Annex acc. to FCC Title 47 CFR Part 95 M
relating to
s.m.s, smart microwave sensors GmbH
DRVEGRD 166

Annex no. 4
User Manual
Functional Description

Title 47 - Telecommunication
Part 95 - Personal Radio Services
Subpart M – The 76 – 81 GHz Band Radar Service
Measurement Procedure:
ANSI C63.26-2015

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User manual/ Functional description of the test equipment (EUT)

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DRVEGRD 166 USER MANUAL

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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
RFIC	Radio Frequency 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 166 with type 166 antenna.

4 GENERAL DESCRIPTION

4.1 SENSOR DESCRIPTION

DRVEGRD 166 is a UMRR for multiple automotive and industrial applications that features 4D/IMG (imaging radar) technology.

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 less than 35dBm.

The DRVEGRD Sensor Type 166 consists of twelve transmit and sixteen receive antennas, forming a 192 virtual TRX antenna ray. The antenna Type 166 aims at long range and wide horizontal angular coverage. It can achieve a high angular resolution.

The sensor has multiple modes of operation:

- A Long-Range Mode for up to 300m range
- A Medium-Range Mode for up to 132m range
- A Short-Range Mode for up to88m range

The sensor can be used for applications like Adaptive Cruise Control (ACC) and Automatic Emergency Braking (AEB).

The device uses a patented transmit waveform to measure range, radial speed, azimuth and elevation angle, reflectivity and more parameters of multiple stationary and moving reflectors (targets) simultaneously. It is capable of imaging-high definition (4D/IMG), where IMG resolution means that the target features imaging resolution (separation) in four parameters: range, Doppler, azimuth and elevation 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.

4.3 GENERAL PERFORMANCE DATA

After power up or reset, the sensor readings are within specified performance within <15 seconds.
In Table 1 the general performance data of DRVEGRD 166 is given.

Table 1: General performance data

Environmental		
Ambient Temperature	-40 ... +85	degree C
Shock		
Vibration		
IP	67	
Pressure / Transport altitude	0…10.000	m
Mechanical		
Weight	≤ 830	g
Dimensions	121.6 x 170.1 x 47.2	mm
Housing Identification	18	
Antenna Identification	A6 (Type 166)	
DSP Board Identification	A1	
General		
Power Supply	7 ... 32[I] <15	V DC W
Frequency Band	76.0…77.0	GHz
Bandwidth	< 1000	MHz
Max. Transmit Power (EIRP)	<35.0	dBm
Interfaces	Ethernet 100MBit (2-wire) [default]; Ethernet 1Gbit(2-wire) [radar cube streaming]; 2xCAN FD 5Mbit/s	
Connector	MX64 Molex Series	CAN, Power, Ethernet

[I] measured at connector

START-UP TIME

After powering up or resetting, sensor readings meet the specified performance in <15s.

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

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.

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

[1] Not available yet.

developed in-house for easier communication between customer solutions and smartmicro products via Ethernet or CAN/CAN(FD).

5 HARDWARE

5.1 DRVEGRD 166 SENSOR

An example picture of a DRVEGRD 166 sensor is shown below.

Figure 1: Sensor Front view

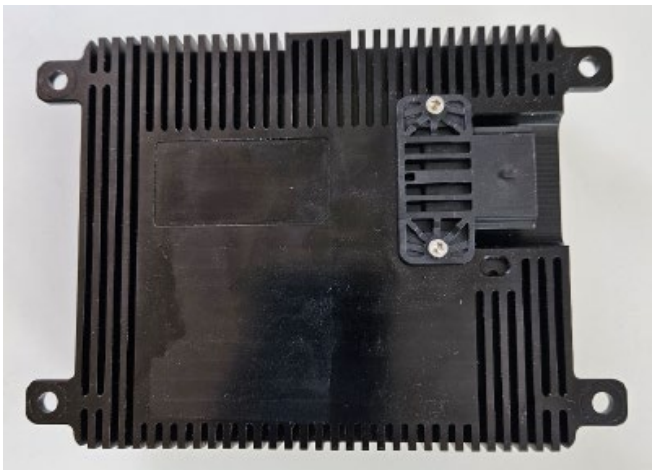


Figure 2: Sensor Rear view

5.2 SENSOR DIMENSIONS

All values are given in mm.

