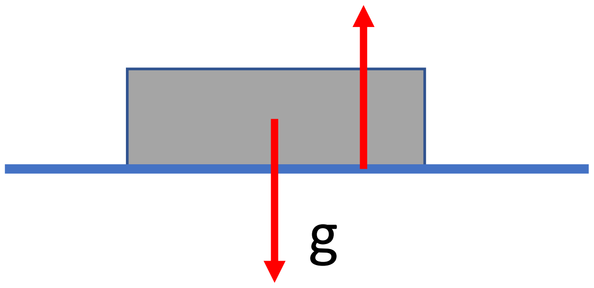
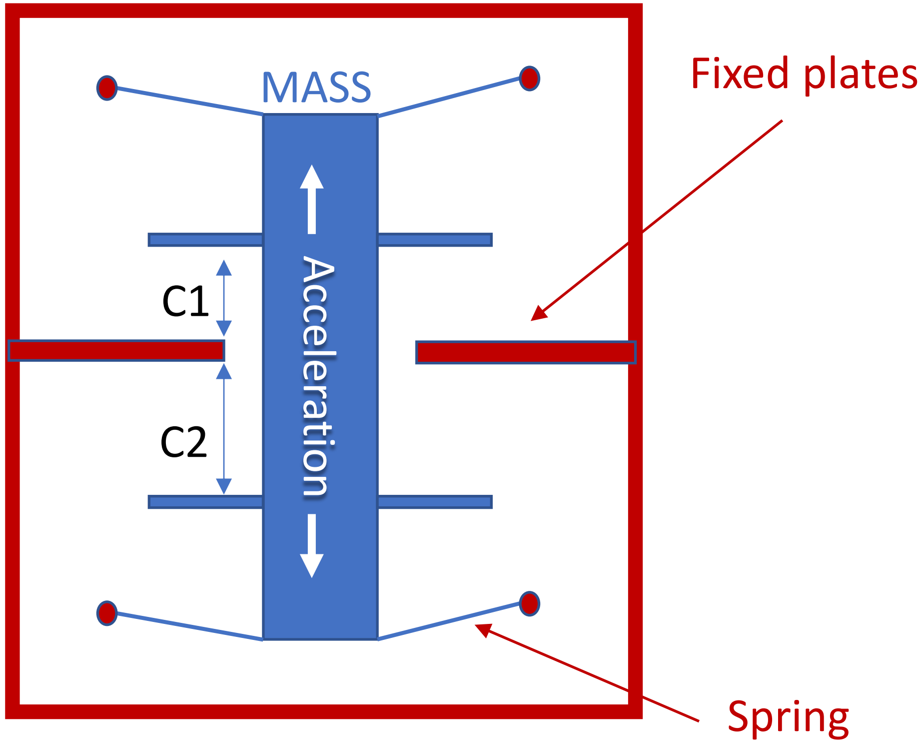
ADXL345
Accelerometer

Accelerometer

- Measures acceleration (rate of change of velocity) of a body in its own rest frame*
- An accelerometer at rest on the surface of the Earth will measure an acceleration due to the Earth's gravity, straight upwards of $g=9.81\ m/s^2$
- By contrast, accelerometers in free fall (falling toward the center of the Earth) will measure zero.



To obtain the acceleration due to motion with respect to the earth, the "gravity offset" must be subtracted.



*Coordinate system (frame of reference) in which the body is at rest

- 3-axis accelerometer
- ±2g, ±4g, ±8g, ±16g
- 13-bit resolution (@ ±16 g)
- Supports both I2C & SPI
- Built in functionality
  - Activity, inactivity sensing
  - Single and double tap sensing
  - Free-fall sensing
- 3 mm x 5 mm x 1 mm package

