TECHNICAL SPECIFICATION

ISO/TS 22239-1

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

Part 1:
Specifications and test methods

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

Partie 1: Spécifications et méthodes d'essai

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

In other circumstances, particularly when there is an urgent market requirement for such documents, a technical committee may decide to publish other types of document:

— an ISO Publicly Available Specification (ISO/PAS) represents an agreement between technical experts in an ISO working group and is accepted for publication if it is approved by more than 50 % of the members of the parent committee casting a vote;

— an ISO Technical Specification (ISO/TS) represents an agreement between the members of a technical committee and is accepted for publication if it is approved by 2/3 of the members of the committee casting a vote.

An ISO/PAS or ISO/TS is reviewed after three years in order to decide whether it will be confirmed for a further three years, revised to become an International Standard, or withdrawn. If the ISO/PAS or ISO/TS is confirmed, it is reviewed again after a further three years, at which time it must either be transformed into an International Standard or be withdrawn.

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.

ISO/TS 22239-1 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 12, *Passive safety crash protection systems*.

ISO/TS 22239 consists of the following parts, under the general title *Road vehicles — Child seat presence and orientation detection system (CPOD)*:

— *Part 1: Specifications and test methods*

— *Part 2: Resonator specification*

— *Part 3: Labelling*

Introduction

This part of ISO/TS 22239 specifies a detection system for the automatic recognition of child seat presence and orientation detection system (CPOD) child seats placed on CPOD passenger seats.

The purpose of this detection system is to improve the overall safety performance of passenger restraint systems, particularly by reducing the risk of an airbag being deployed against a child seat placed on a passenger seat.

The CPOD system is not intended to encourage the placing of children on the front passenger seats of cars. However, in view of the fact that the following scenarios do occur in real life, children can be placed on front passenger seats in these cases:

— in 2-seater vehicles, which have no rear seats;

— when there are more than 2 or 3 children in one vehicle;

— when back seats are folded down for the transport of cargo;

— when the installation of a rearward-facing child restraint system (CRS), and the placing of the child in the CRS on the rear seats, is very difficult or impossible (e.g. in 2-door vehicles);

— when the driver wants to see the baby and have easy access to it.

There might be benefit to be gained by encouraging the use of airbags on rear seats.

For the cases cited above, CPOD technology offers a reliable automatic solution for the protection of children against any possible risk caused by non-deactivated airbags.

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

Part 1: Specifications and test methods

1 Scope

This part of ISO/TS 22239 specifies a child seat presence detection system that enables child seats placed on any passenger seats to be automatically detected where a child is at risk from an active airbag. The system provides the option of using additional information about the orientation of the child seat.

This part of ISO/TS 22239 describes the main system functionality, and provides design recommendations and requirements, compatibility measurements and labelling requirements.

Compliance with the requirements of this part of ISO/TS 22239 ensures compatibility between child seat presence and orientation detection system (CPOD) child seats and CPOD passenger seats.

ISO/TS 22239 applies only to child restraint systems in which the child is orientated in the forward or rearward driving direction.

NOTE 1 Throughout this part of ISO/TS 22239, the term "child seat" is used as an abbreviation of "CPOD child seat".

NOTE 2 Throughout this part of ISO/TS 22239, the term "passenger seat" is used as an abbreviation of "CPOD-equipped passenger seat".

2 Normative references

The following referenced documents are indispensable for the application 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/TS 22239-2:2009, *Road vehicles — Child seat presence and orientation detection system (CPOD) — Part 2: Resonator specification*

ISO/TS 22239-3, *Road vehicles — Child seat presence and orientation detection system (CPOD) — Part 3: Labelling*

ISO 6549:1999, *Road vehicles — Procedure for H- and R-point determination*

UNECE Regulation No.14, *Uniform provisions concerning the approval of vehicles with regard to safety-belt anchorages, ISOFIX anchorages systems and isofix top tether anchorages*

UNECE Regulation No.16 (2005), *Uniform provisions concerning the approval of safety belts, restraint systems, child restraint systems and ISOFIX child restraint systems for occupants of power-driven vehicles*

UNECE Regulation No.44 (2008), *Uniform provisions concerning the approval of restraining devices for child occupants of power-driven vehicles ("child restraint system")*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
child seat presence and orientation detection system
CPOD
radio frequency identification (RFID) system delivering information on the presence, orientation and type of a child seat

3.2
passenger seat reference point
CRP
point located on the centre line of the passenger seat, determined by the procedure in Annex A

3.3
child seat reference point
CRC
point identical to the intersection of the centre plane of the child restraint system and the CR axis defined in UNECE Regulation No.44

3.4
resonator reference point
RRP
point located in the geometrical centre of the base surface of the resonator

3.5
resonator pair reference point
RPRP
point located in the centre between two resonator reference points

3.6
reference co-ordinate system
Cartesian coordinate system associated with the passenger seat and the compatibility test bench, having its origin in the passenger seat reference point, as shown in Figure B.4

3.7
CPOD detection area
3-dimensional area above the passenger seat cushion, where all relevant child seat information needed to adapt the airbag deployment are transmitted to the restraint control module, provided that the resonator pair reference point is located within this area

3.8
CPOD failsafe area
3-dimensional area above the passenger seat cushion, where either all relevant child seat information needed to adapt the airbag deployment or information indicating an incorrect positioning of the child seat is transmitted to the restraint control module, provided that the resonator pair reference point is located within this area

3.9
ISOFIX
system for the connection of child restraint systems to vehicles which has two rigid anchorages in a vehicle seating position located near the seat bight, corresponding rigid attachments on the child restraint system, and a means to limit the pitch rotation of the CRS

[ISO 13216-1:1999]

4 Abbreviated terms

CPOD	Child seat presence and orientation detection system
CRC	Child seat reference point
CRP	Passenger seat reference point
CRS	Child restraint system
CTB	Compatibility test bench
ECU	Electronic control unit
FFCS	Forward facing child seat
PSCTD	Passenger seat compatibility test device
RCM	Restraint control module (electronic unit controlling deployment of supplemental restraints)
RFCS	Rearward facing child seat
RFID	Radio frequency identification
RMI	Restraint system malfunction indicator (vehicle-manufacturer-specific)
RPRP	Resonator pair reference point
RRP	Resonator reference point

5 Principle

5.1 General

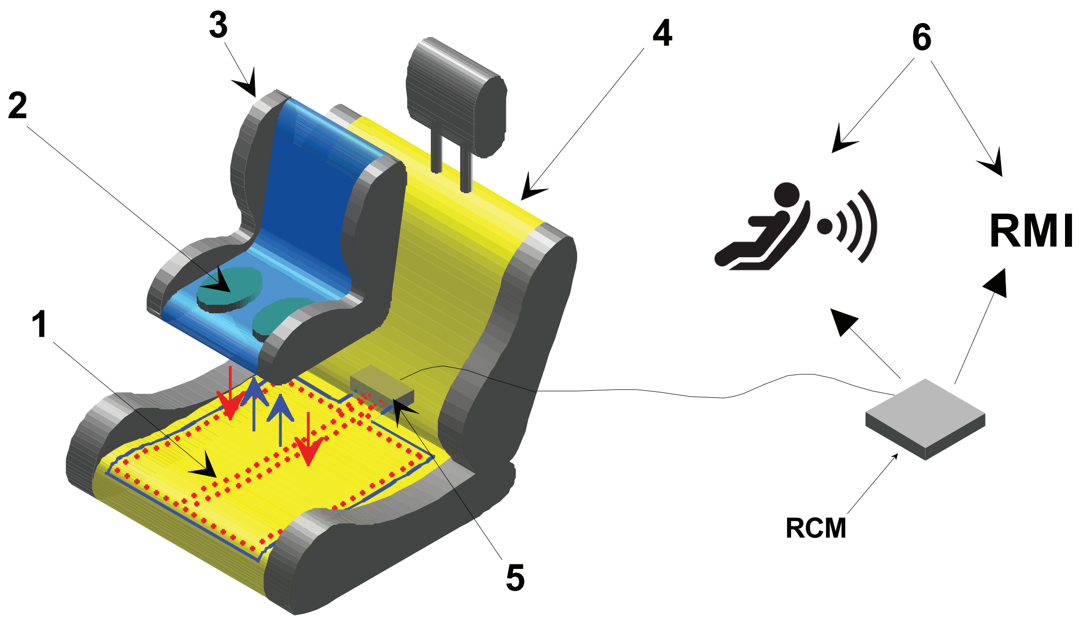
CPOD is an RFID sensing system which is capable of determining the presence and orientation of a CRS placed on a passenger seat. Depending on the positioning of the CRS, different types of information are transmitted to the RCM.

If the CRS is correctly placed on the passenger seat such that its RPRP is located within the CPOD detection area (see 3.7), the CRS is detected by the system.

If the CRS is placed outside of the CPOD detection area but within the CPOD failsafe area (see 3.8), the system either detects the CRS or recognizes an incorrect CRS positioning.

The gathered information is sent to the central RCM, which enables the adaptation of the airbag deployment specific to the occupancy situation.

NOTE The specifications of this part of ISO/TS 22239 are in compliance with Reference [6].



Key

1 CPOD sensor consisting of
  one transmitting antenna
  two receiving antennas
2 CPOD resonators
3 CPOD child seat
4 passenger seat
5 CPOD electronics
6 in-vehicle information

Figure 1 — CPOD system topology

5.2 Compatibility

The compatibility of the system is given if the CPOD component compatibility checks have been passed. These compatibility checks consist of the following parts:

a) CRS compatibility check to verify the performance of the CRS design;

b) resonator compatibility check to verify the electrical performance of the resonators;

c) passenger seat compatibility check to verify the performance of passenger seat and CPOD sensor design.

The flow chart in Figure 2 shows how these compatibility checks fit together to assure CPOD compatibility of the entire system.

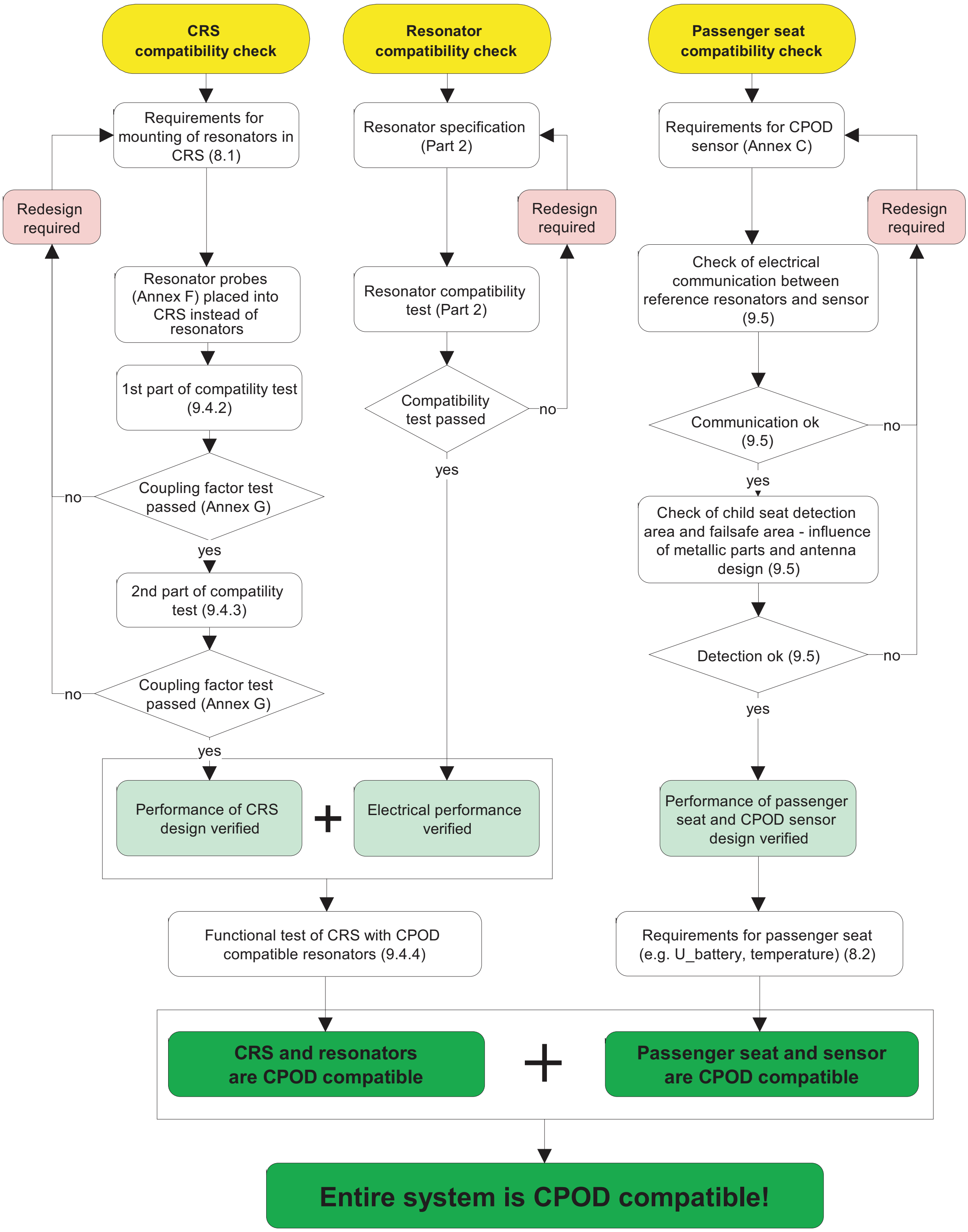


Figure 2 — Main steps for obtaining CPOD compatibility of the entire system

6 System functionality

In order to achieve its performance and, in addition, to provide failsafe behaviour in case of an error, the following features are implemented in the CPOD system:

— generation of a sinusoidal signal in the 130 kHz band for contact-less energy and information transmission;

— adaptation of the transmitting signal to different environmental conditions by variation of frequency and amplitude;

— demodulation of the signal phase modulated by the CRS resonators;

— monitoring of the power and demodulation circuits of the system via integrated self-diagnosis;

— interface to RCM for transmission of CPOD data;

— monitoring of transmitting and receiving antennas for disconnections and short circuits;

— detection of presence of CRS which are compliant with this part of ISO/TS 22239;

— detection of the orientation of CRS which are compliant with this part of ISO/TS 22239 in vehicles where the orientation of the CRS impacts the airbag deployment.

Examples of CRS orientations are given in Figures 3 to 5.

Compliance with the detailed system functionality specifications of Annex C shall be provided.

Figure 3 — CRS in forward facing position

Figure 4 — CRS in rearward facing position

Figure 5 — Example of CRS wrongly positioned

Depending on the positioning of the CRS, the CPOD system delivers the information to the RCM as shown in Figure 6, provided that the RPRP is located within the CPOD detection area.

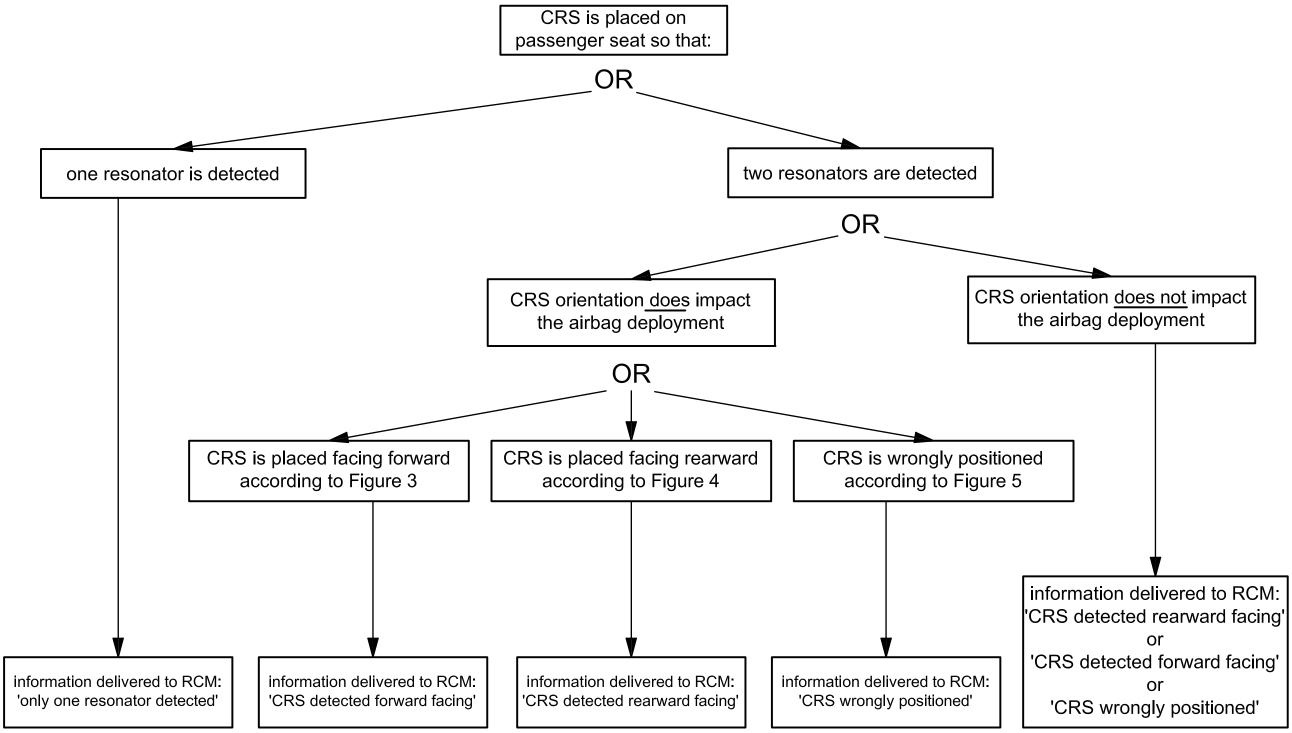


Figure 6 — Information to be submitted to RCM

7 Design recommendations

7.1 General

In order to maximize the chance of passing the compatibility measurements successfully, the following recommendations should be respected during the design of CRSs and passenger seats fitted with CPOD.

7.2 Installation of CPOD resonators into CRS

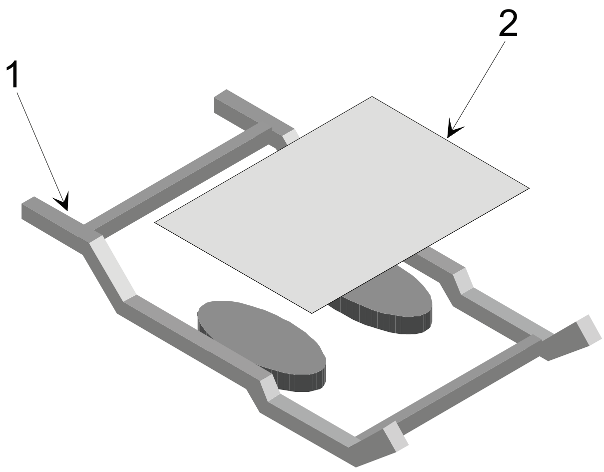
7.2.1 Electroconductive materials might have an influence on the resonator detection in the CRS. Therefore, the distance between large electroconductive materials and the resonators in the CRS should be maximized during the design of the CRS.

The detection capability of the system is very sensitive to electroconductive materials above the resonator pair or directly between the resonator pair and the CPOD passenger seat. Possible problems can be avoided by replacing these materials by non-electroconductive materials, as shown in Figure 8.

7.2.2 Closed electroconductive loops as indicated by Figure 7 might have an influence on the resonator detection in CRS. Therefore, the distance between closed electroconductive loops and the resonators in the CRS should be maximized during the design of the CRS.

Closed electroconductive loops, which surround the volume above or below the resonator pair, should be avoided. This can be achieved by cutting closed loops using non-electroconductive materials, as shown in Figure 8.

7.2.3 The distance between the bottom of the resonators inside the CRS and the surface of the CRS compatibility test bench should not exceed 30 mm when the CRS is placed correctly on the CTB in accordance with Annex D (see Figure 9). In addition, in that position, the bottom of the resonator should be parallel with the corresponding seat surface below it. An inclination of ± 15° should not be exceeded (see Figure 9).

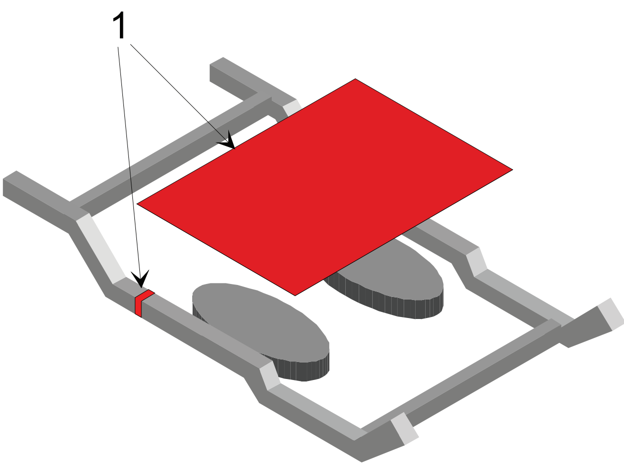


Key

1 electroconductive loop

2 electroconductive surface

Figure 7 — Closed electroconductive loop or surface close to the resonators



Key

1 non-electroconductive

Figure 8 — Closed conducting loop opened using a non-electroconductive connection

Dimensions in millimetres

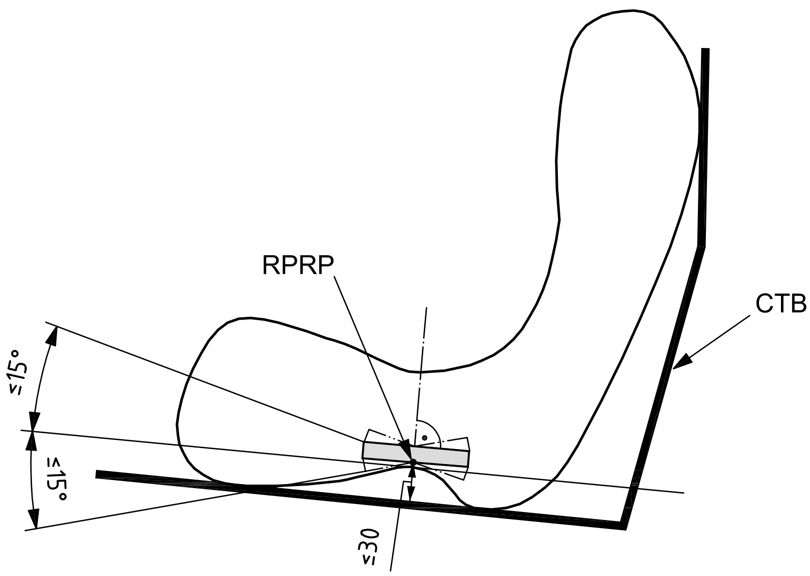
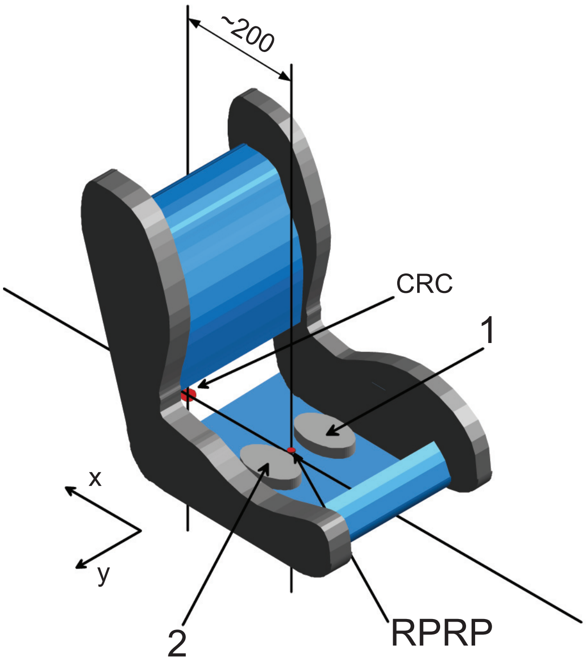


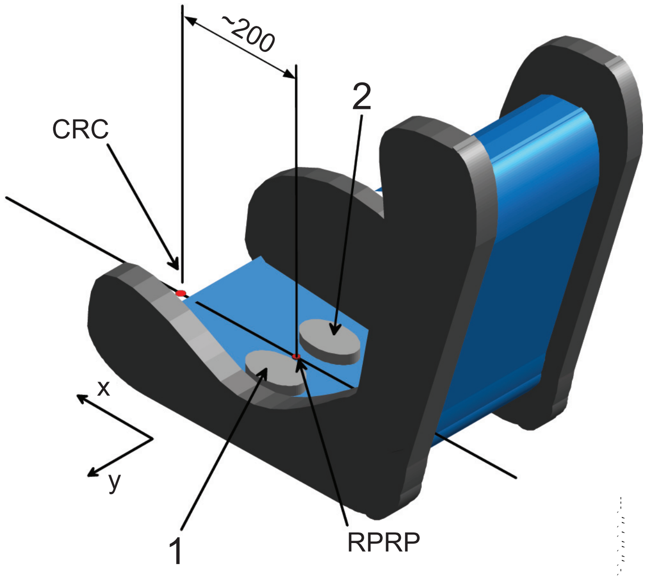
Figure 9 — Distance between resonator reference point and CTB surface

7.2.4 The distance between the CRC and RPRP (see Figure 10) should be chosen in such a way that the resonator pair reference point remains within the CRS detection area when varying the CRS compatibility test bench adjustments in accordance with 9.4.2 and 9.4.3. A value as close as possible to 200 mm is recommended for this distance.

