



SLOVENSKI STANDARD
oSIST prEN IEC 63305:2022

01-oktober-2022

Podvodna akustika - Kalibracija zvočnega vala vektorskih sprejemnikov v frekvenčnem območju od 5 Hz do 10 kHz

Underwater Acoustics - Calibration of acoustic wave vector receivers in the frequency range 5 Hz to 10 kHz

iTeh STANDARD PREVIEW
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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**UNDERWATER ACOUSTICS –
CALIBRATION OF ACOUSTIC WAVE VECTOR RECEIVERS
IN THE FREQUENCY RANGE 5 Hz TO 10 kHz**

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International Standard IEC 63305 has been prepared by IEC technical committee 87: Ultrasonics.

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Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

NOTE: Words in **bold** in the text are defined in Clause 3.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

The National Committees are requested to note that for this publication the stability date is 20XX.

THIS TEXT IS INCLUDED FOR THE INFORMATION OF THE NATIONAL COMMITTEES AND WILL BE DELETED AT THE PUBLICATION STAGE.

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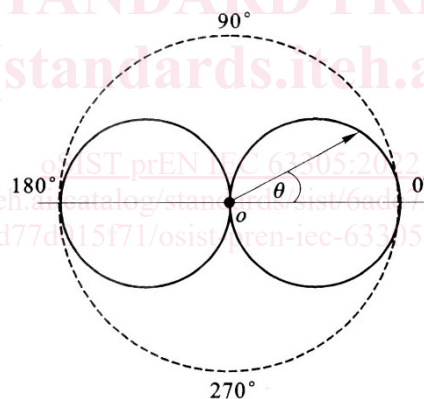
INTRODUCTION

2

3 Usually, **acoustic wave vector receivers** (sometimes referred to simply as **vector**
4 **receivers**) are designed and constructed based on two kinds of principles. One is the
5 sound pressure difference (gradient) principle. When measuring, it is rigidly fixed on a
6 mount and supporting in water. Another is the co-vibrating (**inertial**) principle. When
7 measuring, it is suspended on a mount and supporting in water, which makes the **vector**
8 **receiver** co-vibrating in the same direction with the **sound particle** in the sound wave
9 field.

10 Unlike the traditional piezoelectric **hydrophones** which are sensitive to the sound
11 pressure, **acoustic wave vector receivers** measure **sound particle** motion (velocity,
12 acceleration or displacement) or **sound pressure gradient**, and have strongly
13 directional response in their working frequency range. The calibration of these **vector**
14 **receivers** which measure **sound particle** motion or **sound pressure gradient** are
15 considered in this standard.

16 The output voltage of an **acoustic wave vector receiver** channel to be calibrated is
17 proportional to the **sound particle** motion or **sound pressure gradient** at the reference
18 centre of the receiver. And the directivity of the **acoustic wave vector receiver** channel
19 is independent of acoustical frequency, with a cardioid pattern similar to the shape of
20 Arabic figure "8" shown in Figure 1, and the ratio of the output voltage of the receiver
21 channel at angle θ to the maximum output voltage on the axial direction is equal to
22 $\cos\theta$. [1]



23

24 **Figure 1 – Ideal directivity pattern of a vector receiver channel**

25

26

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31

UNDERWATER ACOUSTICS – CALIBRATION OF ACOUSTIC WAVE VECTOR RECEIVERS IN THE FREQUENCY RANGE 5 Hz TO 10 kHz

32

1 Scope

33 This International Standard specifies the calibration methods of **acoustic wave vector**
34 **receivers** (sometimes referred to simply as **vector receivers**) in the frequency range
35 5 Hz to 10 kHz.

36

2 Normative references

37 The following documents, in whole or in part, are normatively referenced in this
38 document and are indispensable for its application. For dated references, only the
39 edition cited applies. For undated references, the latest edition of the referenced
40 document (including any amendments) applies.

