Metrozet TSA-101DH
Downhole Triaxial Seismic Accelerometer

Downhole Triaxial Force-Balance Accelerometer
- **Strong Motion Sensor: +/- 4 g Range**
- **Wide Bandwidth: DC to >200 Hz**
- **Low Noise: 2.2 x 10^{-8} g/rtHz at 1 Hz**
- **High Dynamic Range:**
  - **162 dB at 1 Hz**
  - **137 dB, 0.1 Hz to 100 Hz, Integrated**
- **Low Thermal Drift: 60 micro-g/^{o}C**
- **High Acuuracy:**
  - **0.015% Total Non-Linearity**
  - **Ultra-Low Hysteresis: 0.005%**
- **Packaged for downhole applications**
  - **3.00" diameter standard housing (316 SS)**
  - **Multi-pin hermetic connector**
  - **1000m water depth rating**

Metrozet's TSA-101DH is advanced borehole sensor for the most critical applications in downhole earthquake recording and free-field ground motion monitoring. It utilizes the same innovative sensor element found in Metrozet's high performance TSA-100S surface package. The TSA-101DH provides a large sensing range (+/- 4 g), wide frequency response (DC to >200 Hz), high accuracy (ultra low non-linearity and hysteresis), and industry-leading noise performance.

The TSA-101DH is packaged for downhole applications. The standard, watertight package includes a 3.00" diameter, stainless steel pressure housing and a high quality hermetic electrical connector. It is designed for operation at water depths of up to 1000 m (1430 psi). The package diameter can be reduced significantly further, in order to support applications in smaller boreholes. Please contact Metrozet to discuss your specific application.

As the technical data below shows, the TSA-101DH is a very high performance alternative to a number of common common borehole accelerometers (Kinemetrics HypoSensor and FBA-23DH and Reftek 131A-02/BH).

Highest Performance
The TSA-101DH provides the highest overall performance of any strong motion (+/- 4 g) seismic accelerometer. In particular, it provides superior performance over the industry-standard EpiSensor/HypoSensor, in a number of critical areas. The comparative data shown below provides a clear picture of the performance enhancements delivered by the TSA-101DH

Competitive Pricing
You can expect highly competitive pricing through our distributors, OEM and system integration partners as well as our direct purchase program.

Please Click Here to request a competitive quotation for your next borehole installation.

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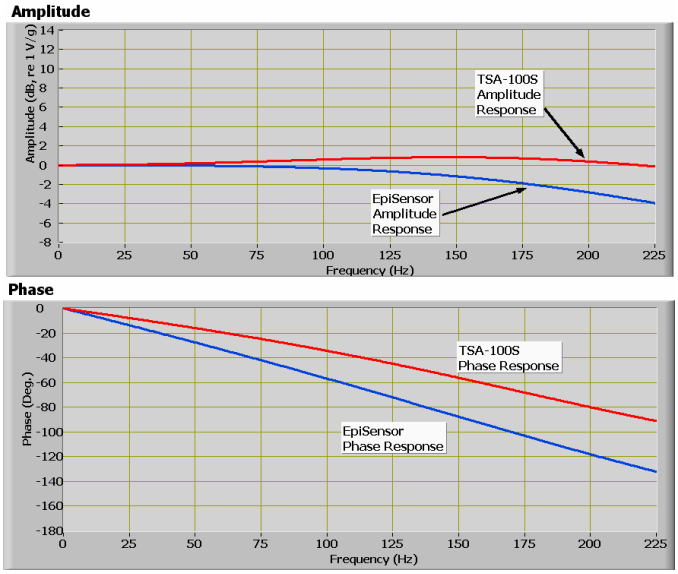
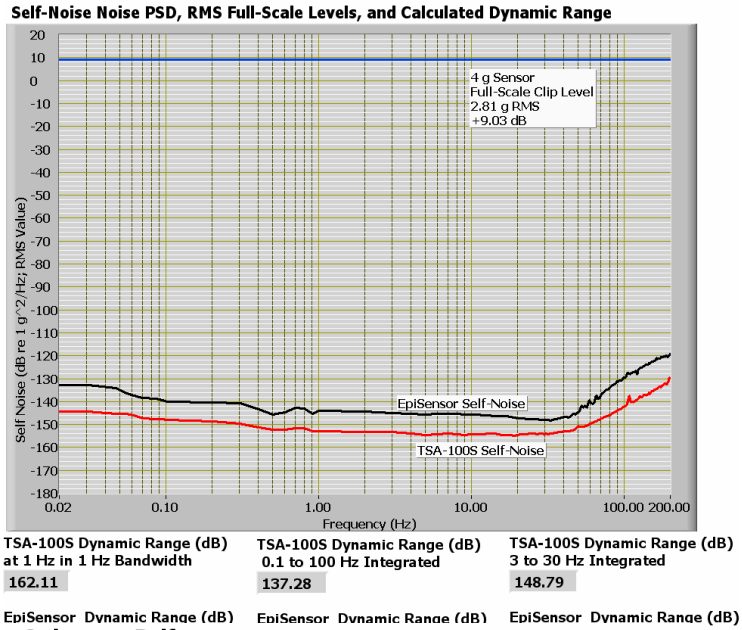
Highest Performance

