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### REVISION HISTORY

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**TITLE:** Installation Specifications and User Manual, 24 GHz  
Radar Sensor, Model 6208428

**DOCUMENT NO:** E814702

**INSTALLATION SPECIFICATION**

**REV. 000, PAGE 1 OF 16**

## 1.0 PURPOSE/SCOPE

This document describes the specifications for installation of type 24 GHz Radar Sensors.

## 2.0 MATERIALS/EQUIPMENT

N/A

## 3.0 APPLICABLE DOCUMENTS

Outline see Fig 1.

DIN 40050-9 IP6K9K

IEC 68-2-6 Fc	IEC 68-2-7	IEC68-2-10	IEC68-2-11 Ka
IEC 668-2-14Nb	IEC 68-2-27	IEC 68-2-29	IEC68-2-30
IEC68-2-32	IEC68-2-38	IEC68-2-50	IEC68-2-51
IEC68-2-52	IEC68-2-56	IEC68-2-64Fh	IEC529, 13.4
SAE J1211	SAE J1812	SAE J1879	

## 4.0 DEFINITIONS

N/A

## 5.0 SPECIFICATIONS

### 5.1. Preface

This chapter describes the specifications to install 24 GHz radar sensors into vehicles. These specifications shall be complied with to enable the specified characteristics of the sensors as well as the complete system. Due to the various installation situations and applications, a measurement check is required to verify the actual installation implementation.

### 5.2. 24 GHz Sensors

This chapter describes the characteristics relevant to the installation of 24 GHz sensors in vehicles. Note that there are three types of 24 GHz sensors, each supporting various applications as follows:

24 GHz Mid Range Radar (MRR) – used of medium range applications  
24 GHz Short Range Radar (SRR) – used of short range applications  
24 GHz Multi Mode sensor (MMS) – combined SRR and MRR functionality.

Unless otherwise stated the specifications contained in this document apply to all 24 GHz sensor types.

In addition general specifications are mentioned, which have to be followed for each position to enable sufficient sensor performance. Therefore the following guidelines are to be observed very carefully. See annex for performance measurements.

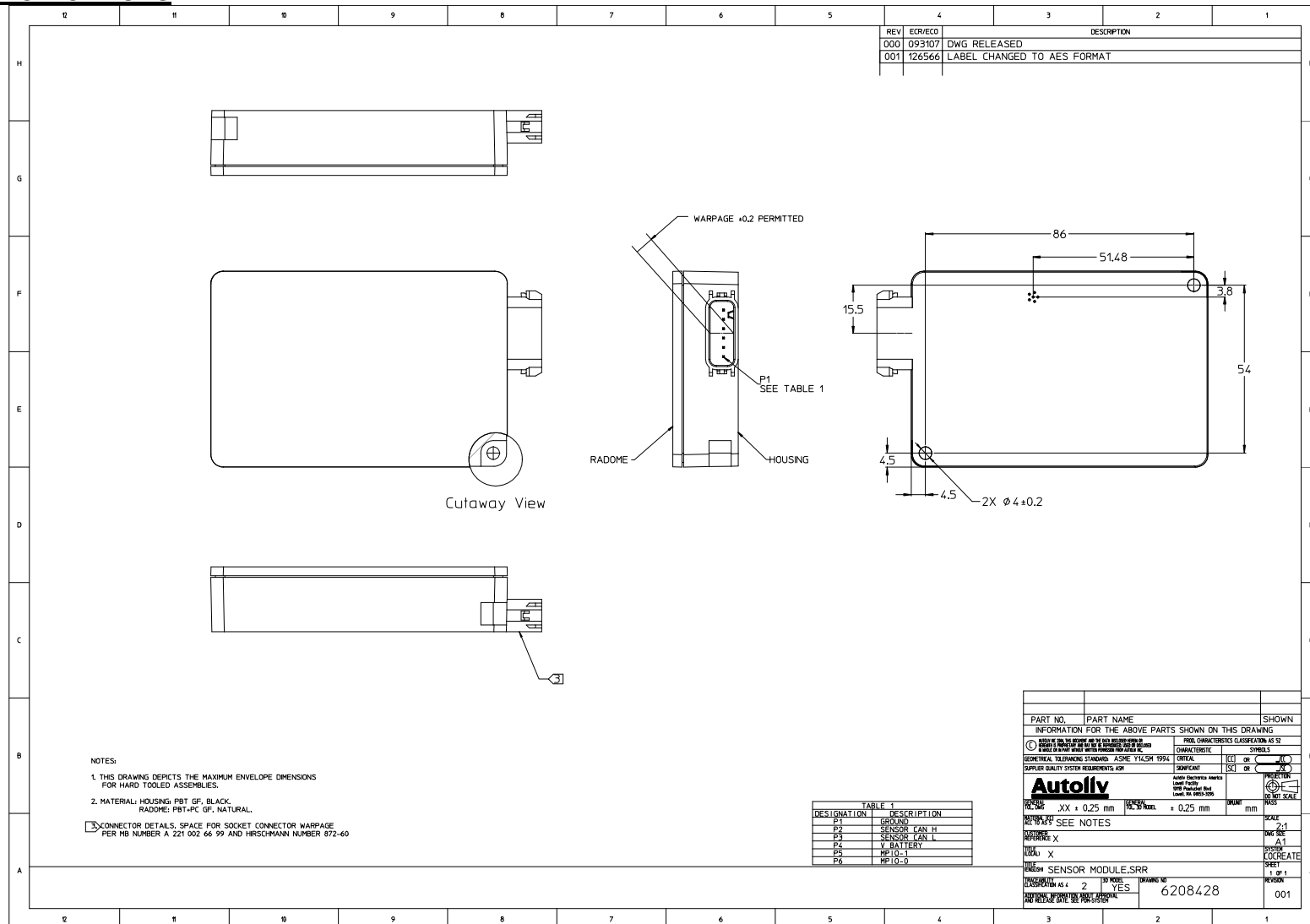
5.2.1. Dimensions and Weight of the 24 GHz Sensor

