MOLECULAR-ELECTRONIC BROADBAND SEISMOMETERS

Unlike traditional broadband seismometers, the molecular-electronic seismometers are very rugged and aren't equipped with arresters and other special devices for handling, packing, unpacking and transportation. The instruments' sensing elements are self-centering and thus don't require any external mass centering or mass position controls. The seismometers will be fully functional within installation tilts of up to 15°. The complete technical parameters of the seismometers are presented in datasheets or on Company's web site at www.r-sensors.ru.

The R-sensors LLC' broadband seismometers product range includes the following types:

CME-60XX – Three components broadband seismometers. The seismometers in this series are made of three MET sensing elements with electrodynamic force feedback, which ensure high precision, stability of parameters and low self-noise of the sensor.

The following modifications for **CME-60XX** are available:

- **CME-6011** is a model intended mostly for field surveys. It is optimized for long term standalone operation from a standard 12 volt accumulator during field seismic exploration. The model is produced in standard (26 mA) and low-power (10 mA) versions. It is furnished with the protection of sensing elements from faulty voltage which may be applied under circuitry malfunction caused by unwanted moisture ingress inside the seismometer in flooded areas.
- **CME-6111** is a universal broadband seismometer. It suits both for field surveys and for permanents sites as well. This model is distinctive by its wide variety of power supply options which facilitates further device integration with third party's equipment - power supply and digitizers. The module construction of the seismometer allows for quick faulty sensor replacement on site by a qualified engineer. The sensor can be supplied without outer case for its further integration in combined digital systems with digitizer.
- **CME-6211** is a low frequency (120sec) and low noise model with improved isolation from unwanted atmospheric pressure and ambient temperature changes. Despite this model is mostly intended for stationary sites, the device does not require any special measures for transportation and installation
- All the sensors can be produced either in standard (– 12 ..+ 55 ºC) (10.4^{o}F - 131^{o}F) or in low-temperature (– 40 ..+ 55 ºC) (-40^{o}F - 131^{o}F) version.

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CME-4XXX – Compact three component broadband molecular-electronic seismometers for general purposes**.** These devices are equipped with one vertical electrodynamic force feedback sensor identical to those in 6011's and two original horizontal ceramic MET sensors of doughnut type. The wide varieties of devices' modifications give an opportunity to conduct measurements almost regardless of weather or natural conditions.

CME-4311 - A low noise compact broadband molecular--electronic seismometer.

The following options for **CME-4311** are available:

- Low power consumption option (7.5 mA @ 12 Vdc) - **CME-4311LP**
- Field option (10 sec – 20 Hz or 10 sec – 50 Hz)
- Borehole version (down to 150m depth, steel case) **CME-4311BH150**
- Off-shore version (fully hermetic for underwater installation down to 10m depth**)** **- CME-4311WP10**
- Ocean-bottom version (for use with external hermetic sphere, light case and low power) **- CME-4311OBS**
- Short period option (1 Hz – 50 Hz) - **CME-3311**
- One component version – vertical **CME-4311v** or horizontal **CME-4311h**
- Low temperature option (– 40 ..+ 55 ºC) for all the above types

CME-4211 - A compact inexpensive three component broadband molecular-electronic seismometer for noisy environment (when ambient noise is higher than the NLNM)**.** This device has simplified construction comparing to CME-4311.

The following options for **CME-4211** are available:

- Low power consumption option (7.5 mA @ 12 Vdc) - **CME-4211LP**
- Field option (10 sec – 20 Hz or 10 sec – 50 Hz)
- Post hole (down to 10-15m depth, plastic case) version **CME-4211BH15**
- Borehole (down to 150m depth, steel case) version **CME-4211BH150**
- Off-shore version (fully hermetic for underwater installation down to 10m depth**)** **CME-4211WP10**
- Ocean-bottom version (for use with external hermetic sphere, light case and low power) **CME-4211OBS**
- Short period option (1 Hz – 50 Hz) - **CME-3211**
- High frequency option (passband up to 100 Hz)
- One component version - vertical **CME-4211v** or horizontal **CME-4211h**
- Low temperature option (– 40 ..+ 55 ºC) for all the above types

