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Annex acc. to FCC Title 47 CFR Part 15
relating to
s.m.s, smart microwave sensors GmbH
UMRR-0C Type 42

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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Operational Description | UMRR-0C Type 42
Radar Sensor Documentation

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1 Contents

2 Abbreviations

ADC	Analog-to-digital converter
CAN	Controller area network
DAC	Digital-to-analog converter
DSP	Digital signal processing; digital signal processor
EEPROM	Electrically erasable programmable read-only memory
FMCW	Frequency modulated continuous wave
MMIC	Monolithic microwave integrated circuit
RAM	Random access memory
RS485	Physical communication layer standard EIA RS-485
SPI	Serial peripheral interface
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-0C Type 42 radar sensor with type 42 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 24 GHz ISM band (24000 MHz to 24250 MHz), the used bandwidth is smaller than 250 MHz. The maximum transmit power is 12,7dBm.

Antenna type 42 is used, consisting of one transmit and eight receive antennas, both linear polarized. The 2 way 3 dB cut-off angle in az. +-25deg. and in el. +-5deg.
The antenna has two main lobes. The greater man lobe is at +17°, counting clockwise, the second at -20°.

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 <30 seconds. In Table 1: General performance data are given.

Table 1: General performance data

Environmental		
Ambient Temperature	-40 ... +74	degree C
Shock	100	g_{rms}
Vibration	14	g_{rms}
IP	67	
Pressure / Transport altitude	0…10.000	m
Mechanical		
Weight	1340	g
Dimensions	See 5.2	
Housing Identification	07	
Antenna Identification	2A	
DSP Board Identification	0C	
General		
Power Supply	13 ... 32 [I] 11.8	V DC W
Frequency Band	24.000…24.250	GHz
Bandwidth	< 250	MHz
Max. Transmit Power (EIRP)	12.7	dBm
Interfaces	CAN V2.0b (passive) [II] RS485 half or full duplex 10/100 Ethernet	
Connector	12 Pin plug Hirose LF10WBRB-12PD	CAN, Power, RS485, Eth.

[I] measured at connector
[II] Also available: Relay contacts, see interfaces. It is recommended to use an external surge protection for power, CAN, RS485, Ethernet and other interface ports.

5 Hardware

5.1 UMRR sensor

An example picture of a UMRR (universal medium-range radar) sensor (housing type 070707) is shown in the figures below.