Dimensions in millimetres



a) Forward facing CRS



b) Rearward facing CRS

Key

1 left resonator

2 right resonator

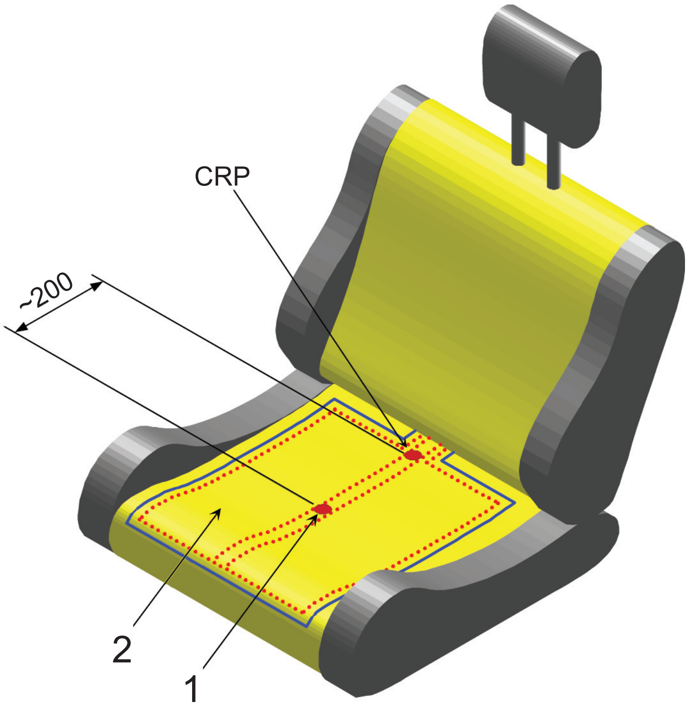
Figure 10 — Assembly of resonators in CRS

7.3 Installation of CPOD sensors into passenger seats

With respect to the installation of CPOD sensors into passenger seats:

- it is recommended to position the CPOD sensors directly under the seat cover instead of foaming them;
- the maximum distance between CPOD sensor and surface of the seat cover should not exceed 20 mm;
- the seat area should be designed to be as flat as possible (see Clause A.2, Note);
- for non-adjustable seat cushions, the distance between CPOD sensor and the passenger's seat metal shell should be maximized;
- the distance between the seat's CRP and the centre of the CPOD sensor should be as close as possible to 200 mm, as indicated by Figure 11;
- during CPOD sensor design, account should be taken of any possible seat adjustment and/or feature that could affect the performance of the system; in order to improve the detection performance of a CRS, the two receiving antennas should overlap (see Figure 11).

Dimensions in millimetres



Key

1 centre of CPOD sensor

2 CPOD sensor consisting of

one transmitting antenna

two receiving antennas

Figure 11 — Assembly of CPOD antennas into passenger seat

8 Design requirements

8.1 Requirements for CPOD child seats

8.1.1 Only resonators that are CPOD compatible in accordance with ISO/TS 22239-2 shall be used.

8.1.2 CRS shall be equipped with two CPOD resonators.

8.1.3 Easy removal of the resonators without special tools shall be avoided by CRS design.

8.1.4 The distance between both resonator reference points shall be 140 mm ± 2 mm, as indicated in Figure B.1.

8.1.5 The resonator pair shall be positioned symmetrically in the CRS in accordance with Figure 10, such that the right resonator is assembled into the CRS right side and the left resonator in the CRS left side (CRS left and right side referenced on the child's line of sight).

— **Exception for CRS types 4** (see ISO/TS 22239-2:2009, Table 2): The resonators shall be assembled symmetrically in the CRS such that, if the CRS is mounted on the passenger seat, the left resonator is positioned above the left side and the right resonator is placed above the right side of the passenger seat (passenger seat's left and right side referenced on the driving direction).

— **For all CRS types**: The resonator pair reference point shall be part of the x-z plane of the passenger seat if the CRS is mounted correctly on the passenger seat.

8.2 Requirements for CPOD passenger seats

8.2.1 Passenger seat design

Passenger seats shall be designed to allow the installation of the fixture (Gabarit) in accordance with Annex A.

8.2.2 CPOD sensor

CPOD passenger seats shall be equipped with a CPOD sensor consisting of one transmitting and two receiving antennas. The CPOD sensor shall meet the requirements defined in Annex C. In addition, it shall meet the manufacturer's seat and electronic requirements.

It shall be assured that the CPOD sensor maintains its function during the entire life cycle (e.g. position of the antennas in the seat cushion, environmental stability), as specified by the seat/vehicle manufacturer.

8.2.3 Operating range for CPOD passenger seats

The CPOD system shall meet its functionality in accordance with Clause 6 within the limits specified in Table 1.

Table 1 — CPOD operating range

Parameter	min.	max.
Operating temperature T_{OP} °C	–35	85
Operating voltage (12 V power net) $V_{OP,12}$ V	10	16
Operating voltage (24 V power net) $V_{OP, 24}$ V	20	32

9 Compatibility measurements

9.1 General specification

In order to ensure the performance of the CPOD system, the CRS manufacturers and the vehicle manufacturers shall perform compatibility measurements for introducing new CRS respectively new CPOD passenger seats. By means of these compatibility measurement procedures, it is ensured that all released CRS and all released CPOD passenger seats feature CPOD performance, which is characterized as described below.

a) If the CRS is placed on the passenger seat, such that the RPRP (see Annex B) remains within the detection area, the CRS is detected by the CPOD sensor in the seat:

- for vehicles where the airbag deployment is influenced by the orientation of the CRS on the seat, CPOD performance means that the presence and orientation is detected by the CPOD sensor;
- for vehicles where the airbag deployment is not influenced by the orientation of the CRS on the seat (e.g. the airbag is switched off in any case when a CRS is detected, independent of its orientation), CPOD performance means that only the presence of the CRS is detected by the CPOD system.

b) If the CRS is placed on the passenger seat, such that the RPRP in the CRS remains within the failsafe area, at least one resonator is detected by the CPOD sensor in the seat.

9.2 Compatibility test parameters range

The test temperature, T_{test}, and test voltage (vehicle), V_{test}, shall be as defined in Table 2 when performing the compatibility measurements:

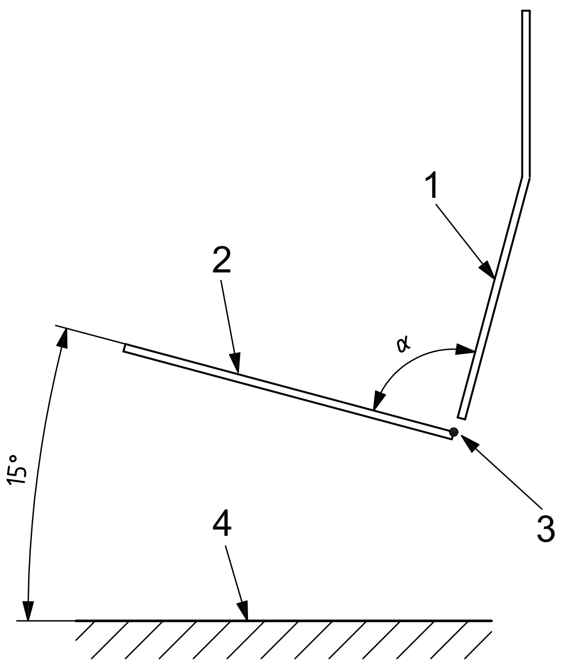
Table 2 — Compatibility test parameters

Parameter	min.	max.
Test temperature T_{test} °C	18	28
Test voltage (vehicle) V_{test} V	nominal voltage ± 2 %	

9.3 Adjustment of backrest inclination

9.3.1 Adjustment of CTB backrest angle, α

The CTB backrest angle, α, is defined as the angle between the seat plane of the CTB and the lower part of the CTB backrest, as indicated in Figure 12.



Key

1 backrest (lower part)

2 seat plane

3 rotation centre

4 bottom

Figure 12 — Definition of CTB backrest angle, α

9.3.2 Adjustment of passenger seat backrest angle, φ

9.3.2.1 General

The passenger seat backrest angle, φ, is defined as the angle between the passenger seat surface and the backrest of the seat. To determine the target backrest angle, φ, the H-point machine as specified in ISO 6549 shall be used without using the lower leg segments.

9.3.2.2 Installation procedure for the three-dimensional H-point machine

The installation procedure for the three-dimensional H-point machine is as follows.

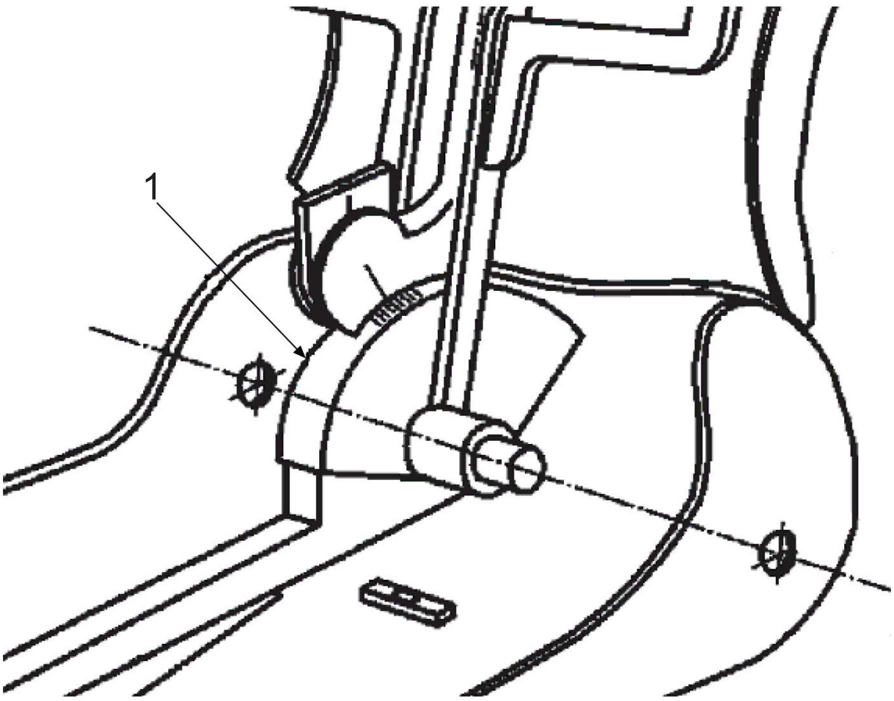
— Place muslin cotton tightly over the seat area to be checked.

— Place the seat and torso assembly of the three-dimensional H-point machine (ISO 6549), such that the centre plane of the occupant coincides with the centre plane of the H-point machine.

NOTE In vehicles with individual seats, the centre plane of the seat represents the centre plane of the occupant. On bench seats, the centre plane of the occupant is specified by the manufacturer.

— Position the H-point machine on the seat as specified in ISO 6549:1999, 5.9 to 5.13.2.

— After the H-point machine is correctly positioned, rotate the headroom probe to its fully rearward position. The actual backrest angle, φ, can be read from the hip angle quadrant of the H-point machine (see Figure 13).



Key

1 hip angle quadrant

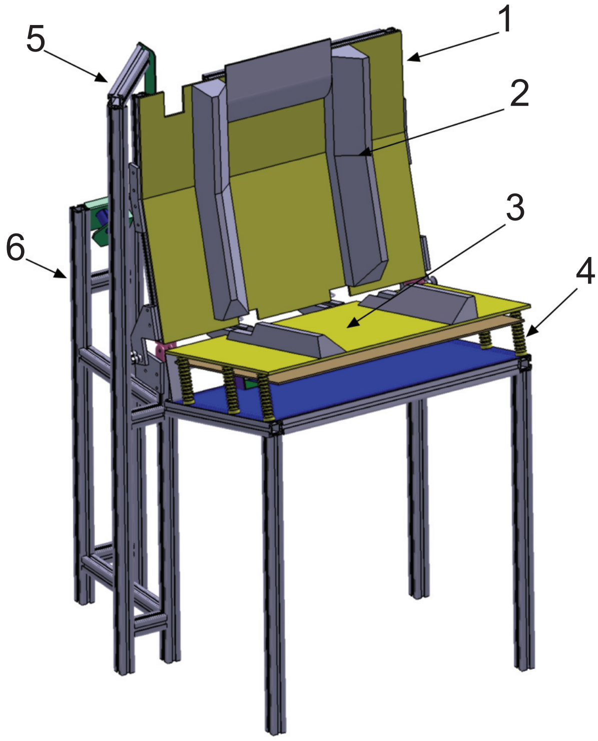
Figure 13 — Backrest angle indicator on ISO 6549 H-point machine

9.4 Compatibility measurements for CRS

9.4.1 General compatibility test description

In order to perform a CPOD compatibility check with a CRS, the CRS compatibility test bench (see Figure 14) shall be used. The CRS compatibility test bench is based on the UNECE Regulation No.44 test seat bench and is specified in Annex D. It consists of a seat surface, an adjustable backrest including removable cheeks, and an antenna structure under the seat surface used to measure the magnetic coupling between the antennas and the resonators in the CRS to be tested. Before the compatibility test can be performed, the correct functionality of the coupling factor measurement setup shall be confirmed by performing the functionality check described in Clause G.3 with the resonator probes defined in Annex F. After the functional test, the resonators in the CRS to be tested shall be replaced by the resonator probes that were used during the functional check.

The compatibility measurement is divided into two parts (see 9.4.2 and 9.4.3).



Key

1 adjustable backrest
2 removable cheeks
3 seat surface
4 carrier for antenna structure
5 pillar loop
6 belt retractor

Figure 14 — CPOD CRS compatibility test bench

9.4.2 Compatibility test (Part 1)

9.4.2.1 Compatibility test bench adjustment

The CTB backrest angle, α (see Figure 12) shall be adjusted to 90° in accordance with 9.3.1 in order to simulate a worst case scenario. The tests shall be conducted with the cheeks of the backrest, the cheeks on the seat surface of the test bench in order to produce a maximum displacement of the CRS in the negative x-direction and a maximum possible distance in the z-direction between the CRS and the antennas.

For the test of ISOFIX CRS, the ISOFIX anchorages of the test bench shall be adjusted in their foremost position.

9.4.2.2 Installation procedure for CRS without ISOFIX

The CRS shall be placed on the test bench in its designed orientations (forward or rearward facing) and as defined in the CRS owner's manual. If the CRS has adjustable or add-on features (e.g. footrest, adjustable backrest or angle of the cradle), which have an influence on the position of the CRS on the test bench (x-, z-displacement, inclination), these features shall be additionally tested in all possible combinations. The CRS shall be pushed against the backrest of the test bench with a force of 50 N.

If adjustable devices of the CRS are changed under the force of 50 N, the CRS shall be pushed back with the maximum possible force up to 50 N that is feasible without changing the position of the adjustable devices.

Wherever this is feasible (normal conditions), the CRS shall be placed symmetrically to the test bench's centre y-plane.

The CRS shall be fastened to the test bench with the test bench restraint system, as defined in the CRS owner's manual for the installation on passenger seats. During the installation procedure, a lap belt tension and shoulder belt tension each of (50 ± 5) N shall be reached.

If the CRS is equipped with an anti-rotation device, the CRS shall be tested in the following two positions without using this feature:

a) in full contact with the seat surface of the test bench;

b) with the wedge specified in Figure D.9.

The wedge shall be placed on the seat surface in such a way that the front faces of both the wedge and the seat cushion are in one plane, as shown in Figure D.9.

9.4.2.3 Installation procedure for CRS with ISOFIX

The CRS shall be placed on the test bench in its designed orientations (see 9.4.2.2) and as defined in the CRS owner's manual. If the CRS has adjustable or add-on features (e.g. footrest, adjustable backrest or angle of the cradle), which have an influence on the position of the CRS on the test bench (x-, z-displacement, inclination), these features shall be additionally tested in all possible combinations.

The ISOFIX connectors of the CRS shall be connected to the ISOFIX anchorages. In contrast to the definitions in its owner's manual, the connectors shall remain in their fully extended position.

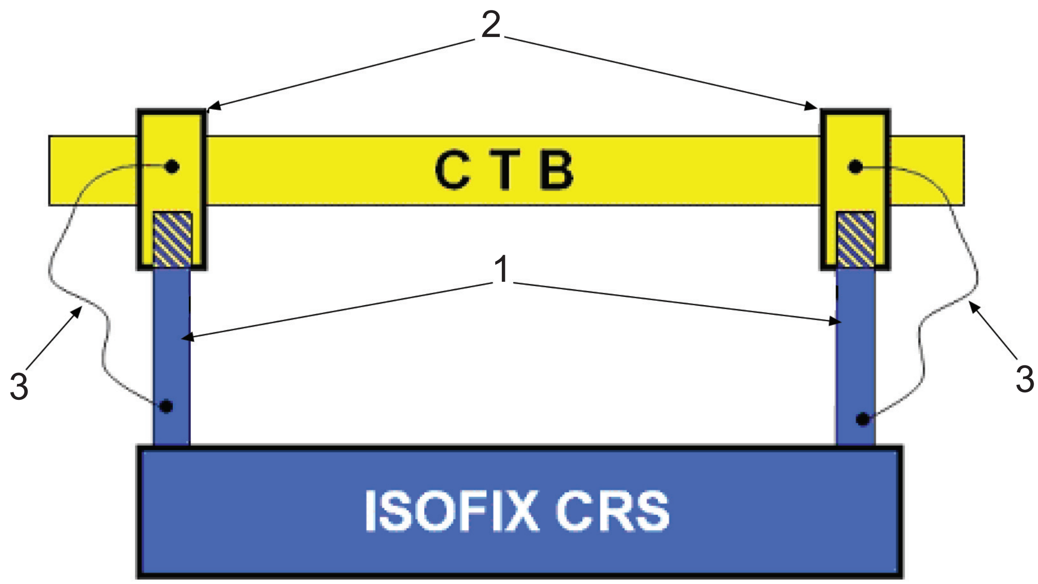
In the event that an electrical connection between the CRS and the ISOFIX anchorages can be excluded over the lifetime of the CRS, the electrical connection between CRS and CTB is not requested during testing. If an electrical connection between the CRS and the ISOFIX anchorages cannot be excluded, the ISOFIX connectors of the CRS shall be electrically connected to the test bench, as shown in Figure 15.

If the CRS is equipped with anti-rotation devices, the CRS shall be tested in the following two positions without using these features:

a) in full contact with the seat surface of the test bench;

b) with the wedge specified in Figure D.9.

The wedge shall be placed on the seat surface in such a way that the front faces of both the wedge and the seat cushion are in one plane, as shown in Figure D.9.



Key

1 ISOFIX connector (fully extended)

2 ISOFIX anchorages

3 electrical connection

Figure 15 — Electrical connection between CRS ISOFIX connectors and test bench

9.4.2.4 Installation procedure for CRS with LATCH system

The CRS shall be placed on the test bench in its designed orientation and as defined in the owner's manual. If the CRS has adjustable or add-on features (e.g. footrest, adjustable backrest or angle of the cradle), which have an influence on the position of the CRS on the test bench (x-, y-, z-displacement, inclination), these features shall be additionally tested in all possible combinations.

The lower attachments of the CRS shall be connected to the ISOFIX anchorages. The lower attachments shall be fastened in such a way that the CRS is pulled back to the backrest of the test bench until full contact to the backrest is reached without losing full contact between the CRS and the seat surface.

If the CRS is equipped with an anti-rotation device, the CRS shall be tested in the two following positions without using this feature:

a) in full contact with the seat surface of the test bench;

b) with the wedge specified in Figure D.9.

The wedge shall be placed on the seat surface in such a manner that the front faces of both the wedge and the seat cushion are in one plane, as shown in Figure D.9

If electrical conductivity is likely to occur between the CRS and the test bench due to the materials used for the lower anchorages, these anchorages of the CRS shall be electrically connected to the test bench as shown in Figure 15.

9.4.3 Compatibility test (Part 2)

9.4.3.1 Compatibility test bench adjustment

The CTB backrest angle, α (see Figures 12 and 16) shall be adjusted to 120° in accordance with 9.3.1, in order to simulate a worst case scenario. The test shall be conducted without the cheeks of the backrest, but with the cheeks on the test bench's seat surface installed in order to produce a maximum possible distance between the CRS and the antennas.

For the testing of ISOFIX CRS, the ISOFIX anchorages of the test bench shall be adjusted in their rearmost position.

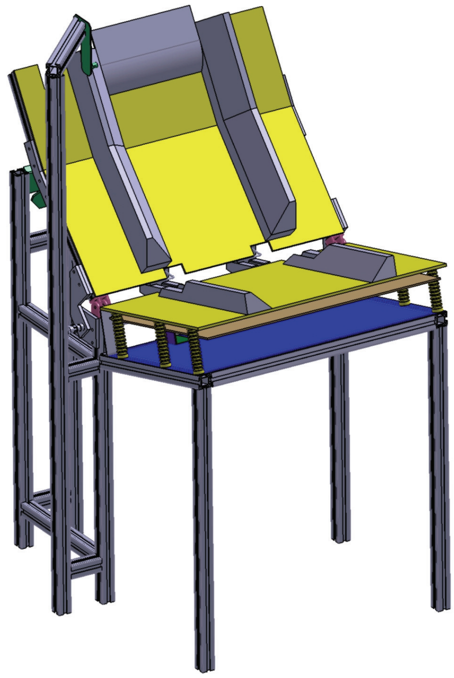


Figure 16 — CRS compatibility test — 2nd part (most reclined position)

9.4.3.2 Installation procedure for CRS without ISOFIX

The CRS shall be placed on the test bench in its designed orientations and as defined in the owner's manual. If the CRS has adjustable or add-on features (e.g. footrest, adjustable backrest or angle of the cradle), which have an influence on the position of the CRS on the test bench (x-, y-, z-displacement, inclination), these features shall be additionally tested in all possible combinations. The CRS shall be pushed against the backrest of the test bench with a force of 50 N.

The CRS shall be placed symmetrically to the test bench's centre y-plane.

The CRS shall be fastened to the test bench with the restraint system defined in the owner's manual for installation on passenger seats. During the installation procedure, a lap belt tension and shoulder belt tension each of (50 ± 5) N shall be reached.

If the CRS is equipped with an anti-rotation device, the CRS shall be tested in the following two positions without using this feature:

a) in full contact with the seat surface of the test bench;

b) with the wedge specified in Figure D.9.

The wedge shall be placed on the seat surface in such a way that the front faces of both the wedge and the seat cushion are in one plane, as shown in Figure D.9.

9.4.3.3 Installation procedure for CRS with ISOFIX

The CRS shall be placed on the test bench in its designed orientations and as defined in the owner's manual. If the CRS has adjustable or add-on features (e.g. footrest, adjustable backrest or angle of the cradle), which have an influence on the position of the CRS on the test bench (x-, y-, z-displacement, inclination), these features shall be additionally tested in all possible combinations

The ISOFIX connectors of the CRS shall be connected to the ISOFIX anchorages.