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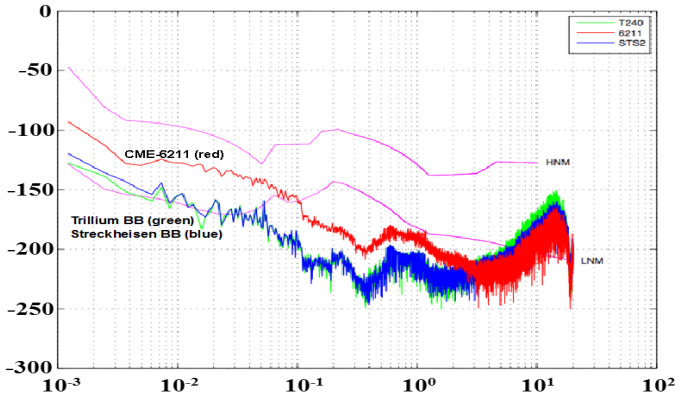
CME-6211 BROADBAND SEISMOMETER OVERVIEW

combine the low-noise molecular-electronic sensing element (transducer) and the electrodynamic feedback, which results in very flat response over wide frequency range, high dynamic range and greatly improved time and temperature stability of the instrument parameters. The electrodynamic force feedback technique can be used for self-calibration or periodical self-testing.

Like other molecular-electronic instruments, the CME-6211 seismometer is very rugged and does not require any special means or procedures for transportation and installation. The only procedure to start the operation is to place the seismometer on the rigid horizontal surface, turn the power on and wait for several minutes. The seismometer can be used in various areas including permanent stations and field experiments.

Configuration	**Triaxial, orthogonal - Vertical, North, East**
Sensitivity	**2000 V/(m/s) or customized**
Maximum input signal	**10 mm/sec**
Frequency bandwidth	**0,008 (120 sec) – 50 Hz**
Maximum output swing	**±20V, differential mode**
Output impedance	**1000 Ohms**
Dynamic range at 1 Hz	**140 dB**
Integral noise in the band 0,008 (120 sec) – 20 Hz	**9.8 nm/sec (19,6 μV)**
Self-noise	**See plot below**
Cross-axis sensitivity	**-50 dB**
Non-linearity at 1 Hz	**0.2%**
Temperature range*	**Standard -12°C - +55°C (10.4°F - 131°F) Low-temperature -40°C - +55°C (-40°F - 131°F)**
Supply voltage* (all possible options)	**+9 - +36 V single supply, isolated / +12V single supply / ±12 V dual supply ± 5V dual supply / +5V single supply**
Power consumption	**700 mW (58 mA @ +12 Vdc) from isolated source / 400 mW from non-isolated source at +12Vdc**
Settling time till correct readings after power on	**10 - 20 minutes, depending on low frequency cut-off**
Mass Lock , Mass Centering	**None required**
Self-calibration	**Built-in calibration coil**
Connector type, cable	**Hermetical MS-3102E type, 10/14 pin. 1.5 meter (4.92 ft) UTP cable or customized length**
Case type, material	**Double-shielded waterproof, aluminum**
Case accessories	**Bubble level, handle, three leveling feet, protective cap for connector**
Weight	**12.2 kg (26,9 lbs)**
Dimensions including handle, diameter x height	**254 x 260 mm (10” x 10.26”)**



Source: *Incorporated Research Institutions for Seismology (IRIS), Program for Array Seismic Studies of the Continental Lithosphere (PASSCAL) instrument center and EarthScope USArray array operations facility , 2010*

*- One option out of the list

Some of presented features and parameters apply to specific versions of the seismometer. Specifications are subject to change without notice.

