
**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



Reference number
ISO/TS 22239-2:2018(E)

AVA Documents
Document Sharing Hub
© ISO 2018



COPYRIGHT PROTECTED DOCUMENT

© ISO 2018

All rights reserved. Unless otherwise specified, or required in the context of its implementation, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

Page

Foreword	v
1 Scope	1
2 Normative references	1
3 Terms and definitions	1
4 CPOD resonator components	2
5 Coil requirements	2
6 Electrical properties	3
6.1 Digital resonator protocol	3
6.2 Subcarrier bitstream	5
6.3 Modulation	7
6.3.1 General	7
6.3.2 Useful resonator signal, $\Phi_{\text{RESO,NORM}}(t)$	8
6.3.3 Lowpass filtering	11
6.3.4 Spectral contents of $\Phi_{\text{RESO,NORM}}(t)$	11
6.3.5 The useful signal, $\theta(f_{\text{TX}}, H_{\text{TX}})$	13
6.3.6 The useful signal power, $P_{\theta}(f_{\text{TX}}, H_{\text{TX}})$	13
6.3.7 Noise power, $P_{\text{NOISE}}(f_{\text{TX}}, H_{\text{TX}})$	13
6.3.8 The signal-to-noise ratio (SNR)	15
6.3.9 Definition of $W(H_{\text{TX}})$	15
6.3.10 Definition of $N(H_{\text{TX}})$	16
6.4 Modulation parameters	17
7 Resonator timing	19
7.1 General	19
7.2 Power-up	20
7.3 Reset	20
7.4 Relevant timing and reset parameters	21
8 Electrical and environmental parameters	22
8.1 Absolute maximum ratings	22
8.2 Operating ranges	23
8.3 Storage conditions	23
9 CPOD resonator compatibility test	23
10 Resonator environmental qualification	23
10.1 Application profile	23
10.2 Common test parameters	25
10.3 Operating states	25
10.3.1 General	25
10.3.2 Operating state A (transport and storage)	25
10.3.3 Operating state B (non-functional state)	25
10.3.4 Operating state C (functional state)	25
10.3.5 Operating state D (intermitting functional state)	26
10.4 Parametrical test and parameter checking	26
10.4.1 Parametrical test before/after every single test	26
10.4.2 Continuous parameter check	26
10.5 Qualification tests	26
10.5.1 General	26
10.5.2 Acceptance criteria	26
10.5.3 Temperature storage (transport and storage)	26
10.5.4 Low temperature durability test	27
10.5.5 High temperature operating endurance test	27
10.5.6 Power thermal cycle endurance (PTCE)	28
10.5.7 Thermal shock test	29

10.5.8	Temperature cycling test, constant humidity	30
10.5.9	High temperature and humidity endurance (HTHE)	31
10.5.10	Vibration test	31
10.5.11	Mechanical shock test	33
10.5.12	Fall test, not packed	34
10.5.13	Protection against intrusion of hard bodies	34
10.5.14	Protection against intrusion of fluids	35
10.5.15	Corrosion test with gutting corrosion gas	35
10.5.16	Salt spray test	36
10.5.17	Resistance to chemical substances	36
10.6	Electromagnetic compatibility (EMC) test	38
10.6.1	General	38
10.6.2	Functional status qualification	38
10.6.3	Acceptance criteria	39
10.6.4	Community	39
10.7	Electrostatic discharge (ESD) test	47
10.7.1	Test parameters	47
10.7.2	Discharge locations	47
10.7.3	Powered-up test	48
10.7.4	Packaging and handling test (unpowered test)	49
10.8	Magnetic field stress test	49
10.8.1	Test parameters	49
10.8.2	Test procedure	49
10.8.3	Acceptance criteria	49
10.9	Qualification flow chart	50
Annex A (normative) CPOD resonator compatibility test set-up		51
Annex B (normative) CPOD resonator compatibility test parameters		56
Annex C (normative) Continuous parameter check		59
Annex D (normative) CPOD reference resonator		62

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.

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

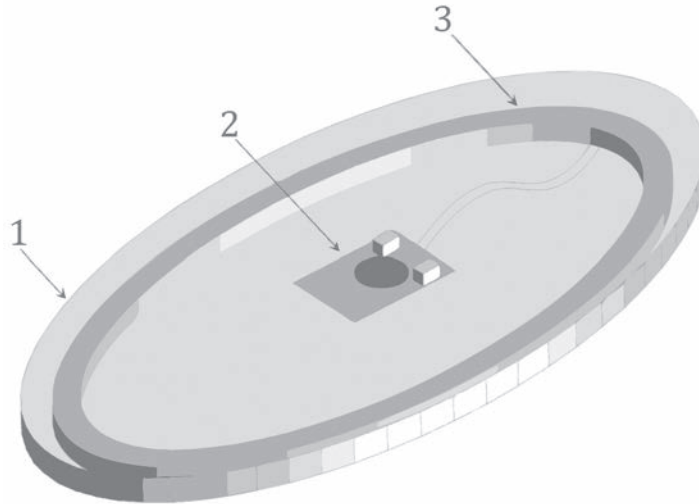
For the purposes of this document, the terms and definitions given in ISO/TS 22239-1 apply.

