



Features

- Small (10.4 x 6.7 x 2.7mm)
- Excellent bias repeatability over temperature
- Dual-axis MEMS accelerometer in a hermetically sealed ceramic LCC surface mount package for temperature and humidity resistance
- Five dynamic range options; $\pm 0.85g$, $\pm 2.5g$, $\pm 10g$, $\pm 30g$, $\pm 96g$
- Analogue and digital (SPI®) outputs for linear acceleration and temperature
- Wide bandwidth (typically 170Hz digital, 250Hz analogue)
- Temperature range -40 to +125°C
- Low power consumption (3mA Typ) from a 3.3V supply
- Integral temperature sensor
- RoHS compliant

Applications

- Aerospace and industrial
- Aircraft AHRS and controls
- Platform stabilisation
- Drilling guidance
- Surveying and mapping
- Land and marine navigation
- Transportation
- Inertial measurement units
- Levelling and tilt sensing

1 General Description

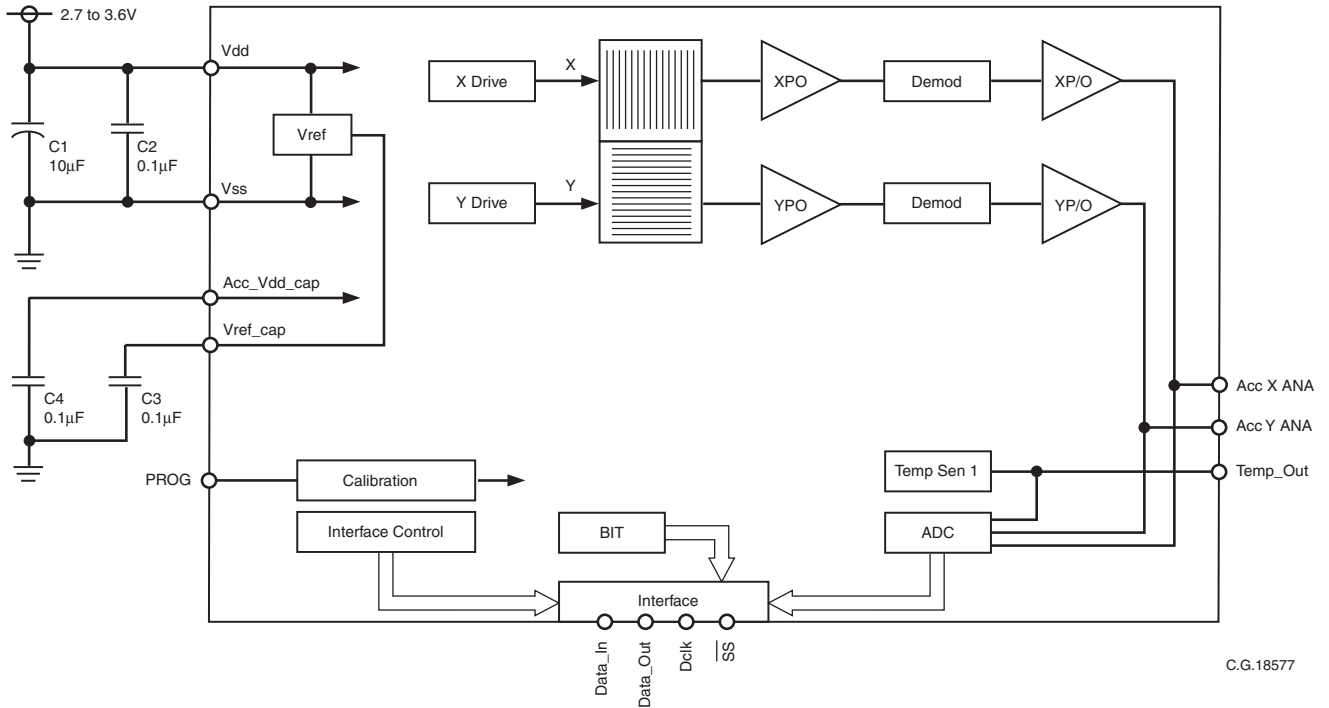
Gemini™ is a new family of integrated MEMS accelerometers from Silicon Sensing, providing high performance dual-axis linear acceleration measurement in a small surface mounted package. It comprises a dual-axis MEMS sensing device with a dedicated control ASIC in a single ceramic LCC package. Sensor data is output via analogue and digital (SPI®) interfaces. The CAS290 series of parts are the orthogonal version of the CAS200 (flat) package.

The CAS290 series of parts provides two in-plane axes of linear acceleration sensing and is available in five different dynamic ranges:

- $\pm 0.85g$ - CAS291
- $\pm 2.5g$ - CAS292
- $\pm 10g$ - CAS293
- $\pm 30g$ - CAS294
- $\pm 96g$ - CAS295

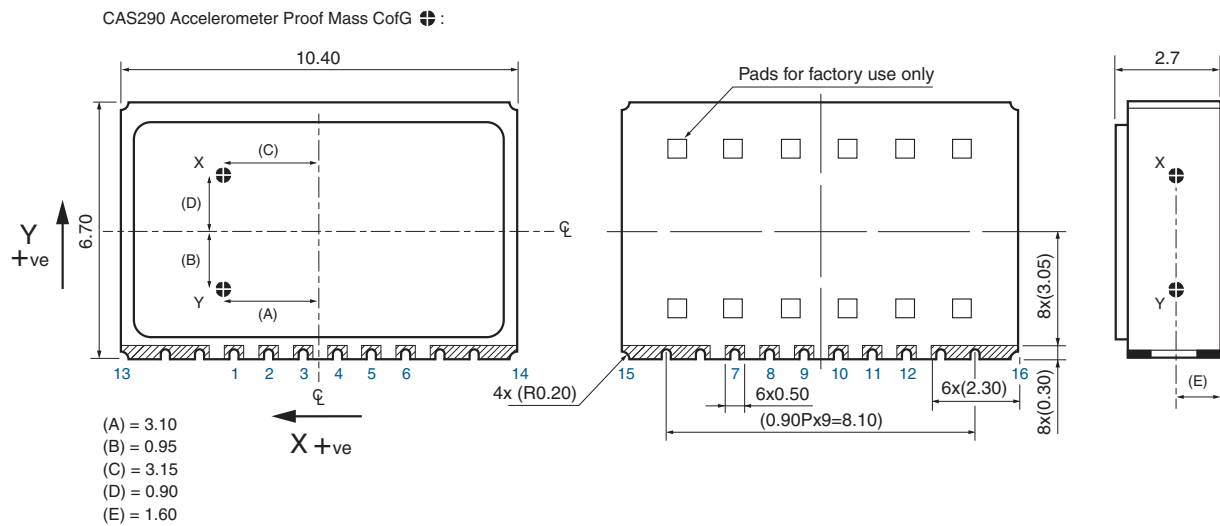
CAS290 is supplied as a PCBA surface mountable standard LCC ceramic packaged device, which is hermetically sealed providing full environmental protection.

Precise linear acceleration sensing is achieved by a Silicon MEMS detector forming an orthogonal pair of sprung masses. Each mass provides the moving plate of a variable capacitance formed by an array of interlaced 'fingers'. This structure also provides critical damping to prevent resonant gain. Linear acceleration results in a change of capacitance which is measured by demodulation of the square wave excitation.



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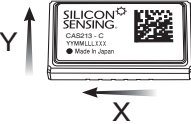
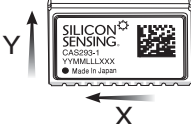
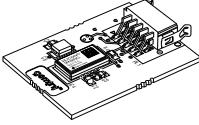
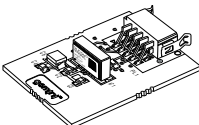
Figure 1.1 CAS290 Functional Block Diagram



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Figure 1.2 CAS290 Overall Dimensions

2 Ordering Information

| Part Number | Sense Axes | Description | Measurement Range | Mode | Overall Dimensions | Supply Voltage |
|-------------|---|---|-------------------|---------------------------|--------------------|----------------|
| | | | | | mm | V |
| CAS211 |  | Dual-axis, (X,Y) linear accelerometer | ±0.85g | Digital SPI® and Analogue | 10.4x6.0x2.2H | 2.7-3.6 |
| CAS212 | | | ±2.5g | | | |
| CAS213 | | | ±10g | | | |
| CAS214 | | | ±30g | | | |
| CAS215 | | | ±96g | | | |
| CAS291 |  | Dual-axis, (X,Y) linear accelerometer | ±0.85g | | 10.4x6.0x2.7H | |
| CAS292 | | | ±2.5g | | | |
| CAS293 | | | ±10g | | | |
| CAS294 | | | ±30g | | | |
| CAS295 | | | ±96g | | | |
| CAS211-EVB |  | Evaluation Boards for the CAS211, 212, 213, 214 or 215 parts (includes the sensor). | ±0.85g | | 34x26 | |
| CAS212-EVB | | | ±2.5g | | | |
| CAS213-EVB | | | ±10g | | | |
| CAS214-EVB | | | ±30g | | | |
| CAS215-EVB | | | ±96g | | | |
| CAS291-EVB |  | Evaluation Boards for the CAS291, 292, 293, 294 or 295 parts (includes the sensor). | ±0.85g | 34x26 | | |
| CAS292-EVB | | | ±2.5g | | | |
| CAS293-EVB | | | ±10g | | | |
| CAS294-EVB | | | ±30g | | | |
| CAS295-EVB | | | ±96g | | | |

3 Specification

Unless otherwise specified the following specification values assume Vdd = 3.15 to 3.45V over the temperature range -40 to +125°C.

