
**Road vehicles — Child seat presence
and orientation detection system
(CPOD) —**

**Part 2:
Resonator specification**

*Véhicules routiers — Système de détection de la présence d'un siège
enfant et de son orientation (CPOD) —*

Partie 2: Spécifications relatives aux résonateurs

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 36, *Safety and impact testing*.

This second edition cancels and replaces the first edition (ISO 22239-2:2009), which has been technically revised to take account of the development in technology since the first edition was published. The main changes compared to the previous edition are as follows:

- coil geometry parameters have changed;
- CPOD resonator protocol has changed;
- modulation parameters have been updated;
- the temperature storage test has been redefined;
- the CPOD resonator test parameters have been updated; and
- the ESD test has been updated.

A list of all parts in the ISO/TS 22239 series can be found on the ISO website.

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Road vehicles — Child seat presence and orientation detection system (CPOD) —

Part 2: Resonator specification

1 Scope

This document specifies the child seat presence and orientation detection (CPOD) resonator as part of the CPOD system. It defines the electrical and environmental requirements to be met by the resonators as a condition for CPOD compatibility.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 10605:2008, *Road vehicles — Test methods for electrical disturbances from electrostatic discharge*

ISO 11452-1, *Road vehicles — Component test methods for electrical disturbances from narrowband radiated electromagnetic energy — Part 1: General principles and terminology*

ISO 11452-2, *Road vehicles — Component test methods for electrical disturbances from narrowband radiated electromagnetic energy — Part 2: Absorber-lined shielded enclosure*

ISO 11452-3, *Road vehicles — Component test methods for electrical disturbances from narrowband radiated electromagnetic energy — Part 3: Transverse electromagnetic (TEM) cell*

ISO 20653, *Road vehicles — Degrees of protection (IP code) — Protection of electrical equipment against foreign objects, water and access*

ISO/TS 22239-1:2018, *Road vehicles — Child seat presence and orientation detection system (CPOD) — Part 1: Specifications and test methods*

ISO 22241-1, *Diesel engines — NO_x reduction agent AUS 32 — Part 1: Quality requirements*

IEC 60068-2-11, *Environmental testing — Part 2: Tests. Test Ka: Salt mist*

IEC 60068-2-38, *Environmental testing — Part 2: Tests. Test Z/AD: Composite temperature/humidity cyclic test*

IEC 60068-2-60, *Environmental testing — Part 2: Tests — Test Ke: Flowing mixed gas corrosion test*

3 Terms and definitions

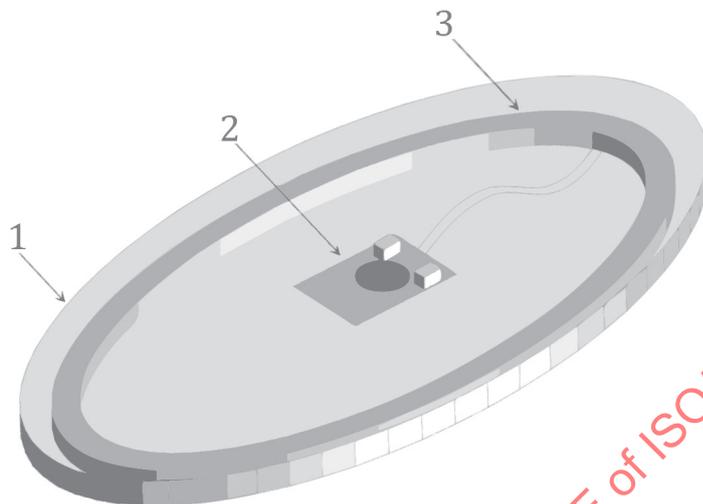
For the purposes of this document, the terms and definitions given in ISO/TS 22239-1 apply.

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

- IEC Electropedia: available at <https://www.electropedia.org/>
- ISO Online browsing platform: available at <https://www.iso.org/obp>

4 CPOD resonator components

The CPOD resonator shall consist of a coil and of electronics. It might be encapsulated by a housing as indicated in [Figure 1](#). In order to pass the resonator compatibility test successfully, the different components shall meet the requirements defined. The transponders shall be passive, i.e. they shall take their energy out of the magnetic field produced by the CPOD sensor.



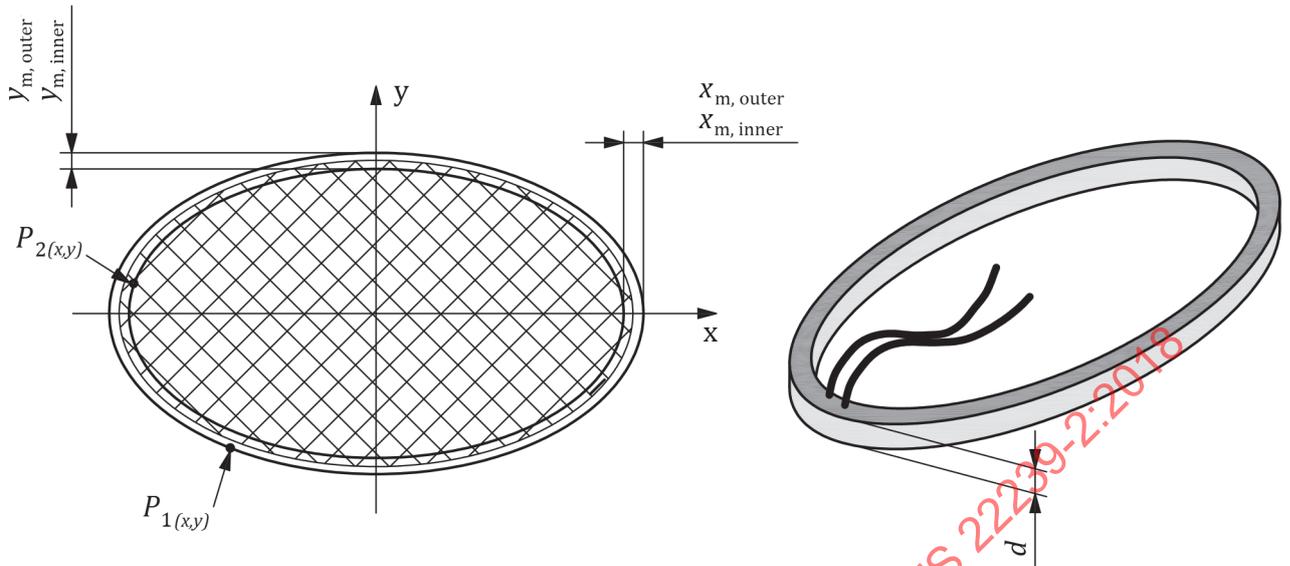
Key

- 1 encapsulation/housing
- 2 electronics
- 3 coil

Figure 1 — CPOD resonator components

5 Coil requirements

The CPOD resonator coil shall be an air coil with an elliptical shape. The geometry of the resonator probe coil is defined as indicated in [Figure 2](#).



Key

$P_{1(x,y)}, P_{2(x,y)}$ position vectors determined by [Formula \(1\)](#)

Figure 2 — Resonator coil geometry

The position vectors of the inner and outer shape of the coil are described by [Formula \(1\)](#) with parameters as specified in [Table 1](#):

$$P_{(x,y)} = \left(\frac{x}{x_m} \right)^2 + \left(\frac{y}{y_m} \right)^2 = 1 \tag{1}$$

Table 1 — Coil geometry parameters

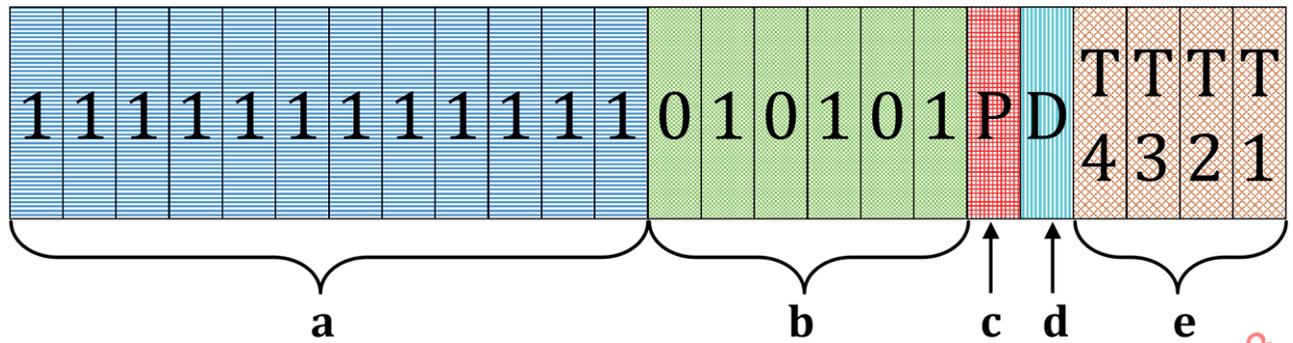
Dimensions in millimetres, measured at 25 °C

Parameter	min.	max.
$x_{m,outer}$	—	57,4
$y_{m,outer}$	—	32,8
$x_{m,inner}$	53,4	—
$y_{m,inner}$	28,6	—
d	—	1,5

6 Electrical properties

6.1 Digital resonator protocol

By generating a modulated magnetic field that is detected in the receiving antennae of the CPOD sensor in the seat, the resonator shall transmit a digital data protocol which is built up as indicated in [Figure 3](#).



- a Header: Sequence of 12 bits with logical bit value = 1.
- b Synchronization sequence: Sequence of three logical 0/1 transitions.
- c Parity bit: Odd parity for T4-, T1-bit.
- d Divider bit: Subcarrier divider bit:
1 → divider by 40;
0 → divider by 56, right resonator.
- e Child seat type: T4 ... T1.

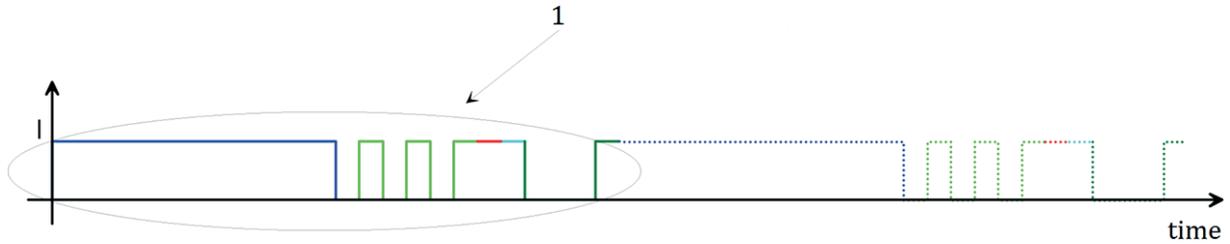
Figure 3 — CPOD resonator protocol

Additional information about the child seat is provided via the child seat type bits as defined in [Table 2](#).

Table 2 — Child seat type classification

Type	T4	T3	T2	T1	Description
0	0	0	0	0	Not allowed
1	0	0	0	1	Rear-facing child seat
2	0	0	1	0	Forward-facing child seat
3	0	0	1	1	Convertible child seat, resonators in stiff connection with child seat
4	0	1	0	0	Convertible child seat, resonators not connected with child seat
5	0	1	0	1	Booster cushion
6	0	1	1	0	Carry-cots
7	0	1	1	1	Not yet defined
8	1	0	0	0	Not yet defined
9	1	0	0	1	Not yet defined
10	1	0	1	0	Not yet defined
11	1	0	1	1	Not yet defined
12	1	1	0	0	Not yet defined
13	1	1	0	1	Not yet defined
14	1	1	1	0	Not yet defined
15	1	1	1	1	Not yet defined

The protocol shall be repeated cyclically if the exiting magnetic field is still present. Thus, after the T4-bit, the next bit shall again be the first bit of the header part of the data protocol (see [Figure 4](#)).



Key

- 1 resonator protocol

Figure 4 — Cyclical sending of the resonator protocol

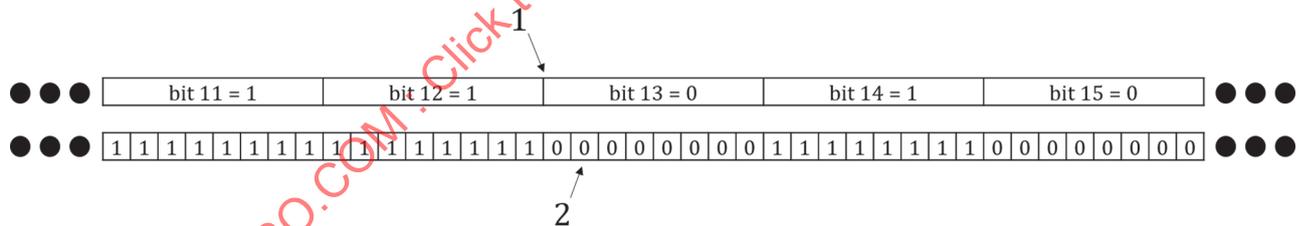
Depending on whether it is a left or a right resonator, the bit frequency of the data protocol varies as shown in [Table 3](#).

Table 3 — Data protocol bit frequency

Resonator type	Parameter	Data protocol frequency
left	$f_{data,left}$	$f_{TX}/40/8 = f_{TX}/320$
right	$f_{data,right}$	$f_{TX}/56/8 = f_{TX}/448$

6.2 Subcarrier bitstream

Every resonator protocol bit value in accordance with [Figure 3](#) logically summarizes eight consecutive bits of the same logical value (hereafter defined as subcarrier bits) with another, higher bit frequency (hereafter defined as subcarrier frequency). The relation between data protocol bits and subcarrier bits is indicated in [Figure 5](#).

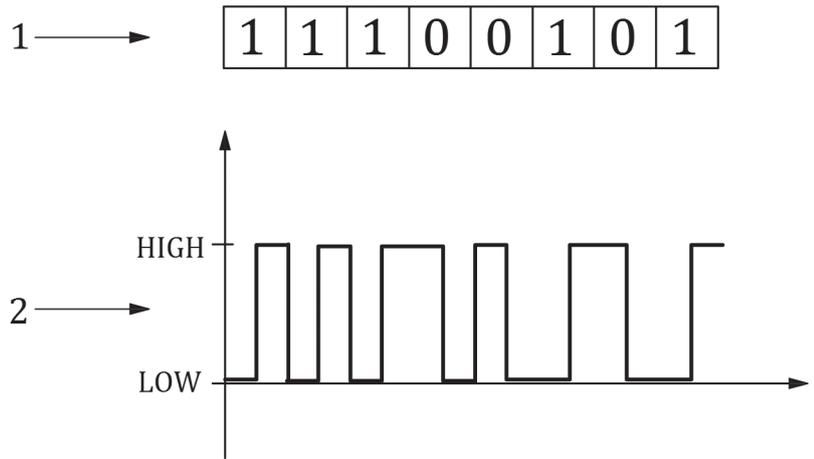


Key

- 1 resonator data protocol
- 2 subcarrier bitstream

Figure 5 — Difference between original and resonator Manchester coding

In order to prepare the subcarrier bits for transmission, every subcarrier bit value shall be Manchester coded, as indicated in [Figure 6](#).



Key
 1 subcarrier bit values
 2 resulting Manchester code

Figure 6 — Manchester coding of subcarrier bit values

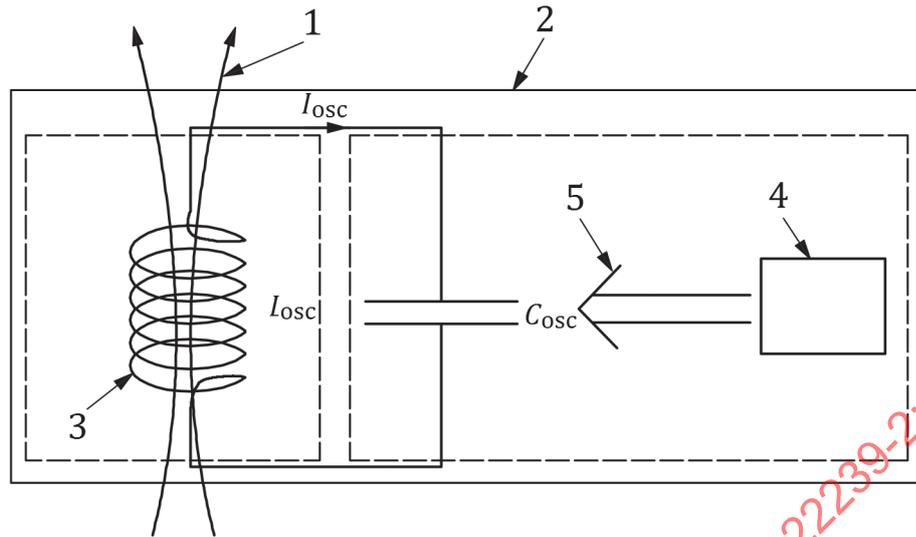
A subcarrier bit value of 1 shall cause a LOW to HIGH transition in the Manchester code pattern. A subcarrier bit value of 0 shall cause a HIGH to LOW transition on the Manchester pattern.

Table 4 — Subcarrier bit frequency, $f_{\text{subcarrier}}$

Resonator type	Parameter	Data protocol frequency
left	$f_{\text{subcarrier}}$	$f_{\text{TX}}/40$
right	$f_{\text{subcarrier}}$	$f_{\text{TX}}/56$

If there is a 0 to 1 transition or a 1 to 0 transition in the resonator data protocol, the resulting Manchester code shows a $\pm 180^\circ$ phase shift (phase shift keying, PSK).

The frequency of the subcarrier bits stream, as well as the phase angle of the concerned Manchester code, shall be used to modulate the magnetic field generated by the resonator, e.g. [Figure 7](#) shows the main structure of the analogue front end of a resonator. The impedance of the LC oscillator is controlled by the Manchester code derived by the subcarrier bits stream, e.g. a HIGH level in the Manchester code leads to state one of the oscillators impedance (HIGH state); a low level in the Manchester code leads to state two (LOW state) of the oscillator's impedance.



Key

- 1 magnetic field
- 2 resonator
- 3 resonator oil
- 4 control logic
- 5 impedance variation of LC oscillator

Figure 7 — Exemplified electrical structure of resonator analogue front end

6.3 Modulation

6.3.1 General

The resonators shall produce a phase modulation in the receiving antenna which is demodulated by the CPOD electronic control unit (ECU). Depending on the magnetic field supplying the resonators with energy, these shall produce a corresponding magnetic field that assures compatibility with all CPOD-compatible systems. The Manchester code of the bitstream specified in 6.2 shall be used to control physically the state of modulation.

