

Topic	Common seismic sensors
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Introduction

These data sheets describe some widely used broadband seismic sensors, and a few other sensors that are new or have an interesting principle of operation. We present them as examples of a format in which seismic sensors might be uniformly described; our choice does not imply any recommendation for or against a specific instrument.

Manufacturers' specifications, especially for complex characteristics such as sensitivity and dynamic range, are sometimes realistic, sometimes optimistic, and sometimes useless. Some widely used broadband seismometers have recently been tested for noise at the USGS Albuquerque Seismological Lab. We have used these data wherever possible (see Ringler and Hutt, 2010). But independent information is not always available, and then the information from the manufacturer's data sheet must somehow be translated into our scheme. We have done this to the best of our knowledge, but errors and even a subjective bias cannot be ruled out.

Noise specifications are among the most important for the seismologist and among the most difficult for the manufacturer. Seismometers are typically produced in a noisy industrial environment, so most manufacturers cannot easily test their products for self-noise. New instruments often show transient disturbances which may disappear within a few months in a permanent installation but interfere with noise tests immediately after production. In order to ascertain the noise specifications, lengthy tests of each instrument at a remote quiet site would be required, and a substantial portion of the production might have to go to scrap. Customers are not willing to pay for this, and consequently manufacturers do not guarantee the noise specifications. Nevertheless, depending on details of the production process and on the time allocated to testing, some manufacturers turn out a higher proportion of faultless instruments than others. The user should be aware of this problem, but we cannot extrapolate it from the past into the future, and cannot quantify it in our data sheets. Also, part of what appears to be self-noise is often of environmental origin, and depends on undocumented details of the site and the test setup.

The "category" information in the data sheets may require some explanation. The term "broadband" (BB) is commonly used for seismometers that have a flat response to velocity from short periods to at least 30 seconds. The nominal bandwidth is however not what really matters. Instruments should be named after the frequency band in which they deliver useful signals. We will therefore use the term "broadband" for instruments that can be used throughout the classical short-period and long-period bands, and "very broadband" or VBB for instruments suitable to record free oscillations of the Earth. "Symmetric triaxial" means that the sensitive axes of the mechanical sensors are 54.7 degrees from vertical (Galperin 1955 and 1977), such as in the STS2 and the Trilliums.

Below, the sensor data sheets are alphabetically ordered. Another overview over broadband seismometers is found at http://sismic.iec.cat/orfeus/instrumentation/vault_sensors.html.

Type	BBVS-60
Manufacturer	Beijing GangZhen Mechanical 6 Electronic Technology Co. Ltd
Address	No. 20 Jinxing Rd, Daxing district, Beijing 102628, China
Phone (Fax)	++86-10-60212319 (-37)
E-mail	geodevice@sina.com
Homepage	http://www.geodevice.cn/
Category	Force-balance broadband, three component
Flat response	Velocity 16.7 mHz (60 s) to 50 Hz
Resolution: NLNM	16.7 mHz to 8 Hz
within 10 dB of NLNM	8 mHz to 20 Hz
within 20 dB of NLNM	5 mHz to 50 Hz
Operating range	± 10 mm/s
Generator constant	2000 Vs/m
Output	differential, ± 10 V per line
Weight	12 kg
Size	24 cm dia., 27 cm high
Power	9 to 18 volts, 1.1 watts
Manual control	Mass lock
Remote control	centering
Remote diagnostic	Mass position
Accessories	Tools, thermal insulation
Typical installation	All purpose
Data Sheet	http://www.geodevice.cn/en/productInfo.aspx?n=20090921143217421562
Remarks	This instrument uses an astatic leaf-spring suspension like the Streckeisen seismometers.

Type	CMG-3ESP
Manufacturer	Guralp Systems Limited
Address	3 Midas House, Calleva Park, Aldermaston, Reading RG7 8EA, UK
Phone	++44 118 9819056
E-mail	sales@guralp.com
Homepage	www.guralp.com
Category	Force-balance BB, three-component
Flat response	velocity 33 mHz (30 s) to 50 Hz, others available
Resolution: NLNM	25 mHz to 16 Hz (manufacturer)
within 10 dB of NLNM	
within 20 dB of NLNM	
Operating range	± 10 mm/s
Generator constant	2000 Vs/m, others available
Output	differential, ± 10 V per line
Weight	9 kg
Size	17 cm dia., 32 cm high
Power	10 to 30 volts, 0.6 watts
Manual control	mass lock
Remote control	centering, mass lock optional
Remote diagnostic	mass position
Accessories	control and breakout box
Typical installation	all purpose. Submersible version is available
Data sheet	http://www.guralp.com/products/3ESP/
Remarks	