Figure 1 shows the dimensions of the 24 GHz sensor and details the mounting of the sensor.

Please refer to Fig. 1 for the detailed drawing.

Sensor weight: 150 grams max.

**5.0 SPECIFICATIONS**



**Figure 1**

**IMPORTANT NOTE:** The two mounting holes are not specified for mounting the complete sensor. They do not provide the mechanical properties to keep the sensor in place. They shall be used to fix the sensor in a mounting bracket. Mounting tabs are to be fastened tight to mounting bracket using appropriate fastener. Maximum strength per tab is 270 N.

## 5.0 SPECIFICATIONS

### 5.2 24 GHz Sensor (cont'd)

#### 5.2.2 Keep-Out Zone / Azimuth Angle Measurement Range

Figure 2 displays the keep out area of the 24 GHz sensor.

Within the detection area of the antennas there must not be objects like screws, mounting brackets, license plates etc. The impact reducing foam material, clips or fascia laminations has to be avoided in that area.

Within the keep out zone of the antennas there must be no vertical character lines present in the fascia. Mounting bracket material shall not enter the non-conductive keep out zone. Bracket retention features which interface with the surface of the sensor radome shall not enter the keep out zone noted in **Section 5.2.5**

The keep out zone in the azimuth direction is  $\pm 45^\circ$ . The angle is established 7mm from the edge of the sensor.

*Note: For blind spot applications the keep out zone in the azimuth direction shall be  $\pm 65^\circ$ .*