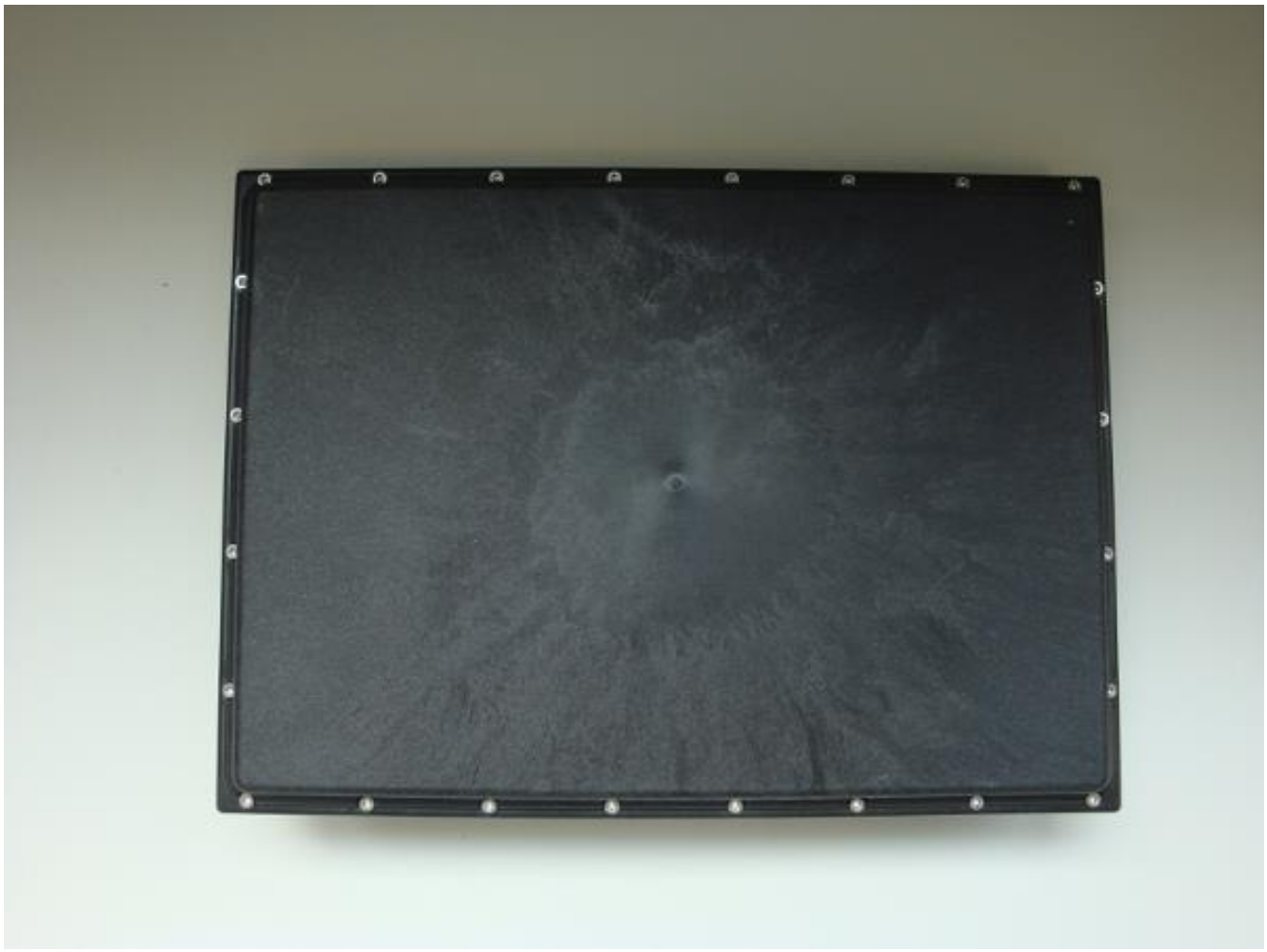

Figure 1: UMRR sensor, housing type 070707, front

Figure 2: UMRR sensor housing 070707 rear

5.2 Sensor Dimensions

All values given in mm.