3.1 Digital Output Specification

| Parameter | CAS291 | CAS292 | CAS293 | CAS294 | CAS295 | Notes |
|---|---|---|---|---|---|---|
| Dynamic range | ±0.85g | ±2.5g | ±10g | ±30g | ±96g | – |
| Scale factor | 33,500lsb/g | 11,000lsb/g | 2,800lsb/g | 1,050lsb/g | 300lsb/g | Nominal (non-ratiometric) |
| Scale factor error at +25°C | ±1% | ±1% | ±1% | ±1% | ±1% | – |
| Scale factor variation over temperature | ±1.2% | ±1.2% | ±1.2% | ±1.2% | ±1.2% | -40°C to +125°C normalised to 25°C |
| Scale factor stability (one year) | ±1,000ppm | ±1,000ppm | ±1,000ppm | ±1,000ppm | ±1,000ppm | Max change over one year |
| Scale factor non-linearity | 0.5% FSR | 0.5% FSR | 2% FSR | 2% FSR | 2% FSR | Max error from best fit straight line over the full range |
| Bias setting error at +25°C | ±335lsb | ±110lsb | ±28lsb | ±30lsb | ±30lsb | Uncompensated (see note 1) |
| Bias run to run variation at +25°C | ±0.35mg | ±0.75mg | ±0.75mg | ±3.0mg | ±8.0mg | – |
| Bias stability (one year) | ±7.5mg | ±7.5mg | ±7.5mg | ±25mg | ±75mg | Max change over one year |
| Bias variation over temperature | ±50mg | ±50mg | ±50mg | ±150mg | ±500mg | -40°C to +125°C normalised to 25°C |
| Resolution/threshold @1Hz | 0.03mg | 0.10mg | 0.10mg | 0.30mg | 1.0mg | With over-sampling techniques |
| Noise spectral density | ≤50µg/√Hz | ≤150µg/√Hz | ≤150µg/√Hz | ≤350µg/√Hz | ≤1,200µg/√Hz | Typical |
| Bandwidth | >170Hz | >170Hz | >170Hz | >170Hz | >170Hz | – |
| Vibration rectification | 0.15mg/g ² @ 0.5g _{rms} | 0.15mg/g ² @ 2.0g _{rms} | 0.15mg/g ² @ 8.0g _{rms} | 0.1mg/g ² @ 12g _{rms} | 0.1mg/g ² @ 12g _{rms} | Bias change under applied random vibration 20Hz to 2kHz |

Note 1:

The bias setting error is a fixed offset, set with 3.3V applied to the device. This bias may change for other applied voltages and can be removed by external compensation.

3.2 Analogue Output Specification

| Parameter | CAS291 | CAS292 | CAS293 | CAS294 | CAS295 | Notes |
|---|---|---|---|---|---|---|
| Dynamic range | ±0.85g | ±2.5g | ±10g | ±30g | ±96g | – |
| Scale factor | 1,150mV/g | 375mV/g | 96mV/g | 36mV/g | 10mV/g | Nominal (ratiometric) |
| Scale factor error at +25°C | ±1.5% | ±1.5% | ±1.5% | ±1.5% | ±1.5% | – |
| Scale factor variation over temperature | ±1.2% | ±1.2% | ±1.2% | ±1.2% | ±1.2% | -40°C to +125°C normalised to 25°C |
| Scale factor stability (one year) | ±1,000ppm | ±1,000ppm | ±1,000ppm | ±1,000ppm | ±1,000ppm | Max change over one year |
| Scale factor asymmetry | ±750ppm | ±750ppm | ±1,500ppm | ±2,000ppm | ±2,000ppm | Difference between best fit straight line slope in positive and negative ranges |
| Scale factor non-linearity | 0.5% FSR | 0.5% FSR | 2% FSR | 2% FSR | 2% FSR | Max error from best fit straight line over the full range |
| Bias run to run variation at +25°C | ±0.35mg | ±0.75mg | ±0.75mg | ±3.0mg | ±8.0mg | – |
| Bias stability (one year) | ±7.5mg | ±7.5mg | ±7.5mg | ±25mg | ±75mg | Max change over one year |
| Bias variation over temperature | ±50mg | ±50mg | ±50mg | ±150mg | ±500mg | 40°C to +125°C normalised to 25°C (see note 2) |
| Resolution/threshold @1Hz | 0.03mg | 0.10mg | 0.10mg | 0.30mg | 1.00mg | – |
| Noise spectral density | ≤50µg/√Hz | ≤150µg/√Hz | ≤150µg/√Hz | ≤350µg/√Hz | ≤1,200µg/√Hz | Typical |
| Bandwidth | >250Hz | >250Hz | >250Hz | >250Hz | >250Hz | – |
| Vibration rectification | 0.15mg/g ² @ 0.5g _{rms} | 0.15mg/g ² @ 2.0g _{rms} | 0.15mg/g ² @ 8.0g _{rms} | 0.1mg/g ² @ 12g _{rms} | 0.1mg/g ² @ 12g _{rms} | Bias change under applied random vibration 20Hz to 2kHz |

Note 2:

The acceleration outputs are at a nominal Vdd/2 voltage. Typical variation from device to device is ±10.0mV, and may change with variation in power supply voltage. The fixed offset can be removed by external compensation.

Specification Continued

| CAS291, CAS292, CAS293, CAS294 & CAS295 | | | | |
|--|----------------|----------------|----------------|---|
| Parameter | Minimum | Typical | Maximum | Notes |
| Temperature Sensor (Digital Output): | | | | |
| Scale factor | - | 11lsb/°C | - | At +25°C |
| Offset | - | 2380lsb | - | At +25°C |
| Temperature Sensor (Analogue Output): | | | | |
| Scale factor | - | 5mV/°C | - | - |
| Offset | - | 1.49V | - | At +25°C |
| Repeatability | -5°C | - | +5°C | - |
| Start Up: | | | | |
| Start up time | - | - | 20ms | - |
| Recovery time | - | - | 10ms | From over range/shock |
| Physical: | | | | |
| Mass | - | 0.6grams | - | - |
| Misalignment | -40mrad | ±25mrad | +40mrad | By the correct use of fixtures during the soldering process the typical misalignment of ±25mrad can be achieved |
| Orthogonality | - | 1.7mrad | - | Internal relative to the other sensor |

4 Absolute Minimum/Maximum Ratings

| | Minimum | Maximum |
|-------------------------|--------------|---|
| Electrical: | | |
| Vdd | -0.3V | +4.0V |
| ESD protection | - | 2kV HBM |
| Environmental: | | |
| Temperature (operating) | -40°C | +125°C |
| Temperature (storage) | -55°C | +150°C |
| Humidity | - | 90% RH non-condensing |
| Shock (operating) | - | 1,000g 1ms 1/2 sine |
| Shock (non-operational) | - | 10,000g 0.1ms 1/2 sine (CAS294, CAS295) 6,500g 0.1ms 1/2 sine (CAS291, CAS292, CAS293) |
| Life: | | |
| Unpowered | 15 years | - |
| Powered | 12,000 hours | - |

Notes:

Exposure to the Absolute Maximum Ratings for extended periods may affect performance and reliability.

5 Typical Performance Characteristics

Graphs showing typical performance characteristics for Gemini™ are shown below:

Note: Typical data is with the device powered from a 3.3V supply.

