Annex acc. to FCC Title 47 CFR Part 15
relating to
s.m.s, smart microwave sensors GmbH
DRVEGRD 169

Annex no. 5
User Manual
Functional Description

Title 47 - Telecommunication
Part 15 - Radio Frequency Devices
Subpart C – Intentional Radiators
ANSI C63.4-2014
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User Manual / Functional Description of the test equipment (EUT)

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USER MANUAL DRVEGRD 169 UMRR-9F TYPE 169

PROJECT TITLE:

USER MANUAL DRVEGRD 169 UMRR-9F TYPE 169

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DRVEGRD 169 UMRR-9F TYPE 169 RADAR SENSOR

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1 CONTENTS

2 ABBREVIATIONS

ADC	Analog-to-digital converter
CAN	Controller area network
DSP	Digital signal processing; digital signal processor
FMCW	Frequency modulated continuous wave
MMIC	Monolithic microwave integrated circuit
UMRR	Universal medium-range radar

3 INTRODUCTION

*This document is a short documentation of the general purpose **u**niversal **m**edium **r**ange **r**adar (UMRR) UMRR-9F Type 169 radar sensor with type 169 antenna.*

4 GENERAL DESCRIPTION

1. SENSOR SPECIFICATIONS

DRVEGRD 169 is a 79GHz radar sensor for multiple automotive applications that features 4D/PxHD technology.

The sensor's antenna aims at ultra-short, short and medium range and very wide horizontal angular coverage. It features:

A straight beam with wide field of view

Selectable modes: ultra-short-, short-, medium- and long-range mode

2. MEASUREMENT PRINCIPLE

Using a patented transmit waveform, the sensor measures range, radial speed, azimuth angle, elevation angle, reflectivity and more parameters of multiple stationary and moving reflectors (targets) simultaneously. It is capable of ultra-high definition (4D/PxHD), where PxHD resolution means that the sensor features resolution (separation) in three parameters: range, Doppler, and azimuth angle.

The sensor is almost unaffected by weather, temperature, and lighting conditions. It withstands high shock and vibration levels, is maintenance-free and made for a long lifetime.

4D/PXHD MEASUREMENT

A 4D Doppler based radial motion detection principle is integrated:

a) *Direct unambiguous Doppler measurement (speed)*
b) *Direct range measurement*
c) *Direct azimuth angle measurement (horizontal angle)*
d) *Direct elevation angle measurement (vertical angle)*

Moving reflectors can be detected as well as stationary reflectors.

With its multi-target capability, the sensor can detect many reflectors within the field of view at a time (target list = point cloud). Additionally, optional filter algorithms are implemented for certain applications for the tracking of all detected reflectors over time. Those tracking algorithms are integrated in the sensor. Multiple objects can be tracked simultaneously.

The result of tracking is an object list with the following parameters:

X-position	*Heading angle*
Y-position	*Length*
Absolute velocity	*Object ID and more*

In addition, status and diagnose data from the sensor are reported. The sensor optionally reports such a list of all tracked objects in every measurement cycle of typically ~55ms length. Based on all detected targets and tracked objects within the field of view an application algorithm, such as blind spot warning, lane change assist or collision warning, may be implemented.

PIXEL-HIGH DEFINITION RESOLUTION - OBJECT SEPARATION PERFORMANCE

The sensor divides the field of view into range gates and performs a Doppler (speed) measurement separate for each individual range gate.

Individual reflectors are separated by detection algorithms if having either:

- *A different radial speed value or*
- *A different range value or*
- *A different azimuth angular position*

USER CONFIGURABILITY

The operational mode and frequency band are user-configurable:

The sensor allows to switch between short-range mode, medium-range mode and long-range mode. The modes differ regarding the waveform and the detection performance.

There are three user-configurable frequency bands. These frequency bands are non-overlapping in long and Medium-Range Mode, so that the mutual interference can be reliably avoided. In Short-Range Mode and Ultra-Short-Range Mode, the bands will partly overlap.