Metrozet's TSA-101DH provides superior performance

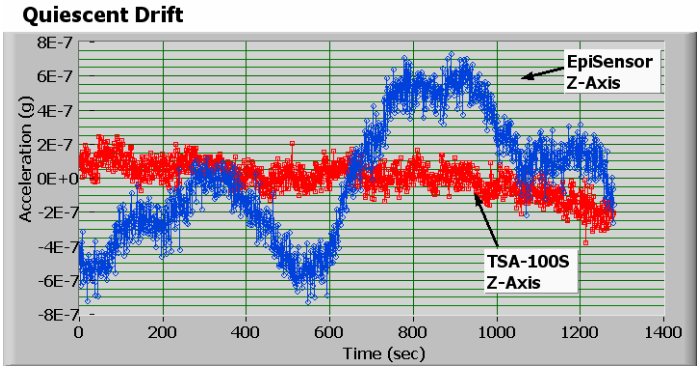
(Comparison of TSA-101DH's sensor elements to competing technology)



Upper Left: Amplitude and phase response;
The TSA-101DH has higher amplitude response and smaller phase shifts than the EpiSensor, at all frequencies.



Upper Right: Self-noise, full-scale range, and dynamic range;
The TSA-101DH has nearly 10 dB lower self noise at all frequencies (from DC to 200); the TSA-101DH has 9 dB greater dynamic range at 1 Hz, and more than 11 dB greater dynamic range over a 0.1 Hz to 100 Hz bandwidth.



Lower Right: Quiescent drift; both sensors have been stabilized in a low noise seismic laboratory for 48 hours; the TSA-101DH drift is 5X lower than that of the EpiSensor, over a 1200 second period.

Comparison of Key Specifications

Specification	*Metrozet TSA-101DH*	*Kinemetrics HypoSensor*
Bandwidth	**DC to >200 Hz (-90° phase point)**	DC-150 Hz (-90° phase point)
Dynamic Range (in +/- 4 g Sensors)	**162 dB, at 1 Hz, in 1 Hz bandwidth** **148 dB, typical, 3 Hz to 30 Hz, integrated** **137 dB, typical, 0.1 Hz to 100 Hz, integrated**	153 dB, at 1 Hz, in 1 Hz bandwidth 141 dB, typical, 3 Hz to 30 Hz, integrated 126 dB, typical, 0.1 Hz to 100 Hz, integrated
Offset Temperature Drift	**60 micro-g/°C, Horizontal** **320 micro-g/°C, Vertical**	500 micro-g/°C, all axes
Non-Linearity	**0.015% TOTAL non-linearity, over +/-1 g range**	0.1% 2nd order non-linearity, over +/- 1 g range
Hysteresis	**0.005% of full-scale**	0.1 % of full-scale
Cross-Axis Sensitivity	**0.002% within sensor** **0.5% total, including mounting misalignment**	1% total, including mounting misalignment

