

SAR10Z Series Angular Rate Sensor With DC Response

The SAR10Z and SAR10HZ contains a ButterflyGyro™ MEMS die and a BiCMOS mixed mode ASIC, housed in a custom SOIC package that can be efficiently handled by automated production lines. The sensor is factory calibrated and compensated for temperature effects to provide high-accuracy digital output over a broad temperature range. SAR10Z has ± 250 °/s range and SAR10HZ has ± 100 °/s range.

Tuning of the excitation and detection frequency as well as perfect mechanical and electrical balancing the dual masses result in very low sensitivity to shock and vibrations.

By utilizing a unique sealed cavity technology, the vibrating masses are contained within the low-pressure hermetic environment needed for creating low dynamic damping and high Q factors, without any degradation over the lifetime of the device whatever tough environmental conditions.

A SPI interface enables an easy and effective communication between the application and the SAR10Z or SAR10HZ. The angular rate data output is a 12-bit 2's complement format at a maximum rate of 2000 samples per second. A number of functions are available through the digital SPI interface including advanced self diagnostics.

SAR10Z
SAR10HZ

Edition 2009-07-01

Published by

Sensoror Technologies AS

P.O. Box 196

N-3192 Horten

Norway

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1 Product Description

1.1 Features

- High reliability and robustness over long lifetime
- Low vibration sensitivity
- High overload and shock capability (5000 g)
- Sensitive axis parallel to mounting plane
- Butterfly balanced design for high mechanical common mode rejection
- Closed-loop force feedback operation with electrostatic frequency tuning
- Low bias drift
- Ideal mono crystalline Si material
- Wafer level sealing with controlled Q-factor
- Low power
- Single supply +5 VDC
- Fully digital with SPI communication and on chip OTP calibration
- Digitally controlled sample rate up to 2000 SPS
- Bandwidth defined by built in 4th order digital LP filter
- Intrinsic continuous diagnostic monitoring
- Temperature sensor
- No external components required

1.2 Overview

The SAR10(H)Z consists of a ButterflyGyro™ MEMS die and a BiCMOS ASIC housed in a miniature SOIC plastic package. The sensitive axis is parallel to the mounting plane. The function is based on the excitation of a reference motion in the butterfly structure. An angular rotation of the device will generate Coriolis forces, whose frequency equals that of the reference motion and whose resulting vibration amplitude is a measure for the angular rotation. By utilizing Sensoror's unique patented sealed cavity technology, the vibrating masses are contained within the low-pressure hermetic environment needed for creating low dynamic damping and high Q factors, without any degradation over the lifetime of the device. The gyro die is built as a triple stack consisting of a bottom glass die with metalized patterns defining excitation and detection electrodes, a middle micro machined mono crystalline silicon die with the oscillating masses, which also represent a common opposite electrode, and a third top cap glass die. A time multiplexed, switched interface is used between the gyro die and the ASIC. This makes it possible to improve the symmetry by using the same electrodes for drive interface and sense interface. By the symmetric mechanical design and by connecting the electrodes cross-wise symmetric, the "butterfly" masses are operating in a balanced anti-phase movement. The balanced operation of both the excitation mode and the detection mode makes SAR10(H)Z almost insensitive to environmental vibrations, limiting effects causing bias drift as well as improving the Q-factors. A fine-tuning of the oscillation frequencies to allow for force-feedback operation is done during final test for each sensor by applying and programming an electrostatic bias to reduce mechanical stiffness and thereby

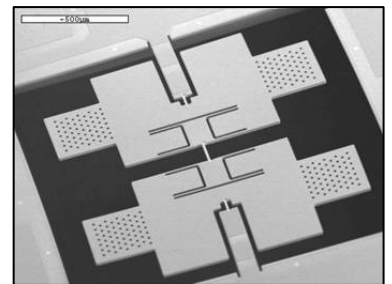


Figure 1.2 SAR10Z Element structure

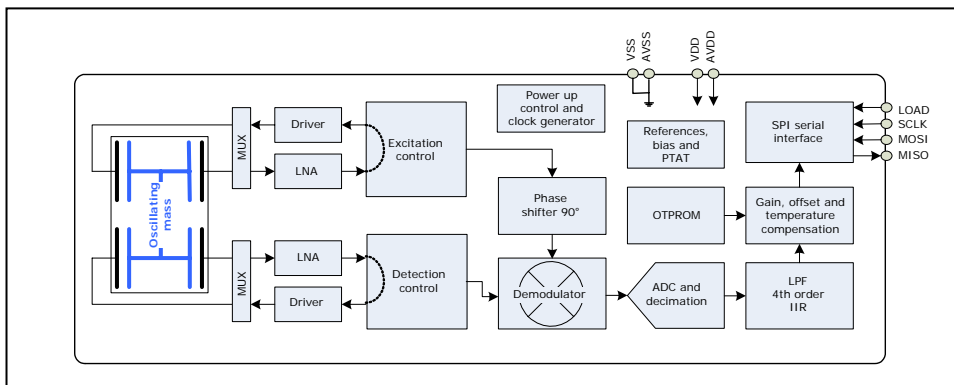


Figure 1.1 SAR10Z Block diagram

calibrate detection mode frequency. Fixed algorithms use individually determined calibration coefficients stored in OTPROM poly fuse cells. Readings from the internal temperature sensor are used for accurate angular rate definitions. An SPI interface enables communication between application and SAR10(H)Z. The angular rate data output is a 12-bit 2's complement format. A number of functions are available through the digital SPI interface.