The Long-Range Mode can be used for applications like Lane Change Assist (LCA(C)), Blind Spot Detection (BSD), Rear Cross Traffic Alert (RCTA), or Exit Assistant, whereas the Medium-Range Mode can be used for Rear or Front Cross Traffic Alert (RCTA/FCTA) applications. The Short-Range Mode can be applied for Parking Search and the Ultra-Short-Range Mode for Parking.[1]

[1] *An application-specific tracking or sensor data fusion is required.*

4.1 TRANSMIT SIGNAL

The UMRR transmit frequency is in the band from 77 GHz to 81 GHz, the used bandwidth is less than 4 GHz. The maximum transmit power is +26 dBm.

Antenna type 169 consists of three transmit and four receive antennas, which are linear polarized. The Tx0 and Tx1 have the same antenna characteristics but different center position on the board. The Tx2 squints in azimuth with -30° comparing to Tx0 and Tx1. The 2-way 20 dB cut-off angle in azimuth (Az.) and 6dB cut-off angle in elevation (El.).

The device uses different FMCW transmit signal waveforms for distance and speed measurement.

4.2 GENERAL PERFORMANCE DATA

After power on or reset, the sensor readings are within specified performance within <4 seconds. In Table 4-1 the general performance data of UMRR-9F Type 169 are given.

Table 4-1: General performance data

Environmental		
Ambient Temperature	-40 … +85	degree C
Shock	20	g_{rms}
Vibration	14	g_{rms}
IP	67	
Pressure / Transport Altitude	0…10.000	m
Mechanical		
Weight	≤186	g
Dimensions	79 x 97 x 22,45	mm
Housing Identification	12	
Antenna Identification	A9	
DSP Board Identification	9F	
General		
Power Supply	7 … 32[I] <5	V DC W
Frequency Band	77.0…81.0	GHz
Bandwidth	< 4	GHz
Max. Transmit Power (EIRP)	26.0	dBm
Interfaces	2-wire Automotive Ethernet 100Mbit (optional by software) 2xCAN FD 5Mbit/s	
Connector	TE 1411001-1 series	CAN, Power, RS485, Eth.

[I] measured at connector

5 HARDWARE

5.1 UMRR SENSOR

An example picture of a DRVEGRD 169 UMRR-9F Type 169 sensor is shown in the figures below, see Figure 5-1 and ***Fehler! Verweisquelle konnte nicht gefunden werden.****.*

Figure 5-1: Front view of DRVEGRD 169

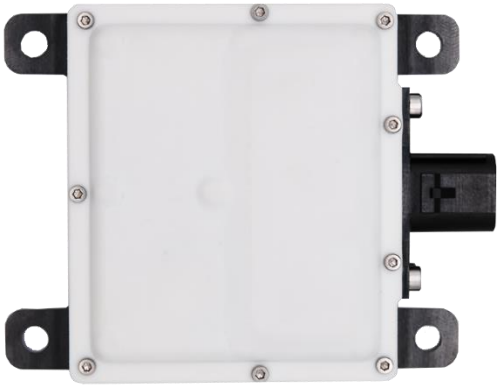
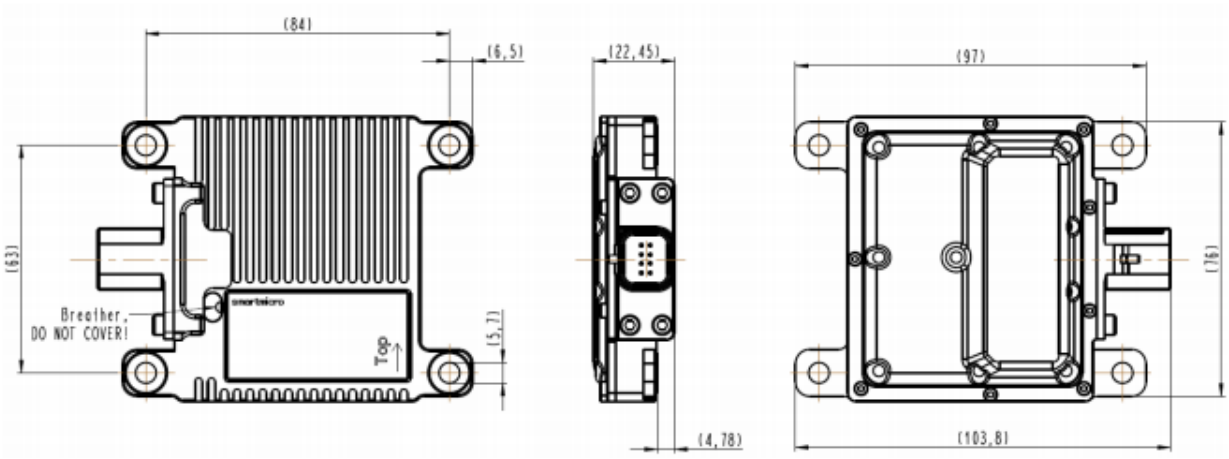


