Low Cost ±100 *g* Single Axis Accelerometer with Analog Output

ADXL190*

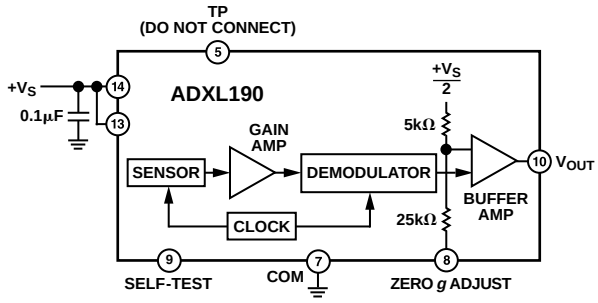
FEATURES

*i*MEMS® Single Chip IC Accelerometer
40 Milli-*g* Resolution
Low Power 2 mA
400 Hz Bandwidth
+5.0 V Single Supply Operation
2000 *g* Shock Survival

APPLICATIONS

Shock and Vibration Measurement
Machine Health
Shipping Recorders
Military Fuze, Safe and Arm

FUNCTIONAL BLOCK DIAGRAM



GENERAL DESCRIPTION

The ADXL190 is a complete acceleration measurement system on a single monolithic IC. It contains a polysilicon surface-micromachined sensor and signal conditioning circuitry to implement an open-loop acceleration measurement architecture. The ADXL190 is capable of measuring both positive and negative accelerations up to ±100 *g*, making it suitable for shock and vibration measurement.

Typical noise floor is 4 m*g*/$\sqrt{\text{Hz}}$ allowing signals below 40 milli-*g* to be resolved. The ADXL190 can measure both dynamic accelerations, (typical of vibration) or static accelerations, (such as inertial force or gravity).

The ADXL190 has a two-pole Bessel switched-capacitor filter. Bessel filters, sometimes called linear phase filters, have a step response with minimal overshoot and a maximally flat group delay. The –3 dB frequency of the poles is preset at the factory to 400 Hz. These filters are also completely self-contained and buffered, requiring no external components.

The product features a built-in self-test feature that exercises both the mechanical structure and electrical circuitry. When triggered by a logic high on the self-test pin, an electrostatic force acts on the beam equivalent to approximately 20% of full-scale acceleration input, and thus a proportional voltage change appears on the output pin. No external components other than a decoupling capacitor are required.

The ADXL190 is available in a hermetic 14-lead surface mount cerpak, specified over the –40°C to +105°C temperature range.

*Patent Pending.
*i*MEMS is a registered trademark of Analog Devices, Inc.

REV. 0

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ADXL190–SPECIFICATIONS ($T_A = T_{MIN}$ to T_{MAX}, V_S = +5 V, Acceleration = 0 *g* unless otherwise noted)

Parameter	Conditions	ADXL190WQC Min	Typ	Max	Units
SENSOR INPUT					
Dynamic Range[1, 2, 3]	Without Zero-*g* Adjust	±105			*g*
Alignment Error			±1		Degrees
Nonlinearity			0.2		%
Cross Axis Sensitivity			±2		%
SENSITIVITY					
Initial[4]	Ratiometric	16.5	18.0	19.5	mV/*g*
Temperature Drift[5]	Δ from +25°C		±0.5		%
ZERO *g* BIAS LEVEL					
Initial[2, 3]	Ratiometric	2.3	2.5	2.7	V
0 *g* Offset vs. Temperature[5]	Δ from +25°C		1.0		*g*
Zero *g* Adjustment Gain		0.45	0.50	0.55	$\Delta V_{OUT}/\Delta V$ 0 *g* Adjust
Zero *g* Adjust Pin Input Impedance		20	30	40	kΩ
NOISE PERFORMANCE					
Noise Density			4	12	mg/√Hz rms
FREQUENCY RESPONSE					
3 dB Bandwidth		360	400		Hz
Sensor Resonant Frequency			24		kHz
SELF-TEST					
Output Change[6]		450		990	mV
Logic "1" Voltage		3.5			V
Logic "0" Voltage				1.0	V
Input Impedance			50		kΩ
ANALOG OUTPUT					
Output Voltage Range	I_{OUT} = ±100 µA	0.25		V_S – 0.25	V
Capacitive Load Drive		1000			pF
POWER SUPPLY					
Specified Performance		4.75		5.25	V
Quiescent Supply Current			2.0	5.0	mA
TEMPERATURE RANGE					
Specified Performance		–40		+105	°C

NOTES

[1]Product is tested at ±50 *g*, and the combination of 0-*g* error, sensitivity error, and output voltage swing measurements provide the calculations for dynamic range.