In the event that an electrical connection between the CRS and the ISOFIX anchorages can be excluded over the lifetime of the CRS, an electrical connection between CRS and CTB is not requested during testing. If an electrical connection between the CRS and the ISOFIX anchorages cannot be excluded, the ISOFIX connectors of the CRS shall be electrically connected to the test bench, as shown in Figure 15.

If the CRS is equipped with an anti-rotation device, the CRS shall be tested in the following two positions without using this feature:

a) in full contact with the seat surface of the test bench;

b) with the wedge specified in Figure D.9.

The wedge shall be placed on the seat surface in such a way that the front faces of both the wedge and the seat cushion are in one plane, as shown in Figure D.9.

9.4.3.4 Installation procedure for CRS with LATCH system

The CRS shall be placed on the test bench in its designed orientations and as defined in the owner's manual. If the CRS has adjustable or add-on features (e.g. footrest, adjustable backrest or angle of the cradle), which have an influence on the position of the CRS on the test bench (x-, y-, z-displacement, inclination), these features shall be additionally tested in all possible combinations.

The lower attachments of the CRS shall be connected to the ISOFIX anchorages and fastened until contact to the backrest of the test bench is reached.

If the CRS is equipped with an anti-rotation device, the CRS shall be tested in the two following positions without using this feature:

a) in full contact with the seat surface of the test bench;

b) with the wedge specified in Figure D.9.

The wedge shall be placed on the seat surface in such a manner that the front faces of both the wedge and the seat cushion are in one plane, as shown in Figure D.9.

If electrical conductivity is likely to occur between the CRS and the test bench due to the materials used for the lower anchorages, these connectors of the CRS shall be electrically connected to the test bench.

9.4.3.5 Testing

The CRS compatibility test shall be performed by conducting the magnetic coupling factor measurement in accordance with Annex G. The CRS is CPOD compatible if the pass/fail criteria defined in Annex G are met.

9.4.4 CRS functional test

9.4.4.1 General

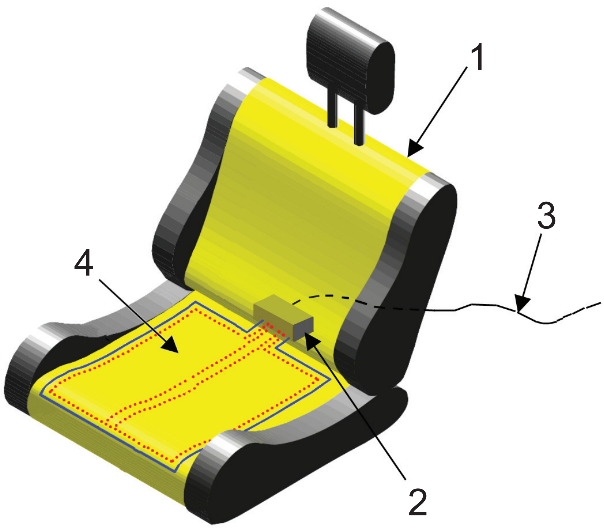
In order to prove its CPOD compatibility, the CRS, in addition to the compatibility test, shall pass the CRS functional test. For this test, the CRS shall be in serial state, which means that it shall be equipped with a pair of serial resonators (resonators which are intended to be assembled into the CRS during series production).

The functional test shall be performed using a CPOD-compatible passenger seat with presence and orientation detection capability (see Figure 17), on which the CRS concerned can be installed. For example, a CRS designed to be connected to the seat via ISOFIX connectors shall be tested with a CPOD-compatible ISOFIX passenger seat.

9.4.4.2 CRS functional test setup

The passenger seat's backrest angles, φ, shall be adjusted to 95° in accordance with 9.3.2. The CRS to be tested shall be placed on the passenger seat and installed as appropriate for its intended use.

9.4.4.3 CRS functional test procedure



Key

1 CPOD passenger seat

2 CPOD sensor electronics

3 CPOD connecting cable

4 CPOD sensor consisting of

- one transmitting antenna (solid blue line)
- two receiving antennas (dotted red line)

Figure 17 — CPOD-equipped serial passenger seat

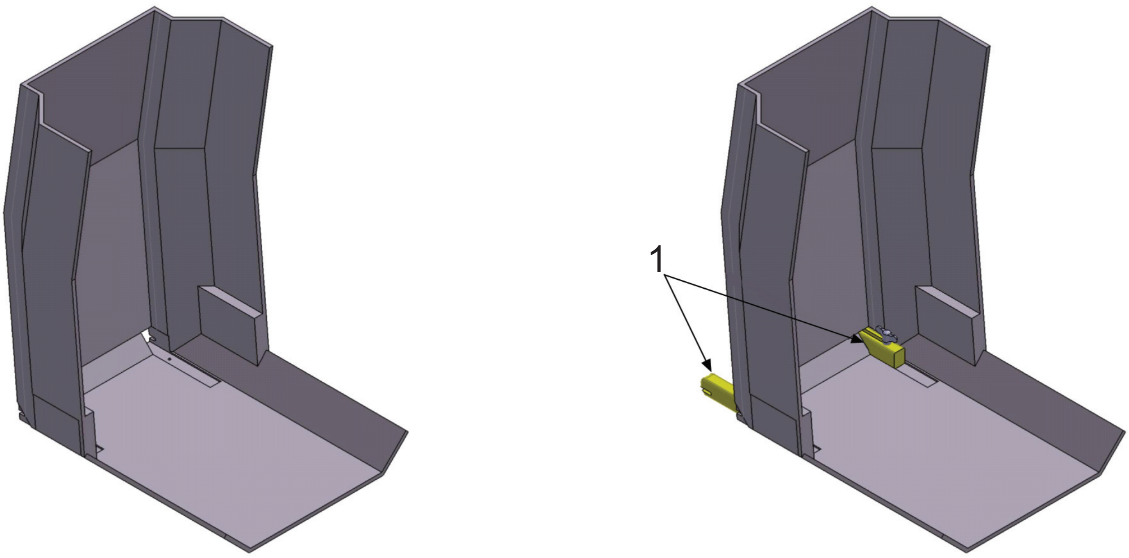
The detection status delivered by the CRS sensor shall be monitored by evaluating the data transmitted via the connecting cable. The maximum test duration is determined by the maximum duration that might be needed by the sensor in the CPOD passenger seat to detect a CPOD child seat and to transmit the status. This duration shall be determined before testing and shall include qualification times (if qualification cannot be switched off), etc.

The test is passed if the detection status delivered by the CPOD sensor in the seat corresponds to the mounting position of the CRS to be tested. If, after the maximum test duration, the CPOD sensor has not yet transmitted the correct detection state, the test has failed and the CRS is not CPOD compatible.

9.5 Compatibility measurements for passenger seats

9.5.1 General test description

In order to perform the CPOD compatibility measurement with a passenger seat equipped with a CPOD sensor, depending on whether the seat to be tested is equipped with ISOFIX connectors or not, the PSCTD in accordance with Figure 18 and Annex E shall be used with or without ISOFIX connectors.



a) Non-ISOFIX configuration **b) ISOFIX configuration**

Key

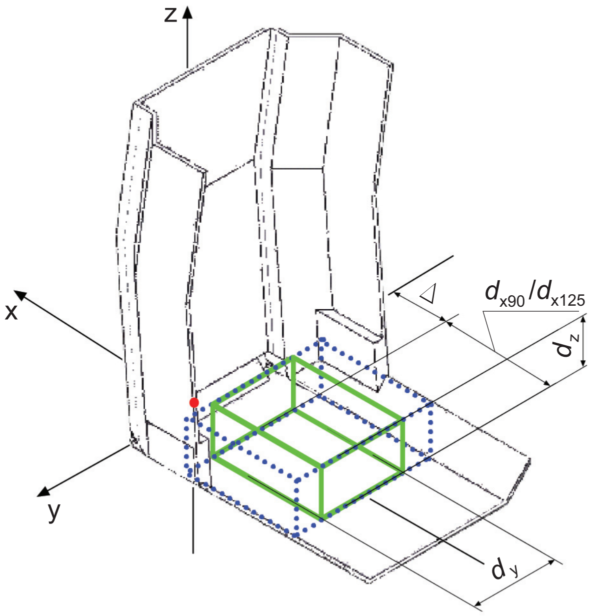
1 ISOFIX connectors

Figure 18 — CPOD passenger seat compatibility test device (PSCTD)

Since the design of the passenger seat directly impacts the requirements concerning, for example, height or length of the detection area, the CPOD detection area and CPOD failsafe area dimensions can only be determined specifically for every CPOD passenger seat design.

The passenger-seat-specific CPOD detection area consists of a standard volume plus offsets in negative x- and positive z-directions. Only the offsets depend on the passenger seat design, the standard volume has an equal size on every passenger seat. The same applies for the passenger-seat-specific CPOD failsafe area. In order to determine the passenger-seat-specific detection and failsafe area, the volume definition illustrated in Figure 19 applies.

As shown in Figure 19, both the detection and failsafe volume are symmetrical to the x/z-plane of the PSCTD. In order to consider the influence of the passenger seat backrest angle adjustment on the displacement of a CRS, the lengths of the volumes depend on the passenger seat backrest angles to be adjusted during passenger seat compatibility testing. The different lengths of the volumes are indicated by d_{x90} and d_{x125} in Figure 19. For a 90° backrest angle, the volume length is defined by d_{x90}, for a backrest angle of 125°, the volume length is defined by d_{x125}. The values for Δ, d_{x90}, d_{x125}, d_y and d_z are defined in Table 3.



Key

detection volume

failsafe volume

Figure 19 — CPOD detection and failsafe volume

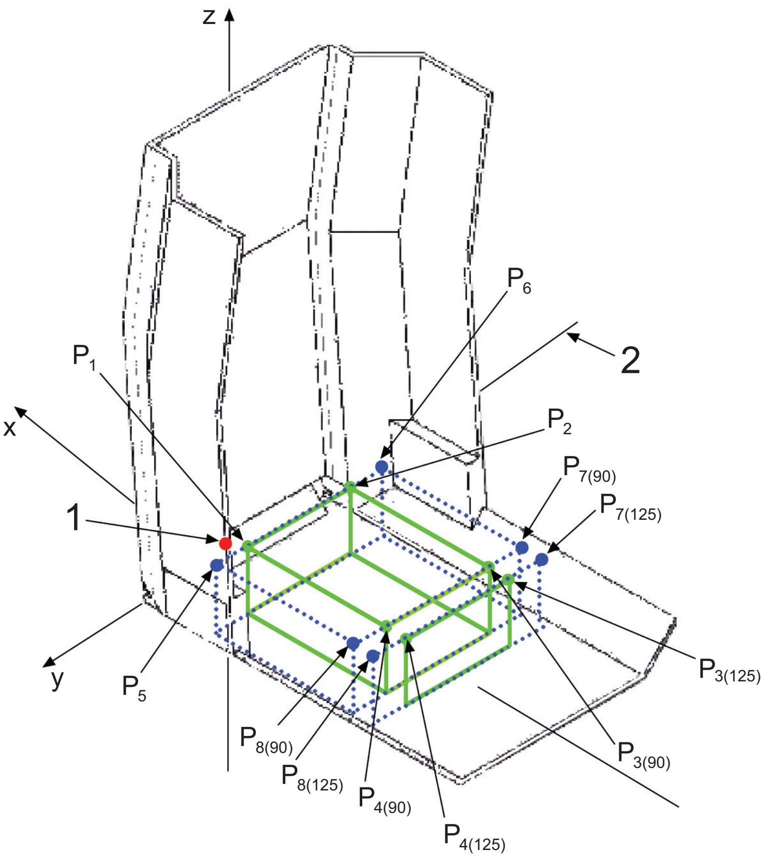
Table 3 — Detection/failsafe main volume definition

Dimensions in millimetres

Parameter	Detection volume	Failsafe volume
Δ	130	
d_{x90}	90	
d_{x125}	200	
d_y	40	100
d_z	65	

In order to find the passenger-seat-specific detection and failsafe area, only the co-ordinates of the upper corners of both volumes shall be taken into account (see Figure 20).

The location of the corners in Figure 20, positioned on CRC as the origin of the PSCTD specific co-ordinate system, are defined by Table 4.



Key

1 CRC of PSCTD

2 PSCTD specific co-ordinate system

Figure 20 — CPOD detection/failsafe volume corner definition

Table 4 — CPOD detection/failsafe area corner location definition

Dimensions in millimetres

Volume	Corner location	Co-ordinate		
		x	y	z
Detection area	P_1	130	20	65
	P_2	130	–20	65
	$P_{3(90)}$	220	–20	65
	$P_{4(90)}$	220	20	65
	$P_{3(125)}$	330	–20	65
	$P_{4(125)}$	330	20	65
Failsafe area	P_5	130	50	65
	P_6	130	–50	65
	$P_{7(90)}$	220	–50	65
	$P_{8(90)}$	220	50	65
	$P_{7(125)}$	330	–50	65
	$P_{8(125)}$	330	50	65

9.5.2 Determination of passenger-seat-specific detection/failsafe area

9.5.2.1 General

The process of determining the passenger-seat-specific detection/failsafe can be split into two parts, as described below.

a) In the first part, the standard detection and failsafe area are determined. The length and width of the standard detection and failsafe area is independent of the passenger seat design; only the position in negative x-direction and the height of the detection and failsafe area is seat specific.

b) In the second part, the seat-specific influence of the passenger backrest adjustment on the displacement of a CRS in negative x-direction is determined. This influence could lead to the need for an offset in length of the detection and failsafe area, compared to the length of the standard detection and failsafe area. This offset is passenger seat design specific.

9.5.2.2 Determination of standard detection/failsafe area

9.5.2.2.1 Passenger seat adjustment

The passenger seat angle φ shall be adjusted to 125° in accordance with 9.3.2, in order to simulate a worst case scenario. All seat adjustments (e.g. height adjuster, tilt mechanism, head restraints, lumber support) shall be adjusted in such a manner as to create a maximum displacement of the PSCTD in the negative x- and positive z-direction relative to the passenger seat. If the seat is equipped with a longitudinal cushion adjustment, the cushion shall be adjusted in its most rearward position.

9.5.2.2.2 Installation procedure for the PSCTD

For the ISOFIX configuration, the installation procedure for the PSCTD is the following:

— The ISOFIX connectors of the PSCTD (Figure 18 and Annex E) shall be connected to the ISOFIX anchorages of the passenger seat in their fully extended position.

For the non ISOFIX configuration, the installation procedure for the PSCTD is the following:

— The PSCTD shall be placed facing forward on the passenger seat, such that the seat back surface can contact the back of the passenger seat. It shall be pushed against the seat back of the passenger seat with a force of 50 N. If a passenger seat adjuster is changed under the force of 50 N, the PSCTD shall be pushed back with the maximum possible force up to 50 N that is feasible without changing this passenger seat adjuster. The PSCTD shall be placed symmetrically to the passenger seat centre y-plane.

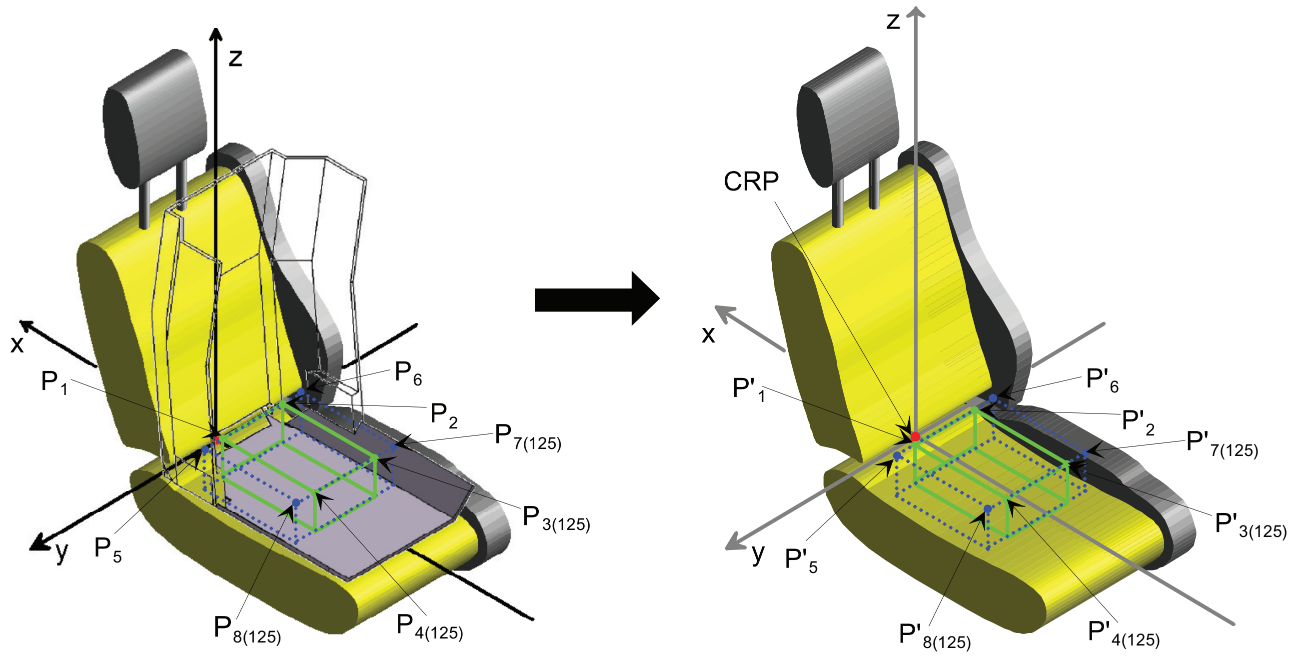
9.5.2.2.3 Determination of standard detection/failsafe area co-ordinates

If an ISOFIX passenger seat is to be checked for compatibility, different PSCTD configurations shall be used to determine the standard detection and failsafe area. The x co-ordinates of the positions shall be determined with the PSCTD configuration leading to the maximum shift of the PSCTD in the negative x-direction. The z co-ordinates of the positions shall be determined with the PSCTD configuration leading to the maximum shift of the PSCTD in the positive z-direction.

If a non-ISOFIX passenger seat is to be checked for compatibility, the non-ISOFIX configuration of the PSCTD shall be used.

The position and volume of the standard detection area are defined by the locations of the points P_1, P_2, $P_{3(125)}$ and $P_{4(125)}$ in the PSCTD, with their co-ordinates measured inside the reference co-ordinates of the passenger seat. This leads to P'_1, P'_2, $P'_{3(125)}$ and $P'_{4(125)}$.

The position and volume of the standard failsafe area are defined by the locations of the points P_5, P_6, $P_{7(125)}$ and $P_{8(125)}$ in the PSCTD, with their co-ordinates measured inside the reference co-ordinates of the passenger seat. This leads to P'_5, P'_6, $P'_{7(125)}$ and $P'_{8(125)}$. See Figure 21 for illustration.



a) From PSCTD

b) To passenger seat

Figure 21 — Transformation of co-ordinates of standard detection and failsafe area

9.5.2.3 Determination of passenger-seat-specific detection/failsafe area length offset

9.5.2.3.1 Passenger seat adjustment

The passenger seat's backrest angle, φ, shall be adjusted to 90° in accordance with 9.3.2, in order to simulate a worst case scenario. All seat adjustments (e.g. height adjuster, tilt mechanism) shall be positioned so as to produce a maximum displacement of the PSCTD in positive x- and positive z-direction relative to the passenger seat. If the seat is equipped with a longitudinal cushion adjustment, the cushion shall be adjusted in its most forward position.

9.5.2.3.2 Installation procedure of PSCTD

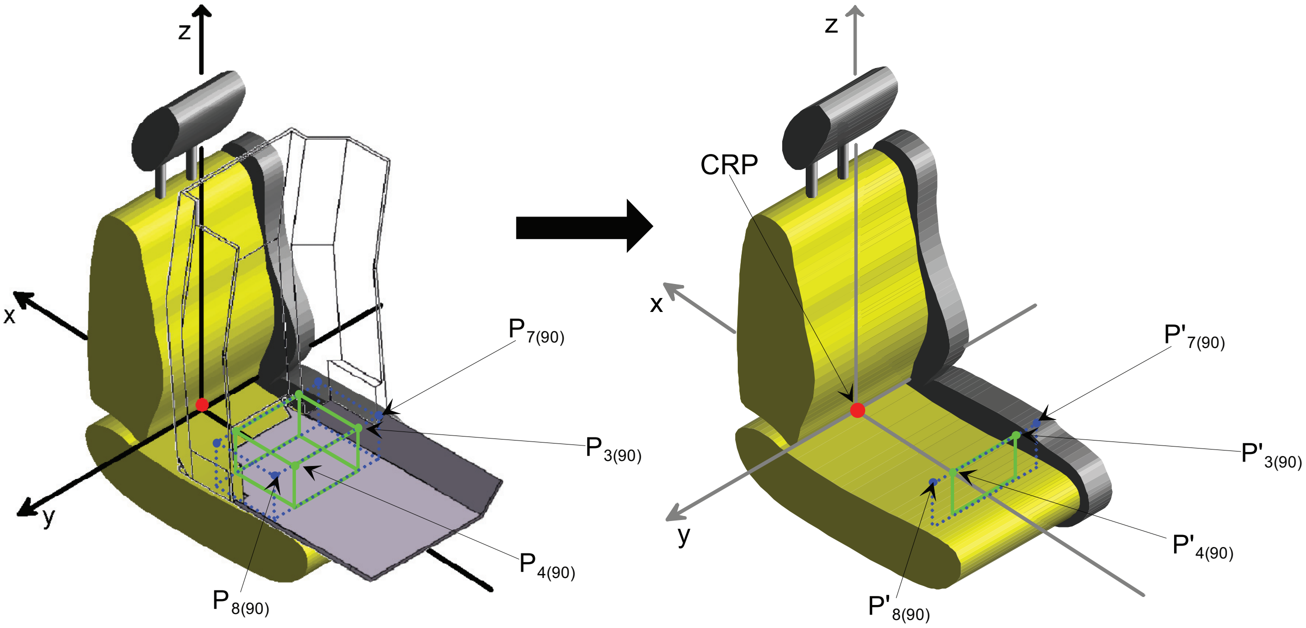
See 9.5.2.2.2.

9.5.2.3.3 Determination of passenger-seat-specific detection/failsafe area length offset

If an ISOFIX passenger seat is to be checked for compatibility, different PSCTD configurations shall be used to determine the standard detection and failsafe area. The x co-ordinates of the positions shall be determined with the PSCTD configuration leading to the maximum shift of the PSCTD in the negative x-direction. The z co-ordinates of the positions shall be determined with the PSCTD configuration leading to the maximum shift of the PSCTD in the positive z-direction.

If a non-ISOFIX passenger seat is to be checked for compatibility, the non-ISOFIX configuration of the PSCTD shall be used.

