*R600V.DAE0 Operating Manual (EN)*

# Off-Highway Ground & Crop Radar Sensor

Last Update: 28 Nov 2019



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# 1 General Information

## 1.1 Scope

This manual is intended for the Baumer “Off-Highway Ground & Crop Radar Sensor” family and contains information about its installation and commissioning. The sensors and their software configurations are listed below:

**Tab 1** Applicable Products

| Art. no. | Product | Type | SW Version |
|---|---|---|---|
| 11209335 | R600V.DAE0-11209335 | Radar sensor for sprayer applications | R600VMSF 1.4.0 (or higher) |
| 11188367 | R600V.DAE0-11188367 | Radar sensor for general applications | R600VMOF 1.8.0 (or higher) |



Read this operating manual carefully and follow its safety instructions!

## 1.2 Comments, notes, and warnings



**NOTE**
Provides helpful operation instructions or other general recommendations.



**ATTENTION**
Indicates a possibly situation that may lead to damage.



**CAUTION**
Indicates a possibly hazardous situation. If it is not avoided injuries may occur or the device be damaged.

## 1.3 Intended Use

### *1.3.1 General*

The “Radar Sensor for Ground & Crop Radar Sensor” has been developed with the off-highway market (agriculture vehicles, construction vehicles, etc.) in mind. It is intended for use cases in which the structured ground (rough terrain, stubble, etc) and/or crop distance on a vehicle (e.g. a tractor) or an implement (e.g. combine header, sprayer boom) shall be determined. For flat and unstructured surfaces (e.g. asphalt, concrete) the usage of the “Off-Highway Distance Radar Sensor” (R600V.DAH5-11205779) is recommended. The 122GHz

band can be used in many different applications. The original equipment manufacturer or system integrator must observe local restrictions regarding the usage and/or placing in the market of this product.



**NOTE**

For flat and unstructured surfaces (e.g. asphalt, concrete) the usage of the "Off-Highway Distance Radar Sensor" (R600V.DAH5-11205779) is recommended.

The sensor may be integrated into vehicles with 12VDC and 24VDC vehicle power supplies, and provides a CAN SAE J1939 interface with a set speed of 250kbit/sec (may be customized to allow 500kbit/sec for customer specific sensors). The output rate defaults to 50ms, but may be varied between 10ms and 1000ms. High visibility LEDs display the sensor status, even in bright ambient light.

### *1.3.2 Audience*

This manual is intended for original equipment manufacturers (OEMs), or system integrators; but not the end-users of equipment. It is the responsibility of the OEM / system integrator to provide a user manual where relevant information from this manual is passed on, if it either directly affects the safety or indirectly as discovered during a safety assessment of the consequences of this product's integration. The Baumer "Off-highway Ground & Crop Radar sensors" are not intended for safety applications and potentially explosive atmospheres. The OEM or system integrator must ensure the safety of the equipment on which this product is used.

The manual is written based on current information. Baumer reserves the right to update products, documentation and its manuals if better information becomes available.



**CAUTION**

This product must not be used in safety applications and in potentially explosive atmospheres.

### *1.3.3 Application Policy*

Baumer products are applicable to a wide range of applications and / or end-use cases. Baumer cannot know all possible conditions under which products are installed, used, and operated. Every application and / or use-case is unique. The suitability and functionality of a Baumer product and its performance under different applications and / or end-use cases can only be verified by testing, and shall ultimately be the responsibility of the Baumer customer using a Baumer product. When the product configuration (software version, electronics revisions, mechanical revisions, etc.) is changed the customer needs to validate and verify the Baumer product to ensure the proper function in the application and / or end-use case.

**NOTE**
The original equipment manufacturer or system integrator must ensure the suitability of this product in the application and / or use case through extensive testing.

Intellectual property rights may exist for some applications and / or end-use cases that may affect the usage and/or placing on the market of machines manufactured by the OEM using a Baumer product. Baumer does neither implicitly nor explicitly warrant the usage for specific application and / or end use case.

**NOTE**
The original equipment manufacturer or system integrator must consider third party intellectual property rights. No warranty is given for the application and/or end use case.

The product shall not be used for functional safety applications. Possible malfunctions and failed measurements of the sensor must be intercepted at the system level and shall not lead to unsafe situations in the system. The customer shall perform its own safety assessment to account for sensor behaviour in particular situations (e.g. distance fluctuations in static situations, operator caused distance manipulation by hand or other objects). The product shall not be used in the direct control and modification of the state of function of the vehicle.

**CAUTION**
This product must not be used in safety applications. A sensor malfunction must not lead to an unsafe situation.

**CAUTION**
The product shall not be used in the direct control and modification of the state of function of the vehicle.

