DATASHEET

SF3600.A

30S.SF3600A.A.12.12

Energy
Mil/Aerospace
Industrial

Inertial
Tilt
Vibration
Seismic

Features

- Three axis output
- ±3g linear output
- Best in class noise level of 0.3 $\mu g_{rms}/\sqrt{Hz}$
- Wide dynamic range of 120 dB (100 Hz BW)
- Large bandwidth (DC to 1000Hz BW)
- Analog servo accelerometer
- Self test input
- Demonstrated high reliability
- RoHS compliant

The SF3600 product has been designed and developed for “strong motion” seismic sensing applications. This MEMS capacitive product is largely used for seismic and vibration sensing when extreme low noise measurement is required. Features such as wide dynamic range, excellent bandwidth, low distortion, high shock tolerance, and thermal stability make it ideal for applications such as earthquake and seismology measurements, homeland and border security or structural monitoring.

The SF3600 is a three axis combination of SF1600 Si-Flex™ accelerometers that operates from a bipolar power supply voltage that can range from ± 6V to ± 15V with a typical current consumption of 36mA at ± 6V. The linear full acceleration range is ± 3g with a corresponding sensitivity of 1.2V/g. It can operate over a wide temperature range from -40°C to +85°C and can withstand a shock of up to 1000g without performance degradation. The frequency response (bandwidth) over the full scale range is DC to > 1000Hz.

Accelerometer specifications

All values are specified at +20°C (+68°F) and ±15 VDC supply voltage, unless otherwise stated

	Units	**SF3600**
Linear output range	g peak	± 3
DC bias	mg max.	± 200
Scale factor / Sensitivity	V/g	1.2 ± 0.12
Dynamic range (0.1 to 100 Hz BW)	dB typ. (min.)	117 (113)
Noise (10 to 1000 Hz)	$\mu g_{rms}/\sqrt{Hz}$ typ. (max.)	0.3 (<0.5)
Noise (0.1 to 100 Hz)	μg_{rms} typ.	3.3
Bandwidth [1]	Hz	DC to > 1000
Cross-axis rejection	dB typ.	> 46
Bias thermal coefficient	mg/°C typ. (min. / max)	0.2 (-1 / +1) (ref ± 1g)
Sensitivity temperature coefficient (ref ± 1g)	ppm/°C typ. (min. / max)	120 (-150 / +250) (ref ± 1g)
Linearity error	% typ. (max.) within ± 1g	< 0.2 (<1%)

[1] The bandwidth is defined as the frequency band for which the sensitivity has decreased by less than 3dB

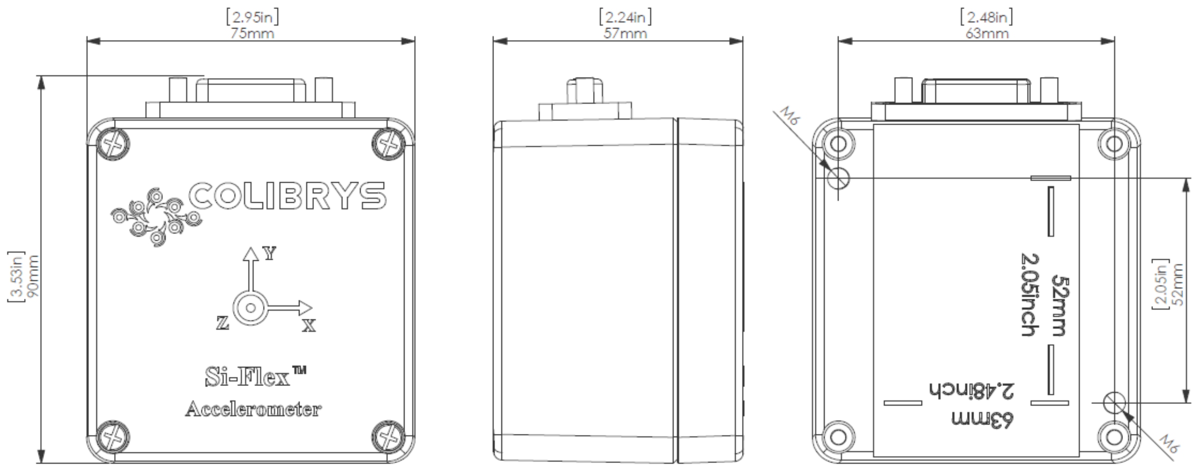
Environmental specifications

	SF3600
Operating temperature range	-40°C to +85°C (-67°F to 255°F)
Shock resistance	Up to 1'000 g peak (0.5ms half-sine, single shock, not repetitive, in one direction o, p or i)
ESD sensitivity	Class 2 (requirements MIL-STD-883-G, 1 Method 3015.7), Human Body Model 2kV
Ultrasonic cleaning	The product can't be cleaned with ultrasonic bath. Such a cleaning process will largely affect the sensor integrity

Packaging

The tri-axial sensor configuration is implemented in waterproof, cast aluminum housing. An electronic board interface allows electrical interconnection between these three accelerometers and the common oscillator.