In order to define the passenger-seat-specific detection area length offset, the locations of the points $P_{3(90)}$ and $P_{4(90)}$ in the PSCTD shall be determined inside the reference co-ordinates of the passenger seat. This leads to $P'_{3(90)}$ and $P'_{4(90)}$. In order to define passenger-seat-specific failsafe area length offset, the locations of the points $P_{7(90)}$ and $P_{8(90)}$ in the PSCTD shall be determined inside the reference co-ordinates of the passenger seat. This leads to $P'_{7(90)}$ and $P'_{8(90)}$. See Figure 22 for illustration.



a) From PSCTD **b) To passenger seat**

Figure 22 — Transformation of most rearward co-ordinates

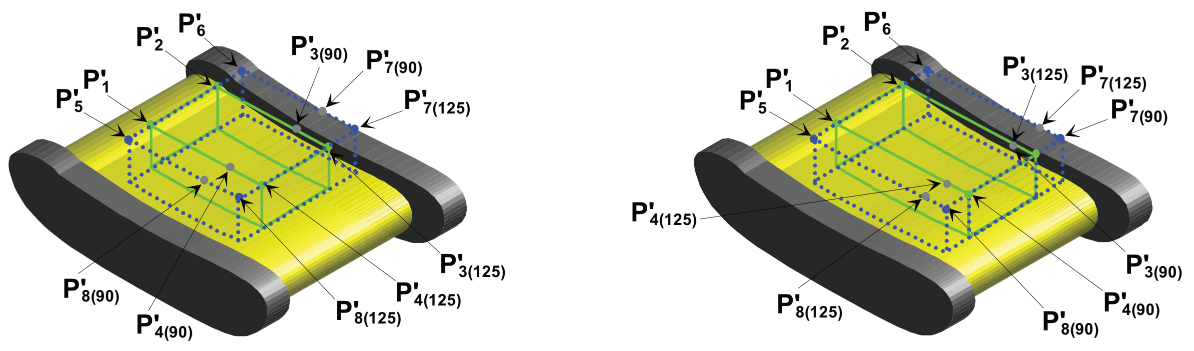
If the x co-ordinate of $P'_{3(90)}/P'_{4(90)}$ is more negative than the x co-ordinate of $P'_{3(125)}/P'_{4(125)}$ of the standard detection area, the passenger-seat-specific detection area is defined by the co-ordinates P'_1, P'_2, $P'_{3(90)}$ and $P'_{4(90)}$. Compared to the standard detection area, there is an offset in volume length.

If the x co-ordinate of $P'_{3(125)}/P'_{4(125)}$ of the standard detection area is more negative than the x co-ordinate of $P'_{3(90)}/P'_{4(90)}$, the passenger-seat-specific detection area is equal to the standard detection area and defined by the co-ordinates P'_1, P'_2, $P'_{3(125)}$ and $P'_{4(125)}$.

If the x co-ordinate of $P'_{7(90)}/P'_{8(90)}$ is more negative than the x co-ordinate of $P'_{7(125)}/P'_{8(125)}$ of the standard failsafe area, the passenger-seat-specific failsafe area is defined by the co-ordinates P'_5, P'_6, $P'_{7(90)}$ and $P'_{8(90)}$. Compared to the standard failsafe area, there is an offset in volume length.

If the x co-ordinate of $P'_{7(125)}/P'_{8(125)}$ of the standard failsafe area is more negative than the x co-ordinate of $P'_{3(90)}/P'_{4(90)}$, the passenger-seat-specific failsafe area is equal to the standard failsafe area and defined by the co-ordinates P'_5, P'_6, $P'_{7(125)}$ and $P'_{7(125)}$.

See Figure 23.



a) Without failsafe/detection area length offset **b) With failsafe/detection area length offset**

Key

— seat-specific detection area

..... seat-specific failsafe area

NOTE Depending on the way the co-ordinates of P'_1 to P'_8 are determined, the planes A and B do not have to be parallel to the x-y plane of the reference co-ordinate system.

Figure 23 — Determination of passenger-seat-specific detection/failsafe area

9.5.3 Compatibility test procedure for passenger seats

The test shall be carried out with a reference resonator pair in accordance with Annex B of this part of ISO/TS 22239 and ISO/TS 22239-2:2009, Annex D. During this test, the resonator pair shall be placed in different positions within the passenger-seat-specific detection and failsafe area. This positioning of the resonator pair may be done manually or by a machine.

The test shall be performed in accordance with the procedure described below.

a) **Test of CPOD performance in the passenger-seat-specific detection area**:

The reference resonator pair shall be moved with a defined step width Δx, Δy and Δz, with its RPRP inside the passenger-seat-specific detection area and rotated in accordance with Table 5.

b) **Test of CPOD performance in the passenger-seat-specific failsafe area**:

The reference resonator pair shall be moved with a defined step width Δx, Δy and Δz, with its RPRP inside the passenger seat specific failsafe area and rotated in accordance with Table 5.

During testing, the resonator pair shall be positioned such that the bottoms of the resonators are in parallel (tolerance ± 2°) to the x/y-plane of the reference co-ordinate system. It shall be ensured that the detection of the resonator pair is also tested directly at the outer boundary of the passenger-seat-specific detection/failsafe area. Alternatively, in order to keep the adjusted step width, the test area shall be increased accordingly, such that the tested area includes the detection/failsafe area. If the positioning of the resonator pair is not possible due to contact with the seat cushion (bolsters, etc.), testing at these locations is only required for angles γ where no contact occurs.

The dwell time of the resonator pair during the test shall correlate with the sensor's reaction time, e.g. if a CPOD sensor has a reaction time of 5 s in total to detect the presence of a resonator pair and to deliver the information to the vehicle, the dwell time shall be greater than 5 s.

In order to speed up the test, the CPOD sensor might feature a high speed test mode, which can be used to monitor the transitions of the detected states within a shorter duration. This is allowed only if the reaction times are the only differences in the detecting behaviour between high speed mode and normal operation in the vehicle.

Table 5 — Passenger seat compatibility test parameters

Parameter	Value min.	Value max.
Step width of movement in negative/positive x-direction Δx mm	—	10
Step width of movement in a negative/positive y-direction Δy mm	—	10
Step width of movement in a negative/positive z-direction Δz mm	—	10
Tolerance of positioning of resonator pair in positive/negative x-, y- and z-directions Δ_{TOL} mm	—	1
Rotation of resonator pair in accordance with Clause B.2 γ degree	0, +15, +30, +45, +60, +75, +90, +105, +120, +135, +150, +165, +180, +195, +210, +225, +240, +255, +270, +285, +300, +315, +330, +345	
Tolerance of γ-adjustment γ_{TOL} degree	—	2

9.5.4 Test result interpretation

The passenger seat is CPOD compatible if the following requirements are fulfilled during the compatibility test specified in 9.5.3:

a) for vehicles where the orientation of the CRS does impact the airbag deployment, the CPOD sensor shall deliver the information in accordance with Table 6;

b) for vehicles where the orientation of the CRS does not impact the airbag deployment, the CPOD sensor shall deliver the information in accordance with Table 7;

c) in order to test the ability of the system to extract the digital information generated by the CPOD resonators, the type of child seat detected by the reference resonators shall be $TYPE_{REFRES}$, in accordance with ISO/TS 22239-2:2009, Annex D, for all tested locations of the reference resonator pair.

10 Labelling

CPOD child seats and CPOD passenger seats in compliance with this part of ISO 22239 shall be labelled in accordance with ISO/TS 22239-3.

Table 6 — Information in cases where orientation of CRS does impact airbag deployment

Angle γ [a]	RPRP located in	Information to be transmitted to RCM
+345°, 0°, +15°	detection area	"CRS detected rearward facing"
	failsafe area	"CRS detected rearward facing" or "CRS wrongly positioned" or "only one resonator detected"
+30°, +45°, +60°, +75° +285°, +300°, +315°, +330°	failsafe area detection area	"CRS detected rearward facing" or "CRS wrongly positioned" or "only one resonator detected"
+90°, +270°	failsafe area detection area	"CRS wrongly positioned" or "only one resonator detected"
+105°, +120°, +135°, +150° , +210°, +225°, +240°, +265°	failsafe area detection area	"CRS detected forward facing" or "CRS wrongly positioned" or "only one resonator detected"
+165°, +180°, +195°	detection area	"CRS detected forward facing"
	failsafe area	"CRS detected forward facing" or "CRS wrongly positioned" or "only one resonator detected"

[a] See Clause B.2.

Table 7 — Information in cases where orientation of CRS does not impact airbag deployment

Angle γ [a]	RPRP located in	Information to be transmitted to RCM
+345°, 0°, +15° +165°, +180°, +195°	detection area	"CRS detected rearward facing" or "CRS detected forward facing" or "CRS wrongly positioned"
	failsafe area	"CRS detected rearward facing" or "CRS detected forward facing" or "CRS wrongly positioned" or "only one resonator detected"
+30°, +45°, +60°, +75°, +90° +105°, +120°, +135°, +150° +210°, +225°, +240°, +265°, +270° +285°, +300°, +315°, +330°	failsafe area detection area	"CRS detected rearward facing" or "CRS detected forward facing" or "CRS wrongly positioned" or "only one resonator detected"

[a] See Clause B.2.

Annex A
(normative)

Determination of the passenger seat reference point (CRP)

A.1 General

The passenger seat reference point (CRP) will be used as the origin of the reference co-ordinate system, in accordance with Clause B.3, and for passenger-seat-specific geometric determinations. The CRP shall be defined using the fixture (Gabarit, see Figure A.1) specified in UNECE Regulation No.16 (2005), Annex 17, Appendix 1.

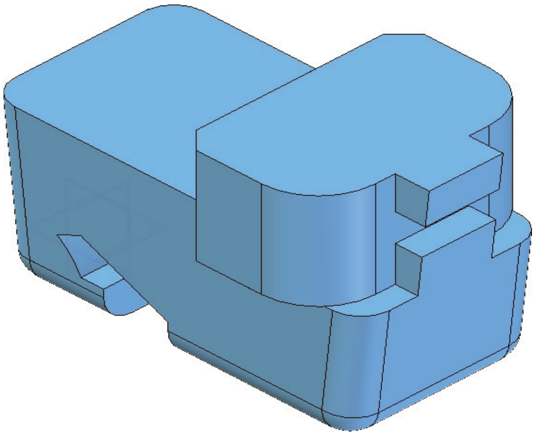


Figure A.1 — 3D view of fixture (Gabarit) in accordance with UNECE Regulation No.16 (2005), Annex 17, Appendix 1

A.2 Procedure

In order to determine the CRP, the procedure outlined below shall be followed.

— Make the adjustments specified in Table A.1 (if the components are fitted).

— Place a thin cotton cloth on the seat-back and cushion.

— Place the fixture as described in Figure 1 of UNECE Regulation No.16 (2005), Annex 17, Appendix 1, on the vehicle seat.

— The fixture shall be placed symmetrically on the seat.

— Apply a force of (100 ± 10) N to the centre of the front plane of the fixture parallel to its bottom plane against the backrest of the passenger seat. Then release the force.

— Apply a force of (100 ± 10) N to the centre of the top plane of the fixture downwards against the seat cushion of the passenger seat. Then release the force.

The CRP is determined as the intersection of the fixture's centre y-plane with its back and bottom plane.

NOTE Only passenger seats that allow the Gabarit test tool to fit on the seat surface can be compliant with this part of ISO/TS 22239.

If the tool cannot be placed correctly on the seat's surface because the seat mirror is too narrow, the CRP point cannot be correctly determined.

If it is not possible to bring the fixture (Gabarit) in full contact with the seat's backrest, perhaps because the backrest is too narrow, the CRP cannot be determined either, see Figure A.2.

In both cases, the passenger seat is not compliant with this part of ISO/TS 22239. Nevertheless, such a passenger seat, equipped with a CPOD sensor might detect any CPOD-compatible CRS, which is to be proven by a unique and seat-specific test programme.

The PSCTD and the procedure defined in 9.5 are in that case not suitable and not sufficient to check the performance. Therefore, the vehicle manufacturer shall provide an increased CRS detection area and failsafe area in order to meet the compatibility requirements.

Table A.1 — Passenger seat adjustment for CRP determination

Component	Detail	Adjustment
Seat	height adjustment	lowest position
	fore/aft adjustment	rearmost
Seat cushion	height adjustment	lowest position
	depth adjustment	foremost
	side bolster	flat/exhausted
	tilt adjustment (rear & front edge)	down
	thigh support	max.
Backrest cushion	side bolster	flat/exhausted
	lumbar support	flat/exhausted
Headrest	adjustment	lowest position
Backrest	inclination angle	95° angle between backrest and seat cushion (adjusted with H-point machine)

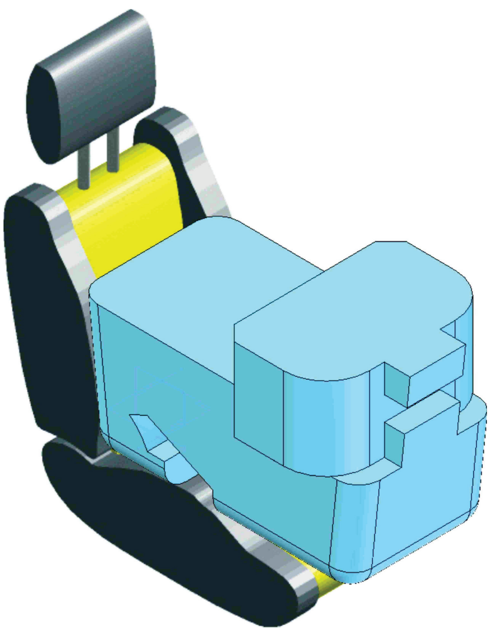


Figure A.2 — Non-compliant passenger seat, CRP determination not possible

Annex B
(normative)

Geometrical descriptions

B.1 Resonator and resonator pair reference point

Each resonator should be a symmetrical unit in both the x- and the y-direction, as indicated in Figure B.1. The intersection between the resonator's symmetrical axes is defined as resonator reference points

The resonator pair should also be constructed in a symmetrical way both the x- and the y-direction. The resonator pair reference point is defined as the intersection between the pair's symmetrical axes.

Dimensions in millimetres

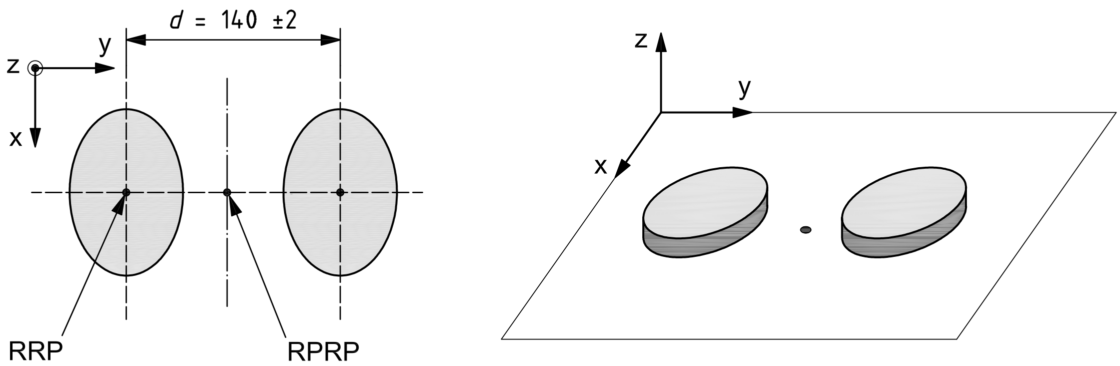
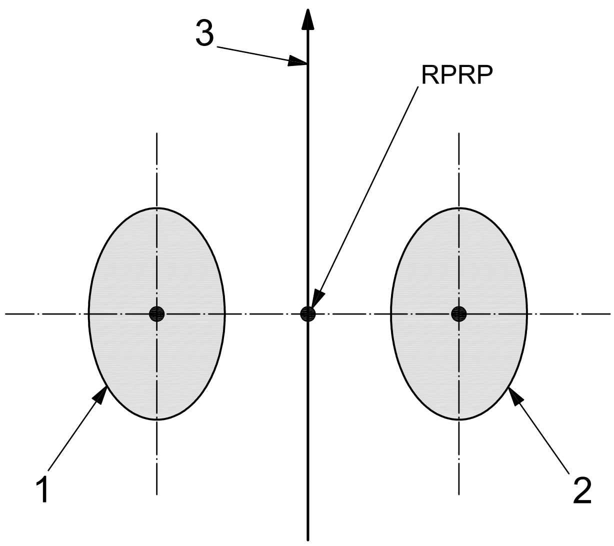


Figure B.1 — Resonator and resonator pair reference points

B.2 Resonator pair symmetrical axis and rotation angle γ

The resonator pair symmetrical axis is defined as the symmetrical axis between the two resonators through the RPRP, where the left resonator is on the left side of the symmetrical axis and the right resonator is on the right side of the symmetrical axis (see Figure B.2).



Key

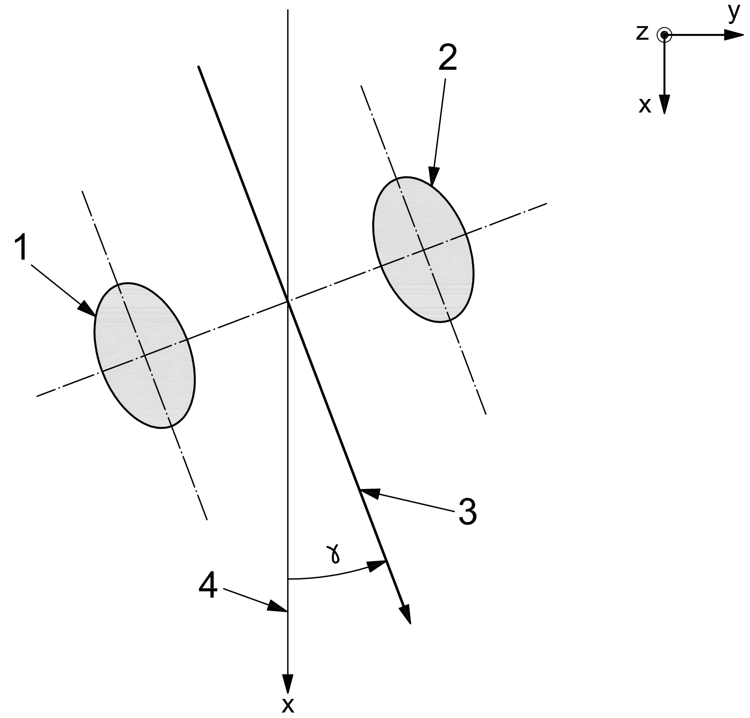
1 left resonator

2 right resonator

3 resonator pair symmetrical axis

Figure B.2 — Definition of resonator pair symmetrical axis

The rotation angle, γ, is defined as the angle between the resonator pair symmetrical axis and the x-axis of the reference co-ordinate system (top view on x/y-plane) (see Figure B.3).



Key

1 left resonator

2 right resonator

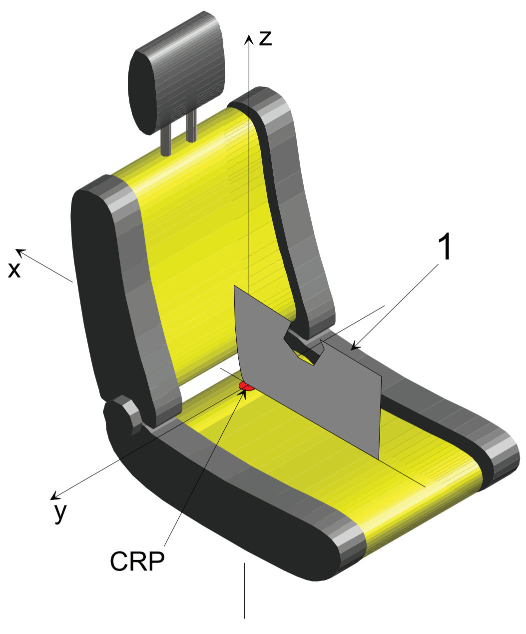
3 resonator pair symmetrical axis

4 x-direction of reference co-ordinate system

Figure B.3 — Definition of rotation angle γ

B.3 Reference co-ordinate system

The reference co-ordinate system is featured in Figure B.4. The inclination of the x-axis is such that the x-axis is part of the lower border of the "middle cut" of the Gabarit.



Key

1 middle cut of Gabarit

Figure B.4 — Reference co-ordinate system

Annex C
(normative)

Detailed specification of the CPOD system functionality

C.1 Components

The CPOD system consists of the following basic components:

- CRS equipped with a left and a right passive resonator;
- antennas in the passenger seat, consisting of one transmission antenna and two receiving antennas;
- CPOD-ECU logical electronic interface.

C.2 System working principle

The transmission antenna transmits an inductive field with frequency f_{TX} to the installed resonators. Each resonator modulates information with a resonator-specific subcarrier frequency, $f_{subcarrier}$, on the frequency f_{TX}. The receiving antennas receive the phase modulated information from the resonators.

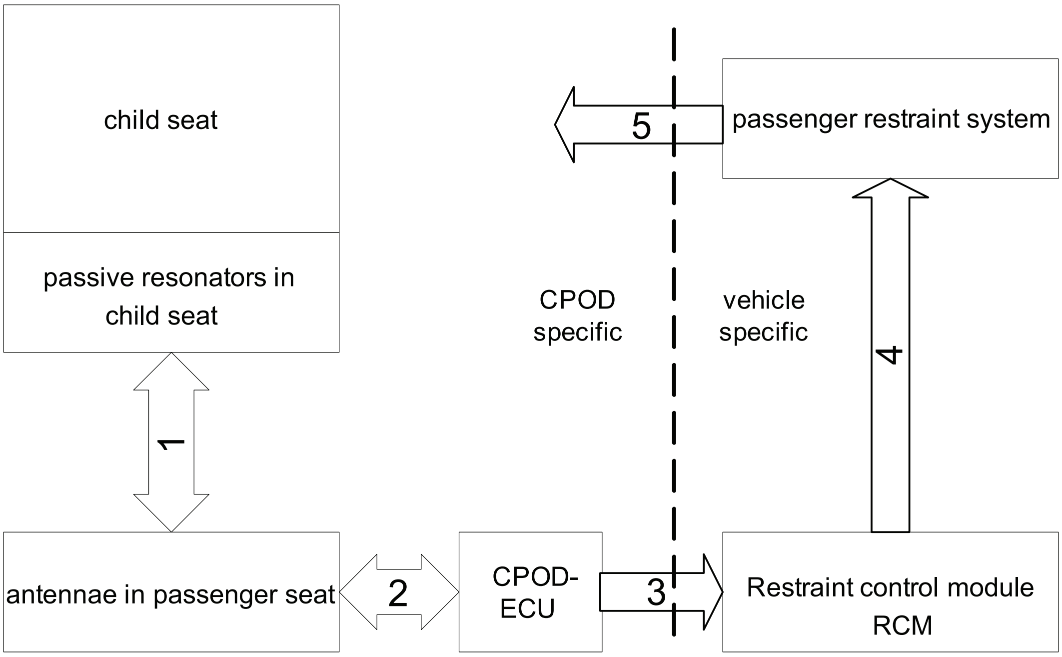
The resonators are installed at the bottom of the CRS. They are supplied by the magnetic field from the transmission antenna. The resonators modulate the transmitted field with resonator-specific information (e.g. CRS type, left or right resonator). The modulated transmitted field is captured by the receiving antennae. Depending on the location of each resonator related to the receiving antenna, the modulated signal has lower or higher amplitude.

C.3 Concept for increasing reliability

The following concept ensures high reliability:

- two passive resonators in CRS (redundancy necessary, because self-diagnosis of resonator is not possible);
- two receiving antennae in passenger seat (for redundancy and orientation detection);
- diagnosis of antennae in passenger seat (short circuit or open circuit detection).

C.4 Block diagram of interfaces



Key

1 Inductive field between antennae in passenger seat and resonators in CRS. RFID communication in 130 kHz range. This interface is described in detail in C.4.1.

2 Electrical interface between antennae in passenger seat and CPOD-ECU. The CPOD-ECU controls the current in the transmitting antenna and analyses the received signal in the receiving antennae. This interface is described below in principle.

3 Electrical interface between CPOD-ECU and RCM. The CPOD-ECU communicates to the RCM the relevant information about the CRS. This content of information is described below. The protocol and physical interface depends on requirements of the original equipment manufacturer.

4 The RCM design as well as the deployment strategy for the passenger airbags is the responsibility of the vehicle manufacturer.