Type	CMG-3ESP Compact
Manufacturer	Guralp Systems Limited
Address	3 Midas House, Calleva Park, Aldermaston, Reading RG7 8EA, UK
Phone	++44 118 9819056
E-mail	sales@guralp.com
Homepage	www.guralp.com
Category	Force-balance BB, three-component
Flat response	velocity 33 mHz (30 s) to 50 Hz (others available)
Resolution: NLNM	40 mHz to 16 Hz (manufacturer)
within 10 dB of NLNM	
within 20 dB of NLNM	
Operating range	± 10 mm/s
Generator constant	2000 Vs /m (others available)
Output	differential, ± 10 V per line
Weight	8 kg
Size	17 cm dia., 19 cm high
Power	10 to 36 volts, 0.6 watts (low-power version available)
Manual control	-
Remote control	mass lock, centering, calibration
Remote diagnostic	mass position
Accessories	-
Typical installation	all purpose.
Data sheet	http://www.guralp.com/products/3ESPC/
Remarks	Guralp offers this seismometer with a wide variety of responses.

Type	CMG-3T, CMG3-TB (borehole)
Manufacturer	Guralp Systems Limited
Address	3 Midas House, Calleva Park, Aldermaston, Reading RG7 8EA, UK
Phone	++44 118 9819056
E-mail	sales@guralp.com
Homepage	www.guralp.com
Category	Force-balance VBB, three-component
Flat response	velocity 8.33 mHz (120 s) to 50 Hz (others available)
Resolution: NLNM	30 mHz to 18 Hz*
within 10 dB of NLNM	5 mHz to 30 Hz*
within 20 dB of NLNM	3 mHz to 50 Hz*
Operating range	± 13 mm/s
Generator constant	1500 Vs/m (others available)
Output	differential, ± 10 V per line
Weight	14 kg
Size	17 cm dia., 34 cm high
Power	10 to 30 volts, 0.75 watts
Manual control	-
Remote control	mass lock, centering, calibration
Remote diagnostic	mass position
Accessories	control and breakout box
Typical installation	observatory, vault, and field use
Data sheet	http://www.guralp.com/products/3T/
Remarks	Tight thermal shielding recommended. Until recently the CMG-3T was one of the two most widely used broadband seismometers (the other one being the STS-2). The noise data are from the borehole version CMG-3TB.

* based on Ringler and Hutt (2010). Resolution above 10 Hz is extrapolated; data from the borehole version.

Type	CTS-1
Manufacturer	Wuhan Lique Seismic Observation Technology Co. Ltd
Address	No. 40 Hongshan Celu, Wuhan, Hubei, China
Phone and Fax	++86-27-87864644
E-mail	actseis@gmail.com
Homepage	www.whlqtech.com
Category	Force-Balance VBB, three component
Flat response	Velocity 8.3 mHz (120 s) to 50 Hz
Resolution: NLNM	10 mHz (100 s) to 10 Hz
within 10 dB of NLNM	2 mHz (500 s) to 20 Hz
within 20 dB of NLNM	
Operating range	± 10 mm/s (velocity)
Generator constant	2000 Vs/m (velocity)
Output	differential, ± 10 V per line
Weight	12 kg
Size	294 mm dia., 27 cm high
Power	9 – 18 V, 2 W
Manual control	
Remote control	Mass lock, centering
Remote diagnostic	Mass position (acceleration output)
Accessories	RCU box
Typical installation	Observatory, vault
Data Sheet	
Remarks	

Type	Episensor ES-T
Manufacturer	Kinematics Inc.
Address	222 Vista Avenue, Pasadena, CA 91107, USA
Phone	++1 626 795 2220
E-mail	sales@kmi.com
Homepage	www.kinematics.com
Category	Force-balance broadband accelerometer
Flat response	acceleration DC to 200 Hz
Resolution: NLNM	not applicable (this is a strong-motion instrument)
within 10 dB of NLNM	n.a.
within 20 dB of NLNM	n.a.
Operating range	user selectable, ± 0.25 g to ± 4 g
Generator constant	user selectable, order of $1 \text{ V s}^2 / \text{m}$
Output	± 2.5 volt single-ended to ± 20 volt differential
Weight	2 kg
Size	13 cm dia., 6 cm high
Power	± 12 V or single 12 V, 0.15 to 0.4 W (depending on option)
Manual control	Centering; set gain
Remote control	-
Remote diagnostic	-
Accessories	-
Typical installation	Anywhere: Strong-motion monitoring, seismic zonation
Data sheet	http://www.kinematics.com/p-87-EpiSensor-ES-T.aspx
Remarks	This is a modern and popular strong-motion sensor. Its large dynamic range overlaps considerably with that of high-sensitivity seismometers, making it possible to record microearthquakes and teleseisms with this instrument.