The ability of a CPOD resonator to generate a phase modulation in the receiving antenna, which can be evaluated by the CPOD sensor, is characterized by two parameters: the parameter W determines the ability of the resonator to produce sufficient receiving amplitude in a CPOD-compatible sensor after demodulation; the parameter N specifies a maximum noise power at the demodulator's output.

Both parameters are derived using the following procedure, whose blocks are explained in 6.3.2 to 6.3.10.

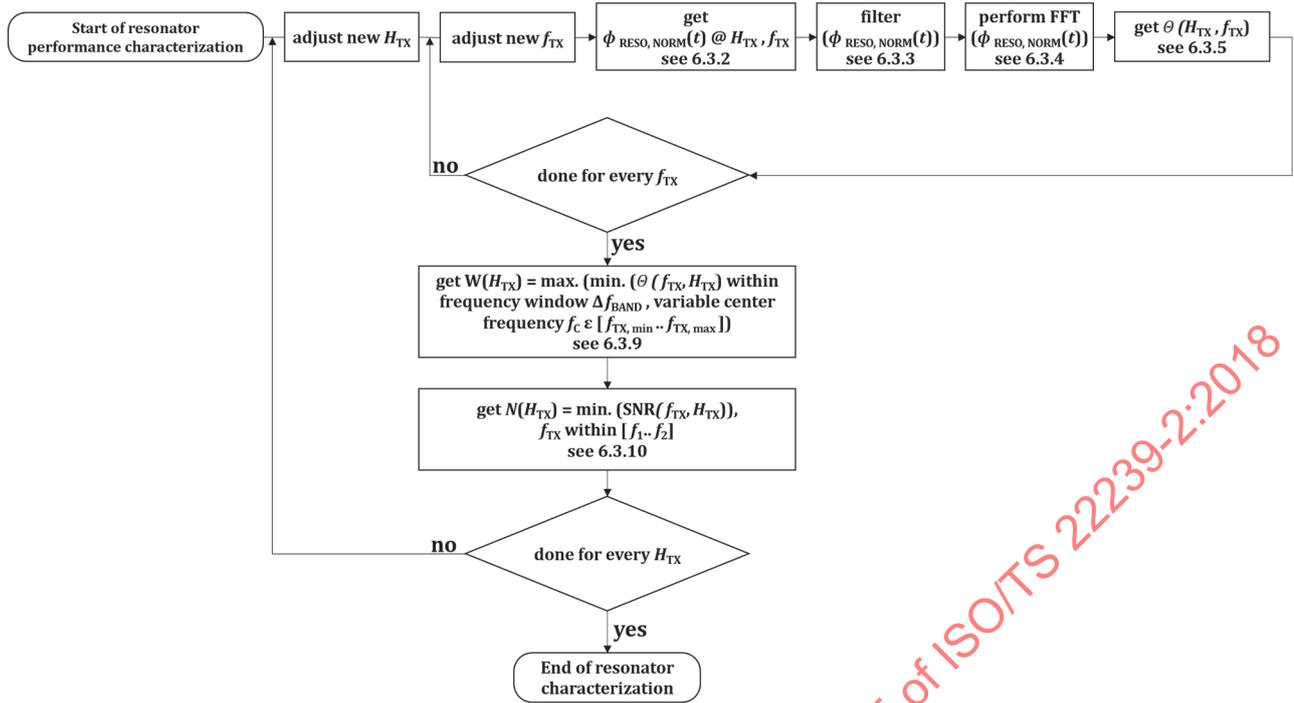
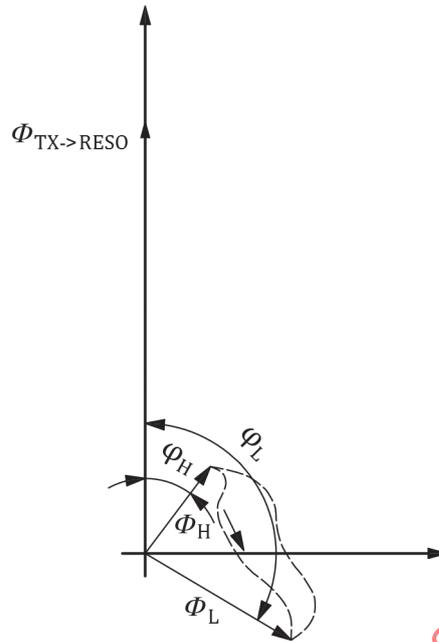


Figure 8 — Procedure to derive $W(H_{TX})$ and $N(H_{TX})$ for magnetic field strength, H_{TX}

6.3.2 Useful resonator signal, $\Phi_{\text{RESO,NORM}}(t)$

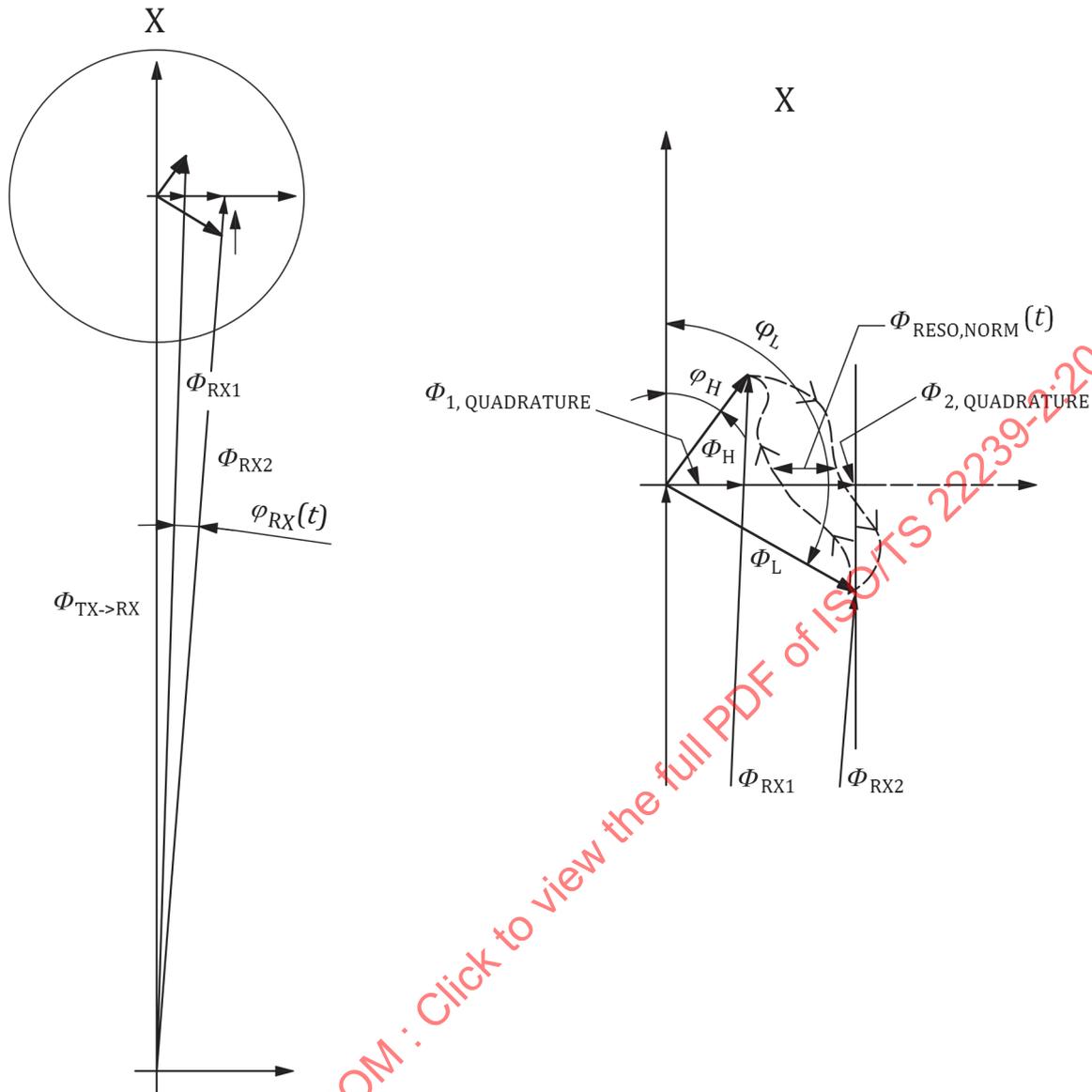
Since CPOD sensors usually have a high magnetic coupling between transmitting and receiving antennae, the useful resonator signal in the resonator magnetic field reduces to the component being perpendicular to the exiting magnetic transmitter field, which is also flooding the receiving antennae. The amplitude phase diagram in Figure 9 shows the relation between exciting magnetic field and resulting resonator magnetic flux.

**Key**

- $\Phi_{TX \rightarrow RESO}$ transmitter magnetic flux component supplying resonator
 Φ_H phase angle between resonator field and resonator magnetic flux, high state of modulation
 Φ_H amplitude of resonator magnetic flux, high state of modulation
 φ_L phase angle between transmitter field and resonator magnetic flux, low state of modulation
 Φ_L amplitude of resonator magnetic flux, low state of modulation

Figure 9 — Resonator amplitude phase diagram

The magnetic flux generated by the resonator, which is flooding the receiving antenna, superposes to the part of the magnetic flux generated by the transmitting antenna, which also floods the receiving antenna. The resulting magnetic flux, Φ_{RX} , in the receiving antenna is indicated in [Figure 10](#).



Key

- $\varphi_{RX}(t)$ phase angle modulation in receiving antenna
- $\Phi_{TX \rightarrow RX}$ transmitter field component flooding receiving antenna
- φ_H phase angle between transmitter field and transponder magnetic flux, high state of modulation
- Φ_H amplitude of resonator magnetic flux flooding receiving antenna high state of modulation
- φ_L phase angle between transmitter field and transponder magnetic flux, low state of modulation
- Φ_L amplitude of resonator magnetic flux flooding receiving antenna, low state of modulation

Figure 10 — Resulting magnetic flux in receiving antenna

Only the quadrature part of the magnetic flux generated by the resonator underlies CPOD compatibility requirements (depending on the physical realization of the resonator, the part of the magnetic flux being in phase with the supplying transmitter field may vary drastically).

The useful signal $\Phi_{\text{RESO,NORM}}(t)$ is defined by [Formula \(2\)](#):

$$\Phi_{\text{RESO,NORM}}(t) = \text{abs}[\underline{\Phi}_{\text{RESO}}(t)] \times \sin\{\arg[\underline{\Phi}_{\text{RESO}}(t)]\} = \text{abs}[\underline{\Phi}_{\text{RESO}}(t)] \times \sin[\varphi(t)] \quad (2)$$

where

$\underline{\Phi}_{\text{RESO}}(t)$ is the complex amplitude of Φ_{RESO} over time;

$\arg[\underline{\Phi}_{\text{RESO}}(t)]$ is the phase difference between Φ_{TX} and $\underline{\Phi}_{\text{RESO}}(t)$ (see [Figure 10](#)).

6.3.3 Lowpass filtering

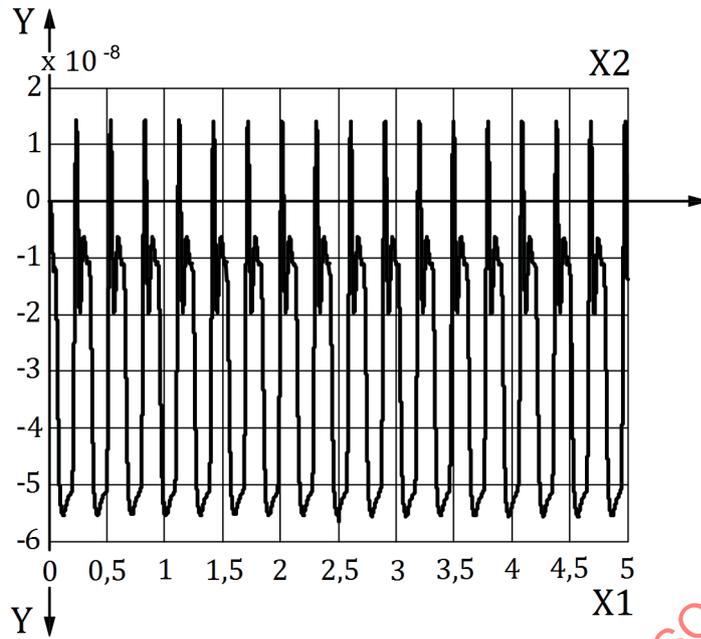
Before performing the Fast Fourier transform (FFT) on $\Phi_{\text{RESO,NORM}}(t)$, the signal shall be filtered by a third order lowpass filter since, usually, the influence of the harmonics on the demodulator output of the CPOD sensor can be neglected for frequency components above the 9th harmonic. [Table 5](#) specifies the lowpass filter to be used.

Table 5 — Definition of lowpass filter

Parameter	min.	max.
End of pass band $W_{\text{p,low}}$ kHz	20	20
Beginning of stop band $W_{\text{s,low}}$ kHz	100	100
Attenuation in pass band $R_{\text{p,low}}$ dB	0	1
Attenuation in stop band $R_{\text{s,low}}$ dB	60	—

6.3.4 Spectral contents of $\Phi_{\text{RESO,NORM}}(t)$

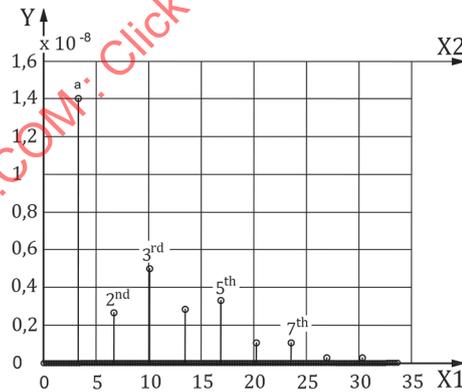
Although Manchester coded bitstream explained in [6.2](#) contains only two discrete states (HIGH and LOW), the transition in the magnetic flux generated by the resonator takes a certain transition time, as indicated by the dotted lines in [Figure 10](#). [Figure 11](#) shows an example for the $\Phi_{\text{RESO,NORM}}(t)$ as a function of time.



Key
 X1 time (ms)
 X2 $\Phi_{\text{RESO,NORM}}(t)$ vs time
 Y resonator magnetic flux (V·s)

Figure 11 — Transitions during modulation (exemplified)

Obviously, the spectral content of the magnetic flux contains the fundamental with subcarrier bitstream frequency, several harmonics, as shown in [Figure 12](#).



Key
 X1 f (kHz)
 X2 spectral contents of $\Phi_{\text{RESO,NORM}}(t)$
 Y magnetic flux amplitude (V·s)
 a Fundamental.

Figure 12 — Spectral contents of $\Phi_{\text{RESO,NORM}}(t)$ (exemplified)

The spectral contents of $\Phi_{\text{RESO,NORM}}(t)$ depends on the frequency, f_{TX} , and the magnetic field strength, H_{TX} , supplying the resonator.

6.3.5 The useful signal, $\theta(f_{TX}, H_{TX})$

The spectral contents of $\Phi_{RX}(t)$ (see [Figure 12](#) for example) shows the subcarrier bit frequency (fundamental) of the phase modulation, $\Phi_{RX}(t)$. The even harmonics (2nd, 4th, 6th, etc.) usually do not have any influence on the performance. Therefore, they are not addressed in this document and may have, as well as their phase angle relation with respect to the fundamental, arbitrary values.

Only the odd harmonics (fundamental, 3rd, 5th, etc.) are taken to define and to calculate the useful signal $\theta(f_{TX}, H_{TX})$, as follows:

$\theta(f_{TX}, H_{TX}) = \text{fundamental} - 1/3 \times 3\text{rd harmonic} - 1/5 \times 5\text{th harmonic} - 1/7 \times 7\text{th harmonic} - 1/9 \times 9\text{th harmonic, etc.}$

Getting the values for $\theta(f_{TX}, H_{TX})$ over the complete f_{TX} frequency range qualitatively leads to the curve shown in [Figure 13](#).

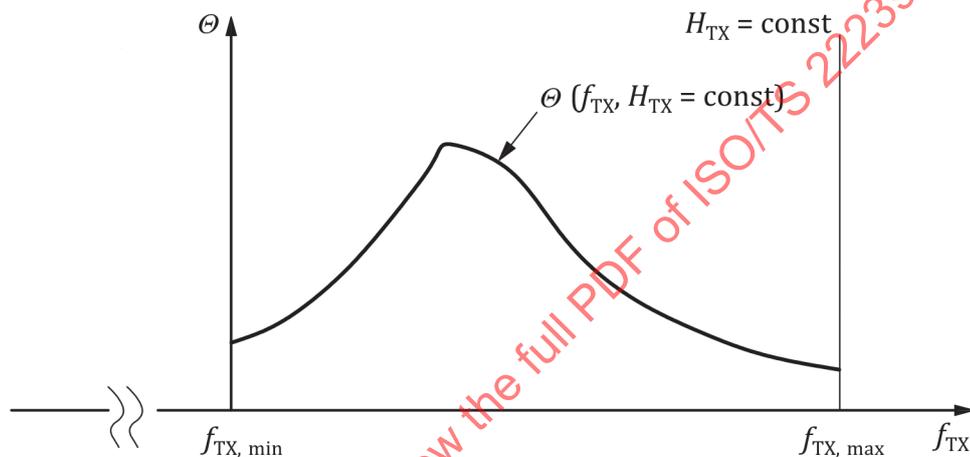


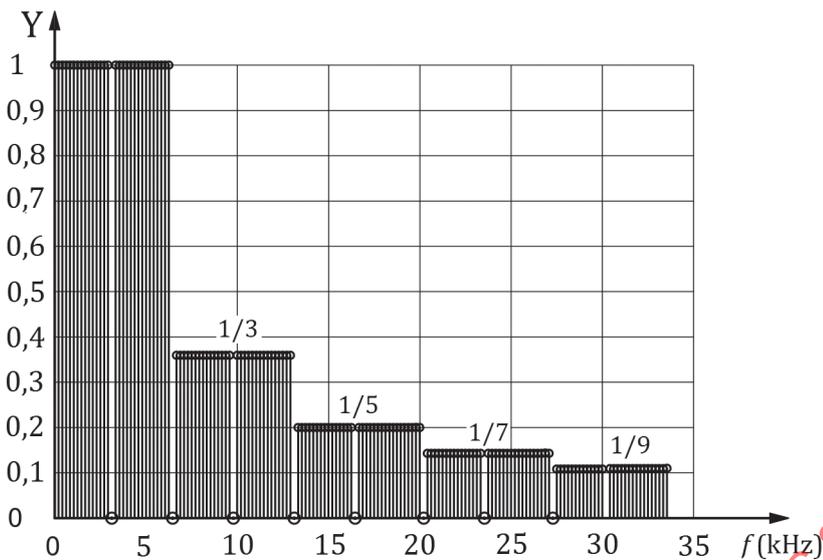
Figure 13 — Qualitative curve of $\theta(f_{TX}, H_{TX})$ for $H_{TX} = \text{const}$

6.3.6 The useful signal power, $P_\theta(f_{TX}, H_{TX})$

The useful signal power, $P_\theta(f_{TX}, H_{TX})$, is defined as $P_\theta(f_{TX}, H_{TX}) = \theta(f_{TX}, H_{TX})^2$.