5 See 4.

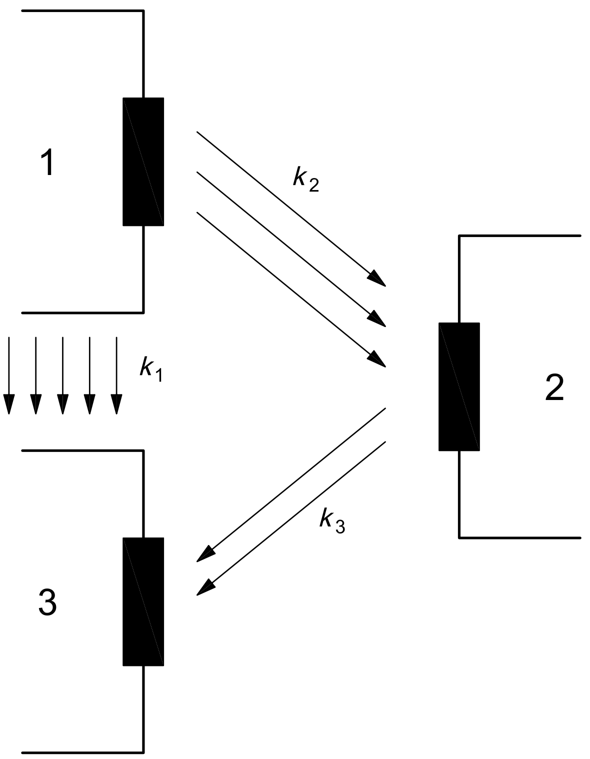
Figure C.1 — Block diagram of interfaces

C.4.1 Interface between resonators and antennae

C.4.1.1 General

The communication between resonators and CPOD is based on RFID methods.

For CRS detection, an inductively coupled system is used. Transmitting and receiving antennae are integrated into the passenger seat. By radiating a magnetic field via the transmitting antenna, the CPOD-ECU inductively excites two separate resonators in the CRS. The resonators receive their operating voltage from the stimulating magnetic field. The resonators themselves modulate the magnetic field with a specific subcarrier frequency, $f_{\text{subcarrier}}$. This modulated signal is coded by resonator information, which is received, demodulated and decoded in the CPOD-ECU.



Key

1 transmitting antenna
2 resonator antenna
3 receiving antenna

k_1 magnetic coupling factor between transmitting antenna and receiving antenna
k_2 magnetic coupling factor between transmitting antenna and resonator antenna
k_3 magnetic coupling factor between resonator antenna and receiving antenna

NOTE For simplification, only one receiving antenna and one resonator antenna is shown.

Figure C.2 — Coupling principle between the antenna and resonator

C.4.1.2 Transmitted field

C.4.1.2.1 General

The transmitting antenna transmits an inductive, sinusoidal field, $H_{\mathrm{TX}} = \hat{H} \times \sin\left(2\pi f_{\mathrm{TX}} t + \varphi\right)$.

C.4.1.2.2 Task 1: finding optimum transmitting frequencies

Since the resonant frequencies of both resonators may vary, the transmitting frequency shall be adjusted in such a way that the received, demodulated signal of the left and right resonator is of maximum amplitude, i.e. there could be two different optimum frequencies, $f_{\mathrm{TX,opt}}$, one tuned on the left resonator, $f_{\mathrm{TX,opt,left}}$, and one tuned on the right resonator, $f_{\mathrm{TX,opt,right}}$.

To find the optimum transmitting frequency between 124 kHz and 133 kHz for each resonator, the scanning frequency resolution shall be < 2,2 kHz . In this way, transmitting frequencies are used that are located within a bandwidth of ± 1,1 kHz of the optimum ones.

It shall be considered that the optimum frequency, $f_{\mathrm{TX,opt}}$, could change (e.g. due to temperature). In view of this, a repetition of task 1 is necessary, periodically or in accordance with an appropriate strategy.

C.4.1.2.3 Task 2: resonator protocol read-out

The resonator protocol is read out using optimum frequency $f_{TX,opt}$.

C.4.1.2.4 Task 3: resonator response amplitude measurement

The amplitude of demodulated signal received at the optimum frequencies is measured in order to be input information for presence and orientation detection of CRS.

In order to supply resonators sufficiently in the detection and failsafe area, the transmitted field shall be within the magnetic field operating range in accordance with ISO/TS 22239-2.

In order to avoid damage to resonators, the transmitted field shall not exceed the magnetic field absolute maximum rating in accordance with ISO/TS 22239-2 at any position around the antenna.

C.4.1.3 Modulation in resonator

C.4.1.3.1 Block diagram

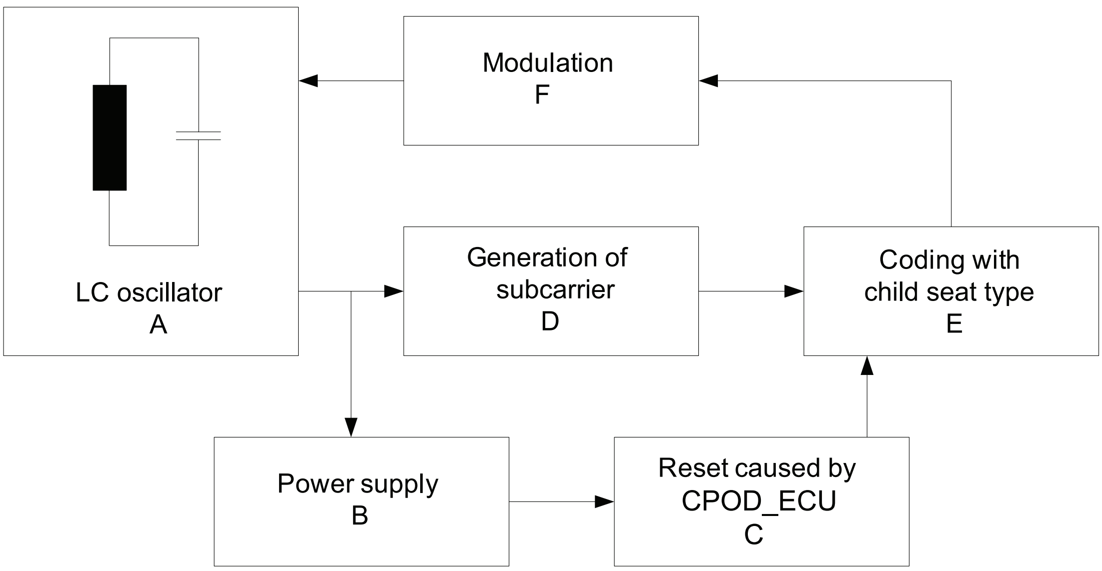


Figure C.3 — Block diagram of resonator

C.4.1.3.2 LC oscillator

For power supply, an LC oscillator inside the resonator works at such a frequency that energy transfer between transmitting antenna and resonator is optimized between 124 kHz and 133 kHz.

If the LC oscillator is in the transmitting field, the received signal in the receiving antennae has a phase shift, which is the carrier of information.

C.4.1.3.3 Power supply

Maximum $T_{power\ up,min}$ after generation of the magnetic field the resonator energy storages shall be charged in order to pass the reset field gap with the length of T_{RESET} in a biased state (absolute values are defined in ISO/TS 22239-2).

C.4.1.3.4 Reset caused by CPOD-ECU

Reset shall be generated at least once at the beginning of task 2 for protocol I read-out, but it is not necessary to repeat it during task 2.

Minimum $T_{\text{power up,min}}$ after generation of the magnetic field the CPOD-ECU stops the transmitting field for T_{RESET}. During T_{RESET}, the remaining transmitting field strength, H_{TX}, should not exceed 1/10 of $H_{\text{RESET,MAX}}$ for increased system robustness. The reset brings the resonator into a defined state, so that the resonator is able to start the protocol transmission with bit one of the resonator protocol, once the magnetic transmitter field is up again from reset (absolute values are defined in ISO/TS 22239-2).

C.4.1.3.5 Generation of subcarrier

The resonator creates internally a (rectangular) subcarrier with frequency $f_{\text{subcarrier}}$ derived from transmitting field f_{T}, as follows:

Left resonator: $f_{\text{subcarrier,left}} = f_{\text{TX}}/40$

Right resonator: $f_{\text{subcarrier,right}} = f_{\text{TX}}/56$

EXAMPLE Example for f_{TX} = 129 kHz:

$f_{\text{subcarrier,left}} = f_{\text{TX}}/40 = 3{,}225$ kHz

$f_{\text{subcarrier,right}} = f_{\text{TX}}/56 = 2{,}304$ kHz

C.4.1.3.6 Coding with CRS type

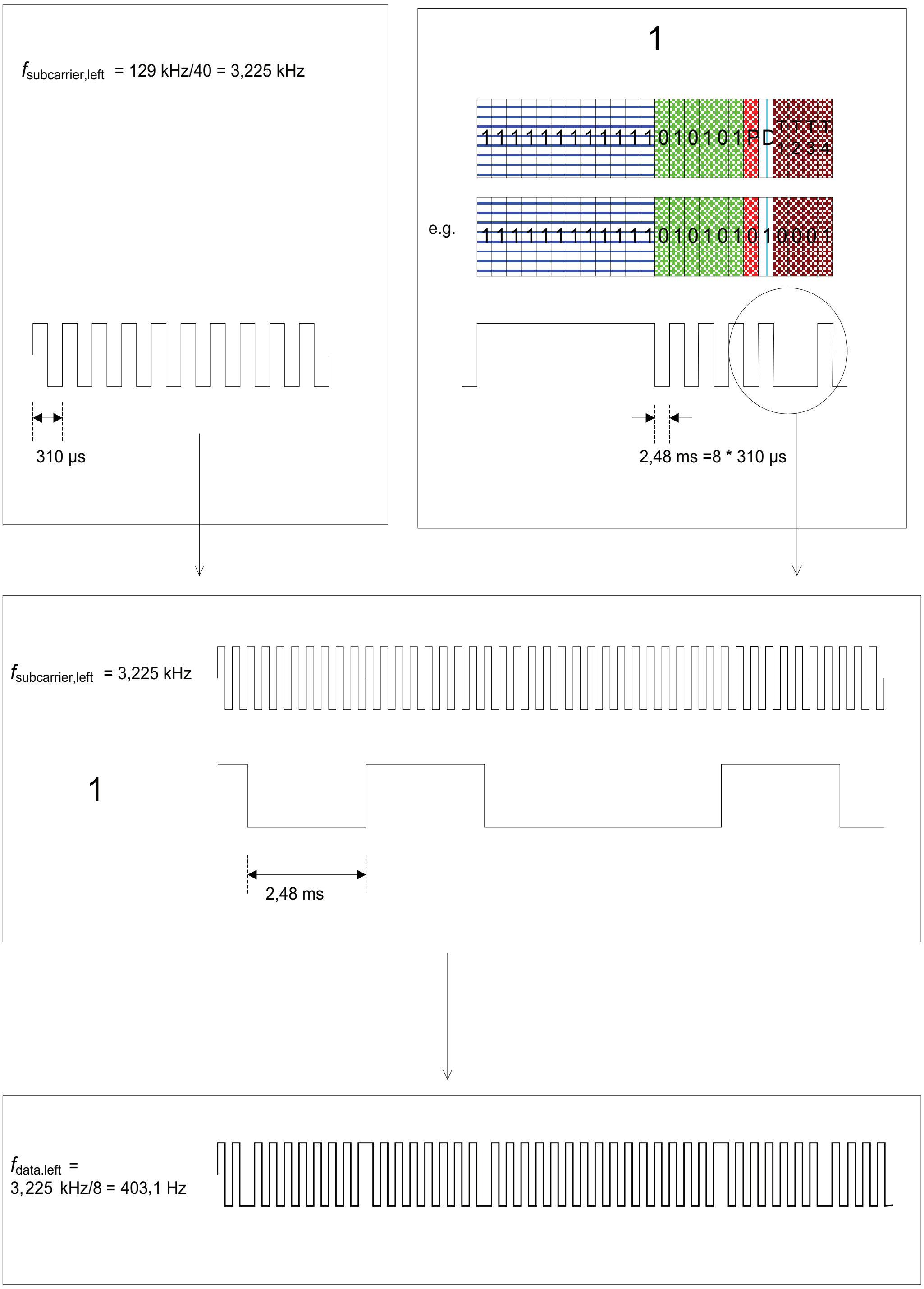
In addition to the different subcarrier, there is the possibility to transmit special CRS-type information from the resonator to the CPOD-ECU. This is done with 24 bits. For details, see ISO/TS 22239-2.

Additional information about the CRS is provided via the CRS type bits, as defined in ISO/TS 22239-2.

C.4.1.3.7 Modulation

The modulation is a phase modulation using non-return-to-zero (NRZ) coding. If the LC oscillator is placed in the transmitting field, the received signal in the receiving antennae shall have a phase shift.

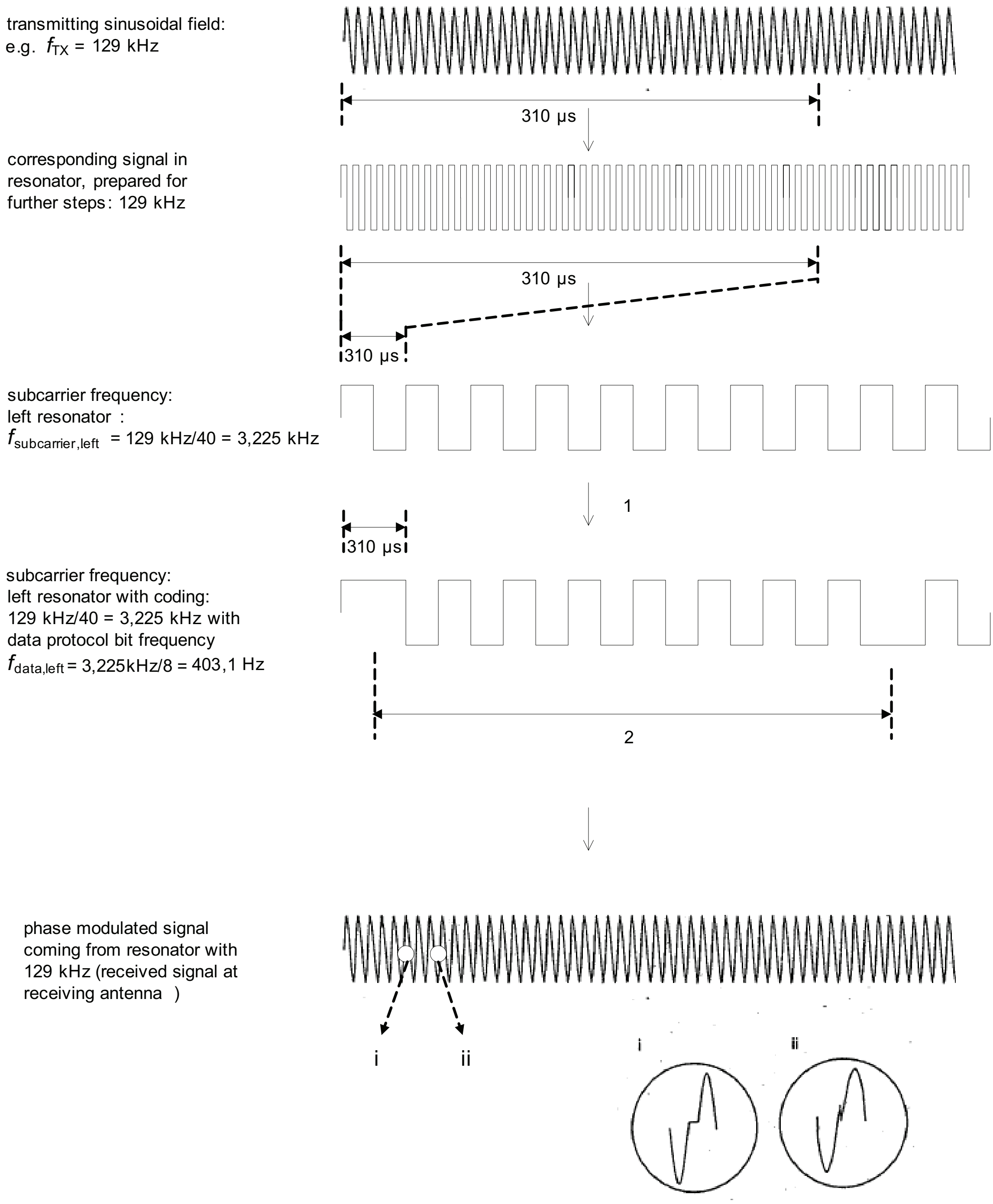
By changing the impedance of the LC oscillator, the phase shift is also changed. This can be achieved by, for example, changing the capacitance of the LC oscillator. The phase shift keying of the transmitting field is done in accordance with Figure C.5.



Key

1	type information of resonator
$f_{subcarrier,left}$	subcarrier frequency of left resonator
$f_{data,left}$	data protocol bit frequency of left resonator

Figure C.4 — Coding principle in resonator



Key

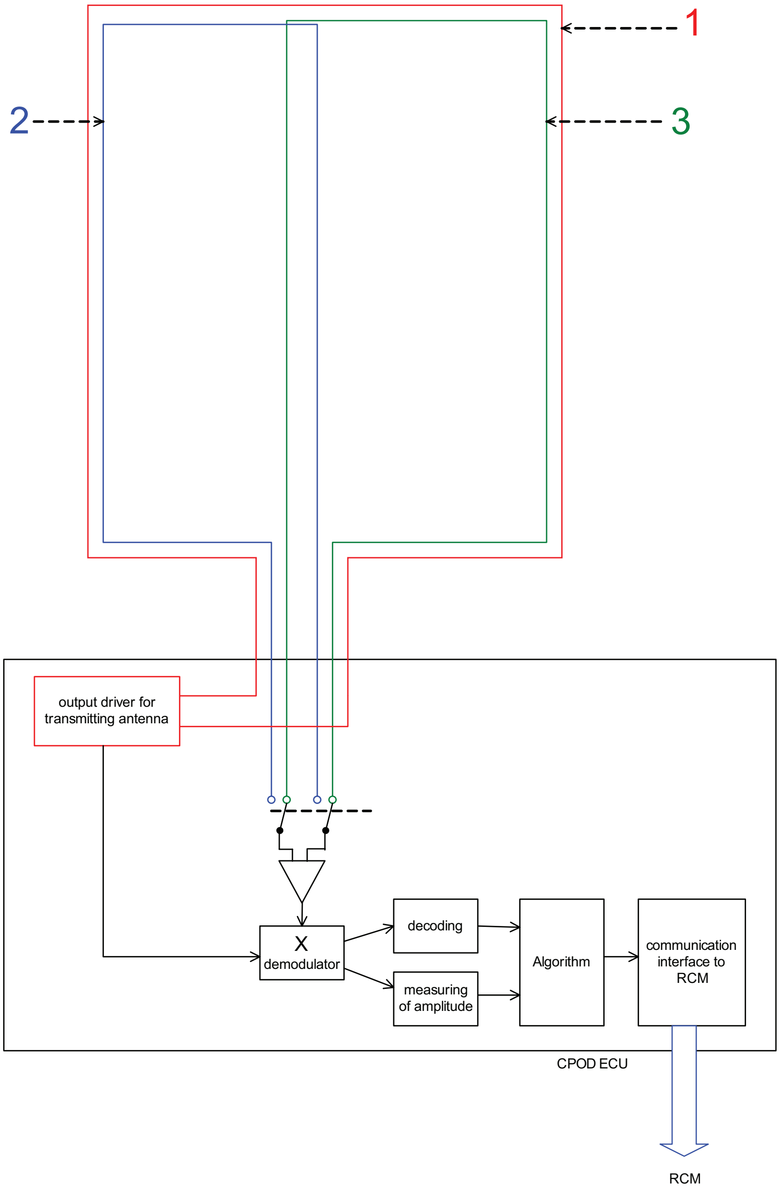
1 details, see C.4.1.3.6

2 one-bit length of type information of resonator

Figure C.5 — Modulation in resonator

C.4.2 Interface between antennae and CPOD-ECU

C.4.2.1 Block diagram



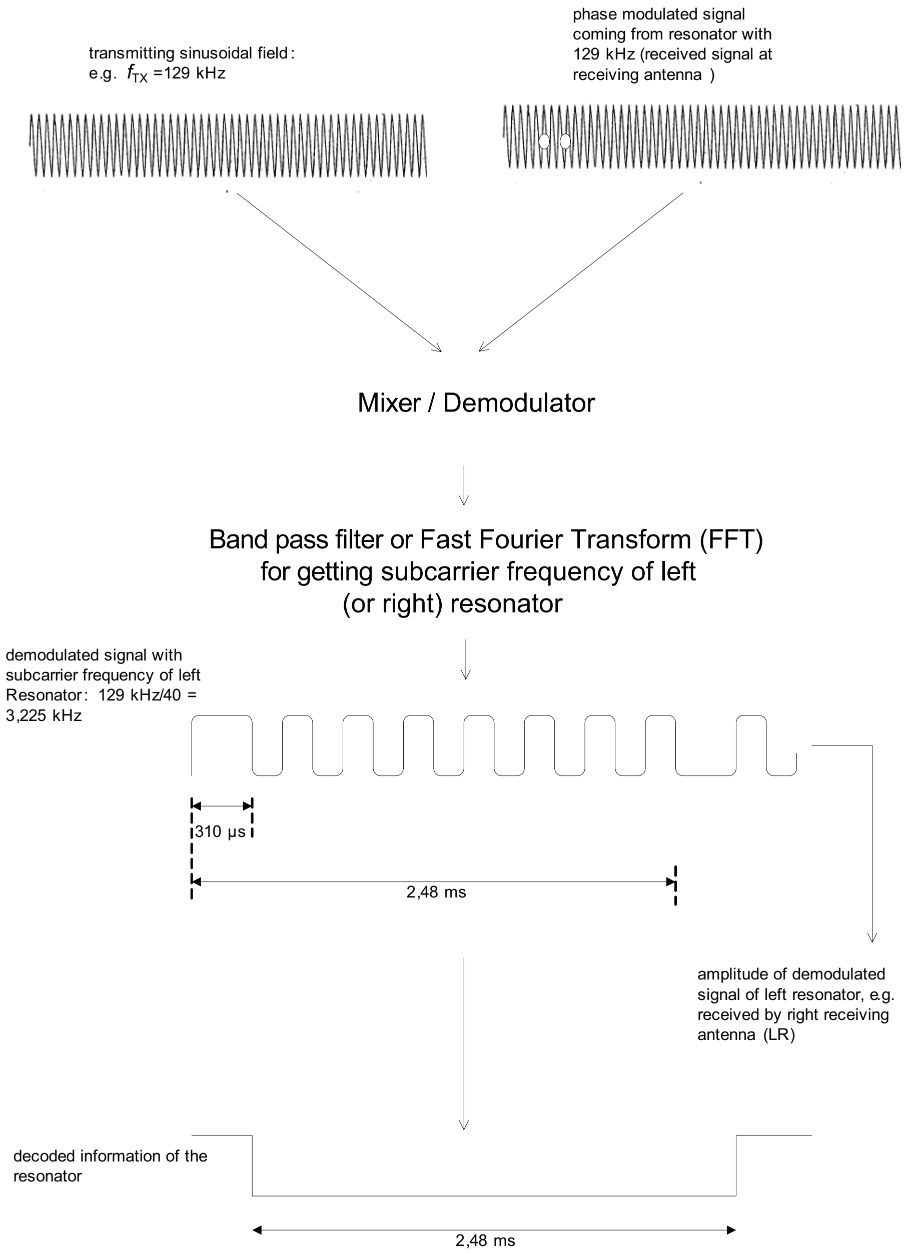
Key

1 transmitting antenna

2 left receiving antenna

3 right receiving antenna

Figure C.6 — Interface antennae — ECU



NOTE The phase shift keying at the received signal of the receiving antenna depends on the magnetic coupling factors between the used antennae. Therefore, the phase shift amplitude of received signal at the receiving antenna as well as the demodulator sensitivity cannot be specified directly.

Figure C.7 — Demodulation in CPOD-ECU

C.4.2.2 Demodulation of received signal

The CPOD-ECU gets the following information:

- CRS type of left resonator;
- CRS type of right resonator;
- amplitude of demodulated signal of
  - left resonator received by left receiving antenna LL,
  - right resonator received by left receiving antenna RL,
  - left resonator received by right receiving antenna LR,
  - right resonator received by right receiving antenna RR.

C.4.2.3 Control of transmitting signal

The CPOD-ECU generates a magnetic field in the transmitting antenna. See C.4.1.2.

C.4.2.4 Diagnostics of antennae

The CPOD-ECU shall detect

- short and open circuit of transmitting antenna,
- short and open circuit of the receiving antennae,
- short circuit between receiving and transmitting antenna.

C.4.2.5 Algorithm

C.4.2.5.1 CRS placement

Based on the amplitudes of the demodulated signals, the algorithm calculates the orientation of the CRS:

a) forward;

b) rearward;

c) wrongly positioned;

d) only one resonator detected.

