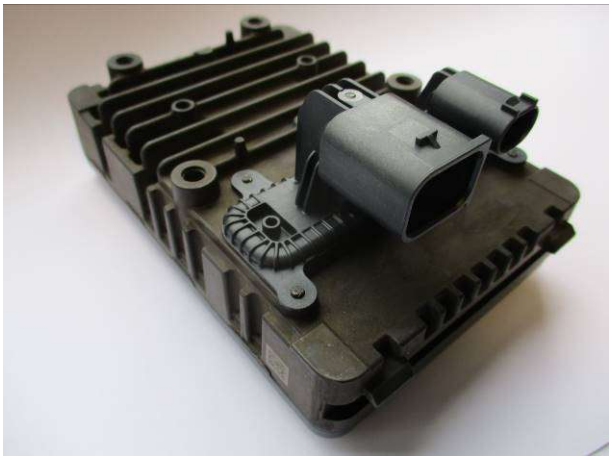

Short Description

ARS 548 RDI

Long Range Radar Sensor

77 GHz

Version 1.0 en

(HW-Ind: 19 - SW-Ind: 2.4.0.2)

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1. Introduction - Overview

1.1 Important information

This short description must be read thoroughly before the device is connected up or put into operation. Dangerous situations may arise otherwise.

This short description is a standard description of most important technical data of the 77 GHz Long Range Radar Sensors manufactured by ADC GmbH, referred to hereafter as the ARS 548 RDI.
Although plant and customer-specific deviations are possible, this documentation does not go into any further details.

All due care was taken when preparing this short description. ADC GmbH shall assume no liability whatsoever for any mistakes or omissions.

ADC GmbH shall assume no liability for injury to persons or damage to property caused by failure to comply with this short description or through improper usage of the device. All warranty claims shall also become void.

Arbitrary reconstruction and/or modification of the device is not permitted for warranty, safety and CE approval-related reasons. In such cases, dangerous situations could arise and all guarantee claims shall become void.

In this description solely it is a matter to devices of generation 5 (G5).

We reserve the right to make technical modifications or to amend the delivery specifications.

Please contact your supplier if it should become necessary to check the technical functions or to repair the device.

Please retain the original packaging in order to protect the ARS 548 RDI against transport damage.

This document describes, in accordance with latest development status, the 77 GHz Long Range Radar Sensor ARS 548 RDI manufactured by ADC GmbH. The document does not claim to cover all the possible applications or deployment areas for these devices. It is amended, corrected and enhanced as approved editions in keeping with development progress. Ensuing new versions are assigned an incremental index number (as underlined in the example below):

Example: 2021_09_16-00 (<u>00</u> = index number)

The contents of the latest released version are binding and make all preceding versions obsolete.

1.2 Introduction – Radar principle

The ARS 548 RDI is a premium model of the 5th generation of 77 GHz long range radar sensors with new RF antenna arrays, which offer digital beam forming. ARS 548 RDI measures independently the distance, speed (Doppler's principle) and angle of objects without reflector in one measurement cycle based on Pulse Compression with New Frequency Modulation. The improved range resolution is available in the complete FoV with a real time scanning frequency of 20 times per second. Simultaneous detection output of target distances up to 300 m, relative speed and angle for each target in azimuth and elevation with a high resolution are possible - with RDI (Radar Detection Interface).

1.3 Application examples

ARS 548 RDI is suitable for various industrial and automotive applications that are realized on beam-based sensor concepts.

- Distance Monitoring/Warning
  Distance monitoring with warning message if the distance to the preceding object is too close.
- Detection and tracking of people, vehicles, animals and equipment for collision avoidance in industrial, construction, agricultural and mining applications
- Monitoring of automated manufacturing processes
- Condition monitoring of industrial plants
- Traffic monitoring for traffic management and safety applications with ability to distinguish objects on different lanes
- Smart cities as intelligent intersections, cross walks, intelligent lightning etc.
- Monitoring and protection of vehicle and pedestrians on railway and restricted areas

Detection of targets in front of a preceding vehicle (by underbody reflections) even if the line of sight is covered.

Furthermore the scanning antenna of ARS 548 RDI allows measurement of object width and height and estimated length. Based on this functionality a classification of the measured targets is carried out.

2. Reference

- **[1] Regulation No 131 of the Economic Commission for Europe of the United Nations (UN/ECE) — Uniform provisions concerning the approval of motor vehicles with regard to the Advanced Emergency Braking Systems (AEBS) (Online, COMMISSION REGULATION (EU) No 347/2012, euroa.eu, http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2014.214.01.0047.01.ENG)**

- **[2] UN/ECE status document TRANS-WP.29-343, Rev.21 (Online, unece.org, http://www.unece.org/fileadmin/DAM/trans/main/wp29/wp29regs/updates/ECE-TRANS-WP.29-343-Rev.21.pdf)**

- **[3] LV 124, Electric and Electronic Components in Motor Vehicles up to 3.5 t - General Component Requirements, Test Conditions and Tests**

- **[4] FCC 2.1091 (b) rules for RF compliance of mobile and portable devices, https://www.gpo.gov/fdsys/pkg/CFR-2011-title47-vol1/pdf/CFR-2011-title47-vol1-part2-subpartJ-subjectgroup-id922.pdf**

- **[5] FCC 47 CFR 1.1310 Radiofrequency Radiation Exposure Limits https://www.gpo.gov/fdsys/granule/CFR-2010-title47-vol1/CFR-2010-title47-vol1-sec1-1310**

- **[6] ETSI 1999/519/EC Council recommendation of 12 July 1999 on the limitation of exposure of the general public to electromagnetic fields http://ec.europa.eu/health/electromagnetic_fields/docs/emf_rec519_en.pdf**

- **[7] BGV B11 Unfallverhütungsvorschrift Elektromagnetische Felder http://www.bgetem.de/share/wbt_emf_2015/pdf/bgv_b11_a08-2011.pdf**

- **[8] BroadR-Reach Physical Level Specification (Online, broadcom.com, http://www.broadcom.com/products/Physical-Layer/BroadR-Reach-PHYs)**

- **[9] Electrical Test Specification - ARS540BW11 (GS 95024-1: 2016-11, GS 95024-2-1: 2010-01, GS 95024-2-2: 2011-02 and GS 95024-2-4: 2014-06)**

3. Sensor Variants

ARS 548 RDI supports the following general configurations with

- One housing variant in Mechanics (see Chapter 5.3)
- One vehicle connector configuration/pin-out including two connectors
- Micro-controller used is Xilinx Zynq UltraScale+
- One vehicle interface - Ethernet (see chapter 5.1.3)
- Nominal operating voltage 12 V DC, voltage limits (see chapter 5.1.1)

For details regarding the mechanical configuration of the sensor, see section 'Housing' of chapter 'Interfaces'.

The micro-controller is selected based on the necessary computational power and further required resources.

4. System Overview

The ARS 548 RDI is a 77 GHz high performance premium long range radar sensor with digital beam-forming scanning antenna which enables highly automated driving in combination with other technologies.

The radar system provides the following features in general:

(is mostly only available for ARS 540 automotive radar)

- Forward Collision Warning, Emergency Brake Assist:
  - Moving objects (0 .. 250 km/h) speed reduction 60 km/h*
  - Stationary objects (0 .. 80 km/h) speed reduction 40..50 km/h*
  - (*) these limitations apply only to radar-only architectures, i.e. without camera fusion
- Compliant with:
  - UN/ECE R131 AEBS regulation [1]
- Sensor designed for and Use Cases implemented for:
  - NHTSA Forward Collision Warning, Collision Imminent Braking
  - EuroNCAP 2018 AEB City / Inter Urban / VRU Pedestrian + Cyclist
  - EuroNCAP 2020 AEB City / Inter Urban / VRU Pedestrian + Cyclist & Junction Assist
  - EuroNCAP 2022 AEB City / Inter Urban / VRU Pedestrian + Cyclist + Powered two-wheeler & Junction Assist

- Auto Alignment
  - Fast auto alignment capability for end of line production testing (EoL)
  - Service alignment without special tools for service stations
  - Continuous alignment capability resp. misalignment detection during normal operation (e.g. load compensation)
- Real elevation measurement feature
  - Capability to distinguish over-rideable and under-rideable objects from real target objects
- Sensor fusion
  - Sensor designed (RAM, ROM, runtime) to host sensor fusion with other sensors (e.g. camera)
- Object Interface and Radar Detection Image
  - Delivers list of detections within FOV with attributes like detection range, azimuth & elevation angle, probability, sensor position info, etc.
- Capability to host safety relevant functions
  - Automotive Safety Integrity Level (ASIL) for safety relevant functions needs to be agreed
- Outstanding interference robustness and advanced interference mitigation:
  - For general interference see section 'Interference Robustness'
  - For interference from other radar sensors see section 'Mutual Interference'
  -
- ARS 548 RDI complies with the applicable frequency regulation standards in the following key markets:
  - European Union
  - U.S.
  - Canada
  - Russia
  - South Korea
  - Australia
  - Japan
  - China
  - Homologation in further countries is available on request

- Compliant with UN/ECE electromagnetic compatibility regulations R 10 [2]
  - ECE R 10: E1 marking provided on customer request only
  - EN 301489 (CE sign) if sold onto the European market
  - CISPR-25 - Radio disturbance characteristics for the protection of receivers used onboard vehicles, boats, and on devices - Limits and methods of measurement
- RoHS compliant
- GADSL compliant
- The ARS 548 RDI product is fully assembled in a plastic-aluminum housing and specially designed for civil automotive application. The use of encryption function is strictly controlled by the firmware made by Continental and the MCU is not removable. Therefore a classification regarding the chapters 3 and 5 of the dual use list from Europe Union and United States of America is ruled out. The final Classification Analysis of the product with the European Dual List, German Ausfuhrliste and the Commerce Control List (USA), is "not restricted" (European laws CE n° 428/2009,388/2012 and Bundesamt für Wirtschaft und Ausfuhrkontrolle) and "EAR99" (Export Administration Regulation).

4.1 Sensor Functions

ARS 548 RDI offers signals which can be used for functions like Emergency Brake Assist (EBA), Radar Detection Image (RDI) along with Object Interface (OI).

These functions are discussed in detail in this chapter.

4.1.1 Object Interface (OI)

Motivation:

- OI is a generic processing step for all subsequent vehicle functions (EBA, ACC, etc.)
- OI as a 'stand-alone function' provides object list output to software modules either allocated on the radar sensor or - via some communication bus - on an external ECU. It allows the customer to define/design the functional behavior of the vehicle functions by his own.

Description:

- OI delivers list of objects to the front and rear of the vehicle.
- Attributes include object dynamics, dimension, shape
- Objects are classified as pedestrians, vehicles (passenger car, truck), motorbikes or bicyclists

Safety Integrity Level according to ISO-26262 *is only available for ARS 540 automotive radar:*

- Depends on specific implementation of subsequent functions (EBA, ACC, etc.): supports functions up to ASIL B

The Object Interface delivers a list of up to **200 objects** with the following data attributes:

- Object ID
- Distance (X, Y, Z)
- Relative and Absolute Velocity (X,Y)
- Relative and Absolute Acceleration (X,Y)
- Width, Length, Heading
- Radar Cross Section
- Existence Probability
- Object Age (in radar cycles)
- Classification (Car, Truck, Bike, Pedestrian etc.)
- Dynamic Property (moving, stationary)
- Yaw rate

Further data attributes (e.g. road border probability, classification of animals, oncoming dynamic property etc.) can be ordered and paid separately with a modified software from the customer.

This list is intended as input to functions provided by Continental and also third party software modules (e.g. customer-furnished EBA function) which are integrated within the sensor's software.

In order to be suitable e.g. for fusion with camera objects / camera information, the list of objects is not function specific.

The object list can also be output via the vehicle interface for use by external ECUs or sensors.

4.1.2 Radar Detection Image (RDI)

Motivation:

Continental's RDI interface is intended for architectures with a central computing ECU. The radar sensor sends "tracked-multicycle base" azimuth & elevation hypothesis, which was then internally processed for object creation, to avoid wrong azimuth and elevation hypothesis output to bus interface.

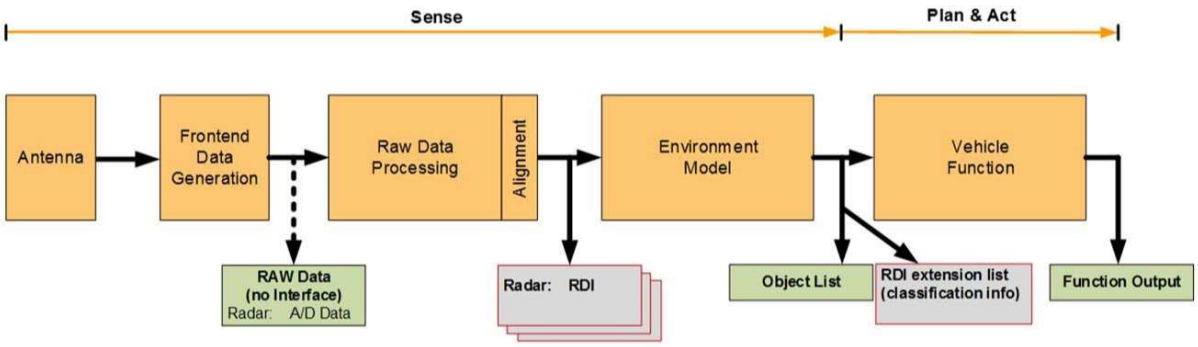


Figure 1: Radar Detection Image - Processing Chain

The RDI interface

- enables early data fusion, including 360° radar view,
- improves standardization of sensor architectures,
- has no negative impact on classic functions like ACC, EBA, etc.,
- allows flexible placement/interchange of short and long range sensors,
- can serve as input to computer vision algorithms.

Native-RDI works only with fast communication buses like Ethernet or LVDS because it typically requires 12 Mbps bandwidth.

RDI data contains 3D position (distance, azimuth, elevation), radar cross section, and Doppler speed. The RDI data is largely hardware independent (it is calibrated and aligned).

For the automotive version ARS 540 this RDI data is then fed into an environmental model (EM/CEM) running on an external ECU (e.g. ADCU or camera). RDI's 'near-raw' data still contains radar artefacts and multiple reflections.

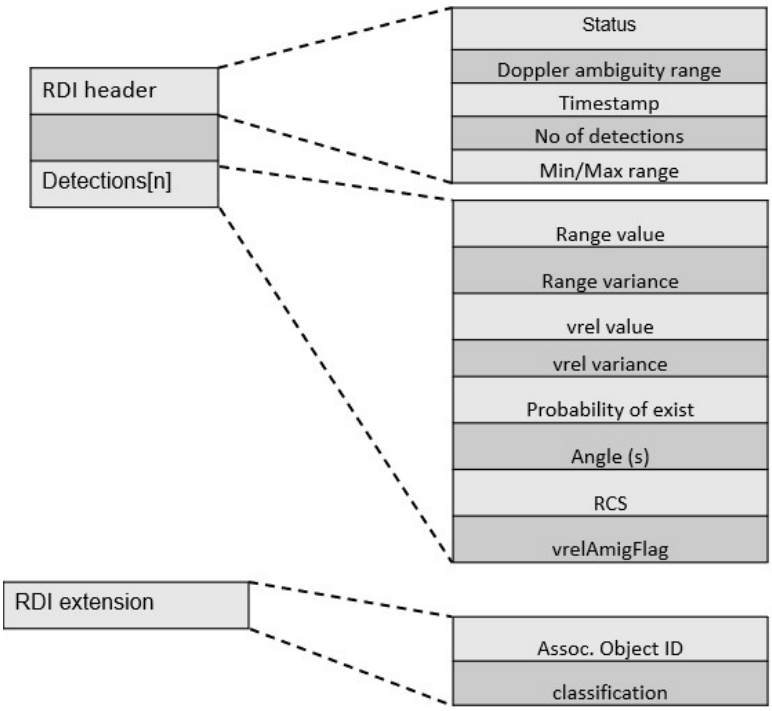


Figure 2: Radar Detection Image - Data Structure

Safety Integrity Level according to ISO-26262 *is only available for ARS 540 automotive radar:*

- Depends on specific implementation of application: RDI covers ASIL B

RDI data shall be provided via 100 Mbit ethernet.

4.2 Sensor Description

4.2.1 Radar Principle

As shown in Figure 20 the radar sensor family uses a pulse compression radar modulation scheme as basic principle for its measurements. This technique avoids the drawbacks of both the classical Pulse-Doppler and the FMCW (frequency modulated continuous wave) approach. Compared with a Pulse-Doppler principle, due to a very large duty cycle the chirped radar works with significantly higher amplitude of RF energy, resulting in a better overall SNR (signal to noise ratio).

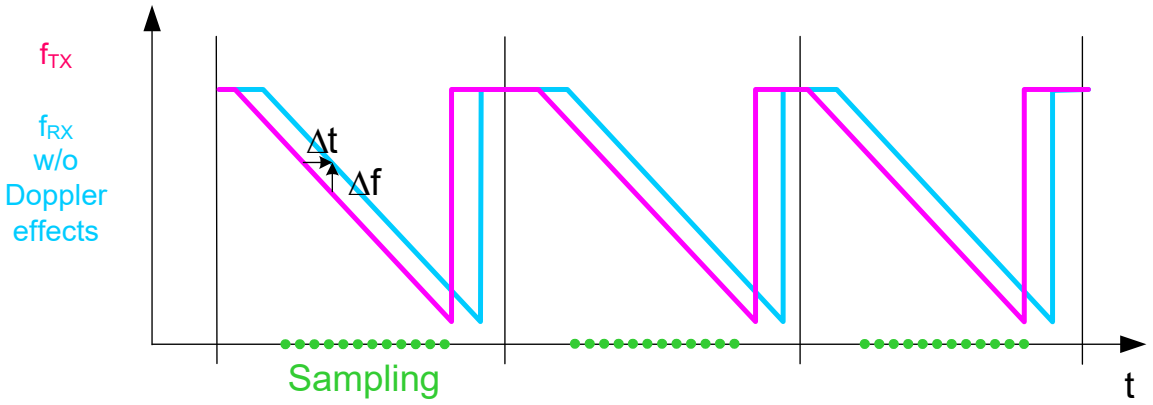


Figure 3: Radar Principle

Compared to FMCW modulation, Continental's pulse compression radar modulation makes it rather easy to separate range, velocity, and angular information in the received signals: ranges and Doppler speeds are calculated by a 2-dimensional fast Fourier transformation (2D-FFT), then the azimuth and elevation angles are determined by subsequent third and fourth FFTs.

As this procedure involves sampling out the individual chirps and processing accordingly, this radar principle is sometimes also referred to as pulse compression radar.

Another benefit of the radar principle is a software adjustable range resolution. The sensor is theoretically capable of setting its range resolution from 1 m and more up to 0.22 m (according to regulatory limits) which could be done internally based on certain traffic situation as well as parameters like vehicle speed, etc. This functionality is achieved by varying the frequency sweep of the chirps. The change can be done once for one single system cycle.

4.2.1.1 Interference Robustness

The radar principle applied and adapted by Continental has the benefit that interferences from other electromagnetic emissions will not create any ghost targets. Such interferences are converted into noise instead and will thus only affect the signal-to-noise ratio (SNR).

The sensor's algorithms check permanently if a temporary enhancement of noise is present (by comparison of short term vs. long term noise levels).

If the noise level is too high, customer functions (EBA, ACC) become deactivated successively.

To ensure high availability, the sensor continuously monitors the noise level while functions are deactivated. Hysteresis is implemented in order to avoid toggling between activated/deactivated mode.

Additional measures are implemented besides noise level monitoring.

For further details on interference robustness and mitigation see section 'Mutual Interference'.

4.2.2 Antenna Principle

Figure shows the antenna principle of digital beam forming used in the radar sensor. In the example one transmitting (TX) antenna and 4 receiving (RX) antennas is used. All RX antennas receive reflections from the same target (ideally) not different in amplitude but in phase due to the slightly different distances to the target as a function of the azimuth angle α_{AZ}.

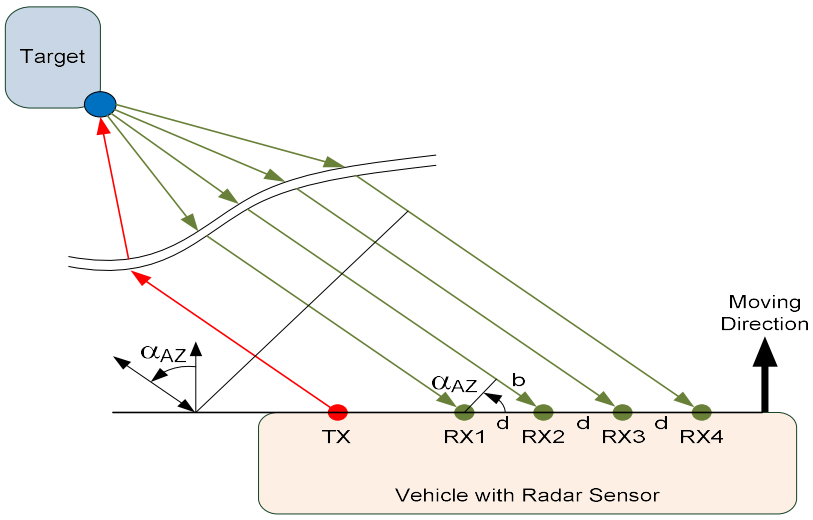


Figure 4: Antenna Principle

The relationship between phase and angle could be expressed as follows:

$$\alpha_{AZ} = arcsin\frac{b}{d}$$

using

$$b = (\varphi_{RX1} - \varphi_{RX2}) * \frac{\lambda}{2\pi} \qquad (\varphi_{RXn} = \text{received phase of RX beam n})$$

For the ARS 548 RDI sensor, 12 TX and 16 RX antennas are used which gives 192 virtual antenna channels. After down converting and digitization of the received radar image complex beamforming is used to determine the four detection dimensions (range, speed, azimuth and elevation angle).

Separate near and far scans are for ARS 548 RDI not available.

4.2.3 Cooling principle and recommendation

Please Note!

The following recommendation must be realized and tested from the customer/user, dependent on the individual application/intended purpose.

In case of using the radar sensor especially stationary and/or in a standstill vehicle or also in a moving vehicle, the customer/user must implement enough airflow in the installation space for the cooling process of the radar in general and especially on the aluminum back cover.

For ARS 548 RDI the sensor unit environment shall perform cooling performance of 23 W during standstill and driving (@1.4 m/s air speed from the front).

In a vehicle with motor compartment ventilator/blower, the radar sensor could start the blower when the critical temperature of the sensor generate a signal in future versions.

The typical operating temperature of the ARS 548 RDI is from -40° to +65° C and the critical temperature when functions of the radar will be switched off is > 65° C. To avoid the switch-off, an additional cooling of the radar will increase the temperature range up to 85° C.

It is also possible to mount a small ventilator/blower on the aluminum back cover of the radar sensor by using two available screwing points.

Further data and information see chapter 8.1.

4.2.4 Radar Characteristics – Technical Data

The dynamic range of the detected radar cross section shall be at minimum between -10 dBm² to +40 dBm².

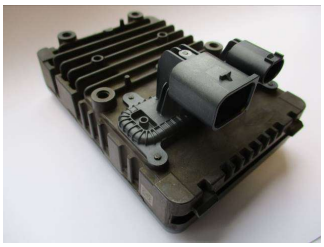
The output power (EIRP, average) is <= 37 dBm @ -40°C ambient temperature. The reduction of the power for countries with lower limits is available on demand.