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.



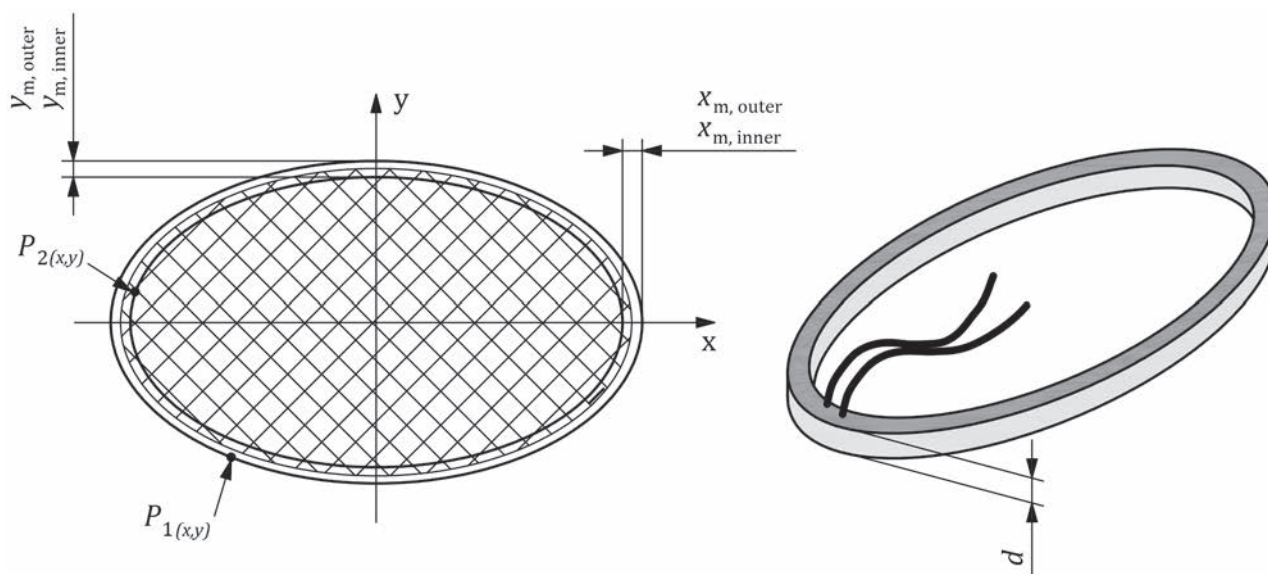
Key

- 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](#):

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

Table 1 — Coil geometry parameters

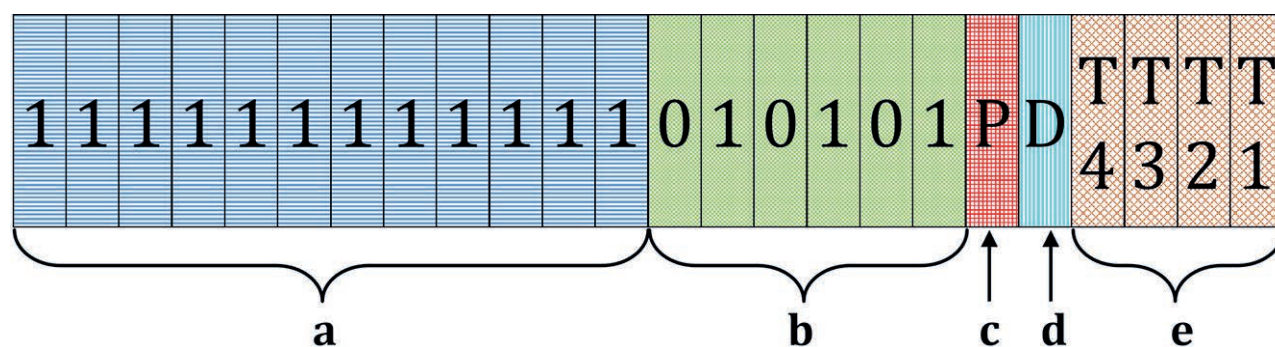
Dimensions in millimetres, measured at 25 °C

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](#)).