Simplified examples:

- if LL ≈ RR and LL >> LR and RR >> RL ➔ CRS forward oriented;
- if LR ≈ RL and LL << LR and RR << RL ➔ CRS rearward oriented;
- if LL ≈ RR ≈ RL≈ LR ➔ CRS wrongly positioned;
- if LL ≈ LR ≈ 0, RR >> 0 or RL >> 0 ➔ only one resonator;
- if LL ≈ LR ≈ RR ≈ RL ≈ 0 ➔ no CRS detected.

NOTE See C.4.2.2 for explanations of LL, RR, RL and LR.

C.4.2.5.2 CRS type

The CRS type is given by the coded information by at least one of the resonators.

C.4.2.5.3 Disturbing signal

If relevant resonator signals are detected, but without or with wrongly coded information, then there is a disturbing signal detected, which can also be caused by a defective resonator.

C.4.2.5.4 Hardware failure

It is checked whether antennae and/or the CPOD-ECU itself are defective.

C.4.3 Interface between CPOD-ECU and RCM

The detected status shall be transmitted to the ECU using a corresponding communication interface:

- CRS detected forward facing;
- CRS detected rearward facing;
- CRS wrongly positioned;
- only one resonator detected;
- no CRS;
- CRS type;
- CPOD hardware failure;
- disturbing signal detected.

Annex D
(normative)

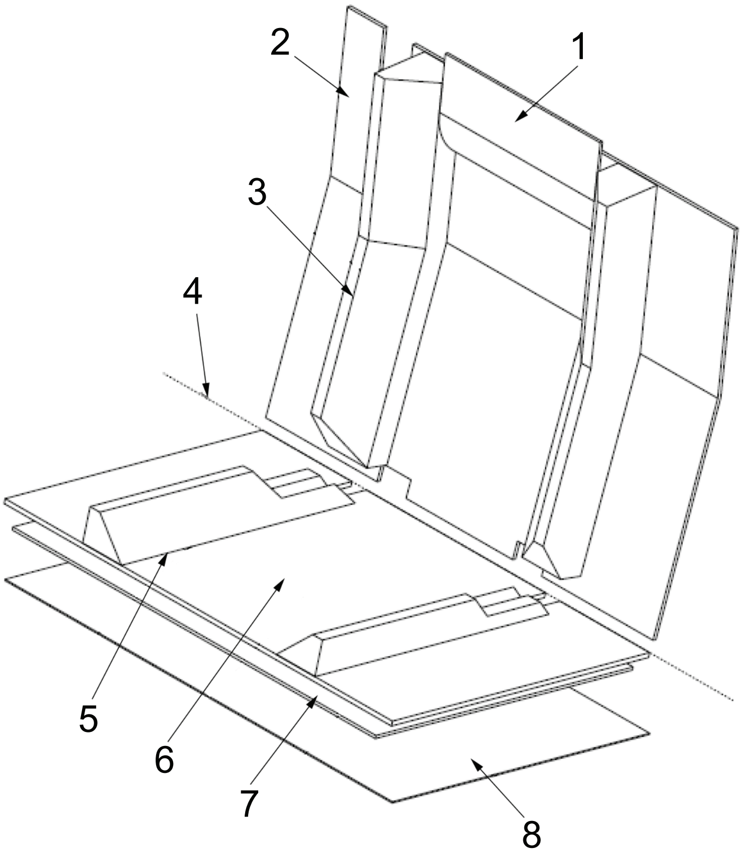
CPOD child seat compatibility test bench

D.1 Requirements

The following requirements apply:

- there shall be no deflection of the seat surface due to mounting of a CRS on the plane;
- non-electroconductive materials shall be used (not required for fasteners, e.g. screws and the aluminium plate, as well as for a supporting frame, which may be used provided there is a distance of at least 150 mm between supporting frame and antenna);
- the ohmic resistance between both ISOFIX anchorages shall be smaller than 1 Ω, while no closed conducting loop shall be created within a distance of 150 mm from the antenna;
- the angle between backrest and seat plane shall be adjustable in accordance with Clause 9;
- no closed conducting loop shall be used within a distance of 150 mm from the antenna;
- see Figures 14 and 16 for a 3D view of the CRS compatibility test bench;
- CRS compatibility test benches shall meet the dimensional requirements specified in Figures D.2 to D.9.
- the three-point retractor belt and its anchorages are to be fitted to the points A, B0 and C, in accordance with the procedure and its components described in the UNECE Regulation No.44 (2008), Annex 13, items 2 and 3 and references (see also Figure D.7);
- the CTB shall be fitted with ISOFIX anchorages fulfilling the requirements of UNECE Regulation No.14 at the points H1 and H2 as shown in Figure D.8; in any case, the required test positions defined in 9.4 shall be achieved;
- the wedge shall be placed on the test bench, if necessary (see 9.4);
- a bracket fixed at the wedge holds the position of the wedge on the CTB: the hole in the bracket and the threaded hole in the wedge shall be dimensioned for the used screw, e.g. ISO M6 (see Figure D.7);
- Figures D.10 and D.11 show the removable left-hand cheeks only (right-hand parts shall be mirror-imaged, see assembly in Figure D.1): the cheeks shall be positioned symmetrically to the centre y-plane of the CTB; the clearance of the cheeks on the seat surface and on the backrest shall be 320 mm;
- the antenna (consisting of one sending and two receiving antennae, as described in this part of ISO/TS 22239) shall be positioned and fixed on the antenna carrier as described in Figure D.12; the antenna is specified in Annex F;
- for dimensioning and positioning of the headrest, see Figure D.13; the headrest height X_H shall be adjusted to 50 mm.

D.2 Dimensional characteristics

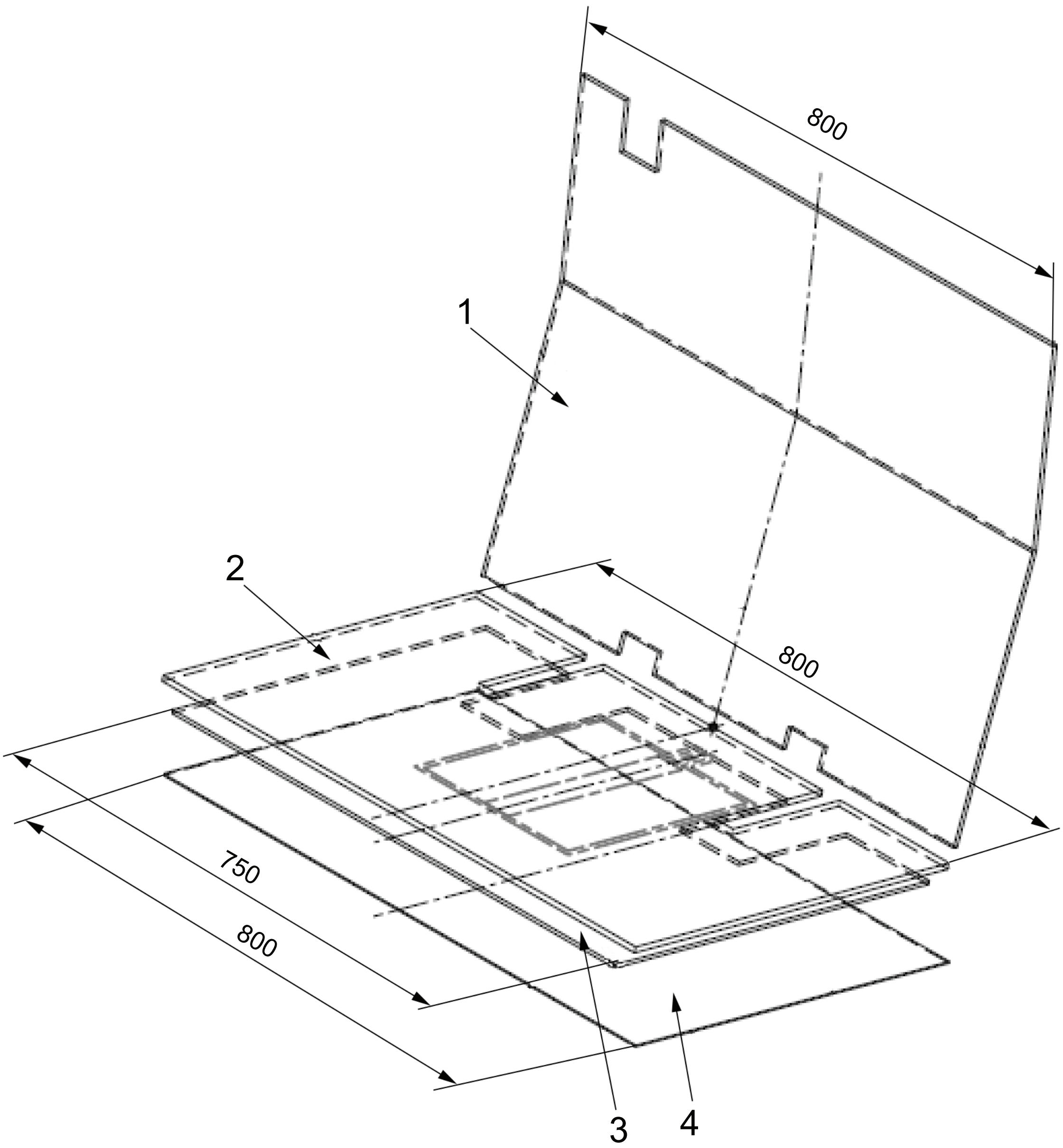


Key

1 headrest
2 angle-adjustable backrest
3 backrest cheeks (removable)
4 rotation axis of angle-adjustable backrest
5 seat plane cheeks (removable)
6 seat plane
7 antenna carrier
8 aluminium plate

Figure D.1 — Basic elements of CRS compatibility test bench (without antenna)

Dimensions in millimetres
General tolerances ±1 mm



Key

1 angle-adjustable backrest

2 seat plane

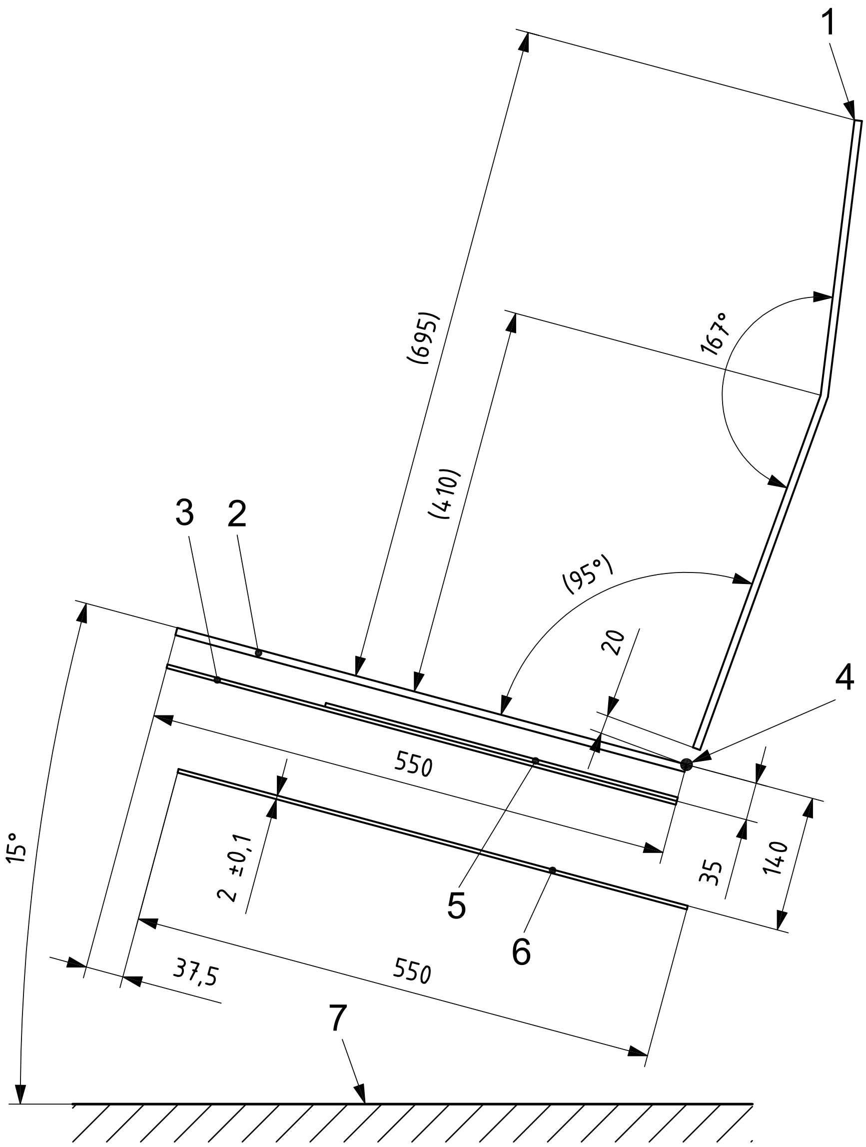
3 antenna carrier

4 aluminium plate

NOTE Values are symmetrical to middle plane.

Figure D.2 — Basic elements and dimensions of CRS compatibility test bench (with antenna) 1

Dimensions in millimetres
General tolerances ±1 mm



Key

1 angle-adjustable backrest
2 seat plane
3 antenna carrier
4 rotation centre
5 antenna
6 aluminium plate
7 bottom

NOTE 1 Figure is side view of CTB.

NOTE 2 Values in brackets are for design only.

Figure D.3 — Basic elements and dimensions of CRS compatibility test bench (with antenna) 2

Dimensions in millimetres
General tolerances ±1 mm

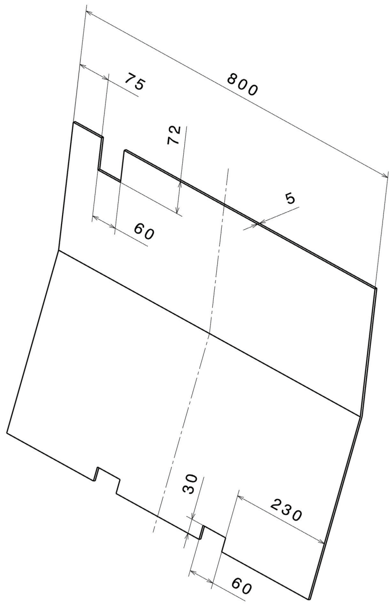


Figure D.4 — Dimensions of the backrest of the CRS compatibility test bench

Dimensions in millimetres
General tolerances ±1 mm

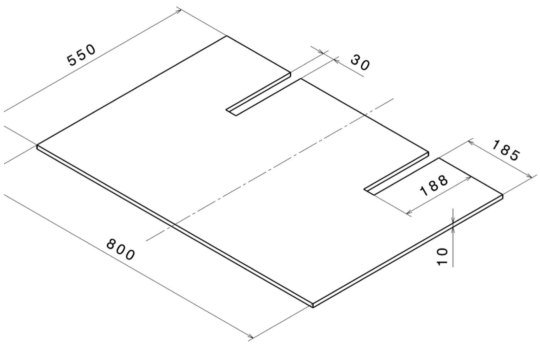


Figure D.5 — Dimensions of the seat surface of the CRS compatibility test bench

Dimensions in millimetres
General tolerances ±1 mm

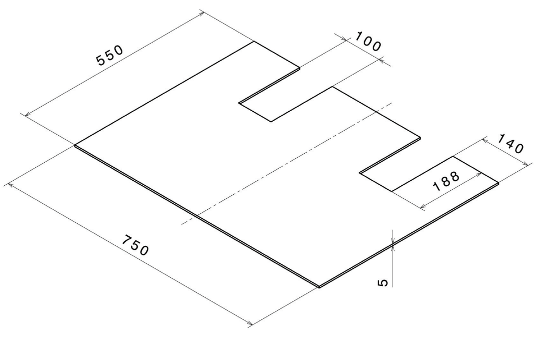
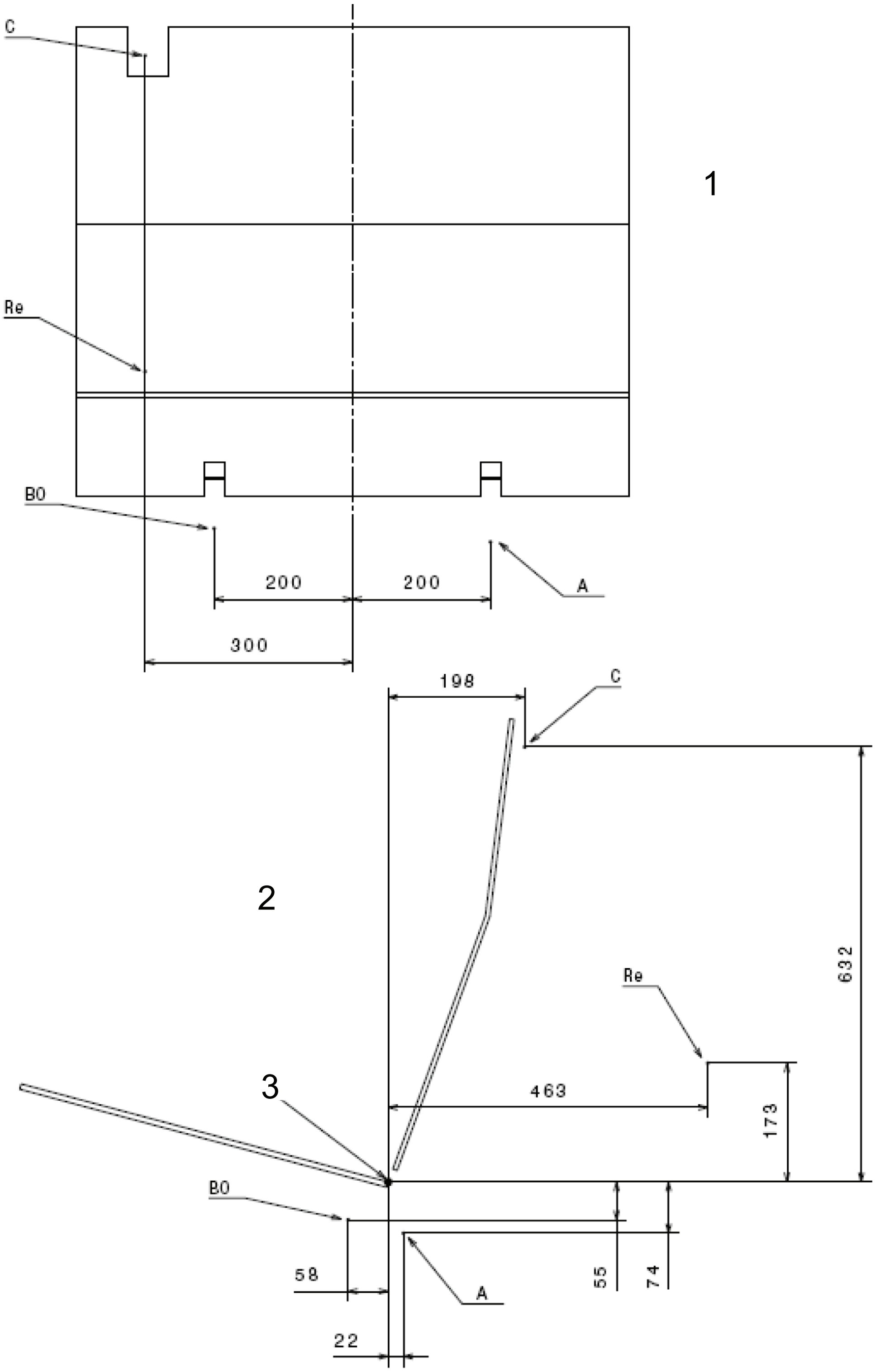


Figure D.6 — Dimensions of the antenna carrier on the CRS compatibility test bench

Dimensions in millimetres
General tolerances ±1 mm



Key

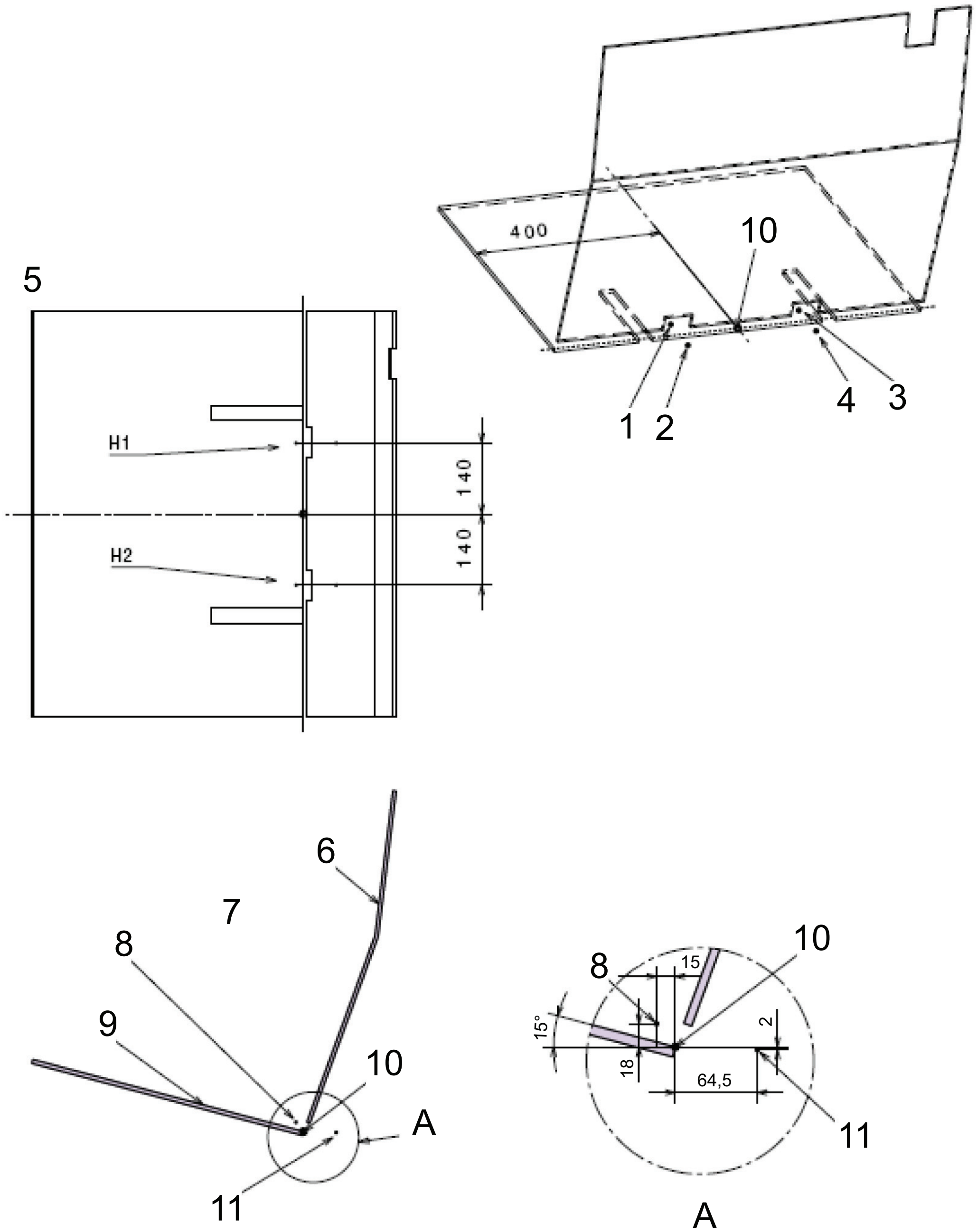
1 front view of CTB

2 side view of CTB

3 upper backside edge of seat plane (= rotation axis of backrest)

Figure D.7 — Dimensioning of the 3-point anchorage points on the CRS compatibility test bench