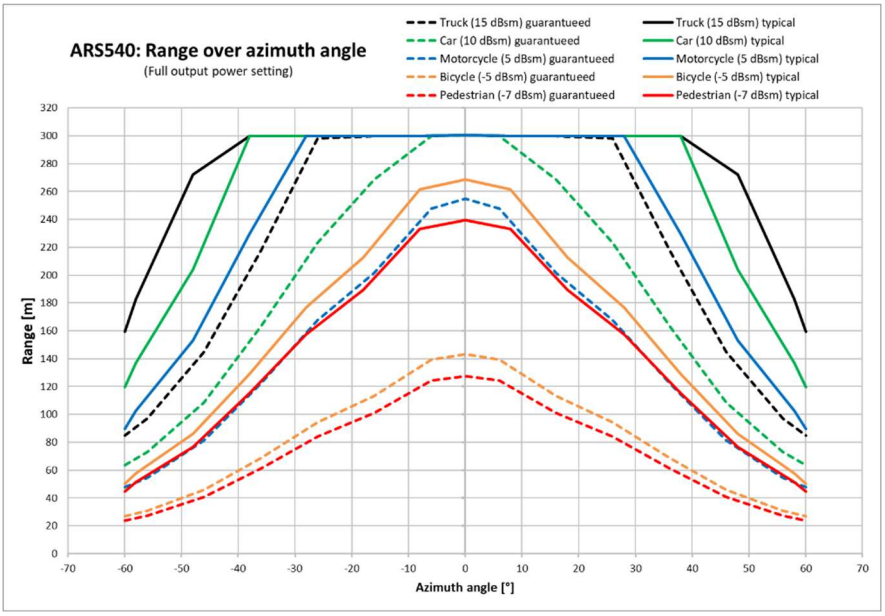
Fehler! Verweisquelle konnte nicht gefunden werden. The Radar Characteristics Design Targets (Technical Data) defines the design targets for radar characteristics and detection ranges of the ARS 548 RDI sensor.

For angle accuracy, influence of radome to be considered additionally and approved.

Table 1: Radar Characteristic Design Targets – Technical Data

ARS 548 RDI Premium
Long Range Radar Sensor 77 GHz





Safe - reliable - robust - new design

The ADC GmbH offers a new type of radar sensor, the ARS 548 RDI, possible adaption include various industrial applications as well as premium upgrade version of the series 50X.

Typical areas of application:
- **Anti-collision protection for autonomous vehicles of every type**
- Headway control for near and far range (vehicles, also as a part for autonomous vehicles)
- Area monitoring system for far range, e.g. of hazardous or restricted areas
- Classification of objects incl. height measuring
- Object detection, e.g. in crowded or unclear areas, also by using a radome as protection

Measuring procedure:
The rugged ARS 548 RDI sensor from Continental measures independently the distance, speed (Doppler's principle) and angle of objects without reflector in one measurement cycle based on Pulse Compression with New Frequency Modulation. The improved range resolution is available in the complete FoV with a real time scanning frequency of 20 times per second. Simultaneous detection output of target distances **up to 300 m,** relative speed and angle for each target in azimuth and elevation with a high resolution are possible - with RDI (Radar Detection Interface).

Advantages:
- **Fast and safe:** The ARS 548 RDI dispels with the apparent contradiction between excellent measuring performance and a high degree of operational safety. The rugged ARS 548 RDI radar sensor is capable of determining the distance to an object in real time scanning and dependent on the driving speed a possible risk of collision.
- **Reliable:** The ARS 548 RDI radar sensor is fail-safe (not under all circumstances) and able to recognize troubles of the sensor and sensor environment and display it automatically.
- **Robust and new design:** By using the newest radar technology with a new design and a new measuring principle for mass production in automotive supply industry, the design is kept very robust with a high performance.

Benefit from the unique features of the latest Continental technology!

ARS 548 RDI Premium
Long Range Radar Sensor
77 GHz

Measuring performance	***to natural targets (non-reflector targets)***	
Distance range		0.2 ... 300 m
Resolution distance measuring		0.22 m
Accuracy distance measuring		±0.15 m depending on ego speed (thresholds at 115/110 kph)
Azimuth angle augmentation	(field of view FoV)	±60° internally processing, ±50° Output of OI/RDI, ±70° keep out zone – for max. misalignment
Elevation angle augmentation	(field of view FoV)	±4°… ±14° - ±4°@300m - ±14°@<100m ±20° keep out zone
Azimuth beam width (3 dB)		1.2°… 1.68° - 1.2°@0…±15° - 1.68°@±45°
Elevation beam width (3 dB)		2.3°
Azimuth Auto Alignment	Only ARS540 automotive	±4.°
Elevation Auto Alignment	Only ARS540 automotive	±6.°
Accuracy azimuth angle		±0.1° … ±0.5° ±0.1°@±15°; ±0.2°@50° ; ±0.5°@60° linear interpolation
Accuracy elevation angle		±0.1°
Speed range		-400 km/h...+200 km/h (negative values: oncoming vehicles)
Speed resolution		0.35 kph
Speed accuracy		±0.1 kph
Cycle time	In standstill: 100 ms	app. 50 ms complete FoV is covered in single cycle time app. 70 ms rear
Antenna channels; Antenna principle		increased number of 1.75xARS430 / 8x incl. virtual antenna; 16 x Rx and 12 x Tx = 192 virtual antennas Digital Beam Forming - new RF/Antenna interconnect
Operating conditions		
Radar operating frequency band	acc. ETSI & FCC	76...77 GHz
Output Power	RMS EIRP, average	<= 35 dBm – 3.16 W @-40°C ambient temperature
Mains power supply	at 12 V DC	+8.5 V...17 V DC
Power consumption	at 12 V DC	~18 W / 1.5 A typ. - ~23 W maximum /~3.0 A peak current
Overvoltage		>18 V DC sensor functions deactivated
Operating-/ storage temperature		-40°C...+85°C / -40°C...+105°C
Life time	LV 124 Specification	8,000 h or 15 years or 300,000 km
Shock		Mechanical acc. LV 124
Vibration		Mechanical acc. LV 124
Protection rating	Ingress Protection	IPx6K/9K (water proof, high-pressure cleaning – ISO 16750+20653) IP6Kx (dust proof – ISO 20653)
Connections		
Monitoring function		self monitoring (fail-safe designed)
Interface		1 x BRR BroadR Reach Ethernet 100 Mbit/s
Housing		
Dimensions / weight radar Weight connector set	W * L * H (mm) / (mass) mass	137 * 90 * 39 (65.5 with connector) / 526 g 4 g 2-pin / 8 g 6-pin connector - without any cable
Material	housing radome / front bottom / plate	PBT GF 30 black (BASF-Ultradur B4300G6 LS sw 15073) / AC-47100 (AlSi12Cu1(FE)) die cast aluminium or EN AW 5754 (3.535) AlMg3 pressed-formed aluminium
Miscellaneous		
Measuring principle (Doppler's principle) in one measuring cycle due basis of pulse compression with stepped frequency modulation to improve range resolution. Independent measurement of distance, speed, azimuth and elevation angle.		
Version ARS 548 RDI	sensor with object output	BRR BroadR Reach Ethernet 100 Mbit/s

4.2.5 Field of View (FoV)

4.2.5.1 Field of View and Detection Ranges

The Field of View (FoV) describes the angular range whose information is output via interface and is the function relevant part of the radar cone as described in the mounting guideline section "Sensor Radar Cone".

For integration purposes one must consider an extended "Keep-out zone" rather than the functional radar cone (see mounting guideline section “Sensor Radar Cone”).

The nominal FoV is +/-50° for output of Object Interface/RDI and +/-60° are internally processed in azimuth and +/-9° for output and +/-14°@<100m and +/-4°@300m in elevation direction. Additionally, Continental offers +/-4° for mounting tolerance in azimuth and +/-6° for mounting tolerance in elevation. The additional tolerance in the elevation includes +/-2° for compensation of different loading states of the vehicle and has been considered to accommodate impact due to loading.

Note: Above azimuth and elevation angles are only for Front Sensor Variant.

FoV restrictions caused by installation in the vehicle or other applications are partly described as mentioned in chapter 6.7.

The Detection Range for different objects in Figure 6 to 8 gives the detection ranges for different object classes (Truck, Car, Motorcycle, Bicycle and Pedestrian) within the FoV of the ARS 548 RDI sensor. The plot consists of curves pertaining to worst/guaranteed case and typical case and the conditions for these cases as listed below in Table 2.

Conditions worst/guaranteed case:	Conditions typical case:
Range for detections, not (tracked) objects	Range for detections, not (tracked) objects
S/N at estimated lower production limit	S/N at estimated avg. of production
Operation at worst case temp.	Operation at ambient room temp.
Misalignment at max. allowed values in azimuth and elevation	Misalignment at half of max. allowed values in azimuth and elevation
Ranges based on 97% detection probability	Ranges based on 97% detection probability
Including 6 dB road reflection	Including 6 dB road reflection
RCSs given for point target for worst and typical case.	RCSs given in legends
4 dB (two-way) radome attenuation	4 dB (two-way) radome attenuation
No rain/snow	No rain/snow

Table 2: Conditions for worst (guaranteed) case and typical case for determining detection range

It is important to note that the conditions considered for the worst case are highly unrealistic as the worst possible conditions are considered for all input parameters at the same time.

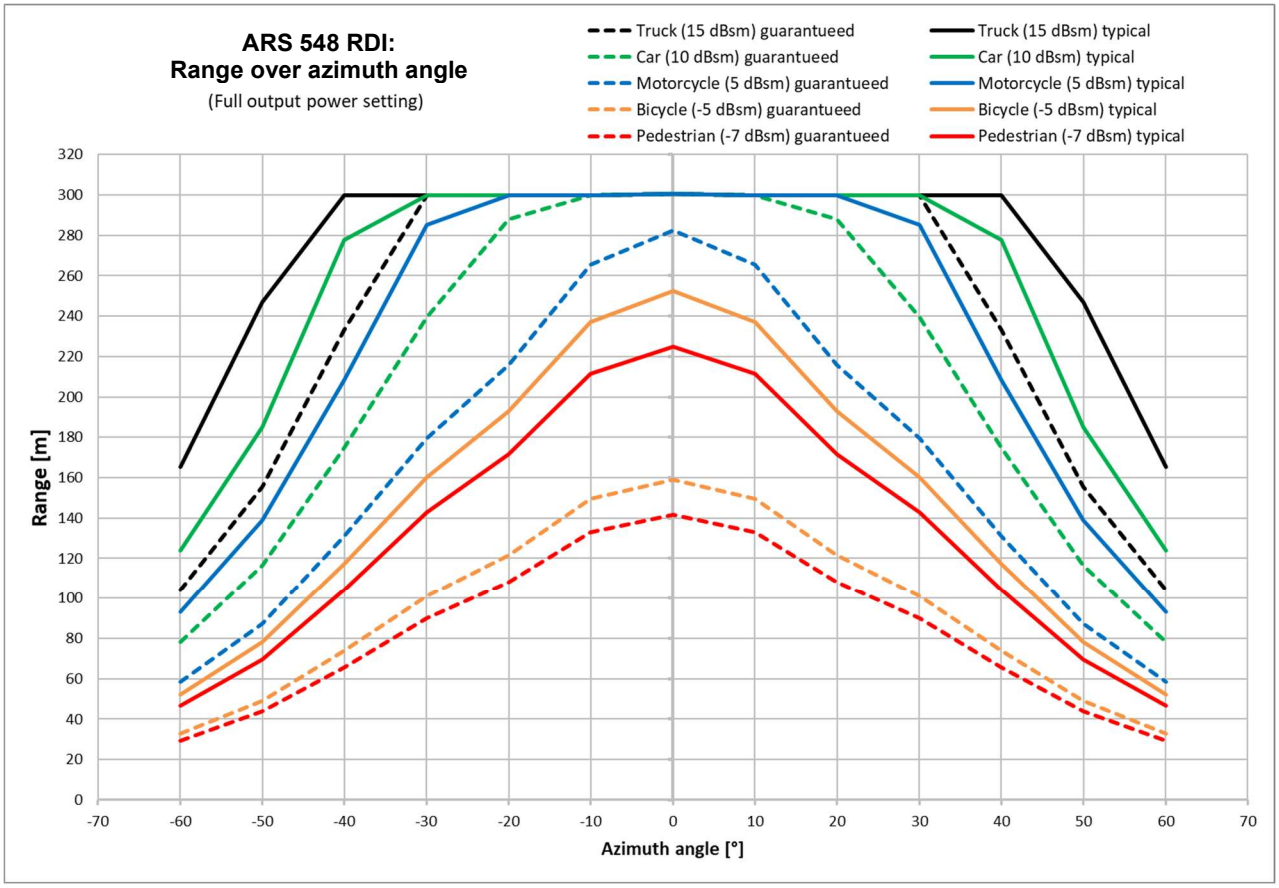


Figure 5: Azimuth Detection Range for different objects

(PR Power Reduction is currently only available for ARS 540 automotive radar)

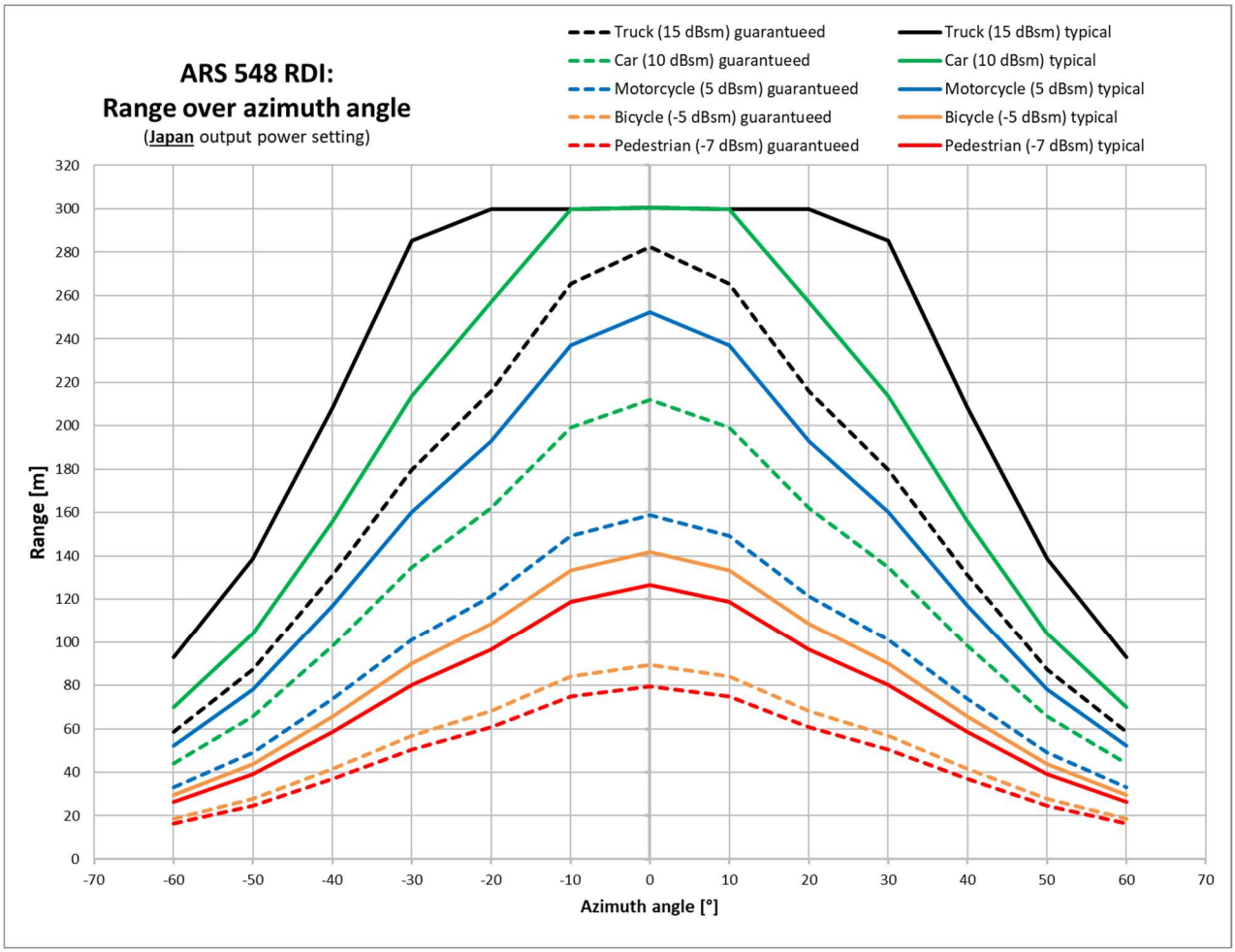


Figure 6: Azimuth Detection Range for different objects for Japan
(reduced power 10 dBm for Japan)

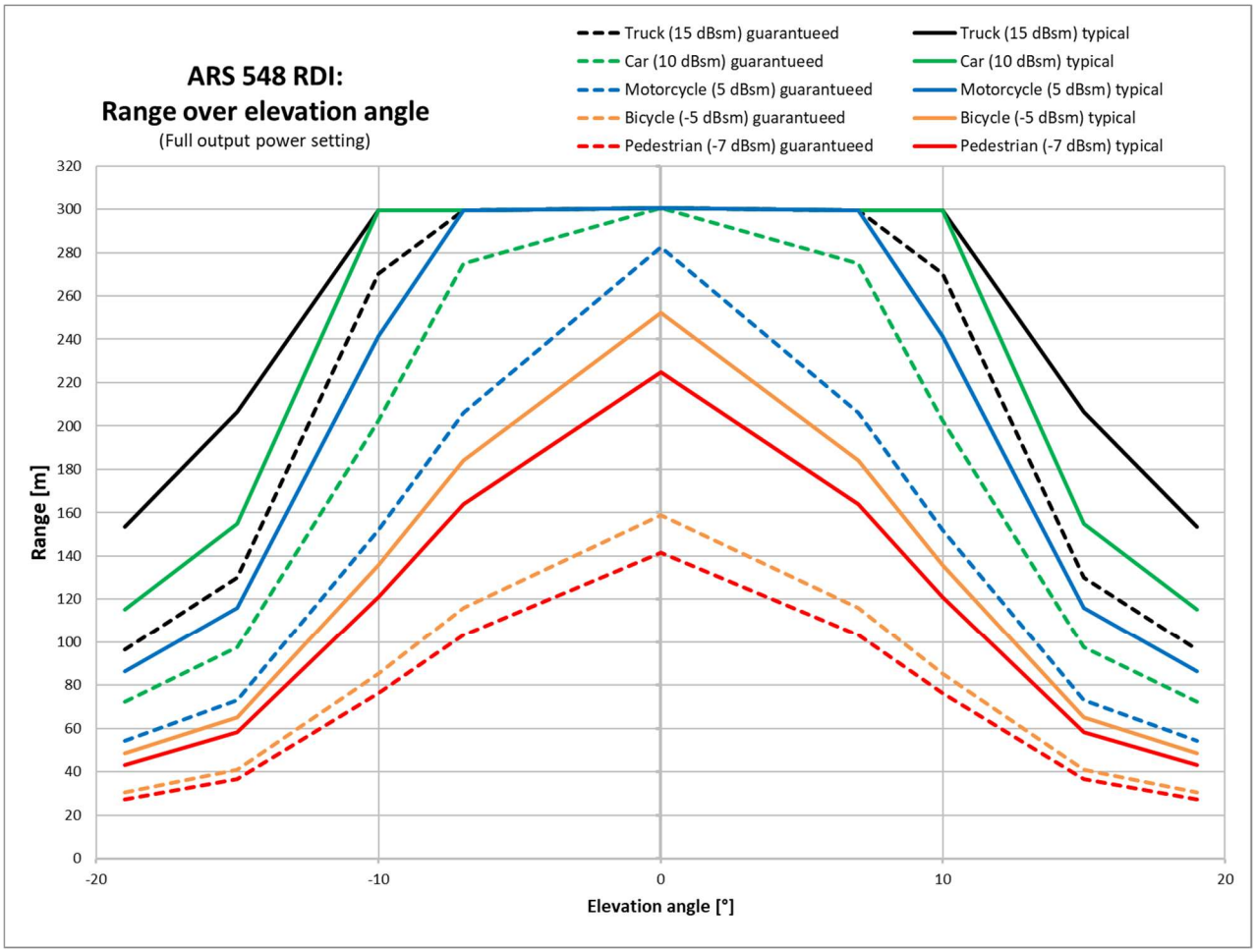


Figure 7: Elevation Detection Range for different objects

(PR Power Reduction is currently only available for ARS 540 automotive radar)

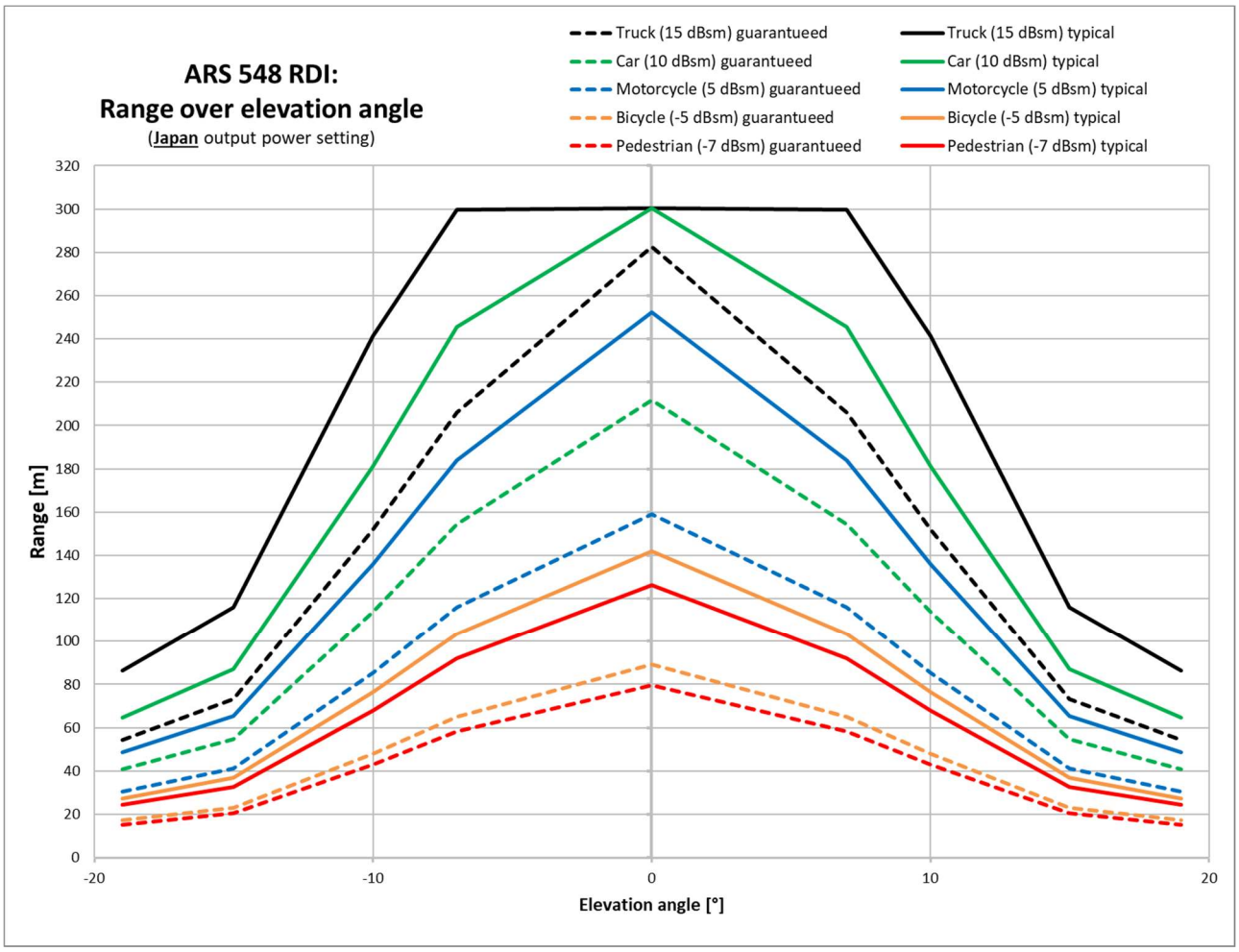


Figure 8: Elevation Detection Range for different objects for Japan
(reduced power 10 dBm for Japan)

The plots generated are for Rest of World output power configuration and do not include special performance limitations especially with regard to detected range.