Baumer ensures the compliance of its products to the specifications and declarations of conformity made available through its website *www.baumer.com*.

All conditions of use provided in the data sheet, top level drawing must be observed. The machines or equipment manufactured by the customer utilizing Baumer product must only be put on the market as covered by the declaration of conformity provided.

**CAUTION**
The technical documentation provided must be observed.

Some applicable documents are listed below, but are not limited to:

**Tab 2** Applicable Documents

| Art. no. | Document Type | Document |
|---|---|---|
| 11209335 | Data sheet (DAB) | DAB Radar sensor for sprayer applications |
| 11209335 | Mounting instruction (MAL) | MAL Radar sensor for sprayer applications |
| 11188367 | Data sheet (DAB) | DAB Radar sensor for general applications |
| 11188367 | Mounting instruction (MAL) | MAL Radar sensor for general applications |
| 11209335, 11188367 | Declaration of conformity (EU) | Baumer_R600V_DE-EN-FR_CoC_81302233 |
| 11209335, 11188367 | Declaration of conformity (US) | Baumer_R600V_EN_DoC_81313208 |

### *1.3.4 Maintenance*

This product does not require any maintenance. If function is impaired dirt should be removed from the lens.

### *1.3.5 Mechanical Damage*

If the product shows mechanical damage to an exterior part, it should be replaced to avoid undetected malfunction. The product must be replaced by skilled and authorized personnel.

### *1.3.6 Disposal (environmental protection)*

Do not dispose of electrical and electronic equipment in household waste. The product contains valuable raw materials for recycling, which is why an old product must be returned to an authorised collection point for correct disposal / recycling. For further information refer to www.baumer.com.

# 2 Integration Guidance

**CAUTION**
Installation, mounting and adjustment of this product must only be executed by skilled and authorized personnel.

## 2.1 Mechanical Integration

### *2.1.1 Mounting Direction, Blind-range*

Mount the sensor with its centre axis approximately perpendicular to the direction of movement and the ground. An angle may affect the measurement due to the Doppler Effect. In field trials an angle of +/- 10° has been shown to be non-detrimental. Care should be taken to evaluate influence of the Doppler Effect on the end-result. There is limited compensation for the Doppler Effect in the software. The distance output is relative to the tip of the lens. A blind range of 300mm must be considered. No (reliable) measurement is possible within the blind range of the sensor, though strong targets may be detected. No targets above 6m are detected.

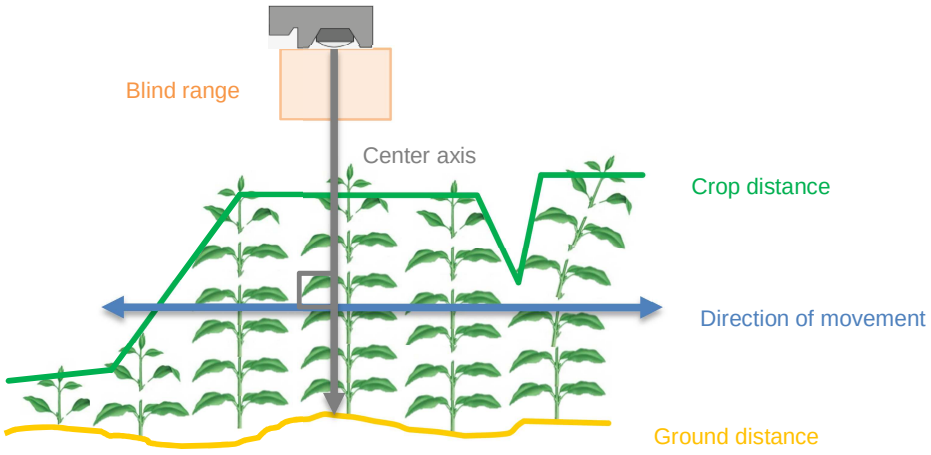



**Fig 1** Mechanical Setup (for visualization only)

### *2.1.2 Mounting*

A mounting plate with a flatness of better than 0.2mm per 100mm shall be used. Baumer recommends soft steel as material to match specified mounting torque. For direct mounting (thread in plate) Baumer recommends a thickness of the steel plate of at least 6mm. For mounting on a thinner soft steel plates (≥3mm) flange nuts must be used instead.