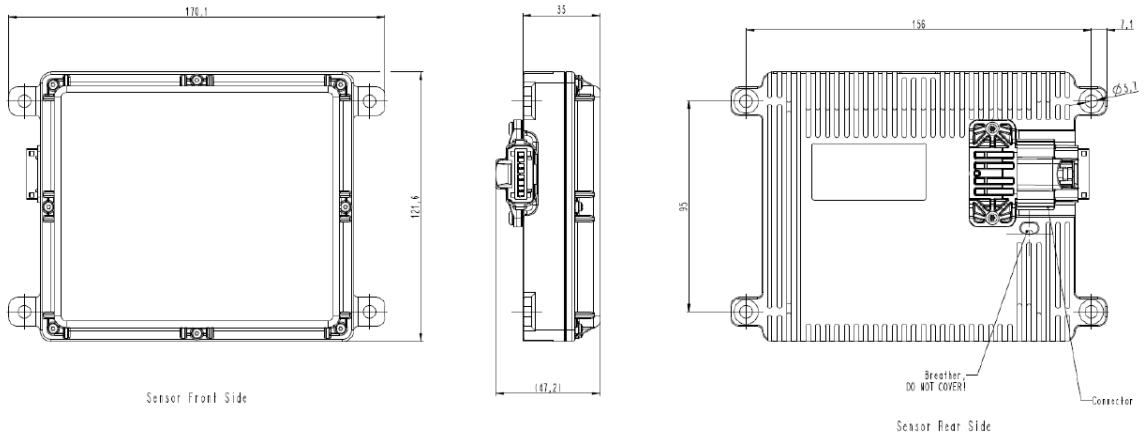
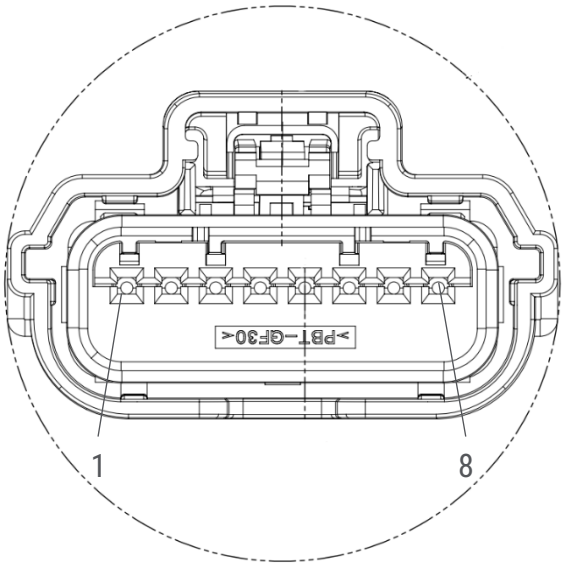


Figure 3: Sensor dimensions

5.3 SENSOR CONNECTOR

The sensor connector is a 8-pin male (plug) connector (waterproof IP67, MX64 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.

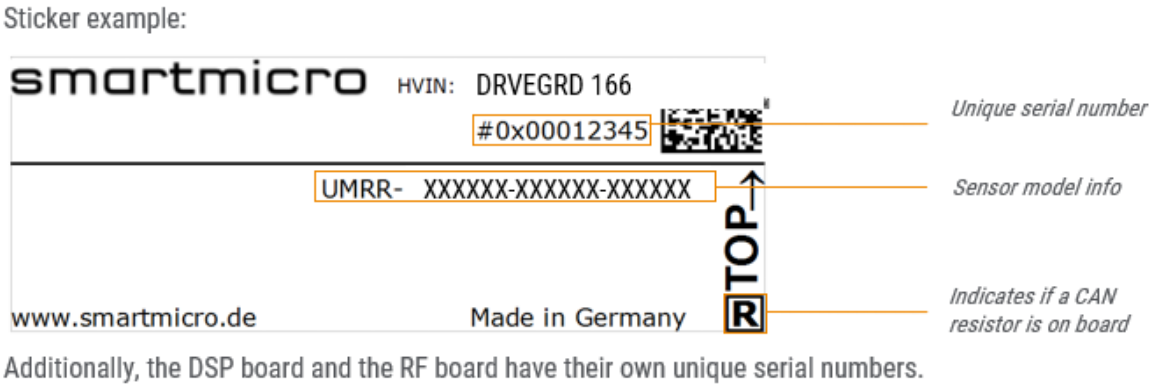


Figure 4: Label Example of DRVEGRD 166

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 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.