The precise dimensions are given in the next figure and the weight of the final product is typically smaller than 400 grams.



Typ. values in mm (inch)

Mounting

In order to accurately measure acceleration signals, the SF3600 must be firmly mounted to a surface, using the bottom of the housing as reference plane to ensure a good axis alignment. Acceleration in the direction indicated on the housing will produce a positive ouput signal.

Physical specifications

	SF3600
Packaging	Waterproof, cast aluminum housing
Hermeticity	Enclosure moisture rating IP rating 67
Weight	< 400 grams
Size	Typ. 80 x 75 x 57 mm (3.15 x 2.95 x 2.25 inch)
Reference plane for axis alignment	Bottom of the housing

Principle of operation

The core of the accelerometer is the capacitive bulk micro-machined silicon sensor. The fundamental technology for the manufacturing of Colibrys accelerometers is based on the structuring of three silicon wafers:

- The center wafer supports the proof mass through a spring. This inertial mass is also the center electrode of the capacitive sensor.
- Upper and lower wafers constitute the external fixed electrodes of the sensor

The three wafers are bounded together by Silicon Fusion Bonding (SFB). This bonding process insures not only a perfect balance between the three wafers of the system but also allows building a hermetic sealed cavity for the spring–mass system. The bonding process is done at high temperature (>1000°C) and at low pressure to ensure an optimal gas damping and bandwidth control.

Applied acceleration or tilt to the sensitive axis changes the inertia, causing the mass to move between the upper and lower electrodes, which results in a change to the values of the capacitors. This differential variation of the sensing capacitors is measured by the custom ASIC. As changes in capacitance are sensed, a restoring electrostatic force is applied to maintain the proof mass in a central (neutral) position. The output signal of the sensor is derived directly from the correction signal used to keep the center-mass in the neutral position. This correction signal is linearly proportional to the acceleration applied (by the ground motion) to the sensor. This type of closed-loop design generally provides better output linearity than open-loop sensors.

The output signal is a DC-coupled acceleration-proportional signal with a typical sensitivity of 1.2V/g for the SF1600 and a bipolar output ranging nominally over ±4.2V. The output of the sensor follows a g * sin(θ) response as it rotates through gravity and can measure the vertical tilt angle (θ) with a high degree of accuracy.

Si-Flex™ accelerometers are calibrated by precisely rotating the accelerometer through the gravity field (±1g) as described by IEEE Standard Specification Format Guide and Test Procedure for Linear, Single-Axis, Pendulous, Analog Torque Balance Accelerometer. The resulting sine wave is analyzed and processed to provide the calibration coefficients K1, K0, K2, and K3.

Equation (1) below shows how the voltage output is linked to calibration data and acceleration. Equation (2) is a basic calculation suitable for most applications, which is obtained from equation (1) by discarding the non-linear terms.

$$Vout = K1K0 + K1a + K1K2\,a^2 + K1K3a^3 \quad (1)$$

$$a \approx Vout/K1 - K0 \quad (2)$$

where

- a is the acceleration (1g = 9.806 m/s^2)
- Vout is the output signal (Volts)
- K1 is accelerometer scale factor [V/g]
- K0 is bias [g]
- K2 is second order non linearity [g/g2]
- K3 is third order non-linearity [g/g3]

Note: The accelerometer scale factor K1 is provided as a single-ended output value. If +Vout and –Vout are used together as a differential output, the scale factor will be 2 * K1.

Electrical specifications

	SF3600
Input voltage (VDD – VSS)	±6 to ±15 VDC
Sensitivity	1.2 ± 0.12
Operating current consumption	Quiescent current of typ. 36 mA @ 6VDC

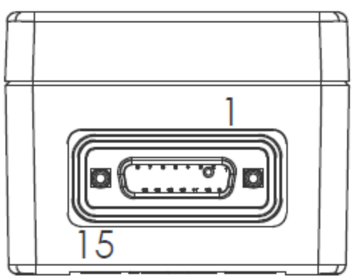
Both the (+) and (-) power supplies must be applied simultaneously to the input pins (within 50 ms). The power supply should have less than 100 µV√Hz noise in order to avoid the possibility of adding noise to the output of the sensor. The ASIC and on-board electronics operate on ± 5V DC provided by internal power conditioning circuitry, reducing the effects of power supply variations on sensor operation. The input power supply connections are reverse polarity protected by a diode bridge. Should reverse polarity power be applied, the unit will self-correct and start normally. The output of the Si-Flex accelerometer is fully buffered and ready to connect to common inputs found on many analog to digital converters, oscilloscopes and digital multi-meters. The nominal output impedance for the Si-Flex accelerometers is typically 10 Ohms.