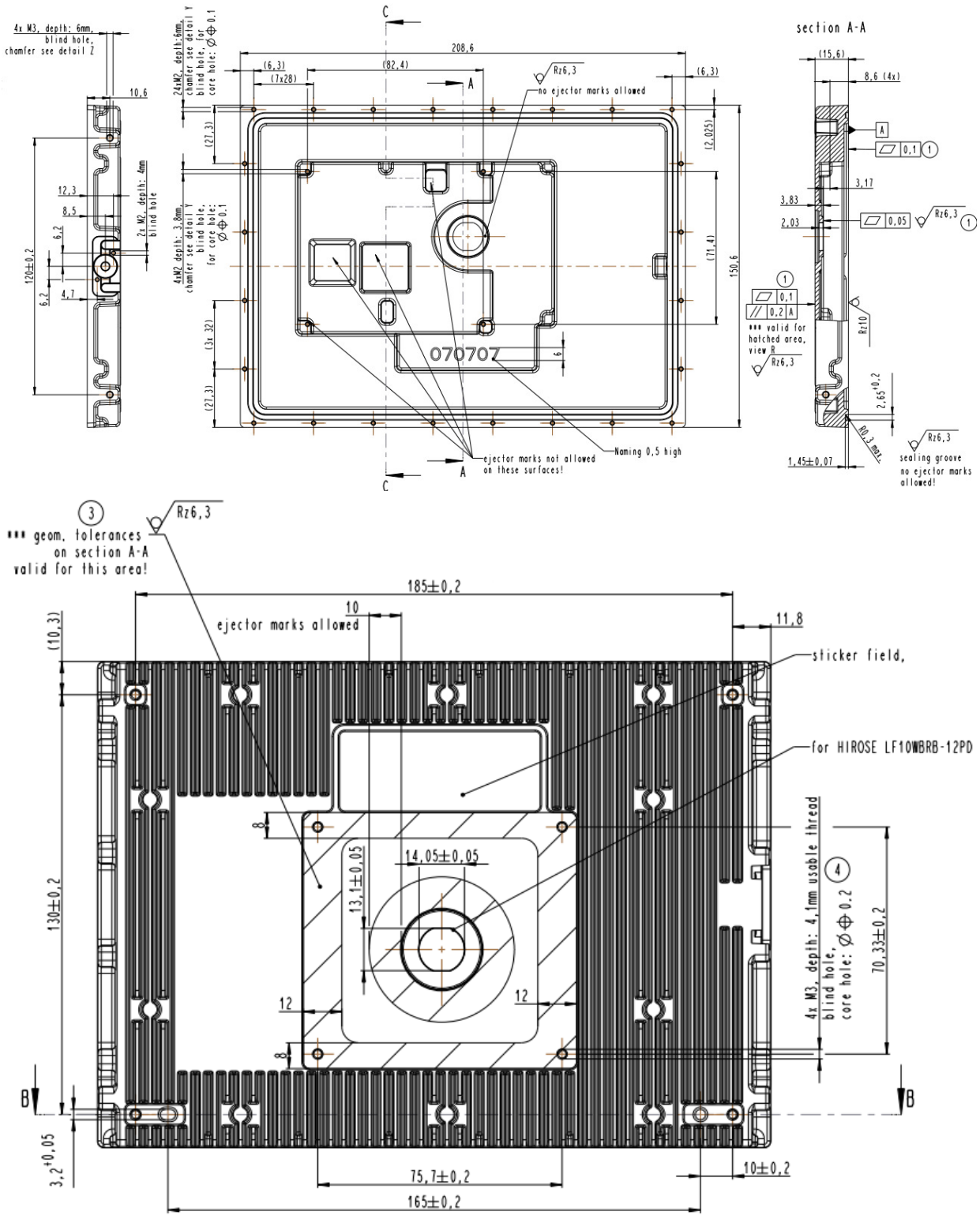

Figure 3: Housing 070707 Dimensions

6 Cables and connectors

6.1 Sensor connector

The used sensor connector is a 12-pin male (plug) circular bayonet type connector (water proof IP67, series LF10WBRB-12PD, manufacturer Hirose, Japan). A female counterpart (socket)e.g. LF10WBP-12S has to be used to connect to the sensor. The pin numbering of the socket is shown in Figure 4 together with the pin description is given in Table 2: Sensor Connector pin out Model UMRR-0C

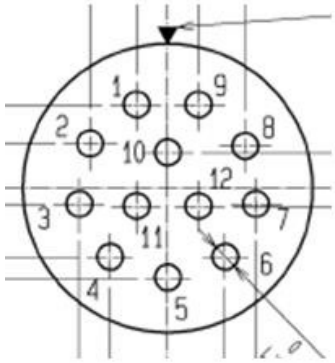

Figure 4: Sensor connector pin out Model UMRR-0C

Table 2: Sensor Connector pin out Model UMRR-0C

Pin	Signal name	Wire Pair	Function
1	Eth_Tx1_P	1	Ethernet – RJ45 Pin 1
2	Eth_Tx1_N		Ethernet – RJ45 Pin 2
3	RS485_IN_N	2	RS485 Input
4	RS485_IN_P		
5	RS485_OUT_N	3	RS485 Output
6	RS485_OUT_P		
7	GND	4	Ground
8	Vcc		7 .. 40 V DC Supply
9	Eth_Tx2_N	5	Ethernet – RJ45 Pin 6
10	Eth_Tx2_P		Ethernet – RJ45 Pin 3
11	CAN Hi	6	CAN Interface
12	CAN Lo		