6.3.7 Noise power, $P_{\text{NOISE}}(f_{TX}, H_{TX})$

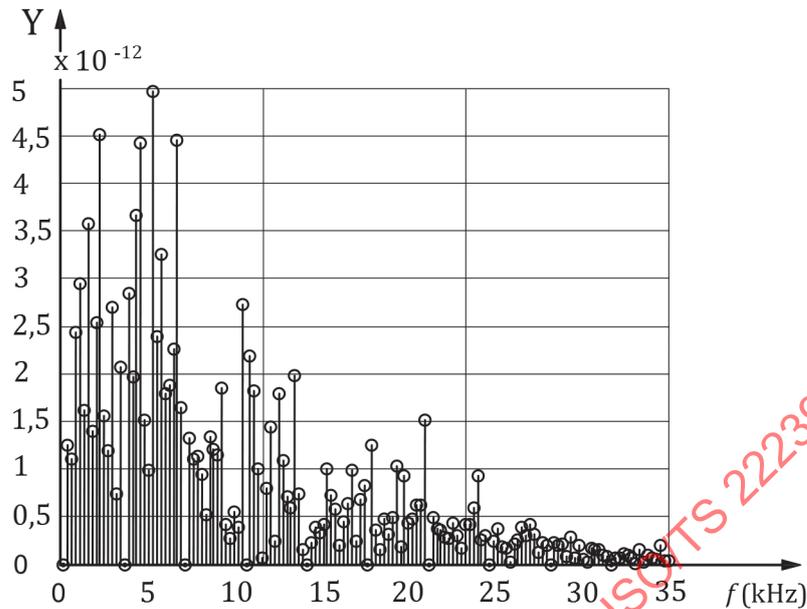
In order to derive the power, $P_{\text{NOISE}}(f_{TX}, H_{TX})$, the spectral contents of $\Phi_{\text{RESO,NORM}}(t)$ (see [Figure 12](#)) shall be taken into account without the DC part, fundamental (odd and even) and its harmonics (set to 0). The remaining part shall be weighted over frequency. The weighting is performed by multiplying the resulting spectrum with the weighting function (see [Figure 14](#)). The resulting noise spectral content is shown in [Figure 15](#).



Key
 Y weighting function

Figure 14 — Weighting function and resulting noise spectral contents of $\varphi_{RX}(t)$

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**Key**

Y noise amplitude (V)

Figure 15 — Resulting noise spectral contents of $\varphi_{\text{NORM}}(t)$

The noise power is defined by [Formula \(3\)](#):

$$P_{\text{NOISE}}(f_{\text{TX}}, H_{\text{TX}}) = \int_f \text{noise_spectrum}^2 \quad (3)$$

The noise power depends on the frequency, f_{TX} , and the magnetic field strength, H_{TX} , supplying the resonator.

6.3.8 The signal-to-noise ratio (SNR)

In order to generate the signal-to-noise ratio (SNR), the useful signal's power as well as the noise power shall be calculated. The SNR is defined by [Formula \(4\)](#):

$$\text{SNR}(f_{\text{TX}}, H_{\text{TX}}) = \frac{P_{\theta}(f_{\text{TX}}, H_{\text{TX}})}{P_{\text{NOISE}}(f_{\text{TX}}, H_{\text{TX}})} \quad (4)$$

In order to characterize the performance of the resonator, SNR shall be recorded over frequency and magnetic field strength.

6.3.9 Definition of $W(H_{\text{TX}})$

Due to the fact that there are only discrete frequency settings that the CPOD transmitter can use, the function $\theta(f_{\text{TX}}, H_{\text{TX}})$ (see [6.3.5](#)) shall be evaluated within a frequency window whose centre frequency is variable and which has a defined width of Δf_{BAND} (see [Figure 16](#)). This is because the transmitting frequency may vary between CPOD sensors.

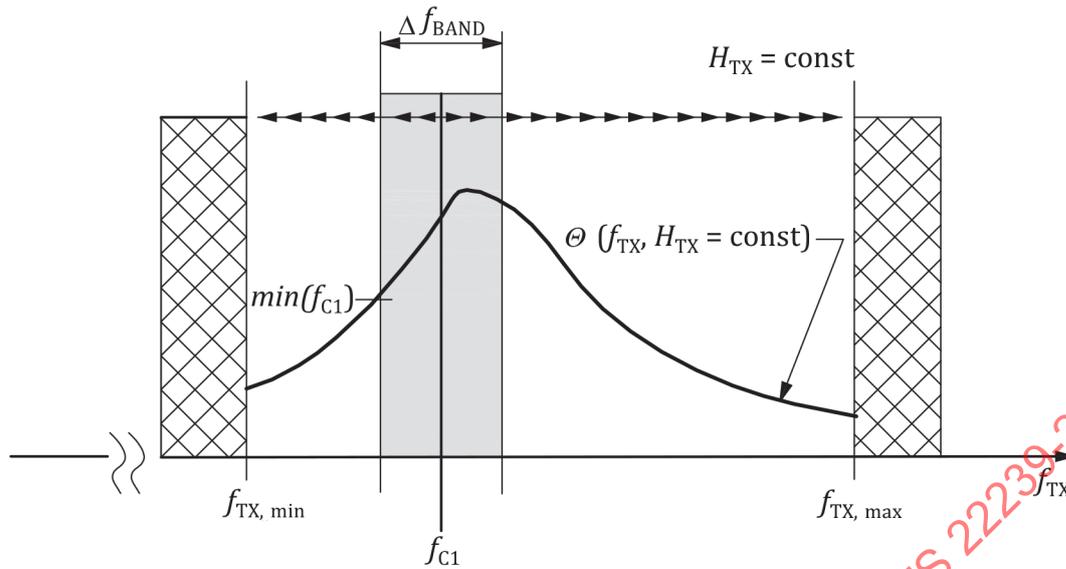


Figure 16 — Evaluation of $W(H_{TX})$ at a given transmitter field strength

$W(H_{TX})$ is defined by [Formula \(5\)](#):

$$W(H_{TX}) = \max \left(\min \left\{ \Theta \left[f_{TX} \varepsilon \left(f_C - \Delta f_{BAND} / 2 \dots f_C + \Delta f_{BAND} / 2 \right), H_{TX} \right] \right\} \right) \quad (5)$$

with $f_C \varepsilon (f_{TX,min} \dots f_{TX,max})$.

When shifting the frequency window over $\Theta(f_{TX}, H_{TX})$ with $f_C = f_{TX,min} \dots f_{TX,max}$, [Formula \(6\)](#) shall be recorded:

$$W(H = H_{TX}) = \max \left(\min \left\{ \Theta \left[f_C \varepsilon \left(f_C - \Delta f_{BAND} / 2 \dots f_C + \Delta f_{BAND} / 2 \right), H_{TX} \right] \right\} \right) \quad (6)$$

This shall be done for all $H_{TX} \varepsilon (H_{OP,min} \dots H_{OP,max})$.

6.3.10 Definition of $N(H_{TX})$

$N(H_{TX})$ specifies the minimum SNR in the f_{TX} frequency range where $\Theta(f_{TX}, H_{TX}) \geq W(H_{TX})$ (see [Figure 17](#) for explanation). In mathematical terms, it is defined by [Formula \(7\)](#):

$$N(H_{TX}) = \min \left\{ \text{SNR} \left[f_{TX} \varepsilon (f_1 \dots f_2), H_{TX} \right] \right\} \quad (7)$$

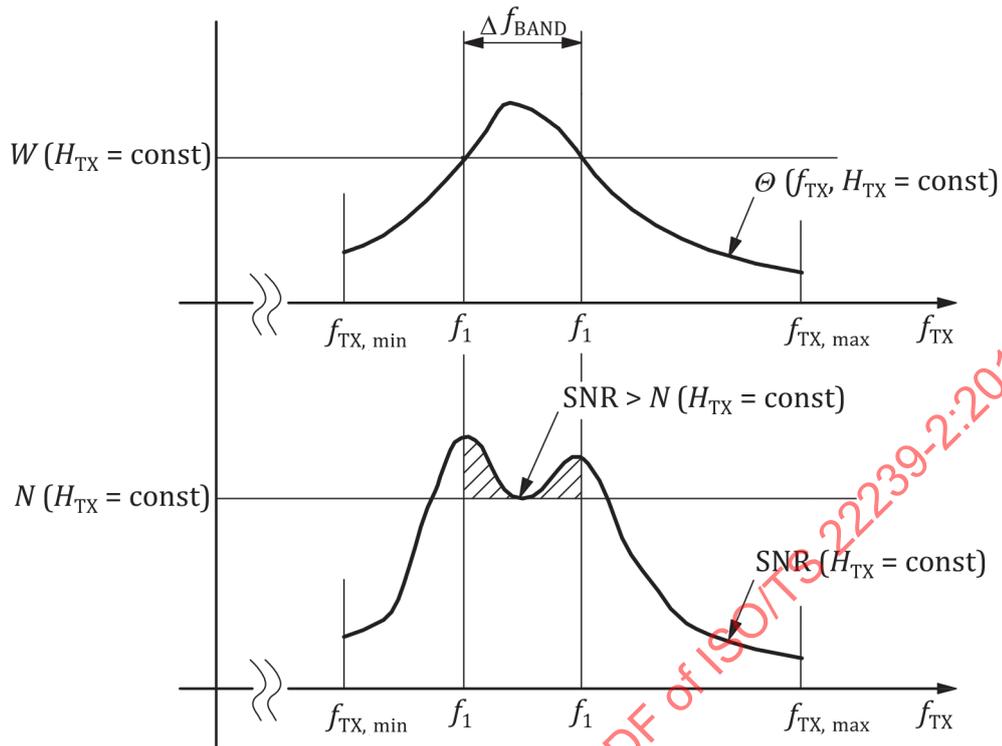


Figure 17 — Example for interpretation of $W(H_{TX})$

6.4 Modulation parameters

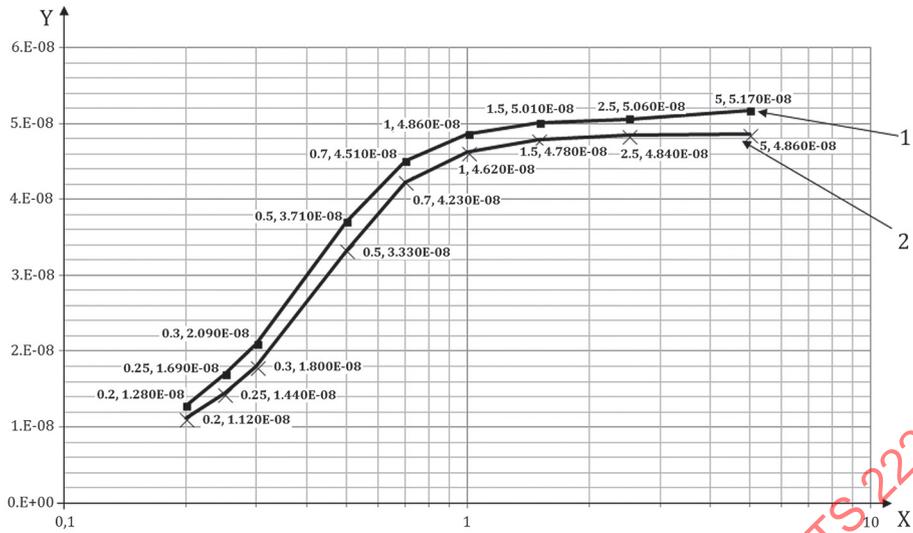
$W(H_{TX})$ and $N(H_{TX})$ shall meet the requirements specified in [Table 6](#).

Table 6 — $W(H_{TX}), N(H_{TX})$ specification

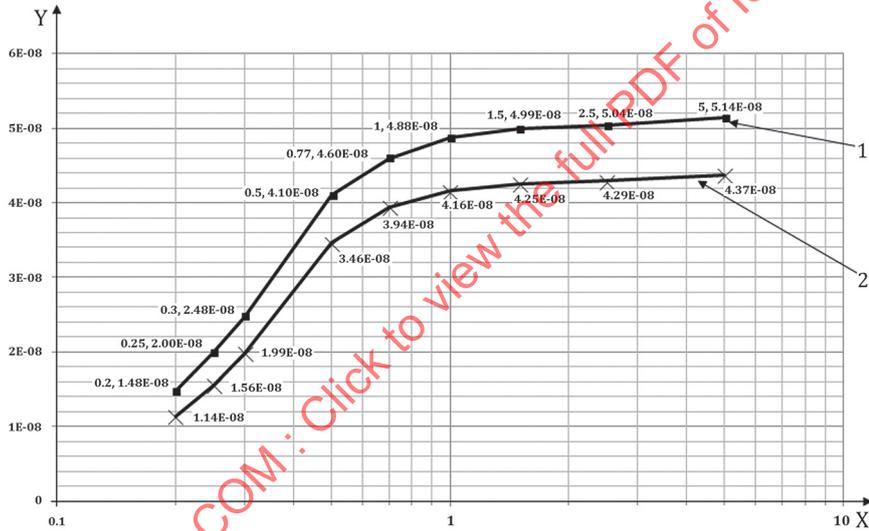
Parameter	Definition	min.	max.
W_{synch}^a V_{spk}	$\Delta f_{\text{BAND}} = 2\,185$ kHz, measured in accordance with 6.3.9 ; measurement starts T_{STARTUP} after reset field gap	As defined in Figure 18	—
N_{synch}^a dB	$\Delta f_{\text{BAND}} = 2\,185$ kHz, measured in accordance with 6.3.10 ; measurement starts T_{STARTUP} after reset field gap	As defined in Figure 19	—
W_{asynch}^b V_{spk}	$\Delta f_{\text{BAND}} = 2\,185$ kHz, measured in accordance with 6.3.9 ; measurement starts after T_{DELAY} , no reset field gap generated	As defined in Figure 18	—
N_{asynch}^b dB	$\Delta f_{\text{BAND}} = 2\,185$ kHz, measured in accordance with 6.3.10 ; measurement starts after T_{DELAY} , no reset field gap generated	As defined in Figure 19	—

NOTE 1 pk = peak value.
 NOTE 2 $N[\text{dB}] = 10 \times \log_{10}[N(H_{TX})]$.
 NOTE 3 For the definition of T_{STARTUP} and T_{DELAY} , see [Table 7](#).

a Resonator protocol generation timing is synchronized with reader timing, since resonator was reset before.
 b Resonator protocol generation timing is asynchronous with reader timing, since resonator was not reset before.