ANALOG DEVICES

3-Axis, ±2 *g*/±4 *g*/±8 *g*/±16 *g* Digital Accelerometer

Data Sheet **ADXL345**

FEATURES

Ultralow power: as low as 23 μA in measurement mode and 0.1 μA in standby mode at V_S = 2.5 V (typical)
Power consumption scales automatically with bandwidth
User-selectable resolution
Fixed 10-bit resolution
Full resolution, where resolution increases with *g* range, up to 13-bit resolution at ±16 *g* (maintaining 4 mg/LSB scale factor in all *g* ranges)
Embedded memory management system with FIFO technology minimizes host processor load
Single tap/double tap detection
Activity/inactivity monitoring
Free-fall detection
Supply voltage range: 2.0 V to 3.6 V
I/O voltage range: 1.7 V to V_S
SPI (3- and 4-wire) and I²C digital interfaces
Flexible interrupt modes mappable to either interrupt pin
Measurement ranges selectable via serial command
Bandwidth selectable via serial command
Wide temperature range (−40°C to +85°C)
10,000 *g* shock survival
Pb free/RoHS compliant
Small and thin: 3 mm × 5 mm × 1 mm LGA package

APPLICATIONS

Handsets
Medical instrumentation
Gaming and pointing devices
Industrial instrumentation
Personal navigation devices
Hard disk drive (HDD) protection

GENERAL DESCRIPTION

The ADXL345 is a small, thin, ultralow power, 3-axis accelerometer with high resolution (13-bit) measurement at up to ±16 *g*. Digital output data is formatted as 16-bit twos complement and is accessible through either a SPI (3- or 4-wire) or I²C digital interface.

The ADXL345 is well suited for mobile device applications. It measures the static acceleration of gravity in tilt-sensing applications, as well as dynamic acceleration resulting from motion or shock. Its high resolution (3.9 mg/LSB) enables measurement of inclination changes less than 1.0°.

Several special sensing functions are provided. Activity and inactivity sensing detect the presence or lack of motion by comparing the acceleration on any axis with user-set thresholds. Tap sensing detects single and double taps in any direction. Free-fall sensing detects if the device is falling. These functions can be mapped individually to either of two interrupt output pins. An integrated memory management system with a 32-level first in, first out (FIFO) buffer can be used to store data to minimize host processor activity and lower overall system power consumption.

Low power modes enable intelligent motion-based power management with threshold sensing and active acceleration measurement at extremely low power dissipation.

The ADXL345 is supplied in a small, thin, 3 mm × 5 mm × 1 mm, 14-lead, plastic package.

FUNCTIONAL BLOCK DIAGRAM

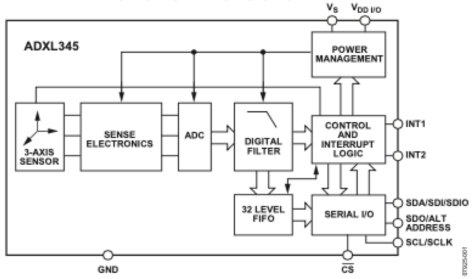


Figure 1.