Type	FSS-3M, FSS-3DBH
Manufacturer	Beijing GangZhen Mechanical & Electronic Technology Co. Ltd
Address	No. 20 Jinxing Rd, Daxing district, Beijing 102628, China
Phone (Fax)	++86-10-60212319 (-37)
E-mail	geodevice@sina.com
Homepage	http://www.geodevice.cn/
Category	Force-balance short-period, three component Surface (M) and borehole (DBH) packages
Flat response	Velocity 0.5Hz to 70 Hz
Resolution: NLNM	0.2 Hz to 6 Hz
within 10 dB of NLNM	0.2 Hz to 10 Hz
within 20 dB of NLNM	
Operating range	±10 mm/s
Generator constant	2000 Vs/m
Output	differential, ±10 V per line
Weight	12 kg (FSS-3M), 8 kg (FSS-3BH)
Size	240 mm dia., 270 mm high (FSS-3M) 10 cm dia., 80 cm high (FSS-3BH)
Power	9 to 18 volts, 0.6 watts
Manual control	No centering necessary. No mass lock?
Remote control	
Remote diagnostic	
Accessories	
Typical installation	All purpose. FSS-3BH is a borehole version.
Data Sheet	http://www.geodevice.net/FSS-3DBH.asp
Remarks	Widely used in China. According to the data sheet, the displacement transducer is electromagnetic (must be an LVDT) – quite unusual for a short-period seismometer.

Type	S-13, GS-13
Manufacturer	Geotech Instruments LLC
Address	10755 Sanden Drive, Dallas, Texas 75238-1336, USA
Phone	(001) 214 221 0000
E-mail	info@geoinstr.com
Homepage	www.geoinstr.com/
Category	Electromagnetic single-component, short-period seismometer , convertible between horizontal and vertical
Flat response	velocity 1 Hz (adjustable) to >100 Hz
Resolution: NLNM	0.07 to 40 Hz with low-noise preamplifier (S-13)* 0.05 to 150 Hz with low-noise preamplifier (GS-13)*
within 10 dB of NLNM	
within 20 dB of NLNM	above 0.04 Hz (GS-13)*
Operating range	large, limited by preamplifier
Generator constant	630 Vs / m with 3600 Ohms coil (S-13) 2180 Vs / m with 3600 Ohms coil (GS-13)
Output	differential, unlimited
Weight	14 kg. Moving mass is 5 kg.
Size	17 cm dia., 38 cm high
Power	passive
Manual control	mass lock, centering, conversion Z / H
Remote control	calibration
Remote diagnostic	-
Accessories	-
Typical installation	observatory, short-period
Data sheet	http://www.geoinstr.com/ds-s13.pdf
Remarks	A widely used high-performance, short-period seismometer. For very quiet sites, model GS-13 is the best choice. It resolves high-frequency signals much better than any broadband-feedback seismometer. See publications by Riedesel et al. (1990) and by Rodgers (1993 and 1994) for information on preamplifier design and noise.

* based on circuit analysis with op-amp LT1007 as a preamplifier. Low-noise model may be inaccurate above 10 Hz.

Type	OYO-Geospace GS-1
Manufacturer	OYO Geospace
Address	7007 Pinemont, Houston, Texas 77040,USA
Phone	++1-713-986-4444 Fax: -8723
E-mail	sales@oyogeospace.com
Homepage	http://www.oyogeospace.com/technologies
Category	Passive electromagnetic single-component short-period
Flat response	Velocity 1 Hz to >100 Hz (2 Hz version is available)
Resolution: NLNM	0.11 to 15 Hz with low-noise preamplifier*
within 10 dB of NLNM	0.07 to 50 Hz with low-noise preamplifier*
within 20 dB of NLNM	0.05 to 150 Hz with low-noise preamplifier*
Operating range	large, limited by preamplifier
Generator constant	275 Vs/m with 4550 Ohms coil
output	differential, unlimited
Weight	2 kg. Moving mass is 0.7 kg.
Size	8 cm dia. , 16 cm high
Power	-
Manual control	No mass lock required. Short signal coil and tilt the instrument for transportation.
Remote control	-
Remote diagnostic	-
Accessories	-
Typical installation	temporary installations, field work
Data sheet	http://www.geospacelp.com/index.php?id=169
Remarks	A three-component package is available as "Seis-Monitor"

* based on circuit analysis with op-amp LT1007 as a preamplifier. Low-noise model may be inaccurate above 10 Hz.