a) Left resonator

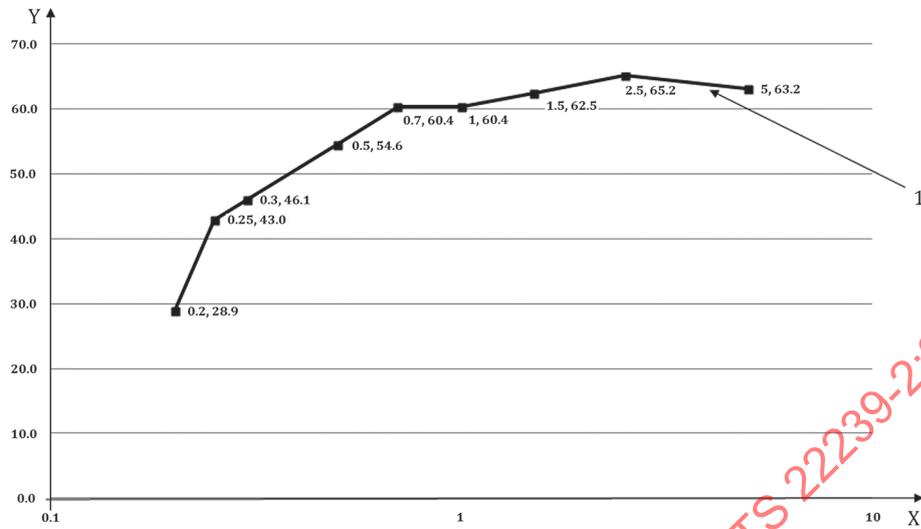


b) Right resonator

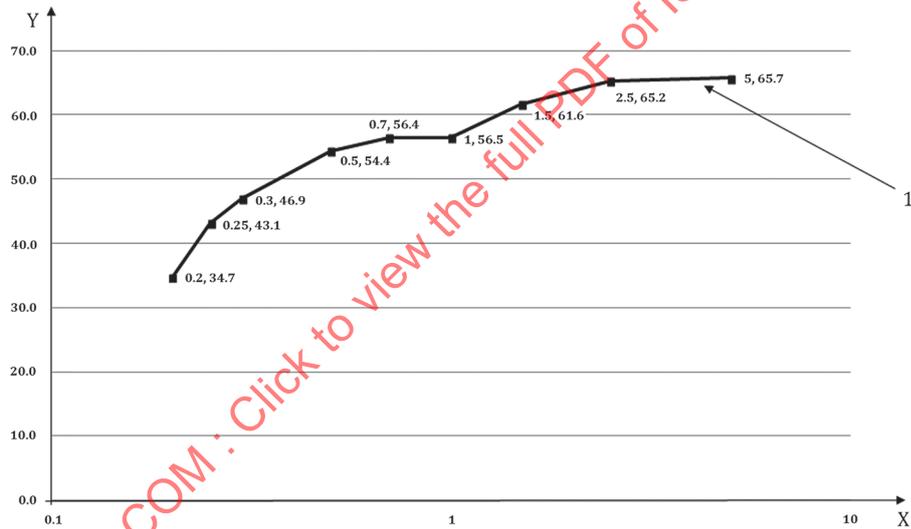
Key

- X H_{TX} (A/m)
- Y $W_{synch,asynch}$ (Vspk)
- 1 max
- 2 min

Figure 18 — $W_{synch,asynch}$ versus magnetic field strength, H_{TX}



a) Left resonator



b) Right resonator

Key

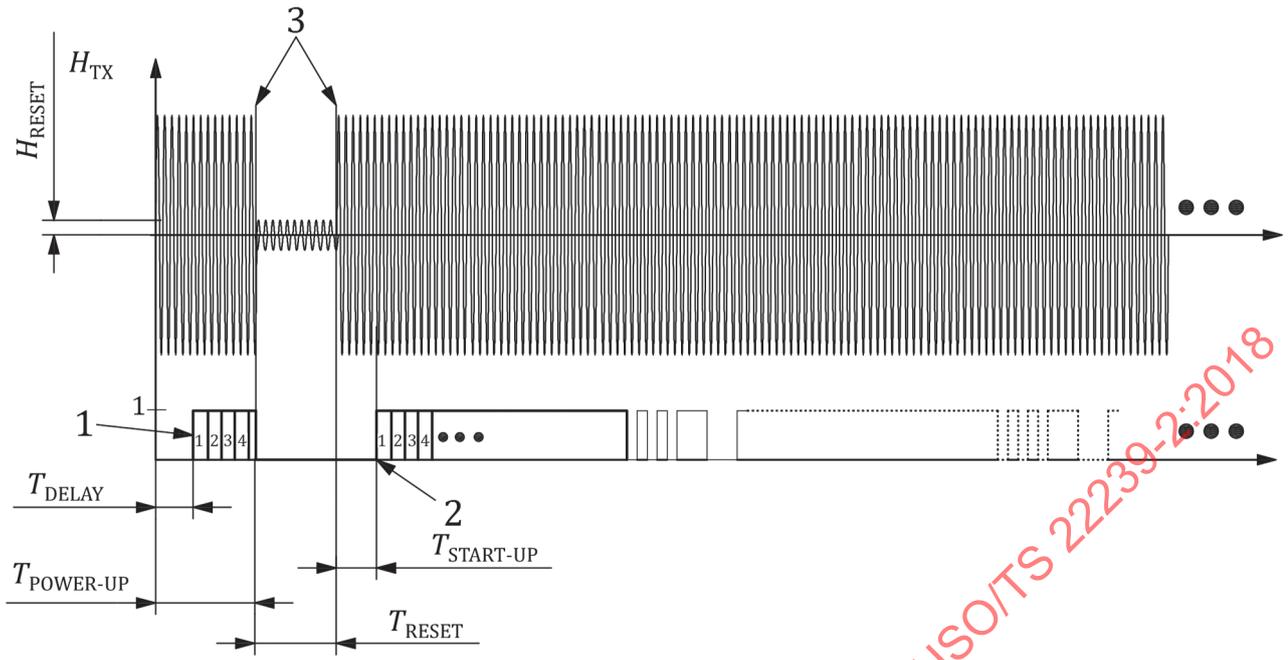
- X H_{TX} (Apk/m)
- Y $W_{synch,asynch}$ (dB)
- 1 min

Figure 19 — $N_{synch,asynch}$ versus magnetic field strength, H_{TX}

7 Resonator timing

7.1 General

The resonator shall meet the timing requirements in order to be CPOD compliant. [Figure 20](#) shows the relevant parameters.



Key

- 1 start of modulation
- 2 start of modulation after reset field gap
- 3 reset field gap ($H_{TX} < H_{RESET}$)

Figure 20 — Resonator timing and reset field strength, H_{RESET}

7.2 Power-up

For the duration of resonator power-up, $T_{POWER-UP}$, the transmitter is switched on to enable the resonator to charge its energy storages, in order to pass a possible following reset gap in a biased state (see Figure 20). During $T_{POWERUP}$, at the latest after T_{DELAY} , the resonator shall begin to transmit its digital protocol, starting with bit one.

7.3 Reset

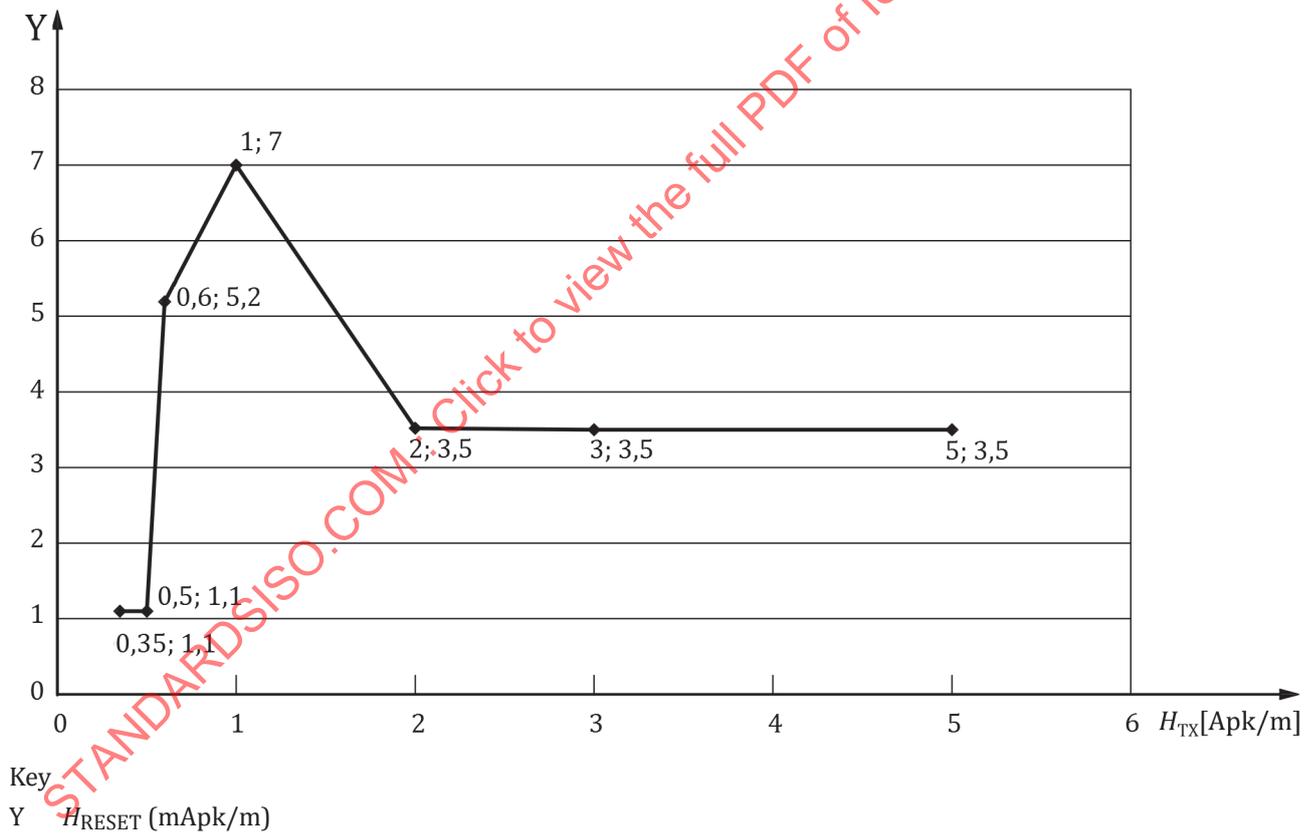
In order to reset the protocol transmission, the transmitter switches off the transmitting field for a duration of T_{RESET} . Once the transmitting field is up from reset and within its operating range again, the resonator, after $T_{STARTUP}$, shall resume the transmission from the beginning of its digital data protocol (bit one).

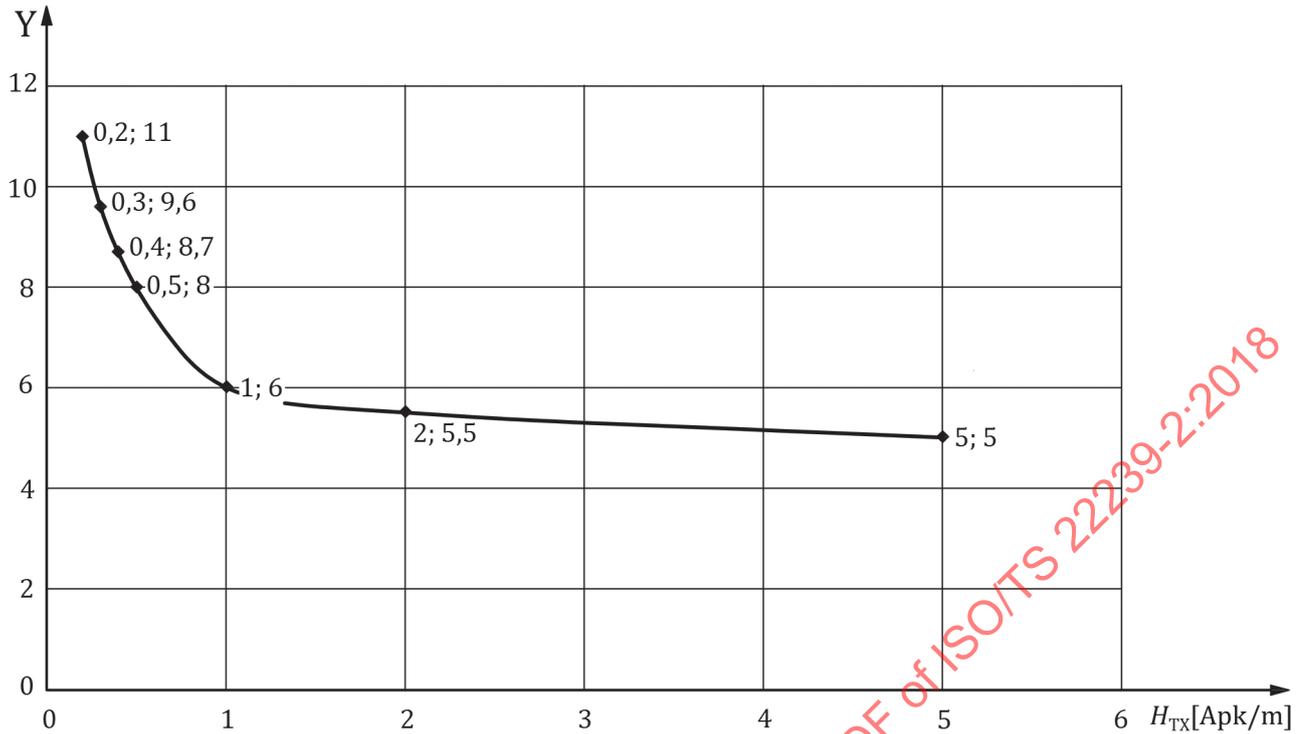
7.4 Relevant timing and reset parameters

Table 7 — Relevant timing and reset parameters

Parameter	Definition	min.	max.
$T_{\text{POWER-UP}}$ ms	Duration for resonator power-up, H_{TX} within operating range	10	—
T_{RESET} ms	Duration of reset field gap, $H_{\text{TX}} \leq H_{\text{RESET}}$	2,5	3,5
$T_{\text{START-UP}}$ ms	Time between end of reset field gap ($H_{\text{TX}} \geq H_{\text{OP,MIN}}$) and start of resonator modulation	0	1
T_{DELAY} ms	Time between $H_{\text{TX}} \geq H_{\text{OP,MIN}}$ and start of resonator protocol transmission, except after reset field gap	—	See Figure 22
H_{RESET} mApk/m	Magnetic field strength to cause resonator reset at the latest after T_{RESET} , $f = f_{\text{TX}}$, measured in accordance with ISO/TS 22239-1:—, Annex G	See Figure 21	—

NOTE For the definition of H_{TX} , H_{RESET} , T_{DELAY} , and T_{RESET} , see Figure 20. For the definition of $H_{\text{OP,MIN}}$, see Table 9.

Figure 21 — H_{RESET} versus magnetic field strength, H_{TX}



Key
 Y T_{DELAY} (ms)

Figure 22 — T_{DELAY} versus magnetic field strength, H_{TX}

8 Electrical and environmental parameters

8.1 Absolute maximum ratings

Correct functionality of the transponder is not required when it is exposed to the absolute maximum ratings mentioned in this clause, but the transponder shall not be damaged during and after exposure to these conditions. When it is back in operating condition, it shall work again in accordance with this document.

Table 8 — Absolute maximum ratings

Parameter	Definition	min.	max.
$H_{MAX,SEQ}$	Maximum magnetic field strength at $f = f_{TX}$, for transmitting sequence ^a , measured in accordance with ISO/TS 22239-1:—, Annex G	—	30 A/m rms
$H_{MAX,CONT}$	Maximum magnetic field strength at $f = f_{TX}$, stressed unlimited, measured in accordance with ISO/TS 22239-1:—, Annex G	—	20 A/m rms
T_{ABS}	Temperature range to which to be exposed	-40 °C	+95 °C

^a There is a worst case timing given for the maximum magnetic field stress (see [Figure 23](#)).

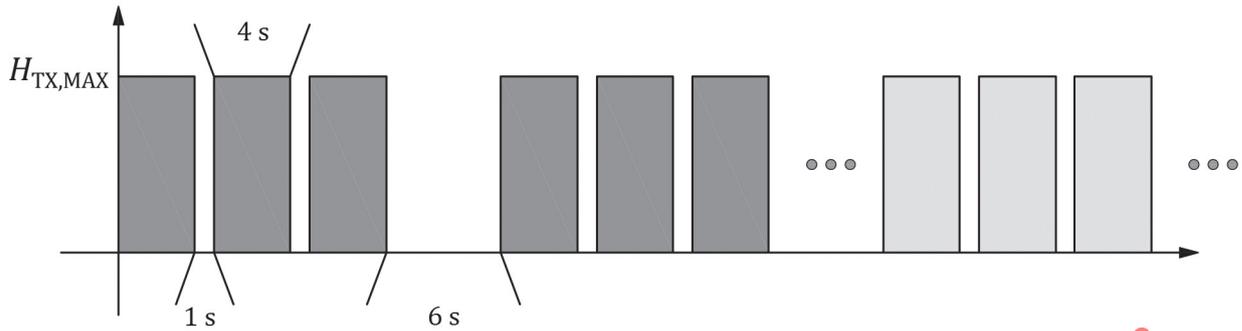


Figure 23 — Timing for maximum magnetic field stress

8.2 Operating ranges

When exposed to the conditions specified in [Table 9](#), the resonator shall feature its full functionality.

Table 9 — Operating ranges

Parameter	Definition	min.	max.
f_{TX}	Magnetic field frequency	124 kHz	133 kHz
H_{OP}	Operating magnetic field strength, measured in accordance with ISO/TS 22239-1:—, Annex G	0,3 Apk/m	5 Apk/m
T_{AMB}	Ambient temperature	-40 °C	+85 °C

NOTE pk = peak value.

8.3 Storage conditions

The storage conditions are specified in [Table 10](#).

Table 10 — Storage conditions

Parameter	min.	max.
Storage temperature T_{STOR} °C	-40	+95

9 CPOD resonator compatibility test

In order to be CPOD compliant, a resonator shall pass the CPOD compatibility test. The CPOD resonator compatibility test set-up in accordance with [Annex A](#) shall be used. The test parameters and the testing procedure are described in [Annex B](#). In addition, the resonator shall pass successfully the environmental qualification programme described in [Clause 10](#).

10 Resonator environmental qualification

10.1 Application profile

The application profile defined in [Tables 11](#) to [14](#) summarizes the mechanical, climatic and chemical influences on the CPOD resonator during its lifetime.

Table 11 — Lifetime and operating time

Parameter	Requirement
Resonator lifetime	15 years
Active operating time (resonator supplied by magnetic field)	6 000 h
Passive operating time (resonator not supplied by magnetic field)	119 000 h

Table 12 — Mechanical exposure

Parameter	Requirement
Vibration	Periodic excitation
	Static excitation
Acceleration	Mechanical shock
	Free fall

Passenger compartment vibration profile
Acceleration up to 500 m/s²
1 m fall height, concrete floor

Table 13 — Chemical exposure

Parameter	Requirement
Protection class	IP5K4
Environmental influences	Salt fog atmosphere
Purifying agents	Chemicals in accordance with Table 31
Corrosive gases	Industrial climate (H ₂ S, NO ₂ , Cl ₂ , SO ₂)

Table 14 — Climatic exposure (temperature/humidity)

Operating state	Parameter	Requirement	
		Temperature °C	Distribution %
During operation in child seat/car	Temperature profile	-40	6
		+23	65
		+60	20
+80		8	
+85		1	
	Temperature class	Passenger compartment, maximum temperature 85 °C	
	Humidity	Relative humidity up to 100 % condensation and freezing	
In child seat/car, non-operating	Temperature	Minimum temperature: -40 °C maximum temperature: +85 °C typical temperature: +23 °C	
	Humidity	Relative humidity up to 100 % condensation and freezing 60 % relative humidity on average	
Transport	Temperature	Minimum temperature: -40 °C maximum temperature: +95 °C	
	Transport duration	Max. 24 h continuously at minimum temperature max. 48 h continuously at maximum temperature	
Storage	Temperature	Minimum temperature: -10 °C maximum temperature: +55 °C	
	Storage duration	5 years	
	Humidity	Max. 85 % relative humidity	

Table 14 (continued)

Operating state	Parameter	Requirement
Long term storage (spare part supply)	Temperature	Minimum temperature: +10 °C maximum temperature: +40 °C
	Storage duration	15 years
	Humidity	Max. 80 % relative humidity
Temperature cycles	Quantity	5 500 over 15 years
	Temperature swing	Average: 34 °C

10.2 Common test parameters

Table 15 specifies the common test parameters.

Table 15 — Common test parameters

Parameter	Definition	Requirement
T_{\min}	Minimum ambient temperature possible at the place of installation of the component; the component shall not show any functional degradation	-40 °C
T_R	Room temperature	(23 ± 5) °C
T_{\max}	Maximum ambient temperature possible at the place of installation of the component; the component shall not show any functional degradation	+85 °C
$H_{T,\min}$	Minimum magnetic field strength applied during test, measured in accordance with ISO/TS 22239-1:—, Annex G	0,3 (Apk/m)
$H_{T,\text{typ}}$	Typical magnetic field strength applied during test, measured in accordance with ISO/TS 22239-1:—, Annex G	0,5 (Apk/m)
$H_{T,\max}$	Maximum magnetic field strength applied during test, measured in accordance with ISO/TS 22239-1:—, Annex G	5 (Apk/m)

NOTE pk = peak value.

10.3 Operating states

10.3.1 General

In general, the CPOD resonators are driven under different conditions during their lifetime. These conditions shall be simulated during the component test/environmental qualification.