41 IEC 60050-801, *International Electrotechnical Vocabulary – Chapter 801: Acoustics and*
42 *electroacoustics*

43 IEC 60500:2017, *Underwater acoustics – Hydrophones – Properties of hydrophones in*
44 *the frequency range 1 Hz to 500 kHz*

45 IEC 60565-1:2020, *Underwater acoustics – Hydrophones – Calibration of hydrophones,*
46 *Part 1: Procedures for free-field calibration of hydrophones*

47 IEC 60565-2:2019, *Underwater acoustics – Hydrophones – Calibration of hydrophones,*
48 *Part 2: Procedures for low frequency pressure calibration*

49 ISO 266:1997, *Acoustics – Preferred frequencies*

50 ISO 18405:2017, *Underwater acoustics – Terminology*

51 JCGM 100:2008, *Evaluation of measurement data – Guide to the expression of*
52 *uncertainty in measurement*

53 JCGM 200:2012, *International vocabulary of metrology basic and general concepts and*
54 *associated terms*

55

3 Terms and definitions

56 For the purposes of this document, the following terms and definitions given in IEC
57 60050-801, IEC 60500:2017, ISO 18405:2017, JCGM 200:2012 and the following apply.

58 ISO and IEC maintain terminological databases for use in standardization at the
59 following addresses:

- 60
- IEC Electropedia: available at <http://www.electropedia.org/>
 - 61 • ISO Online browsing platform: available at <http://www.iso.org/obp>

62

3.1

63 **acoustic wave vector receiver**
64 **vector receiver**

65 receiving transducer whose output voltage of its receiving channel is proportional to the
66 **sound particle** motion (displacement, velocity or acceleration) or **sound pressure**
67 **gradient** on the position of the reference centre of the **vector receiver** in water

68 Note 1 to entry: Due to the different constructions, the **vector receiver** may be one-dimensional **vector**
69 **receiver**, two-dimensional orthogonal **vector receiver** or three-dimensional orthogonal **vector receiver**,

70 and it has different receiving channels. For three-dimensional orthogonal **vector receiver**, whose channels
71 are usually named as x-channel, y-channel and z-channel.

72 Note 2 to entry: The receiving channel of the **vector receiver** has very strong **directional response** (see
73 Figure 1), which is independent of the frequency.

74 Note 3 to entry: According to the vector values which perceived, there are different **vector receivers**,
75 including **inertial vector receiver** and **sound pressure gradient receiver**.

76 Note 4 to entry: Sometimes, the **vector receiver** has sound pressure (scalar) receiving channel, and open-
77 circuit voltage of the sound pressure channel is proportional to the sound pressure on the position of the
78 reference centre of the **vector receiver**.

79 3.2

80 inertial vector receiver

81 receiving transducer that senses **sound particle** motion by measuring the reaction of
82 a proof mass in response to acceleration of the sensor body (e.g., accelerometer,
83 geophone)

84 3.3

85 sound pressure gradient receiver

86 receiving transducer that senses the gradient of sound pressure using two or more
87 **hydrophones** separated by distances that are small relative to the wavelength

88 3.4

89 axial angular deviation loss

90 the larger value of **directional response** of a **vector receiver** channel on the principal
91 axis minus another value of **directional response** on the symmetrical direction

92 Note 1 to entry: The **axial angular deviation loss** is expressed as a (relative) level in decibel, dB.

93 Note 2 to entry: Sometimes, the **axial angular deviation loss** is named as asymmetry or maximum
94 heterogeneity of **directional response** on the principal axis of a **vector receiver** channel.

95 3.5

96 directional response

97 <of a **vector receiver** channel> description, generally presented graphically, of the
98 response of a **vector receiver** channel, as a function of the direction of propagation of
99 the incident plane sound wave, in a given channel direction through the reference centre,
100 at a specified frequency

101 Note 1 to entry: The **directional response** pattern is usually presented in the form of a two-dimensional
102 polar graph. The scale of the polar may be in terms of sensitivity level or in angular deviation loss.

103 Note 2 to entry: The **directional response** pattern of the **vector receiver** channel is a cosine function, that
104 is the ratio of the output voltage of the **vector receiver** channel in the direction of angle θ to the maximum
105 output voltage in the axial direction is equal to $\cos\theta$.

106 [SOURCE: IEC 60500:2017, 3.4, modified – Replace “hydrophone” with “vector receiver
107 channel”, “a specified plan” with “a given channel direction”].