4.2.8 Radar Cone

The exact radiation cones (simplified radiation cone and keep-out zones) will be provided together with the mechanic 3D data as STP file. The relevant details are described in chapter 6.7.

If the customers intended installation of the sensor into the target vehicle or other application will lead to restrictions of its field-of-view, so this must be avoided to get no negative impacts.

4.3 Functional Safety

(is only available for ARS 540 automotive radar)

4.3.1 Safety Goals

The ARS 540 base projects have been developed on a variant-selectable Technical Safety Requirements (TSR) and Technical Safety Concept (TSC).

The safety goal realized in this sensor is to **avoid unintended braking** within the limits allowed for the specific implemented functions.

This safety goal has **maximum ASIL-B**.

The ASIL level for this safety goal depends on the application specific function implementations, which is not part of the Industrial New Markets business.

4.3.2 Safety Critical Errors

For a definition of safety critical errors refer to the sensor's technical safety concept.

This safety concept (TSC) normally must be mutually agreed on between the customer and Continental but cannot be provided here for the Industrial New Markets business.

4.4 Automotive Security & Privacy

(is only available for ARS 540 automotive radar)

The Automotive Security & Privacy is based on ADC resp. Continental internal regulation.

4.4.1 Export Control

The ARS 548 RDI product fully is assembled in a plastic cum Aluminum housing and specially designed for civil automotive applications. The use of encryption

functions is strictly controlled by the firmware made by Continental and the MCU is not removable.

The final classification analysis of the product with the European Dual Use List, German Ausfuhrliste and the Commerce Control List (USA), is "not restricted" (European laws CE n° 428/2009,388/2012 and Bundesamt für Wirtschaft und Ausfuhrkontrolle) and "EAR99" (Export Administration Regulation).

4.4.2 Privacy

In case that any functions which collect and/or process privacy related data shall be included in the ARS 548 RDI radar sensor or collecting and/or processing of privacy relevant data provided by the product outside of the ARS 548 RDI radar sensor is considered, the installation and operation of the product may lead to the requirement of compliance with country specific legal regulations (e.g. data protection laws).

Therefore, we recommend to verify respective country specific legal regulations before installation and operation of this product with enabled collecting and/or processing of privacy related data.

4.5 Dynamic Behavior

4.5.1 Startup / Shutdown Behavior

The time from physically powering up the device until all output signals are available on the vehicle communication interface is < 3 s.

The sensor is capable of 'hot unplugging'.

A controlled shutdown shall not take longer than necessary to terminate all function, and the maximum shutdown time < 10 s.

Remark:

The time from powering up of the sensor until safety critical functions (e.g. EBA) are fully available, cannot be given as a fixed duration. These functions become enabled successively with improving vehicle dynamics model which depends on the movements (track, speed) and environment (static obstacles) of the starting vehicle.

4.5.2 Failure Behavior

(is only available for ARS 540 automotive radar)

When an error has been detected, the sensor can enter any of the following states:

- Category 3 error:
  - Fault affects function (EBA, ACC, etc.)
  - Fault detected by hardware/software, reaction performed by software
  - Reaction: Safe communication only, function degradation / disqualification
  - Diagnostic error entry in non-volatile memory
- Category 2 error:
  - Fault affects sensor infrastructure
  - Fault detected by software, reaction performed by software
  - Reaction: Safe Silence (MCU reset)
  - Diagnostic error entry in non-volatile memory
- Category 1 error:
  - Fault affects sensor infrastructure
  - Fault detected by hardware, reaction performed by hardware/software
  - Reaction: Safe Silence (MCU reset)
  - If possible: diagnostic error entry in non-volatile memory

CAT 1 & 2 faults are infrastructure-relevant, meaning the sensor can no longer be trusted to communicate reliably (e.g. RAM faults, ALU faults, etc.).

CAT 3 faults are function-relevant, meaning the sensor can still communicate its status, but the function itself (EBA, OI, etc.) is compromised (e.g. sensor front-end faults, co-processor faults, etc.).

All internally detected errors may lead to functional inhibitions and diagnostic trouble code entries.

5. Interfaces

5.1 Electrical

5.1.1 Power Supply

The ARS 548 RDI sensor supports 12 V DC nominal operating voltage.

For the sensor supporting a nominal operating voltage of 12V DC, an exemplary behavior for different supply voltage conditions is given in Table 3. Also, the current and power consumptions of the sensor are listed in Table 4.

UBATT (12 V)	Operation Mode	Behavior
<6.5 V	Off	Sensor switched off
6.5 V < UBATT < 8.5 V	Only during Start/Stop cycle	- Sensor functions deactivated - Normal communication on vehicle bus - Limited fault and hardware monitoring (storing of errors) - Fault 'Undervoltage' recorded
8.5 V (6.5 V for max. 90s) < UBATT < 17 V Every 10 ms	Normal/Full Operation	- Normal communication on vehicle bus - Normal hardware monitoring - Full fault monitoring
17 V < UBATT < 32 V	Overvoltage	- Sensor functions deactivated - Normal communication on vehicle bus - Normal hardware monitoring - Full fault monitoring (storing of fault 'overvoltage')

Table 3: Voltage Supply Operation Modes (12 V DC Variant) - exemplary

Supply	Current & Power Consumption		
12 V	Current	Normal Operation	1.5 A (typical)
		Peak Current	~2 A
	Power	Normal Operation	~18 W
		max. Power Consumption	26.5 W
(power consumption of radome heater not considered here)			

Table 4: Current and Power Consumption

A cooling airflow mentioned in chapter Environmental Conditions is mandatory for the safe operation of the sensor.

5.1.2 Connecting the Sensor to the Supply System on-board

The power supply for the radar sensor is provided by vehicle UBATT via ignition (Kl. 15) and ground (Kl. 31) or in general for other applications directly.

To avoid electro-magnetic interferences through the supply lines to the control unit, the connections to UBATT and ground are to be kept as short as possible.

There is an active reverse polarity protection circuit built in.

The protection circuit disconnects the sensor from the battery supply voltage if the voltage level is rising above an upper hysteresis value and re-starts the sensor if the voltage level drops below the lower hysteresis value.

5.1.3 Input/Outputs

The current specification of the ARS 548 RDI sensor assumes the following communication interface:

- 1x Ethernet

5.1.3.1 Ethernet Interface

The sensor supports 100 Mbit/s Ethernet based on BroadR-Reach® physical layer specification [8].

5.1.3.2 Radome Heating Switch Output

(is only available for ARS 540 automotive radar)

The sensor provides a radome heating control to improve availability in case of freezing rain or wet snow. Usual rain and dry snow will not significantly affect availability of the sensor. Heating power is controlled by a pulse width modulation (PWM – Pulse Width Modulation) to compensate for driving speed, voltage level, ambient temperature, etc..

The output is a PWM modulated signal of UBATT. The heat switch and the connector pins support a maximum heater power of 80 W.

The radome heating can be powered over a separate power supply pin, decoupled from the sensor's normal power supply.

The control circuit is short-circuit-proof. In case of malfunction an event is written to the error log.

The heating shall consist of a special arrangement of metallic wires. The wires in the secondary surface shall fulfill the following requirements:

- The orientation of the wires shall be perpendicular to the radar polarization; otherwise the heating acts as radar mirror and would restrict radar propagation. Since the sensor is emitting a horizontally polarized HF signal, the wires have to run vertically. If the sensor is tilted relative to the heating wires, additional losses due to polarization mismatch will occur.
- The perpendicularity of the wires shall be within 90°+/-10°.
- The thickness of the wires shall be smaller than 1/10 of the effective wavelength inside of the material of the secondary surface. Assuming εr = 3 this requires a diameter < 0.2 mm.
- The spacing of the wires shall be regularly and verified by simulation to match with the sensor.
- The spacing of the wires shall be larger than the effective wavelength inside of the material of the secondary surface. Assuming εr = 3 this requires a spacing > 2.2 mm. Continental recommends 5 mm spacing.
- The attenuation caused by the heating wires shall not exceed 0.5 dB (one way). However, this does not change the maximum overall attenuation that is allowed for the radome.

Any radome heating design should be verified and released by the designer/developer of the radome heating to ensure robust radar performance.

5.2 Functional

5.2.1 Input Signals

5.2.1.1 Required Static Parameters

(is only available for ARS 540 automotive radar)

Following static parameters are required from the customer, as they need to be coded into the sensor.

- Wheel base
- Vehicle width
- Vehicle length
- Sensor orientation in relation to the vehicle driving direction
- Sensor longitudinal position (LongPos) in relation to the vehicle reference point
- Sensor lateral position (LatPos) in relation to the vehicle reference point
- Sensor vertical position (VerPos) in relation to the vehicle reference point
- Front variant configuration (FAS Mid/FAS High)

The parameters shall not vary more than +/-5 cm around the coded nominal value. In case of a larger deviation the detection of over- and under-drivable objects may be impaired.

Remark:

- The customer shall provide the tolerance window which inherits max. variation in up- and down-direction. In case of an unsymmetrical window the coded value shall be the midpoint of the window.

5.2.1.2 Required Dynamic Parameters

The following dynamic parameters are required:

- Yaw Rate
- Wheel Speed, Vehicle Speed or Wheel Circumference Velocity
- Steering Wheel Angle
- Driving direction
- Change of vehicle load capacity
- Adjustable suspension (e.g. off-road drive / on-road drive or high ego velocity)

The required signal quality depends on the expected sensor performance. Binary message format and required precision of the dynamic input parameters will be agreed upon in separate documents but here it cannot be provided for Industrial New Markets business.

Input Signals by Interface			
Mandatory	Dynamic Parameters	Vehicle Bus	shared
Mandatory	HMI		
Mandatory	Control Commands (e.g. start service alignment, SW updates)		
	Camera Fusion (Objects + Lane + TSR)		
	Navigation System Fusion (map data)		

Table 5: ARS 540 Input Signals

5.2.2 Output Signals

The output signals depend on expected sensor and vehicle function.

Output Signals by Interface		
Object List	Vehicle Bus	shared
RDI		
EBA Brake Request		
Warning / HMI		
Function Degradation / Blockage Status		
Diagnostic / Error Management		

Table 6: ARS 540 Output Signals

5.3 Mechanical

The device can be integrated in the front end and if required in the rear end of the vehicle as well. For all other applications it depends on the individual mounting situation and requirements.

Information to support the optimal device mounting fixture integration concept are shared between our technical service and the customer.

For mounting location of radar sensor and secondary surface properties please refer to chapter 'Mounting Guidelines' of this Short Description.

5.3.1 Housing

7 shows the mechanic dimensions and masses.

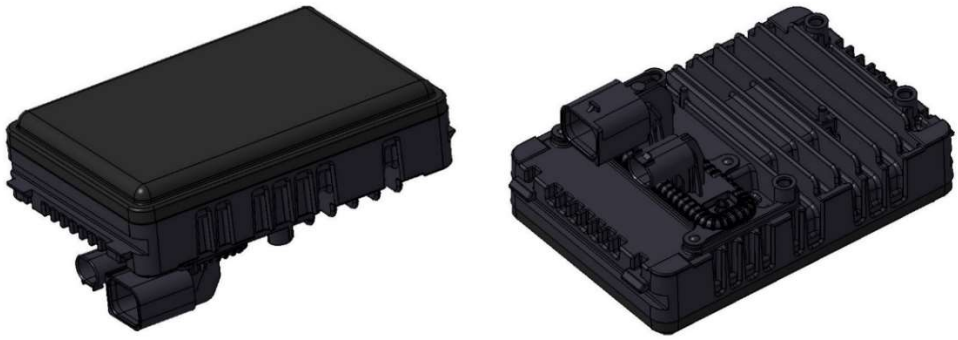
Mechanical Configuration		ARS 548 RDI
Dimension	Width	90 mm (both with and without connector)
	Length	130 mm (without snap fixation) 137 mm (with snap fixation)
	Height	42.06 mm (without connector) 65.56 mm (with connector)
Mass		526 g

Table 7: ARS 548 RDI - Dimension and Mass

The exact dimension of the radar sensor variants could be found in the mechanic drawing / configuration as mentioned in chapter 5.3.2.1.

5.3.2 Fixation / Mechanic Configurations ARS 548 RDI

5.3.2.1 Mechanic Configuration ARS 548 RDI



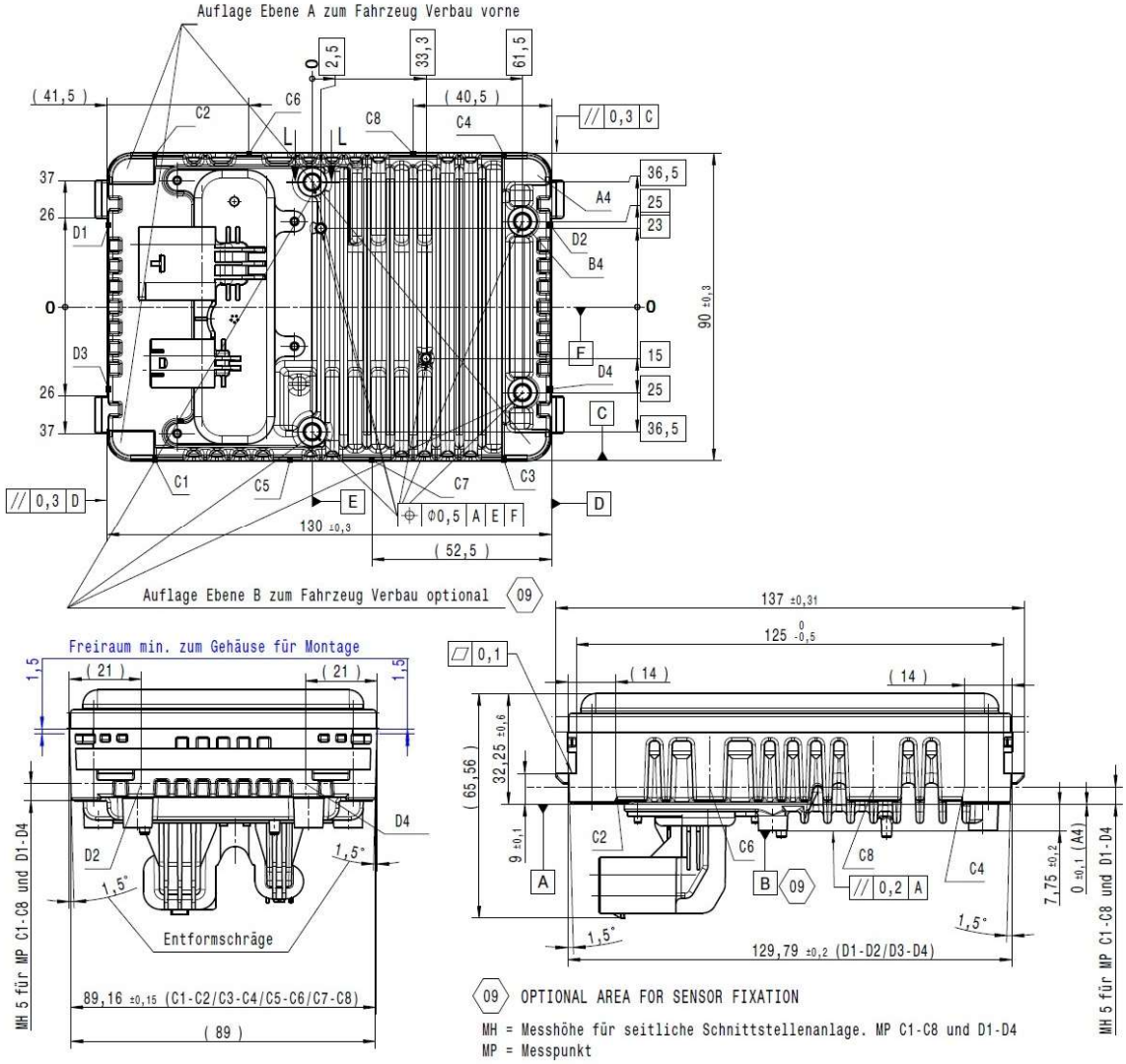


Figure 9: Dimension Drawings – Mechanic Configuration ARS 548 RDI

5.3.2.2 Mechanic Example Configuration Bracket ARS 548 RDI

(only as possible recommendation – not available for sales)

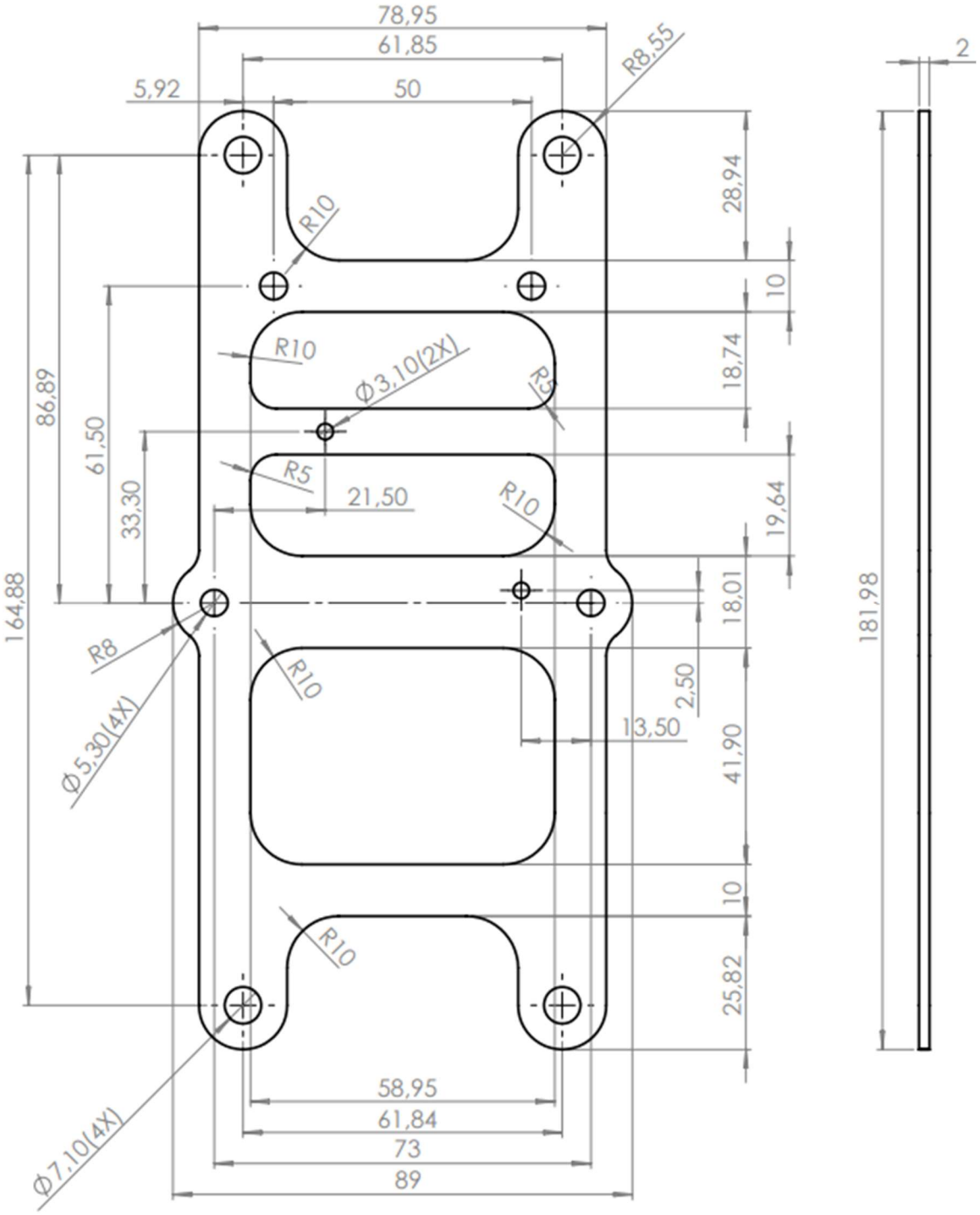


Figure 10: Dimension Drawing – Example Configuration Bracket ARS 548 RDI

5.3.3 Vehicle Connector

5.3.3.1 Connector Orientation

The default mounting orientation has the vehicle connector facing leftwards, from a view in driving direction. The sensor can also be mounted with the connector facing rightwards. The mounting orientation must be coded in the sensor's internal parameters for the automotive version ARS 540.

Mounting orientation affects the position of the TX- and RX-antennas. TX- and RX-antennas have different apertures; therefore they are differently influenced by the structure of the secondary surface. To apply best performance the connector orientation shall be evaluated depending on mounting location from the customer.

5.3.3.2 Vehicle Connector Type and Dimensions

Currently one Connector Type (CT-A) is offered for the ARS 548 RDI sensor.

Connector Type **CT-A**:

- 6 pin main connector
- 2 pin Ethernet connector

5.3.3.3 Vehicle Connector Pin-Out

The pin assignment depends on the communication interface and is designed for ARS 548 RDI as mentioned in Table 9 and Figure 11.

For ARS 548 RDI only **Pin 1** and **Pin 3** for Main power supply can be used (1.5 mm^2 wires needed) and Pin 1 and 2 for Ethernet (0.35 mm^2 wires needed).