Dimensions in millimetres
General tolerances ±1 mm

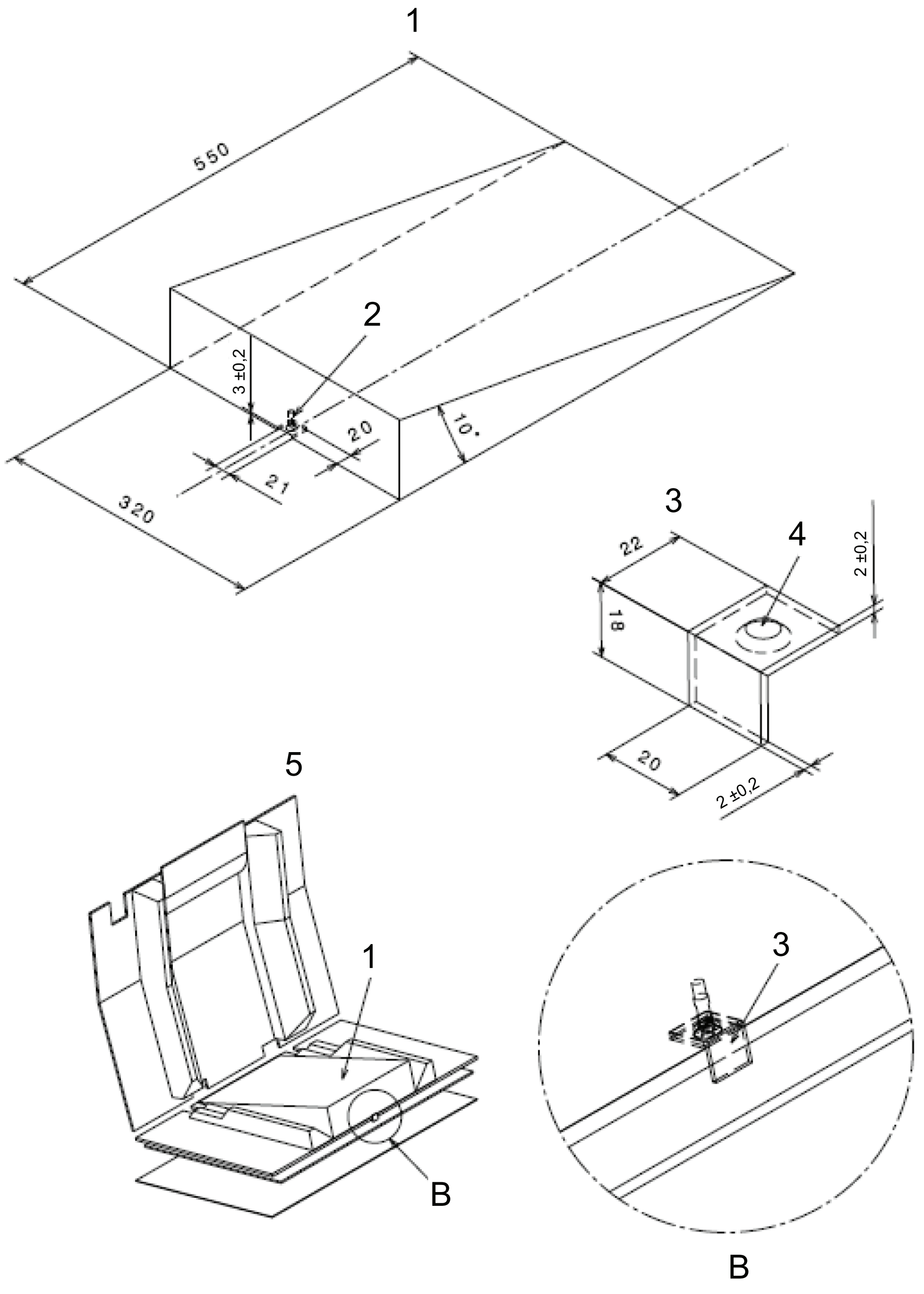


Key

1 H2 foremost
2 H2 rearmost
3 H1 foremost
4 H1 rearmost
5 top view
6 backrest
7 side view
8 H1/H2 foremost
9 seat plane
10 rotation centre
11 H1/H2 rearmost

Figure D.8 — Dimensioning of the ISOFIX anchorages on the CRS compatibility test bench

Dimensions in millimetres
General tolerances ±1 mm



Key

1 wedge

2 threaded hole to fix the bracket

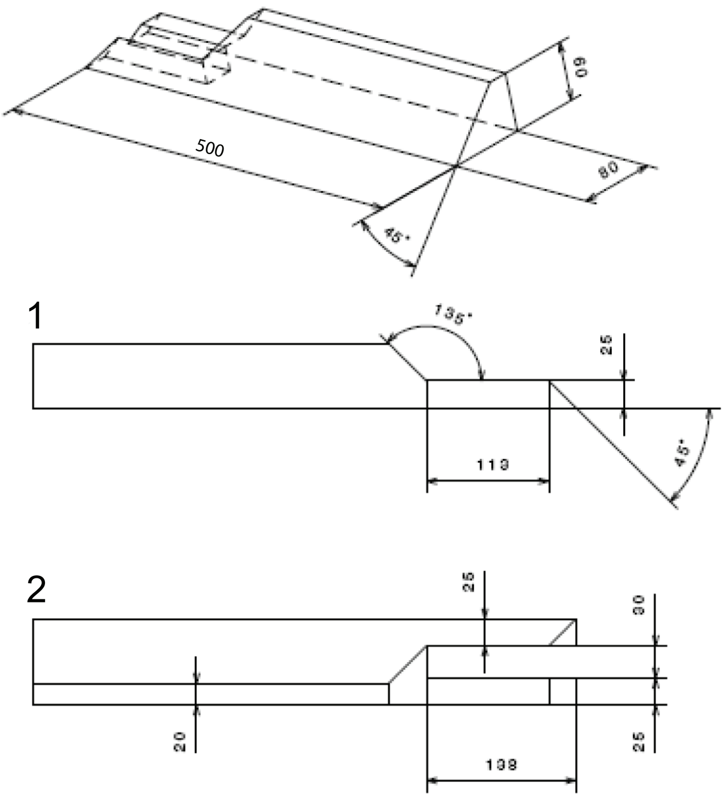
3 bracket

4 hole for screw to fix the bracket and the wedge

5 positioning of the wedge on the CTB

Figure D.9 — Dimensions and assembly of the wedge and fixation bracket

Dimensions in millimetres
General tolerances ±1 mm



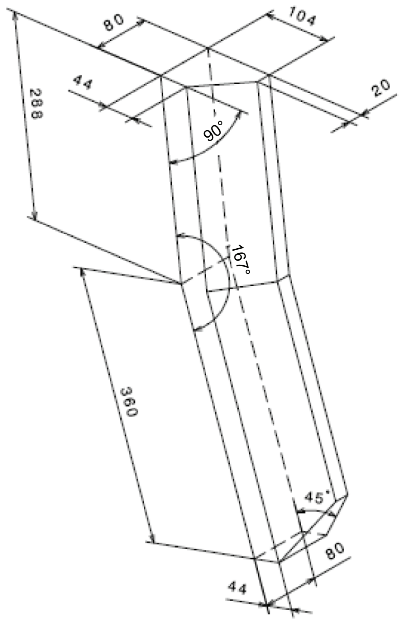
Key

1 side view

2 top view

Figure D.10 — Dimensions of removable cheeks to be mounted on the seat plane

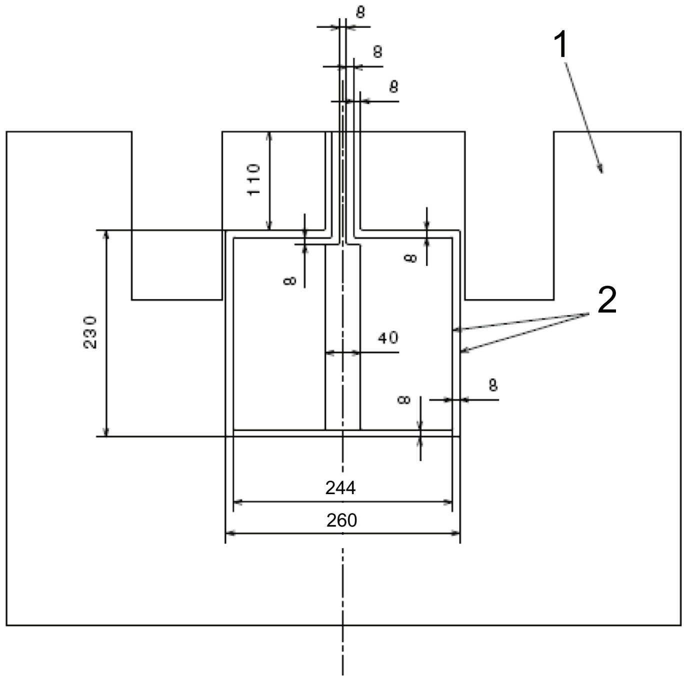
Dimensions in millimetres
General tolerances ±1 mm



NOTE Left backrest cheek as drawn, right one reversed symmetrically.

Figure D.11 — Dimensions of removable cheeks mounted on the backrest

Dimensions in millimetres
General tolerances ±1 mm



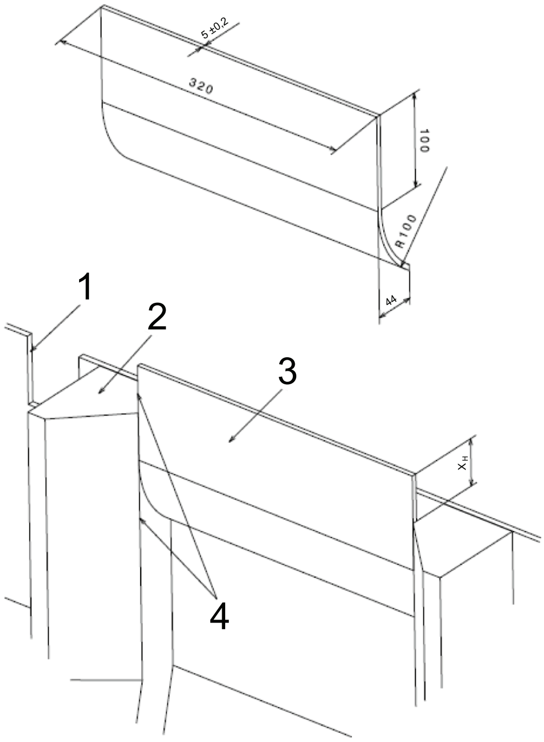
Key

1 antenna carrier

2 antennae

Figure D.12 — Dimensioning and positioning of the antennae

Dimensions in millimetres
General tolerances ±1 mm



Key

1 angle-adjustable backrest

2 backrest cheeks (removable)

3 headrest

4 edges in line

NOTE The headrest is mounted directly between the cheeks of the backrest symmetrically to the centre y-plane of the CTB, as shown.

Figure D.13 — Dimensioning and positioning of the headrest

Annex E
(normative)

CPOD passenger seat compatibility test device

E.1 General

The PSCTD specified in this annex is designed in accordance with the envelope dimensions for a full size rearward facing CRS ISO/R3 (see ISO 13216-1 and UNECE Regulation No.16).

The outer surfaces of the PSCTD are defined. The layout of the inside of the PSCTD (e.g. wall thickness) is decided by the user, but it shall allow adjustment of the required test positions (see 9.5). During use, the toll shall not deform, which shall be ensured by an adequate stiffness of its structure. The weight of the PSCTD shall be (18,5 ± 0,5) kg. All parts, except fasteners and ISOFIX connectors, shall be made of non-conducting material.

The PSCTD shall be fitted with removable ISOFIX connectors, as specified in Figure E.3. The ISOFIX connectors shall be made of conductive material.

Fixing of the connectors to the PSCTD should be made with M6 screws and M6 wing nuts, at the positions of the fixation holes defined in Figure E.3. Otherwise, it shall be ensured that the required test positions can be adjusted, in particular the two defined ISOFIX reference points shall be achieved.

E.2 Dimensional characteristics

Dimensions in millimetres
General tolerances ±1 mm

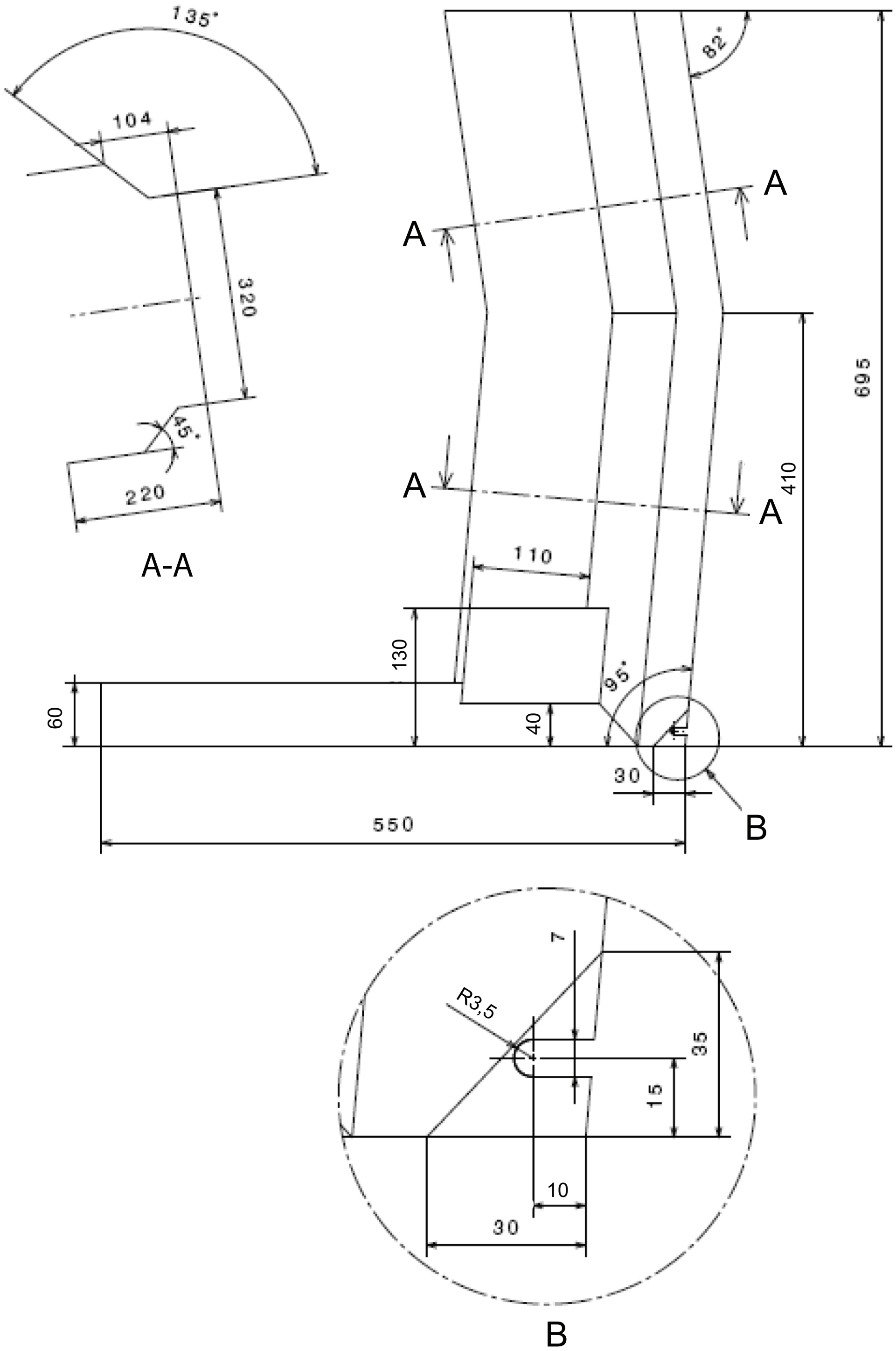


Figure E.1 — Outer contour of passenger seat compatibility test device (PSCTD), side view

Dimensions in millimetres
General tolerances ±1 mm

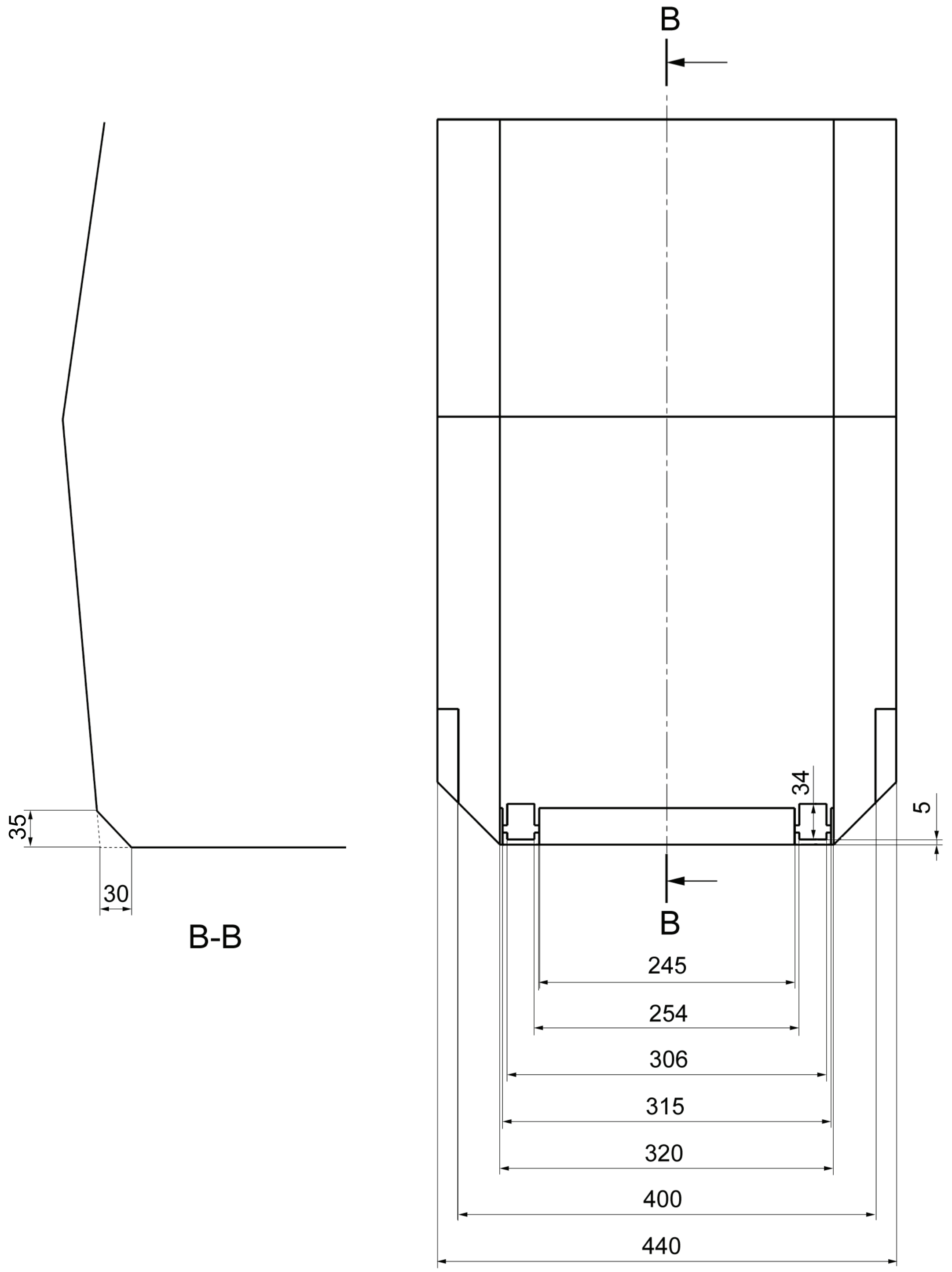
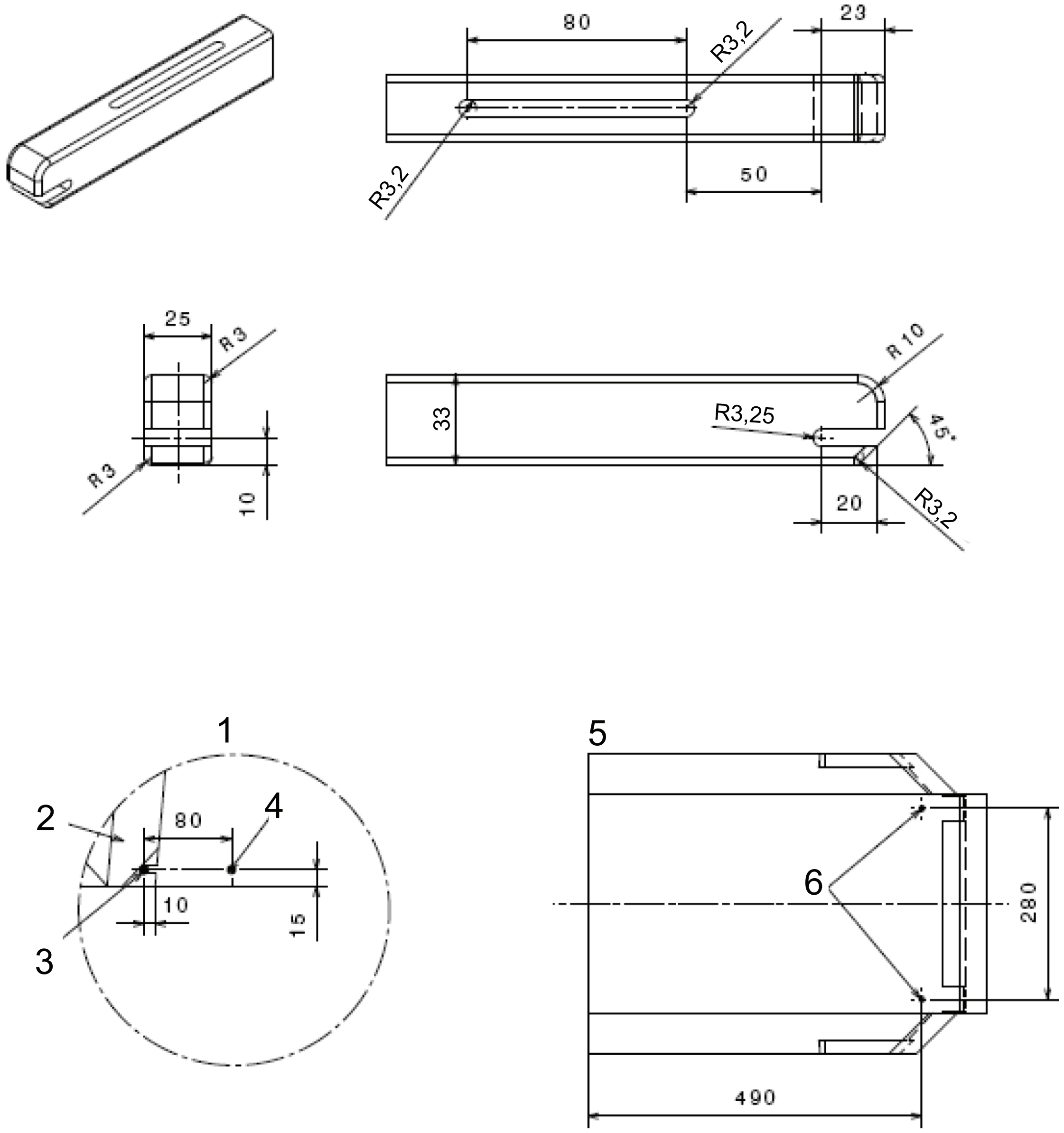


Figure E.2 — Outer contour of passenger seat compatibility test device (PSCTD), back view

Dimensions in millimetres
General tolerances ±1 mm



Key

1 ISOFIX reference points of the PSCTD (side view)
2 backside of the PSCTD
3 retracted position (for H1 and H2 foremost)
4 fully extended position (for H1 and H2 rearmost)
5 top view of the PSCTD
6 fixation holes for ISOFIX connectors

Figure E.3 — ISOFIX connectors for test device

Annex F
(normative)

Additional definitions

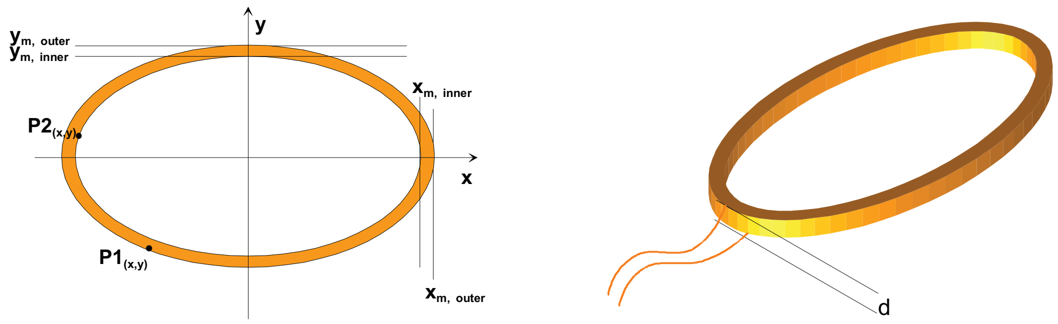
F.1 CPOD resonator probe

F.1.1 Definition of CPOD resonator probe

A resonator probe is an air coil with elliptical shape, covered by a housing with defined thickness.

