

ANGULAR MOLECULAR-ELECTRONIC SEISMIC SENSORS

METR-01/-03, METR-11/-13 and MULTICOMPONENT SENSOR CME-106C

The molecular-electronic seismic sensors model **METR-01/03** and **CME-106C** are designed on the basis of high-sensitive molecular-electronic angular velocity sensors for measurements of the seismic vibrations of the ground, buildings and engineering structures in one or several directions and can be supplied (like CME-106C) with additional linear velocity seismic sensors.

The molecular-electronic seismic sensors are very rugged and not equipped with arresters and other special devices for handling, packing, unpacking and transportation. The instruments do not require leveling and mass centering and thus do not have mass position outputs and centering inputs. The one component sensor METR-01 and 3-component sensor METR-03 and fully functional at installation in any orientation to vertical; CME-106C can be installed at the angles up to $\pm 15^\circ$ relative to the vertical axis.

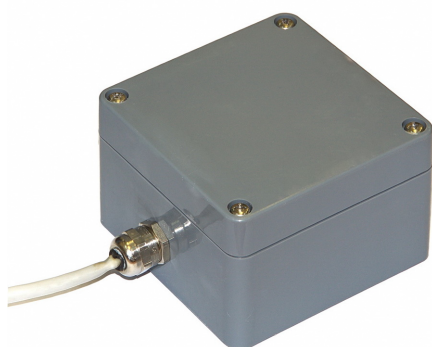
The main features and advantages of the molecular-electronic sensors:

- the high-sensitive molecular-electronic transducer and liquid inertial mass;
- highest sensitivity to the rotational motion;
- direct measurement of the rotational velocity in the operational band;
- wide dynamic range;
- very rugged, no moving mechanical parts to break or wear out;
- no parasitic mechanical resonances;
- no maintenance, mass locking and centering required;
- low power consumption.

Sensors arrangement. The sensors include 1 or 3 high-sensitive molecular-electronic angular motion transducers (sensors); the sensitivity axes of 3-component and multi-component instruments are oriented in three orthogonal directions. The molecular-electronic transducers (sensors) and the electronic board are sealed in aluminum or plastic external case.

Principle of operation. The external mechanical signal (e.g. the seismic vibration of the ground) causes the liquid flow inside the transducer elements. The convective flow of the liquid moves the charged ions of the solution in the space between transducer's electrodes and produces the electric current variations, which give the variations of electric output signal. The electronic board amplifies and corrects the electric signal of the transducers and gives the output voltage proportional to the velocity (angular or linear, depending on the transducer type) of the external seismic signal.

LOW FREQUENCY ANGULAR VELOCITY SENSORS

METR-01 & METR-03
/ROTATIONAL SEISMOMETERS/**METR-01****METR-03**

The one-component angular velocimeter models METR-01 and its 3-component modification METR-03 are designed for seismic investigations in strong motion and rotational seismology and applications in earthquake engineering.

The sensors METR-01/03 have the unique angular sensitivity for so compact devices, low energy consumption and reasonable price, that give it possible to use this innovative equipment in the wide range of applications like seismic control of high-rise buildings, bridges and industrial constructions, vibration monitoring of industrial and scientific equipment, oil and gas exploration geophysics, seismic area control etc.

The sensor's output signal is analogous; output voltage is proportional to the velocity of the ground (sensor installation surface) motion. The sensors can be fixed at any angle and are very easy to install and use. The sensor's housing protects the sensor from dust and water in field applications.

TECHNICAL SPECIFICATIONS FOR METR-01 & METR-03

	METR-01	METR-03
Sensitivity axes	1	3 orthogonal
Frequency range	0.05 – 20 Hz standard (0.033 – 50 Hz optional)	
Sensitivity (scale factor)	50 V·s/rad	
Output	Flat to angular velocity response in the pass band analog, single-ended (differential output is optional)	
Clip level	± 5 V (± 0.1 rad/s)	
Self noise level	-122 dB (relative to 1 rad/s ² /Hz) flat spectral density in the 0 – 10 Hz range	
Integral noise	5.7·10 ⁻⁷ rad/s in 0.05–20Hz pass band	
Installation tilt	ANY	
Resonances	NONE	
Arrests	NOT REQUIRED	
Temperature range	– 12..+55°C standard (– 40..+55°C optional)	
Supply voltage	12 V DC nominal (10.5 to 16 V DC, reverse voltage protection)	
Power consumption	12 mA	24 mA
Output impedance	~ 500 Ohm (1000 Ohm for differential)	
Housing material	Enduring plastic	Aluminum
Dimensions	80 x 80 x 55 mm	120 x 120 x 102 mm
Weight	0.28 kg	1.5 kg