Figure 5-2: Rear View of DRVEGRD 169

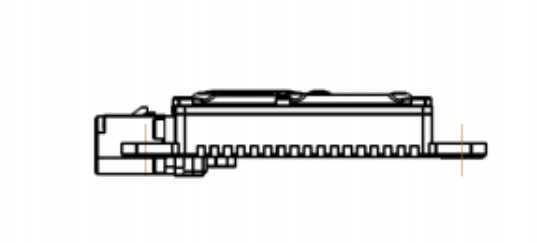
5.2 SENSOR DIMENSIONS

The dimensions of DRVEGRD 169 UMRR-9F Type 169 are given in mm, see Figure 5-3.

Figure 5-3: Dimensions of sensor DRVEGRD 169



Sensor Rear Side | Left Side | Sensor Front Side



Top Side

6 CABLES AND CONNECTORS

6.1 SENSOR CONNECTOR

The sensor connector mates with an 8-pin female connector for automotive interconnections (TE 1411001-1: water proof IP67, manufacturer TE). The pin numbering of the female connector is shown in Figure 6-1 and Figure 6-2. The pin-out of the connector is shown in Table 6-1Table 6-1.

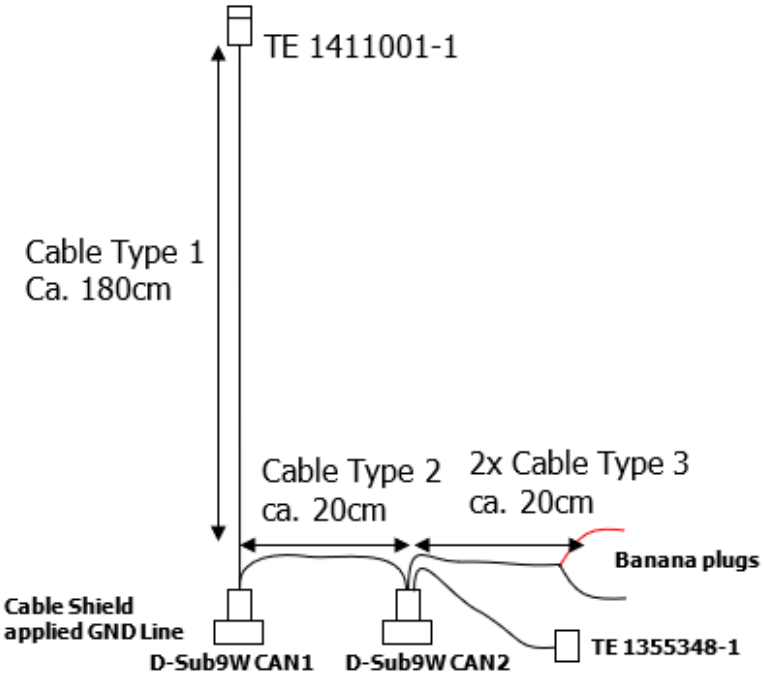


Figure 6-1: The pin out of the connector

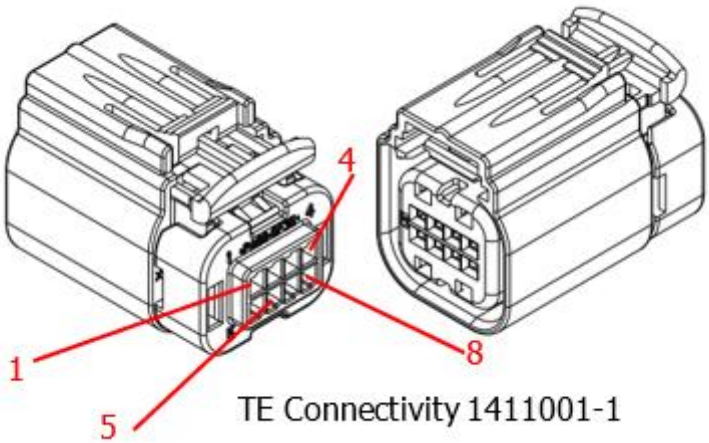


Figure 6-2: Diagram of cable-FF0035 and rear view of female counterpart

Table 6-1: Sensor connector pin-out

TE 1411001-1	Pair	Label	DSUB-9-w CAN1	DSUB-9-w CAN2	Banana plug	TE 1355348-1
1	**1**	**GND**	**3**	**3**	**Black**	
2	**2**	**BroadR_P**				**9**

3	**3**	**CAN2_H**		**7**		
4	**3**	**CAN2_L**		**2**		
5	**1**	**V+**			**Red**	
6	**2**	**BroadR_N**				**8**
7	**4**	**CAN1_H**	**7**			
8	**4**	**CAN1_L**	**2**			
	-	**SHIELD**	**3**			

Please note that in the standard configuration the sensor has 120 Ohms resistor on board (CAN bus termination between CAN_L and CAN_H). A number of cable sets for initial operation and test purposes are offered by Smartmicro, to deliver a fast set-up of a sensor system.

7 DATA INTERFACES

7.1 CAN DATA INTERFACE