Main	Signal Name	Description	Direction
1	UBATT	KL15 Sensor Supply	POWER
2	POS_COD0	Position coding (not used for Front Sensor)	IN Control
3	GND	KL31 Sensor GND	POWER
4	HEAT_OUT	Output for Heater 2nd Pin of Heater connected to GND.	POWER OUT
5	UBATT_HEAT	KL15 HEAT Switch Input	POWER
6	POS_COD1	Position coding (not used for Front Sensor)	IN Control
ETH	**Signal Name**	**Description**	**Direction**
1	ETH0_P	Positive Ethernet ComLine	IN/OUT
2	ETH0_N	Negative Ethernet ComLine	IN/OUT

ETH twisted cables stranding length H = 13 mm

Table 9: Pin assignment ARS 548 RDI - 6 and 2 pin connector

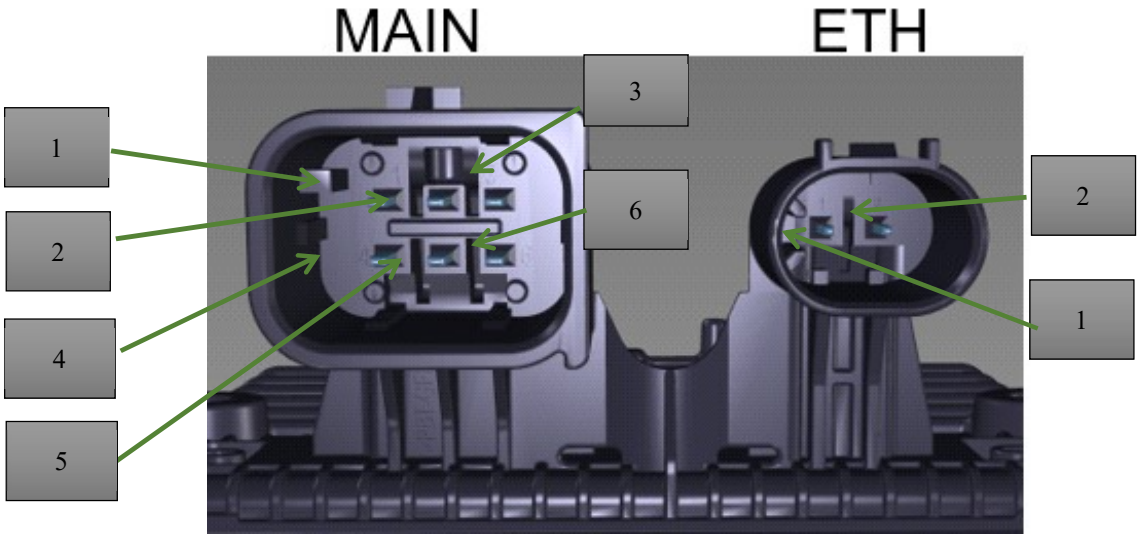


Figure 11: Pin-Out diagram for ARS 548 RDI - 6 and 2 pin connector

MAIN Connector

1. 12 V DC 1,5 A average

2. COD 0 = low = front radar (not supported by Demo-SW)

3. Gnd

4. switchline extern heating OUT (not supported by Demo-SW)

5. switchline extern heating IN (not supported by Demo-SW)

6. COD 1 = low = front radar (not supported by Demo-SW)

Blue = valid in Demo-Software resp. ARS 548 RDI

5.3.4 Label

The ARS 548 RDI's label consists of two parts. One label is situated on the side and is realized as data-matrix code. As shown in Figure 1, the other label is located on the front of the housing; laser marked and containing areas reserved for Continental and for the customer information.

Investigations have shown a negligible effect on radar performance.

For queries and request the serial-ID shall be stated.

Figure 12: Label ARS 548 RDI (mechanic variant)

Here the original labeling of ARS 548 RDI with new A2-C-No. will be placed after availability and approved internal Change Request Process.

5.3.5 Material

All sensor components are confirmed against GADSL (Global Automotive Declarable Substance List).

The ARS 548 RDI's housing consists of following materials:

- Housing (bottom): Aluminum die-cast
- Radome (top): PBT GF30

5.4 Software

(is only available for ARS 540 automotive radar)

The software architecture of the sensor distinguishes between Frame-SW and Algorithm-SW feature.

The SW supports AUTOSAR Release 4.3.

Integration of 3rd party software for further function or other AUTOSAR version needs to be negotiated with New Markets depending on requirements, volumes and resources – separate business with relative high costs and time frame. The ARS 548 RDI software will be explained with signals etc. in a separate document.

Please Note!

The software of the ARS 548 RDI has detections / cluster (untracked and close to raw data) and an object list (OI Object Interface) output. In case the measured cluster are very limited and not enough in quantity and quality to generate objects, so the object list will be set to “0” – no object list available. For the modified software of ARS 548 RDI a separate document “Software Description ARS 548 RDI” or similar name is available.

5.4.1 Frame-SW

The Frame-SW can be separated in 2 main areas with following functionalities:

- Frame SW for internal functions:
  - Safety Operating system: OS (for RPU/APU)
  - Memory Protection Management via MMU and MPU
  - Energy management by defining radar cycle 50 ms and 100 ms (standstill)
  - Hardware abstraction interface
  - Microcontroller abstract interface
  - Processor abstract interface
  - Control and system services
  - Self tests
  - Radar interface (TI API)-interface to radar and TI firmware
  - Algo interface
  - Thermal shut-down / voltage protection
- Frame SW for external functions:
  - Bootloader with flashing
  - Communication interfaces (public and private)
  - Diagnosis with Error & Event Management (DEM's – Diagnosis Error Management)
  - Coding and parameterization (incl. variant handling)
  - Measurement Technology Interface (MTI)
  - Other IOs (e.g. external Radome heating switch)
  - Configuration of Runtime Environment (RTE)

5.4.3 Algorithmic-Software

The Algorithmic-SW can be separated in 4 main areas with following functionalities:

- Data Acquisition and Processing:
  - Radar hardware control
  - Raw signal processing
- Data Analysis and Classification:
  - Course estimation
  - Road description
  - Vehicle dynamic observer
  - Radar detection image
  - Object detection and classification (including pedestrian and bicycle detection)
- High-Level Functions:
  - Emergency brake assist
  - Sensor fusion
- Support and Safety Functions:
  - End of line alignment
  - Service alignment
  - Performance degradation (blockage, radar interference)

6. Mounting Guidelines

6.1 Sensor Coordinate System

(is only available for ARS 540 automotive radar)

The sensor component axis or coordinate system is according to AUTOSAR and ISO-8855 standard. AUTOSAR is the AUTomotive Open System Architecture.

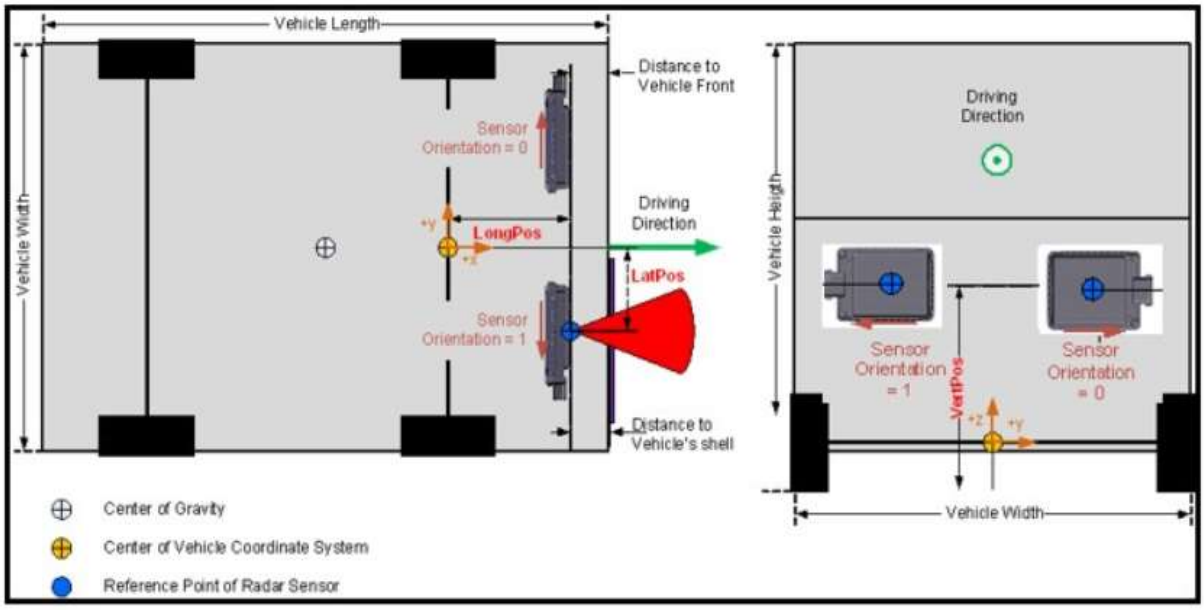


Figure 13: Sensor Coordinate System

The mounting height of the sensor shall be used +/-5cm around the nominal value.

6.2 Sensor Reference Point

The reference point of the sensor - i.e. the center point of the antenna which defines the base of the radar cone - will be provided with the mechanical 2D-drawings.

6.3 Location Mounting Tolerances

The location mounting tolerances describe the admissible horizontal and vertical offset of the sensor location (reference point) compared to the vehicle axis as summarized in the mounting window given in Figure 1 and Figure 18.

This mounting window should not be understood in a “black/white sense”, with full performance everywhere within and zero performance anywhere outside. It rather summarizes Continental’s experience from various customer projects. Outside the given mounting window impaired sensor performance is to be expected. Any such mounting location will require substantial validation effort.

Limits of horizontal deviation based on vehicle axis (LatPos):

- Up to 300 mm out of vehicle center with nominal performance
- From 300 - 600 mm out of vehicle center: with performance limitations for full speed range ACC function

Limits of vertical deviation from road surface (VertCenter + VertPos):

- From 295 - 1000 mm above road-surface level with nominal performance

Notes:

- Performance limitations for full speed range ACC (FSRA) and EBA functions are expected if positioned at outer edge of specified range.
- Performance limitations for EuroNCAP Pedestrian function are expected if positioned at outer edge of specified range.
- Values are measured from the sensor centre.

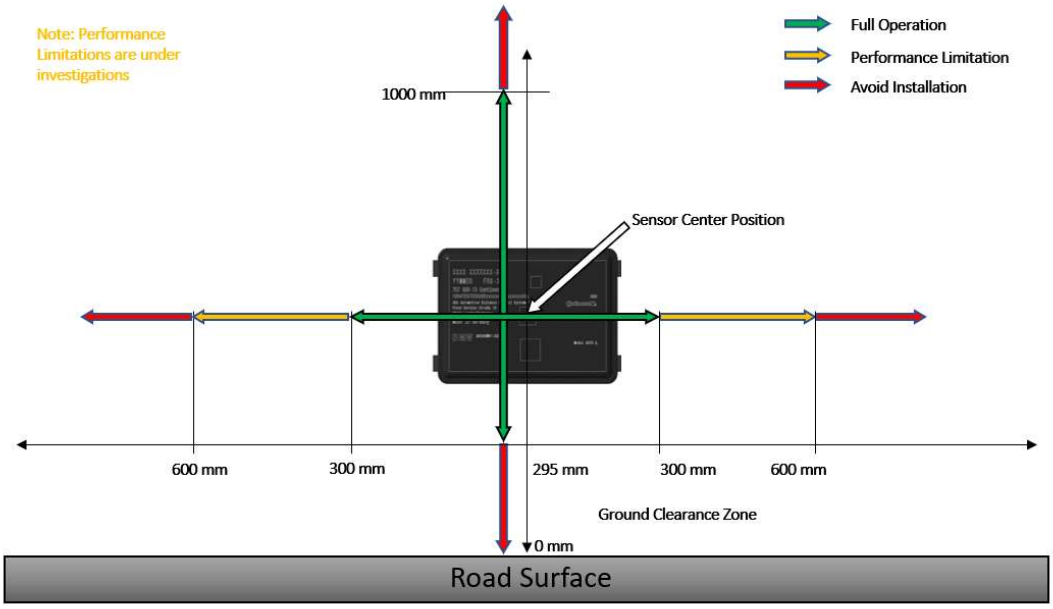


Figure 14: Mounting Location Front

For ARS 548 RDI, Continental offers the possibility of mounting the radars at the rear side of the vehicle. The sensors are to be preferably mounted at the corners of the vehicle in order to minimize the obstruction of the Field of View due to subsequent moving vehicles. Usage of absorber materials is recommended. Figure 15 shows the possible positioning of the sensor and the limitations thereby.

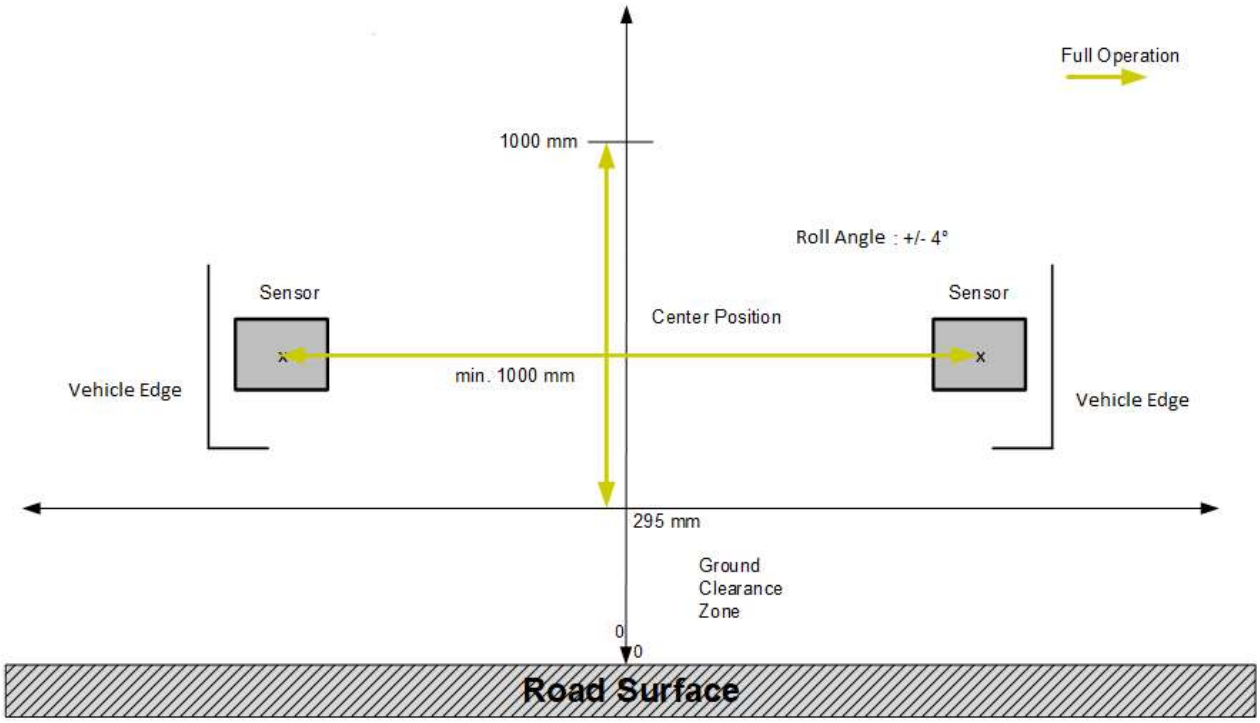


Figure 15: Mounting Location Rear

6.4 Angular Mounting Tolerances

The maximum out of position angles to normal position (sensor-front perpendicular to road surface and perpendicular to vehicle axis) corresponds to alignment capability as given in the chapter "Calibration and Blockage".

The mechanical mounting tolerances include the **sum** of the following contributions:

- Drive axis-vehicle body
- Vehicle Body-Bracket
- Bracket-Sensor
- Change of loading condition (e.g. empty/full trunk)
- Wind load

The better the accuracy of drive axis-vehicle body the more mounting margin is available for the other contributions. The mounting tolerances have to be evaluated individually for each new mounting position.

The alignment feature of the sensor provides on-line calibration to compensate mounting tolerances. Misalignment consists of

- Misalignment in the factory
- Changes over lifetime
- Loading

6.5 Secondary Surface (Radome)

Between the sensor and the exterior of the car there shall be a 'secondary surface'. It protects the sensor from stone chipping and UV radiation. It also prevents direct impact of abrasive media and massive water exposure. The secondary surface may be an emblem, the bumper or a radar optimized structure.

Open mounting of the sensor (i.e. without protective secondary surface) is not supported.

The position and orientation of the sensor in relation to the secondary surface cannot generally be specified, but has to be evaluated individually.

Configuration for optimum system performance depends on:

- Thickness
- Material
- Form
- Distance
- Homogeneity
- Tilt of the secondary surface

For a given appropriate design of the secondary surface, the system can be configured in such a way, that usage is secure and unaffected even when mounting tolerances within the given limits are taken into account.

The position (distance, mounting angle) of the sensor relative to the secondary surface needs to be evaluated/validated by customer and supplier, based on measurements in the anechoic chamber e.g. at Continental and/or simulations on demand.

6.5.1 Secondary Surface - Distance and Angle

According to the mounting position of the sensor for a specific platform resp. application, the distance between the sensor front cover and the secondary surface shall be designed large enough to avoid mechanical interferences, caused by thermal geometry changes or mechanical stress (e.g. vibrations).

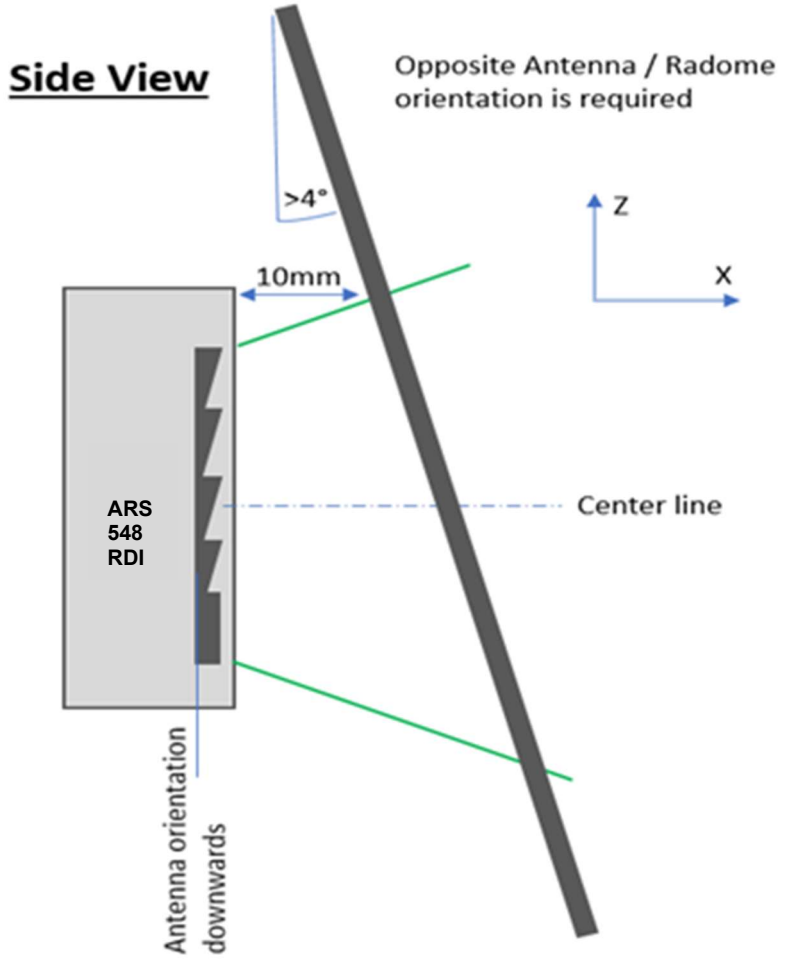


Figure 16: Distance of Secondary Surface (side view)

In addition to that, the distance to the secondary surface shall be large enough to avoid development of a constant water film or snow or mud cover. Continental recommends a minimum distance of 15 mm to the secondary surface, if the sensor is accessible by rain, snow, mud etc. indirectly. If the area between sensor and secondary surface is not accessible by rain, snow, mud, etc. the minimum distance may be reduced to 5 mm.

However, it shall also be considered, that the distance between sensor and secondary surface may have an impact on passive safety (pedestrian protection) and function availability (e.g. blockage). The impact on passive safety and function availability shall be evaluated by the customer.

The combination of sensor unit and mounting position shall be secured against whistling/ wheezing noise. As a proposal this should be checked in a wind tunnel by the customer.

Tilting of the secondary surface:

Relative to the sensor plane, the secondary surface may face slightly upward or downwards, but lateral angles (secondary surface facing left or right) shall be avoided.

The angle between sensor and secondary surface is therefore designated as 'tilt angle'. For the tilt angle applied to the secondary surface, the following points shall be considered:

- A too small tilt angle may introduce multipath reflection between sensor and secondary surface and might increase noise level, reduce non-ambiguous angle area and might cause ghost object issues.
- A too high tilt angle increases the effective thickness and therefore increases damping due to material losses, reduces non-ambiguous angle area and might cause ghost object issues.
- For maximum performance the tilt angle shall be 4° < x < 30°(opposite antenna orientation).
- This tilt angle range is valid for both sensor orientations (connector facing either right or left). The orientation of the sensor antenna and the radome shall always be opposite to each other.
- In case the secondary surface is tilted downwards, the tilt angle shall remain within the corresponding range of -30° < x < -4° (opposite antenna orientation).
- The combination of large tilt angles and large distance to the secondary surface has to be considered with special attention.

Disadvantageous combinations can result in

- Propagation paths through the engine compartment which can lead to ghost targets.
- Multipath propagation e.g. between bracket and secondary surface resulting in higher sidelobes or inaccurate angular measurement.

6.5.2 Secondary Surface - Material Properties

Please note that material properties given by manufacturers normally refer to frequencies in the MHz-range or below. For radar frequencies (in our case 77 GHz) the dielectric constant may differ substantially from the value stated in data sheets.

Materials used as structure for the bumper/secondary surface shall have the following properties:

- Synthetic materials with low dielectric loss factors at the specific radar frequency shall be used in order to achieve low transition damping.
- Synthetic materials with low dielectric constants (ε_r) shall be used in order to obtain low surface reflection.
- The roughness of the material should be below 30 µm.

Possible materials for secondary surfaces are shown in Table 10.

Material	Dielectric constant ε_r @ 77 GHz	Optimum thickness [mm]	Second maximum [mm]	Third maximum [mm]
Polypropylene	2.35	1.292	2.583	3.875
Polyamide	2.75	1.194	2.388	3.582
Polycarbonate	2.80	1.183	2.366	3.550
PC-PBT (Polycarbonate-Type)	2.90	1.163	2.325	3.488
ABS (Acrylonitrile-Butadien-Styrole)	3.12	1.121	2.242	3.363
ASA (Acrylonitrile Styrene Acrylate)	3.80	1.016	2.031	3.047
PMMA (Poly Methyl Methacrylate)	3.40	1.074	2.148	3.221
SMC (Sheet Moulding Compound)	4.85	0.90	1.80	2.70

Table 10: Dielectric Constant and optimal thickness of common bumper materials @ 77 GHz

Based on experience it is important to note, that the actual properties of a certain material may also differ from supplier to supplier according to the used composition or density. Therefore, all values for the dielectric constant given in the paragraph can only be used as a guideline. Continental offers the customer on demand to measure the dielectric constant ε_r of the intended material on a quasi-optical bench.

Material	thickness of 1.optimum (mm)**	thickness of 2.optimum (mm)**	thickness of 3.optimum (mm)**	thickness of 4.optimum (mm)**	attenuation(dB) for 2. Optimum at 77 GHz	real permittivity Er*	applicability	Lambda/2 free air for 77 GHz	
Polypropylene	1,28	2,55	3,83	5,10	0,10	2,33	best	1,948051948	mm
ABS	1,19	2,39	3,58	4,77	0,30	2,7	ok		
Polyamide	1,18	2,36	3,54	4,72	0,30	2,73	ok		
Polycarbonate	1,16	2,33	3,49	4,66	0,17	2,8	ok		
SMC	0,88	1,77	2,65	3,54	1,10	4,85	no		

*Numbers for permittivity might vary depending on manufacturer and chemical composition. Therefore calculated numbers for thickness have to be verified by measurement

**Calculated numbers for thickness only apply for incident angle of secondary surface of 0 degree.

Table 11: Additional material values @ 77 GHz

6.5.3 Secondary Surface - Thickness and Curvature

To achieve high permeability, the overall thickness of the secondary surface has to be carefully selected. The effective wavelength λ_{eff} in the material can be calculated on basis of the measured dielectric constant ε_r as follows:

$$\lambda_{eff} = \frac{c_0}{f}\frac{1}{\sqrt{\varepsilon_r}}$$

Figure 17: Effective Wavelength

The formula given above is only applicable for small to medium tilt angles (approx. up to 30°) of the secondary surface against the sensor front. A multiple of half of the effective wavelength within the material would be appropriate. For example, for the ABS material (ε_r = 3.12 in Table 10) any value of n*1.1 mm (@77 GHz, n=1,2,..) is favorable, whereby with raising thickness the attenuation is increasing.

