DATASHEET

4D/PXHD RADAR SENSOR

DRVEGRD® 171 MSE
MOBILE SPEED ENFORCEMENT

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CONTENT

1 USER SAFETY WARNING

Please read the entire document carefully before using the sensor.

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.

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.

The sensor may become hot during operation. Proper hand protection is recommended for maintenance work.

Do not dispose electrical and electronic equipment in household trash.

TECHNICAL SERVICE

Only use provided or approved equipment for operation. People other than authorized and approved electrical technicians shall NOT attempt to connect the device to a power supply or other controllers, as there is a risk of electrical shock by unsafe handling of the power source.

Do not attempt to service or repair this device:

- No user-maintainable parts are contained in the device.
- To avoid electrical shock, do not remove or open the cover.
- Unauthorized opening will void all warranties.
- smartmicro is not liable for any damages or harms caused by unauthorized attempts to open or repair the device.

RADIATION

Operation is subject to the following two conditions:

- This device may not cause harmful interference.
- This device must accept any interference received, including interference that may cause undesired operation.

This device generates radio frequency energy. There are strict limits on continuous emission power levels to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment.

- Human exposure to transmitted waves from this device is generally considered as safe. Still, it is considered good practice that humans are not subject to higher radiation levels than necessary.

This device may interfere with other devices using the same frequency band.

2 SENSOR SPECIFICATIONS

DRVEGRD 171 MSE is a 76-77GHz radar sensor for multiple Mobile Speed Enforcement applications that features 4D/PxHD technology.

The sensor's antenna aims at long range and wide horizontal angular coverage. With the combination of its 6 TX and 8 RX antennas, forming a 48 virtual TRX antenna array, the sensor can achieve a high angular resolution.

2.1 MEASUREMENT PRINCIPLE

Using a patented transmit waveform, the sensor measures range, radial speed, azimuth and elevation angle, reflectivity, and more parameters of multiple stationary and moving reflectors (targets) simultaneously. It is capable of pixel-high definition (4D/PxHD), where PxHD resolution means that the sensor features very high resolution (separation) in three parameters: range, Doppler, and azimuth angle and additionally measures elevation angle.[1]

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.

smartmicro radars employ a patented A/B fast chirp-sequence frequency-modulated continuous wave (A/B CS-FMCW) modulation.

FMCW radars can natively separate targets in two dimensions: Range and speed. Transmitting, receiving, and processing a single linear frequency ramp (chirp) enables the radar to detect and separate multiple targets within the radar's field of view.

CS-FMCW radars use multiple chirps as part of one measurement (one radar cycle). The results from multiple chirp range measurements are coherently processed, allowing the radar to measure the Doppler frequency of a target over the measurement time (typically in the order of 10-40ms). High-speed, slow-speed and even stationary targets are detected by the smartmicro radar.

smartmicro's patented A/B CS-FMCW technology then allows for direct unambiguous Doppler measurement (covering the complete specified speed interval) in one single measurement cycle.

The patented waveform and the high-performance signal processing allow to precisely measure the range and the speed of any target and even allow resolving multiple targets that are at the same range from the radar but traveling at different radial velocities or vice versa.

smartmicro radars employ multiple transmit, and receive antennas, adding a spatial component to the measurement process. In addition to range and speed, smartmicro 4D radars can measure the direction of any target separately in Azimuth (horizontal) and Elevation (vertical) angles.

[1] Separation in azimuth angle is not available yet.

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, filter algorithms are implemented for the tracking of all detected reflectors over time. This tracking algorithms are integrated in the sensor. Multiple objects are *tracked* simultaneously.

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

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

In addition, status and diagnose data from the sensor are reported. The sensor can then report 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 adaptive cruise control or collision warning, may be implemented.