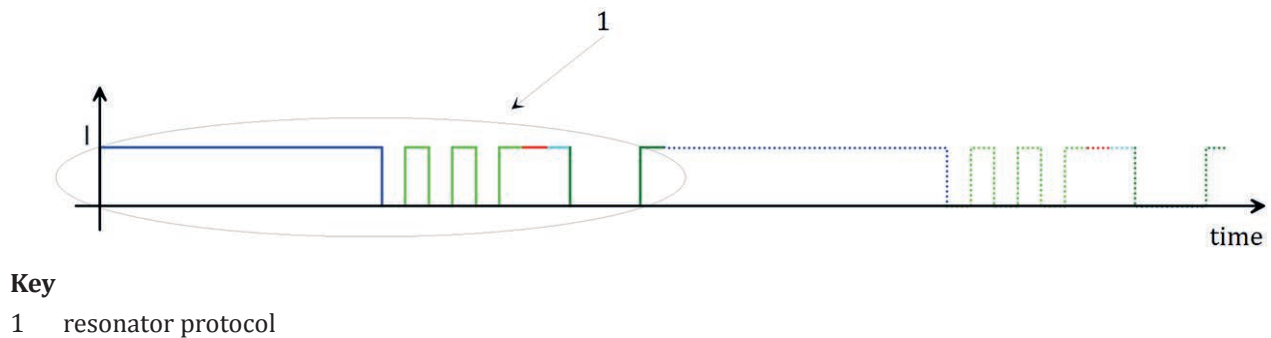


Figure 4 — Cyclical sending of the resonator protocol

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	$f_{\text{data, left}}$	$f_{\text{TX}}/40/8 = f_{\text{TX}}/320$
right	$f_{\text{data, right}}$	$f_{\text{TX}}/56/8 = f_{\text{TX}}/448$

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](#).

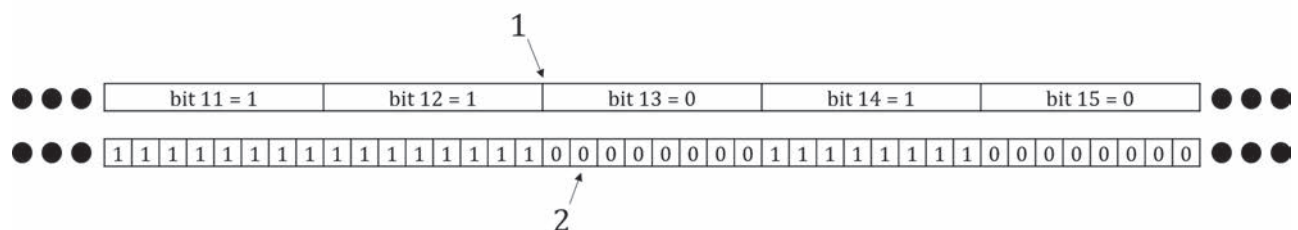
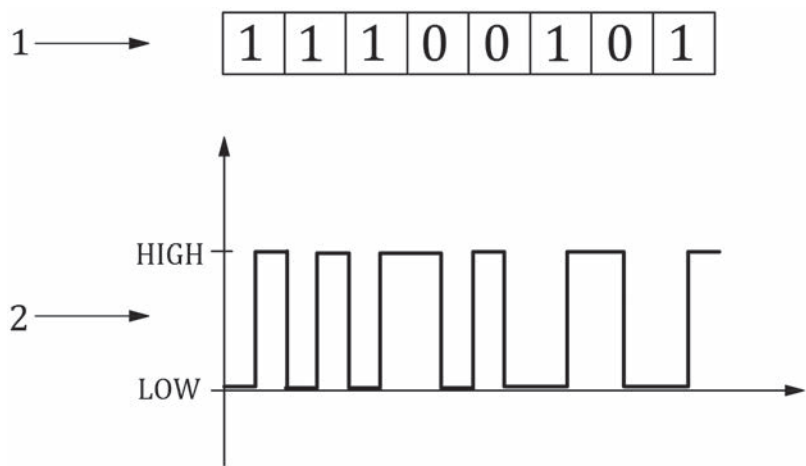