2 Abbreviations and Definitions

2.1 Abbreviations

| | |
|--------|---|
| FSI | Full Scale Input |
| FSO | Full Scale Output |
| SPI | Serial Peripheral Interface |
| ASIC | Application Specific Integrated Circuit |
| ESD | Electro Static Discharge |
| MSB | Most Significant Bit |
| LSB | Least Significant Bit |
| OTPROM | One-Time Programmable Read Only Memory |

2.2 Definitions

- Specifications herein are over the complete temperature and supply voltage operating range unless otherwise is noted
- Voltages are referenced to AVSS/VSS unless otherwise is specified

3 Recommended Operating Conditions

| Characteristics | Symbol | Note | Specifications | | | |
|--------------------------------|--------------|-------|----------------|-------|-----|-------|
| | | | Min | Nom | Max | Units |
| Input range SAR10Z SAR10HZ | Ω FSI | | | ±250 | | °/s |
| | Ω FSI | | | ±100 | | °/s |
| Dynamic overload, angular rate | Ω OVL | 1,5 | ±1200 | ±5000 | | °/s |
| Dynamic overload, shock | | 1,4,5 | ±500 | ±1500 | | g |
| Recovery time dynamic overload | | 1,5 | | 30 | | ms |
| Supply voltage | VDD, AVDD | 2 | 4.45 | 5.0 | 5.5 | VDC |
| Current consumption | | 3 | | | 17 | mA |
| Sensor oscillation frequency | fOSC | | | 9.4 | | kHz |
| Internal master clock | fMCLK | | | 8.0 | | MHz |
| Operating temperature | TOPER | | -40 | | +90 | °C |

- Note 1:** The PRCEN command will have to be issued to revert to normal functionality.
Note 2: Both digital (V_{DD}) and analog (AV_{DD}) supply voltage.
Note 3: Total current consumption from both analog and digital supply.
Note 4: Shock below 500g/1ms will never result in an error condition.
Note 5: By design.



4 Absolute Maximum Ratings

Prolonged exposure to absolute maximum ratings may affect the performance and/or reliability of the device.

| Characteristics | Symbol | Note | Specifications | | | |
|--|-----------|------|----------------|-----|-------------|-------|
| | | | Min | Nom | Max | Units |
| Supply voltage | VDD, AVDD | | -0.5 | | 7.0 | VDC |
| Input voltage, any pin | | | -0.5 | | VDD +0.5 | VDC |
| Input transient current, any pin | | | | | ±100 | mA |
| Short circuit immunity to VDD/AVDD or VSS/AVSS, any output | | | | | 10 | min |
| ESD voltage immunity, Human Body Model, any pin | | 1 | | | 2000 | V |
| ESD voltage immunity, Charge Device Model, any pin | | 2 | | | 500 | V |
| Mechanical shock | | 3 | | | 5000 | g |
| Ambient temperature when operating | | | -40 | | +125 | °C |
| Storage temperature | | | -55 | | +125 | °C |

- Note 1:** According to AEC-Q100-002 Rev. C or JESD22-A114 Rev. F
- Note 2:** According to AEC-Q100-011 Rev. B or JESD22-C101 Rev. D
- Note 3:** According to MIL-STD 883E.

5 SPI Serial Data Interface

Serial data communication with the application is through the SPI interface. The 8 MSBs of an angular rate data sample are mapped to the 8 bit response of the RARH (read angular rate high byte) command. The 4 LSBs of the sample are mapped to the 4 LSBs of the 8 bit response of the RARLX (read angular rate low byte) command. The RARH command latches the 4 LSBs of a sample such that a RARH, RARLX command sequence guarantees bits from the same angular rate sample. The 4 MSBs of the response from the RARLX command is always a '0101' SPI error check bit pattern.

