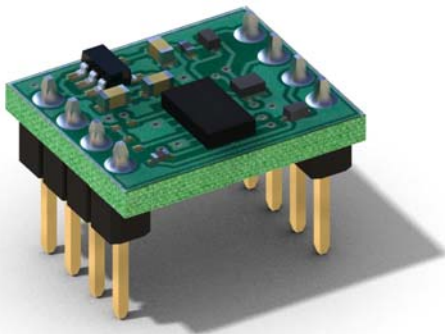


## MMA7455 3-Axis Accelerometer Module (#28526)

### General Description

The Freescale Semiconductor MMA7455L 3-Axis Digital Output Accelerometer is a low power, micro-machined sensor capable of measuring acceleration along its X, Y, and Z axes. It offers several convenient integrated features including an analog to digital converter (ADC), digital low-pass filter, and selectable sensitivity ranges of  $\pm 2g$ ,  $\pm 4g$ , or  $\pm 8g$ . This device can be easily configured to detect quick motion pulses as single-taps, double-taps, and 0g (free-fall) conditions on any or all axes and provides configurable interrupt pins (INT1 and INT2) for each type of event.

Flexibility and compatibility are designed into this module. An on-board voltage regulator and I/O voltage level-shifters make this module especially easy to connect to virtually any microcontroller. It operates over a wide range of supply voltages from 2.5 VDC to 5.5 VDC and communicates via Serial Peripheral Interface (SPI) or Inter-Integrated Circuit (I<sup>2</sup>C) bus.



### Features

- Wide input voltage range
- Digital output (SPI/I<sup>2</sup>C)
- Selectable sensitivity: 8-bit mode ( $\pm 2g/\pm 4g/\pm 8g$ ) or 10-bit mode ( $\pm 8g$ )
- User-configurable interrupts (INT1/INT2)
- User-settable registers for calibrating each axis
- Low current operation
- Compact, 8-pin DIP breadboard-friendly package: 0.5" x 0.6" (12.7 x 15.2 mm)

### Application Ideas

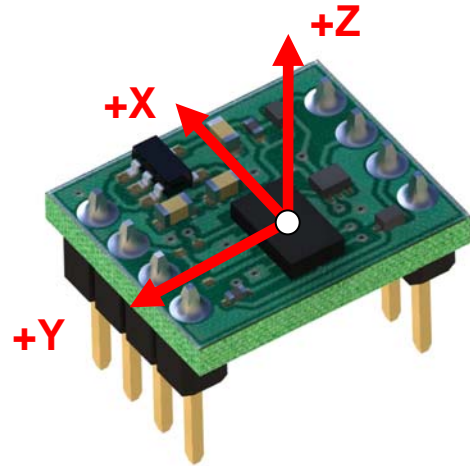
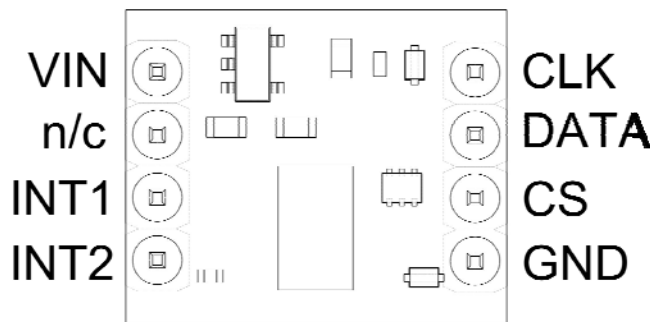
- Inertial measurement units
- Tilt sensing for remote control systems
- Single-tap or double-tap user input
- Multi-axis vibration measurement
- Free-fall detection
- Motion sensing and data logging
- Model airplane flight stabilization

### Key Specifications

- Power requirements: 2.5 – 5.5 VDC; 26  $\mu$ A standby, 0.5 – 3 mA active
- Communication: SPI or I<sup>2</sup>C
- Dimensions: 0.5 x 0.6 x 0.46 in (12.7 x 15.2 x 11.7 mm)
- Operating temperature: -40 to +185 °F (-40 to +85 °C)

**Note:** Demonstration software files may be downloaded from the 28526 product page at [www.parallax.com](http://www.parallax.com).

