

Topic	Common seismic sensors
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Version	May 2002

## 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. The reader is urged to check current versions of the data sheets on the website of the author ([http://www.geophys.uni-stuttgart.de/seismometry/man\\_html/index.html](http://www.geophys.uni-stuttgart.de/seismometry/man_html/index.html)).

A few comments to the specifications are necessary. Manufacturers' specifications, especially for complex characteristics such as sensitivity and dynamic range, are sometimes realistic, sometimes optimistic, and sometimes useless. Whenever possible, we have used data from independent tests. 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 the manufacturer cannot easily test his sensors. 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.

The "category" information in the data sheets may require some explanation. The term "broadband" is commonly used for instruments that have a flat response from short periods to at least 30 seconds. The nominal bandwidth however is 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 broadband instruments sensitive enough to record free oscillations of the Earth. "Symmetric triaxial" are three-component instruments with three equal inclined mechanical sensors, such as the STS2 and the Trillium.

Below, the sensor data sheets are alphabetically ordered. They may be complemented or corrected from time to time.

Type	<b>CMG-3T</b>
Manufacturer	<b>Guralp Systems Limited</b>
Address	3 Midas House, Calleva Park, Aldermaston, Reading RG7 8EA, UK
Phone	++44 118 9819 056
Fax	++44 118 9819 943
E-mail	sales@guralp.com
Homepage	www.guralp.com
Category	<b>Force-balance VBB, three-component</b>
Flat response	Velocity 10 mHz (100 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
within 40 dB of NLNM	
Operating range	$\pm 13$ mm/s
Generator constant	2*750 V s / m
Adequate digitizer resol.	24 bits
Adequate digitizer range	$\pm 20$ V differential
Weight	14 kg
Size	17 cm dia., 37 cm high
Power	10 to 30 volts, 0.75 watts
Calibration coils	feedback coils used, over relays
Mass lock	remote
Mass centering	remote
Fast-settling mode	no
Accessories	control and breakout box
Typical application	Stationary, temporary, and field use
Remarks	Tight thermal shielding recommended. The CMG3 is presently (2002) one of the two most widely used broadband instruments (the other one being the STS2).

Type	<b>Episensor ES-T</b>
Manufacturer	<b>Kinematics Inc.</b>
Address	222 Vista Avenue, Pasadena, CA 91107, USA
Phone	++1 626 795 2220
Fax	++1 626 795 0868
E-mail	<a href="mailto:sales@kmi.com">sales@kmi.com</a>
Homepage	<a href="http://www.kinematics.com">www.kinematics.com</a>
Category	<b>Force-balance broadband accelerometer</b>
Flat response	acceleration DC to 200 Hz
Resolution: NLNM	not applicable (this is a strong-motion instrument)
within 10 dB of NLNM	
within 20 dB of NLNM	
within 40 dB of NLNM	
Operating range	user selectable, $\pm 0.25$ g to $\pm 4$ g
Generator constant	user selectable, order of $1 \text{ V s}^2 / \text{m}$
Adequate digitizer resol.	24 bits
Adequate digitizer range	$\pm 2.5$ volt single-ended to $\pm 20$ volt differential
Weight	2 kg
Size	13 cm dia., 6 cm high
Power	$\pm 12$ V or single 12 V, 0.15 to 0.4 W (depending on option)
Calibration coils	yes
Mass lock	no
Mass centering	screwdriver
Fast-settling mode	inherent
Accessories	
Typical application	Strong-motion seismic recording
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	<b>Le-3d</b>
Manufacturer	<b>Lennartz Electronic</b>
Address	Bismarckstrasse 136, D-72072 Tuebingen, Germany
Phone	++49 7071 93550
Fax	++49 7071 935530
E-mail	<a href="mailto:info@lennartz-electronic.de">info@lennartz-electronic.de</a>
Homepage	<a href="http://www.lennartz-electronic.de">www.lennartz-electronic.de</a>
Category	<b>Active short-period, three-component</b>
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
within 40 dB of NLNM	0.1 to 40 Hz
Operating range	$\pm 13$ mm/s below 4.5 Hz, decreasing at higher freq.
Generator constant	400 V s / m
Adequate digitizer resol.	20 bits (or less with selectable gain)
Adequate digitizer range	$\pm 5$ volts single-ended
Weight	1.8 kg
Size	95 mm dia., 65 mm high
Power	12 V, 0.1 W
Calibration coils	No, but an electronic test pulse can be released.
Mass lock	Not required
Mass centering	Not required
Fast-settling mode	
Accessories	
Typical application	field work
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	<b>Mark L4-3D (L-4C-3D)</b>
Manufacturer	<b>Mark Products</b>
Address	10502 Fallstone Road, Houston, Texas 77099, U.S.A.
Phone	+1-713-498-0600
Fax	+1-713-498-8707???
E-mail	
Homepage	not present in the web, but try <a href="http://www.geoinstruments.com.au/">http://www.geoinstruments.com.au/</a>
Category	<b>Electromagnetic short-period seismometer, three-component</b>
Flat response	1 Hz to about 100 Hz
Resolution: NLNM	0.12 Hz to 10 Hz
within 10 dB of NLNM	to 30 Hz
within 20 dB of NLNM	to 100 Hz
within 40 dB of NLNM	
Operating range	large, limited by preamplifier
Generator constant	270 Vs / m (170 Vs / m when damped to 0.7 of critical)
Adequate digitizer resol.	sub-microvolt, normally used with preamplifier
Adequate digitizer range	any
Weight	12 kg
Size	Approx. 20 cm diameter , 24 cm high
Power	passive
Calibration coils	yes
Mass lock	not required. Sensor should be tilted and coils shorted for transportation.
Mass centering	not required
Fast-settling mode	
Accessories	
Typical application	temporary installations, field work
Remarks	A popular short-period seismometer for field work. See publications by Riedesel et al. (BSSA <b>80</b> ,6) and by Rodgers (BSSA <b>83</b> ,2 and <b>84</b> ,1) for information on preamplifier design and noise.