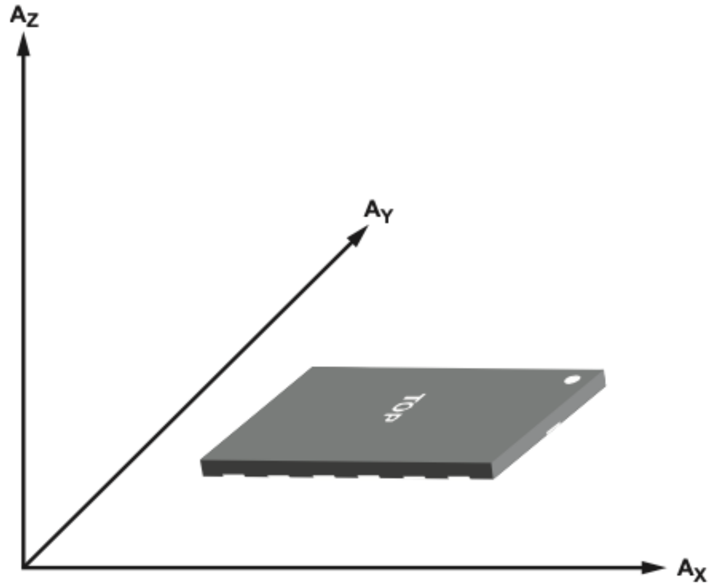
Rev. E

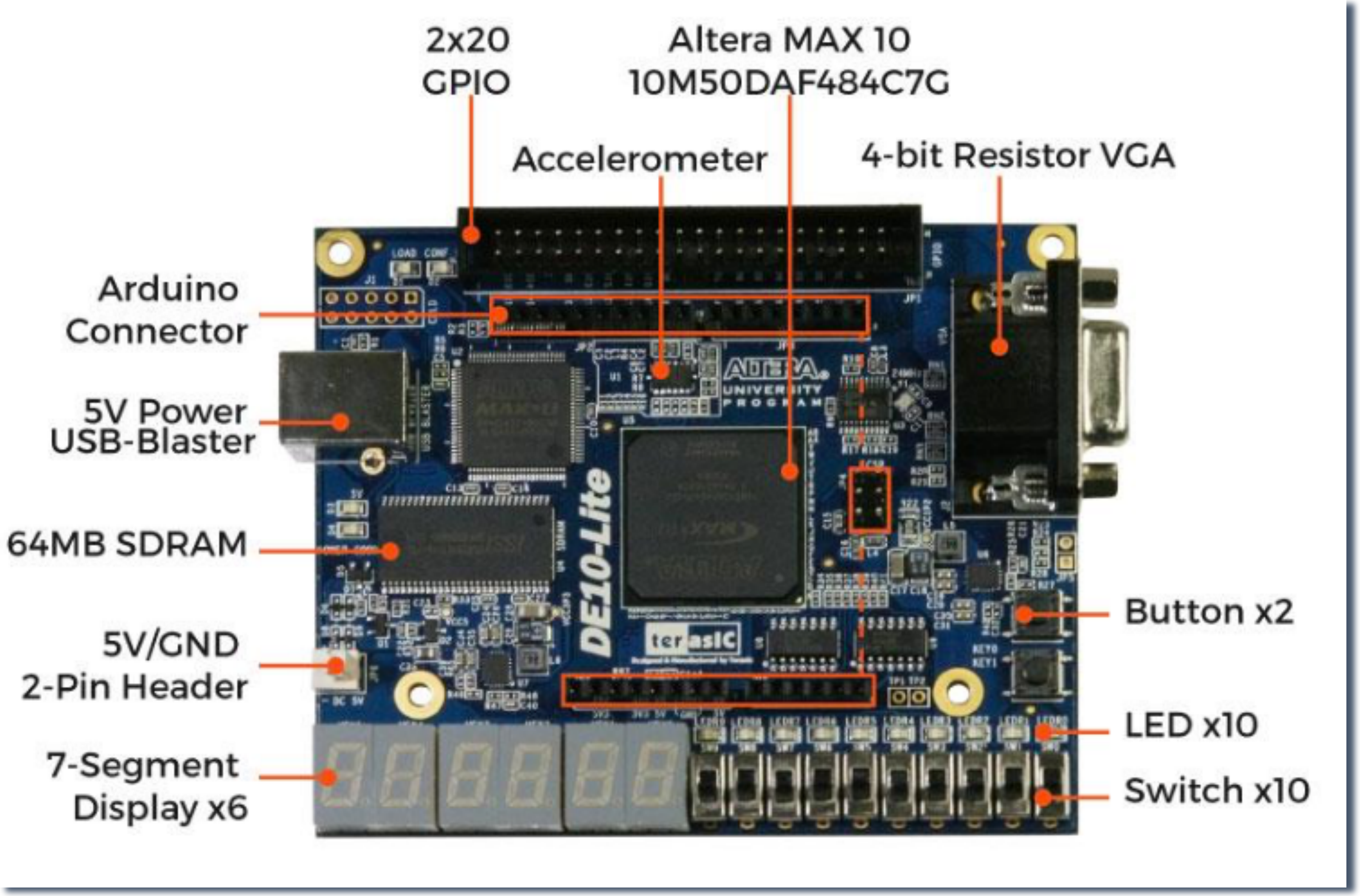
Document Feedback

One Technology Way, P.O. Box 9106, Norwood, MA 02062-9106, U.S.A.
Tel: 781.329.4700