[2]0-*g* is nominally $V_S/2$. Use of the 0-*g* adjustment pin is used to null the 0-*g* error, resulting in increased dynamic range. It can also be used to create an asymmetrical dynamic range if so desired.

[3]The output response is ratiometric and is described by the following equation. V_{OUT} (accel, V_S) = $[V_S/2 \pm (a\ V_S/5\ V)] + [(accel)\ (b\ V_S + c\ V_S^2)(1 \pm 0.08)]$ Where a = 0.2 V, b = 2.712×10^{-3} 1/*g* , c = 0.178×10^{-3} 1/*g*/V.

[4]Measured at 100 Hz, ±50 *g*.

[5]Specification refers to the maximum change in parameter from its initial value at +25°C to its worst case value at T_{MIN} or T_{MAX}.

[6]ST pin Logic "0" to "1"; $\Delta V_{OUT} = (\Delta V_{OUT}$ @ 5 V) × (V_S/5 V).

All min and max specifications are guaranteed. Typical specifications are not tested or guaranteed.
Specifications subject to change without notice.

ABSOLUTE MAXIMUM RATINGS*

Acceleration (Any Axis, Unpowered for 0.5 ms) . . . . . 2000 *g*
Acceleration (Any Axis, Powered for 0.5 ms) . . . . . 1000 *g*
$+V_S$ . . . . . –0.3 V to +7.0 V
Short Circuit Duration (Any Pin to Common) . . . . Indefinite
Operating Temperature . . . . . –55°C to +125°C
Storage Temperature . . . . . –65°C to +150°C

*Stresses above those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only; the functional operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Drops onto hard surfaces can cause shocks of greater than 2000 *g* and exceed the absolute maximum rating of the device. Care should be exercised in handling to avoid damage.

PIN FUNCTION DESCRIPTIONS

Pin No.	Function
1, 2, 3, 4, 6, 11, 12	No Connect
5	Test Point (Do Not Connect)
7	Common
8	Zero *g* Adjust
9	Self-Test
10	V_{OUT}
13, 14	V_S

PACKAGE CHARACTERISTICS

Package	θ_{JA}	θ_{JC}	Device Weight
14-Lead Cerpak	+110°C/W	+30°C/W	5 Grams

PIN CONFIGURATION

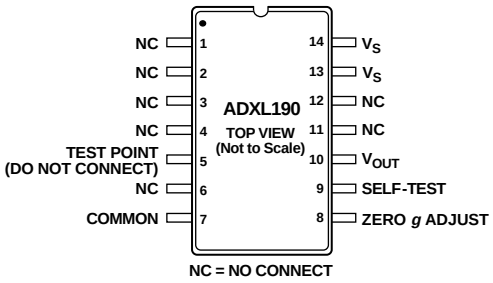


Figure 1 shows the response of the ADXL190 to the earth's gravitational field. The output values shown are nominal. They are presented to show the user what type of response to expect from each of the output pins due to changes in orientation with respect to the earth.

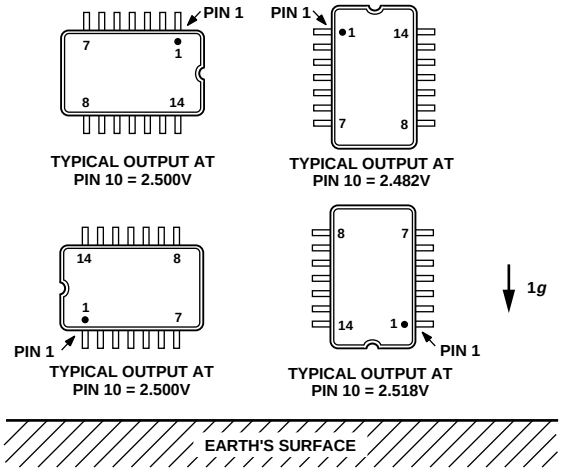


Figure 1. ADXL190 Response Due to Gravity

ORDERING GUIDE

Model	# Axis	Specified Voltage	Temperature Range	Package Description	Package Option
ADXL190WQC	1	+5 V	–40°C to +105°C	14-Lead Cerpak	QC-14

CAUTION

ESD (electrostatic discharge) sensitive device. Electrostatic charges as high as 4000 V readily accumulate on the human body and test equipment and can discharge without detection. Although the ADXL190 features proprietary ESD protection circuitry, permanent damage may occur on devices subjected to high energy electrostatic discharges. Therefore, proper ESD precautions are recommended to avoid performance degradation or loss of functionality.

