Specifications for: Raspberry Shake Pro

Previously known as “Sixaola4”
- Seismograph, Accelerograph, Infrasound -
Born on: 2012 (first versions in <2009)
http://shop.raspberryshake.org/
sales@raspberryshake.org
Last updated: 8-november-2019

Unit

The Sixaola short-period seismograph is an all-in-one, plug-and-go solution for seismology that integrates 3 **velocity** sensors, 3 **accelerometer** sensors (optional), **infrasound** (optional), the digitizer, the hyper damper, the computer and the GPS into *a single box*. The Sixaola is manufactured in Panamá using cutting-edge 3D printing and laser-cutting technology.

Warranty: 3 years from ship date or as long as client maintains an annual technical support contract for 50+ hours/ year.

Specifications subject to change without notice.

Parameter	**Value**
Current Version	SX4-V4
Dimensions (estimated)	*Polycarbonate enclosure:* 160 mm x 160 mm x 100 mm
Weight (estimated)	*Polycarbonate enclosure:* 1.5 kg
IP66 Housing Options	Corrosion-resistant polycarbonate plastic enclosure
Connectors	Ethernet (RJ45), GPS, Power (12V)
Immersion Rating	IP66
Mounting	Aluminum base plate with anchoring slot

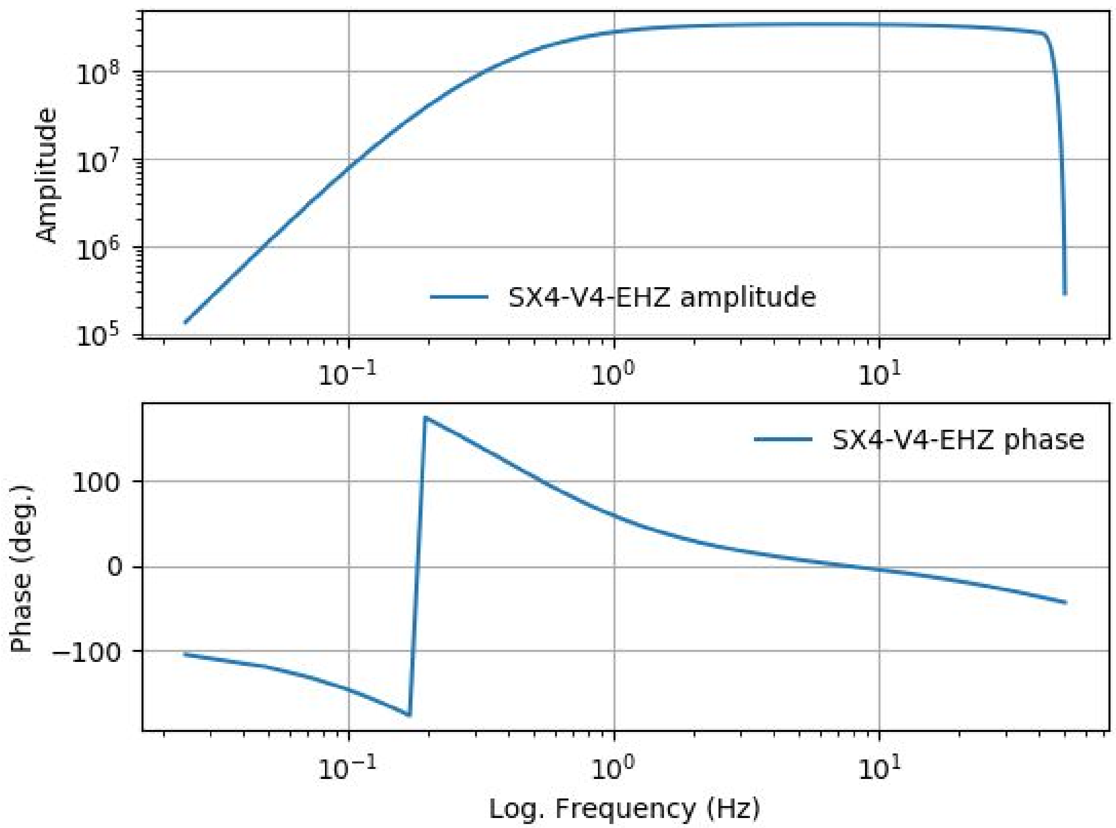
Alignment	North reference provided
Installation Considerations	Designed for plug-and-go installation *Bore and post-hole versions available upon request*
Operating Temperature Range (estimated)	-40 to 60 Celsius Non-condensing humidity 95%
On Board Computer	BeagleBone Black or equivalent Processor: ARM Cortex A(4,8)
Storage Device	16 Gb (or larger) USB (optional) You can replace the USB with a USB of your choice of any size.
Timing	GPS or NTP (if networking available)
Timing Quality	NTP timing quality: +/- 10 ms @ 100 sps