Figure 5 — Difference between original and resonator Manchester coding

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

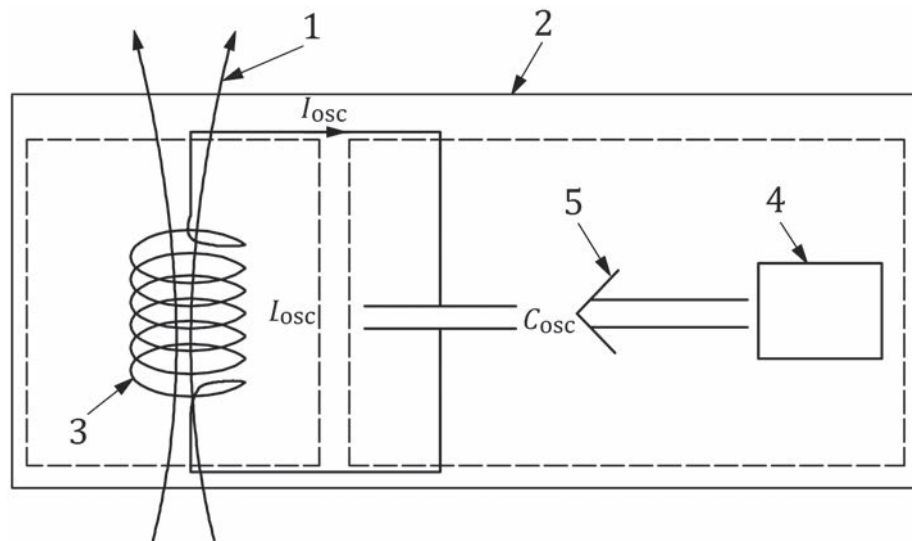
A subcarrier bit value of 1 shall cause a LOW to HIGH transition in the Manchester code pattern. A subcarrier bit value of 0 shall cause a HIGH to LOW transition on the Manchester pattern.

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 bitstream, 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 bitstream, 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](#).

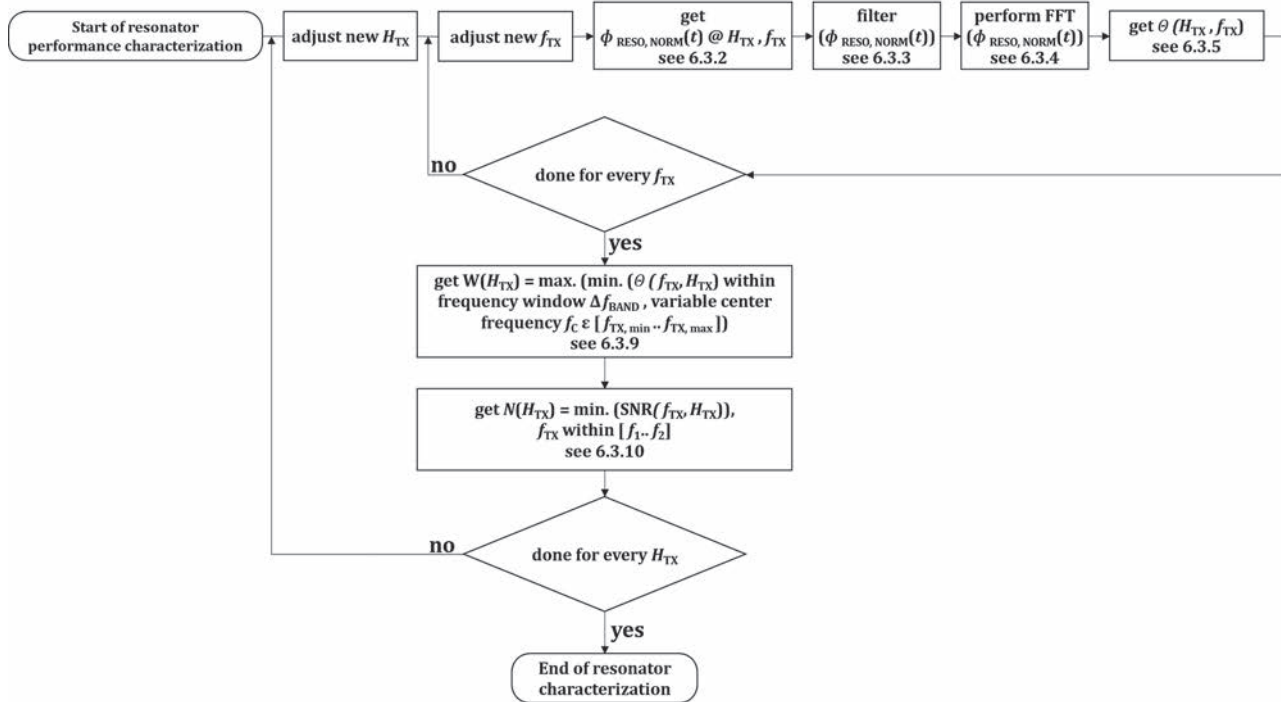
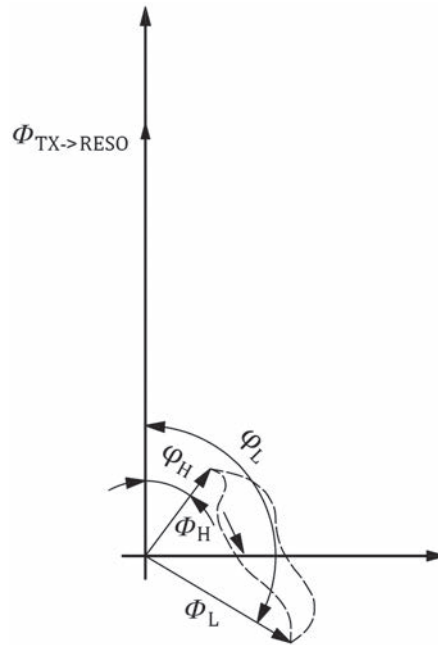