Type	JCZ-1
Manufacturer	Wuhan Lique Seismic Observation Technology Co. Ltd
Address	No. 40 Hongshan Celu, Wuhan, Hubei, China
Phone and Fax	++86-27-87864644
E-mail	actseis@gmail.com
Homepage	www.whlqtech.com
Category	Force-Balance VBB, three component
Flat response	Velocity 2.8 mHz (360 s) to 10 Hz
Resolution: NLNM	5 mHz (200 s) to 10 Hz
within 10 dB of NLNM	1 mHz (1000 s) to 20 Hz
within 20 dB of NLNM	
Operating range	± 10 mm/s (velocity), ± 1 mm/s ² (VLP acceleration)
Generator constant	2000 Vs/m (velocity), 20000 Vs ² /m (VLP acceleration)
Output	differential, ± 10 V per line
Weight	30 kg
Size	51 * 57 cm, 49 cm high
Power	9 – 18 V, 30 W
Manual control	
Remote control	Mass lock, centering
Remote diagnostic	Mass position (acceleration output)
Accessories	TCU and RCU boxes
Typical installation	Observatory
Data Sheet	No English data sheet available at the time of writing
Remarks	Inner temperature stabilized with a thermostat

Type	KS-1
Manufacturer	Geotech Instruments LLC
Address	10755 Sanden Drive, Dallas, Texas 75238-1336, USA
Phone	(001) 214 221 0000
E-mail	info@geoinstr.com
Homepage	www.geoinstr.com/
Category	Force-balance VBB, three-component
Flat response	velocity 3 mHz (330 s) to 5 Hz
Resolution: NLNM	10 mHz to 5 Hz*
within 10 dB of NLNM	4 mHz to 9 Hz*
within 20 dB of NLNM	0.3 mHz to 12 Hz*
Operating range	± 8 mm/s
Generator constant	2400 Vs/m
Output	differential, ± 10 V per line
Weight	43 kg
Size	27 cm dia., 34 cm high
Power	24 V, 2.4 W
Manual control	-
Remote control	mass lock, centering, calibration
Remote diagnostic	mass position
Accessories	-
Typical use	Observatory
Data sheet	http://www.geoinstr.com/ds-ks1.pdf
Remarks	This is the same system as the KS54000 borehole seismometer but packaged in two separate units (mechanical sensors and electronics) for surface installation.

* based on Ringler and Hutt (2010).

Type	KS-2000
Manufacturer	Geotech Instruments LLC
Address	10755 Sanden Drive, Dallas, Texas 75238-1336, USA
Phone	(001) 214 221 0000
E-mail	info@geoinstr.com
Homepage	www.geoinstr.com/
Category	Force-balance, three-component, BB seismometer
Flat response	velocity 83 mHz to 50 Hz
Resolution: NLNM	50 mHz to 15 Hz*
within 10 dB of NLNM	35 mHz to 50 Hz*
within 20 dB of NLNM	15 mHz to >100 Hz*
Operating range	± 10 mm/s
Generator constant	2000 Vs/m
Output	differential, ± 10 V per line
Weight	11 kg
Size	19 cm dia., 29 cm high
Power	9 to 36 V, no current specified
Manual control	mass lock, centering (standard)
Remote control	mass lock, centering (M and borehole models), calibration
Remote diagnostic	mass position
Accessories	
Typical installation	Vault, field deployment
Data sheet	http://www.geoinstr.com/ds-ks2000m.pdf
Remarks	Based on the KS-54000 but smaller and about 20 dB noisier at low frequencies. Standard broadband response. Borehole and short-period versions are available.

* based on Ringler and Hutt (2010). Resolution above 10 Hz is extrapolated.