4D PIXEL-HIGH DEFINITION RESOLUTION - OBJECT SEPARATION PERFORMANCE

The sensor divides the field of view into range gates and azimuth angular beam positions and performs a Doppler (speed) measurement separate for each individual range and angular 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[2]

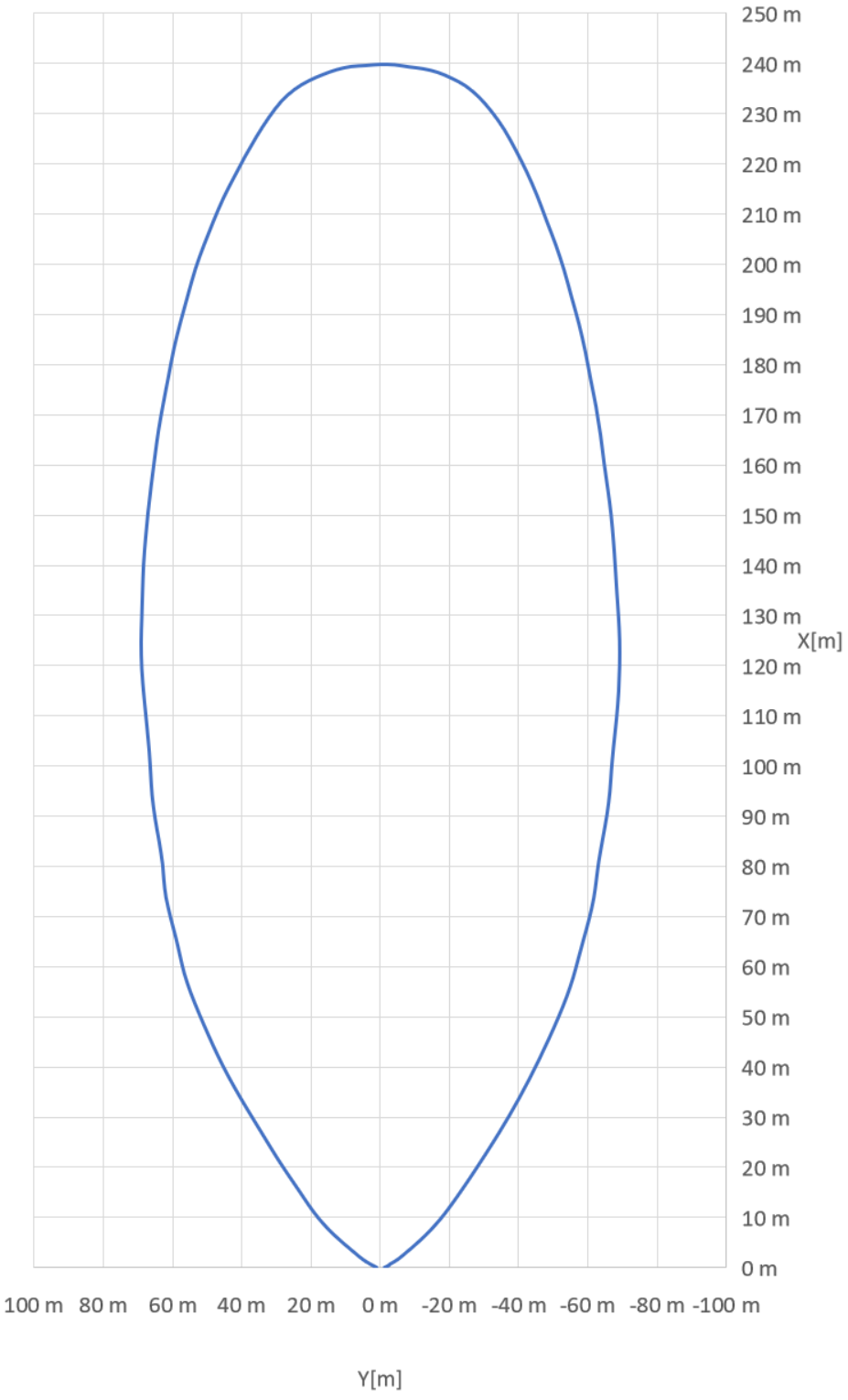
Additionally, the elevation angle is measured.

USER CONFIGURABILITY

Center Frequencies (Frequency Bands): The user can switch between 4, non-overlapping, frequency bands. This feature can be used to avoid interference if multiple sensors are operated while their fields of view are overlapping.