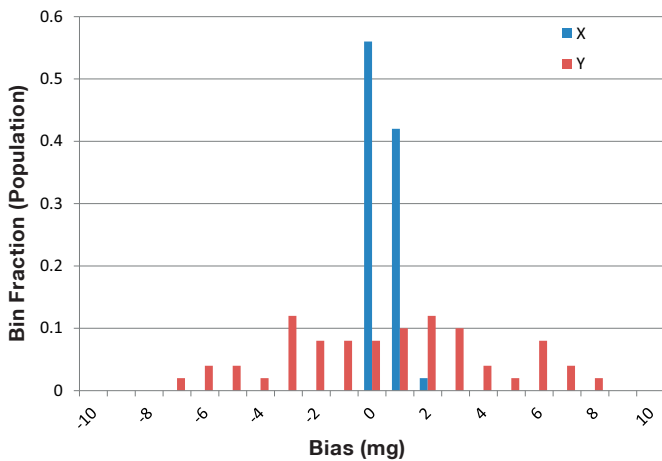


Figure 5.1 CAS291 (0.85g) Bias Distribution at 20°C

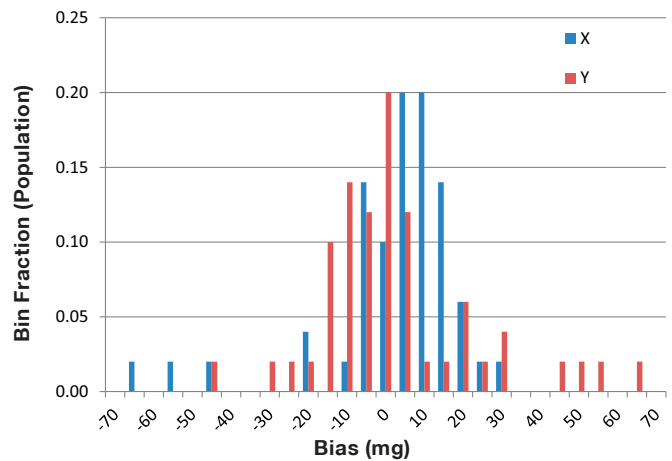


Figure 5.2 CAS292 (2.5g) Bias Distribution at 20°C

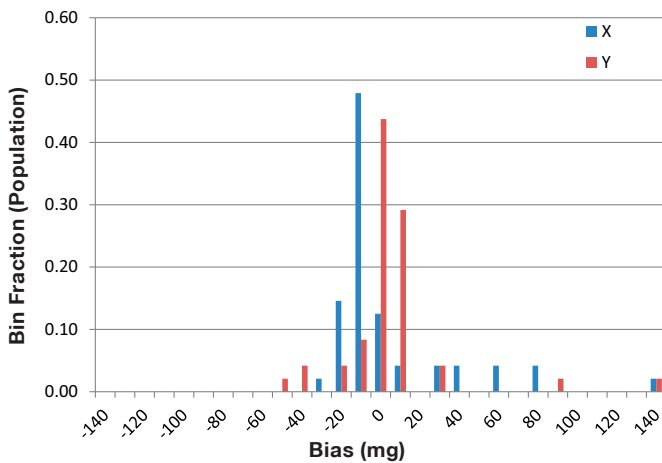


Figure 5.3 CAS293 (10g) Bias Distribution at 20°C

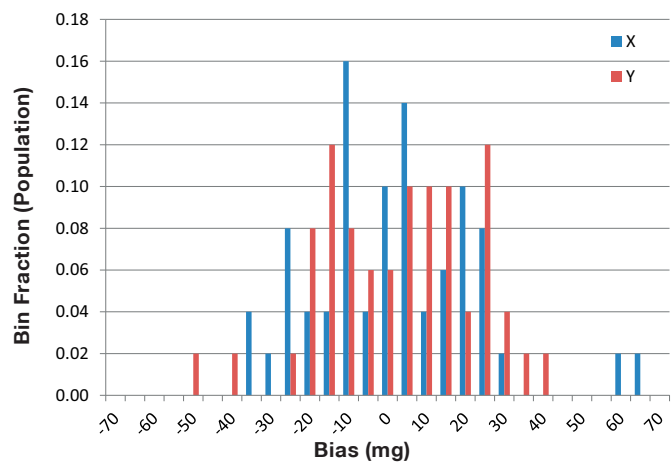


Figure 5.4 CAS294 (30g) Bias Distribution at 20°C

Typical Performance Characteristics Continued

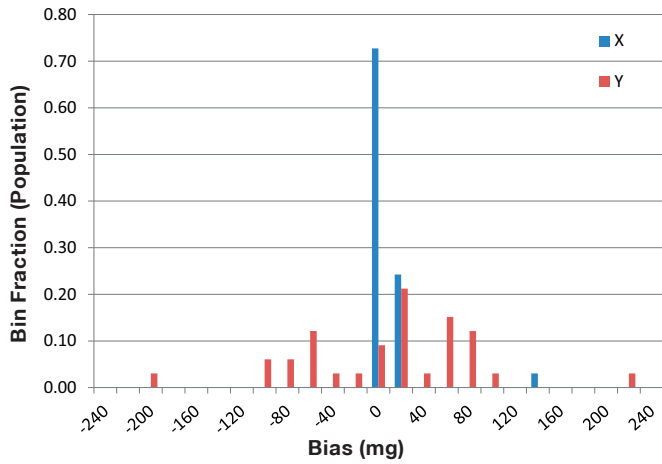


Figure 5.5 CAS295 (96g) Bias Distribution at 20°C

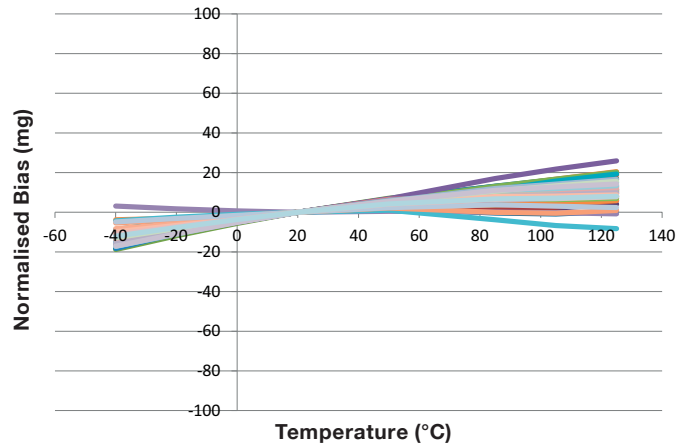


Figure 5.6 CAS291 (0.85g) Accelerometer Y Bias variation with Temperature

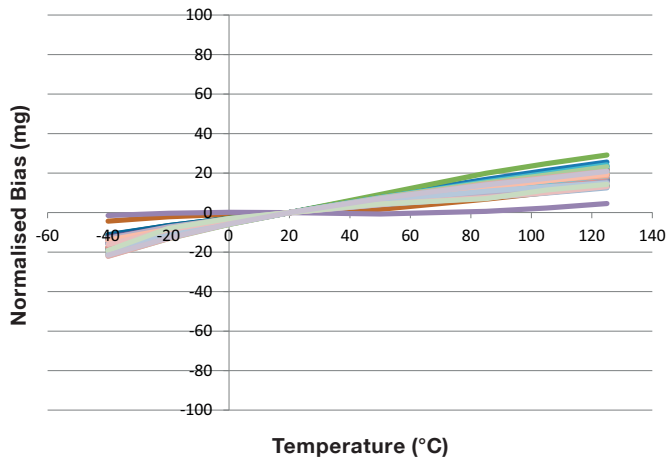


Figure 5.7 CAS292 (2.5g) Accelerometer Y Bias variation with Temperature

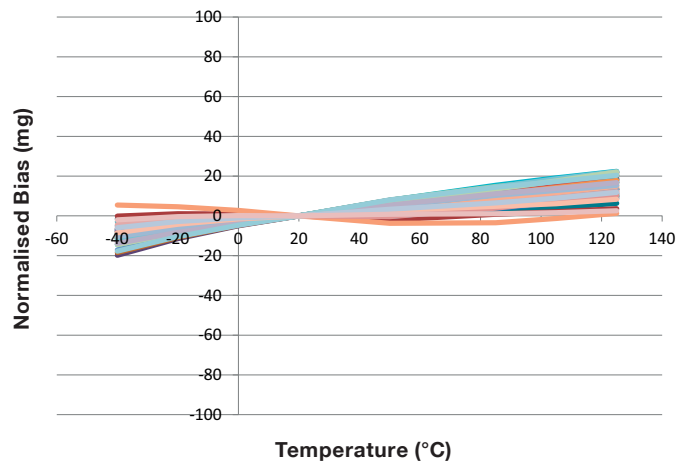


Figure 5.8 CAS293 (10g) Accelerometer Y Bias variation with Temperature

Typical Performance Characteristics Continued

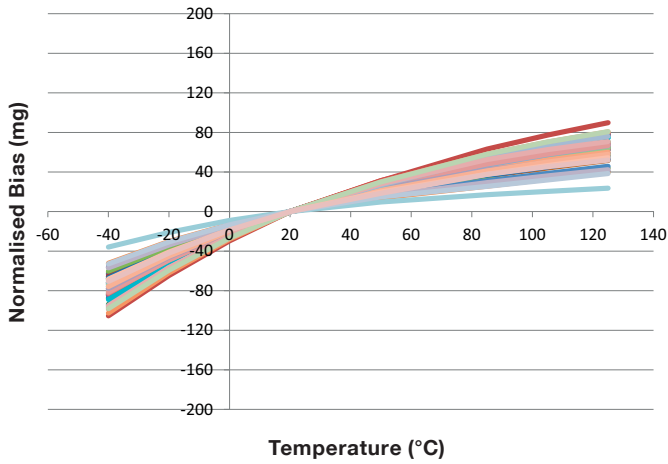


Figure 5.9 CAS294 (30g) Accelerometer Y Bias variation with Temperature

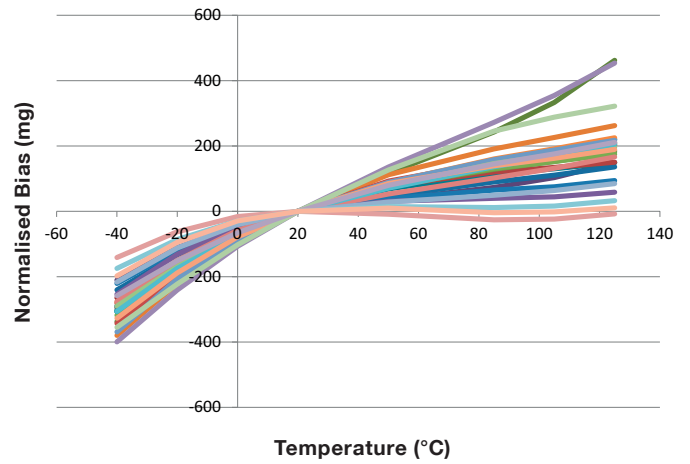


Figure 5.10 CAS295 (96g) Accelerometer Y Bias variation with Temperature

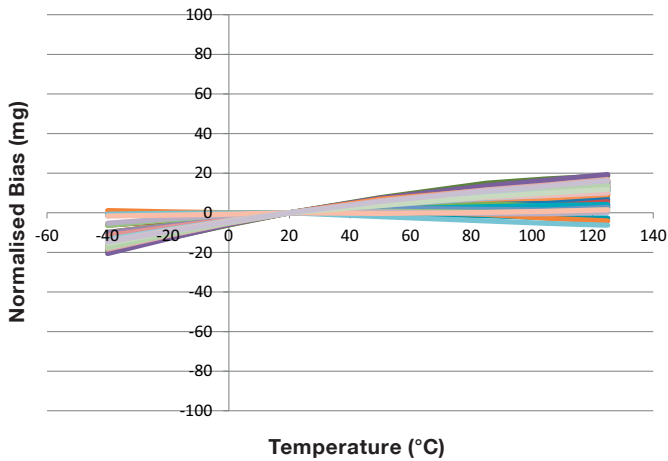


Figure 5.11 CAS291 (0.85g) Accelerometer X Bias variation with Temperature

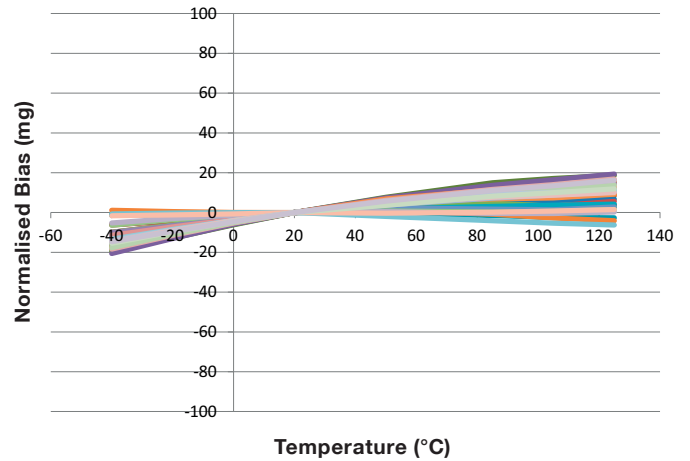


Figure 5.12 CAS292 (2.5g) Accelerometer X Bias variation with Temperature

Typical Performance Characteristics Continued

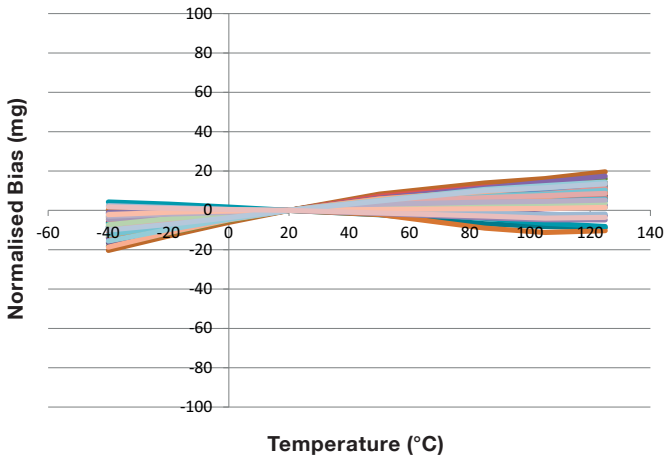


Figure 5.13 CAS293 (10g) Accelerometer X Bias variation with Temperature

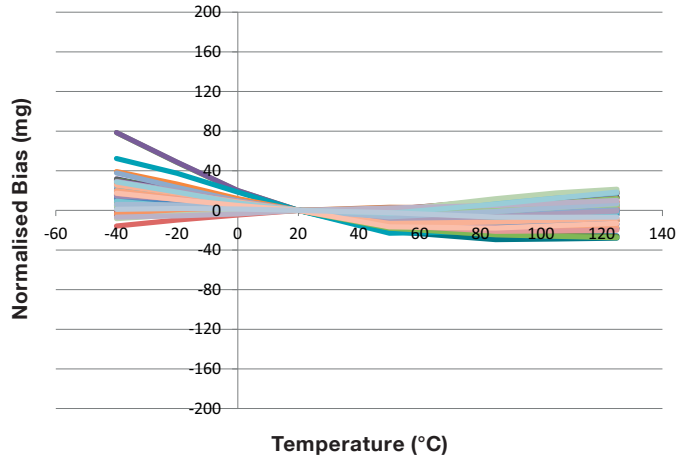


Figure 5.14: CAS294(30g) Accelerometer X Bias variation with Temperature

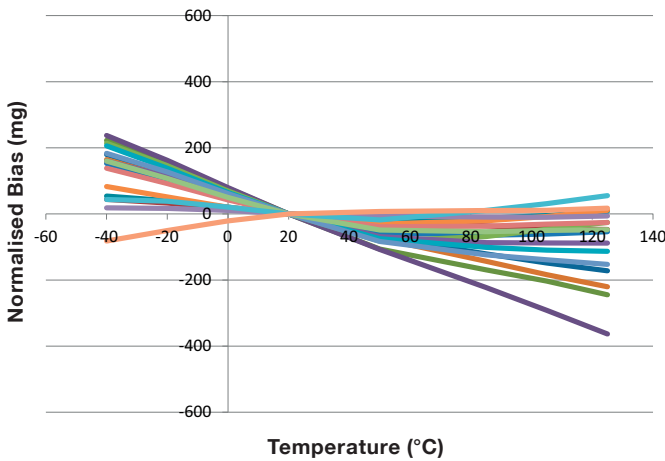


Figure 5.15: CAS295(96g) Accelerometer X Bias variation with Temperature

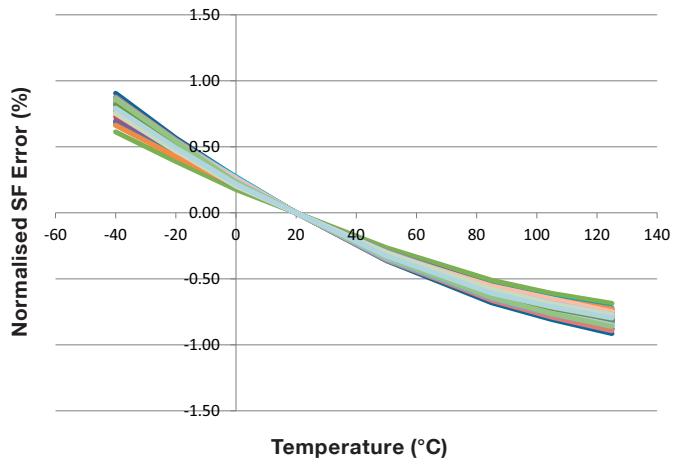


Figure 5.16 CAS291 (0.85g) Accelerometer Y SF Error with Temperature

Typical Performance Characteristics Continued

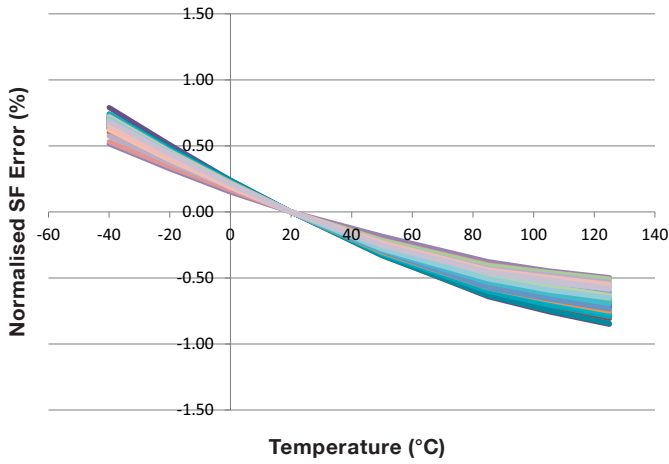


Figure 5.17 CAS292 (2.5g) Accelerometer Y SF Error with Temperature

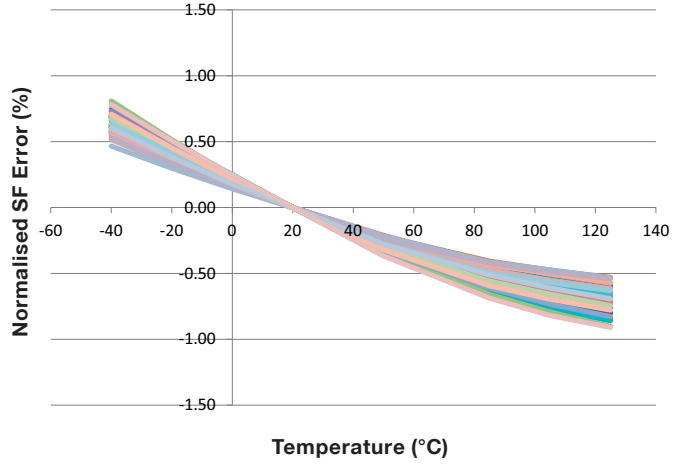


Figure 5.18 CAS293 (10g) Accelerometer Y SF Error with Temperature

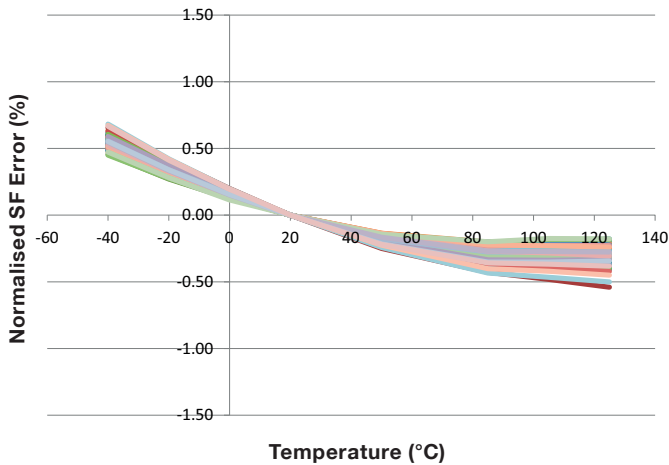


Figure 5.19 CAS294 (30g) Accelerometer Y SF Error with Temperature

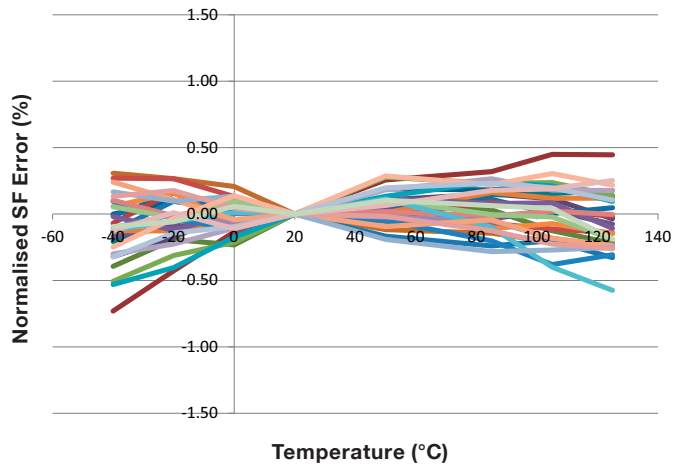


Figure 5.20 CAS295 (96g) Accelerometer Y SF Error with Temperature