Seismograph

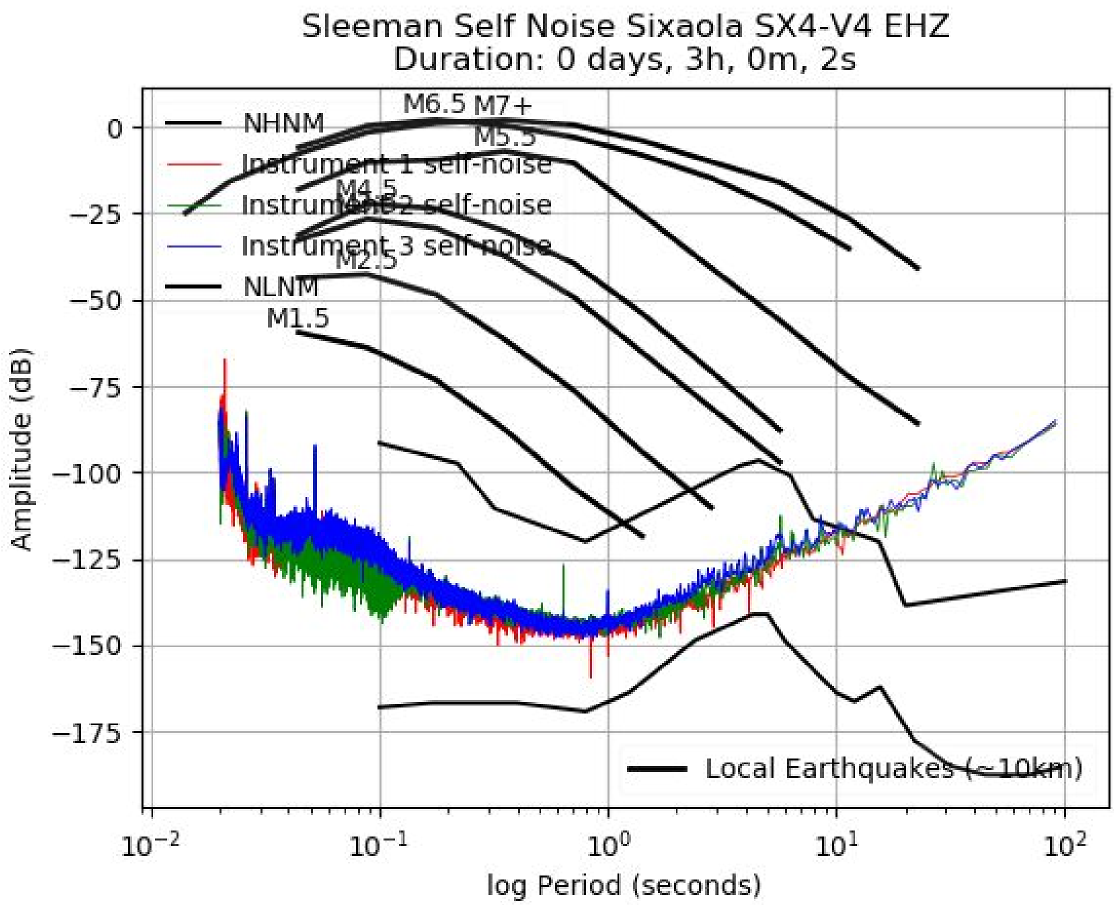
Parameter	Value
Type	3-component, orthogonally placed 4.5 Hz (electronically extended down to 2 seconds) geophones, 380 Ohm
Samples per second	100
Bandwidth (estimated)	V4: -3dB points at 0.7 to 43 Hz V2: -3dB points at 0.7 to 17 Hz
Poles (estimated)	V4: -1 (0.16 Hz, single pole high pass filter) -3.03 x2 (0.48 Hz, double pole high pass filter) -324.63 (51.7 Hz, single pole low pass filter) V2: -1, -3.03, -3.03, -94.5
Zeros (estimated)	V2+: 0, 0, 0
Sensitivity (estimated)	V4: 3.4E+08 counts/ meter/ second +/- 10% precision V2: 3E+08 counts/ meter/ second +/- 10% precision
Clip Level (estimated)	+/- 8,388,608 counts (24-bits) V4: 25 mm/s peak-to-peak from 0.1 to 10 Hz V2: 28 mm/s peak-to-peak from 0.1 to 10 Hz
Minimum Detection Threshold (estimate)	V2+: 0.03 μm/ s RMS from 1 to 10 Hz @ 100 sps