Generally the nominal thickness of the cover material should be selected according to the minimum loss for the given tilt angle.

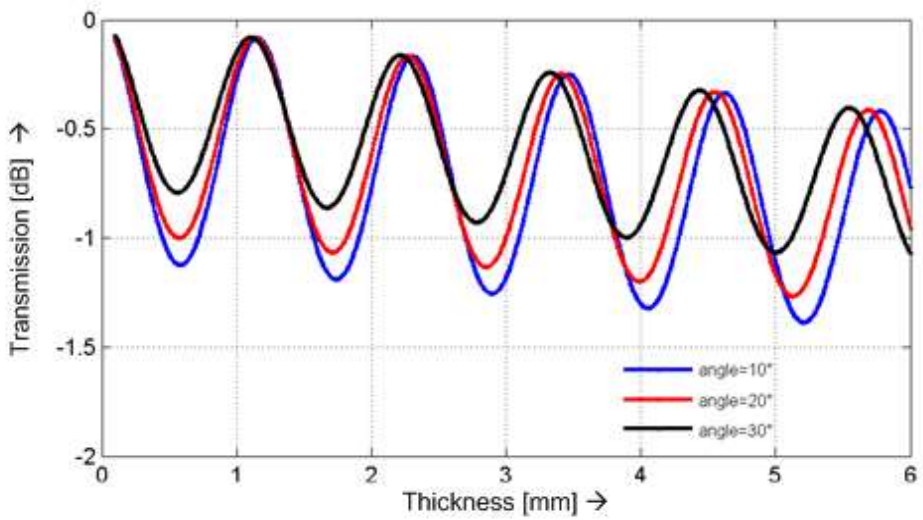


Figure 18: Attenuation in dependency of material thickness and tilt angles

To prevent distortion of the radar beams, the secondary surface shall be as planar as possible while providing constant thickness. Smaller curvature radii affect the radar beam performance and thus the function performance. The allowed curvature radius in y-direction may be calculated from Figure 19 and Figure 20.

To prevent distortions of the radar beam, the secondary surface shall not contain holes, ribbed profiles, sharp edges or abrupt thickness changes.

Exception: Grooves and ridges on the secondary surface which result in thickness variations <0.3 mm, are essentially acceptable and need to be finally confirmed by Radar chamber measurements.

The following recommendations give a general impression of favorable boundary conditions:

- The secondary surface shall have a planar or convex shape, i.e. its sign of curvature shall not change in z-direction (Changes of the curvature sign make the sensor/surface constellation highly sensitive to even small shifts of sensor vs. surface).
- The minimum allowed curvature radius in z-direction corresponds to the minimum allowed curvature radius in y-direction given below.
- The curvature in y-direction of the secondary surface shall be symmetrical to the center line of the sensor.
- The maximum distance between sensor and secondary surface shall appear at the center line of the sensor.

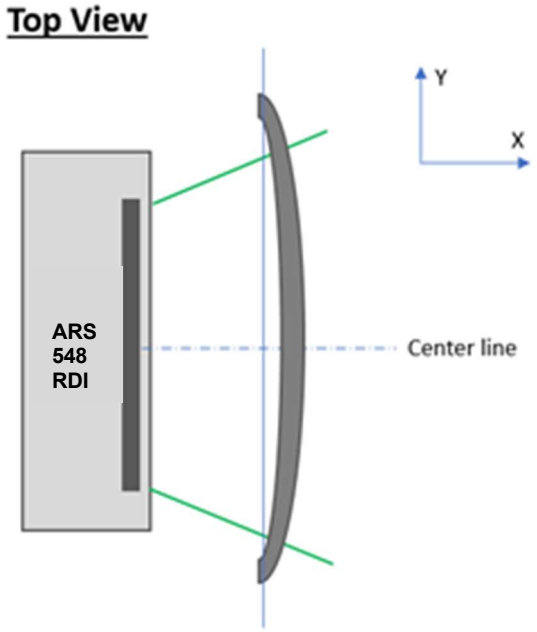


Figure 19: Curvature center position of Secondary Surface

Assuming a minimum distance of 5 mm between sensor and secondary surface (see Figure 20), the variation in distance shall be <3 mm (distance at sensor's center line versus distance at edge of radar cone).

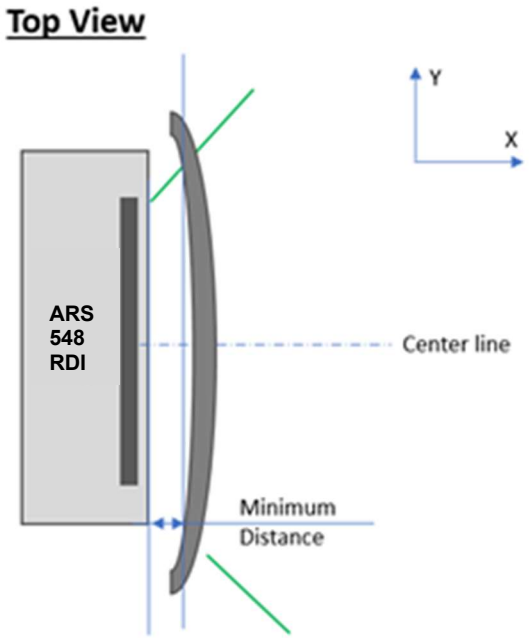


Figure 20: Distance between Sensor Surface and Secondary Surface

While single water drops on the secondary surface are not deemed critical, a closed water film could result in partial or full blockage of the sensor.

Any specific geometry of the secondary surface including the mounting structure of the radar sensor shall be provided to Continental's anechoic radar chamber team on demand in order to evaluate impact on functionality and performance of the sensor. In any case, radar measurements need to be performed.

6.5.4 Secondary Surface - Painting

The secondary surface can in principle be painted but a dedicated analysis and control of the different possible categories of paintings is mandatory to avoid significant performance degradation.

In general the secondary surface will carry several layers of primer, paint and varnishes. These layers in combination with the structure material will influence both surface reflection properties and the transmission damping. All kinds of metallic materials prevent respectively degrade sensor radiation and shall not be used on a secondary surface.

Elements containing metallic particles must be verified. The applicability of metallic paintings is dependent on

- The metal content (percentage) in the painting
- The size and shape of the metal particles in the painting
- Number and thicknesses of different layers of paintings and primers

The number of painting layers shall not exceed 4; the resulting one-way attenuation and reflectivity must always be taken into consideration.

The material thickness tolerance should be +/- 0.1 mm and should be verified by Radar chamber measurements. A summary of all known mechanical design guidelines for painting and structure of the secondary surface is shown in Table 12 resp. Table 12.1.

Factor	GO	NO GO	Performance Degradation
Area	No interference within Zone 1 ; Verification of Zone 2 by Continental is still needed	Parts inside of Zone 1	Interferences have to be agreed by Continental
Material	Approved material	All other materials need to be confirmed by Continental	Non approved materials have to be confirmed by Continental
Thickness	Constant thickness over whole structure as specified	Limits based on Results of Full-Wave Simulation tool	Deviations for desired thickness lead to reflectivity issues / Phase shift errors
Paint/Color radome	No paint/color	Non-approved paint or varnish	Limits based on Results of Raytracing Simulation tool
Air gap inside of Radome	Limits based on Results of Full-Wave Simulation tool	Limits based on Results of Full-Wave Simulation tool	Limits based on Results of Full-Wave Simulation tool
Character Lines - Vertical	Limits based on Results of Full-Wave Simulation tool	Limits based on Results of Full-Wave Simulation tool	Deviations for desired thickness lead to reflectivity issues / Phase shift errors
Character Lines - Horizontal	Limits based on Results of Full-Wave Simulation tool	Limits based on Results of Full-Wave Simulation tool	Deviations for desired thickness lead to reflectivity issues / Phase shift errors
Radome-Curvature	Limits based on Full- Wave Simulation Tool	Limits based on Full- Wave Simulation Tool	DoA error out of limt
Characterlines - Curvature	Limits based on Full- Wave Simulation Tool	Limits based on Full- Wave Simulation Tool	DoA error out of limt
Angle between Sensor/Radome	4° < x < 30° (Opposite antenna/radome orientation is required)	> 30°	< 4° (Opposite antenna/radome orientation is required)
Distance	>= 5 mm (no snow or dirt)	mechanical contact between Sensor and Radom needs to be avoided	mechanical impact to sensor

Table 12: Design Guidelines for Structure and Painting

Also dealerships, repair shops, etc. are to be instructed to adhere to these guidelines when conducting repairs or modifications of the vehicle.

Note: Full wave simulation tool should be used for Secondary Surface development process. Test-parameter are Attenuation, DoA Error, Monopolse, Sidelobe level. All parameters needs be within the limits. The Radome approval finally based on Radar chamber measurements.

6.5.5 Secondary Surface - Attenuation

The maximum attenuation / reflectivity of the secondary surface depends on required function:

To provide ACC/CMS/EBA functionality,

- Two-way attenuation shall not exceed 3dB (+/-30° Az) & 4dB (outer area)
- Max. needed reflection coefficient (incl. reflection homogeneity) is mainly depends on following parameter:
  - Radome shape
  - Tilt angle
  - Radome/Sensor position

  Confirmation of reflectivity coefficient needs to be done by ARS 540 Full-Wave Simulation tool and Radar chamber measurements on demand.

6.5.6 Secondary Surface - General Recommendation

According to Continental's experience the radar sensor should be mounted behind some radar-optimized secondary surface (e.g. dedicated radar cover or customer's logo or special radome housing) rather than behind the vehicle's regular bumper because:

- Additional layers of paint or plastic foil might be put onto the bumper during repairs or aftermarket customizations
- The bumper is prone to deformations (either permanent ones due to accidents or dynamic ones due to wind load)
- Radar attenuation depends significantly on the thickness of the material which might not be guaranteed by a regular bumper

Therefore Continental advises against mounting the radar sensor behind the bumper.

6.5.7 Sample Delivery & Shipping

This engineering and support cannot be provided by New Markets but from the colleagues in the anechoic radar chamber on demand.

The customer shall provide a sufficient number of samples of secondary surfaces.

In case of sensor mounting behind the bumper, the customer shall provide samples for every bumper configuration.

The bumper shall have series characteristics including paint and varnishes. Experience shows that white and silver paint has the largest effects based on their high amount of metallic particles. In order to verify the performance of the radar sensor in the specific mounting position, suitable samples have to be provided for measurements of reflection- and transmission (damping) coefficients.

The sensor shall be protected against damages during shipping and assembly.

6.5.8 Snow deposits on the secondary surface

Snow deposits on the secondary surface may lead to additional attenuations to (parts of) the radar signal. In the worst case, these attenuations may cause partial or full blockage of the radar sensor and thus a degradation of the function performance or a complete deactivation of its functions.

In order to minimize the risk of snow deposits, the secondary surface shall be designed free of horizontal gaps or grooves.

If snow is a prevalent nuisance in the target markets, a radome heating (see above) might be considered.

6.6 Sensor Vehicle Fixation

The customer shall fulfill a set of requirements with regard to assembly and secondary surface structure properties to ensure maximum sensor performance.

The ARS 548 RDI shall optionally have provision to directly attach the sensor to a bracket or vehicle with thread bolts (screws). Standard components like screws and bolts can be used to fasten the sensor but recommended are the bolt screws as mentioned below.

For direct mounting applications to the vehicle or other applications, the ARS 548 RDI sensor shall use fastening screws of type M5 or better self-cutting thread bolts (bolt screws) and shall withstand tightening torques < 6 Nm at the pre-defined 3 resp. 4 mounting position level B (also B4) on the back cover of the radar (Figure 9 – dimension drawing and Figure 22 – Defined mounting position B1, B2, B3). Only 3 of the 4 mounting positions should be used for a better mounting with 3-point-fixation. It must be B1, B2 and B3 in the drawing of Figure 25.

The bolt screw can be ordered at ADC GmbH New Markets in a higher quantity on demand – see hereinafter Figure 21 - drawing bolt screw with dimensions.

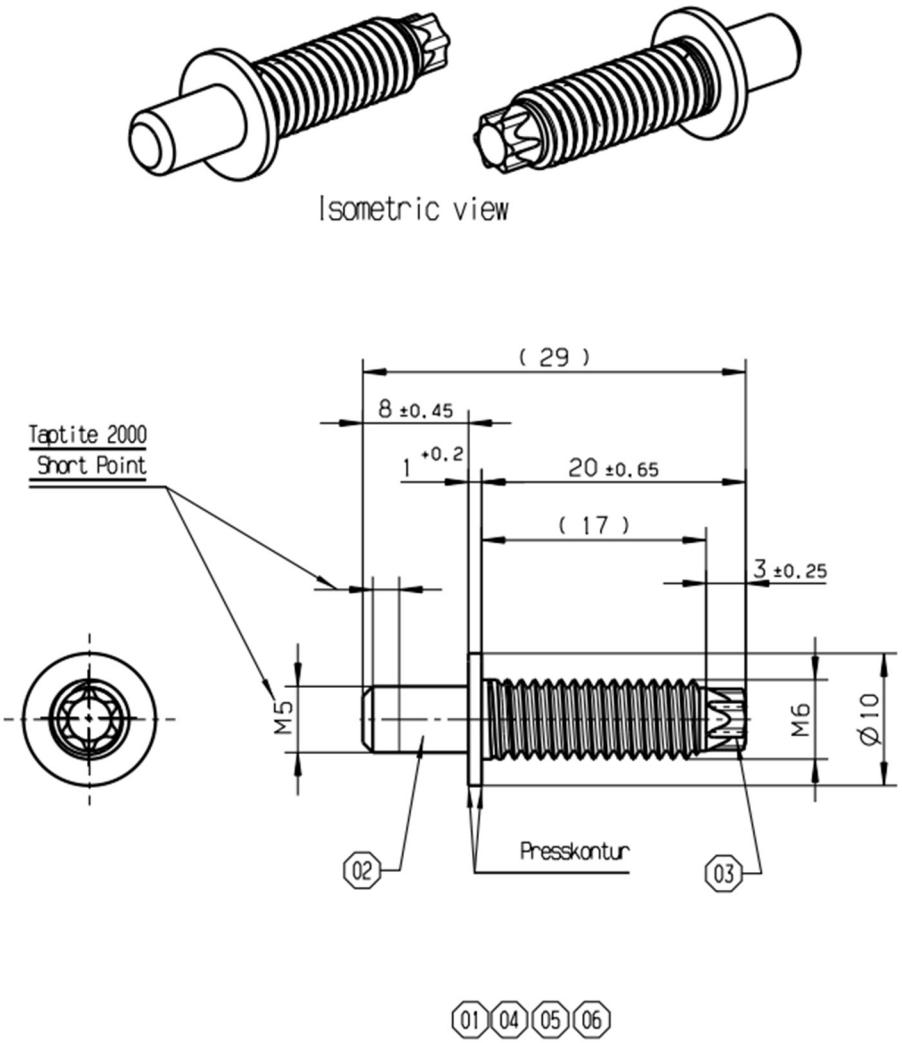


Figure 21: Drawing Bolt Screw

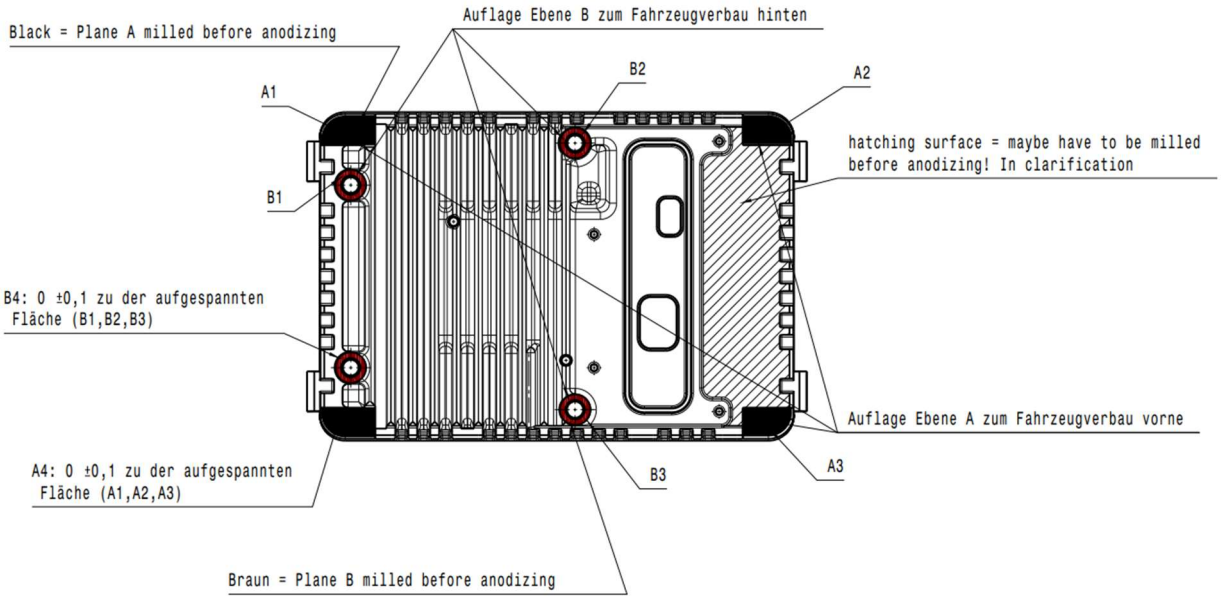


Figure 22: Defined Mounting position B1, B2, B3

The sensor mounting interface elements (e.g. screws) shall be released to fulfill mechanical and electro-chemical (e.g. contact voltage) matching.

Otherwise the bracket (Figure 10 or similar) or the mounting method by using the clip method of the radar, are possible.

6.7 Sensor Radiation Cone

For a proper sensor performance the area in front of the sensor antenna radiation cone needs to be kept free of any materials or objects that may disturb the radar function.

The simplified radiation cone (RF cone and keep-out zone) will be provided as mentioned hereinafter. **The keep-out zone shall not be penetrated by any metallic parts of the vehicle.**

6.7.1 Radar Cone ARS 548 RDI

The following Figure and Figure 24 show the simplified ARS 548 RDI sensor radiation cone in azimuth and elevation direction.

Note: Azimuth and Elevation angles are given in sensor coordinate system.
I.e. angular misalignment of the sensor relative to the vehicle or any lateral displacement has to be taken into account by the customer in addition.
Remark: Keep-Out-Cone and Zone is 120° (+/- 60°) in Azimuth.

Figure 23: simplified Radiation Cone ARS 548 RDI - Azimuth
(without any tolerances)

Figure 24: simplified Radiation Cone ARS 548 RDI - Elevation
(without any tolerances)

In order to achieve full performance for a special OEM, Continental agreed about following additional margin:

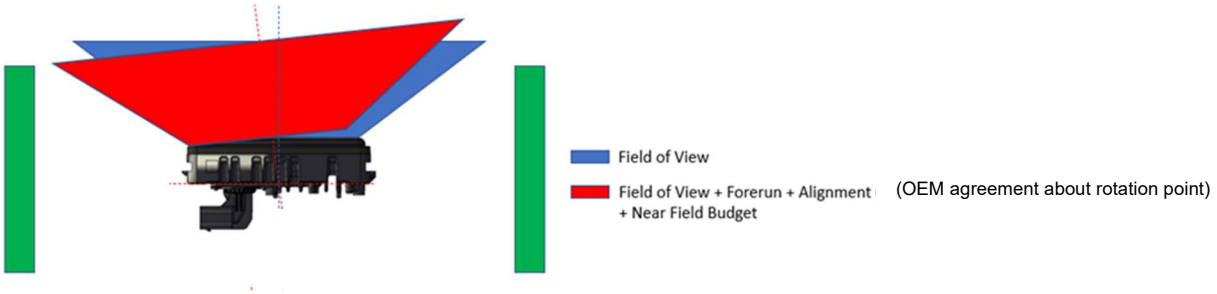


Figure 25: Keep-Out Zone
(including Forerun + Alignment + Near Field Budget e.g. acc. to OEM drawing + 3D Model)

Figure 26: Keep-Out Zone - Azimuth
(including Forerun + Alignment + Near Field Budget e.g. acc. to OEM drawing + 3D Model)

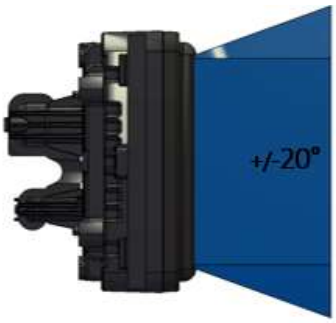


Figure 27: Keep-Out Zone - Elevation
(including Forerun + Alignment + Near Field Budget e.g. acc. to OEM drawing + 3D Model

Note: Radar cone Azimuth (+/-70°) and Elevation (+/-20°) angles are given without any OEM tolerances. The part / position and alignment tolerances still needs to be considered by OEM resp. customer as overall keep-out area (see Figure 28).

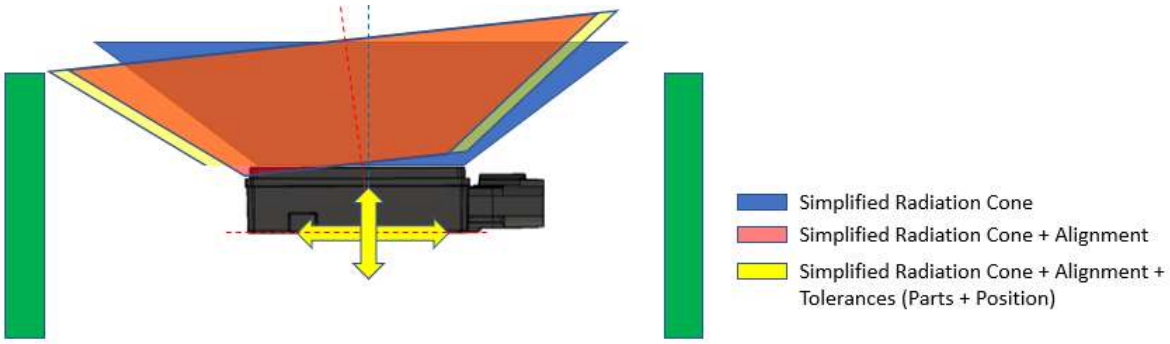


Figure 28: Keep-Out Zones

6.7.2 Additional Requirements for the Radiation Cone

In addition, areas around the sensor radiation cone have to be taken into account according to the following Figure 29.