## Package and Pin Descriptions



Pin #	Pin Name	Description	Pin Type
1	VIN	Input supply voltage	Power
2	n/c	Not connected – reserved for future use	n/a
3	INT1	Interrupt 1/Data Ready	Output
4	INT2	Interrupt 2	Output
5	GND	Ground	Power
6	CS	Chip select - SPI Enable (0), I <sup>2</sup> C Enable (1)	Input
7	DATA	I <sup>2</sup> C Serial Data (SDA), SPI Serial Data (SDI/SDO)	Input/Output
8	CLK	I <sup>2</sup> C Serial Clock (SCL), SPI Serial Clock (SPC)	Input

## Absolute Maximum Ratings

NOTE: These are conditions beyond which permanent device damage may occur; it is not implied that the device will function properly throughout this range. For operational ranges, see the Operating Conditions section below.

Parameter	Min	Typ	Max	Unit
V <sub>IN</sub> (Measured from GND)	0	--	6.5	V
Storage temperature	-40	--	+125	°C
DATA Pin				
Input Voltage	-0.5	--	V <sub>IN</sub> + 0.5	V
Pin Current	-50	--	+50	mA
Maximum Acceleration (all axes)	--	--	5000	g

## Operating Conditions

Parameter	Min	Typ	Max	Unit
V <sub>IN</sub> Supply Voltage	2.5	3.3 – 5	5.5	V
Supply Current <sup>(1)</sup>				
Operational (Sensing) Mode <sup>(1)(2)</sup>	--	437	555	µA
Operational Mode & Pins Loaded <sup>(1)(3)</sup>	--	<3	4.3	mA
Standby Mode <sup>(1)(4)</sup>	--	26	42	µA
Operating Temperature Range	-40	25	85	°C
Output Data (Measurement) Rate				
Data Rate is 125 Hz when 62.5 Hz BW selected	--	125	--	Hz
Data Rate is 250 Hz when 125 Hz BW selected	--	250	--	Hz
Sensitivity <sup>(5)</sup> ±2g range, 8-bit	58	64	70	count/g
0g Output Signal <sup>(5)</sup> ±2g range, 8-bit	-21	0	21	count
SPI Clock Frequency	--	4	--	MHz

### Notes:

1. Supply current measured flowing into VIN pin. V<sub>IN</sub> = 5.5 V
2. Operational Mode current measured with MMA7455L device placed in Measurement Mode and CLK, DATA, and CS pins disconnected.
3. Operation Mode & Pins Loaded is measured as worst-case current draw with CLK, DATA, and CS pins all connected to ground; INT1 and INT2 pins left disconnected.
4. Standby Mode current measured with MMA7455L device placed in standby mode and CLK and DATA lines left high (connected to V<sub>IN</sub>) or disconnected. Value may be higher if these lines are loaded.
5. Values taken from Freescale Semiconductor MMA7455L device specifications.

## Principle of Operation

The Freescale MMA7455L is a surface-machined Micro Electro-mechanical System (MEMS) formed by masking and etching semiconductor materials. It can be visualized as a very small mass suspended in the center of the device by tiny springs. When an acceleration is applied to the device, the mass deflects along one or more axes inside the device. Built-in circuitry constantly measures the amount of deflection along each axis and translates it into acceleration data. Then the data becomes available to be read by an external microcontroller. For more detailed information refer to the Freescale MMA7455L product documentation.

## I/O Level Shifting

Part of what makes this 3-Axis Accelerometer module so useful is its wide power supply and I/O voltage compatibility range of 2.5 V to 5.5 V. The MMA7455L device operates over a supply voltage range of 2.4 V to 3.6 V; so to make it compatible with devices operating up to 5.5 V, a 3.3 V Low Dropout (LDO) voltage regulator was installed, as well as two types of level shifting circuits. This allows the device to operate and communicate over the full voltage supply range.