APPLICATIONS

All the circuitry needed to drive the sensor and convert the capacitance change to voltage is incorporated on-chip requiring no external components except for standard power supply decoupling. Both sensitivity and the zero-*g* value are ratiometric to the supply voltage, so that ratiometric devices following the accelerometer (such as an ADC, etc.) will track the accelerometer if the supply voltage changes. The output voltage (V_{OUT}) is a function of both the acceleration input (a) and the power supply voltage (V_S) as follows:

$$V_{OUT} = V_S/2 - (Sensitivity \times V_S/5\ V \times a)$$

Adjusting the 0 *g* Bias Level

In some cases the user may have an asymmetrical input or may want to fine adjust the zero-*g* output level to obtain maximum dynamic range. The zero-*g* level is adjusted by supplying a voltage to the zero-*g* adjustment pin (see Figure 2).

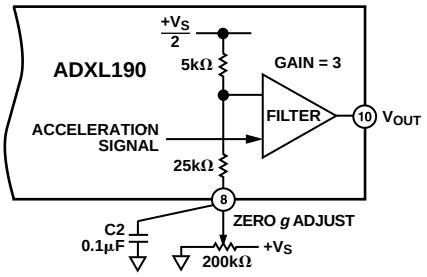


Figure 2. Optional Zero-g Adjust Circuit Detail

Any voltage difference between the zero-*g* adjustment pin and $V_S/2$ is reduced by a factor of 6 by the internal resistor divider. This is then gained by the factor of 3 in the output stage for a total gain of 0.5 for the zero-*g* adjustment. (Note: The ratio of the resistors in the divider is consistent from part-to-part; however, the absolute values can have a ±30% tolerance). The zero-*g* adjustment voltage can be set up by a variety of methods including a potentiometer (as shown in Figure 2), a PWM signal, or with a simple three-state output.

The simplest way is by adding a resistor between the ZERO *g* ADJUST pin and V_S or ground. The output will be offset by:

$$Offset\ (V) = (7.5 \times V_S)/(30 + R)$$

where *R* is in kΩ and connected to V_S.

$$Offset\ (V) = (-7.5 \times V_S)/(30 + R)$$

where *R* is in kΩ and connected to ground.

Resistors may also be connected to microcontroller I/O pins as shown in Figure 3. Using two I/Os that may be set to V_S, ground, or three-state, there are seven possibilities as shown in Table I (one cannot set one I/O pin to V_S and the other to ground). Using such a system, any ADXL190 may be user trimmed to output 2.5 V ± 35 mV at zero *g*.

Table I. Offsets Produced Using the Circuit in Figure 3 for V_S = 5 V

P1	P0	Offset Voltage Produced	Offset in *g*
Three-State	Three-State	0 mV	0
Three-State	0	–71 mV	–4
0	Three-State	–134 mV	–7.4
0	0	–191 mV	–10.6
Three-State	1	71 mV	4
1	Three-State	134 mV	7.4
1	1	191 mV	10.6

Another way to adjust the zero *g* offset is to supply a voltage to the ZERO *g* ADJUST pin. The difference between $V_S/2$ and the voltage at the ZERO *g* ADJUST pin is reduced by a factor of 6 (as a result of the internal 5 kΩ and 25 kΩ voltage divider) and then multiplied by a factor of 3 in the output stage of the ADXL190 resulting in a total gain of 0.5. Offset is thus described by the following equation:

$$Offset\ (V) = (Voltage\ at\ the\ ZERO\ g\ ADJUST\ Pin - V_S/2)/2$$

This voltage may be produced by a variety of methods including a PWM signal from a microcontroller. Care must be taken that the output impedance of this voltage source is less than 5 kΩ and that there is very little ripple (noise). Any noise at the ZERO *g* ADJUST pin will cause output errors.

If an asymmetric range of acceleration is required (e.g., +75 *g* to –125 *g*) a resistor may be connected between the ZERO *g* ADJUST and ground or V_S as described above. For example:

For a range of +75 *g* to –125 *g* the offset required is –25 *g*.

–25 *g* at 18 mV/*g* = 450 mV of offset is required.

Rearranging the offset equations above:

$R = [(7.5 \times V_S)/offset] - 30 = 53.3\ k\Omega$ connected to ground.

For asymmetric operation the *g* range midpoint may be shifted up to ±80 *g* typically.