10.3.2 Operating state A (transport and storage)

Operating state A describes the situation during transport and storage of the resonator (no magnetic field is applied). The resonator is boxed in its original package (transportation package).

10.3.3 Operating state B (non-functional state)

Operating state B describes the situation where the resonator-equipped child seat is located in a car on the passenger seat or on the back seat of a parked car. No magnetic field is applied.

10.3.4 Operating state C (functional state)

Operating state C describes the situation where the resonator-equipped child seat is located on the passenger seat of a car with the ignition on. An exciting magnetic field is applied periodically with a duty cycle equal to 7 % ± 0,1 % (average over time).

10.3.5 Operating state D (intermitting functional state)

Operating state D describes the situation where the resonator-equipped child seat is located on the passenger seat of a car. The ignition state periodically varies between on and off and, therefore, the resonator operating state changes periodically between operating state B and operating state C.

10.4 Parametrical test and parameter checking

10.4.1 Parametrical test before/after every single test

Before and after every single test listed in [10.5](#), a parametrical test shall be performed. The parametrical test shall be performed at T_{\min} , T_R and T_{\max} . A parametrical test consists of the CPOD resonator compatibility test described in [Clause 9](#).

10.4.2 Continuous parameter check

For the tests mentioned in [10.5](#) where a continuous parameter check is required, the parameters tested during the parametrical test shall be tested for only one typical magnetic field strength in order to increase the testing frequency (see [Clause 9](#) and [Annex C](#)). A computer-based data acquisition shall be used.

10.5 Qualification tests

10.5.1 General

By passing the following qualification tests (described in [10.5.2](#) to [10.5.17](#)), the CPOD resonator proves its basic automotive suitability. The qualification plan indicating the test order over time can be found in [10.9](#).

10.5.2 Acceptance criteria

Functional performance shall be verified by parametric measurements in accordance with [10.4.1](#) before the start and after completion of the test. Measured parameters shall meet the limits of this document.

If a continuous parameter check in accordance with [10.4.2](#) is required during testing, the measured parameters during every check shall meet the limits of this document.

10.5.3 Temperature storage (transport and storage)

10.5.3.1 Test parameters

Table 16 — Test parameters

Parameter	Requirement
Duration	164 h
Minimum test temperature	-40 °C
Maximum test temperature	+95 °C
Temperature gradient	0,6 °C/min
Number of parts	5
Operating state	Operating state A during high and low temperature
Parameter check	Parameter test before/after the test in accordance with 10.4.1

10.5.3.2 Test procedure

The test procedure is as described below.

- a) Place component in a temperature chamber.
- b) Ramp down the chamber temperature to -40 °C within 2 h. Keep component at -40 °C for the next 24 h.
- c) Ramp up the chamber temperature to $+95\text{ °C}$ within 2 h. Keep component at $+95\text{ °C}$ for the next 48 h.
- d) Repeat steps b) to c) one more time (total two cycles).

10.5.4 Low temperature durability test

10.5.4.1 Test parameters

Table 17 — Test parameters

Parameter	Requirement
Duration	120 h
Temperature	T_{\min}
Number of parts	5
Operating state	Operating state C, with continuous parameter check in accordance with 10.4.2
Parameter check	Parameter test before/after the test in accordance with 10.4.1

10.5.4.2 Test procedure

The test procedure is as follows.

- a) Place component in a climatic chamber and ramp down the chamber temperature to T_{\min} .
- b) Operate component at T_{\min} for 120 h with continuous monitoring.

10.5.5 High temperature operating endurance test

10.5.5.1 Test parameters

Table 18 — Test parameters

Parameter	Requirement
Duration	1 036 h
Temperature	T_{\max}
Number of parts	5
Operating state	Operating state C, with continuous parameter check in accordance with 10.4.2
Parameter check	Parameter test before/after the test in accordance with 10.4.1

10.5.5.2 Test procedure

The test procedure is as follows.

- a) Place component in a temperature chamber and ramp up the chamber temperature to T_{\max} .
- b) Operate component at T_{\max} for the specified test duration with continuous monitoring.

10.5.6 Power thermal cycle endurance (PTCE)

10.5.6.1 Test parameters

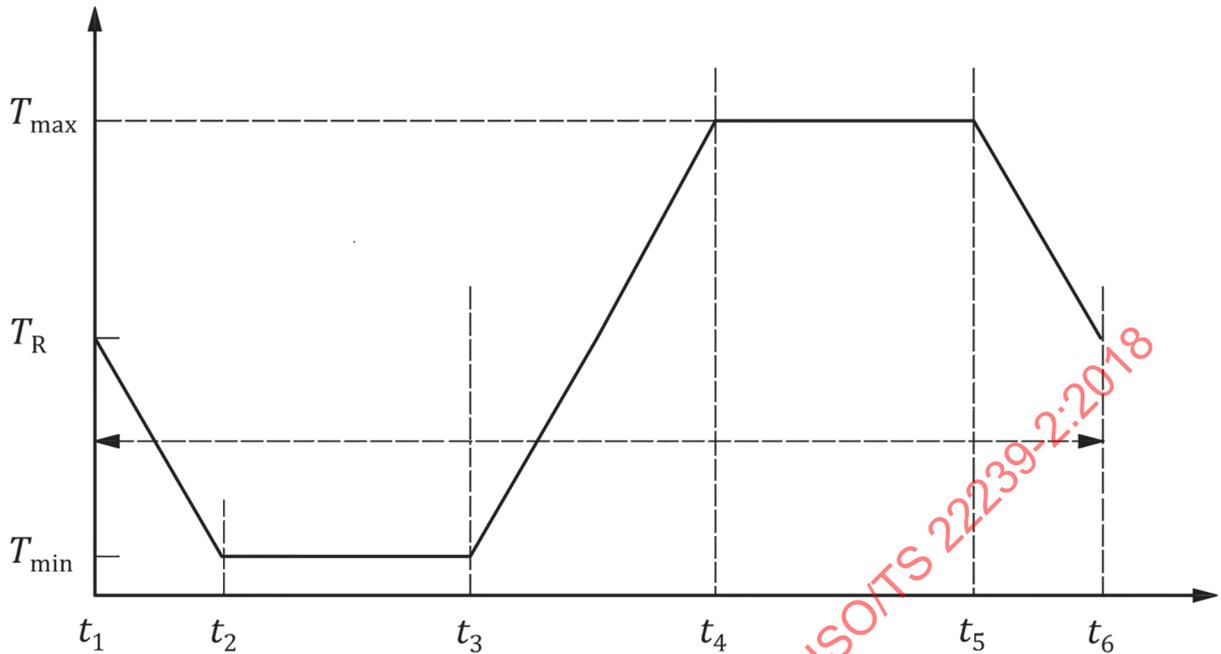
Table 19 — Test parameters

Parameter	Requirement
Number of test cycles	400
Minimum test temperature	T_{\min}
Maximum test temperature	T_{\max}
Temperature gradient	4 °C/min If a gradient of 4 °C/min is not achievable, it can be reduced to 2 °C/min.
Soak time	20 min It shall be verified at least once that the resonator reaches T_{\min} and T_{\max} with a tolerance of ± 2 °C during the soak time; if not, the soak time shall be extended accordingly.
Test duration (informative)	The test duration depends on the soak time and the temperature gradient. Based on a temperature gradient of 4 °C/min and a soak time of 20 min, the test duration can be calculated to 685 h.
Number of samples	5
Operating state	Operating state D, with the following timing: — 1 min operating state C — 9 min operating state B Operating state C, with continuous parameter check in accordance with 10.4.2
Parameter check	Parameter test before/after the test in accordance with 10.4.1

10.5.6.2 Test procedure

Refer to [Figure 24](#) as applicable to the resonator.

- Place component in a temperature chamber, operate component (intermittent operation 1) with continuous monitoring and ramp down the chamber temperature to T_{\min} with the specified temperature change rate (t_1 to t_2 in [Figure 24](#)).
- Keep component at T_{\min} for the specified component soak time (t_2 to t_3).
- Ramp up chamber temperature from T_{\min} to T_{\max} with the specified temperature change rate (t_3 to t_4).
- Keep component at T_{\max} for the specified component soak time (t_4 to t_5).
- Ramp-down the chamber temperature from T_{\max} to T_R with the specified temperature change rate (t_5 to t_6).
- Repeat powered thermal cycle [steps a) to e)] for the specified number of cycles.

**Key** T_{\max} maximum test temperature T_R room temperature T_{\min} minimum test temperature**Figure 24 — PTCE timing****10.5.7 Thermal shock test****10.5.7.1 Test parameters****Table 20 — Test parameters**

Parameter	Requirement
Number of test cycles	100
Minimum test temperature	T_{\min}
Maximum test temperature	T_{\max}
Soak time	20 min It shall be verified at least once that the resonator reaches T_{\min} and T_{\max} with a tolerance of ± 2 °C during the soak time; if not, the soak time shall be extended accordingly.
Rearrangement duration	<30 s
Number of samples	5
Operating state	Operating state B
Parameter check	Parameter test before/after the test in accordance with 10.4.1

10.5.7.2 Test procedure

The test procedure is as described below.

- a) Place component in a chamber with dual temperature zone capability and adjust the temperature zones to T_{max} and T_{min} , respectively. If a chamber with dual temperature zone capability is not available, use two chambers in close proximity and maintain one chamber at T_{max} and another at T_{min} .
- b) Maintain component at T_{min} for specified component soak time.
- c) Transfer component from T_{min} zone to T_{max} zone within 30 s.
- d) Keep component at T_{max} for the specified component-specific soak time.
- e) Transfer component from T_{max} zone to T_{min} zone within 30 s.
- f) Repeat the thermal cycles [steps b) to e)] for the specified number of test cycles.
- g) Allow the component to return to room temperature within 2 h before removing it from the test chamber.

10.5.8 Temperature cycling test, constant humidity

10.5.8.1 Test parameters

Table 21 — Test parameters

Parameter	Requirement
Test duration	240 h
Temperature and humidity profile	In accordance with IEC 60068-2-38 The first five temperature cycles shall be performed with low temperature phases, the following four cycles without low temperature phases (see IEC 60068-2-38)
Minimum test temperature	-10 °C
Maximum test temperature	+65 °C
Relative humidity	93 %, with the exception of those intervals defined in IEC 60068-2-38 where there is no humidity control
Number of samples	5
Operating state	Operating state D, with the following timing: — 50 min operating state C — 50 min operating state B Operating state C, with continuous parameter check in accordance with 10.4.2
Parameter check	Parameter test before/after the test in accordance with 10.4.1

10.5.8.2 Test procedure

The test procedure is as follows.

- a) Place component in a climatic chamber.
- b) Operate component with continuous monitoring while running a temperature and humidity profile in accordance with IEC 60068-2-38.

10.5.9 High temperature and humidity endurance (HTHE)

10.5.9.1 Test parameters

Table 22 — Test parameters

Parameter	Requirement
Test duration	1 048 h
Temperature	T_{\max}
Humidity	85 % relative humidity
Number of samples	5
Operating state	Operating state D, with the following timing: <ul style="list-style-type: none"> — 1 h operating state C — 47 h operating state B Operating state C, with continuous parameter check in accordance with 10.4.2
Parameter check	Parameter test before/after the test in accordance with 10.4.1

10.5.9.2 Test procedure

The test procedure is as described below.

- a) Place component in a test chamber and maintain chamber temperature at 85 °C for 1 h.
- b) Introduce humidity to the chamber and maintain the relative humidity inside the chamber at 85 % RH.
- c) Operate component (1 h operational followed by 47 h non-operational, alternating) with continuous monitoring for the specified test duration. Interrupt test after predefined intervals to perform parametric measurements in accordance with [10.4.1](#). Condensation shall be prevented when replacing the (cold) component into the climatic chamber by heating the component to 85 °C first without humidity and introducing humidity only after the component has reached 85 °C.

10.5.10 Vibration test

10.5.10.1 Test parameters

Table 23 — Test parameters

Parameter	Requirement	
Vibration class	I	
Test duration per coordinate axis	30 h (8 h with superposed temperature profile; 22 h at T_R)	
Temperature gradient of temperature profile	1 °C/min to 1,5 °C/min	
Minimum temperature	T_{\min}	
Maximum temperature	T_{\max}	
Vibration profile broad band noise	Frequency	Acceleration density ^a
	Hz	(m/s ²) ² /Hz
	5	0,884
	10	20,0
	55	6,5
	180	0,25

^a PSD (power spectral density).

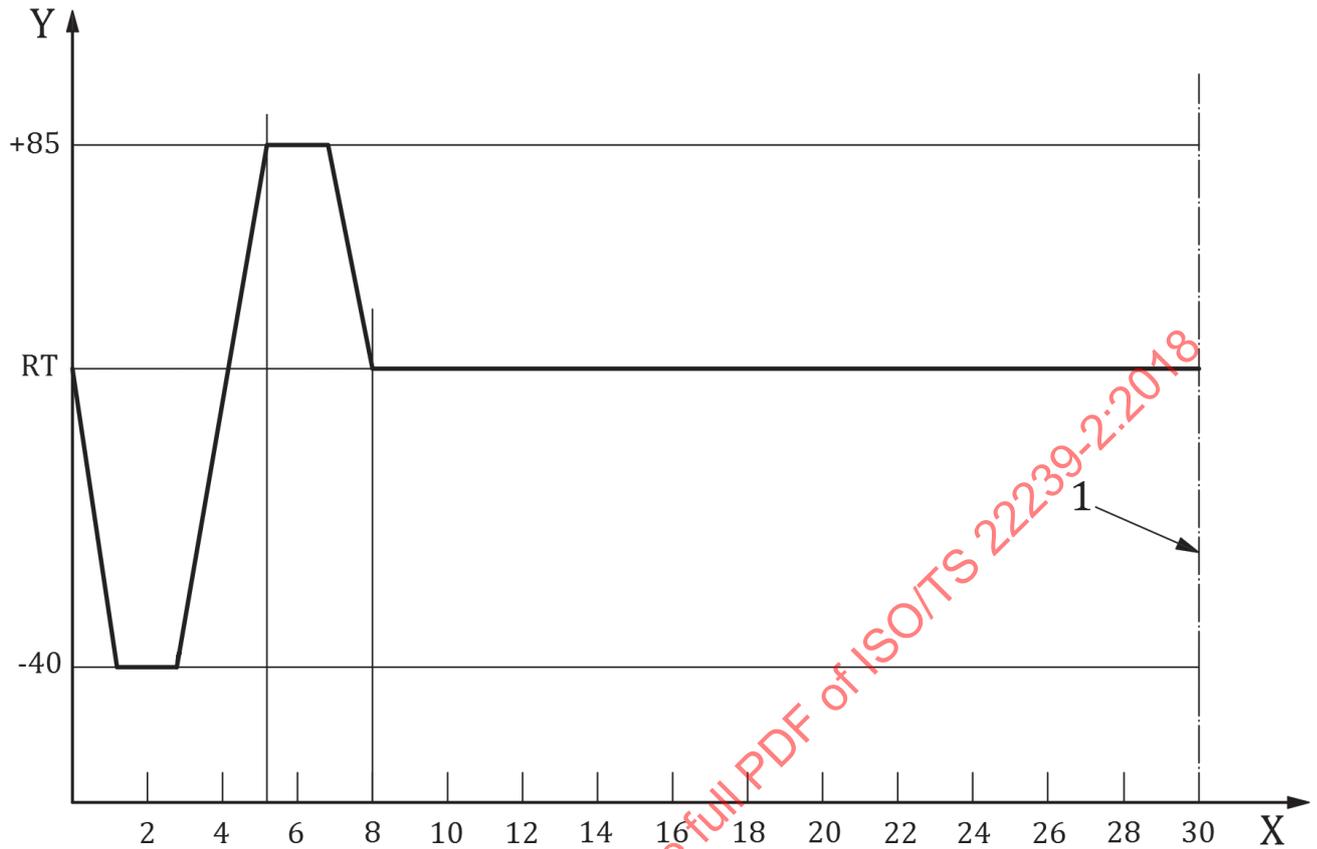
Table 23 (continued)

Parameter	Requirement	
Vibration class	I	
Test duration per coordinate axis	30 h (8 h with superposed temperature profile; 22 h at T_R)	
Temperature gradient of temperature profile	1 °C/min to 1,5 °C/min	
Minimum temperature	T_{min}	
Maximum temperature	T_{max}	
	300	0,25
	360	0,14
	1 000	0,14
	2 000	0,14
	RMS	30,8 m/s ²
Number of samples	5	
Operating state	Operating state B	
Parameter check	Parameter test before/after the test in accordance with 10.4.1	
a PSD (power spectral density).		

10.5.10.2 Test procedure (vibration class I)

The test procedure is as described below.

- a) Program the vibration shaker for the random vibration profile given in [Table 23](#).
- b) Program the temperature chamber for the temperatures, ramp rates and duration shown in [Figure 25](#) and given in [Table 23](#).
- c) Place the component on the vibration shaker inside the temperature chamber. Mount the component in one of the axes using a released bracket or mounting hardware.
- d) Start vibration and temperature sequence and test for the specified test duration per axis.
- e) At the end of the test cycle for one axis, remove component from shaker and perform parameter test after according to [10.4.1](#) (only at RT).
- f) At the end of the test cycle for one axis, repeat steps c), d) and e) for the remaining two axes.



Key

- 1 test duration per axis
- X time (hours)
- Y temperature (°C)

Figure 25 — Temperature profile for vibration class I

10.5.11 Mechanical shock test

10.5.11.1 Test parameters

Table 24 — Test parameters

Parameter	Requirement
Number of shocks per space coordinate ($\pm x, \pm y, \pm z$)	10 (60 shocks altogether)
Acceleration	500 m/s ²
Duration of shock	11 ms
Test temperature	T_R
Number of samples	5
Operating state	Operating state B
Parameter check	Parameter test before/after the test in accordance with 10.4.1

10.5.11.2 Test procedure

The test procedure is as described below.

- a) Define the component's in-vehicle mounting co-ordinates relative to the vehicle coordinates, x (longitudinal), y (transverse), and z (vertical). Mount the component on the shock test equipment to simulate the in-vehicle coordinates.
- b) Apply half-sine pulse 10 times in each direction of $\pm x$, $\pm y$, and $\pm z$ at room temperature. The total number of shocks shall be 60.

10.5.12 Fall test, not packed

10.5.12.1 Test parameters

Table 25 — Test parameters

Parameter	Requirement
Number of falls per sample	1 ^a
Fall height	1 m
Number of samples	6
Operating state	Operating state B
Parameter check	Parameter test before/after the test in accordance with 10.4.1
^a Every sample shall fall on one of its six sides ($\pm x$, $\pm y$, $\pm z$).	