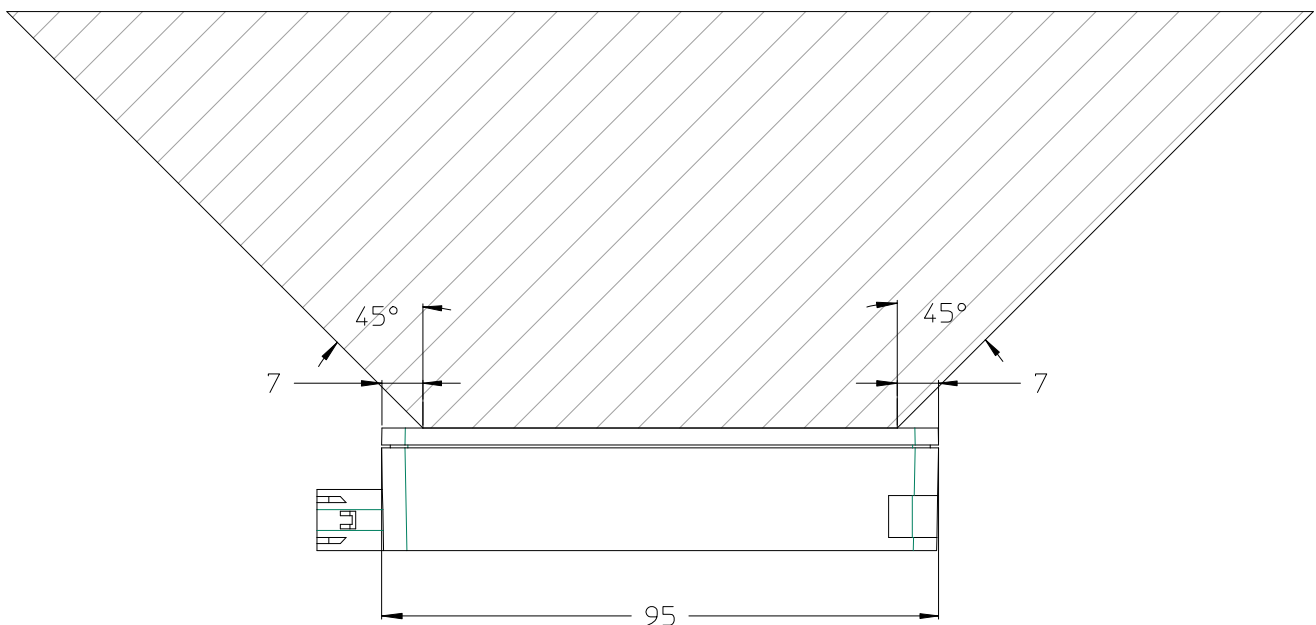


Figure 2

## 5.0 SPECIFICATIONS

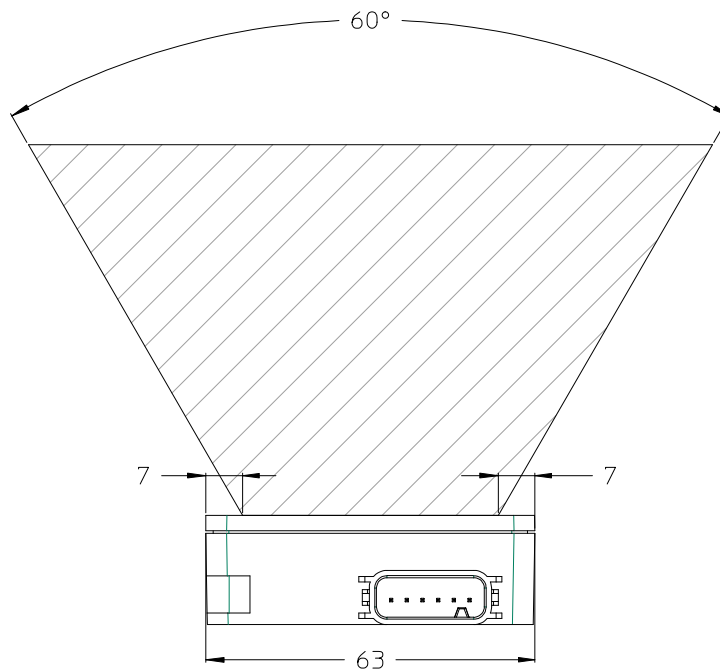
### 5.2 24 GHz Sensor (cont'd)

#### 5.2.3 Conductive material keep-out zone, Angle Elevation

Figure 3 the conductive material keep out area of the 24 GHz Sensor

Within the keep out zone there must not be metal parts like screws, mounting brackets, license plate etc. The impact reducing foam material, clips or fascia laminations has to be avoided in that area.

This conductive material keep out zone in elevation is  $\pm 30^\circ$ . This angle is established 7mm from the edge of the sensor.



**Figure 3**

#### 5.2.4 Non-Conductive material keep-out zone, Angle Elevation

Figure 3a displays the Non-Conductive keep out area of the 24GHz Sensor.

Within the non-conductive keep out zone of the antennas there must be no vertical character lines present in the fascia. Mounting bracket material shall not enter the non-conductive keep out zone. Bracket retention features which interface with the surface of the sensor radome shall not enter the keep out zone noted in **Section 5.2.5**

The non-conductive keep out zone in the elevation direction is  $\pm 20^\circ$ . This angle is established 7mm from the edge of the sensor.

5.2 24 GHz Sensor (cont'd)

5.2.4 Non-Conductive material keep-out zone, Angle Elevation (cont'd)

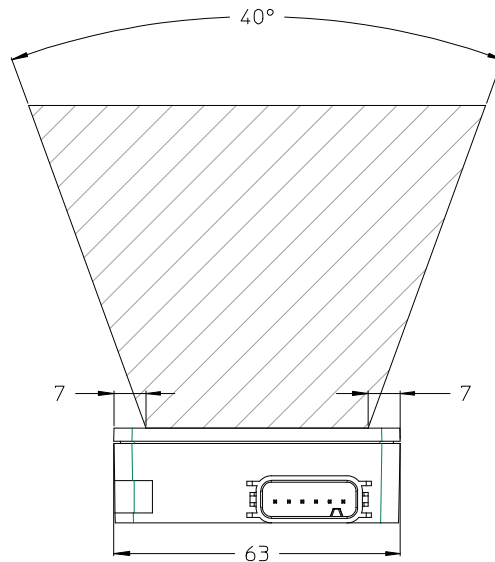


Figure 3a

5.2.5 Bracket to sensor retention features keep out zone

Bracket retention features which are used to hold the sensor into the bracket, shall be made of non-conductive material, and protrude into the face of the sensor radome with enough overlap to overcome any variability in the bracket (ie. bracket to sensor gap, material distortion). A general guideline is to create a retention feature with overlap which is positioned in the allowable shaded area outlined below (Figure 3b).