Technical Support www.analog.com

https://www.analog.com/en/products/adxl345.html





Output voltage increases when accelerated along the sensitive axis

FUNCTIONAL BLOCK DIAGRAM

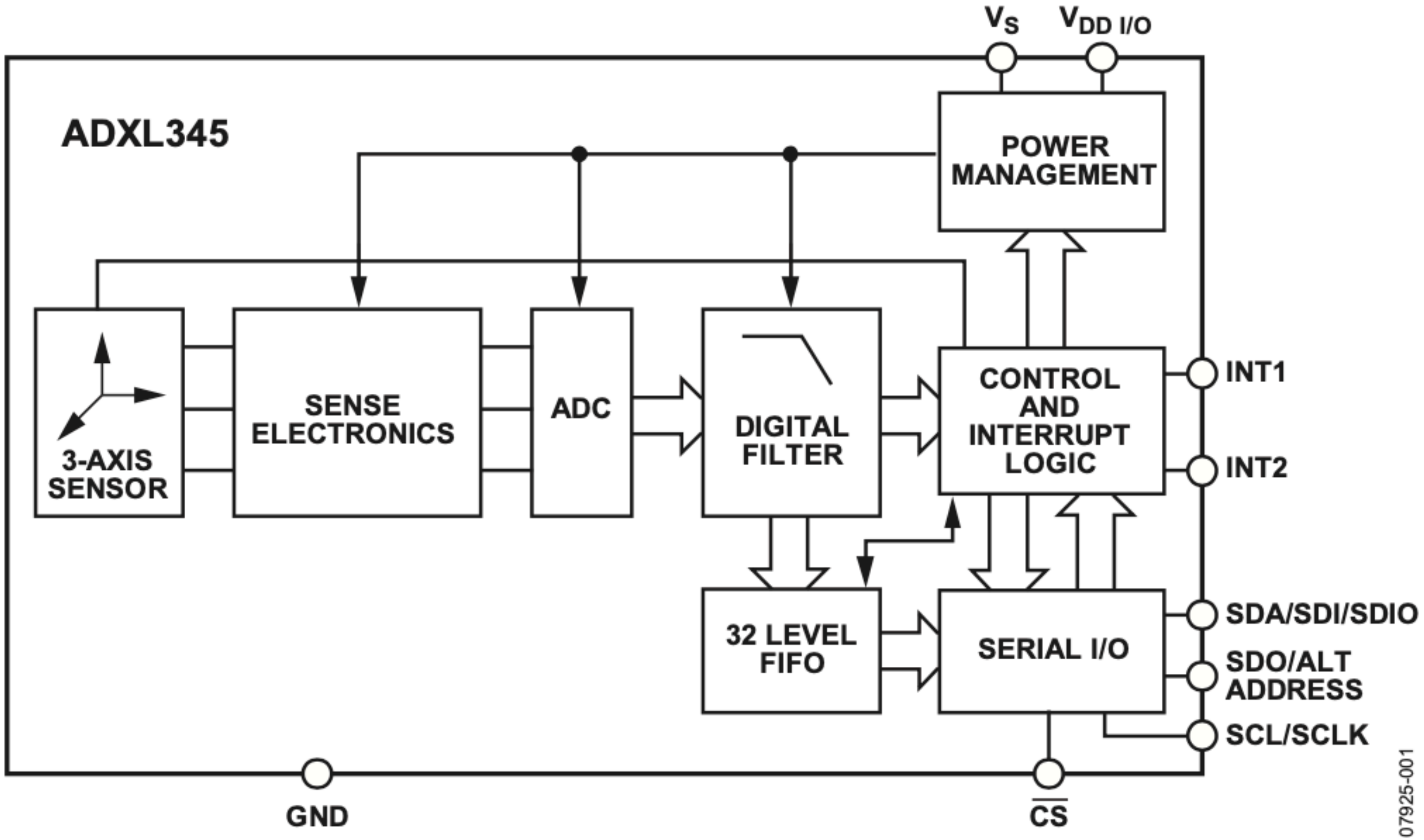


Figure 1.

I2C -mode

I^{2}C

With $\overline{CS}$ tied high to $V_{DD\ I/O}$, the ADXL345 is in I^{2}C mode, requiring a simple 2-wire connection, as shown in Figure 40. The ADXL345 conforms to the *UM10204 I^{2}C-Bus Specification and User Manual*, Rev. 03—19 June 2007, available from NXP Semiconductors. It supports standard (100 kHz) and fast (400 kHz) data transfer modes if the bus parameters given in Table 11 and Table 12 are met. Single- or multiple-byte reads/writes are supported, as shown in Figure 41. With the ALT ADDRESS pin high, the 7-bit I^{2}C address for the device is 0x1D, followed by the R/$\overline{W}$ bit. This translates to 0x3A for a write and 0x3B for a read. An alternate I^{2}C address of 0x53 (followed by the R/$\overline{W}$ bit) can be chosen by grounding the ALT ADDRESS pin (Pin 12). This translates to 0xA6 for a write and 0xA7 for a read.

