Annex acc. to FCC Title 47 CFR Part 95 M
relating to
s.m.s, smart microwaves sensors GmbH
DRVEGRD 152

Annex no. 5
User Manual
Functional Description

Title 47 - Telecommunication
Part 15 - Radio Frequency Devices
Subpart C – Intentional Radiators
ANSI C63.4-2014
ANSI C63.10-2013

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User Manual / Functional Description of the test equipment (EUT)

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USER MANUAL DRVEGRD 152

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1 CONTENTS

2 ABBREVIATIONS

ACC	Adaptive cruise control
ADC	Analog-to-digital converter
AEB	Advanced emergency braking
CAN	Controller area network
DSP	Digital signal processing; digital signal processor
FMCW	Frequency modulated continuous wave
MMIC	Monolithic microwave integrated circuit
RS485	Physical communication layer standard EIA RS-485
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) DRVEGRD 152 radar sensor with type 152 antenna.

4 GENERAL DESCRIPTION

4.1 SENSOR DESCRIPTION

The main task of the UMRR is the detection of any reflectors in the field of view, to measure the distance, the relative speed and the angle to the shortest reflector (and to other reflectors), to detect motion and to track (filter) the results over time.

For this **general purpose measurement application**, range and relative radial speed and the angle value of each reflector inside the antenna beam are measured and the results are reported via the communication links cycle by cycle.

4.2 TRANSMIT SIGNAL

The UMRR transmit frequency is located in the 76 GHz to 77 GHz band, the used bandwidth is smaller than 1 GHz. The maximum transmit power is smaller than 35dBm.

The UMRR-9D sensor Type 152 provides 2 modes, AEB- and ACC-mode. Antenna Type 152 is used, consisting of six transmit and eight receive antennas, both are linear polarized. For both AEB and ACC modes the sensor field-of-view in azimuth is ± 50 degrees and in elevation ± 10 degrees.

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

4.3 GENERAL PERFORMANCE DATA

After power up or reset, the sensor readings are within specified performance within <10 seconds. In Table 1 the general performance data of DRVEGRD 152 are given.

Table 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	≤ 200	g
Dimensions	97 x 143 x 20.3mm	
Housing Identification	16	
Antenna Identification	98 (Type 152)	
DSP Board Identification	9D	
General		
Power Supply	7 ... 32[I] <7	V DC W
Frequency Band	76.0…77.0	GHz
Bandwidth	< 1000	MHz
Max. Transmit Power (EIRP)	<35.0	dBm
Interfaces	CAN V2.0b (passive) Ethernet 100/1000Mbit	
Connector	MX4 Molex Series	CAN, Power, , Eth.

[I] measured at connector

START-UP TIME

After powering up or resetting, sensor readings meet the specified performance in <4s.

4.4 SELF-DIAGNOSIS

The sensor cyclically reports a status message providing its cycle time, run time and diagnosis information. Additionally, the sensor can also provide sensor mode and status information on request.

The diagnosis information provided by the sensor is an optional self-diagnosis feature to allow limited fail-safe capabilities, which helps in detecting for example:

- Sensor blindness[1]
- Detection and automatic suppression of RF interference, or rather signals from other radar sensors operating in the same frequency band

4.5 SENSOR NETWORK

Sensors are typically used standalone. However, for one vehicle multiple sensors can be connected to one sensor fusion ECU. Such networks are possible by using a CAN(FD) or Ethernet interface. All sensors in the network can work on a plug-and-play basis after the configuration of separate frequency channels, which avoid mutual interference. Customer-specific configurations are possible.

4.6 DATA LOGGING AND VISUALISATION TOOLS

Drive Recorder

The visualization of all data (target lists, object lists, etc.) is possible using the Drive Recorder software on a Windows PC. It also provides for example data logging, associated video documentation, play back and analysis functions.

ROS

smartmicro offers Robot Operating System (ROS) support which includes ROS drivers for ROS1/ROS2 environments for easier customer integration of the sensors and ready-to-run real-time visualization using ROS display tools. The proprietary radar protocol can be read into ROS, which facilitates the processing and visualization of radar data.

[1] Not available yet.

Smart Access

In alternative to the provided Drive Recorder or ROS-based solutions, the customer can also develop own software products to interface smartmicro products. For these customer applications, smartmicro provides detailed documentation on topics like the integration of the radar system interface, dbc files or example code (in C). Additionally, smartmicro provides an API developed in-house for easier communication between customer solutions and smartmicro products via Ethernet or CAN/CAN(FD).

5 HARDWARE

5.1 DRVEGRD 152 SENSOR

An example picture of a DRVEGRD 152 sensor is shown below.