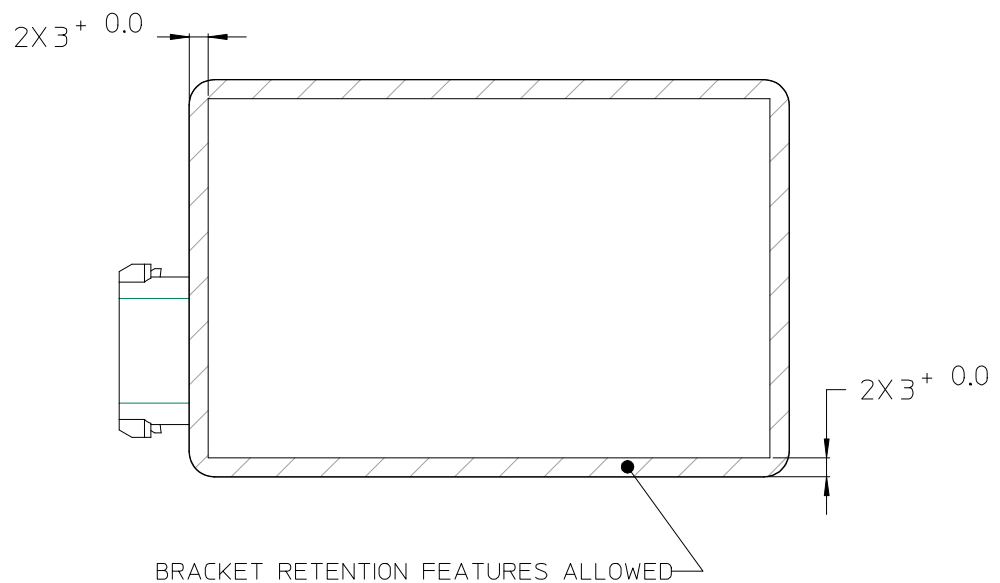
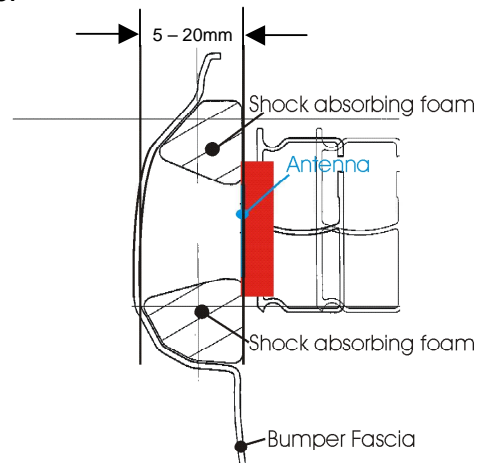


Figure 3b

### 5.3 Installation Specifications for Individual Sensors

#### 5.3.1 Distance to the Bumper Material

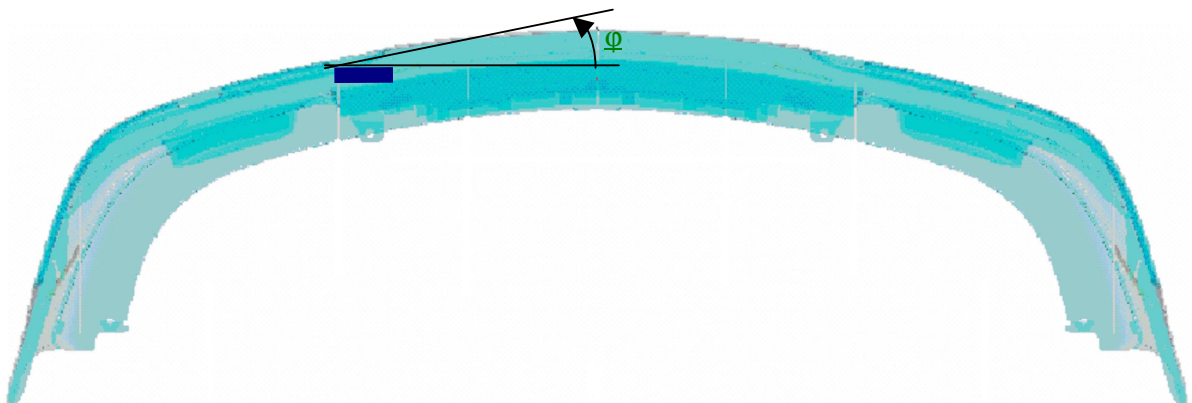
The distance of the 24 GHz Sensor to the bumper shall be between 5 and 20 mm. If the distance is below 5 mm a significant signal loss occurs. If the distance is larger, error ranges may appear within the close range.