108 3.6

109 hydrophone

110 electroacoustic transducer that produces electrical voltages in response to water borne
111 **sound pressure signals**

112 [SOURCE IEC 60500:2017, 3.4, modified – Replace “electrical signals” with “electrical
113 voltages”, “pressure signals” with “sound pressure signals”]

114 3.7

115 lateral angular deviation loss

116 the larger value of **directional response** of a **vector receiver** channel on the principal
117 axis minus the smaller value of **directional response** on the lateral axis

118 Note to entry: The **lateral angular deviation loss** is expressed as a (relative) level in decibels (dB).

119 3.8

120 material element

121 sound particle

122 smallest element of the medium that represents the medium's mean density

123 Note to entry: The characteristic length scale of this element is of the order of several times the mean free
124 molecular path.

125 [SOURCE: ISO 18405:2017, 3.1.1.5][2]

126 3.9

127 sound particle acceleration

128 a

129 contribution to acceleration of a **sound particle** caused by the action of sound

130 Note 1 to entry: **Sound particle acceleration** is a function of time, t , which may be indicated by means of
131 an argument t , as in $a(t)$.

132 Note 2 to entry: For small-amplitude sound waves in an otherwise stationary medium, the **sound particle**
133 **acceleration** and **sound particle velocity** are related by

$$134 \quad a = \frac{\partial u}{\partial t} \quad (1)$$

135 where $u(t)$ is the **sound particle velocity** at time, t , and the partial derivative is evaluated at a fixed
136 position.

137 Note 3 to entry: **Sound particle acceleration** is expressed in units of metre per second squared, $\text{m}\cdot\text{s}^{-2}$.

138 Note 4 to entry: **Sound particle acceleration** is a vector quantity. Spatial components of the **sound**
139 **particle acceleration** may be indicated by assigning subscripts to the symbol. For example, in Cartesian
140 coordinates, $a = (a_x, a_y, a_z)$. By convention in underwater acoustics, the z axis is usually chosen to point
141 vertically down from the sea surface, with x and y axes in the horizontal plane.

142 [SOURCE: ISO 18405:2017, 3.1.2.11][2] [standards/sist/6ade758a-b626-442d-99b6-56d77d015f71/osist-pren-iec-63305-2022](https://standards.sist/6ade758a-b626-442d-99b6-56d77d015f71/osist-pren-iec-63305-2022)

143 3.10

144 sound particle acceleration sensitivity

145 \underline{M}_a

146 <of a **vector receiver** channel> quotient of the Fourier transform of the output voltage
147 signal $\mathcal{F}(U_{VR}(t))$ of a **vector receiver** channel to the Fourier transform of the **sound**
148 **particle acceleration** signal $\mathcal{F}(a(t))$, for specified frequency and specified direction
149 of plane wave sound incidence on the position of the reference centre of the **vector**
150 **receiver** in the undisturbed free field if the **vector receiver** was removed

$$151 \quad \underline{M}_a = \frac{\mathcal{F}(U_{VR}(t))}{\mathcal{F}(a(t))} \quad (2)$$

152 Note to entry: The modulus of the **sound particle acceleration sensitivity** is expressed in units of volt
153 second squared per metre, $\text{V}\cdot\text{s}^2\cdot\text{m}^{-1}$. The phase angle of the sensitivity is expressed in degrees and
154 represents the phase difference between the electrical voltage and the **sound particle acceleration**.

155 3.11

156 sound particle acceleration sensitivity level

157 $L_{M,a}$

158 twenty times the logarithm to the base 10 of the ratio of the modulus of the **sound**
 159 **particle acceleration sensitivity** $|\underline{M}_a|$ of a **vector receiver** channel to a reference
 160 value of sensitivity, $M_{a,ref}$, in decibels

$$161 \quad L_{M,a} = 20 \log_{10} \frac{|\underline{M}_a|}{M_{a,ref}} \text{ dB} \quad (3)$$

162 Note 1 to entry: The unit of **sound particle acceleration sensitivity level** is expressed as a (relative)
 163 level in decibels (dB).

164 Note 2 to entry: The reference value of sensitivity, $M_{a,ref}$, is $1 \text{ V} \cdot \text{s}^2 \cdot \mu\text{m}^{-1}$.