F.1.2 Coil parameters

The geometry of the resonator probe coil is defined as indicated in Figure F.1.



Key

P_1, P_2 position vectors, determined by Equation (F.1)

Figure F.1 — Resonator probe coil geometry

The position vectors of the inner and outer shape of the coil are described by Equation F.1 with parameters as specified in Table F.1.

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

Table F.1 — Coil geometry parameters

Dimensions in millimetres

Parameter	min.	max.
$x_{m,outer}$	—	56,4
$y_{m,outer}$	—	31,6
$x_{m,inner}$	54,4	—
$y_{m,inner}$	29,6	—
d	—	2

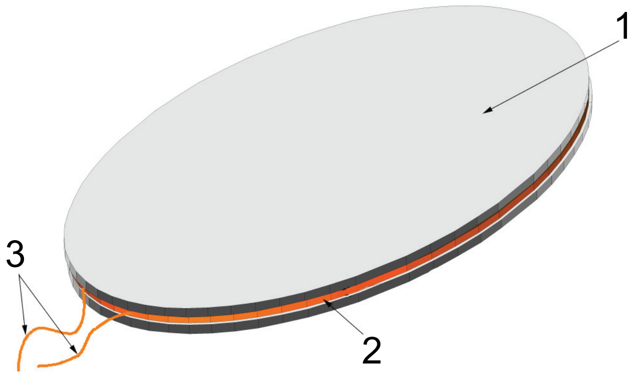
The electrical properties of the coil are specified in Table F.2, and the coil geometry parameters in Table F.1.

Table F.2 — Coil electrical parameters

Parameter	Explanation	min.	Type	max.	Unit
L_{COIL}	inductivity of coil	190	—	220	µH
N_{COIL}	number of windings	30	—	30	1
NOTE An isolated 0,18 mm (diameter) copper wire is used for the coil winding.					

F.1.3 Housing

The coil shall be encapsulated symmetrically by a housing in order to ensure manageability. The magnetic permeability constant, μ_r, of the housing material shall be in the range between 0,98 and 1,02. See Figure F.2.



Key

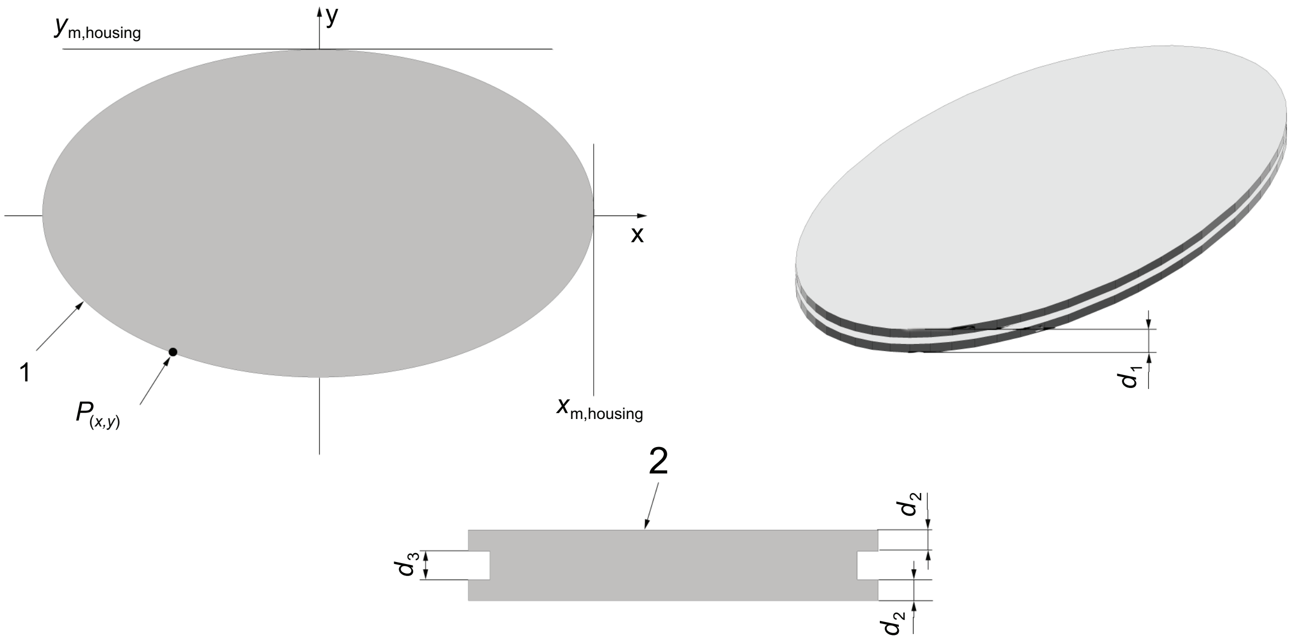
1 housing

2 coil

3 coil wire terminators

Figure F.2 — Resonator probe housing

The geometry of the housing is described in Figure F.3 and Table F.3.



Key

1 top view

2 profile

$P_{(x,y)}$ position vectors

Figure F.3 — Resonator probe housing geometry

Table F.3 — Housing geometry parameters

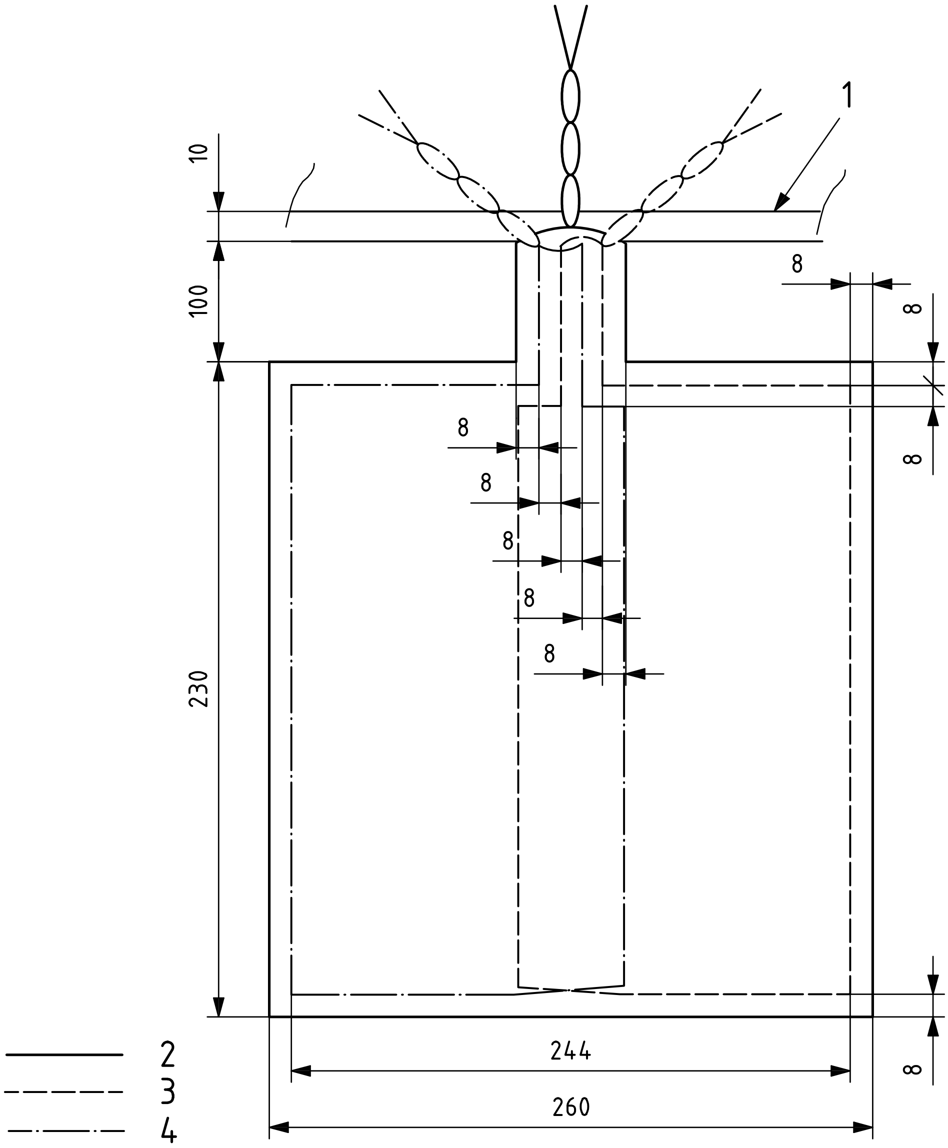
Dimensions in millimetres

Parameter	min.	max.
$x_{m,housing}$	—	56,4
$y_{m,housing}$	—	31,6
d_1	3,9	4,1
d_2	0,95	1,05
d_3	—	2

F.2 CTB antenna definition

Figure F.4 shows the antenna geometry as part of the CTB; see also Figure D.12.

Dimensions in millimetres



Key

1 edge of antenna carrier

2 transmitting antenna

3 right receiving antenna

4 left receiving antenna

Figure F.4 — CTB antenna geometry

Every antenna (transmitting antenna, right and left receiving antenna) shall consist of several windings and shall meet the requirements specified in Table F.4.

Table F.4 — CTB antenna parameters

Parameter	Explanation	Value	Unit
N_{TX}	number of windings, transmitting antenna	10	1
$N_{\mathrm{RX,R}}$	number of windings, right receiving antenna	10	1
$N_{\mathrm{RX,L}}$	number of windings, left receiving antenna	10	1
NOTE An isolated 0,18 mm (diameter) copper wire is used for the coil winding.			

Annex G
(normative)

Magnetic coupling factor measurement procedure

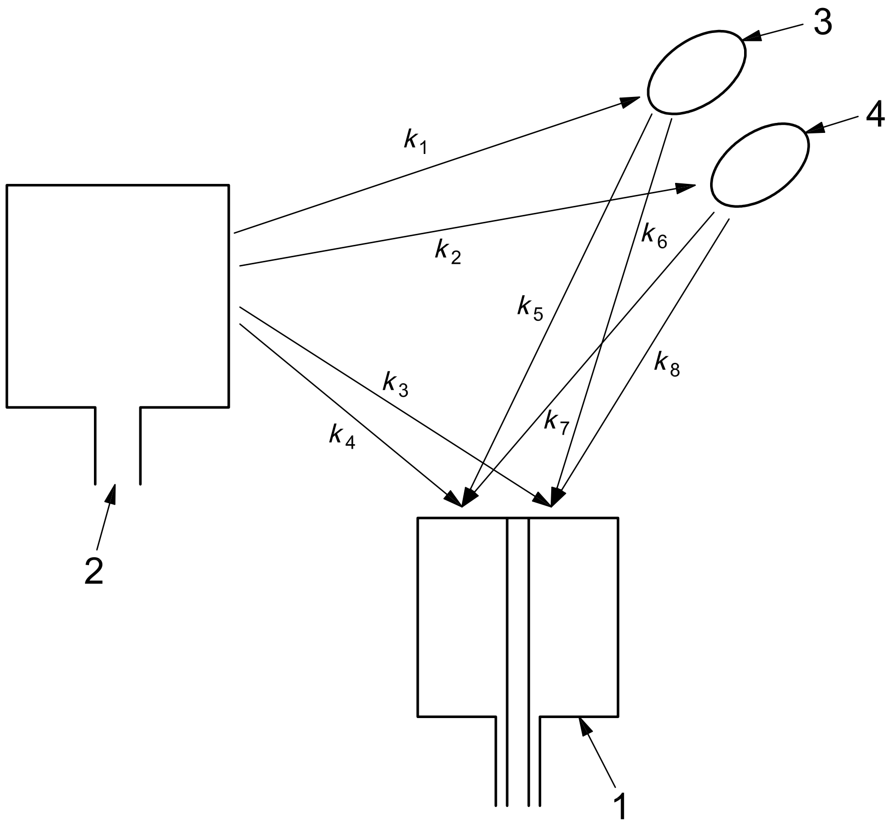
G.1 Definition of magnetic coupling factors

The magnetic coupling factor, $k_{A \rightarrow B}$, between two coils A and B describes the amount of the magnetic flux generated by coil A that floods coil B, divided by the complete amount of magnetic flux generated by coil A.

The CPOD system performance is determined by eight different coupling factors, as indicated in Table G.1 and Figure G.1.

Table G.1 — CPOD magnetic coupling factors

Magnetic coupling factor	from	to
k_1	transmitting antenna	left resonator probe
k_2	transmitting antenna	right resonator probe
k_3	transmitting antenna	right receiving antenna
k_4	transmitting antenna	left receiving antenna
k_5	left resonator probe	left receiving antenna
k_6	left resonator probe	right receiving antenna
k_7	right resonator probe	left receiving antenna
k_8	right resonator probe	right receiving antenna



Key

1 receiving antenna

2 transmitting antenna

3 left resonator probes

4 right resonator probes

Figure G.1 — CPOD magnetic coupling factors

G.2 Measurement procedure

The measurement procedure is as described below.

— Depending on the magnetic coupling factor to be determined, connect the antenna/probe mentioned in the column “from” of Table G.1 with a controlled current source [frequency of (125 ± 2) kHz] to generate the current, I_A.

— Connect the antenna/probe in column “to” with a voltmeter to measure the induced voltage, U_B.

— Ensure that all connecting cables are designed in such a way that the measurement is not influenced (e.g. drilled cables and short wires to reduce additional induced voltage inside of the connection). The resulting resonant frequency during voltage measurement is caused by the inductance of the probe and the parasitic capacitances of probe, connection and input capacitance of the voltmeter. It shall be greater than 1 MHz.

— Increase the current amplitude to values where sufficient voltage amplitude is induced.

— Input the adjusted peak/peak (pp) value of the current amplitude, the measured pp value for the induced voltage and frequency to the following formula and calculate the magnetic coupling factor, $k_{A \to B}$, according to Equation (G.1):

$$k_{\mathrm{A}\to\mathrm{B}} = \frac{N_{\mathrm{A}}}{2\pi \times N_{\mathrm{B}} \times L_{\mathrm{A}}} \times \frac{U_{\mathrm{B,pp}}}{I_{\mathrm{A,pp}} \times f} \qquad \text{(G.1)}$$

where

L_{A} is the inductance of antenna/probe through which the current I_{A} is driven, determined at (125 ± 2) kHz, e.g. with an LCR meter;

N_{A} is the number of windings of antenna/probe through which the current I_{A} is driven;

N_{B} is the number of windings of antenna/probe by which U_{B} is measured.

G.3 Coupling factor measurement functional check

Before running the CRS compatibility test, the functionality of the coupling factor measurement shall be confirmed by the coupling factor measurement functional check. In order to run this test, the following procedure shall be respected:

— use a non-electroconductive spacer to realize a distance of (10 ± 1) mm between the bottom of the resonator probe pair and the surface of the CTB;

— adjust a distance of (210 ± 5) mm between RPRP and CRP of the CTB in the x-direction (see Figure G.2);

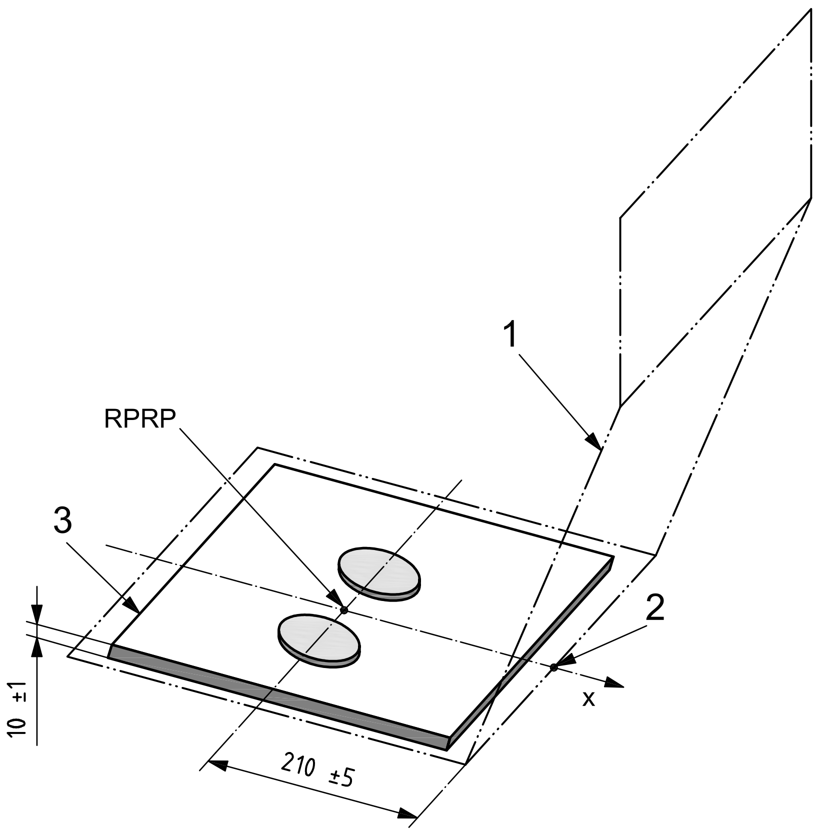
— ensure that the resonator probe pair meets the geometrical requirements of Annex B;

— arrange the resonator probe pair in such a manner that the angle γ between the pair's symmetrical axis and the x-axis of the CTB (see Figure B.3) is equal to 0° ± 3°;

— run a coupling factor measurement.

If the measured coupling factors meet the limits defined in Table G.2, the coupling factor measurement setup can be used to perform the coupling factor measurements during compatibility testing of the CRS. If the measured coupling factors do not meet the limits, the coupling factor measurement setup cannot be used to perform the coupling factor measurements during compatibility test of a CRS.

Dimensions in millimetres



Key

1 CTB symbolized

2 CRP

3 spacer

Figure G.2 — Coupling factor measurement functional test setup

Table G.2 — Magnetic coupling factor functional test limits

Test limit	k_1 %	k_2 %	k_3 %	k_4 %	k_5 %	k_6 %	k_1/k_2	k_3/k_4	k_5/k_6	k_7/k_8
min.	1,50	1,50	24,75	24,75	8,00	8,00	0,95	0,95	9,30	9,30
max.	1,70	1,70	25,25	25,25	8,60	8,60	1,05	1,05	10,50	10,50

G.4 Look-up table

For each test position on the CRS compatibility test box, the magnetic coupling factors k_1 ... k_8 shall be measured. Depending on the test position, the measured coupling factors k_1 ... k_8 shall meet the values specified in Table G.3.

Table G.3 — Magnetic coupling factors look-up table

Test limit	k_1 %	k_2 %	k_3 %	k_4 %	k_5 %	k_6 %	k_7 %	k_8 %	k_1/k_2	k_3/k_4	k_5/k_6	k_6/k_5	k_7/k_8	k_8/k_7
FF [a] min.	1,44	1,44	24,75	24,75	7,10	—	—	7,10	0,95	0,95	4,40	—	—	4,40
FF max.	—	—	25,25	25,25	—	1,85	1,85	—	1,05	1,05	—	—	—	—
RF [b] min.	1,44	1,44	24,75	24,75	—	7,10	7,10	—	0,95	0,95	—	4,40	4,40	—
RF max	—	—	25,25	25,25	1,85	—	—	1,85	1,05	1,05	—	—	—	—

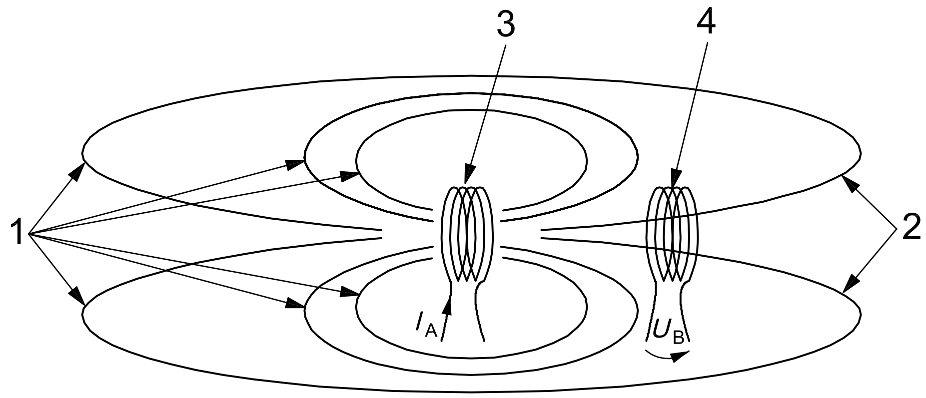
[a] FF = Forward facing position.

[b] RF = Rearward facing position.

G.5 Result of CRS compatibility measurement

If, depending on the test position, the measured coupling factors k_1 ... k_8 meet the values specified in Table G.3, the compatibility measurement is passed successfully.

G.6 Theory



Key

1 magnetic flux generated by coil A

2 part of the generated magnetic flux that floods coil B

3 coil A

4 coil B

Figure G.3 — Coupling principle

A sinusoidal current is driven through the coil and produces the magnetic flux Φ_A around coil A, in accordance with Equation (G.2):

$$N_A \times \Phi_A = L_A \times I_A \rightarrow \Phi_A = \frac{L_A \times I_A}{N_A} \quad \text{(G.2)}$$

where

N_A is the number of coil A turns;

L_A is the inductance of coil A;

Φ_A is the magnetic flux generated by coil A.

A part of the generated magnetic flux, the flux $\Phi_{A \to B}$, floods coil B and induces the voltage U_B, as expressed in Equation (G.3):

$$\begin{aligned} U_B &= -N_B \times d\frac{\Phi_{A \to B}}{dt} \\ &= -j \times 2\pi f \times N_B \times \Phi_{A \to B} \\ &= -j \times 2\pi f \times N_B \times k_{A \to B} \times \Phi_A \\ &= -j \times 2\pi f \times N_B \times k_{A \to B} \times \frac{L_A \times I_A}{N_A} \end{aligned} \qquad \text{(G.3)}$$

where

f is the frequency of I_A;

N_B is the number of coil B turns;

$\Phi_{A \to B}$ is the magnetic flux generated by coil A and flooding coil B;

$k_{A \to B}$ is the magnetic coupling factor between coils A and B ($0 \leqslant k \leqslant 1$).

The magnetic coupling factor is calculated using Equation (G.4):

$$\begin{aligned} k_{A \to B} &= \frac{U_B \times N_A}{-j \times 2\pi f \times N_B \times L_A \times I_A} \\ &= \frac{N_A}{-j \times 2\pi \times N_B \times L_A} \times \frac{U_B}{I_A \times f} \end{aligned} \qquad \text{(G.4)}$$

If the effective values or amplitude values for U_B and I_A are taken for the measurement, the formula reduces to that given in Equation (G.5):

$$\begin{aligned} k_{A \to B} &= \frac{U_B \times N_A}{2\pi f \times N_B \times L_A \times I_A} \\ &= \frac{N_A}{2\pi \times N_B \times L_A} \times \frac{U_B}{I_A \times f} \end{aligned} \qquad \text{(G.5)}$$

The coupling factor measurement shall be performed based on Equation (G.5).

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[4] Canadian Motor Vehicle Safety Standard CMVSS 208, *Occupant restraint systems in frontal impact*

[5] Directive 96/79/EC of the European Parliament and of the Council of 16 December 1996 on the protection of occupants of motor vehicles in the event of a frontal impact

[6] *Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields*, International Commission on Non-Ionizing Radiation Protection (ICNIRP), in close cooperation with the World Health Organization (WHO)

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