Metrozet TSA-101DH: Detailed Specifications

Specification	Value
Technology	Triaxial, force-balance accelerometer with capacitive displacement sensor, restoring coil and calibration coil Metrozet's TSA-101DH uses the identical, proven sensor technology as the TSA-100S
Full-Scale Range	+/- 4 g Peak-to-Peak; superior to Kinemetrics FBA-23DH specification
Responsivity	Factory selectable: 5V/g Differential; 2.5V/g Single-Ended or 2.5 V/g Differential; 1.25V/g Single-Ended; Equivalent to Kinemertics FBA-23DH
Output	Differential to > +/- 20V Peak-to-Peak Single-Ended to > +/- 10 V Peak-to-Peak Output at +/- 2g: Factory selectable: 10 V Differential; 5 V Single-Ended or 5 V Differential; 2.5 V Single-Ended; Equivalent to Kinemertics FBA-23DH
Bandwidth[1]	DC to 200 Hz
Dynamic Range[2]	> 160 dB, at 1 Hz, in 1 Hz bandwidth 147 dB, typical, 3 Hz to 30 Hz, integrated 135 dB, typical, 0.1 Hz to 100 Hz, integrated
Self-Noise[3]	2.2×10^{-8} gRMS /rtHz @ 1 Hz, Typical 2.0×10^{-8} gRMS/rtHz @ 10 Hz, Typical 2.0×10^{-8} gRMS/rtHz @ 20 Hz, Typical 2.8×10^{-8} gRMS/rtHz @ 50 Hz, Typical 7.0×10^{-8} gRMS/rtHz @ 100 Hz, Typical 3.0×10^{-7} gRMS/rtHz @ 200 Hz, Typical Integrated Self-Noise: under 1 µg RMS, 0.01 Hz to 100 Hz (see note)
Offset	< +/- 0.01 g No mechanical offset adjustment or DC auto-zeroing is necessary
Non-Linearity[4]	< 0.015% Total Non-Linearity Under 0.5% over full-scale range 2^{nd} order non-linearity under 1000 µg/g^2
Total Harmonic Distortion[5] (THD)	< -74 dB
Cross-Axis Sensitivity[6]	< 0.002% within each sensor <0.5% total, within triaxial sensor, including axis misalignment
Hysteresis[7]	<200 micro-g peak-to-peak, with +/- 1 g excitation or <0.005% of Full-Scale
Calibration Coil	Standard, digitally enabled Allows DC, sine wave, and pseudo-random noise excitation Sensor output reflects equivalent input acceleration of calibration coil signal Nominal scale factor: 0.04 g/V Calibration Input impedance: >100 MOhms
Offset Temperature Coefficient[8]	Offset drift: 60 micro-g/ºC, typical, Horizontal Sensor 320 micro-g/ºC, typical, Vertical Sensor Amplitude sensitivity and offset remain within 2% of nominal values over -20ºC to +70ºC range
Supply Voltage Range[9]	+/- 12V to +/-16V
Power Consumption	Quiescent: +40 mA/-35 mA on +/-12 V Supply Peak: +/- 75 mA on +/- 12V Supply at +/-2 g Full-Scale Input
Remote Operation	Meets specifications on a standard cable (22 AWG conductors) Single-ended operation using no more than 4 twisted pairs
Operating Temperature Range	-20ºC to +70ºC
Connector	Standard: 12-Socket oceanographic bulkhead connector on endcap SeaCon Micro-Wet-Con series Stainless steel body 10,000 psi pressure rating Optional: Customer-specified bulkhead connector on endcap
Housing	3.0" diameter x 18.75" long watertight, cylindrical pressure housing with distinct axis orientation markings on housing body and endcaps Type 316 stainless steel 1000 m Water depth rating (1430 psi) Low-crevice-corrosion design (no external blind holes)

Notes to specifications:

[1] Upper bandwidth is frequency at which sensor response has -90 degree phase shift.

[2] The ratio of RMS full-scale to RMS noise. The dynamic range at 1 Hz, in a 1 Hz bandwidth, is a figure used by Kinemetrics for their EpiSensor.

*[3] Self-noise measurements utilize inter-sensor coherence techniques. See, for example, "Technique for the Measurement of the Noise of a Sensor in the Presence of Large Background Signals," Review of Scientific Instruments **69**, 2767 (1998). Some published specifications (e.g., CSMIP.CR.2004) express non-measurable specifications down to 0 Hz. Metrozet provides self-noise data for the TSA-101DH over physically measurable bandwidths (e.g., 0.01 Hz to 100 Hz). Please contact Metrozet regarding noise values at frequencies outside this range.*

[4] Non-Linearity is determined with a 180^o tilt test. Total Non-Linearity is the total, peak-to-peak residual error from a linear fit to this data. It is the error over a +/- 1 g range.