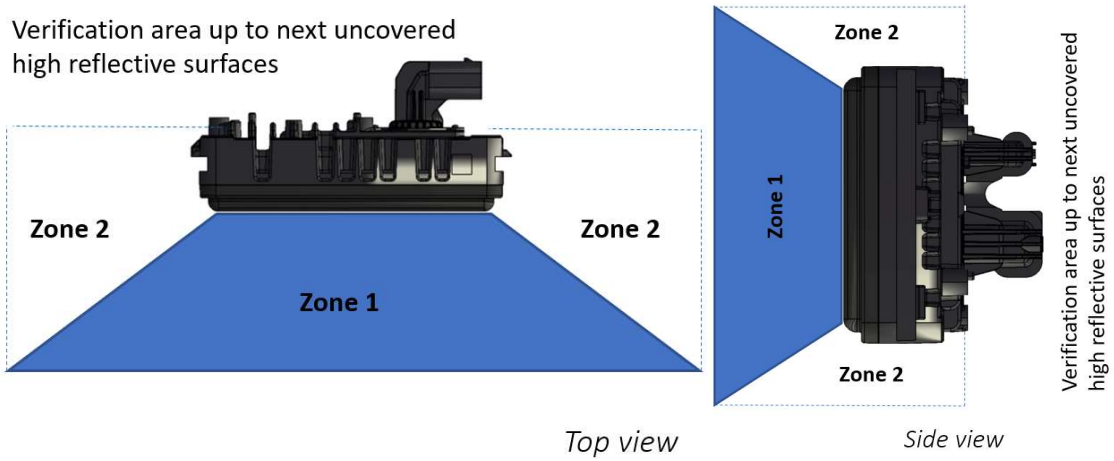


Figure 29: Zone 1 & 2

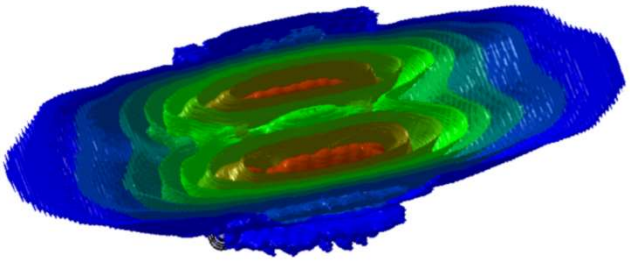


Figure 30: Real Radiation Cone

Legend for details of the keep-out zone:

- Zone 1: Simplified radiation cone + Alignment + Near field tolerances
- Zone 2: Verification Zone (verification necessary)

Zone 1 requirements:

- The customer has to consider the mounting tolerances (position in x,y,z and yaw, pitch, roll) of the device.
- The simplified radiation cone delivered by Continental does only include intrinsic tolerances.
- Extrinsic tolerances are not considered, because these are different for every vehicle platform or application and only known to the customer.

Additional explanations for Zone 2 requirements:

- Zone 2 has to be considered due to unwanted propagations paths. Unwanted incident paths are reflections from positions aside the sensor direct into the sensor or from aside the sensor to the secondary surface and back to the sensor.
- No a-priori dimensions can be given for the Zone 2, because it depends strongly on the material and orientation of the components present around the sensor. The customer shall provide a CAD file with all components within +/-300 mm to the front and to the sides of the sensor. Nevertheless, individual measurements may be necessary.

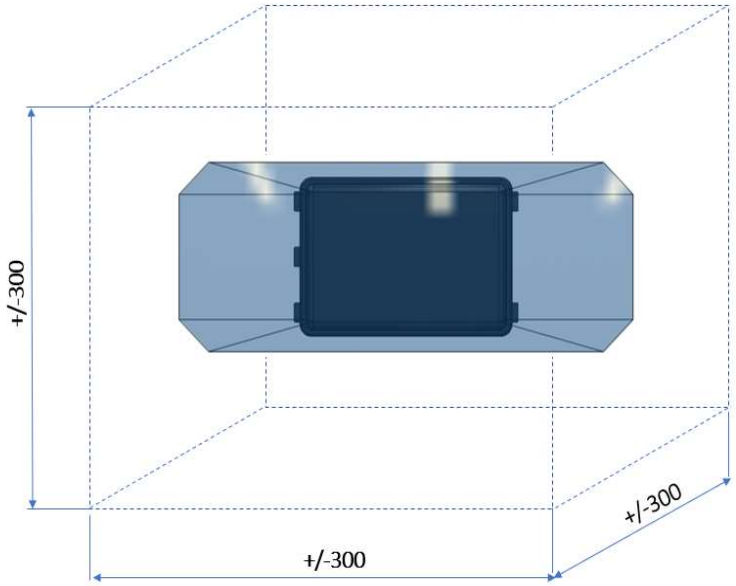


Figure 31: CAD verification cube

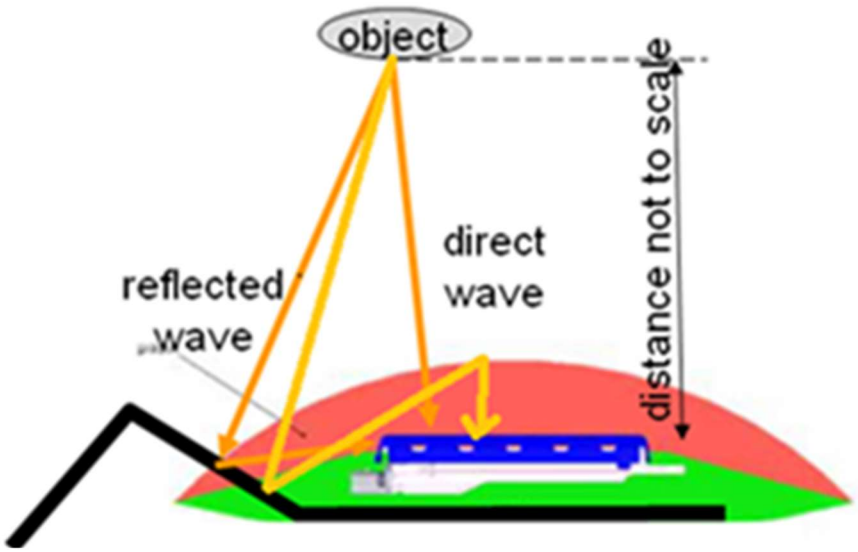


Figure 32: Influences of Chassis Reflections

A minor crash of the vehicle (e.g. a parking dent) may cause a rotation of the sensor in pitch, yaw or roll. As long as the rotation angle of the sensor is less than the compensable misalignment angle in all directions, the sensor will not change to mode ‘Misalignment’. In such case, the radar cones of the sensor will rotate by the same angle as the sensor, i.e. in case of a rotation of the sensor by 4° in azimuth, all the radar cones are also rotated by 4° in azimuth.

Especially, this reserve shall be considered, if the sensor is mounted to the chassis, where a small crash (e.g. a parking dent) may cause a shift or rotation of the secondary surface while the sensor stays unchanged.

Since there is still signal power outside of the radar cones provided by Continental, we recommend another 5 mm reserve around the superposition of all radar cones, i.e. around the combination of all 28 radar cones (12 Tx and 16 Rx cones).

The customer has the responsibility to consider all other possible changes in the constellation of sensor and secondary surface that may be caused by crashes, vibrations etc. This is also valid for all situations where the secondary surface has been displaced angularly with respect to the agreed mounting position of the secondary surface, which may be caused due to minor and major crashes.

7. Calibration and Blockage Detection

(is only available for ARS 540 automotive radar)

7.1 Calibration

7.1.2 Calibration Methods

The sensor can adjust itself both in azimuth (alpha / yaw - horizontally) and elevation (beta / pitch - vertically) directions.

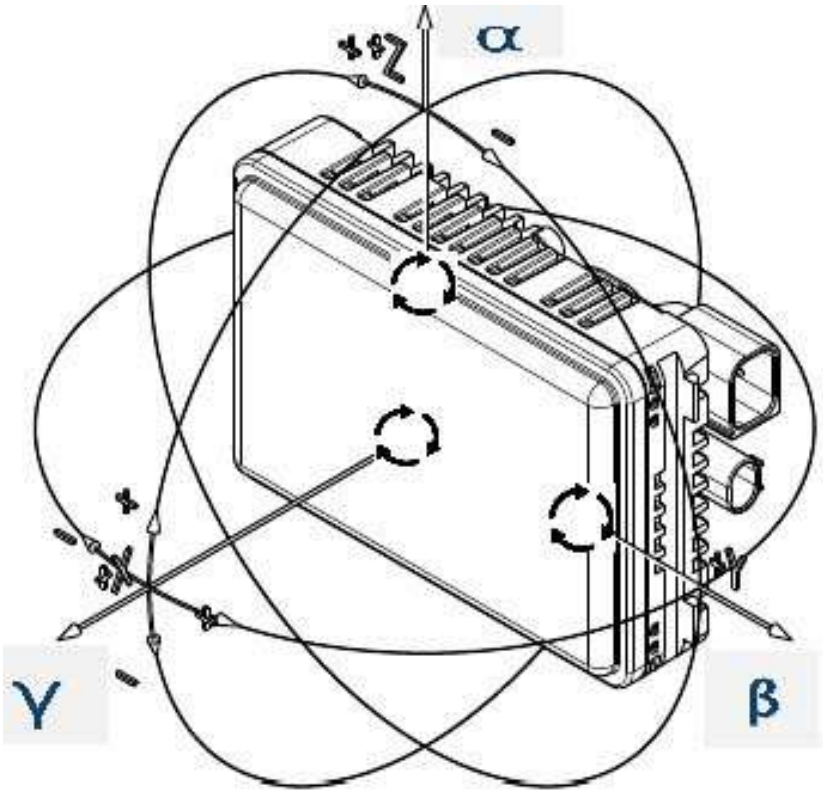


Figure 33: Naming convention for alignment angles

Misalignment includes static deviations due to sensor and mechanical fixture tolerance between sensor reference plane (as described in the drawings) and the driving direction of the vehicle and dynamic deviations caused by changes in loading and suspension.

The static misalignment should be determined by the customer via tolerance chain analysis from vehicle driving direction to sensor mounting reference plane. Temperature variations and mechanical changes over lifetime of the sensor fixture shall be taken into account.

Continental recommends to reserve +/-2° in elevation as margin for misalignment caused by loading of the car and/or adaptive suspension.

Braking may cause temporary misalignment in elevation up to +/-2° (by pitching). Due to its short duration this misalignment will not be detected by auto-alignment.

The customer shall determine the maximum misalignment via simulation or measurement.

The alignment functionality of the sensor can overall compensate the sum of dynamic and static misalignments within certain limits as stated in Table 13.

Total Alignment Range	
Yaw - Azimuth (alpha)	±4°
Pitch - Elevation (beta)	±6°

Table 13: Total Alignment Ranges

The sensor's algorithms are robust against roll angles up to +/-4°.

Auto alignment refers to continuous monitoring of the sensor's calibration state to compensate for temperature effects, unintended mechanical impacts or mechanical misalignment at car manufacturing between the sensor component housing and the vehicle chassis.

There are several possibilities for autonomous alignment, each of these are designed for special situations:

- Online Adjustment (Misalignment Monitoring and Adjustment - MM&A)
- End of line alignment (EoL) – not available for ARS 548 RDI
- Service Alignment (SA) – not available for ARS 548 RDI

During normal operation a continuous misalignment monitoring and adjustment of the sensor calibration state will be done. This monitoring will compensate temperature effects and misalignments between the sensor component housing and the vehicle chassis due to changing of vehicle load capacity or unintended mechanical impacts. The sensor component can adjust itself in both directions azimuth (horizontally) and elevation (vertically). This method needs some minutes to achieve sufficient accuracy. Azimuth misalignment detection is based on stationary targets (no road beams are used) and the elevation misalignment detection performance depends on traffic situations (e.g. maximum accuracy with moving targets in front) while the vehicle is driving.

Safety functions (e.g. emergency braking) shall not cause intervention as long as the uncertainty about alignment state is too high. Upon detection of alignment with sufficient accuracy, the safety functions become gradually enabled. The alignment accuracy which needs to be achieved before enabling a specific safety function depends on the function itself.

Misalignments within the limits will be compensated; larger ones will be notified via a vehicle bus message and stored in the error memory.

7.1.3 End of Line (EoL) Calibration

End of Line (EoL) alignment at the customer work shop provides a fast and precise method to make ensure, that every vehicle which runs off the assembly place, has a completely aligned sensor component.

End of Line (EoL) alignment at the customer workshop is recommended, but not mandatory. For ARS 548 RDI it is not available, but the alignment also can be done manually as described in the chapter Figure 35 of chapter 7.1.4

The maximum accepted misalignment angles at EoL are:

- Azimuth: +/-4°
- Elevation: +/-4° (recommended by Continental, but additional tolerance of +/-2° to be considered due to dynamic loading - refer chapter 7.1.2)

7.1.4 Manually Calibration

The manually calibration / alignment requires a metal plate reflector which needs to be precisely adjusted perpendicular to the vehicle driving vector. Proper alignment of the metal plate has to be ensured in both horizontal and vertical direction. Any misalignment between the vehicle driving vector and the metal plate will lead to a failure of the manually alignment procedure (i.e. a misaligned device).

By using a visualization tool to display the measured data, the RCS value can be used to align the radar sensor in the right way.

Instead of a metal plate reflector it would also be possible (but not recommended) to use a corner reflector.

The properties of an appropriate corner reflector and related placement requirements need to be agreed between the customer and Continental.

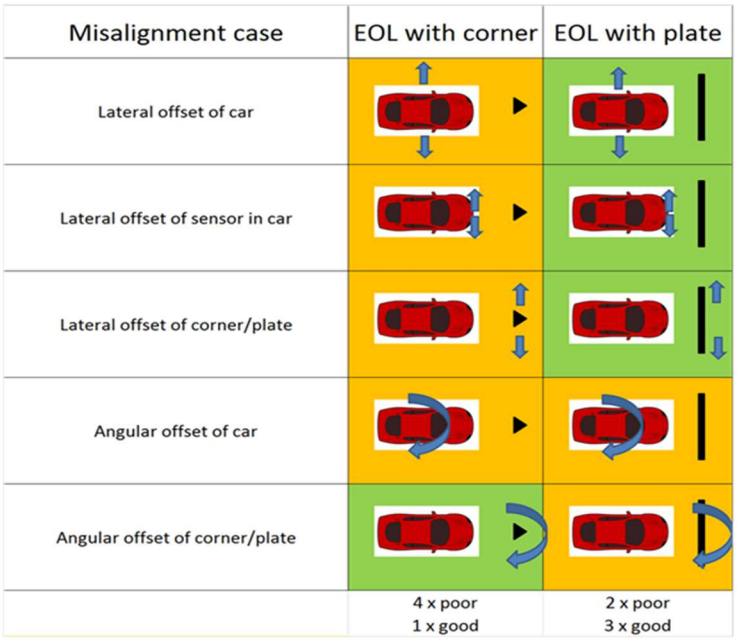


Figure 34: Advantage of plate compared to corner

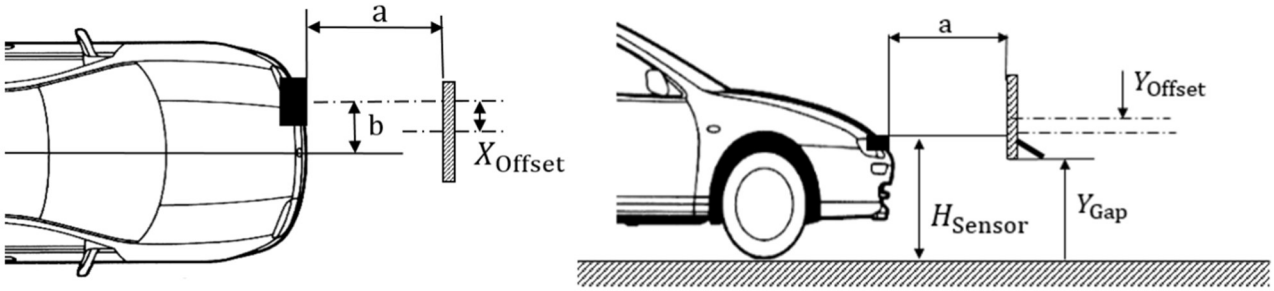


Figure 35: Setup manually alignment, top (left) and side view (right)

The distance a between sensor device and the metal plate shall be within the range 0.8 m < a < 2 m.

The tolerances in X and Y-direction have only impact on the required size of the reflector plate as calculated later.

- The manually alignment procedure is performed in the radar frequency range 76.0 - 77.0 GHz.
- Due to the low distance *a* between sensor device and the metal plate in alignment mode, the near range artifacts are suppressed by using an increased measurement accuracy.

All objects of any material within the area in front of the sensor device as specified by the attached diagram shall be covered with absorber material.

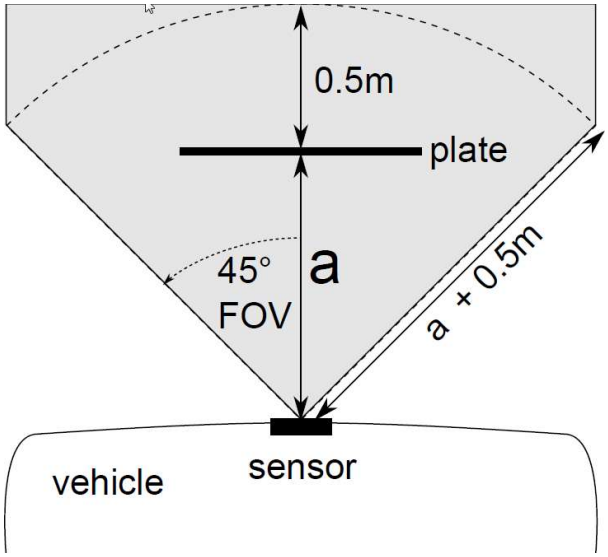


Figure 36: Keep-Out Area for EoL and Manually Calibration

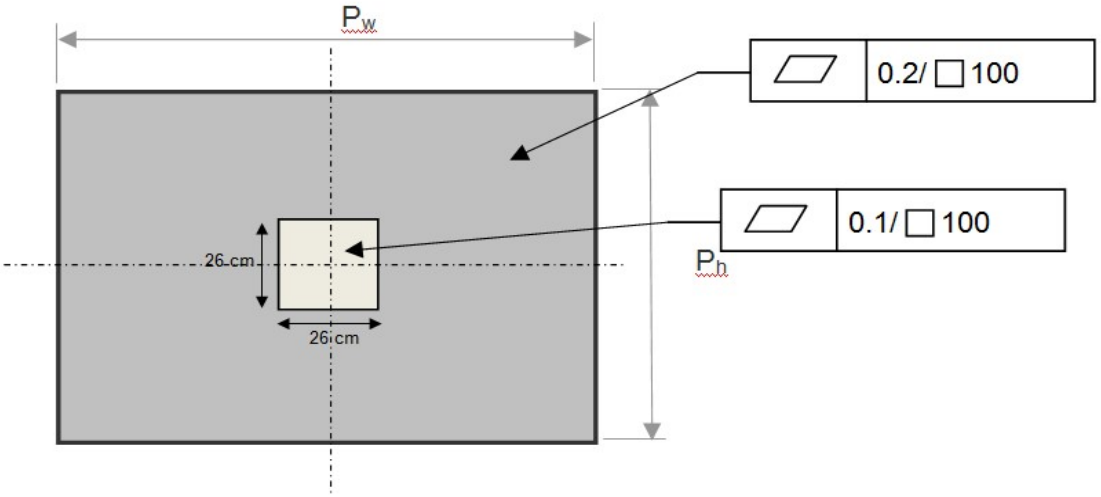


Figure 37: EoL and Manually Calibration reflector plate

Requirements for the material of reflector plate:

- Aluminum
- Iron
- Steel
- Other materials like a mirror are possible, but have to be specified in more detail and have to be investigated by Continental prior to use.

Requirements for the surface finish of the plate:

- Flatness of surface shall be at least f=0.1 mm in each subarea of 80 mm x 80 mm
- Roughness R_z < 50 (is equal to <50 µm)

The reflector plate does not need to be centered and the edges of the reflector plate do not have to be in the FoV. There is no upper limit for the size of the reflector plate.

The following requirements for dimensions and placement of the reflector plate must be fulfilled:

Parameter	Requirement
h_{Sensor}	0.3 … 1.2 cm
X_{offset}	Horizontal sensor mounting tolerance with respect to center of reflector plate
Y_{offset}	Vertical sensor mounting tolerance with respect to center of reflector plate
Y_{Gap}	> 3 cm (= distance between bottom edge of reflector plate and floor)
P_h	= 0.15 m + 0.2 * a + 2 * Yoffset
P_w	= 0.30 m + 0.3 * a + 2 * Xoffset

Table 14: Dimensions and placement requirements for the EoL and Manually Calibration reflector plate

7.1.4.1 Manually Calibration Procedure

During execution of the manually calibration procedure the vehicle must be

- in standstill,
- unloaded,
- no driver in vehicle,
- adaptive suspension must be in default mode.

7.1.5 Auto Alignment (ALN) – Auto Calibration

The ARS 548 RDI provides the function of an Auto Alignment ALN (Auto Calibration). This function depends on the hereinafter described data and values and procedures, which must be taken into account.

For ALN Auto Alignment there is no need for any mechanical adjustment of the device.

The device adjustment/calibration shall take place under the final assembly conditions, thus adapted or integrated in the vehicle system environment (e.g. under bumper, radome).

We have to distinguish between the following different intended purpose / applications:

A. Moving Radar Applications
B. Standstill Radar Applications

Fixed values - already set:

Wheel base = XX mm
Vehicle width = 1,824 mm – incl. mirrors = 2223 mm
Vehicle length = 4,373 mm
Vehicle height = 1,500 mm

Sensor orientation in relation to the vehicle driving direction = Plug to the Right (Top View).

Sensor lateral position (LatPos) in relation to the vehicle reference point:

y = 0 mm +- 50 mm

Sensor vertical position (VerPos) in relation to the vehicle reference point:

z = - 605 mm +- 50 mm

Sensor longitudinal position (LongPos) in relation to the vehicle reference point:

x = tbd. app. = - 500 mm +- 50 mm

A. Moving Radar

Integrated into vehicles – mounting position: front end.

Auto alignment is needed to run!

Auto alignment is running automatically
Once, it is needed to drive with the radar – already mounted - about 2 - 3 km on road.
The radar stores itself calibrating values and keeps itself auto aligned by NVM storage.

Auto alignment always needs inputs of required dynamic parameters:

0x141 AccelerationLateralCog	-65 . . . +65	m/s^2
0x142 AccelerationLongitudinalCog	-65 . . . +66	m/s^2
0x143 VelocityVehicle	0 . . . 350	m/s
0x145 DrivingDirection	0 = standstill vehicle 1 = forward driving vehicle 2 = rear driving vehicle 3 = driving vehicle 13 = reserved 14 = Error 15 = signal without message	
0x146 YawRate	-163.84 . . . +163.83	rad/s
0x147 SteeringAngleFrontAxle	-89.997253 . . . +89.997253	rad/s
0x148 CharacteristicSpeed	10 . . . 60	m/s
(recommendation: default	0	m/s

B. Standstill Radar

Integrated into stationary arrangements – mounting position: different, non-vehicle.

Auto alignment is needed not to run!

Vehicle Speed < 3 Kph:
Radar reduces radar power by 10 dB, auto alignment does not run

Vehicle Speed > 3 kph < 5 kph:
Radar uses standard radar power, auto alignment does not run

Vehicle Speed > 5 kph:
Radar uses standard radar power, and is running auto alignment

Recommendation to avoid decreasing performance of the radar:
Vehicle Speed input has to be set to 4 kph – it makes sense to use the input of 1 m/s!

Recommendation to avoid wrong tracking of the radar:
Vehicle Speed input has to be set to 0 kph - it makes sense to use the input of 0 m/s !

In this case performance in general is not decreased. Only the max. distance of 300 m will be reduced to app. 250 m because of the loss of 10 dB.