10.5.12.2 Test procedure

Drop the component from a height of 1 m onto a concrete surface. The component shall be oriented prior to the release so that each component is released only once in one of the positive and negative directions of its primary $\pm x$, $\pm y$ and $\pm z$ axes.

10.5.12.3 Additional acceptance criteria

Apart from the general acceptance criteria defined in [10.5.2](#), the component shall be visually inspected with the naked eye for any obvious damage. The component shall not show any obvious damage.

10.5.13 Protection against intrusion of hard bodies

10.5.13.1 Test parameters

Table 26 — Test parameters

Parameter	Requirement
Protection class	IP5K4
Test method	ISO 20653
Dust specification	ISO 20653
Dust concentration	ISO 20653
Type of dust exposure	ISO 20653
Number of samples	5
Operating state	Operating state B
Parameter check	Parameter test before/after the test in accordance with 10.4.1

10.5.13.2 Test procedure

Follow ISO 20653 for testing protection class IP5K4.

10.5.14 Protection against intrusion of fluids**10.5.14.1 Test parameters****Table 27 — Test parameters**

Parameter	Requirement
Protection class	IP5K4
Test method	ISO 20653
Number of samples	5
Operating state	Operating state B
Parameter check	Parameter test before/after the test in accordance with 10.4.1

10.5.14.2 Test procedure

Follow ISO 20653.

10.5.15 Corrosion test with gutting corrosion gas**10.5.15.1 Test parameters****Table 28 — Test parameters**

Parameter	Requirement
Test duration	14 days
Test method	IEC 60068-2-60, Method 4
Corrosion gas concentration	H ₂ S: 10 ppb
	SO ₂ : 200 ppb
	Cl ₂ : 10 ppb
	NO ₂ : 200 ppb
Relative humidity	75 %
Test temperature	T_R
Number of samples	5
Operating state class	Operating state B
Parameter check	Parameter test before/after the test in accordance with 10.4.1
NOTE Gas concentration in ppb = parts per billion (1 in 10 ⁹) volume per volume (vol/vol) in air.	

10.5.15.2 Test procedure

The test procedure is as follows.

- a) Place component in a test chamber and subject it to a mixed flowing gas environment in accordance with IEC 60068-2-60.
- b) Terminate testing after the specified test duration.

10.5.16 Salt spray test

10.5.16.1 Test parameters

Table 29 — Test parameters

Parameter	Requirement
Test duration	24 h
Test method	IEC 60068-2-11
Test temperature	35 °C
Salt concentration	(5 ± 1) weight %
Number of samples	5
Operating state	Operating state D, with the following timing: — 5 min operating state C — 55 min operating state B Operating state C, with continuous parameter check in accordance with 10.4.2 .
Parameter check	Parameter test before/after the test in accordance with 10.4.1

10.5.16.2 Test procedure

The test procedure is as follows.

- a) Place component in the test chamber.
- b) Subject component to salt fog atmosphere in accordance with IEC 60068-2-11 while operating the component with continuous monitoring for the specified test duration.

10.5.17 Resistance to chemical substances

10.5.17.1 Test parameters

Table 30 — Test parameters

Parameter	Requirement
Test duration	24 h per fluid application
Amount of test fluid/chemical	100 ml Cleaning fluids shall be applied by spraying; bulk liquids shall be applied by pouring/spilling.
Storage temperature	70 °C
Dwell time at storage temperature	(4 + 12) h = 16 h per cycle (see Figure 26)
Number of samples	5
Operating state	Operating state B
Parameter check	Parameter test before/after the test in accordance with 10.4.1

Table 31 — Collection of chemicals/fluids

Name of fluid/chemical	Description	Sample No.				
		1	2	3	4	5
Interior cleaning fluid cockpit spray	e.g. Caramba Chemie ^a	X	—	X	—	—
Interior cleaning fluid	e.g. Armorall Protectant ^b	X	—	X	—	—
Solvent — Stain remover	e.g. Caramba Chemie ^a	X	—	X	—	—
Leather care foam	e.g. Caramba Chemie ^a	—	—	—	X	X
Plastic and vinyl cleaner	e.g. Caramba Chemie ^a	—	X	—	—	X
Glass cleaner	e.g. Caramba Chemie ^a	—	—	—	—	X
Soapy water	5 % soap concentration	—	X	—	X	—
Hot beverages	100 ml coffee with cream (6 ml) and sugar (6 ml)	X	X	—	—	—
Cold beverages	Regular (non-diet) cola	—	—	X	X	—
Ammonia solution	Aqueous urea solution AUS 32 in accordance with ISO 22241-1	X	—	—	—	—

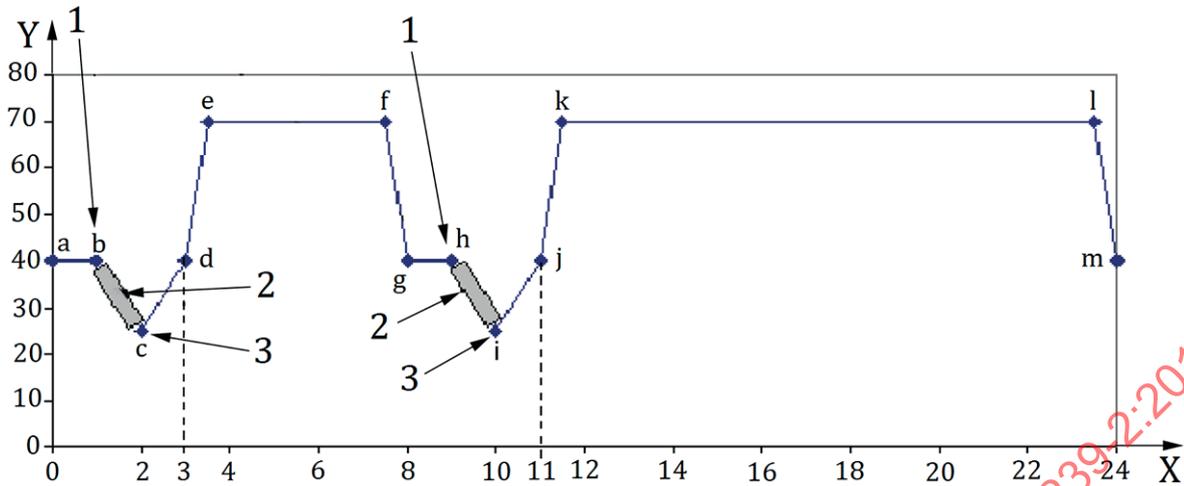
^a Caramba Chemie GmbH and Co.KG, Wanheimerstr. 334/336, D-47055 Duisburg, supplies suitable products available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of these products.

^b Armorall Protectant is an example of a suitable product available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of this product.

10.5.17.2 Test procedure

The test procedure is as described below (see [Figure 26](#)).

- a) Place the component in a temperature chamber maintained at 40 °C.
- b) Keep the component at 40 °C for 1 h (see a to b in [Figure 26](#)). Remove the component from the chamber and apply 100 ml of test fluid/chemical by either spraying or pouring to cover all faces of the component. Store the component at ambient temperature (T_R) for 1 h (see b to c in [Figure 26](#)).
- c) Replace the component in the chamber and keep it at 40 °C for one hour (see c to d in [Figure 26](#)). Then, ramp up the chamber temperature to 70 °C within 30 min (see d to e in [Figure 26](#)) and keep the component at 70 °C for 4 h (for dwell time, see e to f in [Figure 26](#)). Ramp down the chamber temperature to 40 °C within 30 min (see f to g in [Figure 26](#)).
- d) Repeat steps b) and c) for the same fluid, but prolong the dwell time from 4 h to 12 h at high temperature (see k to l in [Figure 26](#)).
- e) Repeat steps b), c) and d) for the next fluid in the set. Continue the process up to a maximum of three fluids per component.



Key

- X time, hours
- Y temperature, °C
- 1 resonator removed from chamber and test fluid applied immediately
- 2 resonator stored at T_R outside chamber
- 3 Resonator replaced in chamber

Figure 26 — Temperature profile (fluid exposure tests)

10.6 Electromagnetic compatibility (EMC) test

10.6.1 General

The electromagnetic compatibility of the CPOD resonators shall be tested using a CPOD compatible passenger seat on which the resonators are positioned in a defined position during the EMC test.

The EMC test shall be performed in accordance with ISO 11452-1,-2 and -3.

Table 32 — Test conditions — General information

Parameter	Requirement
Number of samples	Two resonator pairs
Temperature	$(23 \pm 5) \text{ }^\circ\text{C}$
Humidity	20 % to 80 %
Ground plane	In accordance with ISO 11452-1

10.6.2 Functional status qualification

During the EMC test, the detection status of the CPOD sensor shall be monitored as an indication of the functional status of the resonators under test. By the selection of the CPOD passenger seat, it shall be ensured that only the resonators can be the cause for functional degradation during testing, if such degradation is monitored, i.e. only CPOD passenger seats that remain fully functional under the tested conditions can be used for the resonator EMC test.

ISO 11452-1 classifies possible functional statuses of the device under test (DUT). For the resonator EMC test, class A shall be met during testing (see [Table 33](#)).

Table 33 — Functional status classification

Class	Description for DUT
A	The resonators shall operate as designed during and after exposure to a disturbance.

10.6.3 Acceptance criteria

During EMC testing, the resonator pair itself and its forward-facing orientation shall be detected correctly throughout the complete test duration by the CPOD passenger seat. In addition, the received CRS type (see Table 2) shall comply with the information intended to be sent by the resonators.

10.6.4 Community

10.6.4.1 General

Community shall be in accordance with ISO 11452-1.

10.6.4.2 Modulation

Figure 27 illustrates different types of modulation:

- continuous wave (CW): no modulation;
- amplitude modulation (AM): 1 kHz sine wave at 80 % peak CW = peak AM;
- pulse modulation (PM): GSM-Modulation with PulseDuration = 577 μ s; PulseRepetitionTime = 4 600 μ s.

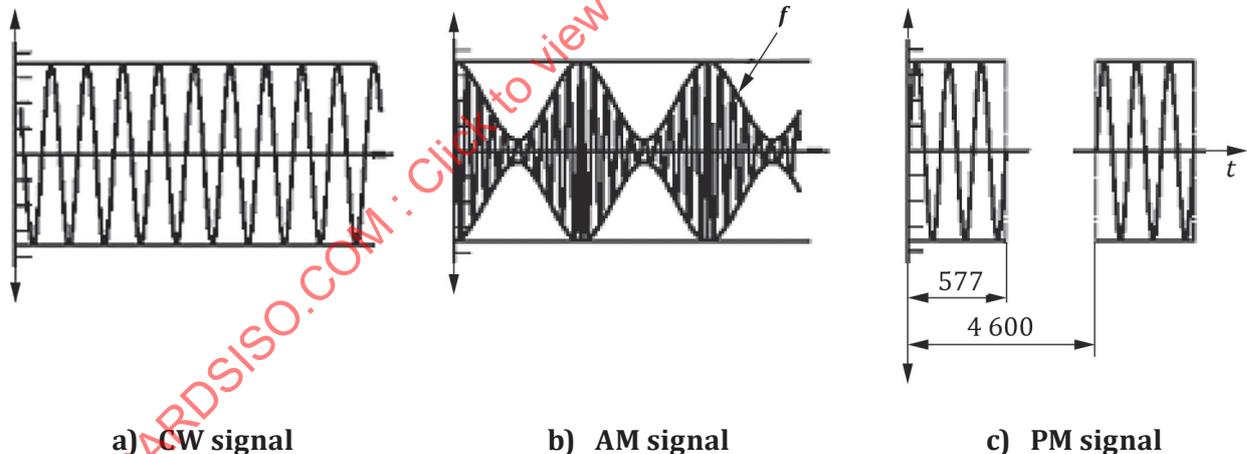


Figure 27 — Different types of modulation

10.6.4.3 RI 01: Immunity with antenna

10.6.4.3.1 General

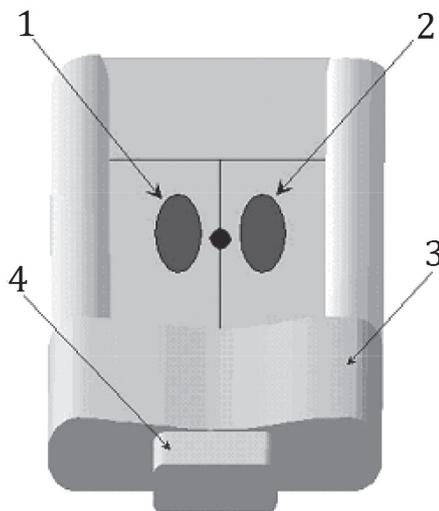
The DUT shall be subjected to radiated immunity testing using an antenna for field generation in accordance with ISO 11452-2 (with ground plane), with changes as defined in this document (substitution method).

10.6.4.3.2 Test location

In accordance with ISO 11452-2, the test location shall be an absorber-lined shielded enclosure.

10.6.4.3.3 Test set-up

In accordance with ISO 11452-2, only a resonator pair can be tested for CPOD compatibility. The resonator pair shall meet the requirements of ISO/TS 22239-1:—, Annex B. It shall be positioned on the CPOD passenger seat in forward-facing orientation (right resonator on passenger seat's right side, left resonator on passenger seat's left side; see [Figure 28](#)).



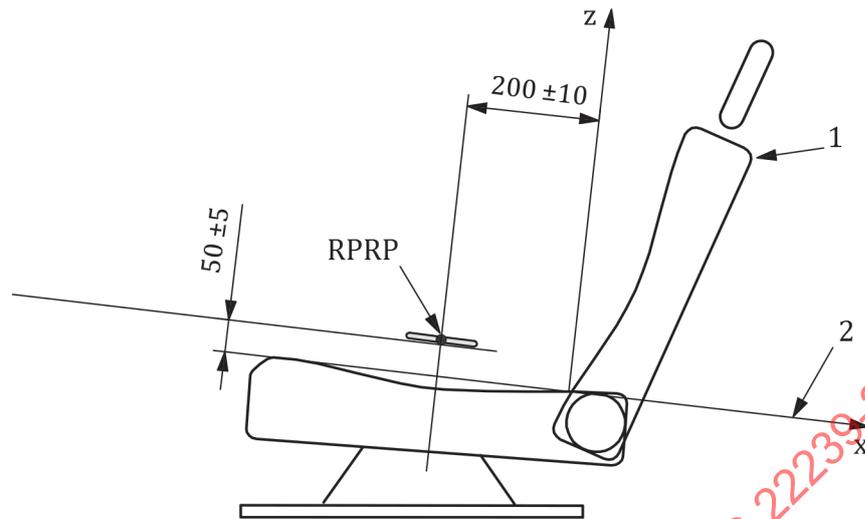
Key

- 1 left resonator
- 2 right resonator
- 3 backrest
- 4 headrest

Figure 28 — Resonator positioning on passenger seat (top view)

In addition, the location of the RPRP shall be equal to $(x, y, z) = [(-200 \pm 10) \text{ mm}, (0 \pm 5) \text{ mm}, (50 \pm 5) \text{ mm}]$ within the passenger seat's reference coordinate system (see ISO/TS 22239-1 for reference coordinate system definition). The bottom of the resonators shall be in parallel to the reference coordinate system's x-y plane (see [Figure 29](#)). The torso angle shall be adjusted to $(27 \pm 5)^\circ$.

Dimensions in millimetres

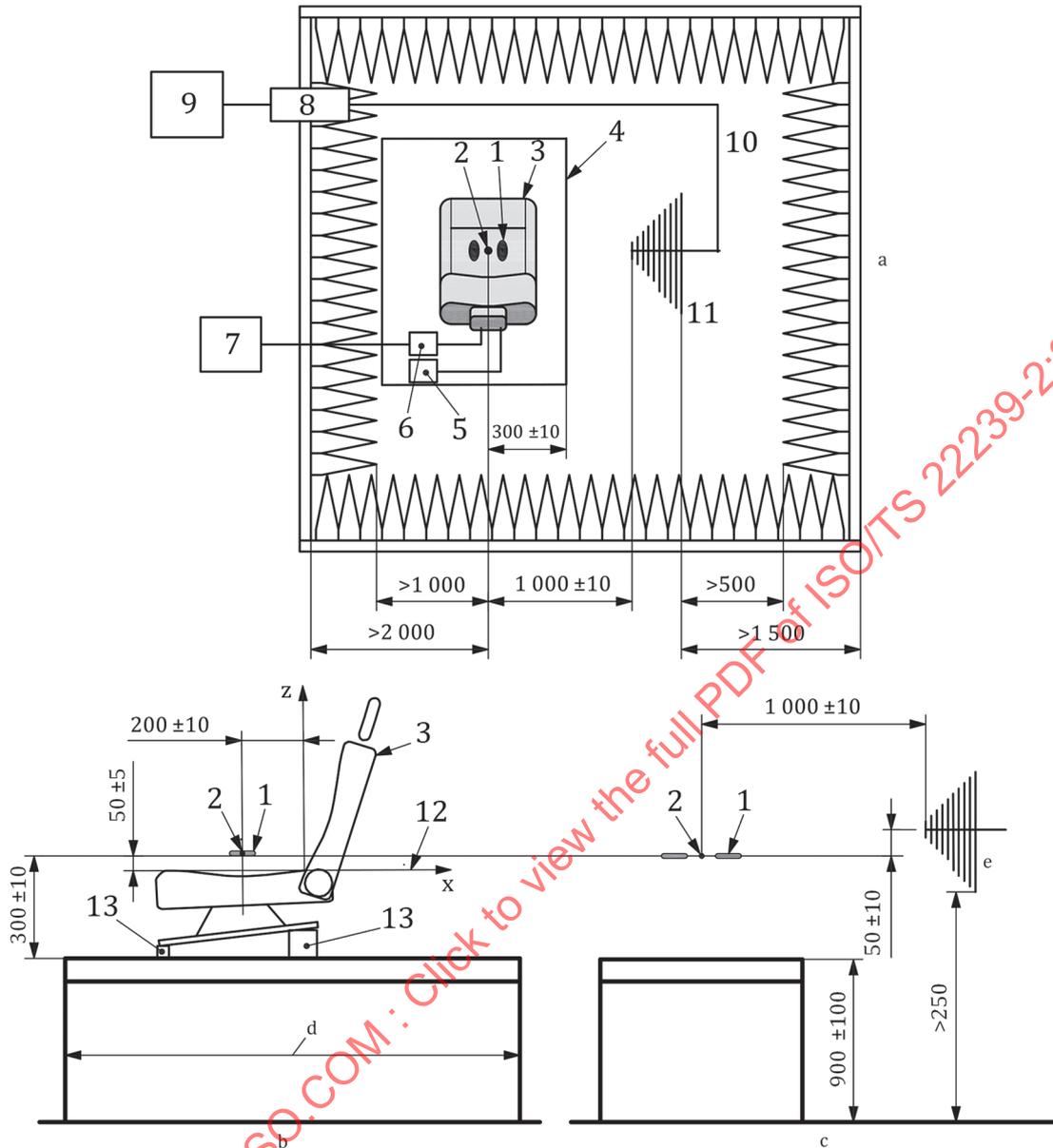
**Key**

- 1 CPOD passenger seat
- 2 reference coordinate system

Figure 29 — Resonator positioning on passenger seat (side view)

[Figures 30](#) and [31](#) show different examples of the complete test set-up.