Figure 1: Sensor Front view

Figure 2: Sensor Rear view

5.2 SENSOR DIMENSIONS

All values are given in mm.

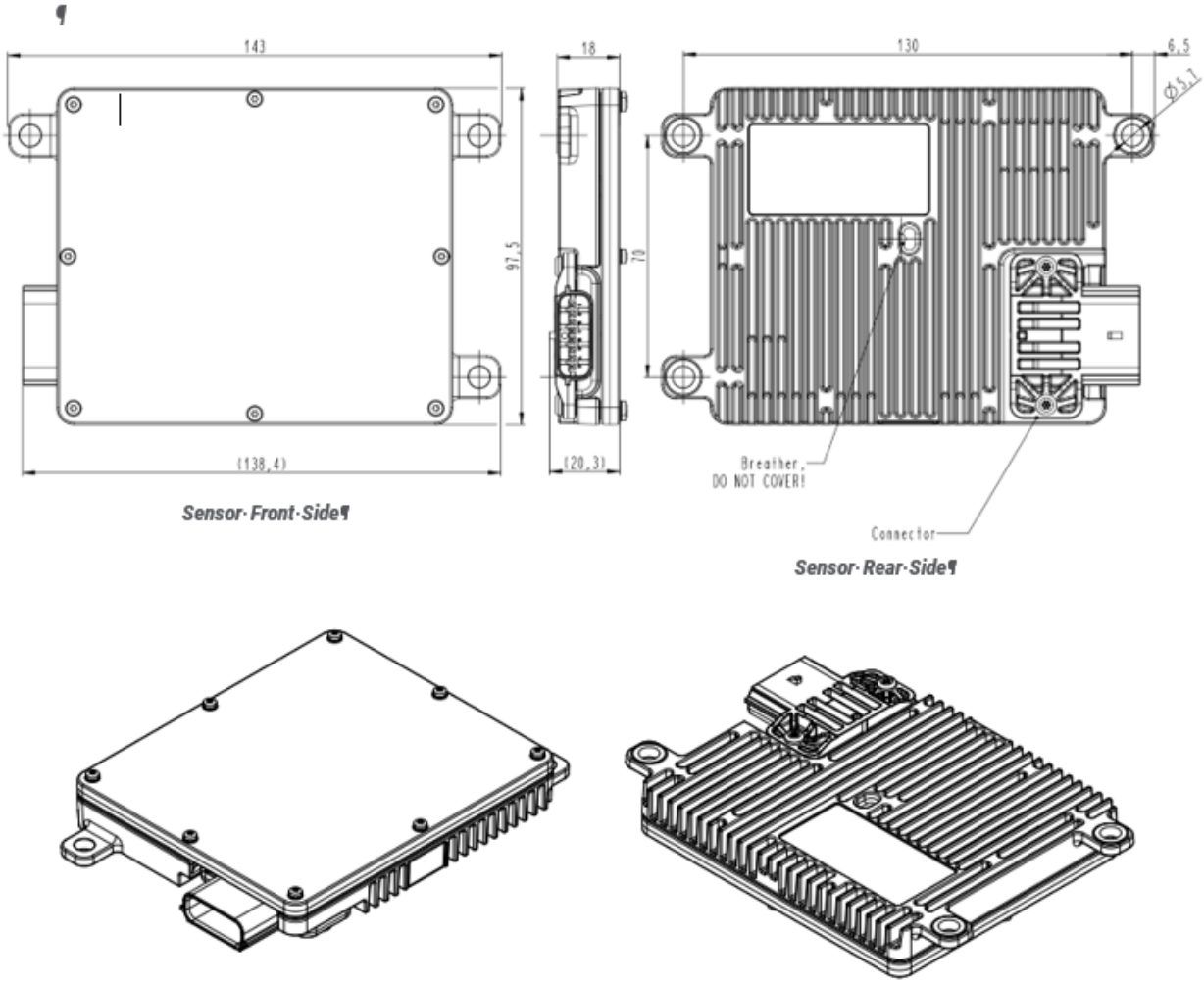
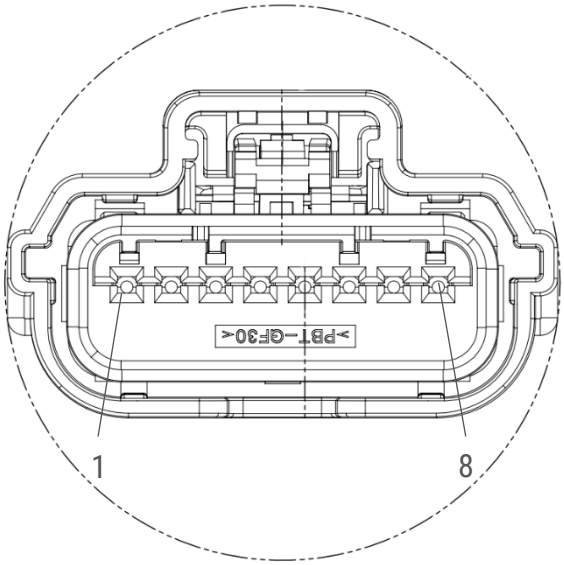