5.1 Signal Definitions and Characteristics

The SPI interface consists of the 4 signals MOSI, MISO, SCLK and LOAD.

| Name | Signal Description |
|-------------|---|
| MOSI | Master Out, Slave In. After a negative edge on LOAD, 8-bit command is shifted in on MOSI, clocked by SCLK (MSB first). |
| MISO | Master In, Slave Out. Output from previous command is stored in a Data Register. At a negative edge on LOAD, the content of the Data Register is loaded to the Data Output Register. While command byte is shifted into the Command Register, Data Output is shifted out on MISO (MSB first). |
| LOAD | Chip Select/Transfer Start Strobe. As long as LOAD=1, the MISO output is in a high-Z mode (tri-stated). A negative edge on LOAD initiates an SPI transfer. The new command is executed after a positive edge on LOAD. If a positive edge occurs on LOAD before at least 8 bits are shifted in on MOSI, the command will be ignored. |
| SCLK | Serial Data Clock. MOSI is read on the positive edge of SCLK, and MISO is shifted out on the negative edge of SCLK. |



| Characteristics | Symbol | Note | Specifications | | | |
|-----------------------|------------------------------|------|----------------|-----|---------------------------|---------|
| | | | Min | Nom | Max | Units |
| High ('1') level | VH | 2 | 0.7VDD | | | V |
| Low ('0') level | VL | 2 | | | 0.3VDD | V |
| Input rise time | trI | 2 | | | 1/(20fSCLK) | s |
| Input fall time | tfl | 2 | | | 1/(20fSCLK) | s |
| Output fall time | tPHL | 1,2 | | | 8.5 | ns |
| Output rise time | tPLH | 1,2 | | | 8.6 | ns |
| Output enable delay | tPHZ tPLZ tPZH tPZL | 1,2 | | | 1.2 0.97 8.4 8.2 | ns |
| Data rate | fSCLK | 3 | | | 8.5 | Mbits/s |
| Capacitive load, MISO | CMISO | 2 | | | 100 | pF |

- Note 1:** With load of 100pF connected to V_{SS}.
- Note 2:** Characteristic is based on proven library I/O cell performance.
- Note 3:** By design.

5.2 SPI Commands

| Name | Command | Address | Output | Description | Note |
|--------------------------------|----------|----------|----------------|---|------|
| Read Commands | | | | | |
| RARH | 10000000 | - | dddd dddd | Read Angular Rate, High Byte | 2 |
| RARLX | 10001110 | - | 0101 dddd | Read Angular Rate, Low Byte eXtended | |
| RTMP | 10110000 | - | 1000 0000 | Read internal temperature | |
| RSR | 10110100 | - | Status byte | Read status register | |
| SafeGuard Commands | | | | | |
| SGDIS1 | 01001110 | 11010111 | 1000 0000 | SafeGuard Disable Command 1 | 1 |
| SGDIS2 | 01100011 | 01010000 | 1000 0000 | SafeGuard Disable Command 2 | |
| SGDIS3 | 00010010 | 10101000 | 1000 0000 | SafeGuard Disable Command 3 | |
| SGEN | 01010101 | - | 1000 0000 | SafeGuard Enable Command | |
| Error Handling Commands | | | | | |
| PRCEN | 10101010 | - | 1000 0000 | Re-enable signal processing after error condition | 3 |

- Note 1:** The three SafeGuard disable commands MUST be issued in the -1,-2,-3 sequence, and with the addresses shown. Any in-between commands or incorrect addresses will reset the Safeguard Disable sequence. A single SGEN command re-enables the SafeGuard.
- Note 2:** The RARH command latches high and low bytes such that a sequence of RARH first followed by RARLX guarantees bits from the same Angular Rate sample.
- Note 3:** In case of a recoverable error condition, issuing this command re-enables continued angular rate readout. Note that for this command to function the SafeGuard must be disabled. See chapter 8 for details.

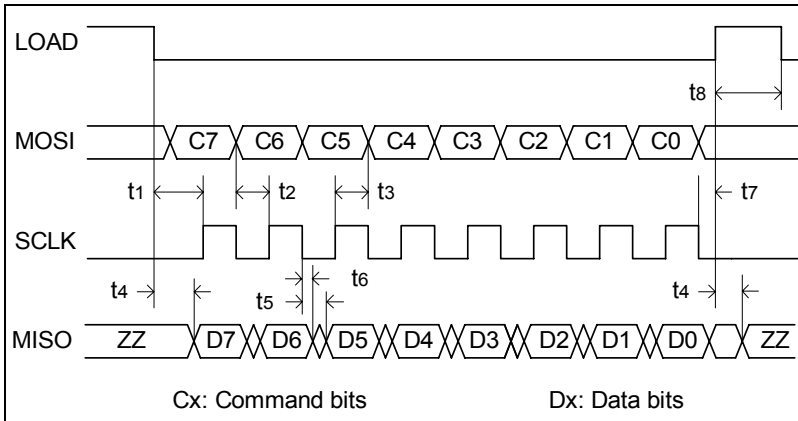


Figure 5.1 SPI interface signal timing diagram

For commands that need an address, the address byte is shifted in prior to the command byte.