Type	<b>PMD 113</b>
Manufacturer	<b>Precision Measurement Devices</b>
Address	105F W. Dudleytown Rd., Bloomfield, CT 06002, USA
Phone	++1 860 242 8177
Fax	++1 860 242 7812
E-mail	pmdsci@worldnet.att.net
Homepage	pmdsci.home.att.net
Category	<b>Broadband molecular-electronic, three-component</b>
Flat response	velocity 16.7 mHz (60 s) to 50 Hz
Resolution: NLNM	unspecified; probably 0.1 to 0.5 Hz (microseismic peak)
within 10 dB of NLNM	unspecified
within 20 dB of NLNM	unspecified
within 40 dB of NLNM	unspecified
Operating range	$\pm 10$ mm/s at low frequencies
Generator constant	2000 V s / m (other values optional)
Adequate digitizer resol.	16 bits (less for low-power version)
Adequate digitizer range	$\pm 20$ V p-p differential (less for low-power version)
Weight	5 kg
Size	18 cm dia., 14 cm high
Power	9 – 13 volt, 0.2 watt; low-power version (<100 mW) with reduced operating range available
Calibration coils	none; sensors are calibrated on a shake table
Mass lock	not required
Mass centering	not required
Fast-settling mode	no
Accessories	
Typical application	ocean-bottom seismographs, school seismographs
Remarks	An unconventional sensor. It is essentially a water-level tiltmeter where the flow velocity of the water through a platinum mesh is measured using the MET effect (molecular-electronic transfer, also used in the “solion” transducer). The vertical sensor supports the water column 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 levelled; they simply start working after power-on. Their performance is however inferior to force-balance sensors.

Type	<b>S-13</b>
Manufacturer	<b>Geotech Instruments LLC</b>
Address	10755 Sanden Drive, Dallas, Texas 75238-1336, USA
Phone	(001) 214 221 0000
Fax	(001) 214 343 4400
E-mail	<a href="mailto:info@geoinstr.com">mailto:info@geoinstr.com</a>
Homepage	<a href="http://www.geoinstr.com/">http://www.geoinstr.com/</a>
Category	<b>Electromagnetic single-component, short-period seismometer</b> , convertible between horizontal and vertical
Flat response	1 Hz (adjustable) to about 100 Hz
Resolution: NLNM	0.06 Hz to 30 Hz with matched low-noise preamplifier
within 10 dB of NLNM	to 100 Hz
within 20 dB of NLNM	
within 40 dB of NLNM	
Operating range	large, limited by preamplifier
Generator constant	630 Vs / m, others optional
Adequate digitizer resol.	sub-microvolt. Normally used with preamplifier.
Adequate digitizer range	any
Weight	14 kg
Size	17 cm dia., 38 cm high
Power	passive
Calibration coil	yes
Mass lock	manual
Mass centering	manual; has an optical mass-position indicator
Fast-settling mode	
Accessories	
Typical application	Observatory
Remarks	A widely used high-performance, short-period seismometer. For sites with extremely low noise, Model GS-13 with a stronger magnet and a generator constant of 2180 Vs / m is available. See publications by Riedesel et al. (BSSA <b>80</b> ,6) and by Rodgers (BSSA <b>83</b> ,2 and <b>84</b> ,1) for information on preamplifier design and noise.