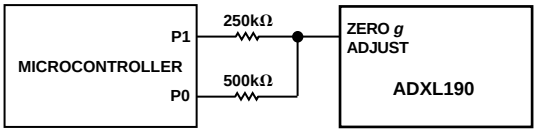
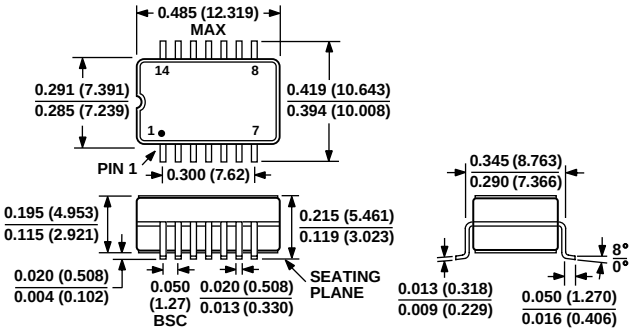


Figure 3. An Offset Adjustment Scheme

OUTLINE DIMENSIONS

Dimensions shown in inches and (mm).

14-Lead Cerpak
(QC-14)



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SUNSTAR商斯达实业集团是集研发、生产、工程、销售、代理经销 、技术咨询、信息服务等为一体的高科技企业，是专业高科技电子产品生产厂家，是具有 10 多年历史的专业电子元器件供应商，是中国最早和最大的仓储式连锁规模经营大型综合电子零部件代理分销商之一,是一家专业代理和分銷世界各大品牌IC芯片和電子元器件的连锁经营綜合性国际公司。在香港、北京、深圳、上海、西安、成都等全国主要电子市场设有直属分公司和产品展示展销窗口门市部专卖店及代理分销商，已在全国范围内建成强大统一的供货和代理分销网络。 我们专业代理经销、开发生产电子元器件、集成电路、传感器、微波光电元器件、工控机/DOC/DOM电子盘、专用电路、单片机开发、MCU/DSP/ARM/FPGA软件硬件、二极管、三极管、模块等，是您可靠的一站式现货配套供应商、方案提供商、部件功能模块开发配套商。**专业以现代信息产业（计算机、通讯及传感器）三大支柱之一的传感器为主营业务，专业经营各类传感器的代理、销售生产、网络信息、科技图书资料及配套产品设计、工程开发。我们的专业网站——中国传感器科技信息网（全球传感器数据库） www.SENSOR-IC.COM 服务于全球高科技生产商及贸易商，为企业科技产品开发提供技术交流平台。欢迎各厂商互通有无、交换信息、交换链接、发布寻求代理信息。欢迎国外高科技传感器、变送器、执行器、自动控制产品厂商介绍产品到 中国，共同开拓市场。**本网站是关于各种传感器-变送器-仪器仪表及工业自动化大型专业网站,深入到工业控制、系统工程计 测计量、自动化、安防报警、消费电子等众多领域，把最新的传感器-变送器-仪器仪表买卖信息,最新技术供求,最新采购商,行业动态，发展方向，最新的技术应用和市场资讯及时的传递给广大科技开发、科学研究、产品设计人员。本网站已成功为石油、化工、电力、医药、生物、航空、航天、国防、能源、冶金、电子、工业、农业、交通、汽车、矿山、煤炭、纺织、信息、通信、IT、安防、环保、印刷、科研、气象、仪器仪表等领域从事科学研究、产品设计、开发、生产制造的科技人员、管理人员 、和采购人员提供满意服务。 **我公司专业开发生产、代理、经销、**销售各种传感器、变送器、敏感元器件、开关、执行器、仪器仪表、自动化控制系统： 专门从事设计、生产、销售各种传感器、变送器、各种测控仪表、热工仪表、现场控制器、计算机控制系统、数据采集系统、各类环境监控系统、专用控制系统应用软件以及嵌入式系统开发及应用等工作。如热敏电阻、压敏电阻、温度传感器、温度变送器、湿度传感器、 湿度变送器、气体传感器、 气体变送器、压力传感器、 压力变送、称重传感器、物（液）位传感器、物（液）位变送器、流量传感器、 流量变送器、电流（压）传感器、溶氧传感器、霍尔传感器 、图像传感器、超声波传感器、位移传感器、速度传感器、加速度传感器、扭距传感器、红外传感器、紫外传感器、 火焰传感器、激光传感器、振动传感器、轴角传感器、光电传感器、接近传感器、干簧管传感器、继电器传感器、微型电泵、磁敏（阻）传感器 、压力开关、接近开关、光电开关、色标传感器、光纤传感器、齿轮测速传感器、 时间继电器、计数器、计米器、温控仪、固态继电器、调压模块、电磁铁、电压表、电流表等特殊传感器 。 同时承接传感器应用电路、产品设计和自动化工程项目。

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