Figure 8 — Procedure to derive $W(H_{TX})$ and $N(H_{TX})$ for magnetic field strength, H_{TX}

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

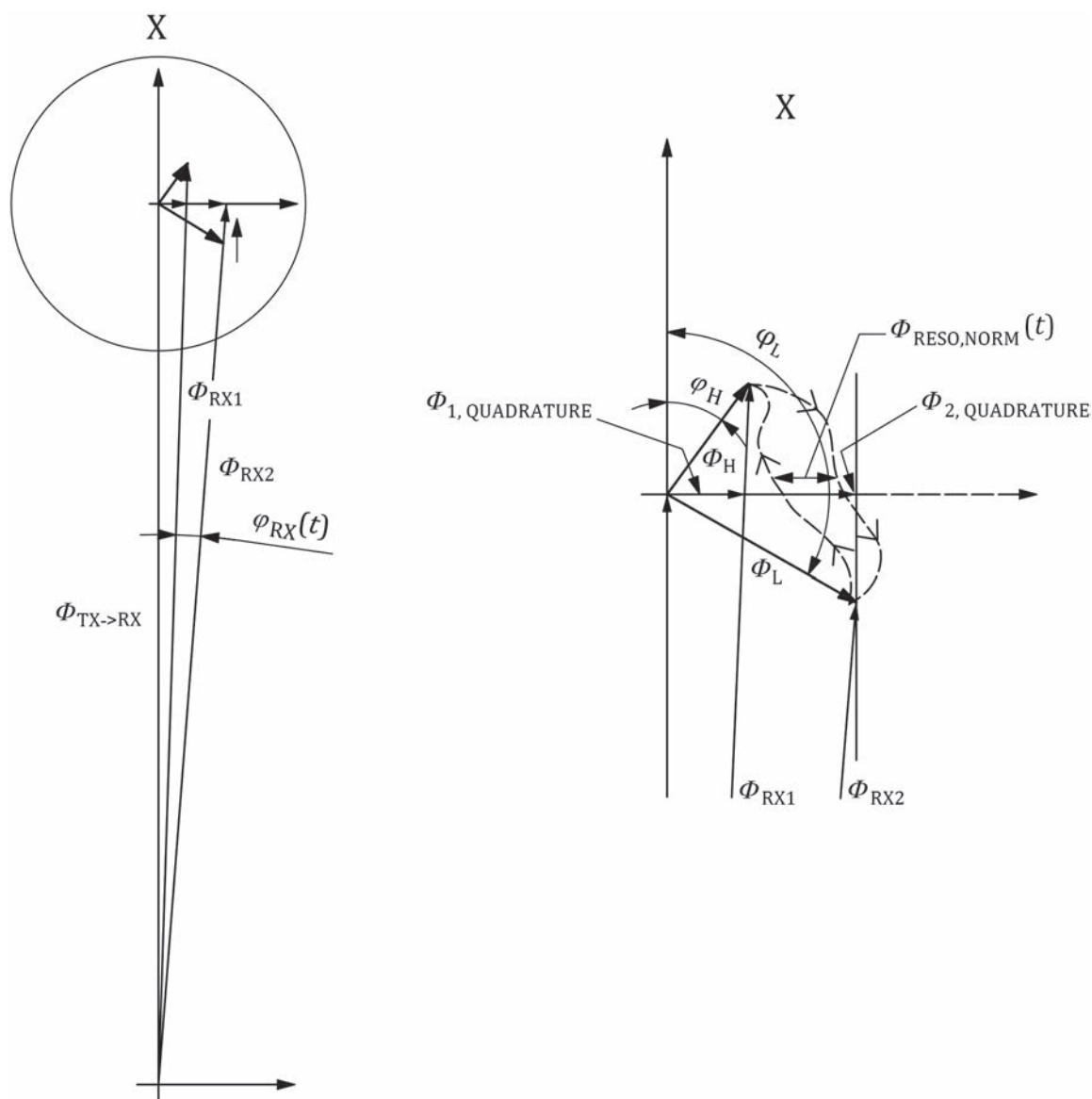
Since CPOD sensors usually have a high magnetic coupling between transmitting and receiving antennae, the useful resonator signal in the resonator magnetic field reduces to the component being perpendicular to the exiting magnetic transmitter field, which is also flooding the receiving antennae. The 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