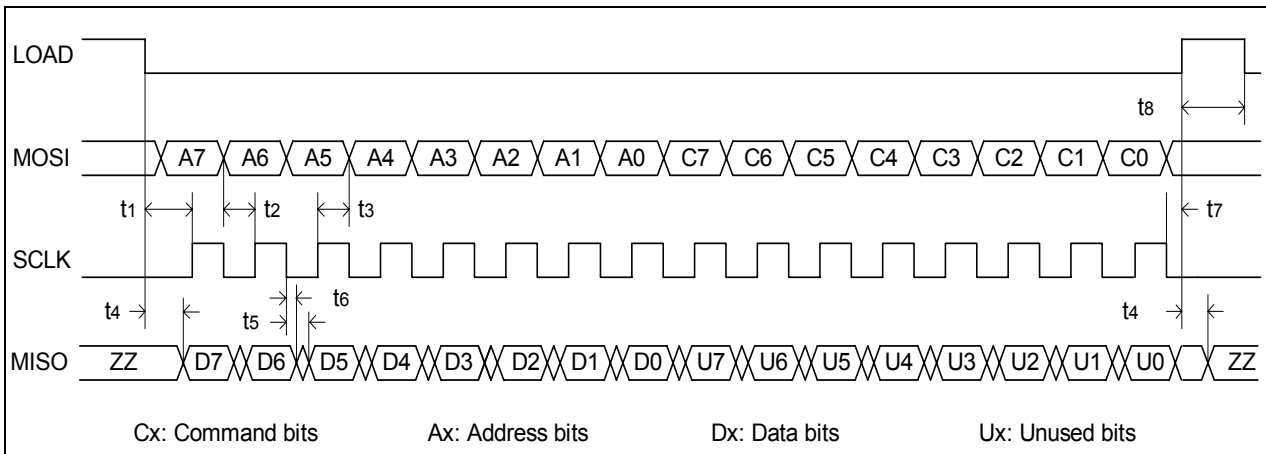


Figure 5.2 SPI interface signal timing diagram for command with address byte

| Symbol | Parameter | Specification | | | Note |
|--------|--|---------------|-----|-------|------|
| | | Min | Max | Units | |
| t1 | Delay from falling edge of LOAD to the first rising edge of SCLK | 10 | | ns | 2 |
| t2 | Delay from stable data at MOSI to rising edge of SCLK (MOSI data setup time) | 10 | | ns | 2 |
| t3 | Delay from rising edge of SCLK to new data at MOSI (MOSI data hold time) | 10 | | ns | 2 |
| t4 | Delay from falling edge or rising edge of LOAD to active or high-Z state of MISO | | 20 | ns | 2 |
| t5 | Delay from falling edge of SCLK to stable new data at MISO (MISO data output delay) | | 20 | ns | 2 |
| t6 | Delay from falling edge of SCLK to removal of old data at MISO (MISO data hold time) | 0 | | ns | 2 |
| t7 | Delay from last falling edge of SCLK to next rising edge of LOAD | 20 | | ns | 2 |
| t8 | Delay from rising edge of LOAD to falling edge of LOAD | 527 | | ns | 1,2 |

Note 1: Minimum 4 internal MCLK cycles = 4 * 1/7.6MHz.
Note 2: By design.



5.3 Error Code

The Error Code is a bit pattern defined as 1000 0000₂. This Error Code is the SPI response during device startup, if an illegal or undefined SPI command is attempted executed, or if a RARH or RARLX command was executed while at the same time any one or more of the Status Register flags is a '0'. The RARH command accesses the 8 MSBs of the 12 bit 2's complement rate data. Negative angular rate data is limited (clamped) to -2032 (binary 1000 0001 0000₂) since the 8 MSBs of rate data in the range -2048 to -2033 (1000 0000 0000₂ to 1000 0000 1111₂) could otherwise be confused with the Error Code. For symmetry reasons positive angular rate data is likewise limited to 2032. Note that this angular rate data limiting does not affect any Status Register flags.