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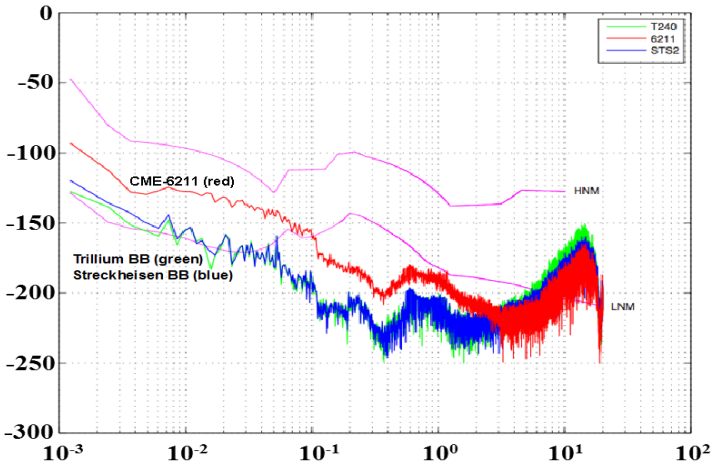
CME-6111 BROADBAND SEISMOMETER OVERVIEW

The CME-6111 seismometers combine the low-noise molecular-electronic sensing element (transducer) and the electrodynamic feedback, which results in very flat response over wide frequency range, high dynamic range and greatly improved time and temperature stability of the instrument parameters. The electrodynamic force feedback technique can be used for self-calibration or periodical self-testing.

Like other molecular-electronic instruments, the CME-6111 seismometer is very rugged and does not require any special means or procedures for transportation and installation. The only procedure to start the operation is to place the seismometer on the rigid horizontal surface, turn the power on and wait for several minutes. The seismometer can be used in various areas including permanent stations and field experiments.

Configuration	**Triaxial, orthogonal – Vertical, North, East**
Sensitivity	**2000 V/(m/s) or customized**
Maximum input signal	**7.5 mm/sec**
Frequency bandwidth	**0,0167 (60 sec) – 50 Hz**
Maximum output swing	**±15V, differential mode**
Output impedance	**1000 Ohms**
Dynamic range at 1 Hz	**133 dB**
Integral noise in the band 0,0167 (60 sec) – 20 Hz	12.3 nm/sec (24.6 μV)
Self-noise	**See plot below**
Cross-axis sensitivity	**-50 dB**
Non-linearity at 1 Hz	**0.2%**
Temperature range*	Standard -12°C - +55°C (10.4°F - 131°F) Low-temperature -40°C - +55°C (-40°F - 131°F)
Supply voltage* (all possible options)	**+9 - +36 V single supply, isolated / +12V single supply / ±12 V dual supply ± 5V dual supply / +5V single supply**
Power consumption	**700 mW (58 mA @ +12 Vdc) from isolated source / 400 mW from non-isolated source at +12Vdc**
Settling time till correct readings after power on	**5 - 15 minutes, depending on low frequency cut-off**
Mass Lock , Mass Centering	**None required**
Self-calibration	**Built-in calibration coil**
Connector type, cable	**Hermetical MS-3102E type, 14 pin. 1.5 meter (4.92 ft) UTP cable or customized length**
Case accessories	**Bubble level, handle, 3 leveling feet, protective cap for connector**
Weight	**7.5 kg (16,53 lbs)**
Dimensions including handle, diameter x height	**204 x 210 mm (8" x 8.27")**



Source: *Incorporated Research Institutions for Seismology (IRIS), Program for Array Seismic Studies of the Continental Lithosphere (PASSCAL) instrument center and EarthScope USArray array operations facility , 2010*

*- One option out of the list

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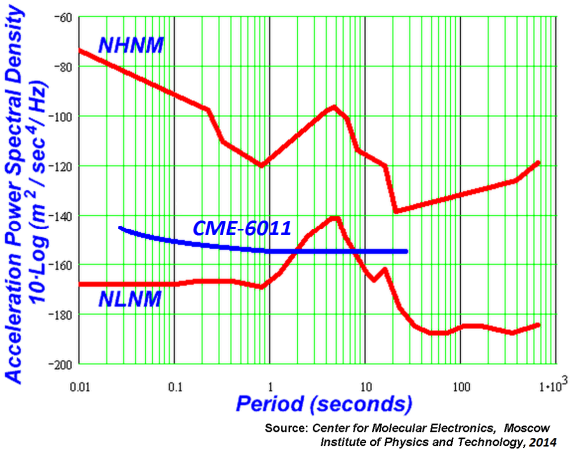
CME-6011 BROADBAND SEISMOMETER

The CME-6011 seismometers combine the low-noise molecular-electronic sensing element (transducer) and the electrodynamic feedback, which results in very flat response over wide frequency range, high dynamic range and greatly improved time and temperature stability of the instrument parameters. The electrodynamic force feedback technique can be used for self-calibration or periodical self-testing.