Figure 3: Sensor dimensions

5.3 SENSOR CONNECTOR

The sensor connector is a 8-pin male (plug) connector (waterproof IP67, MX4 Molex Series 31404). A female counterpart (socket), Molex 64 series 31404, must be used to connect with sensor.



View on solder cup side of socket showing the pin numbering (rear view of female counterpart to be connected to sensor)

Sensor connector pin out:

Pin No.	Cable Connector
1	V_Supply
2	GND
3	Auto_Eth_TX_N
4	Auto_Eth_TX_P
5	CAN1_N
6	CAN1_P
7	CAN0_N
8	CAN0_P

Please note that in the standard configuration the sensor does have a 120 Ohms resistor on board for CAN1 (CAN bus termination between CAN L and CAN H). This resistor is required at either end of a CAN bus. CAN0 has high impedance termination (2.6 kOhm).

Several cable sets for initial operation and test purposes are offered by smartmicro, to deliver a fast set-up of a sensor system. Among those preconfigured ready-to-run cables as well as cable stumps (pig tail cables or various lengths) which carry the connector on one side and open wires on the other.

5.4 SENSOR AND HARDWARE IDENTIFICATION

The sensor housing is tagged with a type sticker containing the product description and the serial number. It also indicates which side of the sensor is the top side.

Sticker example: see Figure 4

Additionally, the DSP board and the RF board have their own unique serial numbers.

Figure 4: Label example of DRVEGRD 152

6 DATA INTERFACES

6.1 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.

6.2 CAN-SETTINGS

Baud Rate:	500kBit/s or lower	
Prescalar:	1	
T_{seg1}:	8	
T_{seg2}:	7	
T_{sjw}:	2	(SJW: synchronization jump width)

Above values for CAN bit timing are illustrated in Figure 5 and used in the UMRR radar sensor (note: the CAN module is integrated in the DSP). For comparison purposes, in Figure 6the CAN bit timing as defined by the CAN protocol is shown.

The CAN bit timing parts as defined by the CAN protocol (Figure 6) 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