Type	<b>STS1-VBB (out of production)</b>
Manufacturer	<b>Streckeisen AG</b>
Address	Dättlikoner Str. 5, CH-8422 Pfungen, Switzerland
Phone	++41 52 315 2161
Fax	++41 52 315 2710
E-mail	none
Homepage	none
Category	<b>Force-balance VBB, separate Z and H components</b>
Flat response	velocity 2.67 mHz (360 sec) to 10 Hz
Resolution: NLNM	<0.3 mHz to 3 Hz
within 10 dB of NLNM	to 10 Hz
within 20 dB of NLNM	to 20 Hz
within 40 dB of NLNM	
Operating range	± 8 mm/s
Generator constant	2*1200 V s / m
Adequate digitizer resol.	24 bits
Adequate digitizer range	± 20 V p-p differential
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
Calibration coils	activated over built-in relays
Mass lock	pins and screws inserted by hand
Mass centering	remote
Fast-settling mode	yes
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 application	Observatory.
Remarks	Operated under partial vacuum; no electronics inside the sensor. This seismometer made the very broadband velocity response popular, and is the only seismometer to resolve ground noise throughout the long-period seismic band. Its sensitivity is matched or slightly exceeded by some tidal gravimeters.

Type	<b>STS2</b>
Manufacturer	<b>Streckeisen AG</b>
Address	Dättlikoner Str. 5, CH-8422 Pfungen, Switzerland
Phone	++41 52 315 2161
Fax	++41 52 315 2710
E-mail	none
Homepage	none
Category	<b>Force-balance VBB, symmetric-triaxial</b>
Flat response	velocity 8.33 mHz (120 sec) to 50 Hz
Resolution: NLNM	30 mHz to 8 Hz
within 10 dB of NLNM	3 mHz to 20 Hz
within 20 dB of NLNM	0.1 mHz to 50 Hz
within 40 dB of NLNM	
Operating range	± 13 mm/s
Generator constant	2*750 V s / m
Adequate digitizer resol.	24 bits
Adequate digitizer range	± 20 V p-p differential
Weight	13 kg
Size	23 cm dia., 26 cm high
Power	9 to 28 volts, older models 1.5 watts, new 0.8 watts
Calibration coils	activated over built-in relays
Mass lock	by screwdriver
Mass centering	remote
Fast-settling mode	yes
Accessories	Host box with power conditioning and two parallel signal connectors included; monitor (breakout) box optional
Typical application	Stationary or temporary. Field use requires extra housing.
Remarks	Tightly-fitting thermal isolation required for optimum performance. The STS2 is presently (2002) one of the two most widely used VBB instruments (the other one being the CMG3). For global very-low-frequency seismology, the STS1 is still unrivalled.

Type	<b>Trillium</b>
Manufacturer	<b>Nanometrics Inc.</b>
Address	250 Herzberg Road, Kanata, Ontario, Canada K2K 2A1
Phone	++1 613 592 6776
Fax	++1 613 592 5929
E-mail	<a href="mailto:info@nanometrics.ca">info@nanometrics.ca</a>
Homepage	www.nanometrics.ca
Category	<b>Force-balance BB, symmetric-triaxial</b>
Flat response	velocity 33 mHz to 50 Hz
Resolution: NLNM	67 mHz to 4 Hz
within 10 dB of NLNM	50 mHz to 10 Hz
within 20 dB of NLNM	40 mHz to 30 Hz
within 40 dB of NLNM	10 mHz to 50 Hz
Operating range	± 5 mm/s
Generator constant	1500 V s / m
Adequate digitizer resol.	18 to 20 bits
Adequate digitizer range	20 V p-p differential
Weight	11 kg
Size	22 cm dia., 18 cm high
Power	9 to 36 volt, 0.4 watt
Calibration coils	yes
Mass lock	no (manufacturer says no lock is required)
Mass centering	remote
Fast-settling mode	
Accessories	
Typical application	Temporary installation and field work
Remarks	The recent mechanical design combines features of the STS2 and CMG3 seismometers. The feedback circuit has however been optimized for maximum temperature range without recentering rather than for maximum resolution.

**References** (see References under Miscellaneous in Volume 2)