Type	KS-54000
Manufacturer	Geotech Instruments LLC
Address	10755 Sanden Drive, Dallas, Texas 75238-1336, USA
Phone	(001) 214 221 0000
E-mail	info@geoinstr.com
Homepage	www.geoinstr.com/
Category	Force-balance, three-component, VBB borehole seismometer
Flat response	velocity 0.003 Hz (330 s) to 5 Hz
Resolution: NLNM	10 mHz to 5 Hz*
within 10 dB of NLNM	4 mHz to 9 Hz*
within 20 dB of NLNM	0.3 mHz to 12 Hz*
Operating range	± 1 mm/s
Generator constant	20000 Vs/m
Output	differential, ± 10 V per line
Weight	66 kg
Size	14 cm dia., 249 cm high
Power	24 V, 2.4 W
Manual control	-
Remote control	mass lock, module leveling / centering, calibration
Remote diagnostic	mass position
Accessories	ancillary equipment for borehole deployment
Typical installation	borehole up to 300 m deep
Data sheet	http://www.geoinstr.com/ds-ks54000.pdf
Remarks	The standard borehole seismometer of the global network. Accepts up to 10 degrees borehole tilt.

* based on Ringler and Hutt (2010).

Type	Le-3d lite
Manufacturer	Lennartz Electronic
Address	Bismarckstrasse 136, D-72072 Tuebingen, Germany
Phone	++49 7071 93550
E-mail	info@lennartz-electronic.de
Homepage	www.lennartz-electronic.de
Category	Active short-period, three-component
Flat response	velocity 1 to 80 Hz
Resolution: NLNM	---
within 10 dB of NLNM	0.2 to 0.5 Hz (microseismic peak)
within 20 dB of NLNM	0.15 to 20 Hz
Operating range	± 13 mm/s below 4.5 Hz, decreasing at higher freq.
Generator constant	400 Vs/m
Output	± 5 V single-ended
Weight	1.8 kg
Size	95 mm dia., 65 mm high
Power	12 V, 0.1 W
Manual control	no mass lock required
Remote control	calibration
Remote diagnostic	-
Accessories	-
Typical installation	monitoring networks, field deployment
Data sheet	http://www.lennartz-electronic.de/MamboV4.5.2/index.php?option=com_content&task=view&id=72&Itemid=55
Remarks	A very small and rugged three-component, short-period, active seismometer. The sensor is a commercial 4.5 Hz geophone whose response is electronically extended by a negative damping resistance (a form of negative feedback). Not as sensitive as larger seismometers but good enough where ground noise is not extremely low. A single-component version Le-1d is also available. Higher performance is offered by the Le-3d/5s and Le-3d/20s.

Type	Le-3d-5s
Manufacturer	Lennartz Electronic
Address	Bismarckstrasse 136, D-72072 Tuebingen, Germany
Phone	++49 7071 93550
E-mail	info@lennartz-electronic.de
Homepage	www.lennartz-electronic.de
Category	Active medium-period, three-component
Flat response	velocity 0.2 to 40 Hz
Resolution: NLNM	0.15 to 1 Hz (microseismic peak)
within 10 dB of NLNM	0.13 to 15 Hz
within 20 dB of NLNM	0.1 to 40 Hz
Operating range	± 13 mm/s below 4.5 Hz, decreasing at higher freq.
Generator constant	400 Vs /m
Output	± 5 V single-ended
Weight	6.5 kg
Size	195 mm dia., 165 mm high
Power	12 V, 0.12 W
Manual control	no mass lock required
Remote control	calibration
Remote diagnostic	-
Accessories	-
Typical installation	monitoring networks, field deployment
Data sheet	http://www.lennartz-electronic.de/MamboV4.5.2/index.php?option=com_content&task=view&id=72&Itemid=55
Remarks	A small and rugged three-component, medium-period, active seismometer. The sensor is a commercial 2 Hz geophone whose response is electronically extended by a negative damping resistance (a form of negative feedback). Not as sensitive as larger seismometers but good enough where ground noise is not extremely low.

Type	Mark L4-3D (out of production)
Manufacturer	Mark Products (disappeared)
Address	
Phone	
E-mail	
Homepage	
Category	Passive electromagnetic three-component short-period
Flat response	velocity 1 Hz to >100 Hz (2 Hz version was available)
Resolution: NLNM	0.12 to 12 Hz with low-noise preamplifier*
within 10 dB of NLNM	0.07 to 35 Hz with low-noise preamplifier*
within 20 dB of NLNM	0.05 to 100 Hz with low-noise preamplifier*
Operating range	large, limited by preamplifier
Generator constant	275 Vs/m with 5000 Ohms coil
output	differential, unlimited
Weight	12 kg. Moving mass is 1 kg per component.
Size	24 cm dia. , 24 cm high
Power	-
Manual control	no mass lock required. Short signal coils and tilt the instrument for transportation.
Remote control	-
Remote diagnostic	-
Accessories	-
Typical installation	temporary installations, field work
Data sheet	http://touro.ligo-la.caltech.edu/~ospjeld/HEPI_Documentation_Website/HEPI_Main_Page/pdfs/L4.pdf
Remarks	A still widely used short-period seismometer for field work. See publications by Riedesel et al. (BSSA 80,6) and by Rodgers (BSSA 83,2 and 84,1) for information on preamplifier design and noise. The Mark L4-3D is out of production but OYO-Geospace offers a comparable three-component package, the “Seis-Monitor” based on the GS-1 geophone.