Dimensions in millimetres

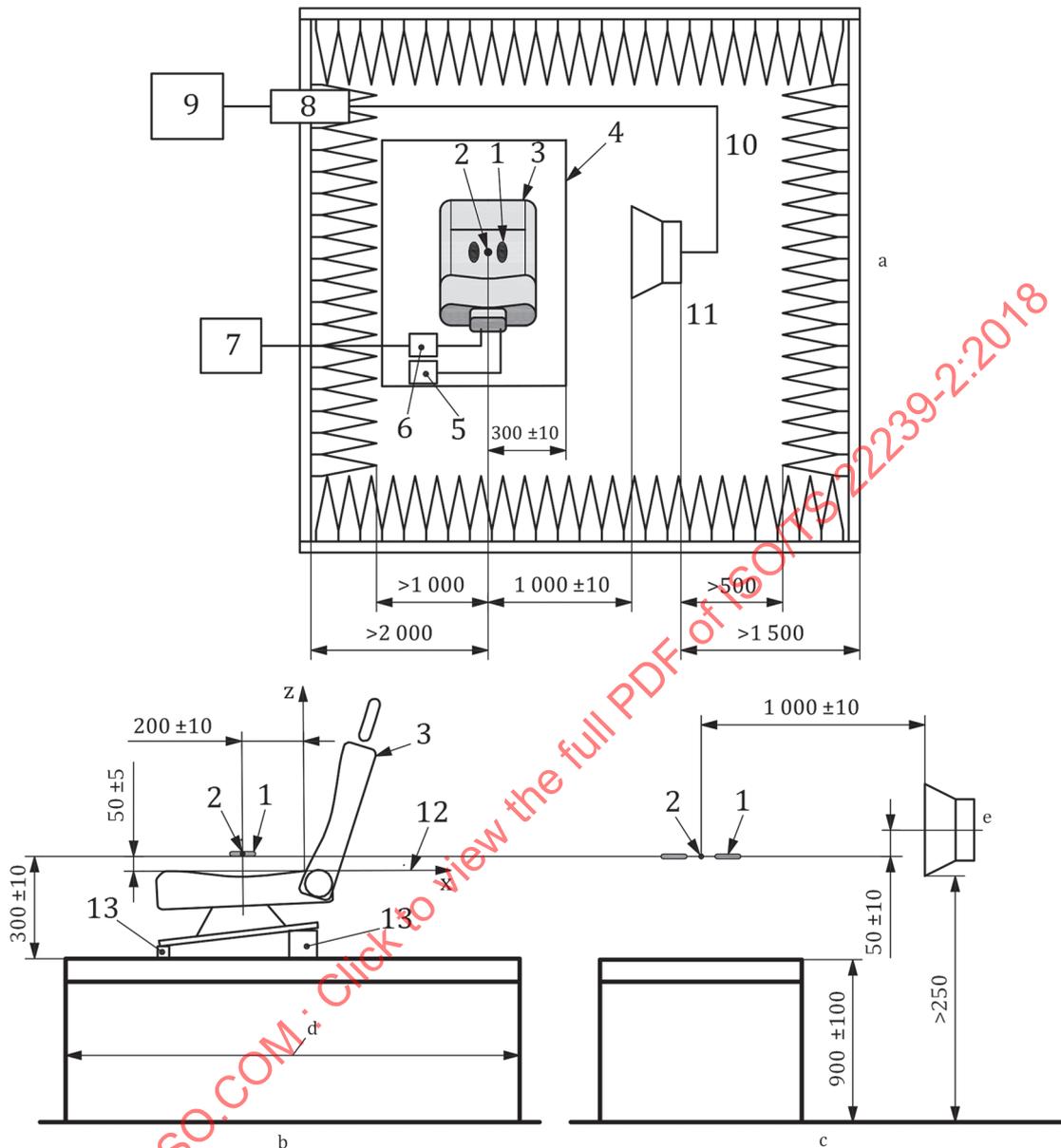


Key

- | | |
|---|--|
| 1 resonator pair under test | 10 high quality double shielded coaxial cable (50 Ω) |
| 2 RPRP | 11 high quality double shielded coaxial cable (50 Ω) |
| 3 CPOD-compatible passenger seat | 12 passenger seat reference coordinate system |
| 4 ground plane (bonded to shielded enclosure) | 13 support |
| 5 power supply, typical voltage | a Upper view (horizontal polarized). |
| 6 converter, e.g. K-line to optical | b Side view. |
| 7 monitoring system | c Front view. |
| 8 bulkhead connector | d See ISO 11452-2. |
| 9 RF signal generator and amplifier | e Vertical polarized. |

Figure 30 — Antenna set-up <1 GHz

Dimensions in millimetres



Key

- | | |
|---|--|
| 1 resonator pair under test | 10 high quality double shielded coaxial cable (50 Ω) |
| 2 RPRP | 11 horn antenna |
| 3 CPOD-compatible passenger seat | 12 passenger seat reference coordinate system |
| 4 ground plane (bonded to shielded enclosure) | 13 support |
| 5 power supply, typical voltage | a Upper view (horizontal polarized). |
| 6 converter, e.g. K-line to optical | b Side view. |
| 7 monitoring system | c Front view. |
| 8 bulkhead connector | d See ISO 11452-2. |
| 9 RF signal generator and amplifier | e Vertical polarized. |

Figure 31 — Antenna set-up >1 GHz

Deviating from ISO 11452-2, the phase centre of the antennae shall be in line with the DUT for the complete frequency range.

The detection state delivered by the CPOD passenger seat shall be monitored outside the shielded enclosure. Thus, the optical converter to be used depends upon the data interface featured by the CPOD passenger seat (e.g. K-Line to optical, LIN to optical).

10.6.4.3.4 Test parameters

Use the appropriate antenna for each frequency range and mention it in the test report.

Minimum dwell time is determined by the maximum duration that might be needed by the sensor in the CPOD passenger seat to indicate a change in the detected state. This duration shall be determined before testing and shall include qualification times (if qualification cannot be switched off), etc.:

- continuous wave (CW): no modulation;
- amplitude modulation (AM): 1 kHz sine wave at 80 %, peak CW = peak AM;
- pulse modulation (PM): GSM-Modulation.

10.6.4.3.5 Requirements and test levels

Table 34 — Antenna settings

Range MHz	Log. step %	Level V/m	Modulation	Class
Vertical polarization				
200 to 520	1	150	CW, AM	A
520 to 800	1	70	CW, AM	A
800 to 1 000	1	70	CW, PM	A
1 000 to 1 200	0,5	70	CW, PM	A
1 200 to 1 400	0,5	150	CW, PM	A
1 400 to 2 700	0,5	70	CW, PM	A
2 700 to 3 200	0,5	150	CW, PM	A
Horizontal polarization				
400 to 520	1	150	CW, AM	A
520 to 800	1	70	CW, AM	A
800 to 1 000	1	70	CW, PM	A
1 000 to 1 200	0,5	70	CW, PM	A
1 200 to 1 400	0,5	150	CW, PM	A
1 400 to 2 700	0,5	70	CW, PM	A
2 700 to 3 200	0,5	150	CW, PM	A

10.6.4.4 RI 02: Immunity with TEM cell

10.6.4.4.1 General

The DUT shall be subjected to radiated immunity testing using a transverse electromagnetic (TEM) cell in accordance with ISO 11452-3, for testing over the frequency range of 1 MHz to 200 MHz.

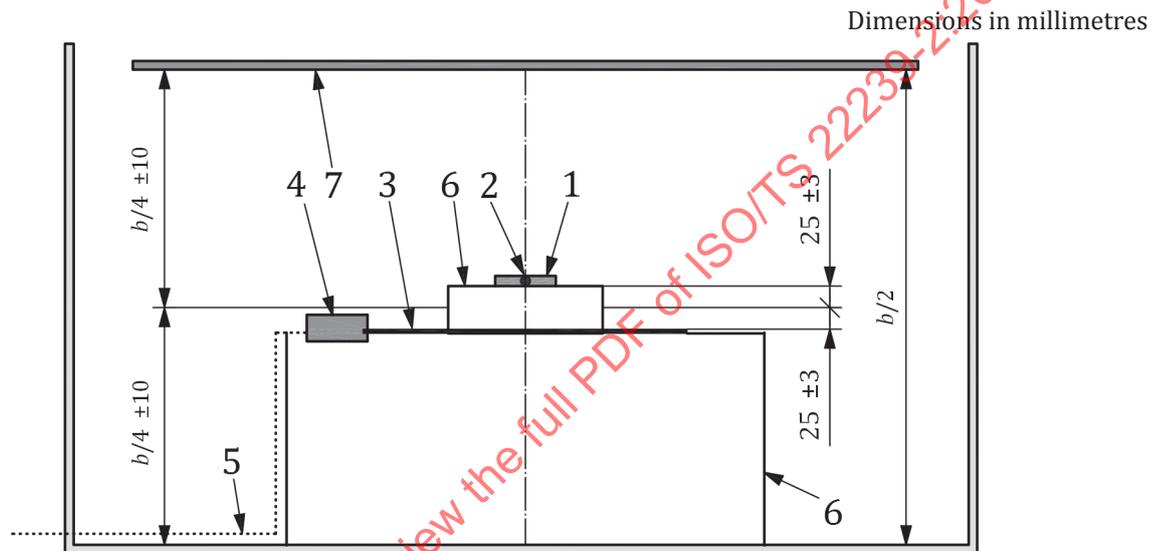
10.6.4.4.2 TEM cell

A TEM cell in accordance with ISO 11452-3 shall be used, with dimensions, $b \geq 56$ cm, $l \geq 60$ cm and $w \geq 60$ cm.

10.6.4.4.3 Test set-up

The test set-up shall be in accordance with ISO 11452-3.

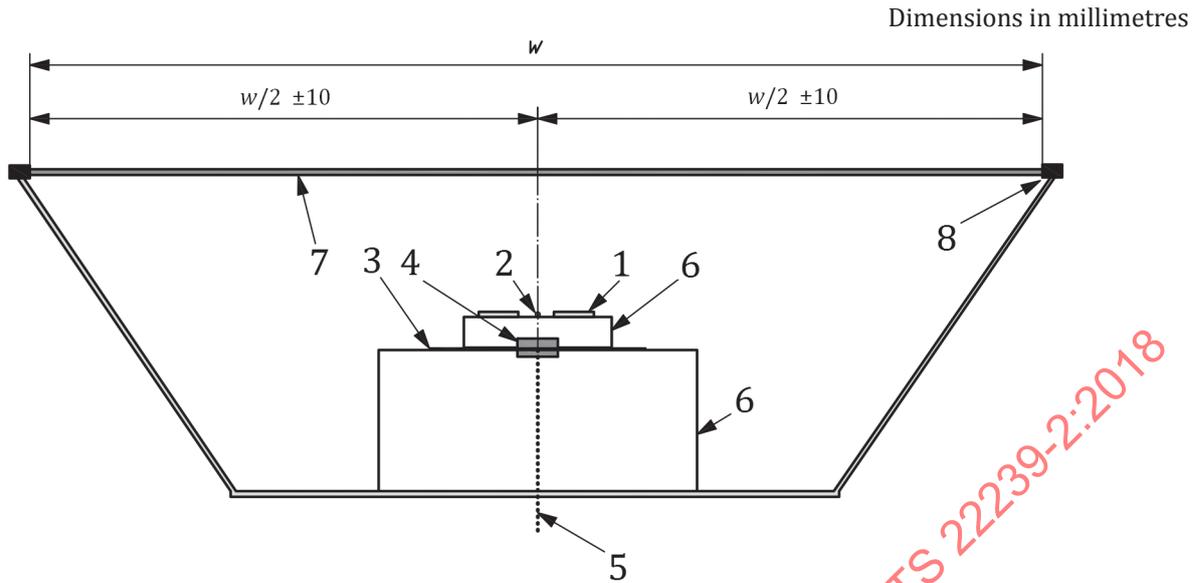
Due to the limited space, instead of using a complete CPOD passenger seat, only a CPOD-compatible sensor shall be positioned in the TEM cell together with resonators to be tested. [Figures 32](#) and [33](#) show the test set-up which applies.



Key

- 1 resonator pair under test
- 2 RPRP
- 3 CPOD sensor (antennae)
- 4 CPOD sensor (electronics)
- 5 CPOD sensor cable harness
- 6 dielectric support (relative permittivity $\epsilon_r \leq 1,4$)
- 7 septum
- b height of TEM cell

Figure 32 — TEM cell set-up (longitudinal view)



Key

- 1 resonator pair under test
- 2 RPRP
- 3 CPOD sensor (antennae)
- 4 CPOD sensor (electronics)
- 5 CPOD sensor cable harness
- 6 dielectric support (relative permittivity $\epsilon_r \leq 1,4$)
- 7 septum
- w length of TEM cell

Figure 33 — TEM cell set-up (side view)

The CPOD sensor shall be positioned in such a manner that the centre of the antenna structure is located right below RPRP, while the position of RPRP follows the specifications in [Figures 32](#) and [33](#).

10.6.4.4.4 Test parameters

Minimum dwell time is determined by the maximum duration that might be needed by the CPOD sensor to indicate a change in the detected state. This duration shall be determined before testing and shall include qualification times (if qualification cannot be switched off), etc.:

- continuous wave (CW): no modulation;
- amplitude modulation (AM): 1 kHz sine wave at 80 %, peak CW = peak AM.

10.6.4.4.5 Requirements and test levels

Table 35 — TEM cell settings

Range MHz	Log. step %	Level V/m	Modulation	Class
1 to 30	1	150	CW, AM	A
30 to 54	1	150	CW, AM	A
54 to 65	1	70	CW, AM	A
65 to 88	1	150	CW, AM	A

Table 35 (continued)

Range MHz	Log. step %	Level V/m	Modulation	Class
88 to 140	1	70	CW, AM	A
140 to 180	1	150	CW, AM	A
180 to 200	1	70	CW, AM	A

10.7 Electrostatic discharge (ESD) test

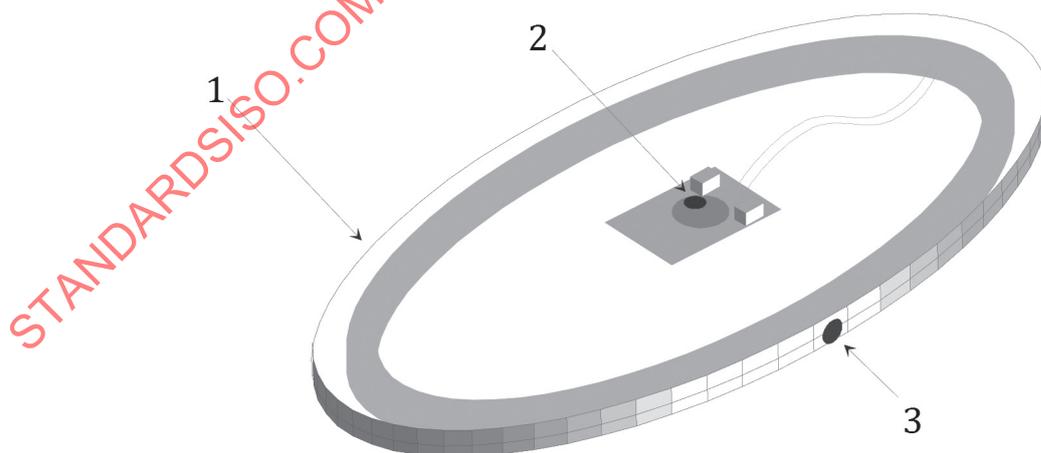
10.7.1 Test parameters

Table 36 — Test parameters

Parameter	Requirement
Test method	In accordance with ISO 10605
Number of samples	6 (3 “left” resonators; 3 “right” resonators)
Number of discharge locations	5
Test temperature	(23 ± 5) °C
Relative humidity	20 % to 60 %
Human body model	-330 pF/330 Ω (powered-up test) -150 pF/330 Ω (unpowered test)
Functional state	No deviations allowed before and after test; deviations during discharges are allowed (applies to powered test)

10.7.2 Discharge locations

At least five different discharge locations shall be defined for the resonators and documented in the test plan. The discharge location selection shall focus on points where discharges on the resonator electronics or on the coil could be possible and where discharges would be most critical (see examples in [Figure 34](#)).