	Note: The minimum detectable level is considered to be 10 dB above the noise RMS. Dynamic range is the full scale sinusoid RMS over the noise RMS in dB.
Digitizer Dynamic range	24-bit ADC Sigma-Delta **ΣΔ** (one/ channel) Model: ADS1281 144 dB (24 bits)
Effective bits (estimated)	V2+: 21 bits (126 dB) from 1 to 10 Hz @ 100 sps (for the entire analog to digital hardware chain). *Note: Whereas most manufacturers report this for their digitizer only, we are reporting it for the entire sensor + ADC hardware chain. The effective bits of the digitizer itself are necessarily better.* This parameter is also commonly known as “Dynamic Range”; “RMS to RMS noise"; or "noise free bits".
Mass Centering	Not required

Velocity Channel Instrument Response:



Sleeman Self-Noise:

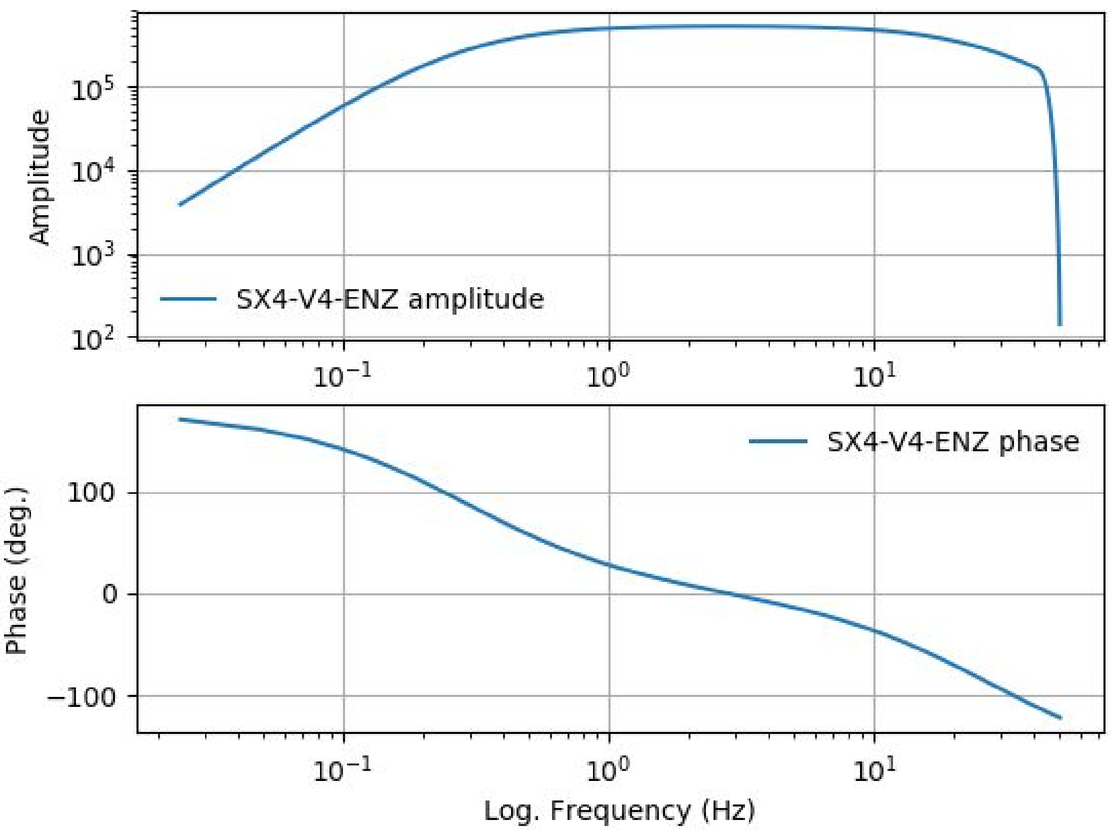


Accelerograph: GeoFlex