This specification gives a detailed description of the CAN data communication used in the UMRR based systems on the sensor CAN. The UMRR is compliant with CAN 2.0B standard.

CAN is a very robust full duplex bidirectional interface.

7.2 CAN-SETTINGS

Baud Rate:	*500kBit/s or lower*	
T_{seg1}:	*8*	
T_{seg2}:	*7*	
T_{sjw}:	*2*	*(SJW: synchronization jump width)*

Above values for CAN bit timing are illustrated in Figure 7-1 used in the UMRR radar sensor (note: the CAN module is integrated in the DSP). For comparison purposes, in Figure 7-2 the CAN bit timing as defined by the CAN protocol is shown.

The CAN bit timing parts as defined by the CAN protocol (Figure 7-2) can be described as follows:

- ***Sync**: This part of bit time is used to synchronize the various nodes on the bus. An edge is expected to lie within this segment. For the UMRR sensor, this segment is always 1 TIME QUANTUM (TQ).*
- ***Prop**: This part of the bit time is used to compensate for the physical delay times within the network. It is twice the sum of the signal's propagation time on the bus line, the input comparator delay, and the output driver delay. For the UMRR sensor, this segment is programmable from 1 to 8 TIME QUANTA (TQ).*
- ***Phase 1**: This phase is used to compensate for positive edge phase error. For the UMRR sensor, this segment is programmable from 1 to 8 TIME QUANTA (TQ) and can be lengthened by resynchronization.*

***Phase 2**: This phase is used to compensate for negative edge phase error. For the UMRR sensor, this segment is programmable from 2 to 8 TIME QUANTA (TQ) and can be shortened by resynchronization*