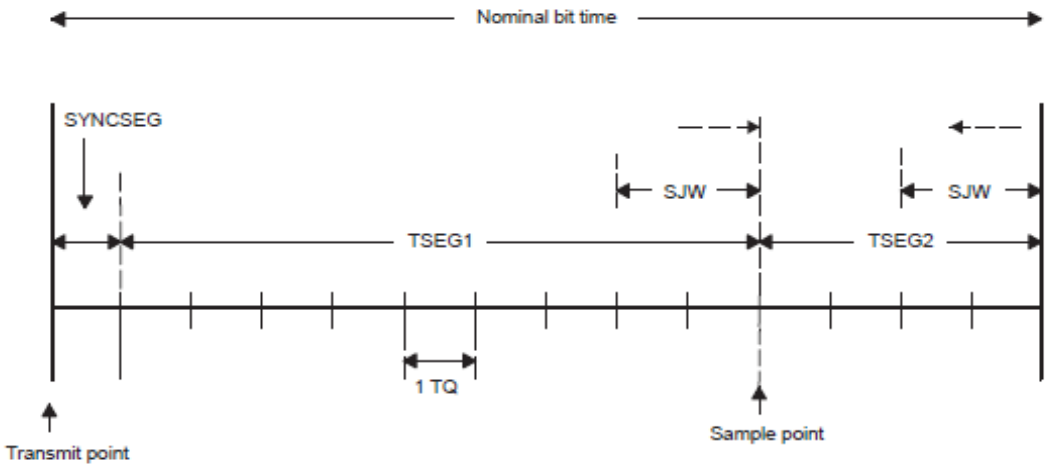


Figure 5: CAN bit timing for UMRR sensor

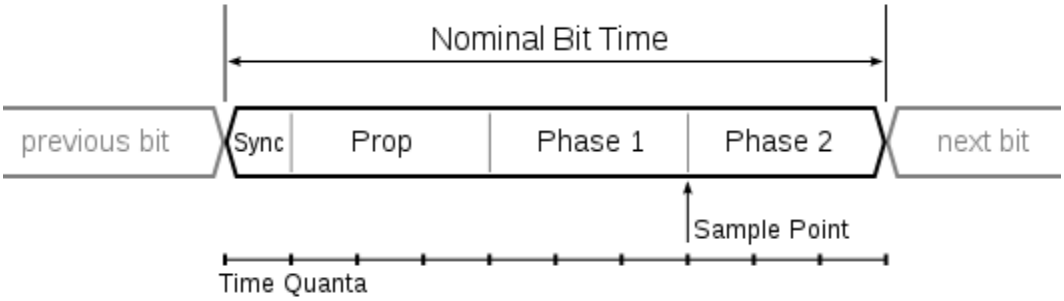


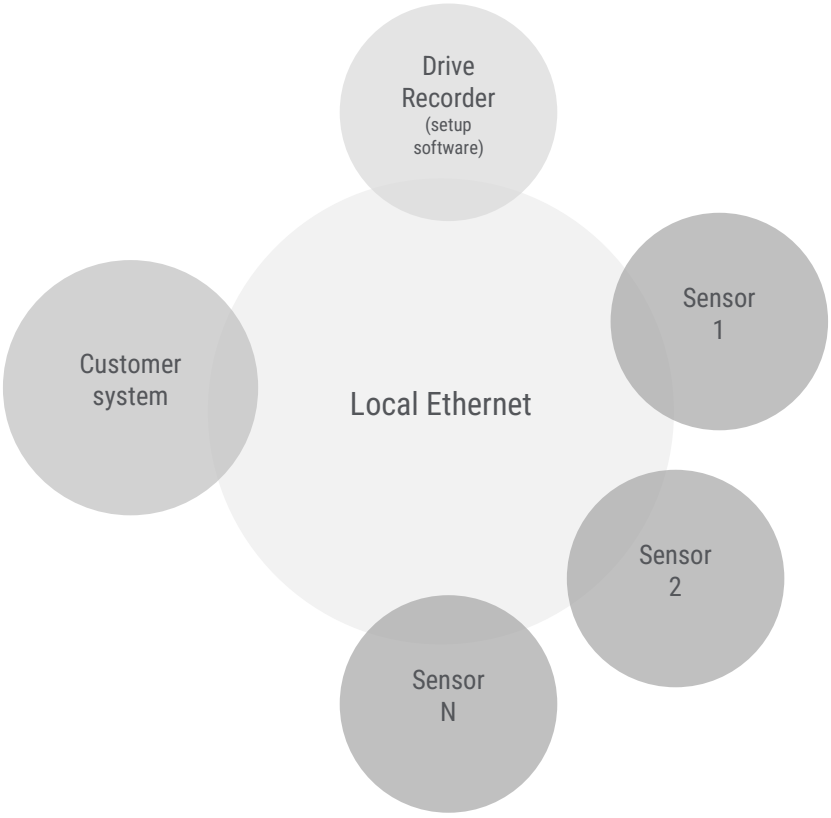
Figure 6: CAN bit timing as defined by the CAN protocol

6.3 ETHERNET CONNECTION

The sensor supports UDP via Ethernet in a Local Area Network (LAN). Communication over low bandwidth environments (minimum of 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, medium and short 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.

7.1 POINT CLOUD

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

- Autonomous driving
- Forward Collision Warning (FCW), AEB, ACC
- Rear Collision Warning (RCW)
- All kinds of 360-degree applications

One or multiple sensors may be integrated into vehicle models. Usually, 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.

8 COMPLIANCE STATEMENT

8.1 DECLARATION OF COMPLIANCE FOR USA / FCC

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.

8.2 FCC LABEL

Figure 7: FCC Label example

8.3 COMPLIANCE STATEMENT FOR CANADA / ISED

8.3.1 COMPLIANCE STATEMENT 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.

8.4.1 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.

8.4.2 INDUSTRY CANADA (IC) LABEL

Figure 8: Label Example for Canada

9 SAFETY INSTRUCTION

9.1 INSTALLATION

Please pay attention to the details below before installing and connecting the sensor:

- Only use provided or approved equipment for the installation.
- Only skilled and instructed persons shall install and connect the sensor. Proper experience in working with mains voltage, electrical and electronic devices is required.