6 Angular Rate and Temperature Output

| Characteristics | Symbol | Note | Specifications | | | |
|---------------------------------------|----------------|--------------|-----------------------------------|----------------------------------|------|------------------------|
| | | | Min | Nom | Max | Units |
| Angular rate data format | | | | | | |
| Word length | | | 12 | | | bit |
| Format | | | 2's complement | | | |
| SPI commands | | | RARH RARLX | | | |
| Scale Factor SAR10Z SAR10HZ | | | | 0.25 0.10 | | (°/s)/LSB (°/s)/LSB |
| Full scale signal | +ΩFSO -ΩFSO | 1 | High byte 00111110 11000001 | Low byte 01011000 01011000 | | |
| Zero rate output | | | High byte 00000000 | Low byte 01010000 | | |
| Error Code | | | High byte 10000000 | Low byte 10000000 | | |
| Sensitivity | | 10 | | | | |
| Shift over temperature | | 8 | | ±0.5 | | % |
| Accuracy | | 1,7 | | ±1 | | % |
| Non-linearity | | | | 0.1 | | %FSO |
| Noise | | | | | | |
| Noise SAR10Z SAR10HZ | | 2,7 2,7 | | 0.25 0.15 | | °/s (rms) °/s (rms) |
| Angular random walk SAR10Z SAR10HZ | | 7, 9 7, 9 | | 1.8 1.2 | | °/√hr °/√hr |
| Bias | | 10 | | | | |
| Initial bias | | 7 | -500 | 0 | +500 | LSB |
| Bias temperature accuracy | | 8 | | | ±3 | °/s |
| In-run bias stability | | 7,9 | | | 125 | °/hr |
| Vibration sensitivity | | 5 | | ±0.03 | | (°/s)/g |
| Alignment error | | | | ±1 | | ° |
| Frequency response | | 4 | | | | |
| Filter sampling rate | fS | | | 2 | | kHz |
| Pass band ripple | | 4,6 | | | 0.2 | dB |
| Group delay | | 6 | | | 13 | ms |
| Passband cut-off frequency | fH | 3,6 | | 50 | | Hz |
| Roll-off for f > fH | | 6 | | 100 | | dB/dec |
| Attenuation for f > 310 Hz | | 6 | | 85 | | dB |



| Characteristics | Symbol | Note | Specifications | | | |
|---------------------------|--------------|------|----------------------|----------------|-----|--------|
| | | | Min | Nom | Max | Units |
| Temperature sensor | | 10 | | | | |
| Word length | | | 8 | | | bit |
| Format | | | 2's complement | | | |
| SPI commands | | | RTMP | | | |
| Scale Factor | | | | 1 | | °C/LSB |
| Full scale signal | Tmax Tmin | 7 | 01011111 11011000 | +95°C -40°C | | |
| Accuracy | | 8 | | ±2 | | °C |

- Note 1:** Calibrated at $f_{\Omega} = 2\text{Hz}$.
- Note 2:** Integrated over $\Delta f = fH$.
- Note 3:** -3dB frequency.
- Note 4:**

LP-filter transfer function:
$$H(z) = \frac{b_{01} + b_{11} \cdot z^{-1} + b_{21} \cdot z^{-2}}{1 - a_{11} \cdot z^{-1} - a_{21} \cdot z^{-2}} \cdot \frac{b_{02} + b_{12} \cdot z^{-1} + b_{22} \cdot z^{-2}}{1 - a_{12} \cdot z^{-1} - a_{22} \cdot z^{-2}}$$

| | | | |
|-----|-------------------|-----|--------------------|
| a11 | 1.91064453125E+00 | a12 | 1.829833984375E+00 |
| a21 | -9.31640625E-01 | a22 | -8.40087890625E-01 |
| b01 | 1.0498046875E-02 | b02 | 7.8125E-03 |
| b11 | -1.0498046875E-02 | b12 | 4.8828125E-03 |
| b21 | 1.0498046875E-02 | b22 | 7.8125E-03 |

- Note 5:** Any axis. Frequencies < 5.4 [kHz]. Stationary vibrations at resonant modes at frequencies > 5.4 [kHz] may cause larger effects.
- Note 6:** By design.
- Note 7:** Measured at 25 °C.
- Note 8:** Within -30 to +70 °C.
- Note 9:** By Allan Variance method.
- Note 10:** Maximum temperature gradient ±5K/min.

7 Power Supply and Start-up

The SAR10(H)Z is designed for a single +5 volt supply. The device has four pins for power connection: V_{DD} , AV_{DD} , V_{SS} and AV_{SS} . The V_{SS} and AV_{SS} pins shall be connected together on the printed circuit board as close to the device as possible. The same rule applies to V_{DD} and AV_{DD} . A simultaneous power-on of the two supplies is essential to prevent internal latch-up conditions. An external power supply decoupling capacitor is needed. This decoupling capacitor should be a low ESR 100nF capacitor connected to the supply line as close to the V_{DD} and V_{SS} pins as possible. An additional decoupling capacitor is needed between pin 6 (REFV) and V_{SS} . This should be a low ESR 10nF capacitor connected as close as possible to pin 6 and V_{SS} pin. The SAR10(H)Z has a supply voltage surveillance circuit which sets the Status Register flag PRNG_OK to '1' only if AV_{DD} is within specified range. If outside this range, the PRNG_OK flag is set to '0'.