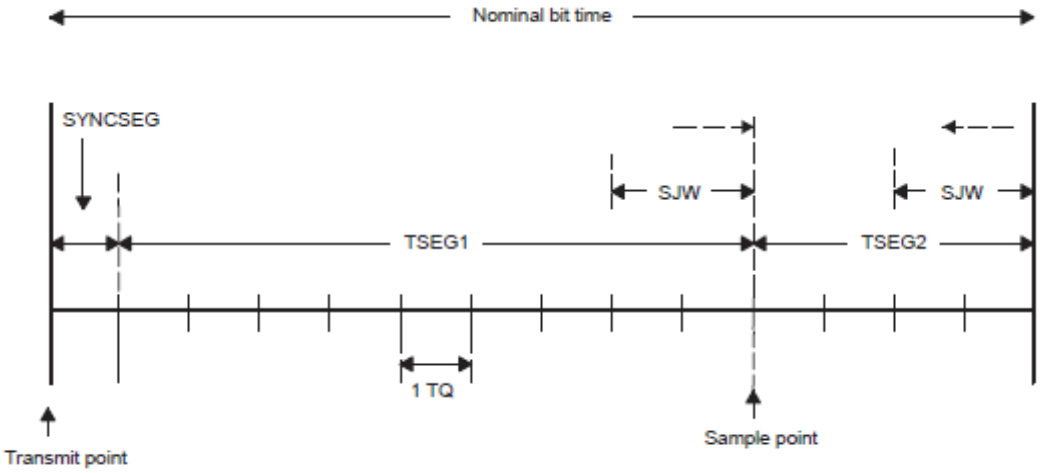


Figure 7-1: CAN bit timing for UMRR sensor

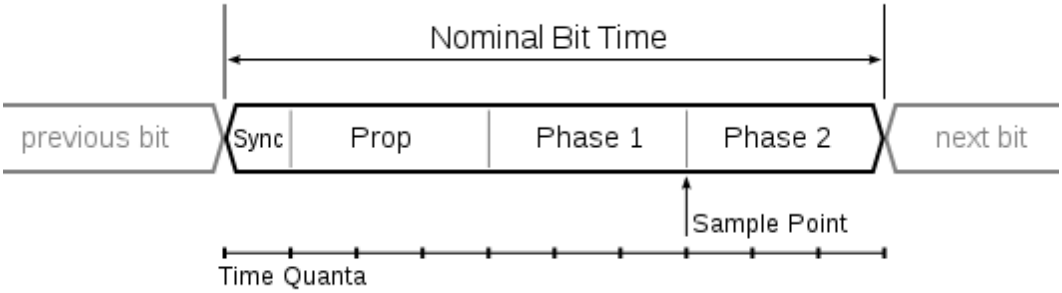


Figure 7-2: CAN bit timing as defined by the CAN protocol

8 APPLICATION-SPECIFIC CHARACTERISTICS

The sensor can be used for different applications by using either point cloud, tracking or collision avoidance firmware.

FUNCTIONAL SAFETY

The sensor can optionally be made compliant to ASIL Level B in customer-specific projects. Requirements and safety concepts need to be agreed between an OEM and smartmicro.

AUTOSAR

The sensor is offered with AUTOSAR compliant software in customer-specific projects. Specifications need to be agreed between an OEM and smartmicro.

8.1 POINT CLOUD

Using the point cloud firmware, the sensor can be used for long-, medium-, short, and ultra-short-range applications in autonomous driving systems, for example:

- *Autonomous driving*
- *Blind Spot Detection (BSD)*
- *Lane Change Assist (LCA)*
- *Forward Collision Warning (FCW)*
- *Side Collision Warning (SCW)*
- *Rear Collision Warning (RCW)*
- *Rear Cross Traffic Alert (RCTA)*
- *Front Cross Traffic Alert (FCTA)*
- *Exit Assistant or Door Open Warning (DOW)*
- *Parking Assistance*
- *All kinds of 360-degree applications*

One or multiple sensors may be integrated into vehicle models by OEMs. Usually, certain OEM-specific engineering efforts are required for the adaptation to specific vehicle models as well as the application of test and qualification procedures. Customer-specific connectors, CAN(FD) or Ethernet interfaces, tracking algorithms, warning algorithms or other software packages can be included.