* based on circuit analysis with op-amp LT1007 as a preamplifier. Low-noise model may be inaccurate above 10 Hz.

Type	PMD BB 603
Manufacturer	Precision Measurement Devices
Address	105F W. Dudleytown Rd., Bloomfield, CT 06002, USA
Phone	++1 860 242 8177
E-mail	sales@pmdsci.com
Homepage	http://www.pmdsci.com/
Category	Molecular-electronic BB three-component, with force feedback
Flat response	velocity 16.7 mHz (60 s) to 50 Hz
Resolution: NLNM	0.05 Hz (20 s) to 5 Hz (manufacturer)
within 10 dB of NLNM	
within 20 dB of NLNM	
Operating range	± 10 mm/s at low frequencies
Generator constant	2000 Vs/m (other values optional)
Output	differential, ± 10 V per line
Weight	11 kg
Size	20 cm dia., 22 cm high
Power	9 – 30 volt, 35 mW; low-power version (15 mW) available
Manual control	No mass lock or centering required
Remote control	Calibration, gain setting over serial port (optional)
Remote diagnostic	-
Accessories	-
Typical installation	battery-powered stations, harsh environments. borehole and OBS versions available.
Data sheet	http://www.pmdsci.com/pdfs/BB603.pdf
Remarks	An unconventional sensor. The horizontals are essentially circular-tube tiltmeters where the flow of an electrolyte through a platinum mesh is measured using the MET effect (molecular-electronic transfer, also used in the “solion” transducer). The vertical sensor supports a column of electrolyte in a vertical tube with a membrane and a spring. These sensors have extremely low power consumption, are very rugged, need not be locked or leveled; they simply start working after power-on. Their performance in other respects is however inferior to force-balance sensors.

Type	REFTEK 151-120 “Observer”
Manufacturer	Refraction Technology, Inc.
Address	1600, 10th Street, Suite A, Plano TX 75074, USA
Phone	++1 214 440 1265
E-mail	Info@reftek.com
Homepage	http://www.reftek.com/
Category	Force-balance VBB, three components
Flat response	Velocity 8.3 mHz (120 s) to 50 Hz
Resolution: NLNM	8 mHz to 15 Hz*
within 10 dB of NLNM	3 mHz to 30 Hz*
within 20 dB of NLNM	0.4 mHz to 50 Hz*
Operating range	± 10 mm/s
Generator constant	2000 Vs/m
Output	differential, ± 10 V per line
Weight	12 kg
Size	24 cm dia., 27 cm high
Power	9 to 18 volts, 1.3 watts
Manual control	mass lock
Remote control	centering
Remote diagnostic	mass position
Accessories	
Typical installation	observatory, vault
Data Sheet	http://www.reftek.com/pdf/151-120.pdf
Remarks	A very good VBB sensor, in the free-mode band comparable to KS-1 and CMG-3TB according to Ringler & Hutt, 2010.

* based on Ringler and Hutt (2010). Resolution above 10 Hz is extrapolated.

Type	STS-1 VBB (out of production, see remarks below)
Manufacturer	Streckeisen AG
Address	Dättlikoner Str. 5, CH-8422 Pfungen, Switzerland
Phone	++41 52 315 2161
E-mail	none
Homepage	none
Category	Force-balance VBB, separate Z and H components
Flat response	velocity 2.67 mHz (360 sec) to 10 Hz
Resolution: NLNM	originally <0.3 mHz to 3 Hz, later versions up to 8 Hz*
within 10 dB of NLNM	0.1 mHz to 13 Hz*
within 20 dB of NLNM	<0.1 mHz to 20 Hz*
Operating range	± 8 mm/s
Generator constant	2400 Vs/m
Output	differential, ±10 V per line
Weight	4 kg (vert.); 5.5 kg (hor.)
Size	12 * 17 * 18 cm (vert.); 20 cm dia. and 16 cm high (hor.) Shields require a space of 50 * 50 cm, 60 cm high.
Power	± 15 volts, 3.5 watts per component
Manual control	mass lock (pins and screws inserted by hand)
Remote control	mass centering, calibration
Remote diagnostic	mass position
Accessories	feedback electronics are separate. Magnetic shield (for vert. comp. only), aluminum shield, glass base plate, vacuum glass bell included. Monitor (breakout) box optional.
Typical installation	observatory
Data sheet	www.software-for-seismometry.de/textfiles/Seismometry/
Remarks	Operated under partial vacuum; no electronics inside the sensor. This seismometer made the very-broad-band velocity response popular, and is the only seismometer to resolve minimum ground noise throughout the long-period seismic band. (Some say it defines the low-noise model.) The STS1 is no longer manufactured by Streckeisen AG but Metrozet LLC (USA) have developed a modern, remotely controllable replacement for the feedback electronics and a modified mechanical sensor. The new system has the excellent low-frequency resolution of the original STS-1 but is easier to install and maintain.