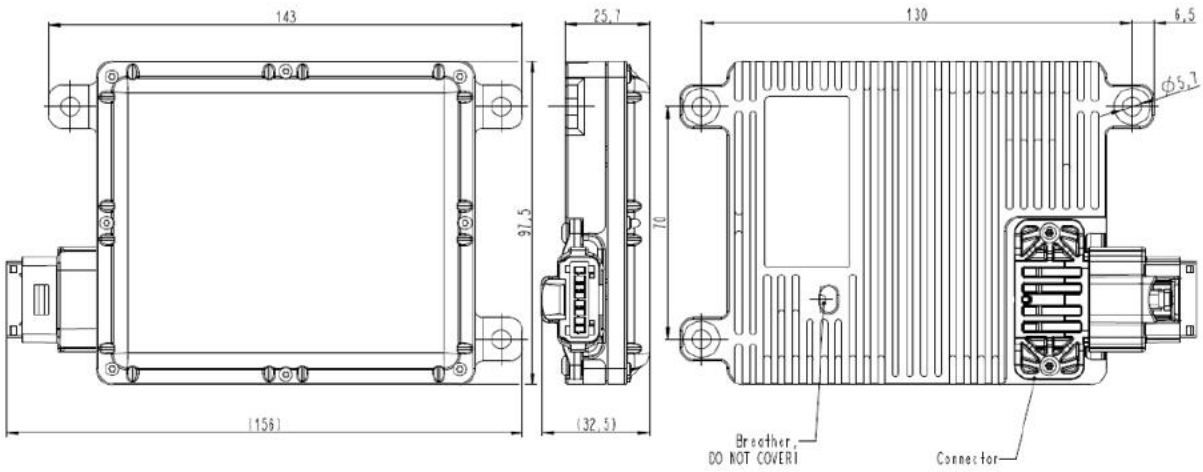
[2] Separation in azimuth angle is not available yet.

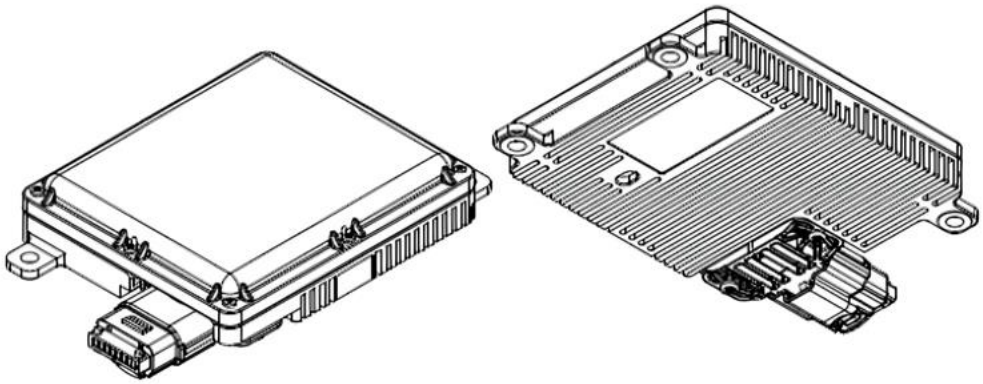
2.2 SENSOR BEAM



2.3 SENSOR DIMENSIONS

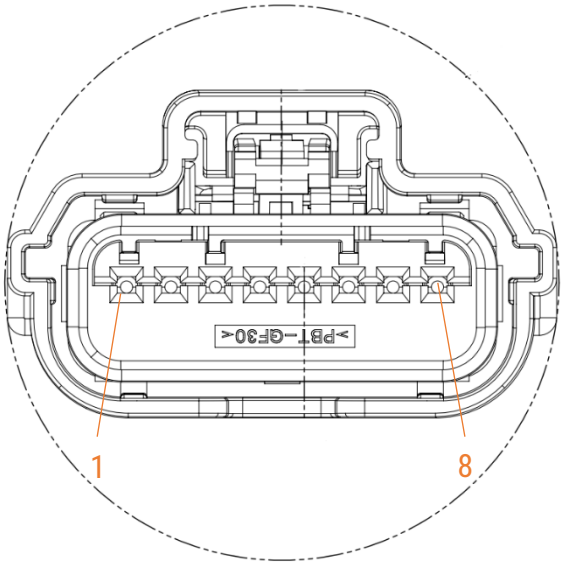
All values are given in mm.