165 3.12

166 sound particle displacement

167 δ

168 displacement of a **sound particle** caused by the action of sound

169 Note 1 to entry: **Sound particle displacement** is a function of time, t , which may be indicated by means of
 170 an argument t , as in $\delta(t)$.

171 Note 2 to entry: **Sound particle displacement** is expressed in metres, m.

172 Note 3 to entry: **Sound particle displacement** is a vector quantity. Spatial components of the **sound**
 173 **particle displacement** may be indicated by assigning subscripts to the symbol. For example, in Cartesian
 174 coordinates, $\delta = (\delta_x, \delta_y, \delta_z)$. By convention in underwater acoustics, the z axis is usually chosen to point
 175 vertically down from the sea surface, with x and y axes in the horizontal plane.

176 [SOURCE: ISO 18405:2017, 3.1.2.9][2]

177 3.13

178 sound particle displacement sensitivity

179 \underline{M}_δ

180 <of a **vector receiver** channel> quotient of the Fourier transform of the output voltage
 181 signal $\mathcal{F}(U_{VR}(t))$ of a **vector receiver** channel to the Fourier transform of the **sound**
 182 **particle displacement** signal $\mathcal{F}(\delta(t))$, for specified frequency and specified direction
 183 of plane wave sound incidence on the position of the reference centre of the **vector**
 184 **receiver** in the undisturbed free field if the **vector receiver** was removed

$$185 \quad \underline{M}_\delta = \frac{\mathcal{F}(U_{VR}(t))}{\mathcal{F}(\delta(t))} \quad (4)$$

186 Note to entry: The modulus of the **sound particle displacement sensitivity** is expressed in units of volt
 187 per metre, $\text{V} \cdot \text{m}^{-1}$. The phase angle of the sensitivity is expressed in degrees and represents the phase
 188 difference between the electrical voltage and the **sound particle displacement**.

189 3.14

190 sound particle displacement sensitivity level

191 $L_{M,\delta}$

192 twenty times the logarithm to the base 10 of the ratio of the modulus of the **sound**
 193 **particle displacement sensitivity** $|\underline{M}_\delta|$ of a **vector receiver** channel to a reference
 194 value of sensitivity, $M_{\delta,ref}$, in decibels

$$L_{M,\delta} = 20 \log_{10} \frac{|M_{\delta}|}{M_{\delta,\text{ref}}} \text{ dB} \quad (5)$$

196 Note 1 to entry: The unit of **sound particle displacement sensitivity level** is expressed as a (relative)
197 level in decibels (dB).

198 Note 2 to entry: The reference value of sensitivity, $M_{\delta,\text{ref}}$, is $1 \text{ V} \cdot \text{pm}^{-1}$.

199 3.15

200 sound particle velocity

201 u

202 contribution to velocity of a **sound particle** caused by the action of sound

203 Note 1 to entry: **Sound particle velocity** is a function of time, t , which may be indicated by means of an
204 argument t , as in $u(t)$.

205 Note 2 to entry: For small-amplitude sound waves in an otherwise stationary medium, the **sound particle**
206 **velocity** and **sound particle displacement** are related by

$$207 \quad u = \frac{\partial \delta}{\partial t} \quad (6)$$

208 where $\delta(t)$ is the **sound particle displacement** at time, t , and the partial derivative is evaluated at a fixed
209 position.

210 Note 3 to entry: **Sound particle velocity** is expressed in units of metre per second, $\text{m} \cdot \text{s}^{-1}$.

211 Note 4 to entry: **Sound particle velocity** is a vector quantity. Spatial components of the **sound particle**
212 **velocity** may be indicated by assigning subscripts to the symbol. For example, in Cartesian coordinates,
213 $u = (u_x, u_y, u_z)$. By convention in underwater acoustics, the z axis is usually chosen to point vertically down
214 from the sea surface, with x and y axes in the horizontal plane.