There are no internal pull-up or pull-down resistors for any unused pins; therefore, there is no known state or default state for the $\overline{CS}$ or ALT ADDRESS pin if left floating or unconnected. It is required that the $\overline{CS}$ pin be connected to $V_{DD\ I/O}$ and that the ALT ADDRESS pin be connected to either $V_{DD\ I/O}$ or GND when using I^{2}C.

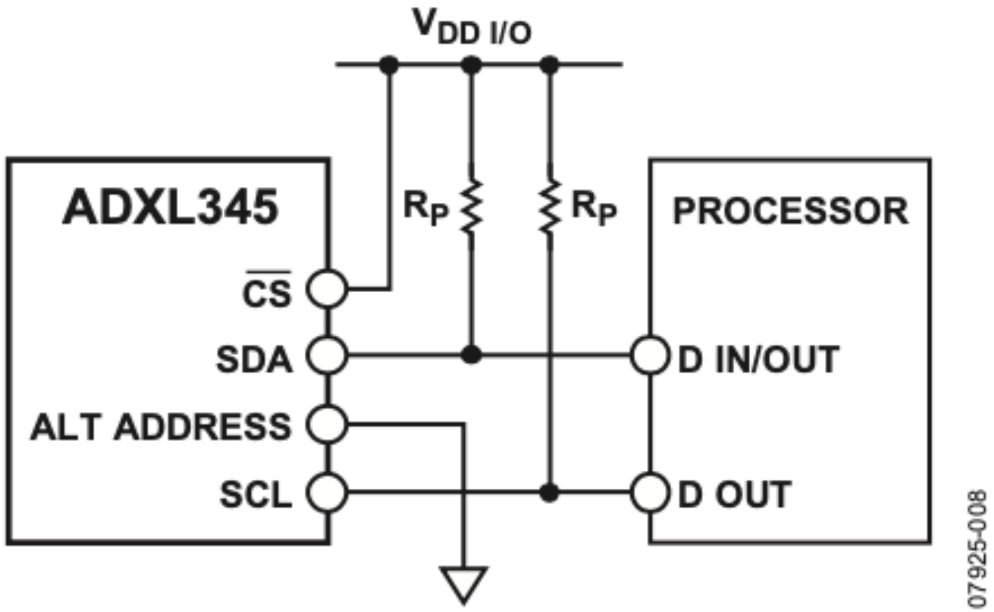


Figure 40. I^{2}C Connection Diagram (Address 0x53)

Table 19.

