

Specifications for: Raspberry Boom (RBOOM) and 'Shake and Boom' (RS&BOOM)

- Your Personal Acoustic and Seismo-Acoustic Home Science Monitors -

An IoT home-automation device

Born on: July, 2017

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Unit

The "Raspberry Boom" (RBOOM) personal infrasound and "Raspberry Shake and Boom" (RS&BOOM) personal seismo-acoustic monitors are all-in-one, IoT plug-and-go solutions for personal infrasonics and seismology that integrates a single vertical velocity sensors with an acoustic pressure transducer, the digitizers, the hyper dampers, and the computer into *a single box*. These monitors are manufactured in Panamá using cutting-edge 3D printing and laser-cutting technology.

Warranty: 1 year from ship date

Specifications subject to change without notice.

Parameter	Value
Versioning	V3
Dimensions (estimated)	<i>Standard enclosure: 135x110x70 mm</i> <i>IP67 enclosure: 160x90x90 mm</i>
Weight (estimated)	0.4 kg
Immersion rating	<i>Standard enclosure: IP10</i>
Connectors	<i>Standard enclosure: Ethernet (RJ45), Power Micro USB (5V, 2.5 Amps), USB 2 ports x4,</i>

	HDMI, Micro SD, CSI Camera port, Composite video and audio output jack
Installation Considerations	<p>Designed for plug-and-go installation</p> <p>Mounting screw anchor slot provided (for RBOOM)</p> <p>Alignment: no alignment required (the infrasound sensor is omnidirectional and the velocity sensor, vertical)</p>
Operating Temperature	0 to 60 C (limited by RPi, the Raspberry Boom itself can go to -20C)
On Board Computer	<p>Wifi-enabled Raspberry Pi 3 Model B</p> <p><i>The Raspberry Shake board/ Software is also compatible with:</i></p> <p>00[10,13],900032: Model B+</p> <p>a[01040,01041,21041,22042]: 2 Model B</p> <p>9000[92,93],9200[92,93]: Zero</p> <p>a[02082,22082,32082,52082]: 3 Model B</p> <p>a020d3: 3 Model B+</p> <p>9000c1: Zero W(H)</p>
Storage Device	<p>8 Gb or + micro SD card</p> <p><u>Est. # days of disk space:</u></p> <p>OS/ software: ~3 Gb</p> <p>Remaining space for data: ~5 Gb</p> <p># days Raspberry Boom (15 Mb/ day/ channel): ~320, more if you use a bigger SD</p>

	# days Raspberry Shake and Boom (15 Mb/ day/ channel): ~160, more if you use a bigger SD
Timing	Network Timing Protocol, NTP (default) GPS timing supported
Timing Quality	NTP timing quality remains within 1 sample of accuracy versus startup accuracy: +/- 10 ms or better @ 100 sps

Microbarograph (Infrasound)