Like other molecular-electronic instruments, the 6011 seismometer is very rugged and does not require any special means or procedures for transportation and installation. The only procedure to start the operation is to place the seismometer on the rigid horizontal surface, turn the power on and wait for several minutes. The seismometer can be used in various areas including permanent stations and field experiments.

Configuration	**Triaxial, orthogonal – Vertical, North, East**
Sensitivity	**2000 V/(m/s) or customized**
Maximum input signal	**7.5 mm/sec**
Frequency bandwidth	**0,033 (30 sec) – 50 Hz** or customized down to 60 sec and up to 100Hz
Maximum output swing	**±15V, differential mode**
Output impedance	**1000 Ohms**
Dynamic range at 1 Hz	**127 dB**
Integral noise in the band 0,033 (30 sec) – 20 Hz	**15.6 nm/sec (31,2 μV)**
Self-noise	**See plot below**
Non-linearity at 1 Hz	**0.2%**
Temperature range*	**Standard -12ºC - +55ºC (10.4ºF - 131ºF)** **Low-temperature -40ºC - +55ºC (-40ºF - 131ºF)**
Supply voltage	**10.5 .. 16Vdc, single supply nominal value - 12V**
Supply current @ nominal voltage*	**30 mA – standard** **10 mA – low power**
Settling time till correct readings after power on	**3 - 7 minutes, depending on low frequency cut-off**
Mass Lock , Mass Centering	**None required**
Self-calibration	**Built-in calibration coil**
Connector type, cable	**Hermetical MS-3102E type, 10 pin. 1.5 meter (4.92 ft) UTP cable or customized length**
Case accessories	**Bubble level, handle, 3 feet**
Weight	**6.5 kg (14,33 lbs)**
Dimensions including handle, diameter x height	**204 x 210 mm (8” x 8.27”)**



Source: *Center for Molecular Electronics, Moscow Institute of Physics and Technology, 2014*

*- One option out of the list

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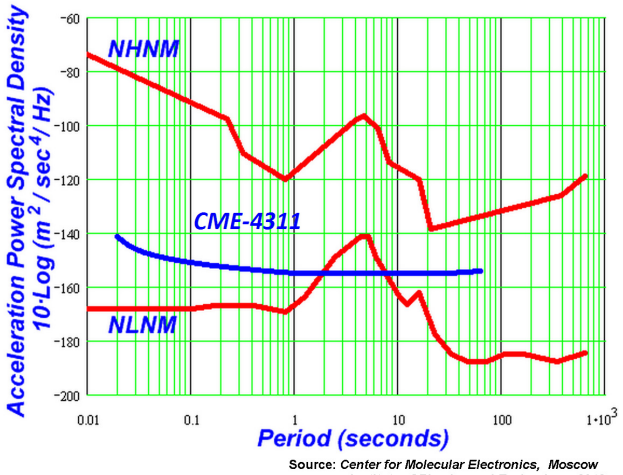
CME-4311 BROADBAND SEISMOMETER

The compact three-component broadband low-noise seismometer CME-4311 is well suited both for permanent and portable installation.

This easy-to-install, very rugged instrument does not require any maintenance, mass locking and centering. The instrument offers the cost-effective solution for installations with the noise level close to Low-Noise Model.