For the DATA pin, a bi-directional level shifting IC is used to translate the lower I/O voltage of the MMA7455L to the possibly higher voltage used by an externally connected device. This particular 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; but can also be driven low/high for SPI protocol. Additionally, it automatically detects the direction of data flow and switches the output drivers accordingly.

The CLK and CS pins operate exclusively as inputs, so simpler and cheaper level shifting circuits can be used. Only a resistor and Schottky diode are required for each pin. See the Module Schematic section for details. When an external device drives the CLK or CS pin low, the I/O pin on the MMA7455L is pulled

down through the Schottky diode to about 0.35 V. This is plenty low enough to be read as a logic low (0) by the MMA7455L accelerometer device. When the CLK or CS pin is driven high or left floating, it gets pulled up to the local  $V_{CC}$  by the 2.2k $\Omega$  resistor. Meanwhile, the diode prevents the possibility of higher external voltages damaging the input pin on the MMA7455L.

## Measured Acceleration Output Values

The MMA7455L converts a detected acceleration into a number which can easily be read by an external microcontroller. The number it generates depends on the sensitivity of the device which can be  $\pm 2g$ ,  $\pm 4g$ , or  $\pm 8g$ . One g represents the acceleration due to the earth's gravity:  $1g \approx 9.8m/s^2$  or  $1g \approx 32.2ft/s^2$ . Of course this value varies depending on the object's latitude and distance from sea level. From a sensory standpoint, there is no detectable difference between forces observed under the influence of acceleration and forces observed under the influence of gravity. Using units of g's is simply a convenient way of relating the magnitude of a measured acceleration to the familiar force of gravity.

The full measurement range is divided up into a number of counts which is determined by the number of bits specified for the data; 8-bit data has 256 counts, and 10-bit data has 1,024 counts. The value of one count, or least significant bit (LSB) of data, can be determined as follows:

$$\text{One LSB} = \frac{\text{Full g-range}}{\text{Number of counts}}$$

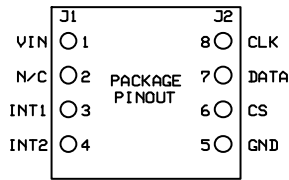
So for a sensitivity range of  $\pm 2g$  (full range = 4g) in 8-bit mode (256 counts), the value of one LSB would be approximately:

$$\text{One LSB} = \frac{4g}{256 \text{ counts}} \approx 0.016 \frac{g}{\text{count}}$$

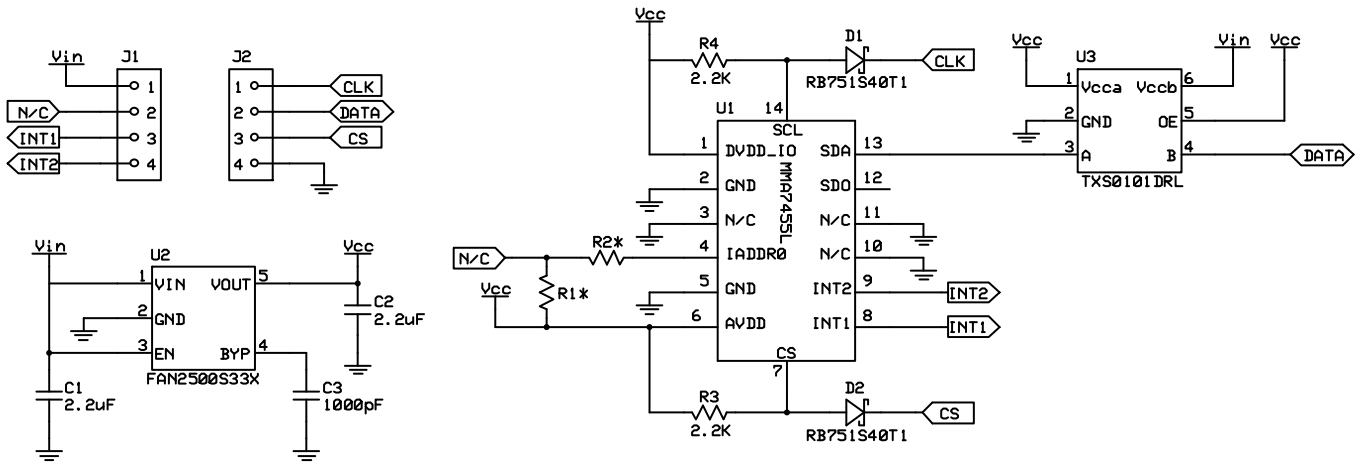
A few key numerical output values over each acceleration range for 8-bit data are shown below for reference.