9 COMPLIANCE FOR EUROPE

9.1 SIMPLIFIED DECLARATION OF CONFORMITY

Hereby, s.m.s, smart microwave sensors GmbH declares that the radio equipment type UMRR-9F Type 169 is in compliance with the Directive 2014/53/EU. The full text of the EU declaration of conformity is available at the following internet address:

http://www.smartmicro.de/company/quality-certificates/.

9.2 SAFETY INSTRUCTION

Note:

Parts of the UMRR-9F Type 169 device may be hot. To ensure protection against accidental contact and fire, operate this device only in compliance with observed safety instructions according EN 62368, corresponding UL Standard or national safety regulation.

Power supply 8 – 24V DC, a PS2 Class power supply with max 3A according to EN62368 should be taken, install by skilled person only. The device can only be used on 12V-supply system of the vehicle's electrical system.

10 DECLARATION OF CONFORMITY

10.1 DECLARATION OF CONFORMITY FOR USA

This device has been tested and found to comply with the requirements set forth in 47 CFR Part 95, Subpart M for both fundamental emissions and unwanted emissions. These limits are designed to provide reasonable protection against any harmful interference when the device is operated in a commercial environment.

Modifying the device without smartmicro's authorization may result in the device being no longer compliant with FCC requirements. In that event, your right to use the device may be limited by FCC regulations, and you may be required to correct any interference to radio or television communications at your own expense.

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

This device complies with the requirements set forth in 47 CFR Section 95.3385 addressing RF exposure from radio frequency devices. To maintain compliance, the minimum separation distance from the antenna to general bystander is 20 cm.

10.2 LABEL

Figure 10-1: FCC Label Sample of DRVEGRD 169

EU Label Sample of DRVEGRD 169

10.3 DECLARATION OF CONFORMITY FOR CANADA

10.3.1 DECLARATION OF CONFORMITY IN ENGLISH

This device complies with Industry Canada license-exempt RSS standard(s).

Operation is subject to the following two conditions:

(1) this device may not cause interference, and

(2) this device must accept any interference, including interference that may cause undesired operation of the device.

IC Radiation Exposure Statement:

This equipment complies with IC RSS-102 radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with the minimum distance 20cm between the radiator & your body.

10.3.2 DÉCLARATION DE CONFORMITÉ EN FRANCAIS

Le present appareil est conforme aux CNR d'Industrie Canada applicables aus appareils radio exempts de licence. Léxploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisaeur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

DÉCLARATION D'EXPOSITION AUX RADIATIONS

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

10.3.3 INDUSTRY CANADA (IC) LABEL

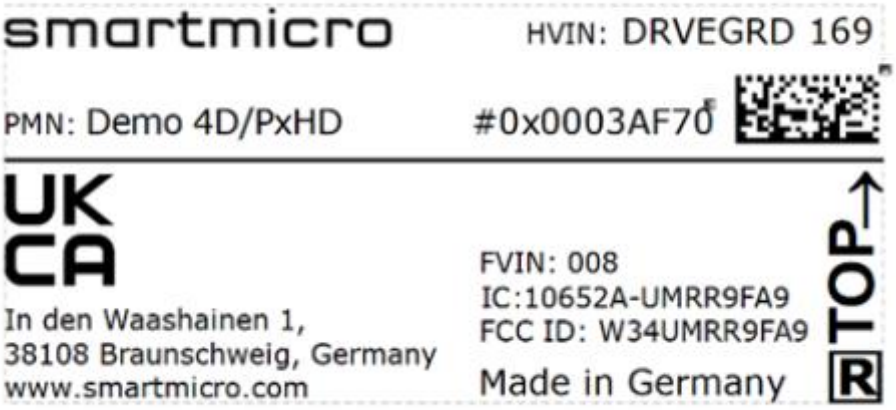


Figure 4: Example Label of Canada