- Do not connect the sensor directly to the mains voltage; instead use the voltage specified for the product.
- Do not wire any connections when power is applied to the device.
- Ground devices carefully to prevent electrical shock.
- All connectors are pin-coded and fit in only one position. Also note the arrow indicating the top side of the sensor.
- Only use fully functional equipment (ladders, aerial work platform, etc.) when working above ground. Staff shall be capable of working at heights.
- Be cautious when installing the sensor on or around active roadways and pay attention to moving traffic.
- Mount the sensor carefully to prevent it from shifting or dropping.
- The sensor must be mounted to a stiff bracket on the vehicle. Vibration, oscillation or other movement will reduce the sensor performance.
- Make sure that installation methods are in accordance with local safety policies and procedures as well as company practices.

9.2 OPERATION

Do not operate the sensor if the device itself or any cables are damaged.

Transmission of radio frequency waves starts after the sensor is powered up and stops when it is disconnected from power.

For testing purposes, the sensor may be laid on its face when it is powered up, given that the surface or connectors will not be damaged this way. Please note that this position is not intended for permanent use.

Note:

Parts of the DRVEGRD 166 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 - 32 V DC, a PS2 class power supply with maximal 3 A according to EN 62368 should be taken, install by skilled person only.

Do not dispose electrical and electronic equipment in household trash.

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