Please note that in the standard configuration the sensor has no 120Ohms resistor on board (CAN bus termination between CAN_Lo and CAN_Hi and RS485 IN / OUT). The resistors are nevertheless required at either end of a CAN / RS485 bus and is in most cases integrated in the cable delivered along with the sensor (if cable is manufactured by Smartmicro).

For the RS485 data interface there is a 120Ohms resistor on board of the sensor.

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. 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.

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}:	1	(SJW: synchronization jump width)

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

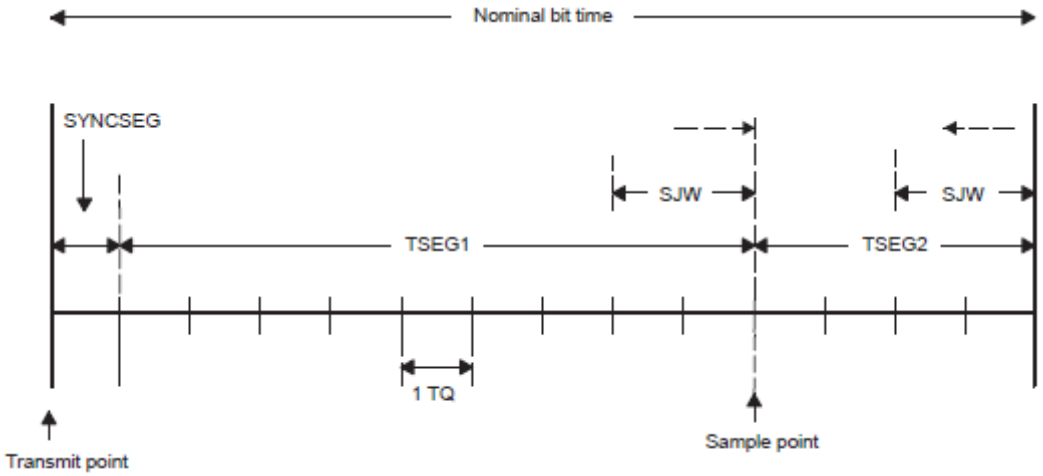

Figure 5: CAN bit timing for UMRR sensor

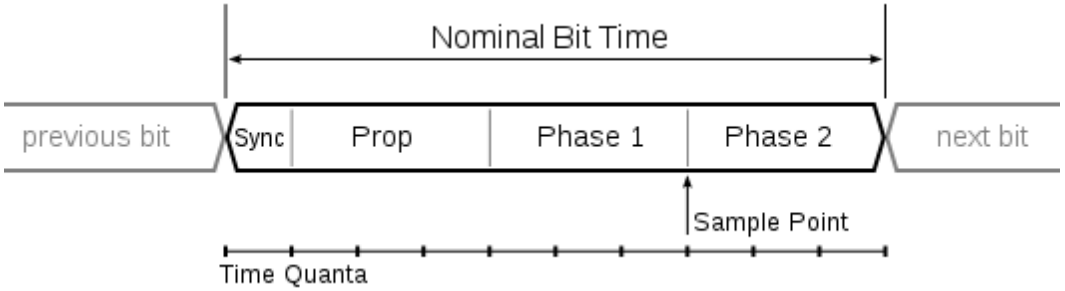

Figure 6: CAN bit timing as defined by the CAN protocol

7.3 RS485 data interface

The RS485 interface from the UMRR sensor has a predefined speed of 230400 baud/s. Typical other data rates are between 921.6kBit/s and 56.7kBit/s.

The RS485 message payload is identical to the CAN format. The data messages will be sent in several packets of one byte.