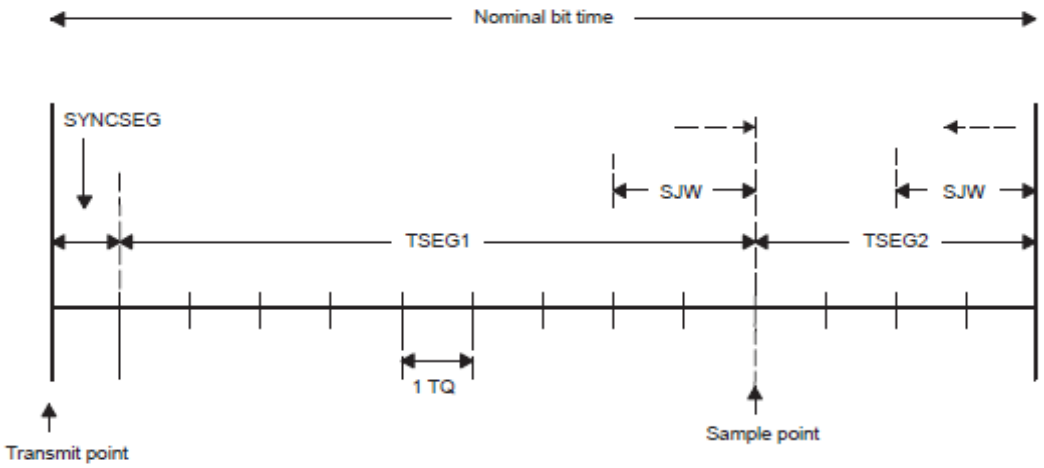


Figure 5: CAN bit timing for UMRR sensor

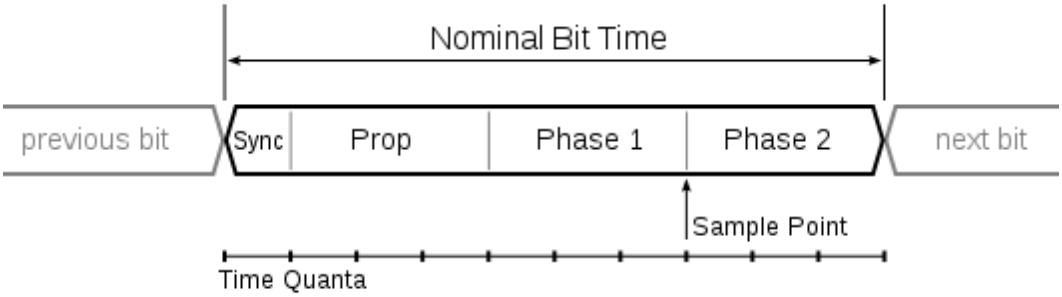


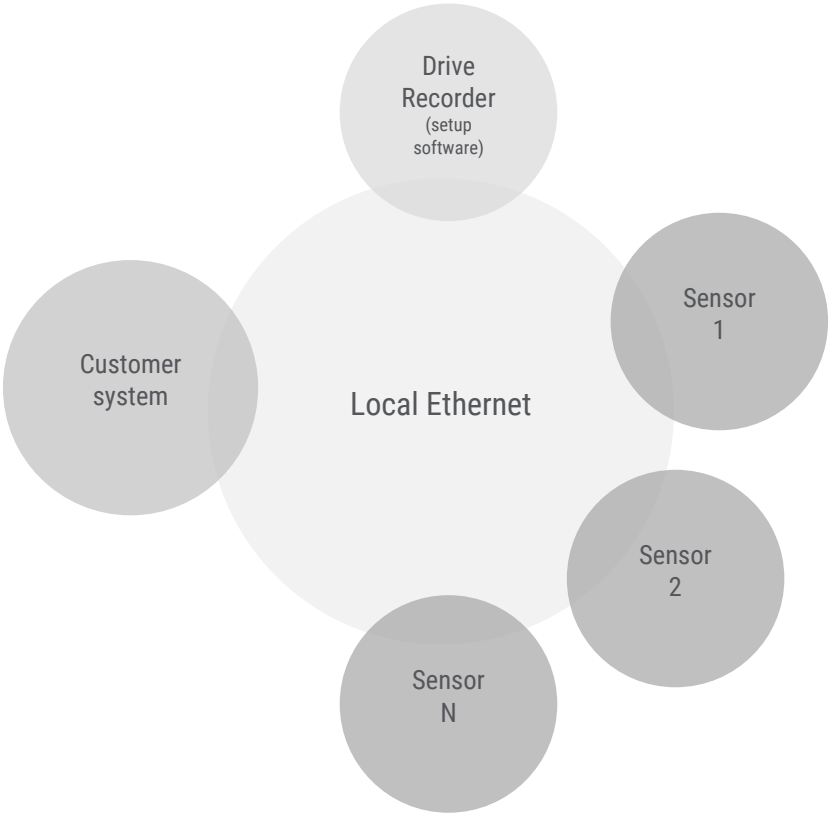
Figure 6: CAN bit timing as defined by the CAN protocol

6.3 ETHERNET CONNECTIONS

The sensor supports UDP via Ethernet in a Local Area Network (LAN). Communication over low bandwidth environments (not less than 100Mbps recommended) or routed networks such as the world wide web are not supported.

Features:

- Ethernet standards IPv4, ARP, IGMP IP multicast and UDP
- Support of Static IP configuration. DHCP is not supported
- smartmicro's proprietary communication protocol "smartmicro transport protocol" with sensor data transmission, which sends a list of detected targets every radar cycle. Operation parameters can be accessed via Ethernet.



7 APPLICATION-SPECIFIC CHARACTERISTICS

The sensor can be used for long and medium range applications in autonomous driving systems, for example:

- Autonomous driving
- Adaptive Cruise Control (ACC)
- Advanced Emergency Braking (AEB)
- Forward Collision Warning (FCW)
- Rear Collision Warning (RCW)

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.

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.

UTILITY VEHICLES

The sensor can be used on utility vehicles with operational voltages of 24V (or even up to 32V). It has been tested against the ISO Standard 7637-2.

8 DECLARATION OF CONFORMITY

8.1 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.

8.1.1 FCC LABEL

Figure 7: FCC Label sample of DRVEGRD 152

8.2 DECLARATION OF CONFORMITY FOR CANADA

8.2.1 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.

8.2.2 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.

8.2.3 INDUSTRY CANADA (IC) LABEL

Figure 8: Sample of IC Label

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