2.4 SENSOR CONNECTOR

The sensor connector is an 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 the 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

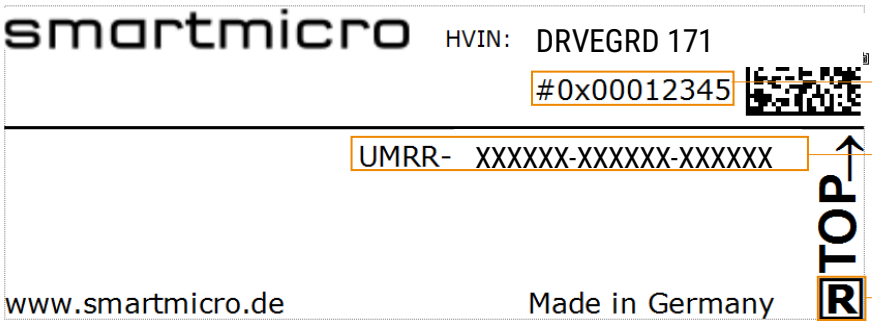
Please note that in the standard configuration the sensor does have a 120 Ohms resistor on board for CAN2 (CAN bus termination between CAN L and CAN H). This resistor is required at either end of a CAN bus. CAN1 has high impedance termination (2.6 kOhm).

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.

2.5 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:



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

3 GENERAL PERFORMANCE DATA

Parameter		Extra-Long-Range Mode
Operating Frequency		76…77GHz
Center Freq. (Bands)[3]		4
Range	Min./Max.[4]	1.2m/240m | 3.94ft/787.4ft
	Separation	≤ 2.4m | ≤ 7.87ft
	Sensitivity on Passenger Car	180m | 590.55ft
	Accuracy[5]	≤ 0.6m | ≤ 1.97ft
Speed	Min./Max.	-400…+200km/h | -249…+124mph
	Separation	≤ 0.26m/s
	Accuracy[6]	≤ 0.07m/s
Angle	Field of View: Azimuth[7]	-50…+50°
	Field of View: Elevation[7]	-10…+10°
	Separation: Azimuth[8]	2°
	Accuracy: Azimuth[9]	≤ 0.25°
	Accuracy: Elevation[9]	≤ 0.5°
Mechanical Details		
Weight		< 455g | < 16.05oz
Dimensions (H/W/D)		97 x 143 x 25.7mm | 3.82 x 5.63 x 1.01in
Further Information		
Initialization Time		< 4s
Update Cycle Time[10]		≤ 55ms (<40ms for Short-Range Mode)
Processing Latency		2-4 cycles
Operating Voltage[11]		7…32V
Power Consumption[12]		< 7W
Bandwidth		< 1000MHz
Point Cloud Rate		up to 255 per cycle (~4.500 points per second)
Max. Transmit Power (EIRP)		< 35dBm
Operating & Storage Temperature		-40…+85°C | -40…+185°F

[3] Can be selected at runtime.
4 Typical values; all values given for bore sight; they may vary depending on the clutter environment. Please note that the radar system can neither achieve a detection probability of 100% nor a false alarm rate equal to zero.
[5] Measured on point reflector having zero radial speed, at bore sight.
[6] Measured on point reflector having constant radial speed, at bore sight.
7 The total field of view is an angle interval in which reflectors can be detected; 3dB field of view is narrower.
[8] Measured for point reflector at bore sight with >25dB S/N. Falls off toward larger absolute angles. Due to RFIC characteristics, angle may have an offset which changes over temperature (-40…+85°C). Not available yet.
9 Typical value; measured at target output level at bore sight, for a point reflector showing >25dB SNR. Error may increase towards larger angles. In addition to this angle error, due to RFIC characteristics, angle may have an offset which changes over temperature (-40…+85°C), typically -1.25deg to +1.25deg over specified operation temperature interval.
[10] Typical value; may be longer depending on the number of detected radar targets.
11 Measured at the connector.
12 Depending on supply voltage and temperature; power consumption increases with supply voltage and with temperature.