HIGH FREQUENCY ANGULAR VELOCITY SENSORS

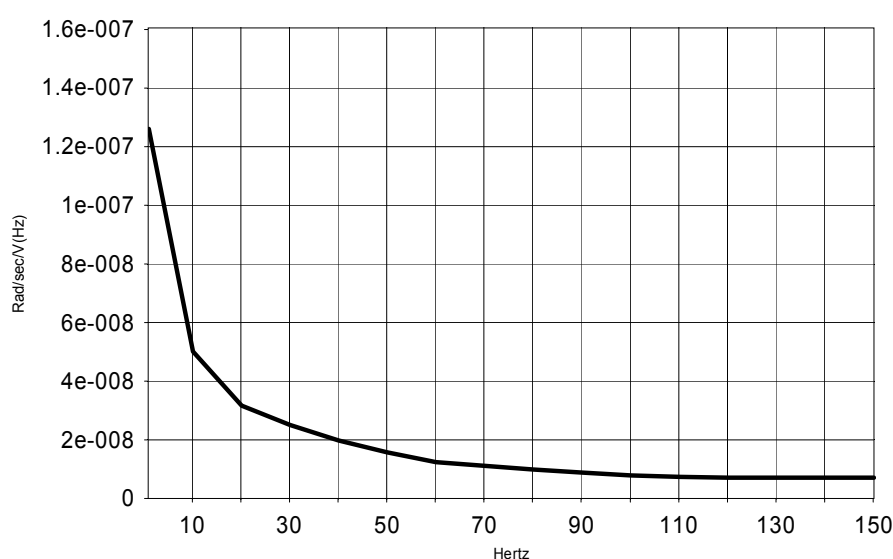
METR-11 & METR-13 /ROTATIONAL GEOPHONES/

These sensors are quite similar to the METR-01 and METR-03 models, but they are optimized for operation in seismic exploration frequency range (1-150 Hz).

TECHNICAL SPECIFICATIONS FOR METR-11 & METR-13

	METR-11	METR-13
Sensitivity axes	1	3 orthogonal
Frequency range	1 – 150 Hz standard (0.5 – 250 Hz optional)	
Sensitivity (scale factor)	50 V·s/rad	
Output	Flat to angular velocity response in the pass band analog, single-ended	
Clip level	± 5 V (± 0.1 rad/s)	
Integral noise	2*10 ⁻⁷ rad/s in 10 – 150Hz pass band	
Installation tilt	ANY	
Resonances	NONE	
Arrests	NOT REQUIRED	
Temperature range	– 12..+55°C standard (– 40..+55°C optional)	
Supply voltage	12 V DC nominal (10.5 to 16 V DC, reverse voltage protection)	
Power consumption	12 mA	24 mA
Output impedance	~ 500 Ohm	
Housing material	Enduring plastic	Aluminum
Dimensions	80 x 80 x 55 mm	120 x 120 x 102 mm
Weight	0.28 kg	1.5 kg

METR-11 and METR-13 Spectrum noise density.



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6-COMPONENT SEISMIC SENSORS **CME-106C / CME-206C**



The 6-component seismic sensors CME-106C and CME-206C combine advantages of the high-sensitive rotational sensor METR-03 with perfect performance 3-component linear velocity seismic sensor MTSS-1001/1003 and include 3 orthogonally oriented rotational and 3 linear velocity transducers.

The sensors have aluminum external case, protecting them from rugged environment. The main possible applications of the sensors are: strong motion seismic measurements, industrial vibration monitoring, vibration isolation analysis, security systems based on area seismic monitoring etc.