Every cycle begins with a start sequence and ends with a calculated checksum and an end sequence. The length of the data payload depends on the number of targets and tracked objects.
Every cycle has one start sequence one end sequence and one checksum.

Table 3: RS485 message structure

Byte\Bit	7	6	5	4	3	2	1	0
0	Start sequence (4 x UINT8)							0xCA
1								0xCB
2								0xCC
3								0xCD
x	Data payload (n x UINT8)							
x								
x								
x								
x								
x								
x								
x								
0	XOR Checksum (UINT8)							
1	End sequence (4 x UINT8)							0xEA
2								0xEB
3								0xEC
4								0xED

Every data message consists of its own message ID, the number of used data bytes and the data bytes itself.

The checksum is calculated on all data except the start sequence and the end sequence. The Checksum is a simple XOR Assignment of all n data bytes.
Byte0 **XOR** Byte1 **XOR** Byte2 … **XOR** Byte (n-1)

Table 4: Structure of a RS485 data payload block

Byte\Bit	7	6	5	4	3	2	1	0
0	CAN message ID (UINT16)							High
1								Low
2	CAN message length (UINT8)							
3	CAN data payload (length x UINT8)							
4								
5								
6								
7								
8								
9								
10								

The sensor receives only one message per cycle. It is important to wait for the end sequence to send an additional command.

8 Designated use

The UMRR general purpose medium range radar is suitable for any application where the distance to and relative radial speed of large objects has to be measured.

Typical applications are:

Automotive: measure shortest distance to obstacle.
Robotics: measure shortest distance to obstacle.
Security: detect motions and measure distance to moving object.
Traffic management: detect moving objects, count those, measure speed and measure distance to moving object.
Cranes: measure distance to ground.
Aircraft: measure distance to ground.

The detection range depends on object size. Very large reflectors can be detected at a range of more than 500 m.

9 Frequency Approval

9.1 Declaration of Conformity for USA

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:

(1) This device may not cause harmful interference, and

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

Usually this is followed by the following FCC caution:
Any changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate this equipment.

Note: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may case harmful interferences to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more following measures:

- Reorient or relocate the receiving antenna
- Increase the separation between the equipment and receiver
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected
- Consult the dealer or an experienced radio/TV technician for help.

9.1.1 FCC Label

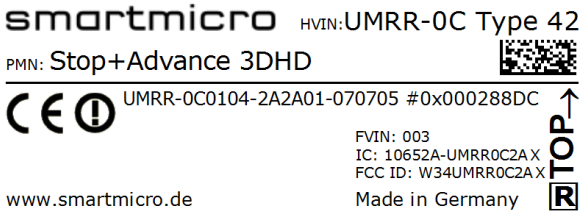

Figure 7: FCC ID

9.2 Declaration of Conformity for CANADA

9.2.1 Declaration of Conformity in English

This device complies with Industry Canada licence-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.

9.2.2 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.

9.2.3 Industry Canada (IC) Label

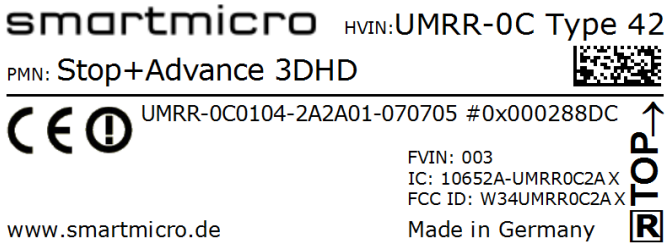

Figure 8: Label including IC, HVIN, PMN, FVIN (Sample)

9.3 Declaration of Conformity for EUROPE

The UMRR-0C Type 42 has been marked with the CE mark. This mark indicates the compliance with the EC Directive 1999/5/EC. A full copy of the Declaration of Conformity can be obtained from s.m.s, smart microwave sensors GmbH, 38108 Braunschweig, Germany or via E-Mail. Please contact us at info@smartmicro.de.