Configuration	**Triaxial, orthogonal – Vertical, North, East**
Sensitivity	**2000 V/(m/s) or customized**
Maximum input signal	**5 mm/sec**
Frequency bandwidth	**0,016 (60 sec) – 50 Hz customized down to 120 sec**
Maximum output swing	**±15V, differential mode**
Output impedance	**1000 Ohms**
Dynamic range at 1 Hz	**124 dB**
Integral noise in the band 0,0167 (60 sec) – 20 Hz	**22,5 nm/sec (45 μV)**
Self-noise	**See plot below**
Cross-axis sensitivity	**-60 dB**
Non-linearity at 1 Hz	**0.5%**
Temperature range*	**Standard -12°C - +55°C (10.4°F - 131°F) Low-temperature -40°C - +55°C (-40°F - 131°F)**
Supply voltage*	**Standard 10,5 .. 30 V DC Low-power 9.5 .. 16 V DC**
Supply current	**27 mA- standard @ 12 V DC 8 mA - low-power @ 12 V DC**
Settling time till correct readings after power on	**15 - 45 minutes, depending on the low frequency cut-off**
Mass Lock , Mass Centering	**None required**
Self-calibration	**Not available**
Connector type, cable	**Russian PC-10TB type, 10 pin 1.5 meter (4.92 ft) or customized length UTP cable included**
Case accessories	**Bubble level, handle, 3 feet**
Weight	**4.6 kg (10,14 lbs)**
Dimensions including handle, diameter x height	**180 x 140 mm (7.09" x 5.51")**



Source: *Center for Molecular Electronics, Moscow Institute of Physics and Technology, 2012*

*- One option out of the list

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CME-4211 BROADBAND SEISMOMETER

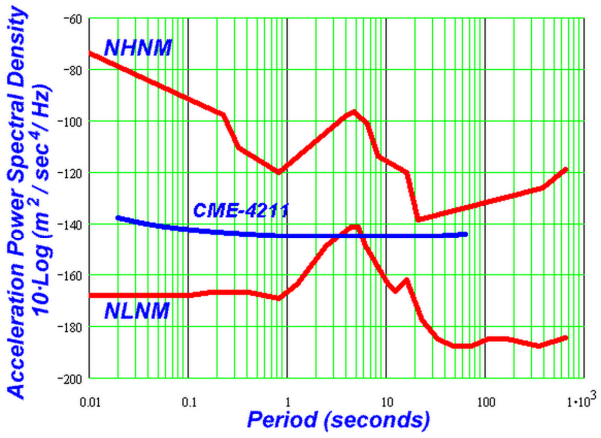
The CME-4211 is a 3-component inexpensive broad-band seismometer well suited for rapid deployment in arrays, monitoring of structures, and for permanent installation in locations with the background noise higher than the New Low Noise Model.

This easy-to-install, very rugged instrument does not require any maintenance, mass locking and centering.

The CME-4211 is presented in the widest variety of options and variants among our production.

This model is ideal for portable applications, requiring high performance, low power consumption, compact size and competitive price.

Configuration	**Triaxial, orthogonal – Vertical, North, East**
Sensitivity	**2000 V/(m/s) or customized**
Maximum input signal	**5 mm/sec**
Frequency bandwidth	**0,033 (30 sec) – 50 Hz or customized down to 60 sec and up to 100Hz**
Maximum output swing	**±15V, differential mode**
Output impedance	**1000 Ohms**
Dynamic range at 1 Hz	**114 dB**
Integral noise in the band 0,033 (30 sec) – 20 Hz	**49.2 nm/sec (98.4 μV)**
Self-noise	**See plot below**
Cross-axis sensitivity	**-60 dB**
Temperature range*	**Standard -12°C - +55°C (10.4°F - 131°F) Low-temperature -40°C - +55°C (-40°F - 131°F)**
Supply voltage*	**Standard 10,5 .. 30 V DC Low-power 9.5 .. 16 V DC**
Supply current *	**27 mA- standard @ 12 V DC 8 mA - low-power @ 12 V DC**
Settling time till correct readings after power on	**10 - 30 minutes, depending on the low frequency cut-off**
Mass Lock , Mass Centering	**None required**
Self-calibration	**Not available**
Connector type, cable	**Russian PC-10TB type, 10 pin 1.5 meter (4.92 ft) or customized length UTP cable included**
Case accessories	**Bubble level, handle, 3 feet**
Weight	**4.3 kg (9,48 lbs)**
Dimensions including handle, diameter x height	**180 x 140 mm (7.09” x 5.51”)**



Source: *Center for Molecular Electronics, Moscow Institute of Physics and Technology, 2012*

*- One option out of the list

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