**Figure 4**

#### 5.3.2 Angle with Respect to Bumper Material

The angle  $\varphi$  of the sensor with regard to the bumper should be  $0^\circ$ , meaning the sensor should be installed parallel to the bumper. If this is not possible, an angle of  $\pm 10^\circ$  shall not be exceeded. Other orientations need to be tested to confirm proper operation.



**Figure 5**



## 5.0 SPECIFICATIONS

### 5.3 Installation Specifications for Individual Sensors (cont'd)

#### 5.3.3 Effect of Type- and Thickness of Fascia Material

Autoliv has examined various fascia material samples with a thickness of 2.5 – 4 mm. Fascia loss effects can be optimized by proper control of the material thickness and dielectric constant. Thickness should be uniform in front of the radar sensor.

Thickness and dielectric constant must be controlled to a tolerance of  $\pm 10\%$  max to ensure optimal performance.

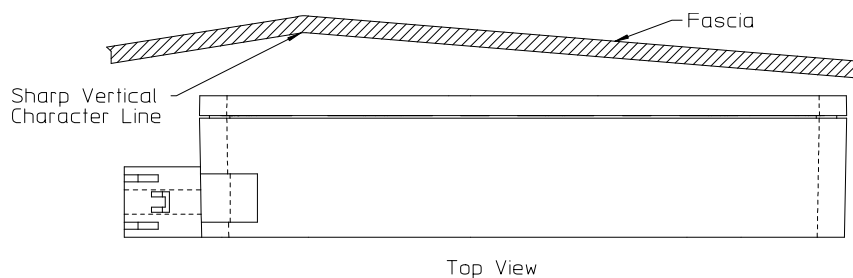
New fascia material shall be evaluated by Autoliv for its characteristics at RF antenna frequency.

#### 5.3.4 Effect of the Paint

Effect of paint is detailed in Appendix A. New paint material shall be evaluated by Autoliv.

#### 5.3.5 Smoothness of Fascia in Front of Antenna

Avoid sharp vertical or near vertical character lines in front of sensor antenna. Horizontal character lines seem to have little effect on sensor performance.



**Figure 6**

## 5.0 SPECIFICATIONS

### 5.3 Installation Specifications For Individual Sensors (cont'd)

#### 5.3.6 Protection from Mud and Dirt Buildup

There will be performance degradation if excessive buildup occurs on the antenna areas and especially for wet mud. Therefore Autoliv strongly recommends the sensor mounting include provisions to protect the antenna face from dirt and mud accumulation. The mounting concept should completely protect the face of the antenna to prevent mud and dirt from entering the free space between the sensor radome and the fascia, yet a small weep hole at the bottom of the bracket is required to allow condensation to dissipate.

#### 5.3.7 Sensor Mounting Thermal Considerations

The sensor is specified to operate in a  $-40^{\circ}$  to  $+85^{\circ}\text{C}$  ambient, still air environment. Natural convection and venting from the front and backside surfaces of the sensor to the ambient air is assumed. Therefore the mounting concept shall leave both the front radome and backside area of the sensor exposed to the ambient air. Minimum area to be left for the backside exposed is as shown below. Bracket reinforced structure such as cross bars are allowed if approximately 80% of backside area remains exposed to ambient air for heat dissipation. Maximum surface temperature in this region is  $+115^{\circ}\text{C}$  at a maximum ambient of  $+85^{\circ}\text{C}$ .