The sensors are compact, having low weight, rugged and very simple in use. The electrodynamic feedback provides the highest performance of the sensors. Since the outputs of the sensor are analog, it should be supplied with a digitizer.

Technical specifications¹

	CME-106C	CME-206C	CME-103C
Sensitivity axes	6 (3 angular and 3 linear, orthogonal topology)	6 (3 angular and 3 linear, orthogonal topology)	3 (2 angular, horizontally oriented axes, and 1 vertical linear)
Frequency range	1 – 100 Hz standard (0.033 – 100 Hz for rotational and 0.5 – 300 Hz for linear components optionally)		
Angular sensitivity	50 V·s/rad		
Linear sensitivity	250 V·s/m		
Output	6 (or 3 in case of CME-103C) analog, single-ended outputs. Flat to angular/linear velocity in the pass band with -3 dB cut-off points.		
Clip level	± 5 V (± 0.1 rad/s and ± 0.02 m/s)		
Integral noise	1.25·10 ⁻⁷ rad/s in standard pass band for rotational outputs 1·10 ⁻⁷ m/s in standard pass band for linear outputs		
Installation tilt	± 15°	ANY	ANY
Resonances	NONE		
Mass centering /leveling	NOT REQUIRED		
Temperature range	– 12..+55°C standard (– 40..+55°C optional)		
Supply voltage	12 V DC nominal (10 to 18 V DC, reverse voltage protection)		
Power consumption	35 mA typical at 12V	50 mA typical at 12V	20 mA typical at 12V
Output impedance	~ 500 Ohm		
Housing material	Aluminum		
Dimensions	173x122x106 mm	150 x 150 x 110 mm	120 x 120 x 110 mm
Weight	2.7 kg	2.7 kg	1.5 kg

¹ Subject to change without notice. Some specs can be modified on a customer request.

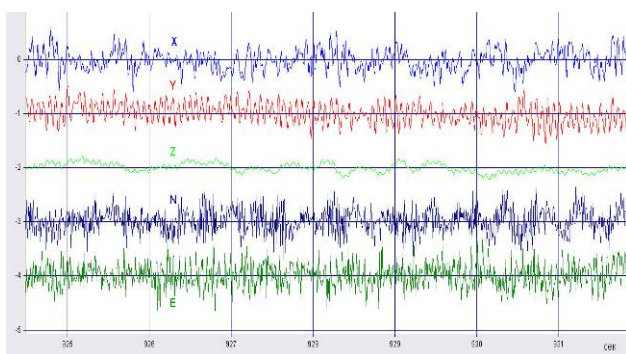
SOME APPLICATIONS OF THE ROTATIONAL AND MULTICOMPONENT SENSORS

Seismic investigation, strong motion and rotational seismology. The sensors of family **METR-03** and **CME-106C** provides qualitatively new measuring means in seismic investigations. The highest sensitivity of the rotational components of the instruments allow direct measurement of the rotational component of seismic fields, more exact detecting of the shear wave arrival parameters and make possible to get to a higher level in seismic investigations. The applications of the rotational seismic sensors in rotational seismology are particularly represented at web-site www.rotational-seismology.org.

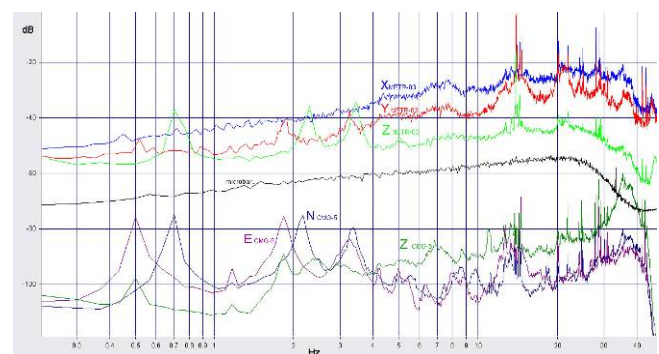
Engineering geophysics, seismic monitoring of high-rise buildings and constructions.

The compact and low-consumption rotational and multicomponent sensors open new opportunities in seismic monitoring and control of tower buildings, bridges, hydroelectric dams, tangent tower and so on.