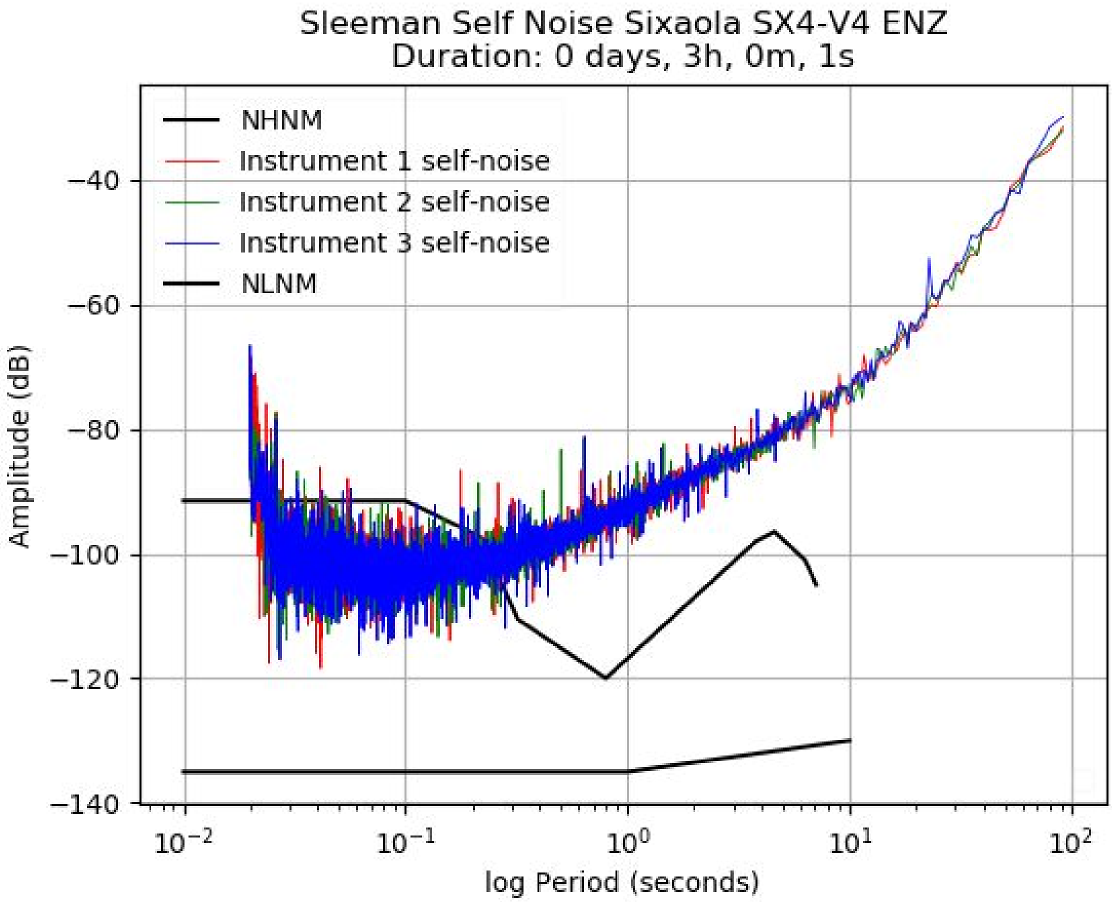
Parameter	Value
Sensor	Raspberry Shake GeoFlex Piezoelectric accelerometer triaxial
Digitizer	24-bit ADC Sigma-Delta ΣΔ (triaxial)
Channels	3, orthogonal
Samples per second	100 or disabled
Bandwidth (estimated)	V2+: -3dB points at 0.4 to 18 Hertz
Poles (estimated)	V4: -1.89 (0.3 Hz, single pole high pass filter) -1.71 (0.27 Hz, single pole high pass filter) -172.80 (27.5 Hz, double pole low pass filter) V2: 3.0E+02 (+/-)2.2E+02; -3.4E+01 0.0E+00; 1.1E+01 0.0E+00; -2.6E+00 (+/-)1.6E+00
Zeros (estimated)	V4: 0,0 V2: -1.5E+02 (+/-)3.1E+02; -3.8E+01 0.0E+00; 1.1E+01 0.0E+00; -1.9E+00 0.E+00; 4.4E-01 0.0E+00
Sensitivity (estimated)	V4: 5.1E+05 counts/ meter/ second squared +/- 5% precision V2: 5E+05 counts/ meter/ second squared +/- 5% precision
Clip Level	V2+: +/-2G (16.2 m/s^2 peak-to-peak from 0.1 to 10 Hz)