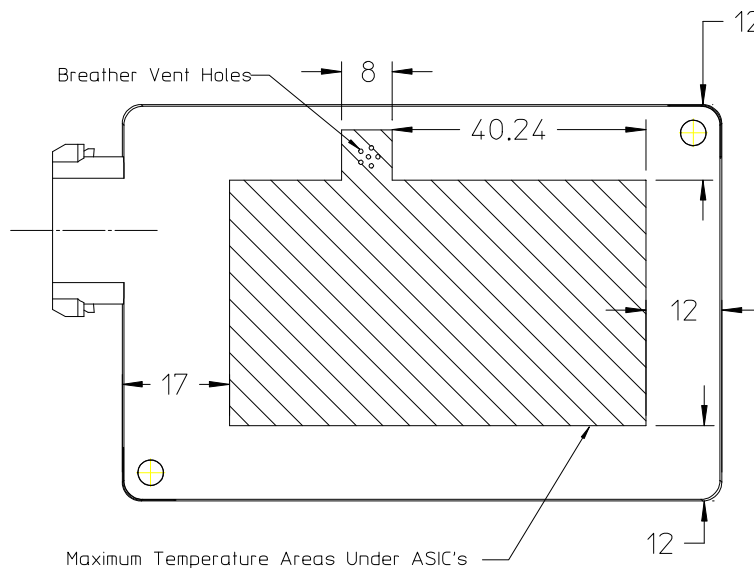


Figure 7

## 5.0 SPECIFICATIONS

### 5.3 Installation Specifications for Individual Sensors (cont'd)

#### 5.3.8 Side Blind Spot Application

##### 5.3.8.1 Sensor Height vs. Elevation Angle

Please follow the following table for setting the elevation angle of the Side Blind Spot sensor.

If packaging above 500 mm is not possible, please consult Autoliv resident engineer to assess alternate locations.  
The sensor can not be mounted below 400 mm under any circumstance.

Sensor Height from Ground	Elevation Angle	Manufacturing Tolerance
500 – 599 mm	+2°	+1.5° / -2.5°
600 – 699 mm	+1°	+1.5° / -2.5°
700 – 800 mm	0°	+1.5° / -2.5°

##### 5.3.8.2 Sensor Azimuth Angle (X-Y Plane)

Each Side Blind Spot sensor should be angled 20° rearward.

##### 5.3.8.3 Sensor X-Position

Side Blind Spot sensor should be located as far rearward as possible while maintaining other packaging requirements (radome to fascia B-side, angle, etc.). For RCTA (Rear Cross Traffic Alert) application, the maximum distance from the center of sensor to the rear of vehicle shall not exceed 300 mm.

##### 5.3.8.4 Sensor Connector Orientation

There is a tradeoff on sensor connector orientation that must be reviewed with Customer. The Side Blind Spot sensor connector may be oriented forward or rearward. If connector is facing forward, the sensor may be positioned further rearward which is a performance benefit for the RCTA (Rear Cross Traffic Alert) application. Also, if the connector is facing forward, the more sensitive side of the sensor (non-connector side) will be facing rearward - a benefit for the Side Blind Spot application. However, it may be advised by Customer to position the sensor with connector facing rearward due to water/salt spray concerns.

## 5.0 SPECIFICATIONS

### 5.3 Installation Specifications for Individual Sensors (cont'd)

#### 5.3.9 ESS-SRR Application

##### 5.3.9.1 Sensor Height and Elevation Angle

Please follow the following table for setting the elevation angle of the ESS-SRR sensor.

If packaging above 500 mm is not possible, please consult Autoliv resident engineer to assess alternate locations.  
The sensor can not be mounted below 400 mm under any circumstance, and 500 mm is strongly recommended for vehicle rear applications.

Sensor Height from Ground	Elevation Angle	Manufacturing Tolerance
500 – 599 mm	+2°	+1.5° / -2.5°
600 – 699 mm	+1°	+1.5° / -2.5°
700 – 800 mm	0°	+1.5° / -2.5°

##### 5.3.9.2 Sensor Azimuth Angle (X-Y Plane)

Front Sensors: Azimuth Angle  $4^{\circ} - 7^{\circ} \pm 1^{\circ}$  outboard  
Rear Sensor: Azimuth Angle  $0^{\circ} \pm 1^{\circ}$

##### 5.3.9.3 Sensor Y-Position

Front SSR sensors shall be located in the cross car position (Y direction) to maintain adequate close range object detection at 400 mm. The 40° azimuth angle detection cones of the two front SRR sensors shall intersect no farther than 400 mm from the center of the fascia in order to provide adequate short range detection for forward looking applications.

##### 5.3.9.4 Sensor Connector Orientation

Front and rear sensors shall be positioned with the connector pointed inboard and the distance from the fascia shall not fall below 5mm or above 20mm. This measurement can be measured 8-10mm from the edge of the antenna.

## 6.0 24 GHZ SENSOR SYSTEM

The following observations refer to the combination of several 24 GHz Sensors into one sensor system. Many applications require several sensors networked together to achieve the desired function. The sensors should be placed in the best possible location for optimal coverage and range performance relative to the specific applications. The optimal locations will be highly dependent on the desired applications and the bumper dimensions. Autoliv can perform analysis and characterization to determine sensor locations to best achieve a desired performance. Attention should be paid that the installation specifications for individual sensors from chapter 5 are maintained. Due to the various installation situations and applications, a measurement check is required to verify the actual installation implementation.