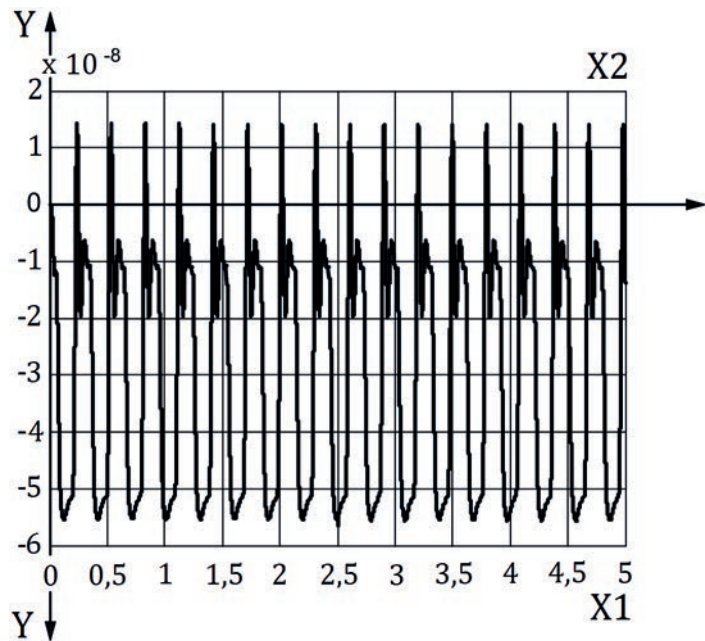
Before performing the Fast Fourier transform (FFT) on $\Phi_{\text{RESO,NORM}}(t)$, the signal shall be filtered by a third order lowpass filter since, usually, the influence of the harmonics on the demodulator output of the CPOD sensor can be neglected for frequency components above the 9th harmonic.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

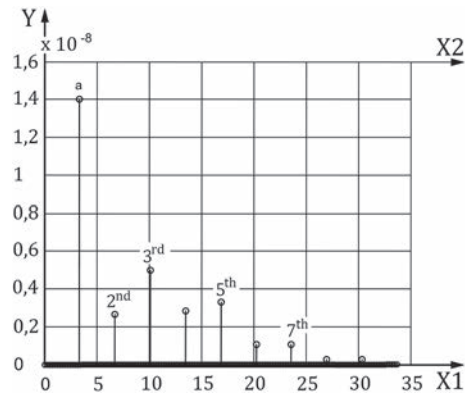
Although Manchester coded bitstream explained in [6.2](#) contains only two discrete states (HIGH and LOW), the transition in the magnetic flux generated by the resonator takes a certain transition time, as indicated by the dotted lines in [Figure 10](#). [Figure 11](#) shows an example for the $\Phi_{\text{RESO,NORM}}(t)$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