Applies to both Raspberry Boom & Raspberry Shake and Boom

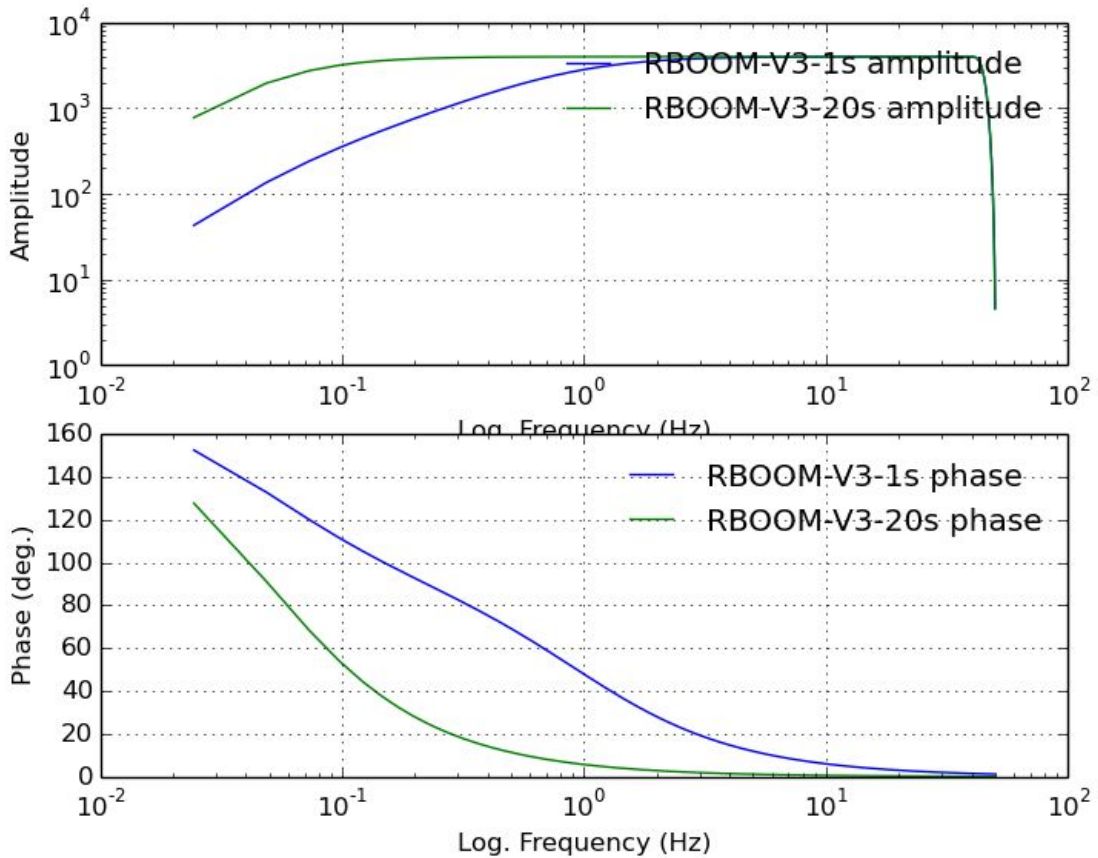
Parameter	Value
Type	Differential pressure transducer
Samples per second	100
Data packet transmission rate	Data packets shipped across serial port at a rate of 4 packets/ second (250 ms/ packet)
Bandwidth (estimate)	-3dB points at 1 Hertz (1 seconds) to 44 Hertz (for 1s mechanical filter, default). -3dB 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:

	<p>-0.312 (20 seconds, single pole high-pass filter, from hardware)</p> <p>-0.312 (20 seconds, single pole high pass filter, from mechanical filter)</p>
Zeros (estimate)	0,0
Sensitivity (estimate)	4000 counts/ Pascal +/- 10% precision
Clip Level (estimate)	<p>+/- 8,388,608 counts (24-bits)</p> <p>0.5 inches of water, corresponding to +/- 125 Pa</p>
Digitizer Dynamic range	<p>24-bit ADC Sigma-Delta $\Sigma\Delta$</p> <p>144 dB (24 bits)</p>
Effective bits (estimate)	<p>21 bits (126 dB) from 1 to 20 Hz @ 100 sps (for the entire analog to digital hardware chain).</p> <p><i>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.</i></p> <p>This parameter is also commonly known as “Dynamic Range”; “RMS to RMS noise”; or "noise free bits".</p>
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 0-60C)