Self test function

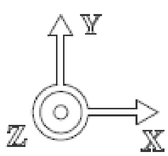
The self-test function allows testing of sensor functionality. A 5V CMOS TTL level pulse of 10 ms duration (for example) injects a signal into the feedback loop that servos the proof mass to a new position. This in turn is reflected as a 10 ms pulse of approximately 800 mg observed in the output signal. This is a true self-test. If for instance the sensor is non-functional, if there is an open or short cut in the output cabling, or there is no DC power to the device, the self test operation will not yield a signal change on the output. The applied logic level high to this pin must be +4 volts minimum and the logic low must be less than 0.5 VDC. The signal is ratiometric to the applied voltage.

The self test feature is intended only as a functional check and not for calibration purposes.

Electrical connections and power supply requirements



Top view



PIN	Signal	Comment
P1	+Vin	Positive Power Input
P2	-Vin	Negative Power Input
P3-P4	UNUSED	
P5	ATEST*	Sensor Self Test Input
P6	X-OUT	X Output
P7	Y-OUT	Y Output
P8	Z-OUT	Z Output
P9	COM Power	The common connection for the bipolar power supply
P10-P12	UNUSED	
P13	COM-X	GND for X-OUT
P14	COM-Y	GND for Y-OUT
P15	COM-Z	GND for Z-OUT

Quality

- Colibrys is ISO 9001:2008, ISO 14001:2004 and OHSAS 18001:2007 certified
- Colibrys is in compliant with the European Community Regulation on chemicals and their safe use (EC 1907/2006) REACH.
- SF3600 product is complaint with the Swiss LSPro : 930.11 dedicated to the security of products
  Note:
  - *SF3600 product is available for sales to professionasl only*
  - *Le produit SF3600 n'est disponible à la vente que pour des clients professionnels*
  - *Die Produkt SF3600 is nur im Vertrieb für kommerzielle Kunden verfügbar*
  - *SF3600 prodotto è disponibile alla vendita soltanto per clienti professionisti*
- Recycling : please use appropriate recycling process for electrical and electronic components

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Glossary of parameters of the Data Sheet + Definitions

-VOUT	Inverted output signal.
+VOUT	Output signal.
ATST	Sensor self test input. A minimum signal of 4 volts is required to produce an output. This input should be maintained at logic low or connected to RTN when not in use. This input can be connected to multiple sensors if one test signal is desired for multiple sensor channels.
RTN	Signal Return (common). All of the signal-return lines are tied together on the board. Separate connection points are provided for various inputs to optimize noise due to cabling. Use this as a signal-return for single-ended operation with either +VOUT or –VOUT.
OFFSET	Used to remove DC coupled to gravity. This input should be tied to RTN if unused.
XTI	External oscillator input for products without the oscillator option. No Connection for products with the oscillator option.
N/C	No Connection. This pin is not used for this device. Do not connect to it.
-PWR	Negative power supply. -6 to -15 VDC can be used. Reverse polarity protected.
+PWR	Positive power supply. +6 to +15 VDC can be used. Reverse polarity protected.

g [m/s^2]

Unit of acceleration, equal to standard value of the earth gravity (Accelerometer specifications and data supplied by Colibrys use 9.80665 m/s²)

Bias [mg]

The accelerometer output at zero g

Bias stability [mg]

Maximum drift of the bias after extreme variation of external conditions (aging, temperature cycles, shock, vibration)

Bias temperature coefficient [µg/°C]

Maximum variation of the bias calibration under variable external temperature conditions (slope of the best fit straight line through the curve of bias vs. temperature). Bias Temperature Coefficient is specified between –40°C and +50°C, where temperature behaviour is linear

Scale factor sensitivity [mV/g]

The ratio of the change in output (in volts) to a unit change of the input (in units of acceleration); thus given in mV/g

Scale factor temperature coefficient [ppm/°C]

Maximum deviation of the scale factor under variable external temperature conditions

Temperature sensitivity

Sensitivity of a given performance characteristic (typically scale factor, bias, or axis misalignment) to operating temperature, specified as worst case value over the full operating temperature range. Expressed as the change of the characteristic per degree of temperature change; a signed quantity, typically in ppm/°C for scale factor and g/°C for bias. This figure is useful for predicting maximum scale factor error with temperature, as a variable when modelling is not accomplished

Axis alignment [mrad]

The extent to which the accelerometer's true sensitive axis deviates from being perfectly orthogonal to the accelerometer's reference mounting surface when mounted to a flat surface

Resolution, Threshold [mg]

Value of the smallest acceleration that can be significantly measured

Non-linearity [% of FS]

The maximum deviation of accelerometer output from the best linear fit over the full operating range. The deviation is expressed as a percentage of the full-scale output (+A_{FS}).

Bandwidth [Hz]

Frequency range from DC to F-3dB where the variation of the frequency response is less than –3dB or -5% for vibration sensors

Noise [ng_{peak}/√Hz]

A measure of the Power Spectral Density (PSD) of the white noise on the accelerometer output caused by either the electronics or by Brownian motion of the proof mass.

Colibrys reserves the right to change these data without notice.

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