Address		Name	Type	Reset Value	Description
Hex	Dec				
0x00	0	DEVID	R	11100101	Device ID
0x01 to 0x1C	1 to 28	Reserved			Reserved; do not access
0x1D	29	THRESH_TAP	$R/\overline{W}$	00000000	Tap threshold
0x1E	30	OFSX	$R/\overline{W}$	00000000	X-axis offset
0x1F	31	OFSY	$R/\overline{W}$	00000000	Y-axis offset
0x20	32	OFSZ	$R/\overline{W}$	00000000	Z-axis offset
0x21	33	DUR	$R/\overline{W}$	00000000	Tap duration
0x22	34	Latent	$R/\overline{W}$	00000000	Tap latency
0x23	35	Window	$R/\overline{W}$	00000000	Tap window
0x24	36	THRESH_ACT	$R/\overline{W}$	00000000	Activity threshold
0x25	37	THRESH_INACT	$R/\overline{W}$	00000000	Inactivity threshold
0x26	38	TIME_INACT	$R/\overline{W}$	00000000	Inactivity time
0x27	39	ACT_INACT_CTL	$R/\overline{W}$	00000000	Axis enable control for activity and inactivity detection
0x28	40	THRESH_FF	$R/\overline{W}$	00000000	Free-fall threshold
0x29	41	TIME_FF	$R/\overline{W}$	00000000	Free-fall time
0x2A	42	TAP_AXES	$R/\overline{W}$	00000000	Axis control for single tap/double tap
0x2B	43	ACT_TAP_STATUS	R	00000000	Source of single tap/double tap
0x2C	44	BW_RATE	$R/\overline{W}$	00001010	Data rate and power mode control
0x2D	45	POWER_CTL	$R/\overline{W}$	00000000	Power-saving features control
0x2E	46	INT_ENABLE	$R/\overline{W}$	00000000	Interrupt enable control
0x2F	47	INT_MAP	$R/\overline{W}$	00000000	Interrupt mapping control
0x30	48	INT_SOURCE	R	00000010	Source of interrupts
0x31	49	DATA_FORMAT	$R/\overline{W}$	00000000	Data format control
0x32	50	DATAX0	R	00000000	X-Axis Data 0
0x33	51	DATAX1	R	00000000	X-Axis Data 1
0x34	52	DATAY0	R	00000000	Y-Axis Data 0
0x35	53	DATAY1	R	00000000	Y-Axis Data 1
0x36	54	DATAZ0	R	00000000	Z-Axis Data 0
0x37	55	DATAZ1	R	00000000	Z-Axis Data 1
0x38	56	FIFO_CTL	$R/\overline{W}$	00000000	FIFO control
0x39	57	FIFO_STATUS	R	00000000	FIFO status

Register 0x00—DEVID (Read Only)

D7	D6	D5	D4	D3	D2	D1	D0
1	1	1	0	0	1	0	1

The DEVID register holds a fixed device ID code of 0xE5 (345 octal).

Read device ID register to make sure that the communication with the ADXL345 is working

```
read_from_i2c_device(0x53,0x0,1,&data);
```

Register 0x2D—POWER_CTL (Read/Write)

D7	D6	D5	D4	D3	D2	D1	D0
0	0	Link	AUTO_SLEEP	Measure	Sleep	Wakeup	

Measure Bit

A setting of 0 in the measure bit places the part into standby mode, and a setting of 1 places the part into measurement mode. The ADXL345 powers up in standby mode with minimum power consumption.

Standby Mode

For even lower power operation, standby mode can be used. In standby mode, current consumption is reduced to 0.1 μA (typical). In this mode, no measurements are made. Enter standby mode by clearing the measure bit (Bit D3) in the POWER_CTL register (Address 0x2D). Placing the device into standby mode preserves the contents of FIFO.

```
write_to_i2c_device(0x53,0x2d,1,0x8);
```

Register 0x31—DATA_FORMAT (Read/Write)

D7	D6	D5	D4	D3	D2	D1	D0
SELF_TEST	SPI	INT_INVERT	0	FULL_RES	Justify	Range	

INT_INVERT Bit

A value of 0 in the INT_INVERT bit sets the interrupts to active high, and a value of 1 sets the interrupts to active low.

FULL_RES Bit

When this bit is set to a value of 1, the device is in full resolution mode, where the output resolution increases with the *g* range set by the range bits to maintain a 4 mg/LSB scale factor. When the FULL_RES bit is set to 0, the device is in 10-bit mode, and the range bits determine the maximum *g* range and scale factor.

Range Bits

These bits set the *g* range as described in Table 21.

Table 21. *g* Range Setting

Setting		
D1	D0	*g* Range
0	0	±2 *g*
0	1	±4 *g*
1	0	±8 *g*
1	1	±16 *g*

```
alt_u8 set_accel_config =  0x20 | 0x8 | 0x1;
write_to_i2c_device(0x53,0x31,1,set_accel_config);
```

Register 0x32 to Register 0x37—DATAX0, DATAX1, DATAY0, DATAY1, DATAZ0, DATAZ1 (Read Only)

These six bytes (Register 0x32 to Register 0x37) are eight bits each and hold the output data for each axis.

Register 0x32 and Register 0x33 hold the output data for the x-axis, Register 0x34 and Register 0x35 hold the output data for the y-axis, and Register 0x36 and Register 0x37 hold the output data for the z-axis.

The output data is twos complement, with DATAx0 as the least significant byte and DATAx1 as the most significant byte, where x represent X, Y, or Z.