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



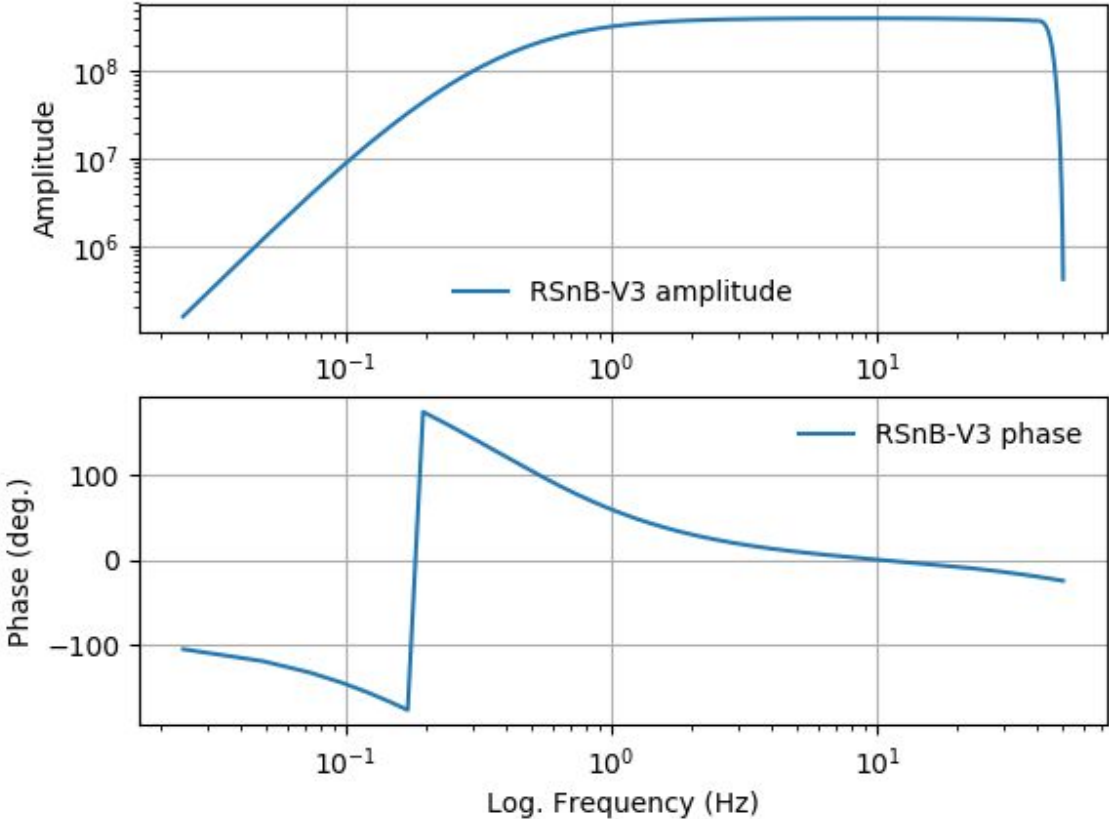
Seismograph

Raspberry "Shake and Boom" only

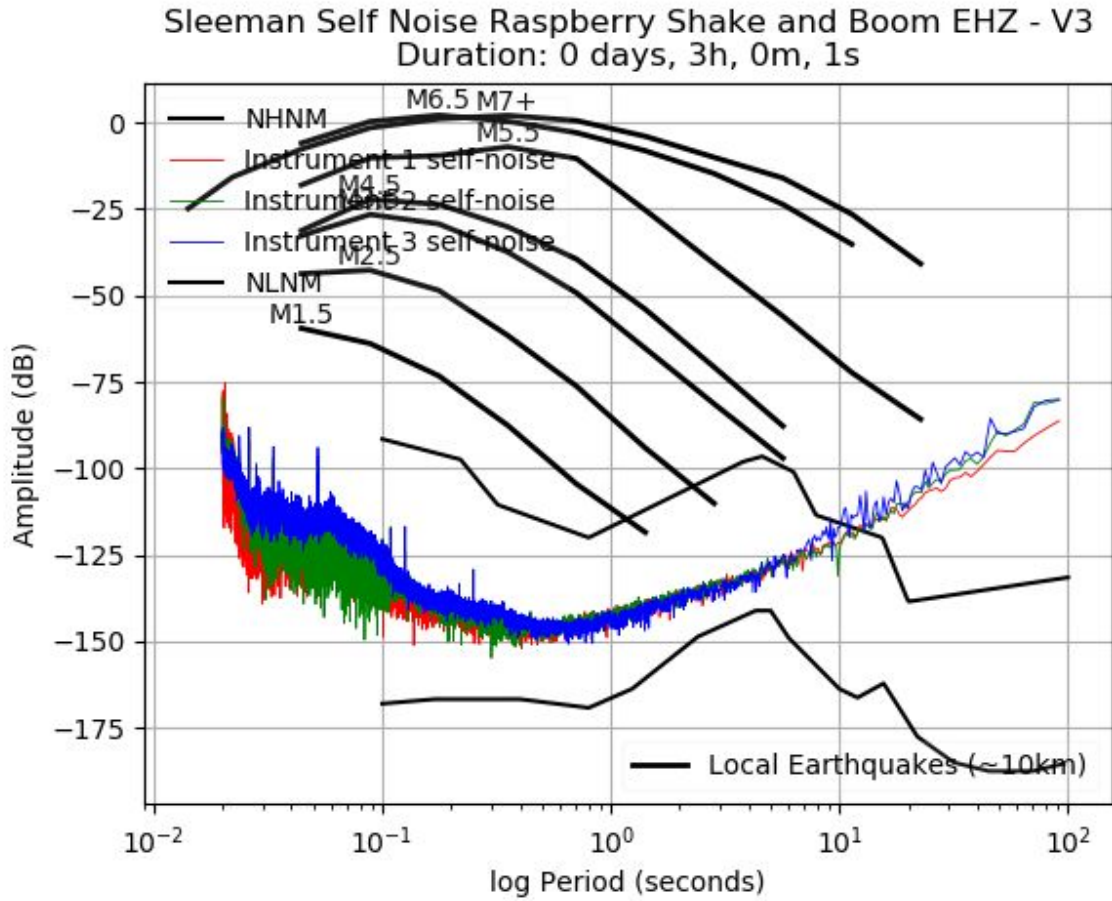
Parameter	Value
Type	Single-component 4.5 Hz 395 Ohm vertical Racotech RGI-20DX geophone with electronic extension to lower frequencies (<1 Hz)
Samples per second	100
<i>Earthquake Early Warning (EEW) compatible</i> <i>data packets shipped across serial port at a rate of 4 packets/ second (250 ms/ packet)</i>	
Bandwidth (estimate)	-3dB points at 0.7 to 44 Hz
Poles (estimate)	-1 (0.16 Hz, single pole high pass filter) -3.03 x2 (0.48 Hz, double pole high pass filter) -666.67 (106 Hz, single pole low pass filter)
Zeros (estimate)	0; 0; 0
Sensitivity (estimate)	3.996500E+08 counts/ meter/ second +/- 10% precision
Clip Level (estimate)	+/- 8,388,608 counts (24-bits) 21 mm/s peak-to-peak from 0.1 to 10 Hz
Minimum Detection Threshold (estimate)	0.08 $\mu\text{m/s}$ RMS from 1 to 20 Hz @ 100 sps <i>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.</i>