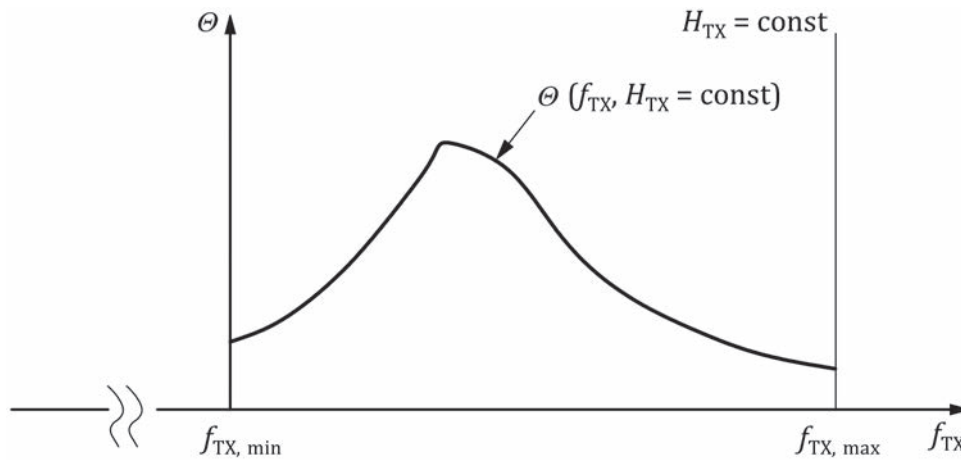


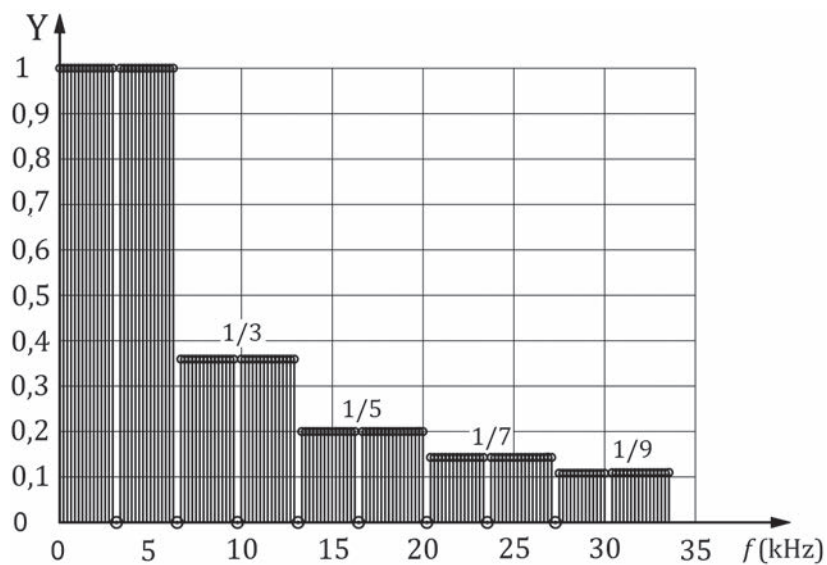
Figure 13 — Qualitative curve of $\theta(f_{TX}, H_{TX})$ for $H_{TX} = \text{const}$

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 $P_\theta(f_{TX}, H_{TX}) = \theta(f_{TX}, H_{TX})^2$.

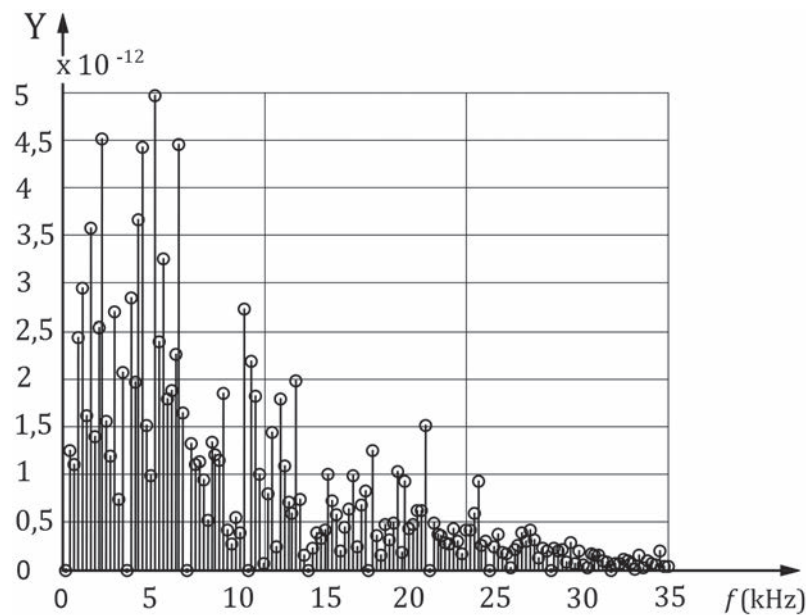
6.3.7 Noise power, $P_{\text{NOISE}}(f_{TX}, H_{TX})$