* based on Ringler and Hutt (2010). Resolution above 10 Hz is extrapolated.

Type	STS-2 (out of production; replaced by STS 2.5)	
Manufacturer	Streckeisen AG	
Address	Dättlikoner Str. 5, CH-8422 Pfungen, Switzerland	
Phone	++41 52 315 2161	
E-mail	none	
Homepage	none	
Category	Force-balance VBB, symmetric-triaxial	
Flat response	velocity 8.33 mHz (120 sec) to 50 Hz	
Resolution: NLNM	30 mHz to 8 Hz ¹	3 mHz to 20 Hz ³
within 10 dB of NLNM	<1 mHz to 20 Hz ¹	0.3 mHz to 35 Hz ³
within 20 dB of NLNM	<0.1 mHz to 50 Hz ¹	<0.1 mHz to 50 Hz ³
Operating range	±13 mm/s	
Generator constant	1500 Vs/m (high-gain version: 20 000 Vs/m)	
Output	differential, ±10 V per line	
Weight	13 kg	
Size	23 cm dia., 26 cm high	
Power	9 to 28 volts, 1.5 watts, low-power version was available	
Manual control	mass lock	
Remote control	centering, short-period mode, calibration, select UVW positions or UVW broadband signals	
Remote diagnostic	mass positions or UVW signals (analog)	
Accessories	A “Host Box” with power conditioning and two parallel signal connectors included	
Typical installation	observatory and vault. Needs additional protection in humid or dirty environments.	
Data sheet	http://www.passcal.nmt.edu/content/instrumentation/sensors/broadband-sensors/sts-2-bb-sensor Manual: http://www.passcal.nmt.edu/webfm_send/488	
Remarks	Tightly-fitting thermal isolation required for optimum performance. Until recently, the STS-2 was one of the two most widely used VBB instruments (the other being the CMG3). Three versions (generations) of the internal electronics exist. Production ended in 2010. The successor model STS 2.5 has the same housing but completely redesigned mechanical sensors and electronics, and can be remotely controlled with a laptop computer. Its performance is similar to that of the third-generation STS-2.	

¹ first generation, ³ third-generation, high-gain STS-2, based on Ringler and Hutt 2010. Resolution above 10 Hz is extrapolated.

Type	STS 2.5
Manufacturer	Streckeisen GmbH; exclusively sold by Quanterra, USA
Address	St: Dättlikoner Str. 5, CH-8422 Pfungen, Switzerland Q: 325 Ayer Rd, Harvard, Ma. 01451, USA
Phone	++41 52 315 6700 (Streckeisen) ++1 978 772 4774 (Quanterra)
E-mail	bkemp@quanterra.com
Homepage	www.quanterra.com ; www.kinematics.com/p-163-Home.aspx
Category	Force-balance VBB, symmetric-triaxial
Flat response	velocity 8.33 mHz (120 sec) to 50 Hz
Resolution: NLNM	3 mHz to 20 Hz ³
within 10 dB of NLNM	0.3 mHz to 35 Hz ³
within 20 dB of NLNM	0.1 mHz to 50 Hz ³
Operating range	±13 mm/s
Generator constant	1500 Vs/m
Output	differential, ±10 volts per line
Weight	12 kg
Size	23 cm dia., 26 cm high
Power	9 to 28 volts, 0.5 watts
Manual control	-
Remote control	mass lock, centering, calibration, short-period mode
Remote diagnostic	mass position, state-of health parameters including temperature, internal humidity, tilt, serial number, supply voltage
Accessories	a "Host Box" with power conditioning and LED status indicators is included.
Typical installation	Observatory, vault. Needs additional protection in humid or dirty environments.
Data Sheet	http://www.kinematics.com/uploads/PDFs/STS-2_5.pdf
Remarks	Tightly-fitting thermal isolation required for optimum performance. The STS 2.5 has the same housing as the STS-2 but completely redesigned mechanical sensors and electronics. Remote control with a laptop computer. The STS 2.5 has not yet been extensively tested but appears to perform equally or slightly better than a third-generation STS-2.