Digitizer Dynamic range	24-bit ADC Sigma-Delta $\Sigma\Delta$ 144 dB (24 bits)
Effective bits (estimate)	<p>21 bits (126 dB) from 1 to 20 Hz @ 100 sps (for the entire analog to digital hardware chain).</p> <p><i>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.</i></p> <p>This parameter is also commonly known as “Dynamic Range”; “RMS to RMS noise”; or "noise free bits".</p>

Seismograph: Velocity Channel Instrument Response



Seismograph: Sleeman Self-Noise



Software

Software installed on Raspberry Shake's RPi computer
100% SeisComP3 compatible Also: AQMS, Antelope, Earlybird, Earthworm, Hydra, ObsPy, SEISAN, ...
Native SeedLink Server (source: GEOFON) with Raspberry Shake's Data Flow Message Router
Tight and automatic integration with SeisComP
Web-interface (HTML) for easy configuration
Software to store continuous seismic data in miniSEED format
Web-based helicorder plot generator (source: USGS)
Swarm (source: USGS)
Software distributed with Docker
Automatic updates
Operating System: Debian 8 (Linux)

Communications

Parameter	Value
Digital bandwidth consumption at 100 Hz, per channel (estimated)	Incoming rates RX: ~24.0 kbits/s Outgoing rates TX: ~94.0 kbits/s TCP Flow rate: 8.4 kbits/s
TCP/IP compatible	
Compatible with Wifi, Ethernet, Cell modem, GPRS, Satellite	

Power

Parameter	Value
Power Supply Voltage	5 Volts DC (2.5 Amp supply)
Power Consumption (RPi + Raspberry Shake, estimated)	Raspberry Boom: Startup: $5 \text{ Volts} \times 0.550 \text{ A} = 3.0 \text{ Watts}$ Run-time: $5 \text{ Volts} \times 0.290 \text{ A} = 1.8 \text{ Watts}$ Raspberry Shake and Boom: Startup: $5 \text{ Volts} \times 0.550 \text{ A} = 3.1 \text{ Watts}$ Run-time: $5 \text{ Volts} \times 0.290 \text{ A} = 1.9 \text{ Watts}$

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@raspberrysake.org