### 6.1. Coordinate System

Figure 8 shows the coordinate system used for identifying sensor position in a multi-sensor application. The arrows indicate positive values. The most forward location on the bumper was selected as reference point. The Z-axis is the vertical axis. Z-values are indicated from the ground surface.

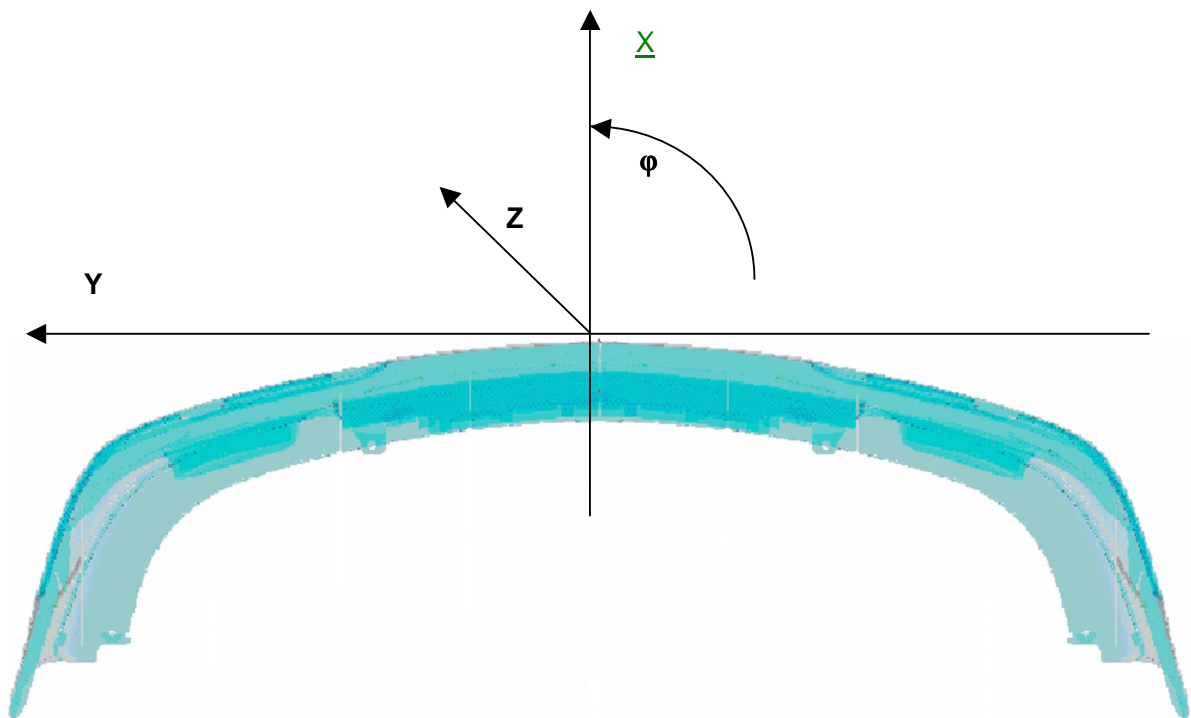


Figure 8

## 6.0 24 GHZ SENSOR SYSTEM

### 6.2. Numbering of the Sensors

The following provides a guideline for sensor numbering (addressing) in a multi-sensor system. The example used is for a front and rear bumper system. Each bumper contains up to 4 sensors connected on a private CAN bus. A separate CAN bus is used for the front and rear bumpers. The sensors transmit data over the CAN bus to a centralized processor which performs sensor data fusion and runs the desired application.

Figure 9 shows the numbering used for a front sensor system.