Sensitivity range	Acceleration	Output Value (hex/decimal)	
$\pm 2g$	-2g	\$81	-127
	-1g	\$C1	-63
	0g	\$00	0
	+1g	\$3F	63
	+2g	\$7F	127
$\pm 4g$	-4g	\$81	-127
	-1g	\$E1	-31
	0g	\$00	0
	+1g	\$1F	31
	+4g	\$7F	127
$\pm 8g$	-8g	\$81	-127
	-1g	\$F1	-15
	0g	\$00	0
	+1g	\$0F	15
	+8g	\$7F	127

# Module Schematic



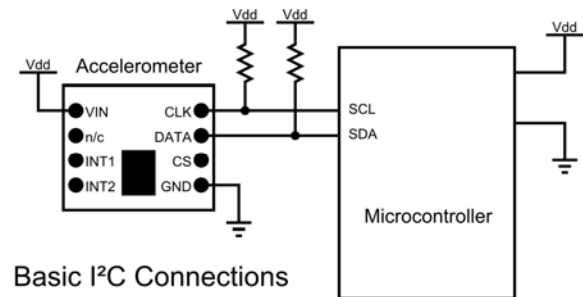
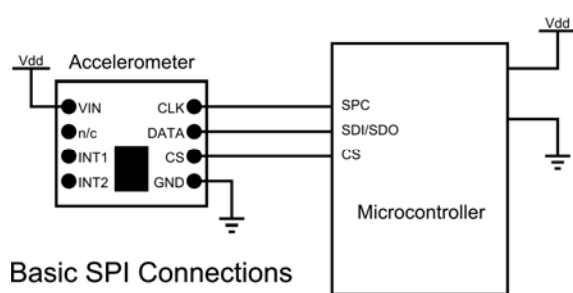
NOTES:  
 \*R1 AND R2 ARE NOT POPULATED. RESERVED FOR FUTURE USE.  
 PIN 12 OF U1 IS N/C



## Quick Start Guide

The following is a very basic procedure to get started initializing and reading values from the Digital 3-Axis Accelerometer module. All the features of the MMA7455L accelerometer are covered in full detail in the Freescale Semiconductor MMA7455L device datasheet. Example test code as well as more advanced code demonstrations of this device for the Propeller and Basic Stamp can be found on the 28526 product page at [www.parallax.com](http://www.parallax.com).

1. With main power off, make the proper connections between the accelerometer and a microcontroller as shown below according to whether SPI or I<sup>2</sup>C is used. The voltage connected to the VIN pin should be the same as the voltage powering the microcontroller communicating with the device. The value of the pull-up resistors used in I<sup>2</sup>C mode depend on the desired data rate, and the total capacitance of the bus. A reasonable starting value for each pull-up resistor is 4.7kΩ. This value may need to be reduced if many devices are connected on the bus (which increases the bus capacitance), or if high data rates are required.



2. Power on the device and initialize the "Mode Control" register (\$16 MCTL). For example: writing a value of \$25 (%00100101) configures the device for SPI 3-wire mode,  $\pm 2g$  measurement range, and puts the device in measurement mode rather than its default standby mode. Refer to the MMA7455L device datasheet for information on proper SPI or I<sup>2</sup>C communication protocol to send and receive data.
3. The device is ready to be read by the microcontroller. Be sure to read from the correct data registers depending on whether 8-bit ( $\pm 2g$ ,  $\pm 4g$ ,  $\pm 8g$ ) or 10-bit ( $\pm 8g$ ) data is used. For example: reading the XOUT8 (\$06) data register returns the 8-bit value for acceleration along the x-axis. Continue reading data from any other desired axes (YOUT8, or ZOUT8). This operation can be performed in a continuous loop in software, or intermittently when required by the application.