215 [SOURCE: ISO 18405:2017, 3.1.2.10][2]

216 3.16

217 sound particle velocity sensitivity

218 \underline{M}_u

219 <of a **vector receiver** channel> quotient of the Fourier transform of the output voltage
220 signal $\mathcal{F}(U_{\text{VR}}(t))$ of a **vector receiver** channel to the Fourier transform of the **sound**
221 **particle velocity** signal $\mathcal{F}(u(t))$, for specified frequency and specified direction of
222 plane wave sound incidence on the position of the reference centre of the **vector**
223 **receiver** in the undisturbed free field if the **vector receiver** was removed

$$224 \quad \underline{M}_u = \frac{\mathcal{F}(U_{\text{VR}}(t))}{\mathcal{F}(u(t))} \quad (7)$$

225 Note to entry: The modulus of the **sound particle velocity sensitivity** is expressed in units of volt second
226 per metre, $\text{V} \cdot \text{s} \cdot \text{m}^{-1}$. The phase angle of the sensitivity is expressed in degrees and represents the phase
227 difference between the electrical voltage and the **sound particle velocity**.

228 3.17

229 sound particle velocity sensitivity level

230 $L_{M,u}$

231 twenty times the logarithm to the base 10 of the ratio of the modulus of the **sound**
232 **particle velocity sensitivity** $|\underline{M}_u|$ of a **vector receiver** channel to a reference value
233 of sensitivity, $M_{u,\text{ref}}$, in decibels

$$L_{M,u} = 20 \log_{10} \frac{|M_u|}{M_{u,ref}} \text{ dB} \quad (8)$$

235 Note 1 to entry: The unit of **sound particle velocity sensitivity level** is expressed as a (relative) level in
236 decibels (dB).

237 Note 2 to entry: The reference value of sensitivity, $M_{u,ref}$, is $1 \text{ V} \cdot \text{s} \cdot \text{nm}^{-1}$.

238 3.18

239 sound pressure gradient

$$240 \nabla p$$

241 spatial derivative of sound pressure with respect to distance in a given direction caused
242 by the action of sound

243 Note 1 to entry: Sound pressure gradient is a function of time, t , which may be indicated by means of an
244 argument t , as in $\nabla p(t)$.

245 Note 2 to entry: For small-amplitude sound waves in an otherwise stationary medium, the **sound pressure**
246 **gradient** and **sound pressure** are related by

$$247 \nabla p = \frac{\partial p}{\partial \mathbf{r}} \quad (9)$$

248 where $\partial p / \partial \mathbf{r}$ is the **sound pressure gradient** at time, t , and the partial derivative is evaluated at a fixed
249 position.

250 Note 3 to entry: Sound pressure gradient is expressed in units of Pascal per metre, $\text{Pa} \cdot \text{m}^{-1}$.

251 Note 4 to entry: Sound pressure gradient is a vector quantity. In Cartesian coordinates, spatial components
252 of the sound pressure gradient may be indicated as $\partial p / \partial \mathbf{r} = (\partial p / \partial x, \partial p / \partial y, \partial p / \partial z)$. By convention in
253 underwater acoustics, the z axis is usually chosen to point vertically down from the sea surface, with x and
254 y axes in the horizontal plane.

255 3.19

256 sound pressure gradient sensitivity

$$257 \underline{M}_{pg}$$

258 <of a **vector receiver** channel> quotient of the Fourier transform of the output voltage
259 signal $\mathcal{F}(U_{VR}(t))$ of a **vector receiver** channel to Fourier transform of the **sound**
260 **pressure gradient** signal $\mathcal{F}(\nabla p(t))$, for specified frequency and specified direction of
261 plane wave sound incidence on the position of the reference centre of the **vector**
262 **receiver** in the undisturbed free field if the **vector receiver** was removed

$$263 \underline{M}_{pg} = \frac{\mathcal{F}(U_{VR}(t))}{\mathcal{F}(\nabla p(t))} \quad (10)$$

264 Note to entry: The modulus of the **sound pressure gradient sensitivity** is expressed in units of volt metre
265 per pascal, $\text{V} \cdot \text{m} \cdot \text{Pa}^{-1}$.

266 3.20

267 sound pressure gradient sensitivity level

$$268 L_{M,pg}$$

269 twenty times the logarithm to the base 10 of the ratio of the modulus of the **sound**
270 **pressure gradient sensitivity** $|\underline{M}_{pg}|$ of a **vector receiver** channel to a reference value
271 of sensitivity, $M_{pg,ref}$, in decibels