Typical Performance Characteristics Continued

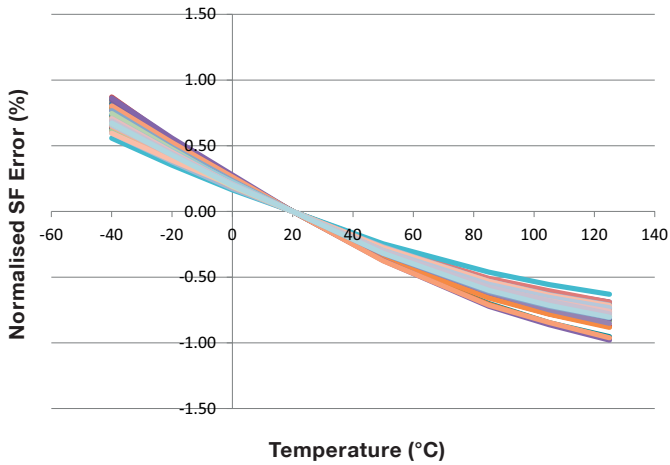


Figure 5.21 CAS291 (0.85g) Accelerometer X SF Error with Temperature

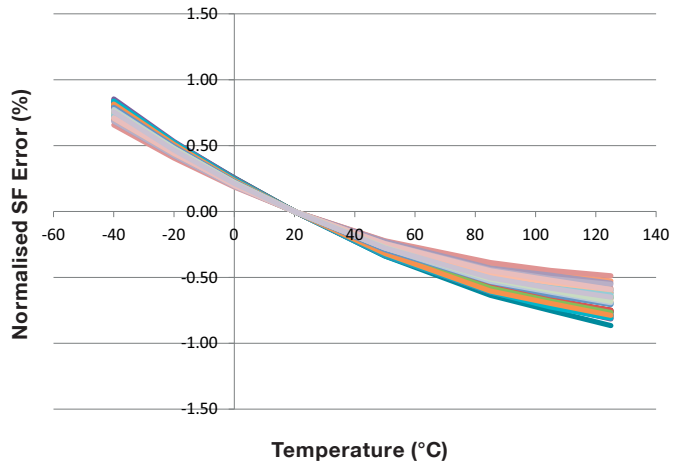


Figure 5.22 CAS292 (2.5g) Accelerometer X SF Error with Temperature

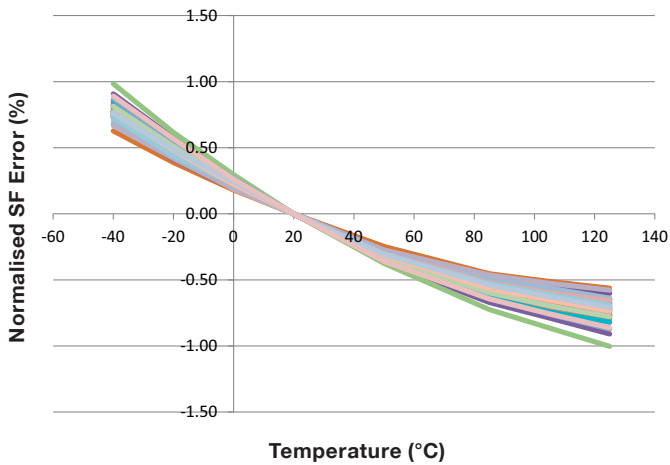


Figure 5.23 CAS293 (10g) Accelerometer X SF Error with Temperature

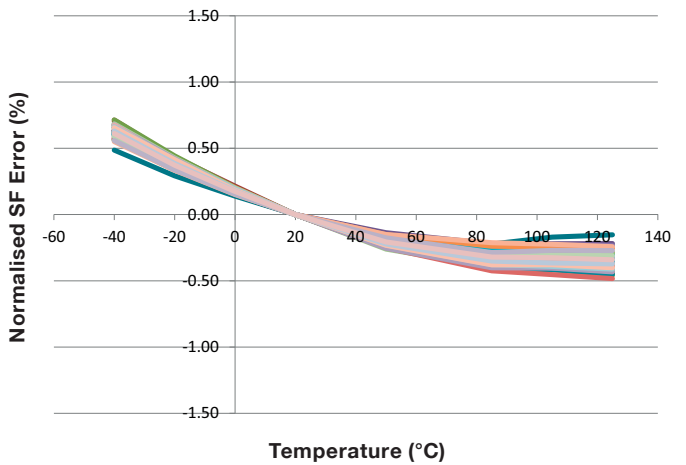


Figure 5.24 CAS294 (30g) Accelerometer X SF Error with Temperature

Typical Performance Characteristics Continued

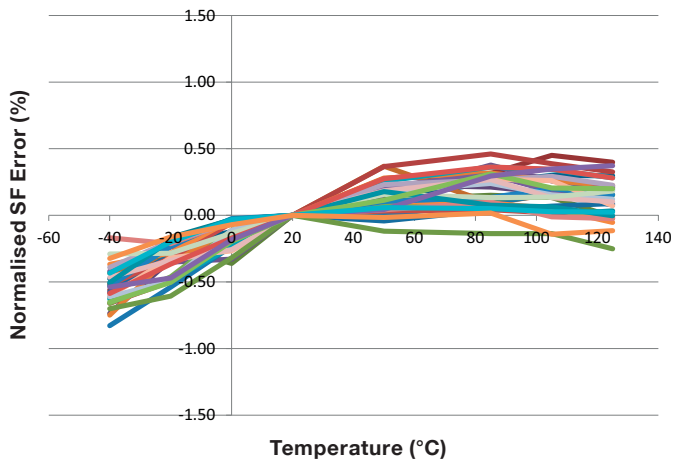


Figure 5.25 CAS295 (96g) Accelerometer X SF Error with Temperature

6 Glossary of Terms

| | |
|--------|---|
| ASIC | Application Specific Integrated Circuit |
| BIT | Built-In Test |
| BW | Bandwidth |
| CBIT | Commanded Built-In Test |
| CofG | Centre of Gravity |
| DAC | Digital to Analogue Converter |
| DRIE | Deep Reactive Ion Etch |
| DSBSC | Double Side-Band Suppressed Carrier Signal |
| ESD | Electro-Static Damage |
| HBM | Human Body Model |
| IPC | Institute of Printed Circuits |
| LCC | Leadless Chip Carrier |
| MEMS | Micro-Electro Mechanical Systems |
| NEC | Not Electrically Connected (Do Not Connect) |
| PCBA | Printed Circuit Board Assembly |
| POR | Power On Reset |
| PPO | Primary Pick-Off |
| SF | Scale Factor |
| SMT | Surface Mount Technology |
| SOG | Silicon On Glass |
| T.B.A. | To Be Advised |
| T.B.C. | To Be Confirmed |

7 Interface

Physical and electrical inter-connect information.

7.1 Physical and Electrical Interface, Pad Layout and Pinouts

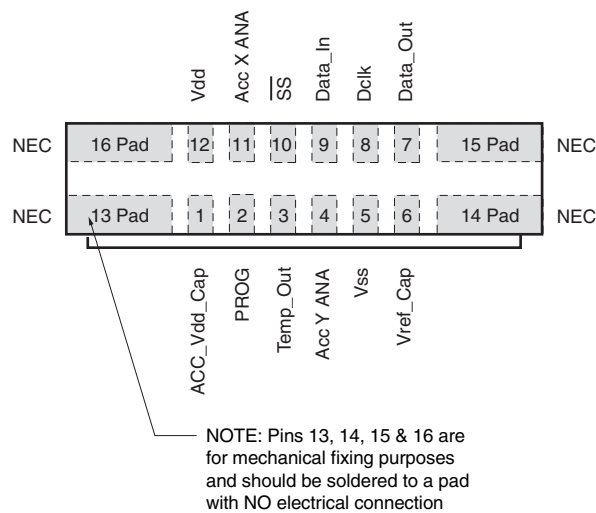
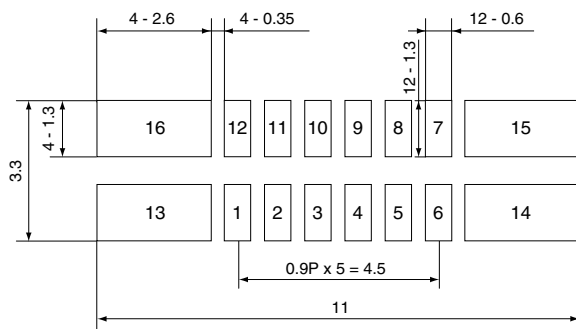


Figure 7.1 Pinout (Top View)

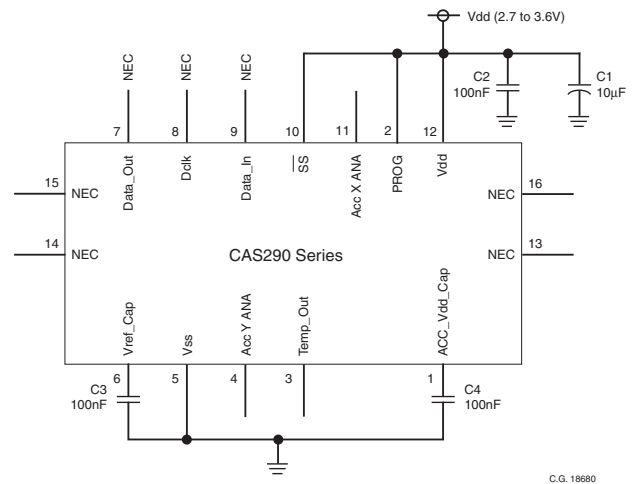
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C.G. 18571

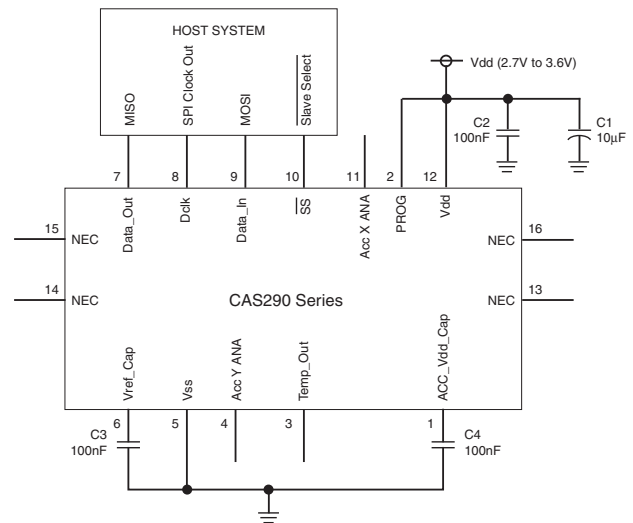
All dimensions in millimetres.

Figure 7.2 Recommended Pad Layout



C.G. 18680

Figure 7.3 Analogue Output Setup



C.G. 18681

Figure 7.4 Digital Output Setup

Note: The Gemini™ accelerometers are capacitive sensors. The routing of signal tracks beneath the package (including power supply signals connecting to starpoints) can cause an offset in accelerometer bias. If such routing is unavoidable, the resulting offset can be removed by compensation at the higher system level.