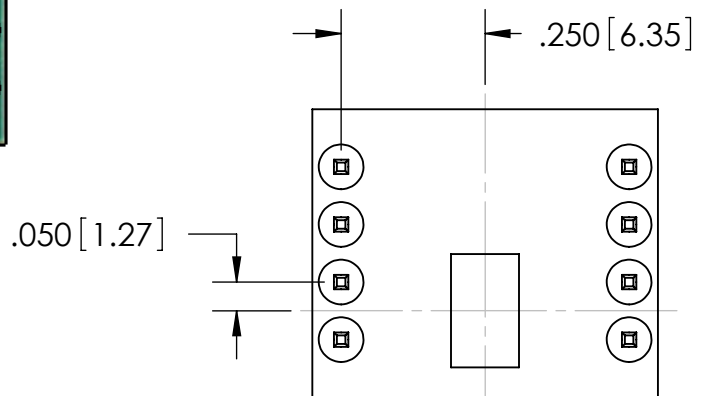
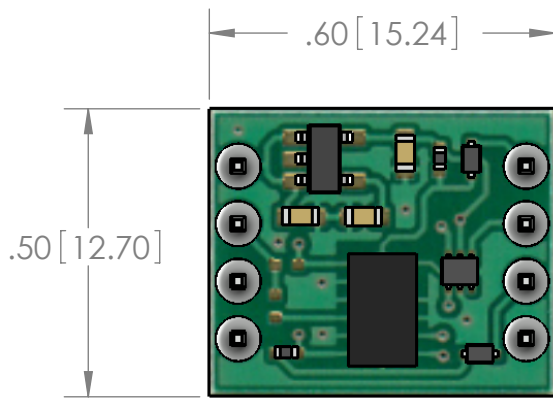
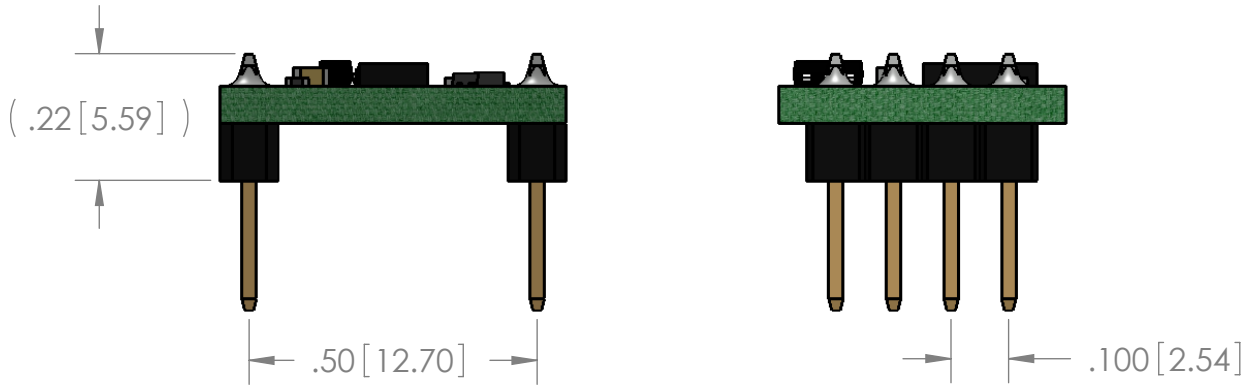
## Module Dimensions

See PDF attached.

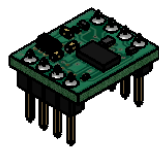
**Material:** ---

**NOTES**

- 1. This drawing is intended for customer reference only.
- 2. Dimensions and board layout are subject to change without notice.



Accelerometer position on circuit board.



Actual Size

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TITLE <b>MMA7455 3-Axis Accelerometer</b>			
SCALE: 3:1	DRAWN BY K. McCullough		SHEET 1 OF 1