Key

- 1 encapsulation/housing
- 2 location above electronics
- 3 possible access to coil for discharge

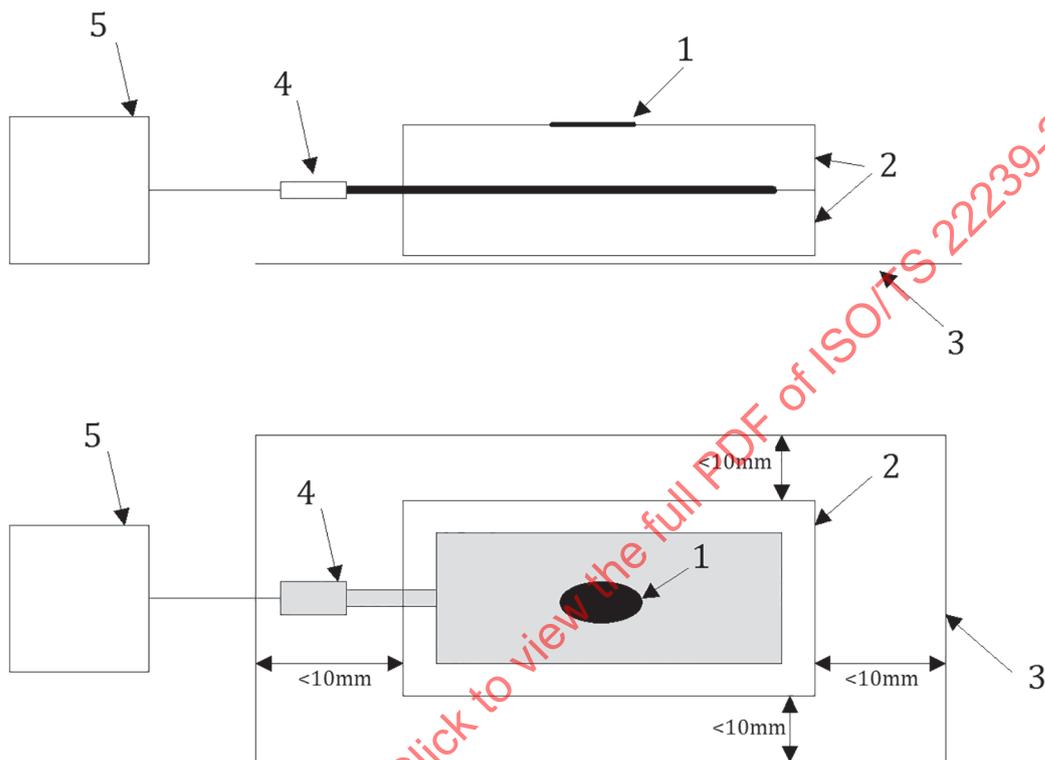
Figure 34 — Example of selection of discharge locations

10.7.3 Powered-up test

The powered-up ESD test shall be performed in accordance with ISO 10605 with the following deviations and definitions.

The resonator is activated (operating state C) by the CPOD compatible sensor between the two isolating blocks. The CPOD sensor is connected to an evaluation unit, e.g. a PC, which is able to read out the detected resonator information (sub carrier signal, resonator type).

Dimensions in millimetres



Key

- 1 transponder under test
- 2 5 cm isolating blocks according to ISO 10605
- 3 HCP according to ISO 10605
- 4 CPOD compatible sensor
- 5 evaluation unit (e.g. PC)

Figure 35 — Test setup powered-up test (side and top view)

The powered-up ESD test shall be performed in accordance with ISO 10605 at each voltage specified in Table 37 and at each location defined in chapter 10.7.1. For the powered-up test, the 330 pF/330 Ω capacitor probe shall be used.

Table 37 — Powered-up ESD test parameters

Type of discharge	Discharge voltage					Minimum number of discharges per voltage and polarity ^a
	kV					
Contact discharge ^b	±4	±8	±15	—		10
Air discharge	±4	±8	±15	±20	±25	10

^a The minimum time duration between two successive discharges is 5 s.
^b Contact discharge applies only if resonator contains of conductive materials accessible from outside.

The resonator under test shall return to normal operation immediately after a discharge. The functional state of the resonators shall be determined by evaluating the data delivered by the CPOD sensor. It shall be ensured that functional degradation of a resonator during testing is detected instantaneously (e.g. by deactivating state qualification in the CPOD sensor).

10.7.4 Packaging and handling test (unpowered test)

Follow ISO 10605:2008, Clause 9. The test shall be done without static dissipative material between resonator under test and HCP. For the packaging and handling test, the 150 pF/330 Ω capacitor probe shall be used. The resonator under test shall be step-stressed in accordance with the voltages specified in [Table 38](#).

Table 38 — Unpowered ESD test parameters

Type of discharge	Discharge voltage			Minimum number of discharges per voltage and polarity ^a
	kV			
Contact discharge ^b	±4	±6	±8	3
Air discharge	±4	±15	±25	3

^a The minimum time duration between two successive discharges is 5 s.
^b Contact discharge applies only if resonator contains of conductive materials accessible from outside.

Functional performance shall be verified by parametric measurements in accordance with [10.4.1](#) before the start and after completion of the test. Measured parameters shall meet the limits of this document.

10.8 Magnetic field stress test

10.8.1 Test parameters

Table 39 — Test parameters

Parameter	Requirement
Number of samples	4 (2 “left” resonators; 2 “right” resonators)
Test temperature	(23 ± 5) °C
Continuous stress duration	1 min
Continuous stress field strength	$H_{MAX,CONT}$
Pulsed stress duration	2 min
Pulsed stress field strength	$H_{MAX,PULSED}$
Transmitting frequency	max_freq($H_{OP,MAX}$); see following test procedure
Operational state	B
Parameter check	parameter test before/after the test in accordance with 10.4.1

10.8.2 Test procedure

Perform the resonator compatibility test in accordance with [Clause 9](#). Push the button “Pulsed Stress” and wait for the end of the pulsed stress test. Push the button “Constant Stress” and wait for the end of the constant stress test.

10.8.3 Acceptance criteria

Functional performance shall be verified by parametric measurements before the start and after completion of the test. Measured parameters shall meet the limits of this document.

10.9 Qualification flow chart

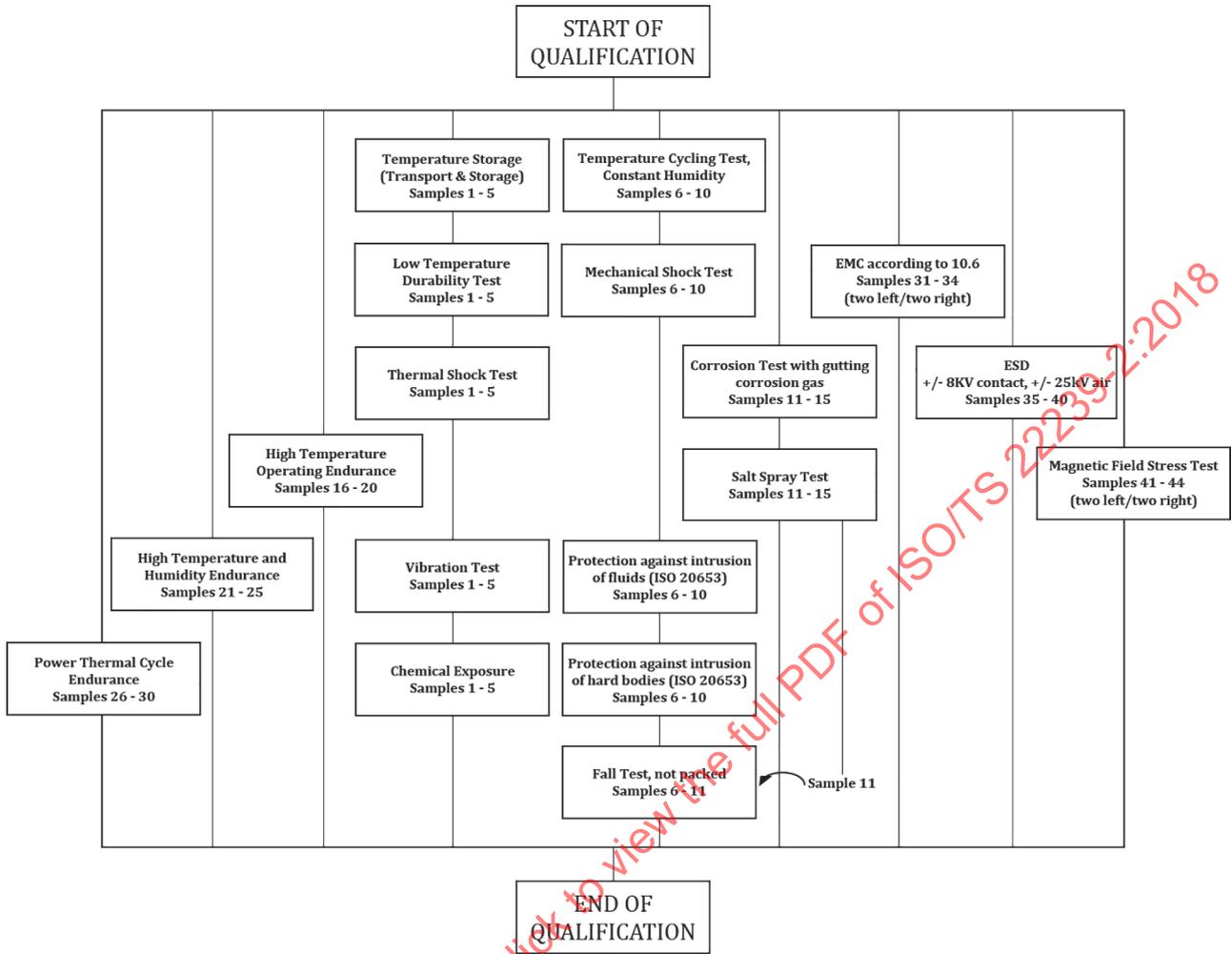


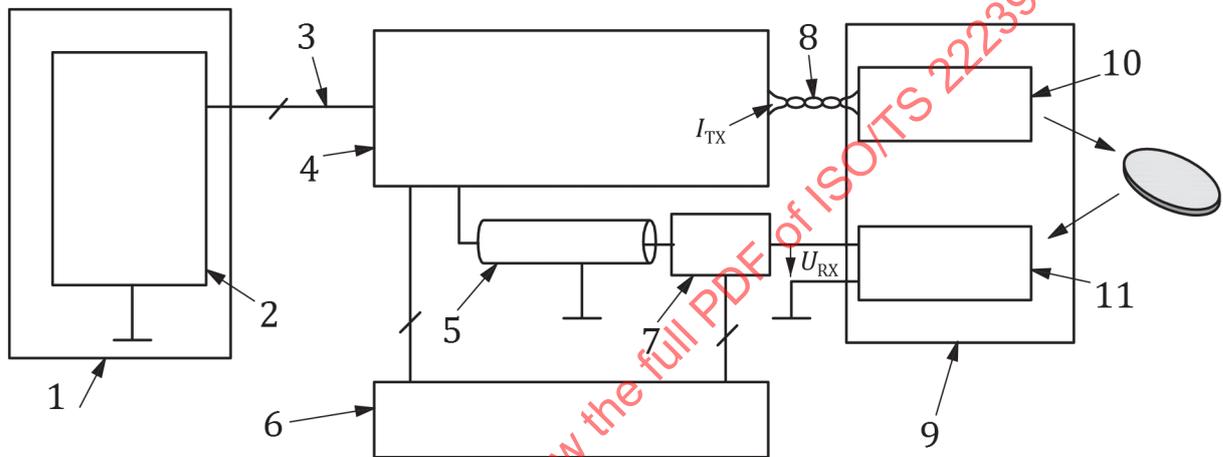
Figure 36 — Qualification flow chart

Annex A (normative)

CPOD resonator compatibility test set-up

A.1 Structure

The CPOD resonator compatibility test set-up consists of different components, as indicated in [Figure A.1](#).



Key

1	PC	7	buffer
2	PC card NI PCI-6115	8	twisted pair (<math><1\text{ m}</math>)
3	connection cable SH68-68-EP (NI)	9	antenna structure
4	interface electronics	10	transmitting antenna
5	coax <math><1\text{ m}</math> (RG174 or equivalent)	11	receiving antenna
6	power supply		

Figure A.1 — Different components of resonator compatibility test set-up

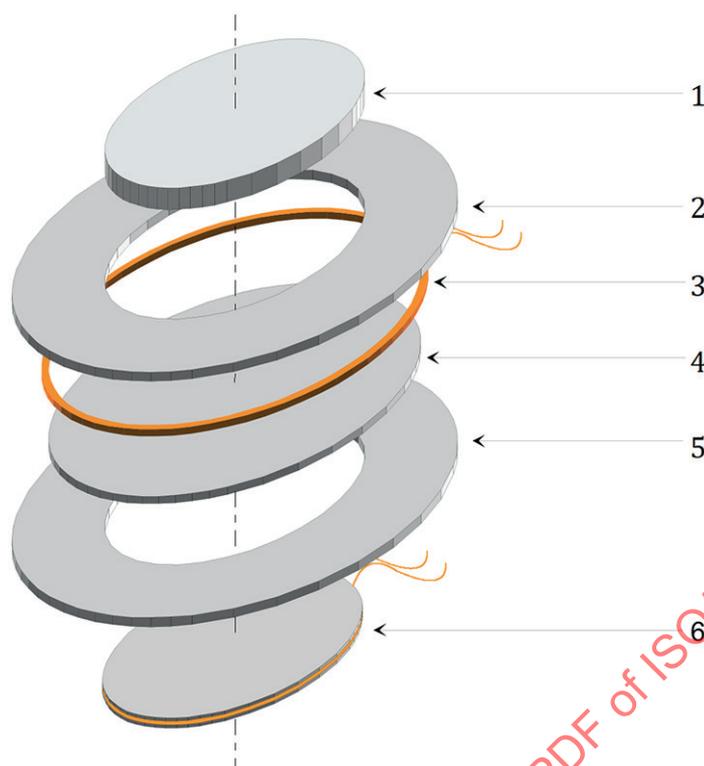
Transmitting and receiving antennae are combined in one defined structure, as indicated by the “exploded” drawing in [Figure A.2](#).

The NI PCI-6115¹⁾ PC card shall be used to control the current source, to measure the transmitting current and to measure the voltage induced in the resonator probe as part of the antenna structure. A Windows²⁾-based PC shall be used. For the connection between interface electronics and PC cards, shielded cable NI SH68-68-EP³⁾ shall be used.

1) NI PCI-6115 is the tradename of a product supplied by National Instruments. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of the product named. Equivalent products may be used if they can be shown to lead to the same results.

2) Windows is the tradename of a product supplied by Microsoft. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of the product named. Equivalent products may be used if they can be shown to lead to the same results.

3) NI SH68-68-EP is the tradename of a product supplied by National Instruments. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of the product named. Equivalent products may be used if they can be shown to lead to the same results.

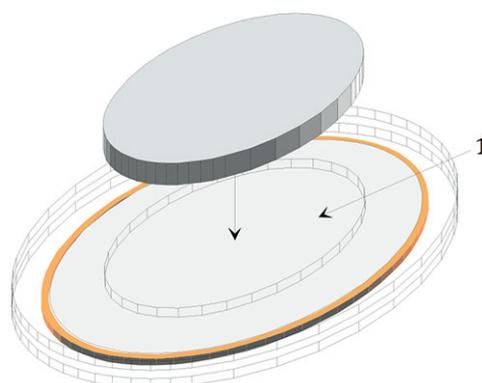


Key

- 1 resonator
- 2 upper transmitting antenna cover
- 3 transmitting antenna
- 4 spacer
- 5 lower transmitting antenna cover
- 6 resonator probe

Figure A.2 — Exploded drawing of resonator compatibility test set-up antenna structure

[Figure A.3](#) shows the top view of the antenna structure.



Key

- 1 resonator box-out

Figure A.3 — Resonator compatibility test set-up antenna structure (top view)

[Figure A.4](#) shows the bottom view of the antenna structure.

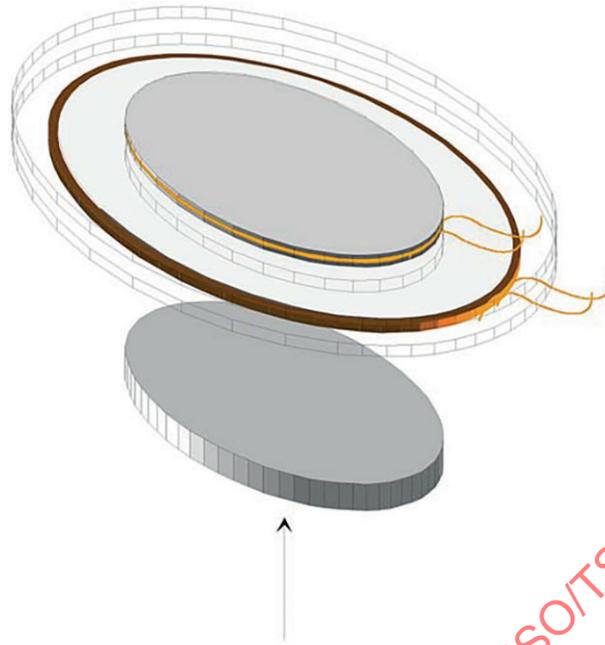
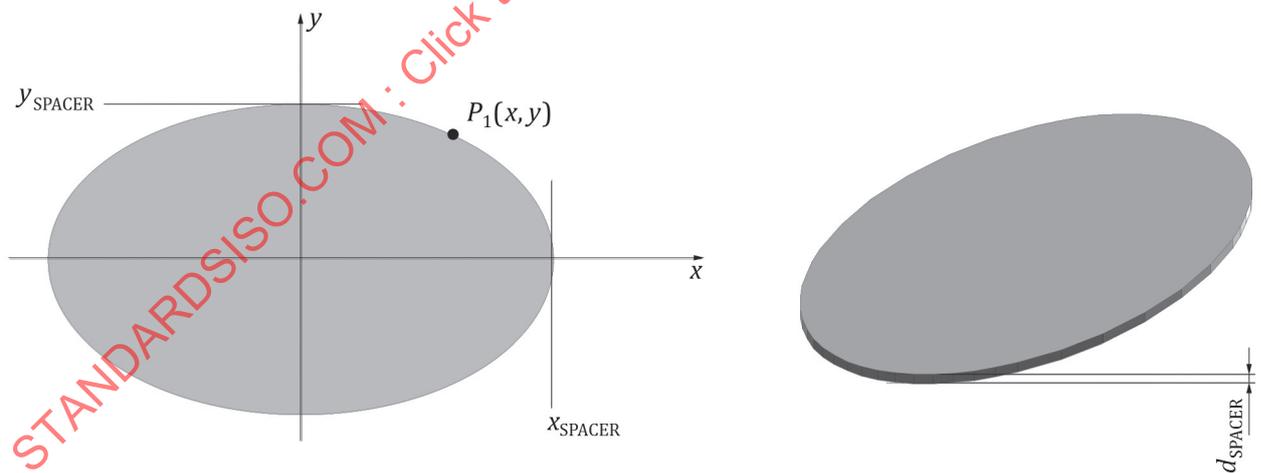


Figure A.4 — Resonator compatibility test set-up antenna structure (bottom view)

A.2 Dimensions

A.2.1 Spacer

The spacer serves as a mechanical carrier for the transmitting antenna and realizes the necessary gap between both transmitting antenna covers.



Key

$P_1(x,y)$ position vector [determined according to [Formula \(A.1\)](#)]

Figure A.5 — Resonator compatibility test set-up antenna structure (top view)

The position vectors of the outer shape of the spacer are described by [Formula \(A.1\)](#):

$$P(x,y) = \left(\frac{x}{x_{SPACER}} \right)^2 + \left(\frac{y}{y_{SPACER}} \right)^2 = 1 \tag{A.1}$$