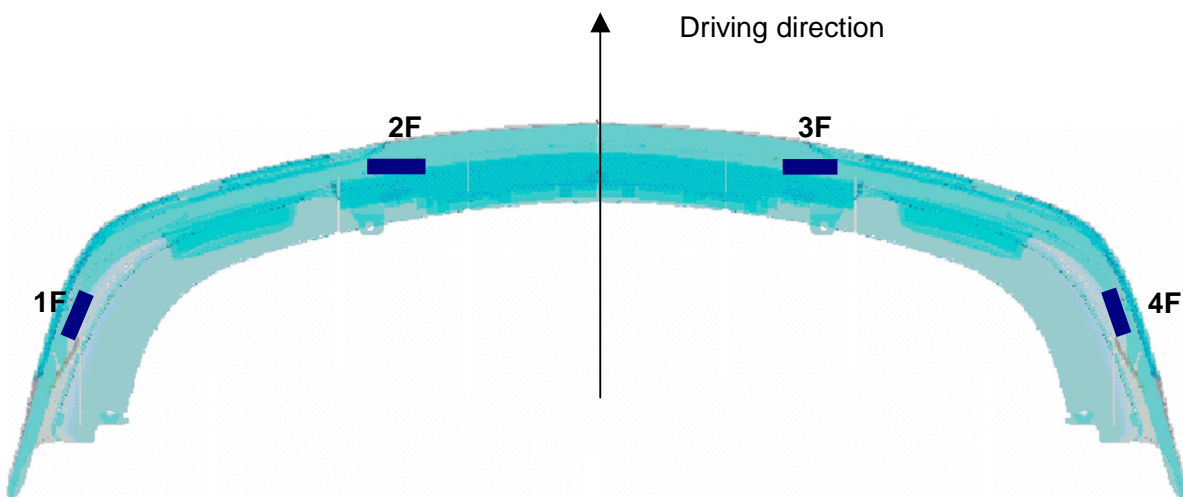


Figure 9

Figure 10 shows the numbering used for a rear sensor system.

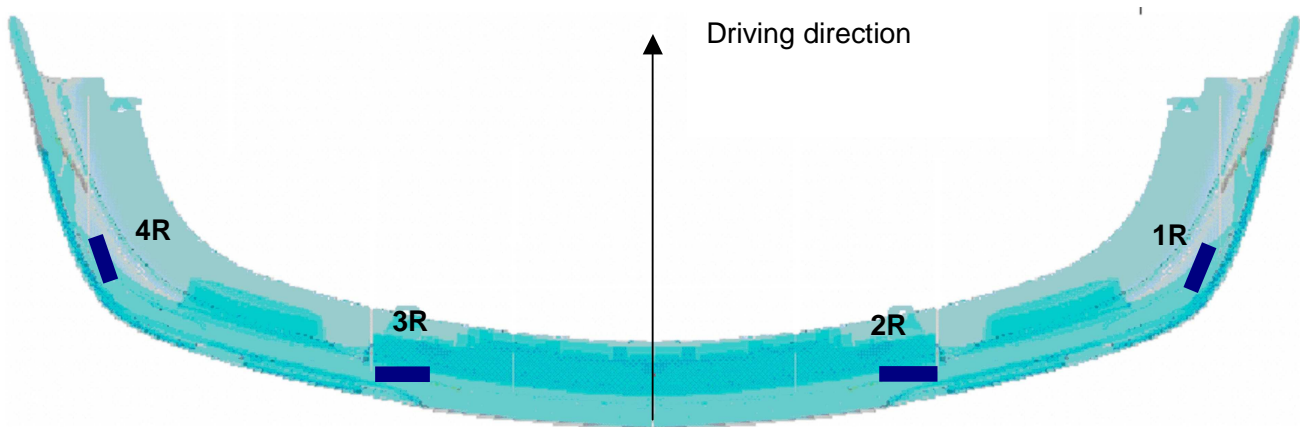


Figure 10

## 6.0 24 GHZ SENSOR SYSTEM

### 6.3. Installation Dimensions

#### 6.3.1 Y-Direction

The Y location of the sensors will determine the extent of the coverage zone and the size of any detection gaps. The location selections are highly dependent on the desired application and bumper dimensions. In general, for a 2 sensor longitudinal system sensors 2 & 3 should be located midway between the center of the bumper and the outer corner. Bumper features (license plates etc.) may not allow this while maintaining the guidelines of section 5. In this case the locations should be as close to the ideal locations as possible while meeting the requirements of section 5. A measurement check is required to verify the actual installation implementation.

#### 6.3.2 X-Direction

The X location of the sensors not as critical as Y in terms of system performance. In general the X locations will be dictated by the contour of the bumper and the installation guidelines of section 5.

## **APPENDIX A**

### **EFFECT OF PAINT**

Depending upon the type of paint, number of coatings, base coats used, etc. the attenuation of the radar signal was measured between 2 and 5 dB (corresponds to reduction of coverage between 11 and 25%). Because attenuation has significant impact on performance, prior inspection of the material and paint samples are suggested. Autoliv can characterize painted fascia samples to determine the radar signal loss effects. Autoliv sensor specifications assume a maximum signal loss (2-way) of 4 dB due to fascia effects. Materials and paints that exhibit greater than 4 dB loss will degrade the specified performance. As noted in 5.3.3 performance can be optimized by proper control of the fascia material thickness and dielectric constant.