Interfaces[13]		1xCAN 500Kbits/s 1xCAN FD 2MBit/s [point cloud] Ethernet 100BASE-T1 100MBit/s (2-wire) [default] Ethernet 1000BASE-T1 1GBit/s (2-wire) [radar cube streaming]
Connector		MX64 Molex Series
Shock / Vibration		tba g_{rms} / tba g_{rms}
Relative Humidity		0…95% (non-condensing)
IP		67
Pressure or Transport Altitude		0…10000m | 0…32800ft

13 It is recommended to use an external surge protection for power, CAN and Ethernet interface ports.

START-UP TIME

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

3.1 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[14]
- Detection and automatic suppression of RF interference, or rather signals from other radar sensors operating in the same frequency band

3.2 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 the 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.

3.3 DATA LOGGING AND VISUALIZATION 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 2

smartmicro offers Robot Operating System (ROS) support which includes ROS 2 drivers 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 2, which facilitates the processing and visualization of radar data.

[14] Not available yet.

Smart Access

An 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 in-house developed API for easier communication between customer solutions and smartmicro products via Automotive Ethernet or CAN/CAN(FD)[15].

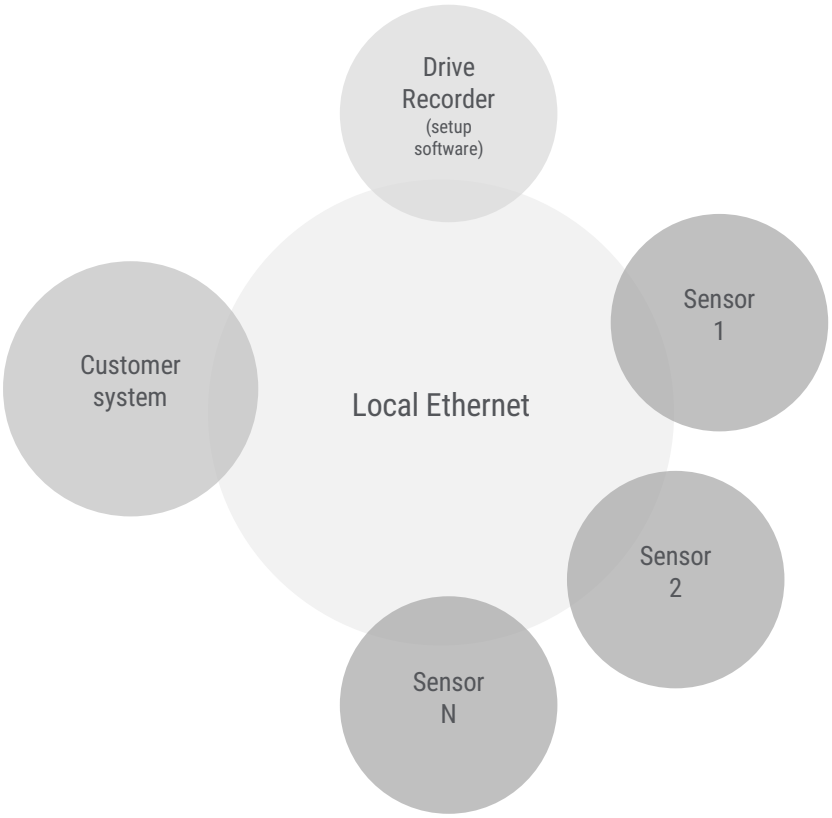
[15] The API supports only CAN and Ethernet, not CAN FD at the moment.

3.4 ETHERNET CONNECTION

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:

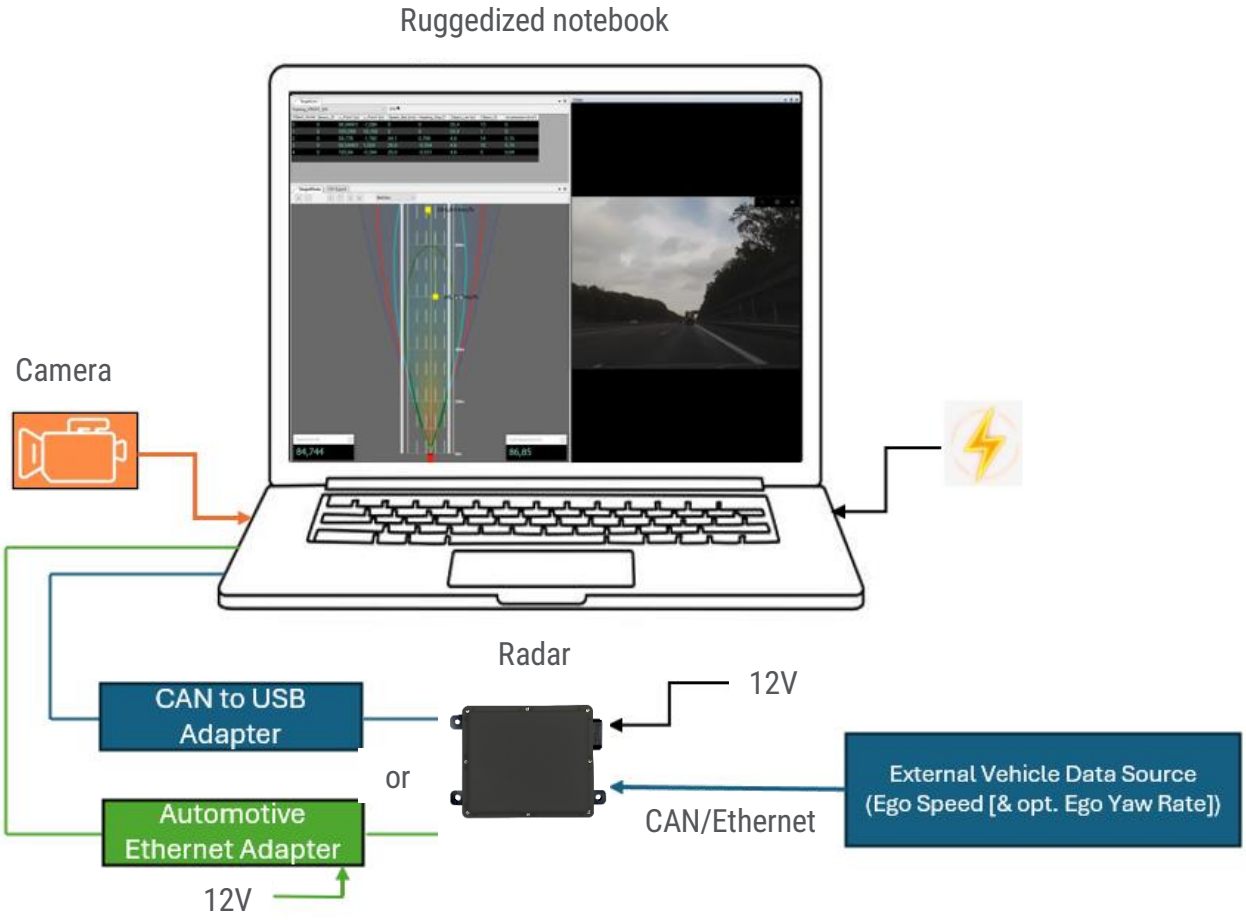
- Ethernet standards IPv4, ARP, IGMP IP multicast and UDP
- Support of Static IP configuration. DHCP is not supported
- smartmicro's proprietary communication protocol "smartmicro transport protocol" with sensor data transmission, which sends a list of detected targets every radar cycle. Operation parameters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



4 APPLICATION-SPECIFIC CHARACTERISTICS

The sensor can be used for different applications by using the tracking firmware.

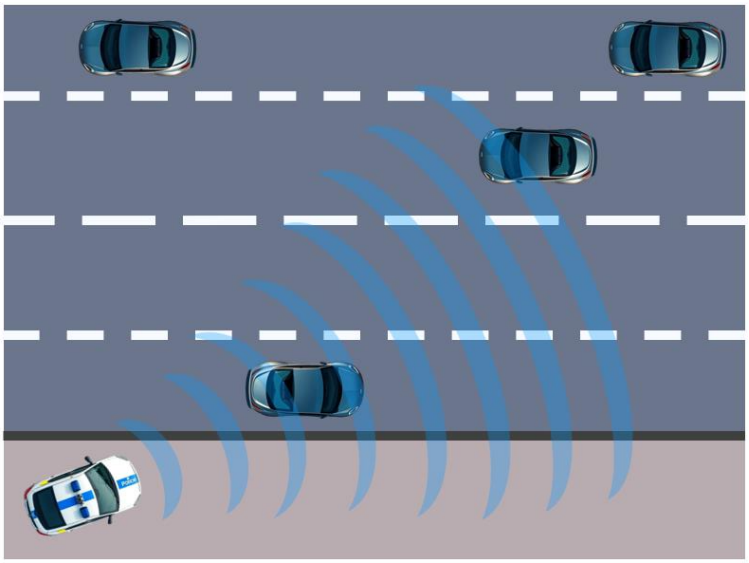
4.1 POSSIBLE SET-UP FOR MOBILE SPEED ENFORCEMENT