Dynamic range	24-bit ADC Sigma-Delta ΣΔ (one/ all channels) Model: ADS1274 144 dB (24 bits)
Effective Bits (estimated)	V4: 21 bits (130 dB) from 1 to 10 Hz @ 100 sps (for the entire analog to digital hardware chain). V2: 21 bits (126 dB) from 1 to 10 Hz @ 100 sps (for the entire analog to digital hardware chain). *Note: Whereas most manufacturers report this for their digitizer only, we are reporting it for the entire sensor + ADC hardware chain. The effective bits of the digitizer itself are necessarily better.* This parameter is also commonly known as “Dynamic Range” or “RMS to RMS noise”.
Noise Level	V4: 12 µm/ s (0.001 Gal, 2.0E-06 g) RMS from 1 to 10 Hz @ 100 sps V2: 19 µm/ s (0.002 Gal, 2.0E-06 g) RMS from 1 to 10 Hz @ 100 sps

Acceleration Channel Instrument Response:



Sleeman Self-Noise:



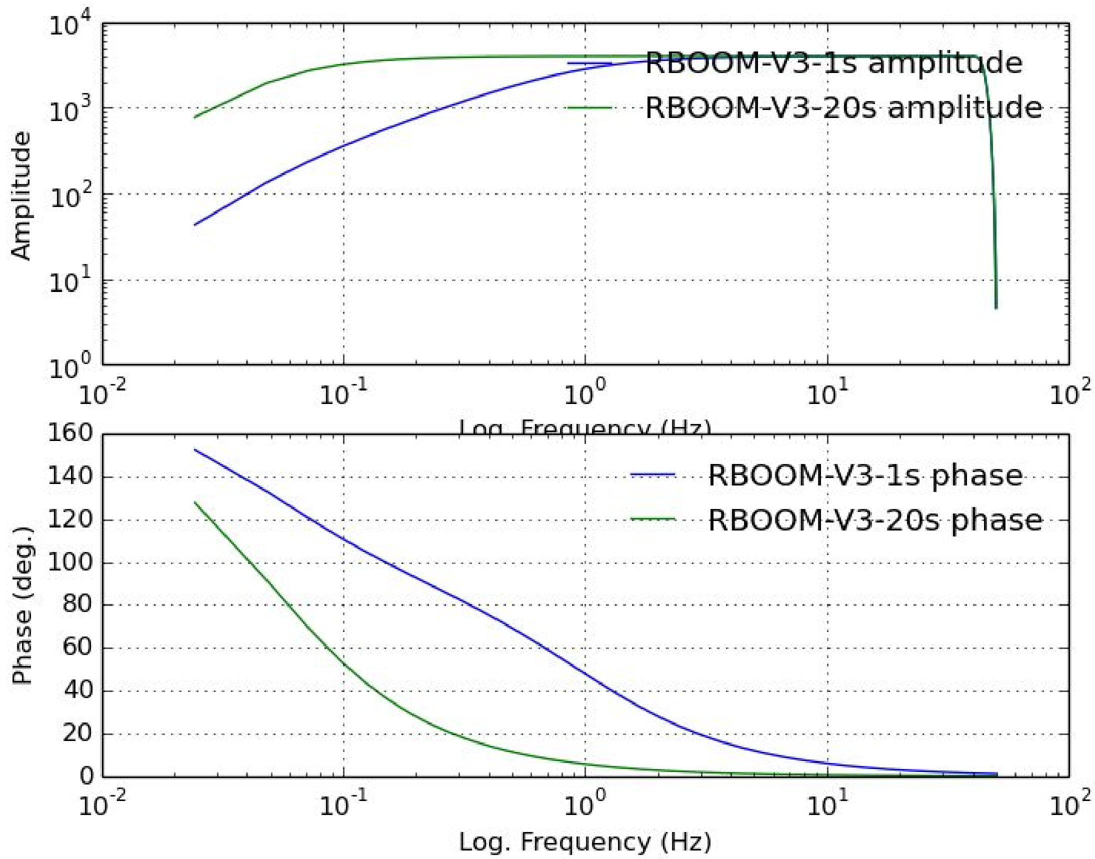
Microbarograph (Infrasound): RBOOM *(Discontinued)*