Auto alignment always needs inputs of 7 required dynamic parameters. No matter if values are already zero or not - they have to be sent.

See below the 7 parameters with their Ethernet Identifiers and their dimensions:

0x141 AccelerationLateralCog	-65 . . . +65	m/s^2
0x142 AccelerationLongitudinalCog	-65 . . . +66	m/s^2
0x143 VelocityVehicle	0 . . . 350	m/s
0x145 DrivingDirection	0 = standstill vehicle 1 = forward driving vehicle 2 = rear driving vehicle 3 = driving vehicle 13 = reserved 14 = Error 15 = signal without message	
0x146 YawRate	-163.84 . . . +163.83	rad/s
0x147 SteeringAngleFrontAxle	-89.997253 . . . +89.997253	rad/s
0x148 CharacteristicSpeed	10 . . . 60	m/s
(recommendation: default	0	m/s

7.2 Blockage Detection

If the sensor or secondary surface is covered by a layer which damps/distorts the radar signal, the functionality of the sensor can be degraded to an unacceptable level. Such a so-called **blockage** has to be detected.

Critical blocking elements are as listed below:

- Snow and snow slush (high attenuation due to high water content)
- Ice (has moderate attenuation, but distorts phase of waves in case of no constant layer thickness)
- Continuous water layer (not only some drops)
- Seldom special cases: aluminum foil suddenly sticking to radome, sticker glued on radome

Blockage detection can be further distinguished as follows:

- **Partial blockage**: attenuation acceptable, but quality of angular measurement degraded to an unacceptable level (e.g. high sidelobes, significant angular errors); is part or outcome of online calibration
- **Full blockage**: large attenuation resulting in an inacceptable reduction of detection range

Since blockage detection is based on evaluation of statistics of detected objects, the device has to work without restrictions even when driving in conditions with very few radar detections like areas covered with snow, deserts, etc.

The blockage algorithm is a statistics based algorithm, therefore all changes in the environmental conditions have to be verified and confirmed by statistical evaluations. This results in a time delay between environmental changes and any system reaction.

Instant system reaction is not possible due to statistical uncertainty.

8. Environmental Conditions

The standard qualification of the sensor is done according to LV124 specification (see reference [3]).

The sensor has to be installed with a maximum protection of long term water exposure to keep best performance for Radar and electrical Function. It is recommended to verify the installation into the car.

8.1 Temperature Range Specification

The sensor provides full operation at an ambient operating temperature range between -40°C to +85°C.

The sensor provides a storage temperature range between -40°C to +105°C.

In case that the maximum internal temperature is exceeded, the sensor switches to self-protection mode (see also chapter 4.2.5).

The aluminum back cover of the sensor is the main element for heat transfer.

- Cooling air must have sufficient access to the back cover of the sensor.
- The back cover of the sensor shall be in direct contact with thermal conductive materials.

For ARS 548 RDI the sensor unit environment shall perform cooling performance of 26.5 W during standstill and driving (@1.4 m/s air speed from the front).

Furthermore, the cooling shall not be deteriorated by radiant heat from other hot vehicle parts.

It is urgently recommended to check whether cooling is sufficient (even under extreme conditions) for every intended mounting position.

During repainting the sensor shall be in off-state and the maximum vehicle painting temperature shall not exceed +130°C for more than 15 minutes.

In addition to that, the vehicle painting temperature shall not exceed +110°C for more than 60 minutes. Beyond this temperature limit, the sensor is in the off-state.

Attention: During operation in high temperature conditions the sensor can become **hot**. If the mounting position does not exclude contact of human beings, a warning sticker might be appropriate.

Fehler! Verweisquelle konnte nicht gefunden werden. shows the temperature range specification for the radar sensor family.

Temperature Ranges		
Storage	Min	-40°C
	Max	+105°C
Normal Operation	Min	-40°C
	Max	+85°C

Fehler! Verweisquelle konnte nicht gefunden werden.**: Temperature Range Specification**

8.2 Endurance

shows the environmental condition specification for the radar sensor family.

Environmental Condition Specification		
LV 124 Specification *(see reference [3])*	Mechanical Vibration	Profile D
	Agreed Life time (or)	8.000 h
		15 years
	Mileage	300 000 km
	Temperature distribution	Profile 1

: Environmental Condition Specification

8.3 Electrical Conditions

The design is focused to meet standard specifications of automotive industry. Interface circuits are well known from former products. Electrical design and mechanical design will be focused to achieve high attenuation of interferences from the environment and low radiation to the environment.

E.g. the PCB is encapsulated and the connector pins are in a separate chamber built by two metallic plates. The PCB will have separate plains for ground and common voltage supplies.

8.4 Ingress Protection (IP Code)

The sensor is dust proof according to IP6Kx (ISO 20653).

The sensor is water proof according to IPx6K/9K (ISO 20653).

The sensor has a venting area for pressure compensation. The customer has to integrate the sensor in such a way, that this area shall not be in direct contact with pressurized water jets and effective measures shall be taken to prevent blockage of the venting membrane from dirt, mud or other liquids.

Constant formation of a water film on the venting area is to be avoided as the water may get sucked inside due to pressure differences.

8.5 Mutual Interference

The sensor uses several internal mechanisms to suppress or at least recognize interference from other radar sources. If the received interferences are too high, the sensor detects a higher noise level which prevents the sensor to detect targets with small RCS values. If this condition is detected and at the same time there is no stable relevant object (target) the sensor stops normal operation and announces the error code “external interference”. The sensor can just communicate via vehicle bus in this mode, no object detection or other application runs on the sensor! When the interference is not detected anymore, the sensor switches back to normal operation automatically.

To avoid frequent switch off, several suppression mechanisms are implemented internally.

1. Bandwidth limitation

   The radar modulation scheme itself guarantees that any interference which has a bandwidth broader than about 1 kHz will be filtered out by the different FFT algorithm for distance and relative speed.

2. Over amplification control

   The sensor detects the amplitude of the IF path and can control amplification of this path to avoid over amplification and saturation. This functionality avoids ghost targets created by an amplifier which is in saturation.

3. FMCW interference suppression

   The modulation scheme “Pulse Compression” uses two FFTs to determine range and Doppler shift as two independent signals. Any signal from FMCW (“slow chirps”) radar will cause an implausible value (noise) in the second FFT.

4. Non linear filters

   Signals coming from similar radar or even from a Continental radar itself can be filtered out by non linear filter algorithm implemented in signal pre-processing chain.

5. Pseudo noise coding

   Pseudo noise coding at different points of the micro timing of a single chirp guarantees that only the own signal reflected by targets increases over the integration time over all chirps for every beam. The signals from non-coherent sources will create just noise.

   The sensor's radar concept reduces the occurrences of ghost targets caused by external interferer. The sensor performance is according to industry standard with physical limitations of the radar technology, Continental is not liable for a 100% object detection performance and related claims.

8.6 Influence on Human Health

The radar sensor is compliant with international regulatory requirements (e.g. FCC “Federal Communications Commission” and ETSI “European Telecommunications Standards Institute”) and accordingly should not be hazardous to human health. In addition, studies by independent experts have proven that automotive radars have no negative influence on persons (e.g. 'Forschungsbericht von der Forschungsgemeinschaft Funk e.V. - Newsletter 4-00').

8.6.1 Operation of the unmounted sensor

During development or servicing it may become necessary to operate the sensor in a laboratory environment without a vehicle (bumper, body) around it. Personnel may thus get close to the sensor and be exposed to its RF emissions.

ARS radar sensors are "mobile devices" according to FCC §2.1091 (b) which proposes that generally a 20 cm distance is maintained between the "..transmitter’s radiating structure and the body of the user or nearby persons..." (see reference [4]).

Given this 20 cm safety distance, the sensor’s RF emissions in any direction remain within the safety limit of 1 mW/cm^2 (= 10 W/m²) stated by

- FCC §1.1310 see reference [5],
- ETSI 1999/519/EC see reference [6], and
- BGV B11 see reference [7]

for general population / uncontrolled exposure.

8.7 Homologation Country Classes (HCC)

Frequency regulations for radio devices like radar sensors differ between countries all around the world. Most common regulations are from ETSI (EU) and FCC (USA). Several other countries refer to these standards but for some countries with specific regulations different settings are required.

To ease the setting for all countries, Continental has grouped them into 2 HCC's (Homologation Country Classes) with identical RF setting (primarily output power):

- HCC-1: Rest of World (EU, US, ...)
- HCC-2: Japan – requires reduced output power approx. -10 dB

For all countries, any operation of a sensor without calibrated HCC set that matches the countries regulation is not permitted. Even for test drives a dedicated test license must be obtained for all countries. It is the customer's responsibility to operate radar devices only when in compliance with the legal constraints of the respective region or country.

The HCC-2 for Japan only can be set on demand with additional costs. It is not as standard version available. The output power reduction for Japan has to be used for vehicle as well as for stationary (fix mounted) applications.

Any operation of a radar sensor in HCC's which are not explicitly calibrated in production will not work. If no parameter set is found for the requested HCC the sensor will switch off its functions.

Continental provides one method for selecting the HCC, which are described as follows.

- Fixed HCC setting by Continental - **used HCC-1 for ARS 548 RDI**:
  - By default HCC selection is done in non-volatile memory ("PPAR" flashed at Conti production site).

9. Notes on Safety and Risks

This chapter is intended to enable owners and operators of the ARS 548 RDI to recognize all usage-related risks in good time, i.e. in advance wherever possible.

The ARS 540 RDI was developed for use in automobiles and ARS 548 RDI is modified on software based on automotive software. Users must be in possession of basic technical knowledge, and it is assumed that this is the case. The device should only be used by trained operators.

The person or owner responsible for the device must ensure that all operators understand and observe these safety notes.

If the ARS 548 RDI is part of a system, the system manufacturer is responsible for ensuring that the safety-related aspects are heeded, e.g. the operating manual (short description), labeling and instructions.

9.1 Areas of responsibility

Scope of responsibility of the manufacturer regarding the original device or equipment:

ADC Automotive Distance Control Systems GmbH
New Markets - Industrial Sensors
Continental – Autonomous Mobility (AM)
Peter-Dornier-Straße 10
D-88131 Lindau
Germany

ADC GmbH is responsible for supplying the device, including the short description and the optional original accessories, in a technically safe and sound condition.

Scope of responsibility of the manufacturer of third-party accessories:

Manufacturers of third-party accessories are responsible for the development, implementation and communication of safety concepts for their products, and their effects in conjunction with the ARS 548 RDI device from ADC GmbH.

Scope of responsibility of the owner (customer, end customer and end user):

⚠ *The owner is responsible for ensuring that the device (and equipment) are used for their intended purpose, for the actions of his employees, for giving instruction to the employees, and for the operational safety of the equipment.*

The owner is subject to the following obligations:

- He must understand the safety information on the device and the instructions given in the operating manual.
- He must be familiar with the locally applicable accident prevention regulations.
- He is to notify ADC GmbH, or one of its authorized dealers, as soon as a device or the equipment displays any safety defects.

The owner is responsible and has to confirm that the owner (customer, end customer and end user) will add resp. copy the following disclaimer and information, incl. the declaration of conformity in their own documentation resp. manual.

9.2 Homologation

The radar sensors of series ARS 548 RDI Premium are allowed for the usage in research & testing purposes. See homologation information also in chapter 8.7.

A generally radio license for the bandwidth of 76 – 77 GHz for “Ground Based Vehicles” is available for Europe and U.S.A. since begin of 2020 for the ARS 50X series.

Ground Based Vehicles are all rubber or rail mounted vehicles (car, truck, bus, construction machine, agricultural machine, cranes (RTG, STS, gantry cranes etc. - no tower cranes), autonomous or automated driving vehicles (AGV, robotics etc.) and marine (ship, boat, vessel, yacht, cruise liner etc.).

This typically is also valid for 24 GHz radars and in most countries in the world.

Typical in U.S.A. and North America generally it is prohibited to use the radars for stationary applications (fix mounted) and in flying objects.

But for TTT (Telematics, Traffic, Transport) stationary applications can be allowed to use. Here individually each customer in their country has to clarify it at the notified body or the administration of authority in the country.

The same is valid for flying objects. Here a single license or special regulations for defense and military companies or on airports are possible.

Here you will find a link for the access to the newest Declaration of Conformity of all available radar sensors from ADC GmbH, which can be download from each customer to update the own documentation.

http://continental.automotive-approvals.com/

9.2.1 EU & EFTA Declaration of Conformity

(Compliance Information in all European languages)

Date: 08/03/2021 File: ARS5-A_COMPL-INFO_EU_V1.0.docx	COMPLIANCE INFORMATION ARS5-A	Continental

COUNTRY:	**European Union & EFTA**
PRODUCT:	**ARS5-A**
Frequency Range (GHZ)	**76.0 – 77.0**

Compliance Information required:

A	Product	☒
B	Manual	☒

A) Product Label Information:

CE mark: CE

B) User Manual Information:

1. Generic information — The language text shall be included in the user manual; see appendix.
2. Language text: — The language text shall be included in the user manual, see appendix.

Requirements on User Manual information (size, type, font):

1. Generic information — Text shall be printed in a readable format and size.
2. Language text: — Text shall be printed in a readable format and size.

Date: 08/03/2021 File: ARS5-A_COMPL-INFO_EU_V1.0.docx	COMPLIANCE INFORMATION ARS5-A	Continental

Appendix:

A) Generic information:

Manufacturer Postal Address

	ADC Automotive Distance Control Systems GmbH Peter-Dornier-Strasse 10, 88131 Lindau, Germany

B) Language Text (EU Member states):

01_RED_BG_Bulgarian

ОПРОСТЕНА ЕС ДЕКЛАРАЦИЯ ЗА СЪОТВЕТСТВИЕ	С настоящото ADC Automotive Distance Control Systems GmbH декларира, че този тип радиосъоръжение ARS5-A е в съответствие с Директива 2014/53/ЕС. Цялостният текст на ЕС декларацията за съответствие може да се намери на следния интернет адрес: http://continental.automotive-approvals.com/
	радиочестотната лента или ленти, в която или които работи радиосъоръжението: 76–77 GHz
	максималната радиочестотна мощност, излъчвана в радиочестотната лента или ленти, в която или които работи радиосъоръжението.: 3.16W (35dBm RMS EIRP)

02_RED_ES_Spanish

DECLARACIÓN UE DE CONFORMIDAD SIMPLIFICADA	Por la presente, ADC Automotive Distance Control Systems GmbH declara que el tipo de equipo radioeléctrico ARS5-A es conforme con la Directiva 2014/53/UE. El texto completo de la declaración UE de conformidad está disponible en la dirección Internet siguiente: http://continental.automotive-approvals.com/
	Banda o bandas de frecuencia en las que opera el equipo radioeléctrico: 76–77 GHz
	Potencia máxima de radiofrecuencia transmitida en la banda o bandas de frecuencia en las que opera el equipo radioeléctrico: 3.16W (35dBm RMS EIRP)

03_RED_CS_Czech

ZJEDNODUŠENÉ EU PROHLÁŠENÍ O SHODĚ	Tímto ADC Automotive Distance Control Systems GmbH prohlašuje, že typ rádiového zařízení ARS5-A je v souladu se směrnicí 2014/53/EU. Úplné znění EU prohlášení o shodě je k dispozici na této internetové adrese: http://continental.automotive-approvals.com/
	Kmitočtové pásmo (kmitočtová pásma), v němž (v nichž) rádiové zařízení pracuje: 76–77 GHz
	Maximální radiofrekvenční výkon vysílaný v kmitočtovém pásmu (v kmitočtových pásmech), v němž (v nichž) je rádiové zařízení provozováno: 3.16W (35dBm RMS EIRP)

04_RED_DA_Dansih

FORENKLET EU-OVERENSSTEMMELSESERKLÆRING	Hermed erklærer ADC Automotive Distance Control Systems GmbH, at radioudstyrstypen ARS5-A er i overensstemmelse med direktiv 2014/53/EU. EU-overensstemmelseserklæringens fulde tekst kan findes på følgende internetadresse: http://continental.automotive-approvals.com/
	Frekvensbånd, som radioudstyret fungerer på: 76–77 GHz
	Maksimal radiofrekvenseffekt, der udsendes i de frekvensbånd, som radioudstyret fungerer på: 3.16W (35dBm RMS EIRP)

Date: 08/03/2021 File: ARS5-A_COMPL-INFO_EU_V1.0.docx	COMPLIANCE INFORMATION ARS5-A	Continental

05_RED_DE_German

VEREINFACHTE EU-KONFORMITÄTSERKLÄRUNG	Hiermit erklärt ADC Automotive Distance Control Systems GmbH, dass der Funkanlagentyp ARS5-A der Richtlinie 2014/53/EU entspricht. Der vollständige Text der EU-Konformitätserklärung ist unter der folgenden Internetadresse verfügbar: http://continental.automotive-approvals.com/
	Das Frequenzband oder die Frequenzbänder, in dem bzw. denen die Funkanlage betrieben wird: 76–77 GHz
	Die in dem Frequenzband oder den Frequenzbändern, in dem bzw. denen die Funkanlage betrieben wird, abgestrahlte maximale Sendeleistung: 3.16W (35dBm RMS EIRP)

06_RED_ET_Estonian

LIHTSUSTATUD ELI VASTAVUSDEKLARATSIOON	Käesolevaga deklareerib ADC Automotive Distance Control Systems GmbH, et käesolev raadioseadme tüüp ARS5-A vastab direktiivi 2014/53/EL nõuetele. ELi vastavusdeklaratsiooni täielik tekst on kättesaadav järgmisel internetiaadressil: http://continental.automotive-approvals.com/
	Sagedusriba(d), millel raadioseade töötab: 76–77 GHz
	Raadioseadme töösagedus(t)el edastatav maksimaalne saatevõimsus: 3.16W (35dBm RMS EIRP)

07_RED_EL_Greek

ΑΠΛΟΥΣΤΕΥΜΕΝΗ ΔΗΛΩΣΗ ΣΥΜΜΟΡΦΩΣΗΣ ΕΕ	Με την παρούσα ο/η ADC Automotive Distance Control Systems GmbH, δηλώνει ότι ο ραδιοεξοπλισμός ARS5-A πληροί την οδηγία 2014/53/ΕΕ. Το πλήρες κείμενο της δήλωσης συμμόρφωσης ΕΕ διατίθεται στην ακόλουθη ιστοσελίδα στο διαδίκτυο: http://continental.automotive-approvals.com/
	Οι ζώνες συχνοτήτων στις οποίες λειτουργεί ο ραδιοεξοπλισμός: 76–77 GHz
	η μέγιστη ραδιοηλεκτρική ισχύς στις ζώνες συχνοτήτων στις οποίες λειτουργεί ο ραδιοεξοπλισμός: 3.16W (35dBm RMS EIRP)

08_RED_EN_English

SIMPLIFIED EU DECLARATION OF CONFORMITY	Hereby, ADC Automotive Distance Control Systems GmbH declares that the radio equipment type ARS5-A is in compliance with Directive 2014/53/EU. The full text of the EU declaration of conformity is available at the following internet address: http://continental.automotive-approvals.com/
	Frequency band(s) in which the radio equipment operates: 76–77 GHz
	Maximum radio-frequency power transmitted in the frequency band(s) in which the radio equipment operates: 3.16W (35dBm RMS EIRP)

09_RED_FR_French

DECLARATION UE DE CONFORMITE SIMPLIFIEE	Le soussigné, ADC Automotive Distance Control Systems GmbH, déclare que l'équipement radioélectrique du type ARS5-A est conforme à la directive 2014/53/UE. Le texte complet de la déclaration UE de conformité est disponible à l'adresse internet suivante : http://continental.automotive-approvals.com/
	Bandes de fréquences utilisées par l'équipement radioélectrique : 76–77 GHz
	Puissance de radiofréquence maximale transmise sur les bandes de fréquences utilisées par l'équipement radioélectrique : 3.16W (35dBm RMS EIRP)

Date: 08/03/2021 File: ARS5-A_COMPL-INFO_EU_V1.0.docx	COMPLIANCE INFORMATION ARS5-A	Continental

11_RED_HR_Croation

POJEDNOSTAVLJENA EU IZJAVA O SUKLADNOSTI	ADC Automotive Distance Control Systems GmbH ovime izjavljuje da je radijska oprema tipa ARS5-A u skladu s Direktivom 2014/53/EU. Cjeloviti tekst EU izjave o sukladnosti dostupan je na sljedećoj internetskoj adresi:: http://continental.automotive-approvals.com/
	Frekvencijski pojas (frekvencijski pojasi) u kojem (kojima) radijska oprema radi: 76–77 GHz
	Najveća radiofrekvencijska snaga koja se prenosi u frekvencijskom pojasu (frekvencijskim pojasima) u kojem (kojima) radijska oprema radi: 3.16W (35dBm RMS EIRP)

12_RED_IT_Italian

DICHIARAZIONE DI CONFORMITÀ UE SEMPLIFICATA	Il fabbricante, ADC Automotive Distance Control Systems GmbH, dichiara che il tipo di apparecchiatura radio ARS5-A è conforme alla direttiva 2014/53/UE. Il testo completo della dichiarazione di conformità UE è disponibile al seguente indirizzo Internet: http://continental.automotive-approvals.com/
	Bande di frequenza di funzionamento dell'apparecchiatura radio: 76–77 GHz
	Massima potenza a radiofrequenza trasmessa nelle bande di frequenza in cui opera l'apparecchiatura radio: 3.16W (35dBm RMS EIRP)

13_RED_LV_Latvian

VIENKĀRŠOTA ES ATBILSTĪBAS DEKLARĀCIJA	Ar šo ADC Automotive Distance Control Systems GmbH deklarē, ka radioiekārta ARS5-A atbilst Direktīvai 2014/53/ES. Pilns ES atbilstības deklarācijas teksts ir pieejams šādā interneta vietnē: http://continental.automotive-approvals.com/
	Frekvenču joslu(-as), kurā(-ās) radioiekārtas darbojas: 76–77 GHz
	Frekvenču joslā(-ās), kurā(-ās) darbojas radioiekārtas, maksimālo pārraidītā signāla jaudu.: 3.16W (35dBm RMS EIRP)

14_RED_LT_Lithunian

SUPAPRASTINTA ES ATITIKTIES DEKLARACIJA	Aš, ADC Automotive Distance Control Systems GmbH, patvirtinu, kad radijo įrenginių tipas ARS5-A atitinka Direktyvą 2014/53/ES. Visas ES atitikties deklaracijos tekstas prieinamas šiuo interneto adresu: http://continental.automotive-approvals.com/
	Dažnių juosta (-os), kurioje (-iose) veikia radijo įrenginiai: 76–77 GHz
	Didžiausia radijo dažnių galia, perduodama toje (tose) dažnių juostoje (-ose), kurioje (-iose) veikia radijo įrenginiai: 3.16W (35dBm RMS EIRP)

15_RED_HU_Hungarian

EGYSZERŰSÍTETT EU-MEGFELELŐSÉGI NYILATKOZAT	ADC Automotive Distance Control Systems GmbH igazolja, hogy a ARS5-A típusú rádióberendezés megfelel a 2014/53/EU irányelvnek. Az EU-megfelelőségi nyilatkozat teljes szövege elérhető a következő internetes címen:: http://continental.automotive-approvals.com/
	Az(ok) a frekvenciasáv(ok), amely(ek)en a rádióberendezés működik: 76–77 GHz
	Az abban a frekvenciasávban vagy azokban a frekvenciasávokban továbbított maximális jelerősség, amely(ek)ben a rádióberendezés üzemel: 3.16W (35dBm RMS EIRP)