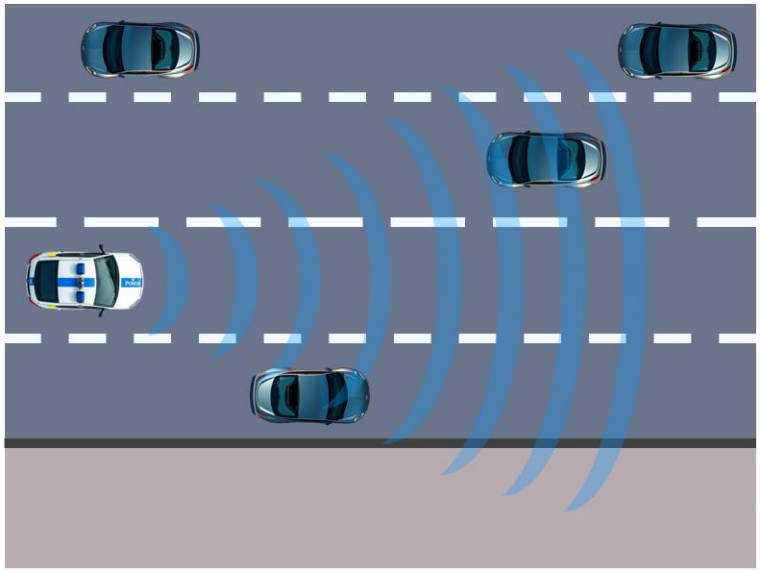
4.2 VEHICLE TRACKING - EXAMPLE SITUATIONS

The Mobile Speed Enforcement (MSE) product has a tracking algorithm integrated that operates on the detected point cloud from the sensor and can identify moving vehicles. The tracking algorithm provides an output for each detected object with its position, absolute speed over ground and heading direction (besides other additional attributes). This can be used for multiple applications, where vehicle tracking is desired.

Stationary Speed Enforcement (e.g. on the side of the road)



Mobile Speed Enforcement from a driving vehicle (enforcement vehicle is moving through traffic):



4.2.1 EGO VEHICLE SPEED REFERENCE

The mobile speed enforcement vehicle needs its own speed, also called EGO speed, as a speed reference for correct operation of the vehicle tracking algorithms.

BUILT-IN EGO SPEED REFERENCE

By default, the sensor determines the speed information by itself, typically by using the relative speed of the sensor towards stationary objects in its field of view, without any external speed reference inputs.

EXTERNAL EGO SPEED REFERENCE

To maximize the tracking performance, the vehicle data (EGO speed, EGO yaw rate) can also be fed into the sensor via CAN or Ethernet. More details on the data transfer can be found in the product documentation.

4.3 HEAVY 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.

5 COMPLIANCES

The sensor model complies with the following EU directives:

- RED 2014/53/EU
- RoHS 2011/65/EU
- EC 1907/2006 REACH

Applied Standards:

- Spectrum Usage:
  - EN 301 091-1 V2.1.1
- EMC:
  - EN 301 489-1 V2.2.0
  - EN 301 489-51 V2.1.0
- Health and Safety:
  - EN 62311: 2008
  - EN 62368-1: 2014 + AC: 2015

Regarding spectrum usage, this sensor model was tested and certified by independent test labs (formally approved by a test lab or notified body):

- EU RED directive
- FCC part 95M
- ISED RSS-251

This sensor model is also generally compliant with the following regional regulations (but may not be formally tested/approved):

- EAC
- CETECOM
- SRRC
- KCC
- MIIT
- NCC

Note: This statement of compliance means that the sensor allows operation compliant to the listed standards. However, not all standards are certified through test labs. Formal frequency approval or registration is not accomplished for all countries. In certain countries or regions, a customer-specific local frequency approval is reasonable. smartmicro supports customers throughout this process.

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