| Pin Number | Pin Name | Signal Direction | Pin Function |
|---------------------------|-----------------|------------------|--|
| 1 | Vdd_Cap | - | Used to smooth supply to CAS200. A 100nF X7R dielectric ceramic capacitor is recommended. |
| 2 | PROG | Input | For factory use, must be connected to Vdd in operation |
| 3 | Temp_Out | Output | Analogue temperature output. Scaling 5mV/°C at 3.3V supply - Ambient temperature reading of 1.474V |
| 4 | Acc Y ANA | Output | Y Accelerometer analogue output |
| 5 | Vss | - | Return connection for applied power (0V) |
| 6 | Vref_Cap | - | Used to decouple the internal voltage reference via an external capacitor. A 100nF X7R dielectric ceramic capacitor is recommended. |
| 7 | Data_Out | Output | Digital mode: SPI_MISO. Only enabled when SPI_Select is low. Tri-stated when SPI_SELECT is high. |
| 8 | Dclk | Input | Digital mode: SPI_CLK Internal Pull-up |
| 9 | Data_In | Input | Digital mode: SPI_MOSI Internal Pull-up |
| 10 | \overline{SS} | Input | Digital mode: SPI_SELECT Internal Pull-up |
| 11 | Acc X ANA | Input | X Accelerometer analogue output |
| 12 | Vdd | - | Positive power supply to the sensor. Range from 2.7 to 3.6V. Should be decoupled with a 100nF X7R dielectric ceramic capacitor, a bulk storage capacitor of 10µF should be nearby. |
| Side Pads (13,14,15 & 16) | NEC | - | Not Electrically Connected. These pins provide additional mechanical fixing to the Host System and should be soldered to an unconnected pad. |

Table 7.1 Input/Output Pin Definitions

| Parameter | Minimum | Maximum | Units |
|-------------------------------------|---------|---------|-------|
| Supply | | | |
| Supply voltage (functional) | 2.7 | 3.6 | V |
| Supply voltage (full specification) | 3.15 | 3.45 | V |
| Supply voltage limits | -0.3 | 4.0 | V |
| Supply current | - | 5 | mA |
| Disretes | | | |
| Input voltage low | -0.5 | 0.3xVdd | V |
| Input voltage high | 0.7xVdd | Vdd+0.5 | V |
| Output voltage low | - | 0.4 | V |
| Output voltage high | 0.8xVdd | - | V |
| Analogue | | | |
| Output impedance | - | <1k | Ω |
| Output load capacitance | - | 300 | pF |
| Input impedance | 50k | - | Ω |
| Output source/sink current | - | 1 | mA |

Table 7.2 Electrical Characteristics

7.2 Digital Interface

This section defines the SPI® interface timing and the message types and formats to and from the Gemini™ CAS290 sensor.