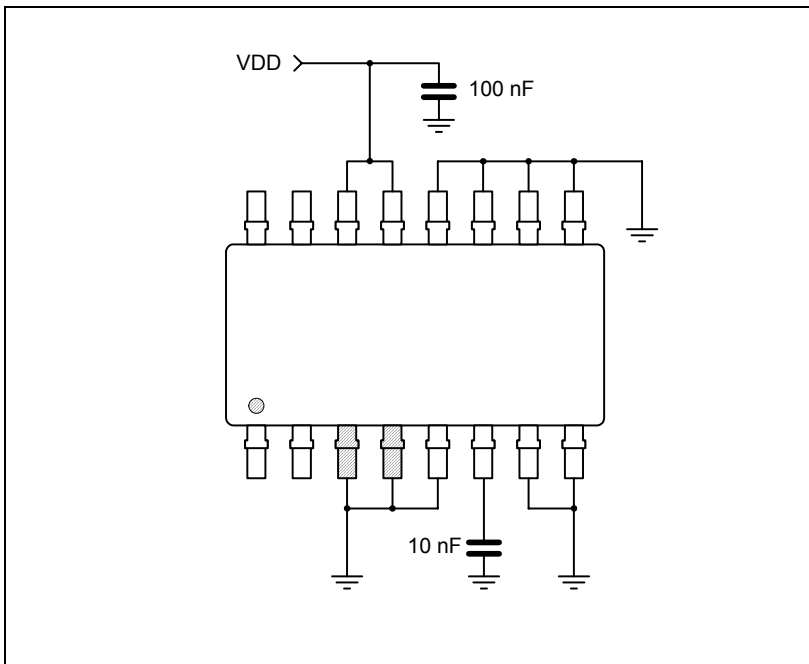


Figure 7.1 Power Supply and Decoupling (top view)

| Characteristics | Symbol | Note | Specifications | | | |
|--|---------------------|------|----------------|-----|------|-------|
| | | | Min | Nom | Max | Units |
| Supply voltage rise time to VDD-MIN | t _D | 1 | 0.001 | | 10 | ms |
| Start-up time | t _{INIT} | 2 | | 90 | | ms |
| Time to rate data within full specifications | t _{STABLE} | 2 | | | 500 | ms |
| Minimum AVDD for internal RESET | V _{RU} | 3, 7 | | | 1.0 | VDC |
| Detectable AVDD glitch | t _G | 7 | 10 | | | ns |
| Reset threshold | V _{RESET} | 4 | 2.5 | | 3.5 | VDC |
| Status Register AVDD OK flag (PRNG_OK) threshold | V _{PRNGH} | 5 | 5.55 | | 5.91 | VDC |
| | V _{PRNGL} | | 4.2 | | 4.43 | |
| Reset delay | t _{RSTN} | 6, 7 | 128 | | 208 | μs |

- Note 1:** The voltage V_{DD-MIN} is the lower limit for V_{DD} and A_{VDD} as specified in 2.5.
- Note 2:** The startup time is defined as the time until the Status Register EXC_OK flag goes to '1' (sensor excitation has stabilized). Reading from the device during this time interval causes the device to respond with Error Code. The time to stable data is defined as the time from the end of t_{INIT} until the angular rate data is within full specifications. Angular rate data can however be read from the device during this time interval.
- Note 3:** Internal reset signal is defined for supply voltage above V_{RU}.
- Note 4:** Internal reset is activated when the supply voltage passes V_{RESET}. The reset threshold has a small hysteresis (approx. 0.1V).
- Note 5:** The RARH and RARLX commands return the Error Code when AV_{DD} ≤ V_{PRNGL} or AV_{DD} ≥ V_{PRNGH}.
- Note 6:** For correct OTP power-down a reset pulse width of minimum 50 μs is needed.
- Note 7:** By design.