Parameter	Value
Type	Differential pressure transducer
Samples per second	100 or disabled
Data packet transmission rate	Data packets shipped across serial port at a rate of 4 packets/ second (250 ms/ packet)
Bandwidth (estimate)	-3dB points at 1 Hertz (1 seconds) to 44 Hertz (for 1s mechanical filter, default). -3dB points at 0.08 Hertz (13 seconds) to 44 Hertz (for 20s mechanical filter). Rolloff past low frequency corners: 2 poles or 40dB/decade
Poles (estimate)	There is a hardware single-pole high-pass filter with a -3 dB point around 0.05 Hz. With 1s mechanical filter attached: -0.312 (20 seconds, single pole high pass filter, from hardware) -6.289 (1 Hz, single pole high pass filter, from mechanical filter) With 20s mechanical filter attached: -0.312 (20 seconds, single pole high-pass filter, from hardware) -0.312 (20 seconds, single pole high pass filter, from mechanical filter)

Zeros (estimate)	0,0
Sensitivity (estimate)	4000 counts/ Pascal +/- 10% precision
Clip Level (estimate)	+/- 8,388,608 counts (24-bits) 0.5 inches of water, corresponding to +/- 125 Pa
Digitizer Dynamic range	24-bit ADC Sigma-Delta **ΣΔ** 144 dB (24 bits)
Effective bits (estimate)	21 bits (126 dB) from 1 to 20 Hz @ 100 sps (for the entire analog to digital hardware chain). *Note: Whereas most manufacturers report this for their digitizer only, we are reporting it for the entire sensor + ADC hardware chain. The effective bits of the digitizer itself are necessarily better.* This parameter is also commonly known as "Dynamic Range"; "RMS to RMS noise"; or "noise free bits".
Error band	~1%
Linearity of the pressure measurement (included in total error band measurement)	<0.5%
Gain Calibration	Automatic
Mechanical filter High Pass filter options	1s, 20s (all units ship with both)
Operating Temperature of sensor	Compensated operating range: 0 to 50 C Max. operating range: -25 to 85 C (though the rest of the electronics are limited to 60C)

The Raspberry Boom infrasound sensor was based on Jeffrey Johnson's InfraBSU sensor and the work published in (1) Marcillo, O., Johnson, J.B., and Hart, D. (2012) Implementation, Characterization, and Evaluation of an Inexpensive Low-Power, Low-Noise Infrasound Sensor Based on a Micromachined Differential Pressure Transducer and a Mechanical Filter, Journal of Atmospheric and Oceanic Technology 29:1275-1284; and (2) Johnson, J.B. and Ripepe, M. (2011) Volcano Infrasound: A review, Journal of Volcanology and Geothermal Research 206:61-69.

Microbarograph: Acoustic Channel Instrument Response



Software

Software installed on Sixaola's on-board computer
Native SeedLink Server with ODF-MSG-ROUTER
Web-interface (HTML) for remote configuration
Blue Tooth/ Blue Term enabled for configuration with an Android device
Event Detection: O-Triggers, Raspberry Shake's implementation of the Carls trigger algorithm; amplitude based STA/ LTA. All parameters including STA, LTA, Ratio, Quiet, trace length and pre-event length are configurable by the end user.
Software to store continuous data and triggered waveforms in miniSEED format
One-click instrument response generator (formats: dataless SEED, RESP)
Operating System: Debian (Linux)

Also Available Upon Request:

- Zero Config Server transmission protocol - TCP/IP broadcast (1-way) data transmission to central Zero Config Server
- VTun- tunneling software to break through Firewalls

Communications

Parameter	Value
Digital bandwidth consumption at 100 Hz, 6 channels (estimated)	Tx 286 B/ s - 1 kB/ s Rx 95 B/ s - 360 B/ s Tx 34 - 70 Mb/ day
TCP/IP compatible	
Compatible with Ethernet, Cell modem, GPRS, Satellite	

Power

Parameter	Value
Power Supply Voltage (estimated)	9.7 - 16.5 Volts DC
Power Consumption (estimated)	12 Volts x 0.35 Amps = 4.2 Watts
Power Protection	Reverse voltage and overvoltage protected Internal, resettable fuse

Calibration Mechanism: Calibration not required over time but can be verified using the OSOP Calibration Table. All seismographs are verified prior to shipping to ensure that their gain is within 10% of the nominal instrument response (up to 10% variation attributable to geophones and capacitors).

Questions?

Email us at sales@raspberryshake.org