The SPI® interface, when selected, will be a 4-wire interface with the following signals:

| | |
|----------|-------------------------------|
| Dclk | SPI® clock |
| Data_In | Message data input to sensor |
| Data_Out | Message data output by sensor |
| SS | Select sensor |

Signal electrical characteristics are defined in Table 7.3.

| Parameter | Minimum | Maximum | Units |
|---------------------|---------|---------|-------|
| Input voltage low | -0.5 | 0.3xVdd | V |
| Input voltage high | 0.7xVdd | Vdd+0.5 | V |
| Output voltage low | - | 0.4 | V |
| Output voltage high | 0.8xVdd | - | V |
| Leakage current | -2 | 2 | µA |
| Pull-up current | 10 | 50 | µA |

Table 7.3 SPI® Electrical Characteristics

SPI_SELECT, SPI_CLK and SPI_MOSI all have internal pull-up resistors in the sensor ASIC.

SPI_MISO is held in tri_state if SPI_SELECT is High and is driven if SPI_SELECT is Low.

7.3 Signal Timing

The interface will transfer 6 bytes (48 bits) in each message. The message rate will be 1kHz (recommended), (1Hz-min, 10kHz-max) with a SPI® clock frequency of 1MHz (nom), (100kHz-min 8MHz-max). A sampling rate greater than 500Hz is recommended to reduce the effects of aliasing.

The sensor will be a slave on the interface. All accesses shall use SPI® Mode 0.

Figure 7.5 specifies the interface timing for correct operation.

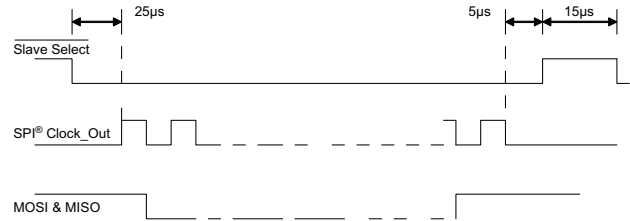


Figure 7.5 SPI® Timing Diagram

7.4 SPI® Message Format

This section defines the types and formats of the messages to the Gemini™ sensor.

7.4.1 Messages to ASIC (MOSI)

The messages to the sensor shall be sent in the following order:

- Byte 1 Command Byte (transmitted first, MSB first)
- Byte 2 Data 1
- Byte 3 Data 2
- Byte 4 Data 3
- Byte 5 Data 4
- Byte 6 Checksum (see note 3)

Data Format:

| | | | |
|--------------|----------|---|--------------|
| Command Byte | Bit 7 | Set to 0 | |
| | Bit 6 | '0' = CBIT disabled '1' = CBIT enabled | |
| | Bit 5 | Set to 0 | |
| | Bit 4 | Set to 0 | |
| | Bits 3:0 | Message Type | |
| | '0001' | Acceleration Y and X Request | |
| | '0010' | Status and Temperature Request | |
| | '0000' | SSSL Use Only | } Do not use |
| | '0011' | SSSL Use Only | |
| | '0100' | SSSL Use Only | |
| | '0101' | SSSL Use Only | |
| | '0110' | SSSL Use Only | |
| | '0111' | SSSL Use Only | |
| | '1000' | SSSL Use Only | |
| | '1001' | SSSL Use Only | |
| | '1010' | SSSL Use Only | |
| | '1011' | SSSL Use Only | |
| | '1100' | SSSL Use Only | |
| | '1101' | SSSL Use Only | |
| | '1110' | SSSL Use Only | |
| | '1111' | SSSL Use Only | |

Message Data:

The following table defines the content of each byte of the input message.

| Message Type | Data Byte | Byte Content |
|----------------------------------|-----------|------------------------|
| Acc Y/Acc X or Status/Temp | 1 | Bits (7.0) set to 0x00 |
| | 2 | Bits (7.0) set to 0x00 |
| | 3 | Bits (7.0) set to 0x00 |
| | 4 | Bits (7.0) set to 0x00 |

Table 7.4 Message Content to Gemini™

Example message data:

1. To request Acc Y and Acc X data only.

- Command Byte = 0x01
- Data 1 Byte = 0x00
- Data 2 Byte = 0x00
- Data 3 Byte = 0x00
- Data 4 Byte = 0x00
- Checksum = 0xFE

2. To request Status and Temperature.

- Command Byte = 0x02
- Data 1 Byte = 0x00
- Data 2 Byte = 0x00
- Data 3 Byte = 0x00
- Data 4 Byte = 0x00
- Checksum = 0xFD

3. To request CBIT and Acc Y and Acc X data.

- Command Byte = 0x41
- Data 1 Byte = 0x00
- Data 2 Byte = 0x00
- Data 3 Byte = 0x00
- Data 4 Byte = 0x00
- Checksum = 0xBE

4. To request CBIT and Status and Temperature.

- Command Byte = 0x42
- Data 1 Byte = 0x00
- Data 2 Byte = 0x00
- Data 3 Byte = 0x00
- Data 4 Byte = 0x00
- Checksum = 0xBD

7.4.2 Message from Gemini™ (MISO)

The messages from the sensor shall be sent in the following order.

- Byte 1: Status Byte (MSB transmitted first)
- Byte 2: Data 1
- Byte 3: Data 2
- Byte 4: Data 3
- Byte 5: Data 4
- Byte 6: Checksum (see notes 3 and 4)

The data is output in 2's complement format, most significant byte first.

Data Format:

The Status Byte content depends on the message requested.

| | | |
|-------------|---------|--|
| Status Byte | Bit 7 | Sensor BIT Status '1' = BIT Failed '0' = Sensor OK |
| | Bit 6 | ACC 1 BIT Status '1' = Acc Y Failed '0' = Acc Y OK |
| | Bit 5 | ACC 2 BIT Status '1' = Acc X Failed '0' = Acc X OK |
| | Bit 4 | '1' = Previous Input Checksum BIT Failed '0' = Previous Input Checksum BIT OK |
| | Bit 3 | '0' = CBIT disabled '1' = CBIT enabled |
| | Bit 2:0 | Output Message Type '001' = Acc Y/ Acc X '010' = Status Message/ Temperature Message '000' } '011' } Not used '100' } '101' } '110' } '111' } |

Message Data Content:

The output message data content will depend on the command byte from the previous input message. The content is indicated by bits (2:0) of the Status byte.

| Message Type | Data Byte | Byte Content |
|--------------|-----------|---|
| Acc Y/Acc X | 1 | Bits (7:0) - Acc Y MS bits (15:8) |
| | 2 | Bits (7:0) - Acc Y LS bits (7:0) |
| | 3 | Bits (7:0) - Acc X MS bits (15:8) |
| | 4 | Bits (7:0) - Acc X LS bits (7:0) |
| Status/Temp | 1 | Status Byte 1 (see note 5) Bit (7:6) - acc_bit_status Bit 5 - vref_cap_bit Bit 4 - acc_cap_bit Bit 3 - cbit_en Bit 2 '0' = OTP Parity OK '1' = OTP Parity Fail Bit 1 '0' = Previous input checksum Message Checksum OK '1' = Previous input checksum Message Checksum Fail Bit 0 '1' |
| | 2 | Bits (7:0) - (set to '0x00') |
| | 3 | Bits (7:0) - Temperature MS bits (15:8) |
| | 4 | Bits (7:0) - Temperature LS bits (7:0) |

Table 7.5 Message Content from ASIC

Notes:

3. The checksum is the LS byte of the 1's complement of the first 5 bytes of message. If the checksum is incorrect the input message will be ignored and the checksum error flagged in the status byte of the next SPI® message. The content of the message following a bad checksum message shall be the message type selected in the last 'good' message. The message type shall default on power-up to Acc Y/Acc X message.

4. The checksum for the output message is calculated before the message is loaded into the SPI® registers. When the checksum is about to be calculated, the Data Bytes are stored and updates to them are inhibited. The Checksum is then calculated on the Status Byte and these 4 Data Bytes. The Status Byte can continue to be updated for a short time after the Checksum has been calculated. Therefore when the Status Byte, 4 Data Bytes and the Checksum are loaded into the SPI® register there is a small chance that the Checksum will be incorrect. It is therefore advised that if a Checksum Error is detected that the Status Byte should still be interrogated for the Status, such as BIT Fault.

5. For the status byte the following conditions apply.

Acc_bit_Status (0) = Acc Y '0' = Pass, '1' = Fail
 Acc_bit_Status (1) = Acc X '0' = Pass, '1' = Fail
 Vref_cap_bit '0' = Pass, '1' = Fail
 Acc_cap_bit '0' = Pass, '1' = Fail
 CBit_en '0' = CBIT OFF, '1' = CBIT ON

7.5 CBIT

The Gemini™ sensor has a Commanded Built in Test (CBIT) function which stimulates the output to give a synthetic acceleration output. This allows the acceleration channel to be functionally tested, identifying potential failure.

CBIT can be requested using the Command Byte as detailed in Section 7.4.1. The sensor will respond by applying a fixed offset to both acceleration outputs. The offset applied depends on the CAS variant being used, see Table 7.6 for details. The offset added will have a ±20% tolerance due to MEMS tolerance effects. The time taken to apply these offsets will be less than 35ms.

The intrusive nature of CBIT is such that whilst the sensor may continue to be used to indicate acceleration, the performance is not guaranteed while CBIT is asserted.