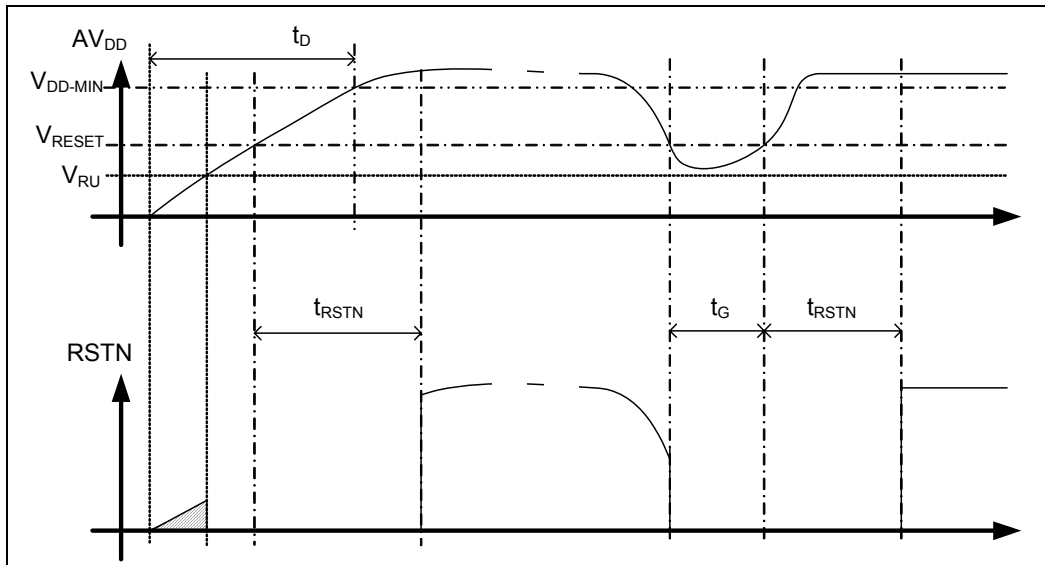


Figure 7.2 Power-Up and Power Glitch Reset Timing



8 Status Register and Internal Diagnostic Monitoring

Internally in the SAR10(H)Z, 6 error monitoring functions are employed to make sure an irregular output angular rate is detected. If any of the monitoring functions detects an irregular condition the corresponding flag becomes a '0', otherwise a '1'. The Status Register flags are available to the application via the RSR SPI command. It is assumed that a flag can signal an "error" for any length of time. To make sure short error ('0') pulses are visible to the application, the '0' pulses are "stretched" in time to between 1.5 and 2.0 ms.

| Bit Position | Flag Name | Monitoring function | Recoverable |
|--------------|----------------|---|-------------|
| 7 | ADC_OK | ADC_OK is '0' if an ADC overflow occurs, otherwise '1'. | Yes |
| 6 | SIG_OK | SIG_OK is '0' if an arithmetic overflow or underflow occurs in the digital signal processing, EXCEPT if the signal amplitude exceeds the output range in the final scaling (by the S0INV parameter), otherwise '1'. | No |
| 5 | OTPPAR_OK | OTPPAR_OK is '0' if OTP parity check fails, otherwise '1'. | No |
| 4 | ATEST_INACTIVE | ATEST_INACTIVE is '0' if an analog test mode is active, otherwise '1'. This monitoring function will not result in any Error Code signaling. | - |
| 3 | PRNG_OK | PRNG_OK is '0' if the AVDD voltage is out of range, otherwise '1'. | No |
| 2 | DET_OK | DET_OK is '0' if a sensor die detection electrode connection is open or if a leakage current is present on one or both electrodes, otherwise '1'. | No |
| 1 | EXC_OK | EXC_OK is '0' if the excitation control loop fails to lock on resonance frequency such that the excitation amplitude falls below a critical level, otherwise '1'. | Yes |
| 0 | (no name) | Not used. Always '1'. | - |

After power-up and until the device start-up is complete the output from the RARH and RARLX commands is substituted by the Error Code, see 5.3. After start-up, if any of the flags go to '0' (the internal monitoring functions indicate that the output is irregular), the Error Code is the output from the RARH and RARLX commands, and also internal digital signal processing is held. This signaling continues indefinitely until the device is powered down, or, in case of some of the conditions (see 'Recoverable' in the table above), until the PRCEN command is issued.

The PRCEN command execution must obey the following algorithm:

1. Wait until no recoverable error conditions are flagged (polling the Status Register).
2. Wait minimum 30 ms (recommended 100 ms).
3. Execute the SGDIS1, -2 and -3 commands.
4. Execute the PRCEN command.
5. Execute the SGEN command

Note that for the PRCEN command to take effect, the Safe Guard must first be disabled by means of the SGDIS1,-2 and -3 commands. To resume normal operation after recovery, the SafeGuard must be re-enabled by using the SGEN command. If, before the Safe Guard was disabled, a non-recoverable error condition existed, the SAR10(H)Z will return to responding with the Error Code to RARH, -LX commands as well as holding internal digital signal processing even after the SGEN command was issued (the error is non-recoverable). Also note that while the SafeGuard is disabled, no error condition will be latched.