The DATA_FORMAT register (Address 0x31) controls the format of the data. It is recommended that a multiple-byte read of all registers be performed to prevent a change in data between reads of sequential registers.

```
alt_u8 data[6] ={0};
read_from_i2c_device(0x53,0x32,6,&data[0]);
```

Resolution & sensitivity

Table 1 in datasheet

OUTPUT RESOLUTION	Each axis				
All *g* Ranges	10-bit resolution		10		Bits
±2 *g* Range	Full resolution		10		Bits
±4 *g* Range	Full resolution		11		Bits
±8 *g* Range	Full resolution		12		Bits
±16 *g* Range	Full resolution		13		Bits
SENSITIVITY	Each axis				
Sensitivity at X_{OUT}, Y_{OUT}, Z_{OUT}	All *g*-ranges, full resolution	230	256	282	LSB/*g*
	±2 *g*, 10-bit resolution	230	256	282	LSB/*g*
	±4 *g*, 10-bit resolution	115	128	141	LSB/*g*
	±8 *g*, 10-bit resolution	57	64	71	LSB/*g*
	±16 *g*, 10-bit resolution	29	32	35	LSB/*g*
Sensitivity Deviation from Ideal	All *g*-ranges		±1.0		%
Scale Factor at X_{OUT}, Y_{OUT}, Z_{OUT}	All *g*-ranges, full resolution	3.5	3.9	4.3	m*g*/LSB
	±2 *g*, 10-bit resolution	3.5	3.9	4.3	m*g*/LSB
	±4 *g*, 10-bit resolution	7.1	7.8	8.7	m*g*/LSB
	±8 *g*, 10-bit resolution	14.1	15.6	17.5	m*g*/LSB
	±16 *g*, 10-bit resolution	28.6	31.2	34.5	m*g*/LSB
Sensitivity Change Due to Temperature			±0.01		%/°C

Resolution & sensitivity

Full resolution

±2g → 10-bit ($2^{10} = 1024$)
±4g → 11-bit ($2^{11} = 2048$)
±8g → 12-bit ($2^{12} = 4096$)
±16g → 13-bit ($2^{13} = 8192$)

Sensitivity

4g / 1024 = 0.0039 g/LSB
8g / 2048 = 0.0039 g/LSB
16g / 4096 = 0.0039 g/LSB
32g / 8192 = 0.0039 g/LSB

1g / 256 = 0.0039 g/LSB

Preparing the output

```
alt_16 ax, ay, az;
float axf, ayf, azf;
float scale = 1.0/256 // 1g/LSB
alt_u8 data[6] ={0};

read_from_i2c_device(0x53,0x32,6,&data[0]);

ax = (alt_16) ( data[1] << 8 | data[0] );
ay = (alt_16) ( data[3] << 8 | data[2] );
az = (alt_16) ( data[5] << 8 | data[4] );

axf = ax * scale;
ayf = ay * scale;
azf = az * scale;
```