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 $\varphi_{RX}(t)$

**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.

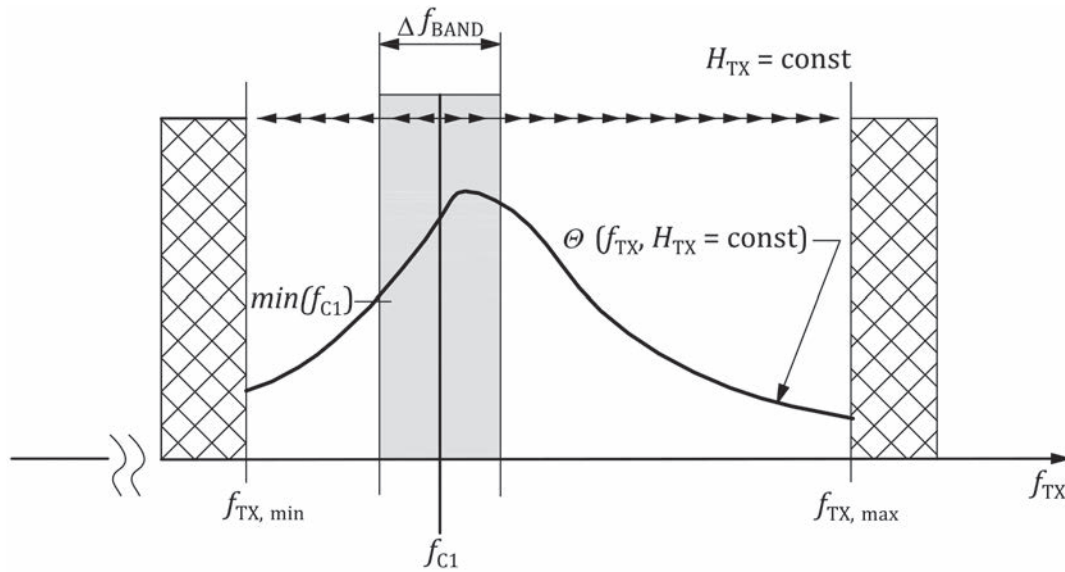


Figure 16 — Evaluation of $W(H_{TX})$ at a given transmitter field strength

$W(H_{TX})$ 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:

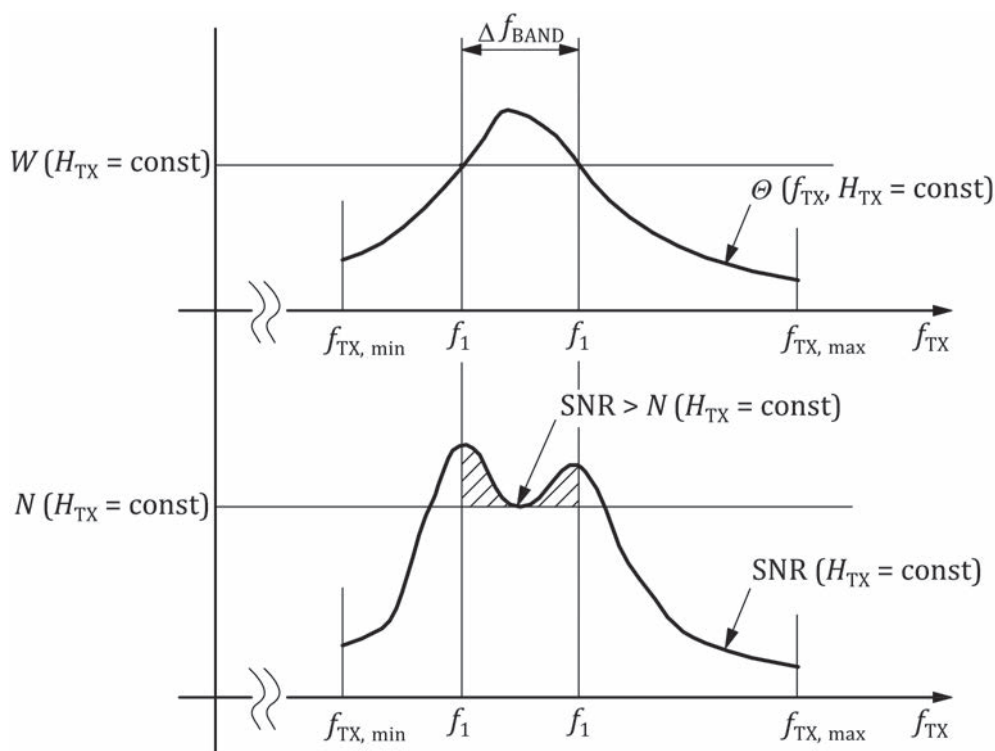
$$W(H = H_{TX}) = \max \left(\min \left\{ \Theta \left[f_C \varepsilon \left(f_C - \Delta f_{BAND} / 2 \dots f_C + \Delta f_{BAND} / 2 \right), H_{TX} \right] \right\} \right) \quad (6)$$

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}	$\Delta f_{\text{BAND}} = 2\,185\text{ kHz}$, measured in accordance with 6.3.9; measurement starts T_{STARTUP} after reset field gap	As defined in Figure 18	—
N_{synch}^a dB	$\Delta f_{\text{BAND}} = 2\,185\text{ kHz}$, 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}	$\Delta f_{\text{BAND}} = 2\,185\text{ kHz}$, 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	$\Delta f_{\text{BAND}} = 2\,185\text{ kHz}$, 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.