9 Mechanical Specifications

9.1 Physical dimensions

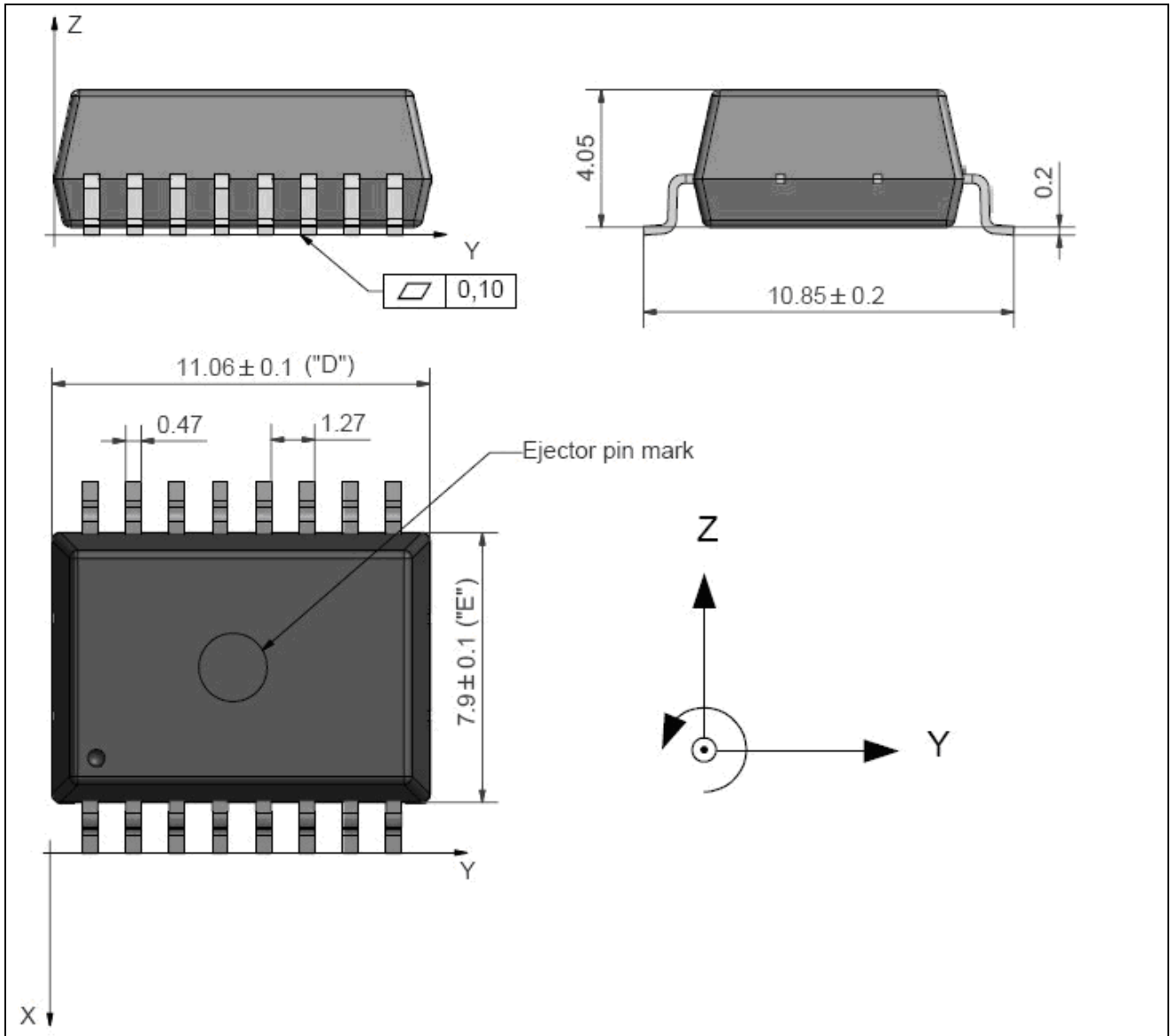


Figure 9.1 Package dimensions and sensitive direction of rotation. Top, side and bottom view.

| Characteristics | Specifications |
|-----------------|----------------------|
| Package type | Plastic moulded SOIC |
| Number of pins | 16 |
| Weight | 1.5 grams |



9.2 Pin Configuration

| Pin Number | Name | Type | Direction | Note | Function |
|------------|------|---------|-----------|------|---|
| 1 | SCLK | Digital | Input | | SPI clock |
| 2 | LOAD | Digital | Input | | SPI load |
| 3 | VSS | Power | - | 1 | Digital ground |
| 4 | AVSS | Power | - | 1 | Analog ground |
| 5 | - | - | - | 2 | Test pin. Connect to ground |
| 6 | REFV | - | - | 3 | Internal voltage reference |
| 7 | - | - | - | 2 | No internal connection. Connect to ground |
| 8 | - | - | - | 2 | Lead frame. Connect to ground |
| 9 | - | - | - | 2 | Lead frame. Connect to ground |
| 10 | - | - | - | 2 | No internal connection. Connect to ground |
| 11 | - | - | - | 2 | Test pin. Connect to ground |
| 12 | - | - | - | 2 | Test pin. Connect to ground |
| 13 | AVDD | Power | - | 1, 4 | Analog +5V supply voltage |
| 14 | VDD | Power | - | 1, 4 | Digital +5V supply voltage |
| 15 | MOSI | Digital | Input | | SPI data input |
| 16 | MISO | Digital | Output | 5 | SPI data output |

Note 1: To be connected externally.

Note 2: Connect to ground to minimize noise levels.

Note 3: Connect a 10nF low ESR decoupling capacitor between this pin and ground.

Note 4: Connect a 100nF low ESR decoupling capacitor between these pins and ground.

Note 5: This signal is tri-stated when LOAD is logical '1' ($> 0.7V_{DD}$).