³ self-noise data are from a third-generation, high-gain STS2, based on Ringler and Hutt (2010). Resolution above 10 Hz is extrapolated.

Type	Trillium 120 P / PA
Manufacturer	Nanometrics Inc.
Address	250 Herzberg Road, Kanata, Ontario, Canada K2K 2A1
Phone	++1 613 592 6776
E-mail	info@nanometrics.ca
Homepage	http://www.nanometrics.ca/
Category	Force-balance VBB, symmetric-triaxial
Flat response	velocity 83 mHz (120 s) to 145 Hz
Resolution: NLNM	25 mHz to 12 Hz*
within 10 dB of NLNM	4 mHz to 20 Hz*
within 20 dB of NLNM	<0.3 mHz to 50 Hz*
Operating range	± 16 mm/s
Generator constant	1200 Vs/m
Output	differential, ± 10 V per line
Weight	7.5 kg
Size	21 cm dia., 22 cm high
Power	9 to 36 volt, 0.62 watt
Manual control	centering (120P). No mass lock required. Motorized mass centering (120PA).
Remote control	centering, UVW/XYZ mode, short/long period mode, firmware updates
Remote diagnostic	mass positions, temperature, serial number, status
Accessories	-
Typical installation	all purpose
Data sheet	http://www.nanometrics.ca/products/trillium-120-ppa
Remarks	Large temperature range without re-centering ($\pm 45^\circ$). A posthole version with remote leveling is available.
* based on Ringler and Hutt (2010) and the manufacturer	

Type	Trillium 240
Manufacturer	Nanometrics Inc.
Address	250 Herzberg Road, Kanata, Ontario, Canada K2K 2A1
Phone	++1 613 592 6776
E-mail	info@nanometrics.ca
Homepage	http://www.nanometrics.ca/
Category	Force-balance VBB, symmetric-triaxial
Flat response	velocity 41.7 mHz (240 s) to 35 Hz
Resolution: NLNM	10 mHz to 10 Hz*
within 10 dB of NLNM	0.3 mHz to 20 Hz*
within 20 dB of NLNM	0.1 mHz to 35 Hz*
Operating range	± 16 mm/s
Generator constant	1200 Vs/m
Output	differential, ± 10 volts per line
Weight	14 kg
Size	25 cm dia., 29 cm high
Power	9 to 36 volt, 0.65 watt
Manual control	none: no mass lock required
Remote control	integrated web browser with many control options
Remote diagnostic	Mass positions, temperature, serial number, status, calibration parameters
Accessories	prefabricated heat shield
Typical installation	observatory, vault.
Data sheet	http://www.nanometrics.ca/products/trillium-240
Remarks	An excellent very-broad-band seismometer, comparable to the STS2 in its performance. May be slightly better than the STS2 at the lowest frequencies when magnetically shielded. Has a modern digital control interface.
* based on Ringler and Hutt (2010) and the manufacturer	

Type	Trillium Compact
Manufacturer	Nanometrics Inc.
Address	250 Herzberg Road, Kanata, Ontario, Canada K2K 2A1
Phone	++1 613 592 6776
E-mail	info@nanometrics.ca
Homepage	http://www.nanometrics.ca/
Category	Miniature Force-balance BB, symmetric-triaxial
Flat response	velocity 8.3 mHz (120 s) to 100 Hz
Resolution: NLNM	50 mHz to 8 Hz*
within 10 dB of NLNM	45 mHz to 20 Hz*
within 20 dB of NLNM	30 mHz to 50 Hz*
Operating range	±26 mm/s
Generator constant	750 Vs/m
Output	differential, ±10 V per line
Weight	comparable to a 1 Hz geophone
Size	comparable to a 1 Hz geophone
Power	9 to 36 volt, 0.16 watt
Manual control	none: no mass lock or centering required
Remote control	RS-232 compatible integrated web server, UVW selection
Remote diagnostic	mass positions, temperature, serial number, poles and zeros
Accessories	-
Typical installation	temporary installations, field work
Data sheet	http://www.nanometrics.ca/products/trillium-compact
Remarks	OBS and all-terrain versions with internal self-leveling gimbal are available.
* based on Ringler and Hutt (2010) and the manufacturer	

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