For full performance acceleration measurement, it is recommended that 35ms is allowed to elapse following the de-assertion of CBIT to allow the sensor to settle again.

| Parameter | CAS290 Variant | Offset Added |
|--------------------------|----------------|--------------|
| Acceleration (both axes) | CAS295 (96g) | 36.5g |
| | CAS294 (30g) | 10g |
| | CAS293 (10g) | 3.75g |
| | CAS292 (2.5g) | 0.92g |
| | CAS291 (0.85g) | 0.23g |

Table 7.6 CBIT Offset for CAS290 Sensor

8 Design Tools and Resources Available

The following is planned to be available from the website in the near future.

| Item | Description of Resource | Part Number | Order/Download |
|---|---|--|--------------------------------------|
|  | Gemini™ Brochure: A one page sales brochure describing the key features of the Gemini™ Accelerometers. | CAS200-00-0100-131 | Download (www.siliconsensing.com) |
|  | Gemini™ CAS200 Datasheet: Full technical information on all part number options. Specification and other essential information for assembling and interfacing to Gemini™ Accelerometers, and getting the most out of them. | CAS200-00-0100-132 | Download (www.siliconsensing.com) |
|  | Gemini™ CAS290 Datasheet: Full technical information on all part number options. Specification and other essential information for assembling and interfacing to Gemini™ Accelerometers, and getting the most out of them. | CAS290-00-0100-132 | Download (www.siliconsensing.com) |
|  | Gemini™ Presentation: A useful presentation describing the features, construction, principles of operation and applications for the Gemini™ Accelerometers. | Gemini_Presentation | Download (www.siliconsensing.com) |
|  | Gemini™ evaluation board: Single Gemini™ fitted to a small PCBA for easy customer evaluation and test purposes. Refer to page 3 for ordering information. | CAS211-EVB CAS212-EVB CAS213-EVB CAS214-EVB CAS215-EVB | Order |
|  | | CAS291-EVB CAS292-EVB CAS293-EVB CAS294-EVB CAS295-EVB | Order |
|  | Solid Model CAD files for Gemini™ Accelerometers: Available in .STP and .IGS file format | CAS200-00-0100-408 | Download (www.siliconsensing.com) |
|  | | CAS290-00-0100-408 | |
|  | Library Parts: Useful library component files of Gemini™ Accelerometers: DxDesigner Schematic Symbols. PADS Decal (Footprint) PADS Part Type File. | — | Download (www.siliconsensing.com) |
|  | Reference Circuit: A useful reference circuit design gerber files for the Gemini™ Accelerometer for use in host systems. | — | Download (www.siliconsensing.com) |
|  | Questions and Answers: Some useful questions asked by customers and how we've answered them. This is an informal (uncontrolled) document intended purely as additional information. | FAQs | View at (www.siliconsensing.com) |
|  | RoHS compliance statement for Gemini™: Gemini™ is fully compliant with RoHS. | — | Download (www.siliconsensing.com) |

9 Cleaning

Due to the natural resonant frequency and amplification factor ('Q') of the sensor, ultrasonic cleaning should NOT be used to clean the Gemini™ Accelerometer.

10 Soldering Information

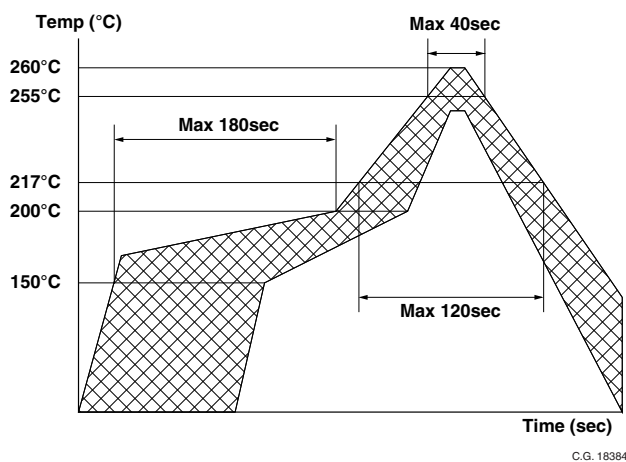


Figure 10.1 Recommended Reflow Solder Profile

11 Part Markings

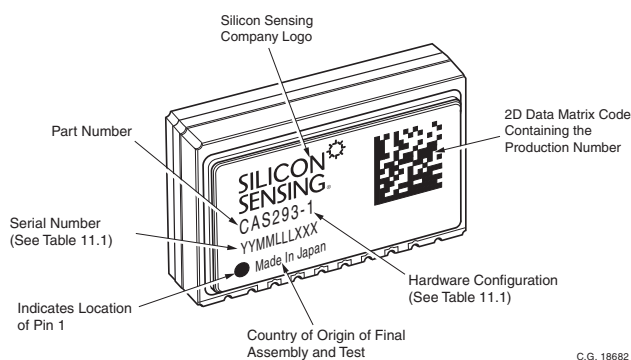


Figure 11.1 Part Marking

| Item | Code | Range |
|---------------|------|-----------|
| Configuration | C | 1 - Z |
| Year number | YY | 00 - 99 |
| Month number | MM | 01 - 12 |
| Lot number | LLL | 000 - 999 |
| Serial number | XXX | 001 - 999 |

Table 11.1 Part Marking (Serial Number)

12 Packaging Information

Gemini™ sensors are supplied in tape format as either straight strips, or on either full-size or mini-reels, depending on the quantity being shipped. Table 12.1 defines the packaging method:

| Shipping Quantity | Gemini™ |
|-------------------|--|
| Qty < 100 | Strip of tape |
| 100 ≥ Qty ≤ 600 | Tape and mini-reel (approx. Ø175mm) |
| Qty > 600 | Tape and full-size reel (approx. Ø330mm) |

Table 12.1 Packaging Tape and Reel Format According to Shipping Quantity

The following information in this section defines the packaging for shipments using full-size reels.

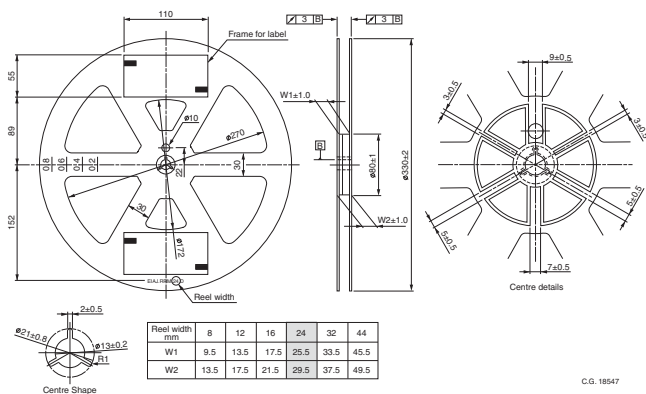
| Layer | Type | Quantity |
|-----------|--------------------------|-------------------------|
| CAS290 | Tape and Reel | Max. 600 pcs/ 1 Reel |
| Inner Bag | Aluminium Damp-proof Bag | 1 Reel/Bag |
| Inner Box | Cardboard Box | Inner Bag x 1/Inner Box |
| Outer Box | Cardboard Box | Inner Box/Outer Box |

Table 12.2 Packaging Information (Full-Size Reel)

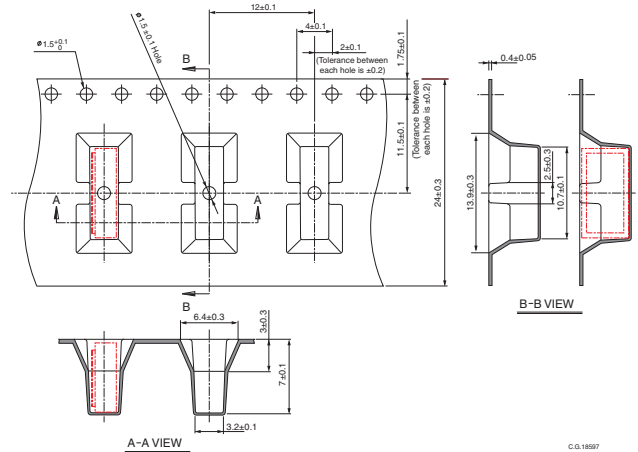
| Item | Dimension | Quantity | Material |
|---------------------|-------------------------|-----------------------|-------------|
| Reel | DR23324C | 1 Reel | PS |
| Emboss Tape | TE2412-110930-1 | 1 Roll | PS |
| Cover Tape | ALS-ATA 21.5mm | 1 Roll | PET, PE, PS |
| Label for Reel | 40mm x 80mm | 1 label/Reel | Paper |
| Desiccant | FA 10g | 1 Inner Bag | - |
| Inner Bag | 0.101mm x 450mm x 530mm | 1 Reel/Inner Bag | MB4800 |
| Tray | 451mm x 429mm x 55mm | 2 Tray/Outer Box | - |
| Pad | 451mm x 429mm x 20mm | 3 Pad/Outer Box | - |
| Inner Box | 413mm x 391mm x 52mm | 2 Inner Box/Outer Box | Cardboard |
| Outer Box | 462mm x 440mm x 208mm | 1 Box | Cardboard |
| Label for Outer Box | 105mm x 127mm | 1 label/Outer Box | Paper |

Table 12.3 Packaging Specification (Full-Size Reel)

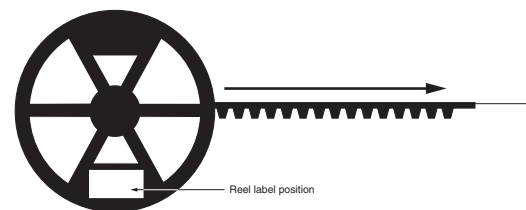
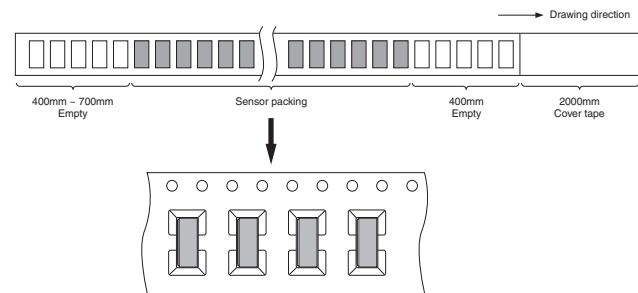
Reel Information