[5] THD is determined using the calibration coil. The coil is driven to produce an equivalent acceleration of 0.1 g Peak at 5 Hz Peak amplitude, and the sensor output is recorded. THD is the ratio of the energy in five harmonic peaks to that in the fundamental signal.

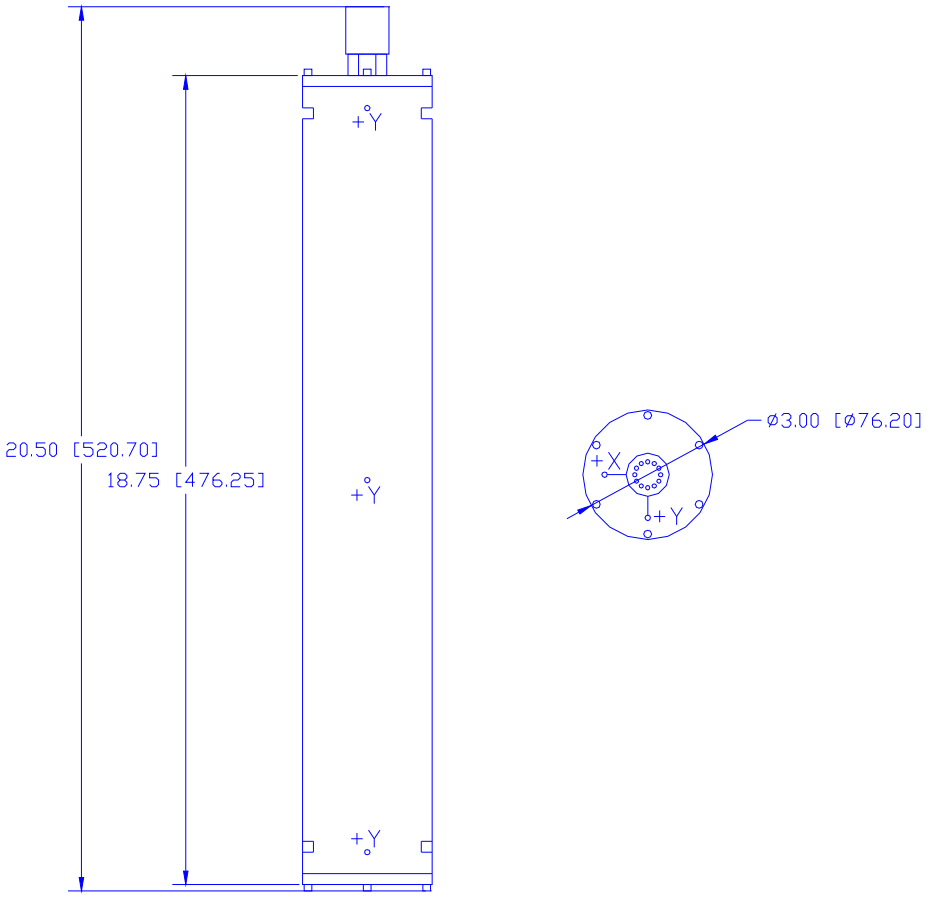
[6]Units are g/g. Cross-axis sensitivity includes both the axis misalignment associated with sensor mounting within the triaxial package, and the inherent sensitivity of each sensor alone. The latter is determined from the 180^{o}tilt test. Mounting misalignment is the dominant factor. The specification is a fraction of the applied signal.

[7] Hysteresis is determined through a repetitive tilt test. Measurements are made at 0^o tilt before and after tilting the sensor through a +/- 1 g range. The test provides a measurement of the variation in sensor reading at 0^o tilt, approaching from +1 g and -1g. Hysteresis is the total error peak-to-peak variation within the measurement set.

[8]This involves measurement of the sensor output in response to a small increase in housing temperature. The temperature rise is approximately 2.5 ^{o}C. It was measured with a small temperature sensor (LM35) mounted to the housing.

[9]This specification guarantees a +/- 4g Full-Scale Rang on short cable. For+/- 2g full-scale operation, on 22AWG cable of up to 2000 m length, the power supply voltage should be +/-14 V to +/-16 V.

Metrozet TSA-101DH: Watertight Package Dimensions



Dimensions in inches [mm]

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