Date: 08/03/2021 File: ARS5-A_COMPL-INFO_EU_V1.0.docx	COMPLIANCE INFORMATION ARS5-A	Continental

16_RED_MT_Maltese

DIKJARAZZJONI SSIMPLIFIKATA TA' KONFORMITÀ TAL-UE	B'dan, ADC Automotive Distance Control Systems GmbH, niddikjara li dan it-tip ta' tagħmir tar-radju ARS5-A huwa konformi mad-Direttiva 2014/53/UE. It-test kollu tad-dikjarazzjoni ta' konformità tal-UE huwa disponibbli f'dan l-indirizz tal-Internet li ġej: http://continental.automotive-approvals.com/
	Il-medda/meded tal-frekwenza li jaħdem fihom it-tagħmir tar-radju: 76–77 GHz
	Il-potenza massima tal-frekwenza tar-radju trażmessa fil-medda/meded tal-frekwenza li jaħdem fihom it-tagħmir tar- radju: 3.16W (35dBm RMS EIRP)

17_RED_NL_Dutch

VEREENVOUDIGDE EU-CONFORMITEITSVERKLARING	Hierbij verklaar ik, ADC Automotive Distance Control Systems GmbH, dat het type radioapparatuur ARS5-A conform is met Richtlijn 2014/53/EU. De volledige tekst van de EU-conformiteitsverklaring kan worden geraadpleegd op het volgende internetadres: http://continental.automotive-approvals.com/
	Frequentieband(en) waarin de radioapparatuur functioneert: 76–77 GHz
	Maximaal radiofrequent vermogen uitgezonden in de frequentieband(en) waarin de radioapparatuur functioneert: 3.16W (35dBm RMS EIRP)

18_RED_PL_Polish

UPROSZCZONA DEKLARACJA ZGODNOŚCI UE	ADC Automotive Distance Control Systems GmbH niniejszym oświadcza, że typ urządzenia radiowego ARS5-A jest zgodny z dyrektywą 2014/53/UE. Pełny tekst deklaracji zgodności UE jest dostępny pod następującym adresem internetowym: http://continental.automotive-approvals.com/
	Zakresu(-ów) częstotliwości, w którym (których) pracuje urządzenie radiowe: 76–77 GHz
	Maksymalnej mocy częstotliwości radiowej emitowanej w zakresie(-ach) częstotliwości, w którym (których) pracuje urządzenie radiowe: 3.16W (35dBm RMS EIRP)

19_RED_PT_Portuguese

DECLARAÇÃO UE DE CONFORMIDADE SIMPLIFICADA	O(a) abaixo assinado(a) ADC Automotive Distance Control Systems GmbH declara que o presente tipo de equipamento de rádio ARS5-A está em conformidade com a Diretiva 2014/53/UE. O texto integral da declaração de conformidade está disponível no seguinte endereço de Internet: http://continental.automotive-approvals.com/
	A(s) banda(s) de frequências em que o equipamento de rádio funciona: 76–77 GHz
	A potência máxima de radiofrequências transmitida na(s) banda(s) de frequências em que o equipamento de rádio funciona: 3.16W (35dBm RMS EIRP)

20_RED_RO_Romanian

DECLARAȚIA UE DE CONFORMITATE SIMPLIFICATĂ	Prin prezenta, ADC Automotive Distance Control Systems GmbH declară că tipul de echipamente radio ARS5-A este în conformitate cu Directiva 2014/53/UE. Textul integral al declarației UE de conformitate este disponibil la următoarea adresă internet: http://continental.automotive-approvals.com/
	Banda (benzile) de frecvențe în care funcționează echipamentul radio: 76–77 GHz
	Puterea maximă de radiofrecvență transmisă în banda (benzile) de frecvențe în care funcționează echipamentul radio: 3.16W (35dBm RMS EIRP)

Date: 08/03/2021 File: ARS5-A_COMPL-INFO_EU_V1.0.docx	COMPLIANCE INFORMATION ARS5-A	Continental

21_RED_SK_Slovak

ZJEDNODUŠENÉ EÚ VYHLÁSENIE O ZHODE	ADC Automotive Distance Control Systems GmbH týmto vyhlasuje, že rádiové zariadenie typu ARS5-A je v súlade so smernicou 2014/53/EÚ. Úplné EÚ vyhlásenie o zhode je k dispozícii na tejto internetovej adrese: http://continental.automotive-approvals.com/
	Frekvenčné pásmo resp. pásma, v ktorých rádiové zariadenie pracuje: 76–77 GHz
	Maximálny vysokofrekvenčný výkon prenášaný vo frekvenčnom pásme, resp. pásmach, v ktorých rádiové zariadenie pracuje: 3.16W (35dBm RMS EIRP)

22_RED_SL_Slovenian

POENOSTAVLJENA IZJAVA EU O SKLADNOSTI	ADC Automotive Distance Control Systems GmbH potrjuje, da je tip radijske opreme ARS5-A skladen z Direktivo 2014/53/EU. Celotno besedilo izjave EU o skladnosti je na voljo na naslednjem spletnem naslovu: http://continental.automotive-approvals.com/
	Frekvenčni pas ali pasovi, na katerih deluje radijska oprema: 76–77 GHz
	Največja energija za radijsko frekvenco, preneseno po frekvenčnem pasu ali pasovih, na katerih radijska oprema deluje: 3.16W (35dBm RMS EIRP)

23_RED_FI_Finnish

YKSINKERTAISTETTU EU-VAATIMUSTENMUKAISUUSVAKUUTUS	ADC Automotive Distance Control Systems GmbH vakuuttaa, että radiolaitetyyppi ARS5-A on direktiivin 2014/53/EU mukainen. EU-vaatimustenmukaisuusvakuutuksen täysimittainen teksti on saatavilla seuraavassa internetosoitteessa: http://continental.automotive-approvals.com/
	Radiotaajuudet, joilla radiolaite toimii: 76–77 GHz
	Suurin mahdollinen lähetysteho radiotaajuuksilla, joilla radiolaite toimii: 3.16W (35dBm RMS EIRP)

24_RED_SV_Swedish

FÖRENKLAD EU-FÖRSÄKRAN OM ÖVERENSSTÄMMELSE	Härmed försäkrar ADC Automotive Distance Control Systems GmbH att denna typ av radioutrustning ARS5-A överensstämmer med direktiv 2014/53/EU. Den fullständiga texten till EU-försäkran om överensstämmelse finns på följande webbadress: http://continental.automotive-approvals.com/
	Det eller de frekvensband där radioutrustningen arbetar: 76–77 GHz
	Den maximala radiofrekvenseffekt som överförs inom det eller de frekvensband där radioutrustningen arbetar: 3.16W (35dBm RMS EIRP)

C) Language Text (EFTA Countries):

01_RED_IS_Icelandic

EINFÖLDUÐ ESB SAMRÆMISYFIRLÝSING	Hér með lýsir ADC Automotive Distance Control Systems GmbH því yfir, að fjSRRkiptabúnaðurinn að gerð ARS5-A er í samræmi við tilskipun 2014/53/ ESB. Textinn í fullri lengd um Samræmisyfirlýsingu ESB er aðgengilegur á eftirfarandi veffangi: http://continental.automotive-approvals.com/
	Bandbreidd(ir), sem fjSRRkiptabúnaðurinn starfar í: 76–77 GHz
	Hámarks fjSRRkiptatíðni sendistyrkleika í bandbreiddinni/bandbreiddunum sem fjSRRkiptabúnaðurinn starfar í: 3.16W (35dBm RMS EIRP)

Date: 08/03/2021 File: ARS5-A_COMPL-INFO_EU_V1.0.docx	COMPLIANCE INFORMATION ARS5-A	Continental

D) Language Text (Custom Union Agreement between EU and Turkey):

01_RED_TR_Turkish

BASİTLEŞTİRİLMİŞ AB UYGUNLUK BEYANI	Işbu belge ile, ADC Automotive Distance Control Systems GmbH şirketi ARS5-A tipi radyo ekipmanının 2014/53/AB sayılı direktife uygun olduğunu beyan eder. AB uygunluk beyanının tam metni aşağıdaki İnternet adresinde mevcuttur: http://continental.automotive-approvals.com/
	Radyo cihazının çalıştığı frekans bandı/bantları: 76–77 GHz
	Radyo ekipmanının çalıştığı frekans bandında/bantlarında iletilen maksimum radyo frekansı gücü: 3.16W (35dBm RMS EIRP)

E) Language Text (Ukraine):

01_RED_UK_Ukrainian

СПРОЩЕНА ДЕКЛАРАЦІЯ ЄС ПРО ВІДПОВІДНІСТЬ	Цим ADC Automotive Distance Control Systems GmbH заявляє, що радіообладнання типу ARS5-A відповідає вимогам Директиви 2014/53/EU. Повний текст декларації ЄС про відповідність доступний за наступною адресою в мережі Інтернет: http://continental.automotive-approvals.com/
	Частотний діапазон(-и), в якому працює радіообладнання: 76–77 ГГц
	Максимальна потужність радіочастотного сигналу, що передається у частотному діапазоні(-ах), в якому працює радіообладнання: 3.16 Вт (35 дБм середньоквадратична ефективна потужність випромінювання)

F) Language Text (United Kingdom):

Publishing of UK User Manual information and applying UKCA marking only valid in combination with UK Declaration of Conformity.

01_UK_English

SIMPLIFIED UK DECLARATION OF CONFORMITY	Hereby, ADC Automotive Distance Control Systems GmbH declares that the radio equipment type ARS5-A is in compliance with Radio Equipment Regulations of the United Kingdom. The full text of the UK declaration of conformity is available at the following internet address: http://continental.automotive-approvals.com/
	Frequency band(s) in which the radio equipment operates: 76–77 GHz
	Maximum radio-frequency power transmitted in the frequency band(s) in which the radio equipment operates: 3.16W (35dBm RMS EIRP)

G) Language Text (Moldova):

Publishing of Moldova User Manual information only valid in combination with Moldova Declaration of Conformity.

01_MD_Romanian

DECLARAȚIA UE DE CONFORMITATE SIMPLIFICATĂ	Prin prezenta, ADC Automotive Distance Control Systems GmbH declară că tipul de echipamente radio ARS5-A este în conformitate cu Reglementarea tehnică „Punerea la dispoziție pe piață a echipamentelor radio".

Date: 08/03/2021 File: ARS5-A_COMPL-INFO_EU_V1.0.docx	COMPLIANCE INFORMATION ARS5-A	Continental

	Textul integral al declarației de conformitate este disponibil la următoarea adresă de Internet: http://continental.automotive-approvals.com/
	Banda (benzile) de frecvențe în care funcționează echipamentul radio: 76–77 GHz
	Puterea maximă de radiofrecvență transmisă în banda (benzile) de frecvențe în care funcționează echipamentul radio: 3.16W (35dBm RMS EIRP)

9.2.2 UK Declaration of Conformity

(Compliance Information)

Date: 03/03/2021 File: ARS5-A_COMPL-INFO_UK_V1.0.docx	COMPLIANCE INFORMATION ARS5-A	Continental

Country:	**United Kingdom**
Product/ model:	**ARS5-A**
Frequency Range:	**76.0 – 77.0 GHz**

Compliance Information required:

A	Product label	☒
B	User Manual	☒

Publishing of UK User Manual information (UKCA mark, Legal Text) and applying UKCA marking only valid in combination with UK Declaration of Conformity.
Note: Importer information in User Manual/accompanying documents to be implemented by 01.01.2021.

A) Product Label Information:

UKCA mark: UK CA

B) User Manual Information:

1. UKCA mark: UK CA
2. Importer information: The importer must provide their name, registered trade name or mark and a postal address at which they can be contacted on the accompanying documents or packaging.
3. Legal Text: The legal text shall be included in the user manual;
   See related part for United Kingdom in "COMPLIANCE INFORMATION European Union & EFTA, ARS5-A"

Requirements on User Manual information (size, type, font):

1. UKCA mark:
   - The Artwork (UKCA mark) shall have at least 5mm in height.
   - The Artwork (UKCA mark) shall be scaled only in original ratio.
   - The Artwork (UKCA mark) can be outlined/ contoured.
2. Importer information: Text must be printed in a readable format and size.
3. Legal text: Text must be printed in a readable format and size.

9.2.3 USA End User Information / User Manual Notice

End user information

2020-12-10

Device description:	Advanced Radar Sensor, ARS5-A
FCC ID:	OAYARS5A

The above stated product is manufactured by the grantee (**ADC Automotive Distance Control Systems GmbH**) and sold as an OEM product.
When end-user instructions are required, as is the case with this product, the certification owner must inform the OEM to notify the end-user.

ADC Automotive Distance Control Systems GmbH will supply the following information to the reseller/distributor dictating what must be included in the end user's manual for the commercial product.

INFORMATION TO BE INCLUDED IN THE END USER'S MANUAL

The following information must be included in the end product user's manual to ensure continued FCC regulatory compliance. The ID numbers must be included in the manual if the device label is not readily accessible to the end user. The compliance paragraphs below must be included in the user's manual:

Advanced Radar Sensor, ARS5-A
FCC ID: OAYARS5A

Radiofrequency radiation exposure information:
This equipment complies with radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance of 20 cm between the radiator and the body of any persons, user or bystander.
This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

US FCC Notice:
Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

9.2.4 CANADA End User Information / User Manual Notice

Continental

User Manual Notice / End user information

2020-12-10

Device description:	Advanced Radar Sensor, ARS5-A
IC ID:	4135A-ARS5A

The above stated product is manufactured by the grantee (**ADC Automotive Distance Control Systems GmbH**) and sold as an OEM product.
When end-user instructions are required, as is the case with this product, the certification owner must inform the OEM to notify the end-user.

ADC Automotive Distance Control Systems GmbH will supply the following information to the reseller/distributor dictating what must be included in the end user's manual for the commercial product.

INFORMATION TO BE INCLUDED IN THE END USER'S MANUAL

The following information must be included in the end product user's manual to ensure continued ISED regulatory compliance. The ID numbers must be included in the manual if the device label is not readily accessible to the end user. The compliance paragraphs below must be included in the user's manual:

Advanced Radar Sensor, ARS5-A
IC ID: 4135A-ARS5A

This device contains licence-exempt transmitter(s)/receiver(s) that comply with Innovation, Science and Economic Development Canada's licence-exempt RSS(s). Operation is subject to the following two conditions:

1. This device may not cause interference.
2. This device must accept any interference, including interference that may cause undesired operation of the device.

L'émetteur/récepteur exempt de licence contenu dans le présent appareil est conforme aux CNR d'Innovation, Sciences et Développement économique Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes :

1. L'appareil ne doit pas produire de brouillage;
2. L'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Radiofrequency radiation exposure information:
This equipment complies with radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance of 20 cm between the radiator and the body of any persons, user or bystander."

Cet équipement est conforme aux limites d'exposition aux rayonnements établies pour un environnement non contrôlé. Cet équipement doit être installé et utilisé avec un minimum de 20 cm de distance entre la source de rayonnement et votre corps.

9.2.5 Information other countries

FCC Notice
Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

Changing of any sensor parameter, including the sensor antenna are prohibited and void the certification of the equipment.

The device was tested with specific antenna and field strength. Only that type of antenna is allowed and you cannot exceed the maximum power it was tested and certified at.

For Taiwan

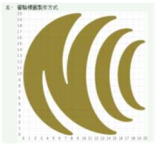


Figure 38: NCC Label

For Ukraine

справжнім (найменування виробника ADC Automotive Distance Control Systems GmbH) заявляє, що тип радіообладнання (позначення типу радіообладнання ARS4-A and ARS 4-B) відповідає Технічному регламенту радіообладнання;
повний текст декларації про відповідність доступний на веб-сайті за такою адресою:
http://continental.automotive-approvals.com/

Figure 39: Ukraine Label

sDoC _RED_Ukrainian **найменування та адресу виробника**	АДС Автомотів Дістанс Контрол Сістемс ГмбХ Пітер-Дорніер-Штрассе 10, 88131, Ліндау, Німеччина (ADC Automotive Distance Control Systems GmbH Peter-Dornier-Strasse 10, 88131, Lindau, Germany)
СПРОЩЕНА ДЕКЛАРАЦІЯ ЄС ПРО ВІДПОВІДНІСТЬ	Цим ADC Automotive Distance Control Systems GmbH заявляє, що радіообладнання типу ARS4-A and ARS 4-B відповідає вимогам Директиви 2014/53/EU. Повний текст декларації ЄС про відповідність доступний за наступною адресою в мережі Інтернет: http://continental.automotive-approvals.com/

Частотний діапазон(-и), в якому працює радіообладнання: 76–77 ГГц

T (35 дБм середньоквадратична ефективна потужність випромінювання)

9.3 Operating risks

The implemented software is not defined for a free use in safety critical systems or in public.

Measures:

The user can generate an own complete system with this sensor, to fulfill safety relevant applications or systems.

Beware of falsified measurements when using a defective device after it has been dropped or subjected to any other prohibited stress or changes, which becomes an overstepping to the specified terms in this manual, e.g. after a lightning strike.

Measures:

Take control the correct measuring periodically, in particular following excessive usage of the device, as well as prior to and following important measuring jobs. May be it is necessary to replace the complete device. Also make sure that the cover or secondary surface are kept clean and pay attention to any possible mechanical damage.

Lacking or incomplete training can lead to incorrect operation or improper usage. This may result in accidents involving serious injury, or damage to property, assets or the environment.

Measures:

All operators are to observe the manufacturer's safety instructions and any instructions given by the owner.

No labeling or warning notices on the ARS 548 RDI are to be concealed when installing the device. This can lead to dangerous situations.

Measures:

Make sure that all labels and signs are readily visible at all times. Additional information can or must be attached as required to ensure safe operation at all times.

When using the devices to measure the distance to, or positioning of mobile objects such as vehicles, cranes, platforms, wagons, machines, etc., falsified measurements may occur as the result of unforeseen events (interruption of the radar beams).

Measures:

Your system must be designed and operated so that in the event of a falsified measurement, device malfunction or a power failure, suitable safety fittings or equipment, e.g. a redundant design, safety switches, etc., ensure that no damage can occur.

When deploying multiple sensors, ensure that there is no mutual interference between them and the ARS 548 RDI.

Measures:

1. Your system must be so designed, installed and operated so as to avoid any direct reception of signals from opposite-facing sensors.
2. Adjacently installed (i.e. parallel receiving) ARS 548 RDI units must be situated an adequate distance apart so that they cannot be affected by data being transmitted from other sensors.

When installing the devices, it must be ensured that the cover or the secondary surface of the ARS 548 RDI is not directly facing ice-particles or water films. Falsified measurements may be the result.

Measures:

Check in all directions and the immediate vicinity of the deployment site of the device, and if necessary mount a heater or other protection at the device.

When welding activities close to the place of installation of the device ARS 548 RDI the device could be damaged or destroyed.

Measures:

The lines of the device have to be separated during the welding activities.

Corresponding to WEEE guideline about Electric and Electronic Old-Devices the old devices have to be professionally disposed respectively recycled by the manufacturer or importer after ending the durability. Make sure, that these old devices in no case have to be loaded to the generic domestic waste – signed by the symbol (icon) in figure 38.

Measures:

Free of charge waste disposal of old devices after ending of the durability by the manufacturer or importer.

Figure 20*: Icon for sign according to WEEE – prohibition for old devices into the domestic waste*

The registration code of the ADC GmbH: **WEEE-Reg.-No. DE 92447412**

Always make sure that the device or equipment is not operated, serviced or used by personnel who have not been properly trained to do so.

9.4 Electromagnetic compatibility

We regard electromagnetic capability to be the facility of the ARS 548 RDI to function correctly in an environment with electromagnetic radiation and electrostatic discharges without causing electromagnetic interference in other devices.

Other devices may be disturbed by electromagnetic radiation. Although the ARS 548 RDI fulfils the stringent requirements of the applicable guidelines and standards, ADC GmbH cannot fully exclude the likelihood of interference from any other devices.

9.5 Maintenance and care

The ARS 548 RDI is practically maintenance-free. The cover or secondary surface should be cleaned depending upon the prevalent environmental factors. Only use a damp, lint-free cloth to clean the cover or secondary surfaces. Under no circumstances should corrosive or aggressively reacting cleaning agents be used.

When cleaning the cover of the ARS 548 RDI, it is absolutely imperative to avoid any scratches or damages of the housing.

When working with safety and components of anti-collision applications, you should proceed in accordance with the valid BGV D6 crane regulations (previously the UVV-VBG 9 crane) by conducting a daily check to ensure that all components and devices of the ADC GmbH and other components of the system integrator of the anti-collision protective system are installed, adjusted and functioning correctly before putting the plant into operation, e.g. during the course of checking the track end thresholds. The functions can be checked by taking test measurements at a defined distance. The radar has no safety or performance level.

A daily check should be performed to ensure that the ARS 548 RDI and system are functioning correctly before putting the plant into operation.

9.6 Service

ADC GmbH must be contacted prior to manipulating the ARS 548 RDI for deployment in a special application or for any other reasons.

You can contact your supplier or the Technical Support team at ADC GmbH regarding the necessity for technical support when putting the device into operation, in the event of operating problems, errors or defects, or regarding any other maintenance-related issues affecting the device or equipment.

9.7 Approval

Safety certification in compliance with DIN EN 61508 (EN 954) Category 1, 2, 3 or 4 is always to be viewed by the owner or plant constructor in conjunction with all the relevant plant components, such as ADC radar sensors, control units, drive and breaking systems, power supplies or tachometer generators, etc., and is to be fulfilled in its entirety. Any required redundancies are to be taken into account accordingly.

10. List of Abbreviations

AEBS	Advanced Emergency Braking Systems
AIA	Automatic Initial Alignment
ASIL	Automotive Safety Integrity Level
AUTOSAR	AUTomotive Open System ARchitecture
BSPC	Basic Security & Privacy Concept
CMS	Collision Mitigation System
CSI	Camera Serial Interface
DEM	Diagnosis Error Management
EoL	End of Line
ETSI	European Telecommunications Standards Institute
FAS	Fahrerassistenzsysteme
FCC	Federal Communications Commission
FFT	Fast Fourier Transformation
FMCW	Frequency Modulated Continuous Wave
FoV	Field of View
GADSL	Global Automotive Declarable Substance List
HCC	Homologation Country Class
ID	Identification Document
IO	Input Output
LatPos	Lateral Position
LKA	Lane Keep Assist
LongPos	Longitudinal Position
MM&A	Misalignment Monitoring and Adjustment
MMIC	Monolithic Microwave Integrated Circuit
MTA	Measurement Technique Adaptor
MTI	Measurement Technique Interface
OI	Object Interface
PCB	Printed Circuit Board
PLL	Phase Locked Loop
PWM	Pulse Width Modulation
RCS	Radar Cross Section
RDI	Radar Detection Image
RF	Radio Frequency
ROM	Read Only Memory
RTE	Runtime Environment
RX	Receiving Path
SA	Service Alignment
SPI	Serial Peripheral Interface
SW	Software
TA	Turn Assist
TSC	Technical Safety Concept
TSR	Technical Safety Requirements
TX	Transmitting Path
UDS	Unified Diagnostic Services
UN/ECE	Economic Commission for Europe of the United Nations
VerPos	Vertical Position

11. Additional information

Please contact your supplier if you are not sure how to correctly install or set up the ARS 40X during assembly with regard to aspects that are covered inadequately, or not all, in this operating manual.

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