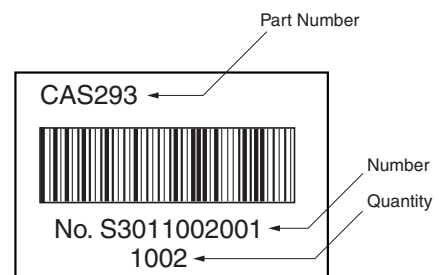
Emboss Tape Carrier Information



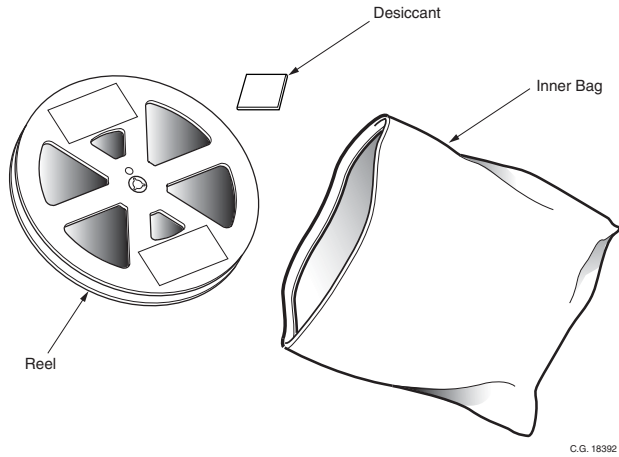
Tape Information



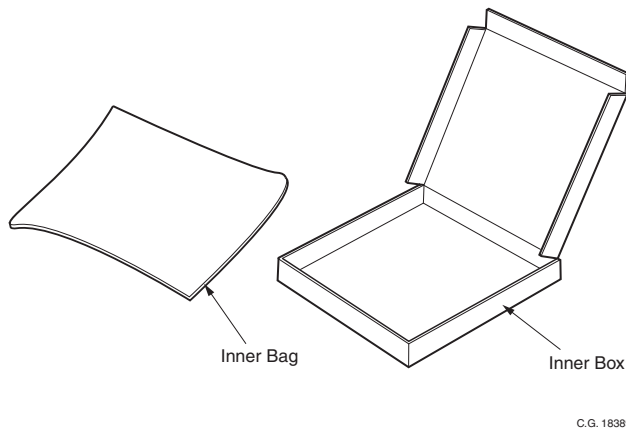
Label for Reel Information



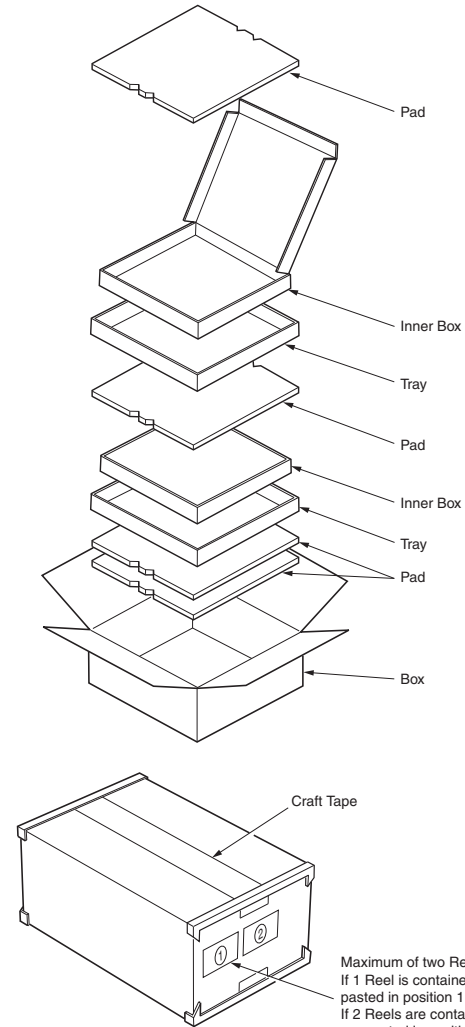
Inner Bag Packing Information



Inner Box Packing Information



Outer Box Packing Information



13 Internal Construction and Theory of Operation

Construction

Gemini™ is supplied as a PCBA surface mountable LCC ceramic packaged device. It comprises four main components; Silicon On Glass (SOG) Dual-Axis MEMS Accelerometer, ASIC and, the Package Base and Lid. The MEMS Sensors and ASIC are housed in a hermetically sealed package cavity with a nitrogen back-filled partial vacuum, this has particular advantages over sensors supplied in plastic packages which have Moisture Sensitivity Level limitations.

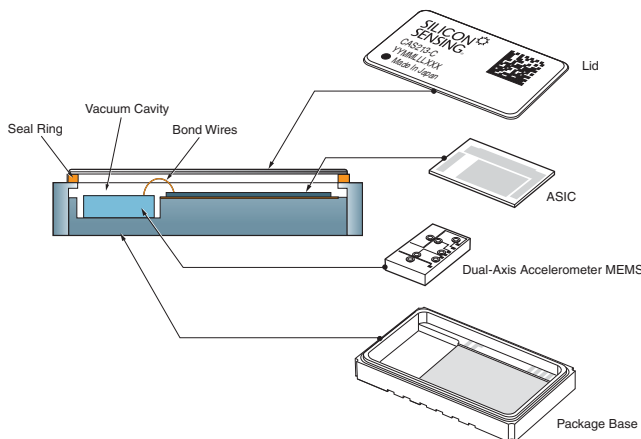


Figure 13.1 CAS200 Main Components

Silicon MEMS Dual-Axis Accelerometer

The Gemini™ dual-axis open loop accelerometer is a one-piece resonating silicon MEMS structure anodically bonded to top and bottom glass substrates to form a hermetically sealed Silicon on Glass (SOG) wafer sub-assembly. A DRIE bulk silicon process is used to create two orthogonal finger-like spring/seismic proof mass structures, each measuring 1.8mm square, and with a resonant frequency of 1.8kHz to 5.2kHz. Figure 13.2 shows a schematic cross section through the SOG wafer.

Capacitive drive and pick-off signals are transmitted by wire bond interconnections, in through-glass vias, between the metallised transducer plates on the MEMS proof mass and the Gemini™ ASIC.

Multiple inter-digitated fingers create increased capacitance thus enabling a high signal-to-noise ratio. The fingers are tapered to increase the resonant frequency and also have a high aspect ratio to provide highly stable performance. The differential gaps between the static electrode fingers and those of the proof mass provide an air squeeze film with near-critical damping.

Control of the accelerometer is handled by the Gemini™ ASIC.

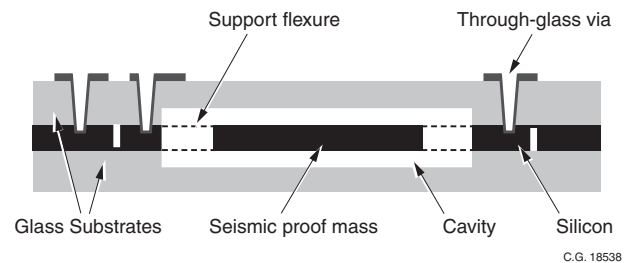


Figure 13.2 Schematic Section of the Silicon On Glass Accelerometer MEMS Wafer Sub-Assembly

ASIC

The ASIC is a 3.93mm x 3.2mm device fabricated using 0.35µm CMOS process. ASIC and MEMS are physically separate and are connected electrically by using gold bond wires and thus the ASIC has no MEMS-to-ASIC internal tracking, meaning there is reduced noise pick-up. Gold bond wires also connect the ASIC to the internal bond pads on the Package Base.

Package Base and Lid

The LCC ceramic Package Base is a multi-layer aluminium oxide construction with internal bond wire pads connected through the Package Base via integral multi-level tungsten interconnects to a series of external solder pads. Similar integral interconnects in the ceramic layers connect the Lid to Vss, thus the sensitive elements are inside a Faraday shield. Internal and external pads are electroplated gold on electroplated nickel.

The Package Base incorporates a seal ring on the upper layer onto which a Kovar® metal Lid is seam welded using a rolling resistance electrode, thus creating a totally hermetic seal. Unlike other MEMS

packages available on the market, Gemini™ has a specially developed seam weld process which eliminates the potential for internal weld spatter. Inferior designs can cause dislodged weld spatter which affects reliability due to interference with the moving MEMS element.

Theory of Operation (Accelerometer)

The accelerometer contains a seismic ‘proof mass’ with multiple fingers suspended via a ‘spring’, all of which is formed in the silicon MEMS structure. The proof mass is anodically bonded to the top and bottom glass substrates and thereby fixed to the Gemini™ Package Base.

When the Gemini™ sensor is subjected to a linear acceleration along its sensitive axis the proof mass tends to resist motion due to its own inertia, therefore the mass and its fingers becomes displaced with respect to the interdigitated fixed electrode fingers. Gas between the fingers provides a damping effect. This displacement induces a differential capacitance between the moving and fixed silicon fingers which is proportional to the applied acceleration.

Capacitor plate groups are electrically connected in pairs at the top and bottom of the proof mass. In-phase and anti-phase waveforms are applied by the Gemini™ ASIC separately to the ‘left’ and ‘right’ finger groups. The demodulated waveforms provide a signal output proportional to linear acceleration.

Figures 13.3(a) and 13.4(b) provide schematics of the accelerometer structure and control loop respectively.

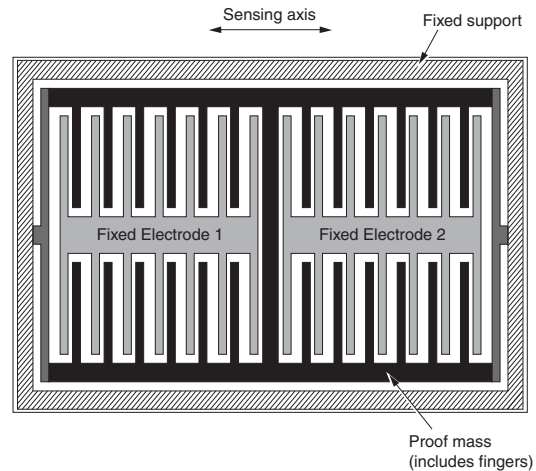


Figure 13.3(a) Schematic of Accelerometer Structure

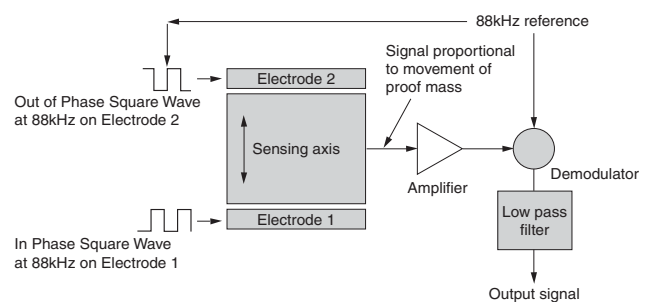


Figure 13.4(b) Schematic of Accelerometer Control Loop

14 Patent Applications

The following patent applications have been filed for the Gemini™ Accelerometers:

| Patent Application | Status |
|--------------------|---------|
| US7047808 | Granted |
| US7267006 | Granted |
| EP1718980 | Granted |



Dual-Axis Accelerometer

CAS290 Technical Datasheet



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Notes

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