Below some test records of the rotational seismometer METR-03 made on the 40-th floor of high-rise building in Moscow are represented. The highest rotational sensitivity of the instrument allows direct measurment of the rotational motion of the building, particularly around vertical axis (light green, see below).

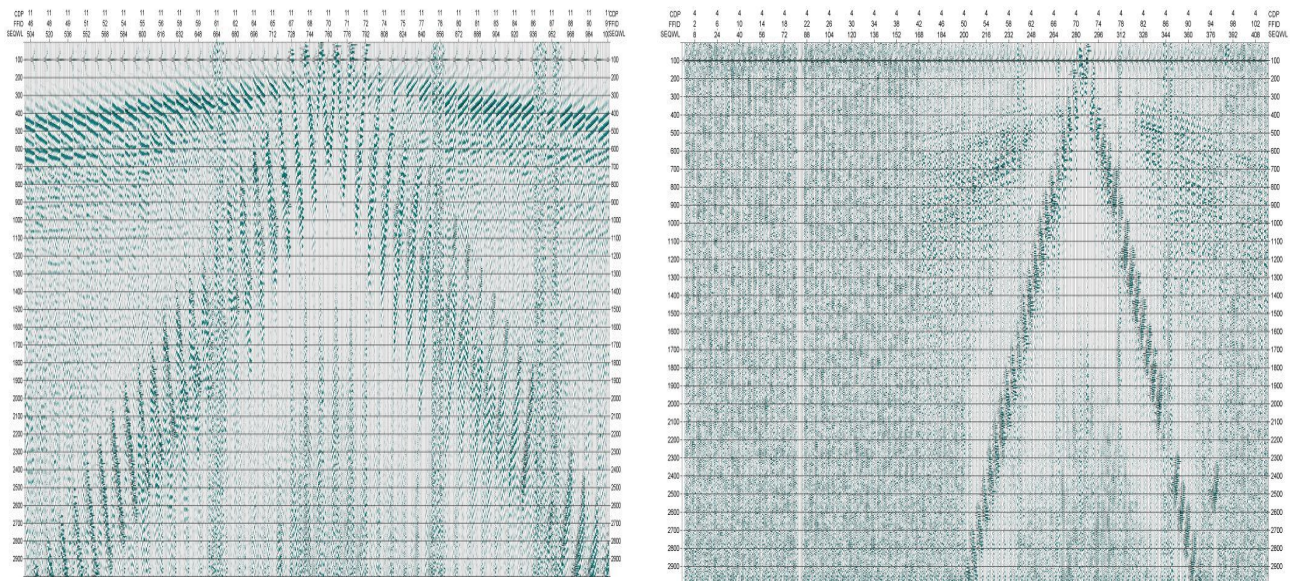


Records of the 40-storied building in Moscow (see above) obtained with the rotational sensor METR-03 (X,Y,Z) and a seismic accelerometer (N,E).



Spectrums of the 45-minute records of rotational and linear vibrations of the high-rise building. (Vertical axis – dB, relative to $1 \text{ rad/s}^2 \text{ Hz}^{1/2}$ and $1 \text{ m/s}^2 \text{ Hz}^{1/2}$ for rotational and linear sensors correspondingly; horizontal axis – frequency, Hz.)

Exploration seismology. One of the most potentially effective application of the high-sensitive rotational and multicomponent sensors and their possibility to improve the detection parameters of the shear wave arrival is oil and gas exploration. Since the rotational sensors work like differentiative measuring device (in fact it measures the curl of the seismic field), one of the main distinctive features of the sensors is its possibility to select powerful distant seismic signal sources and less powerful seismic signals from close sources. It's possible because of the faster decay of the differentiated seismic signal produced by a remote source. Another usefull property of the rotational sensors is their possibility to detect of the arrival of the surface seismic waves and to find their direction with a great accuracy.



The seismogram comparison for linear (left) and angular (right) geophones.

Seismic area control. The rotational sensor show very good possibility to detect the human steps or vehicle motion in the area close to the sensors installation site. Particularly, high-sensitive rotational seismic sensors allow locating the azimuth angle to moving objects in the radius 50-100m with very good accuracy exceeding the accuracy obtained with method used linear seismic sensor. This property can be effectively used in the seismic control of areas.