What to expect

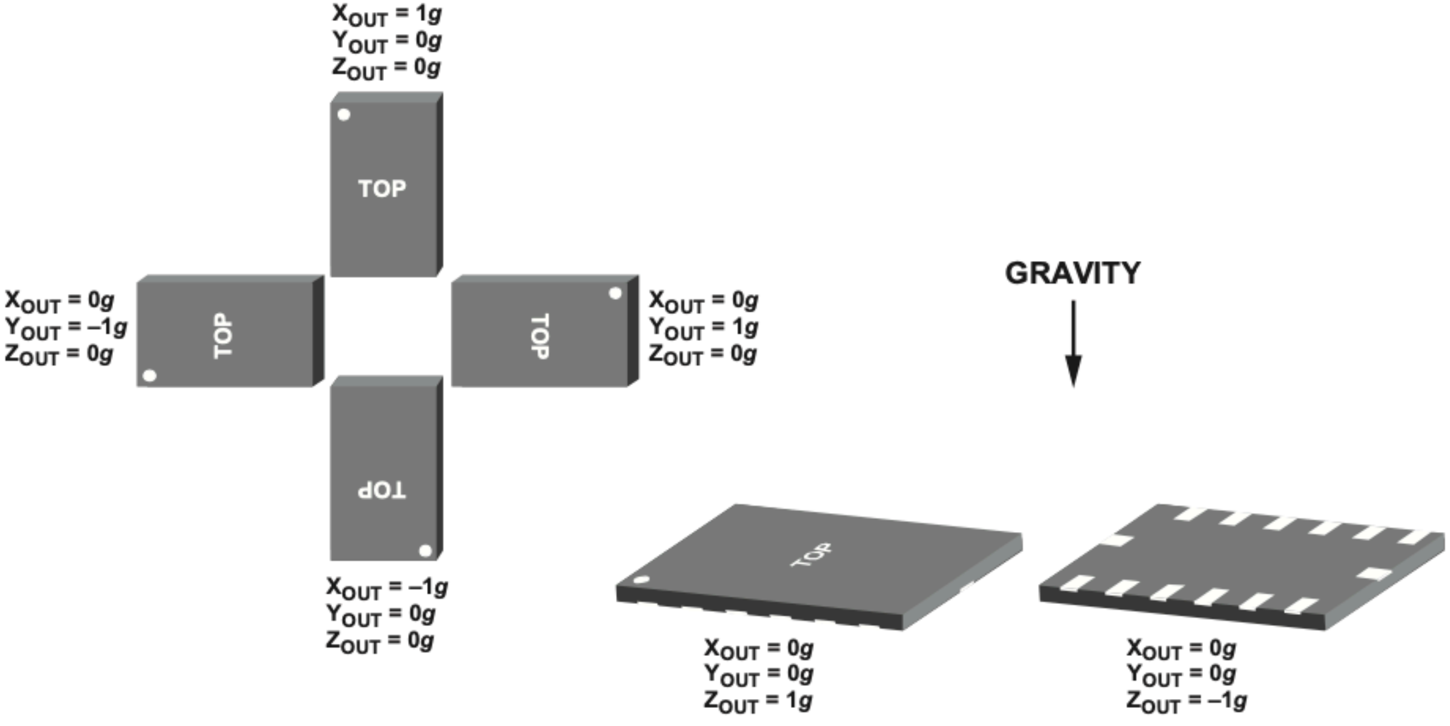
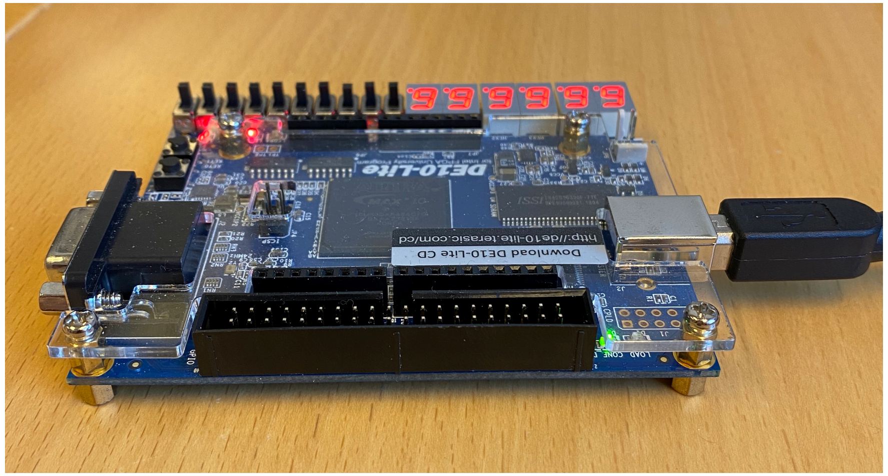


Figure 58. Output Response vs. Orientation to Gravity



DE10-Lite placed on table

alt_u16 alt_16 float

```
ax: (0xffff,    -1, -0.00391) ay: (0xfff3,    -13, -0.05078)  az: (0xf9   ,    249, +0.97266)
ax: (0x0   ,     0, +0.00000) ay: (0xfff3,    -13, -0.05078)  az: (0xf8   ,    248, +0.96875)
ax: (0xffff,    -1, -0.00391) ay: (0xfff7,     -9, -0.03516)  az: (0xf6   ,    246, +0.96094)
ax: (0x0   ,     0, +0.00000) ay: (0xfff4,    -12, -0.04688)  az: (0xfa   ,    250, +0.97656)
```