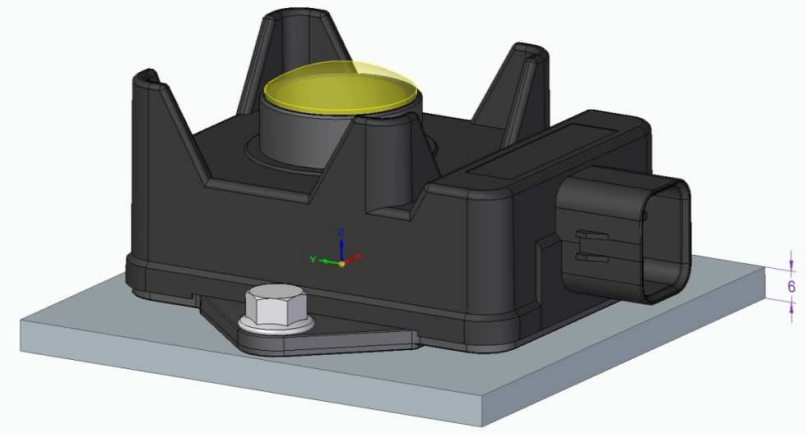



**Fig 2** Mounting on thick soft steel plate (≥6mm).

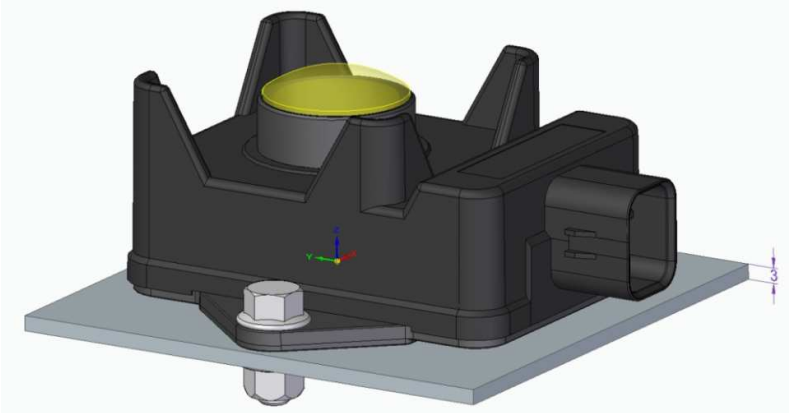



**Fig 3** Mounting on a thin soft steel plate (≥3mm)

It is recommended to use M6 screws per MBM 10105. The mounting torque for 10.9 (property class) screws must be within 12Nm…15Nm, and for 8.8 (property class) screws it must be within 10Nm...12Nm. For the mounting pattern and available tool space for tightening the mounting screws please refer to the Figure below. Enough space must be allowed for the wiring harness to avoid excessive bending of the wires or wire assembly. The wires must also be appropriately secured and be suitable for the application.

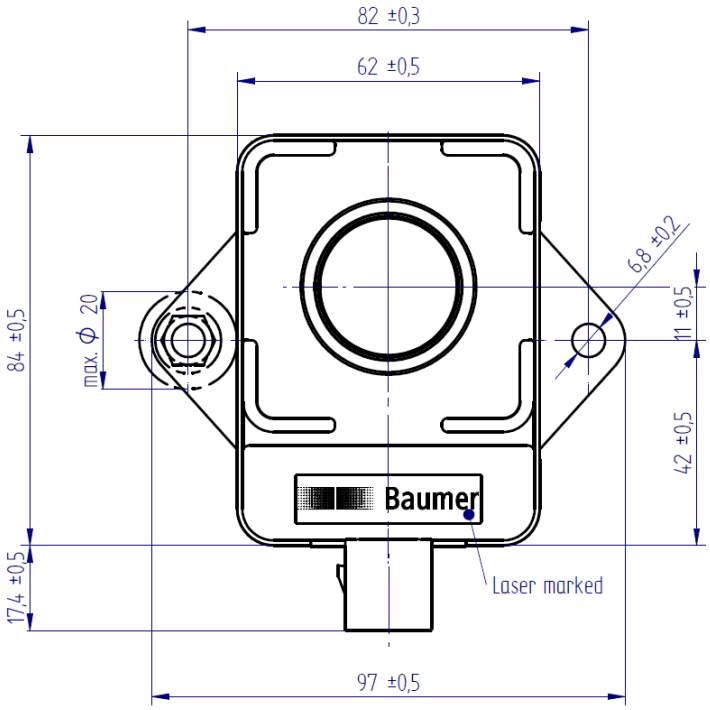



**Fig 4** Mounting pattern, tool space.

**ATTENTION**

Observe mounting torque and tool space to avoid damage.to sensor.

### *2.1.3 Free Space and Directional Sensitivity*

The Baumer off-highway radar sensor is a very sensitive device to deliver superior crop penetration and crop detection performance. The opening angle of the main beam is 6° (for 3dB signal reduction, or approx. 9° for 20dB signal reduction). A typical directional sensitivity is shown below.

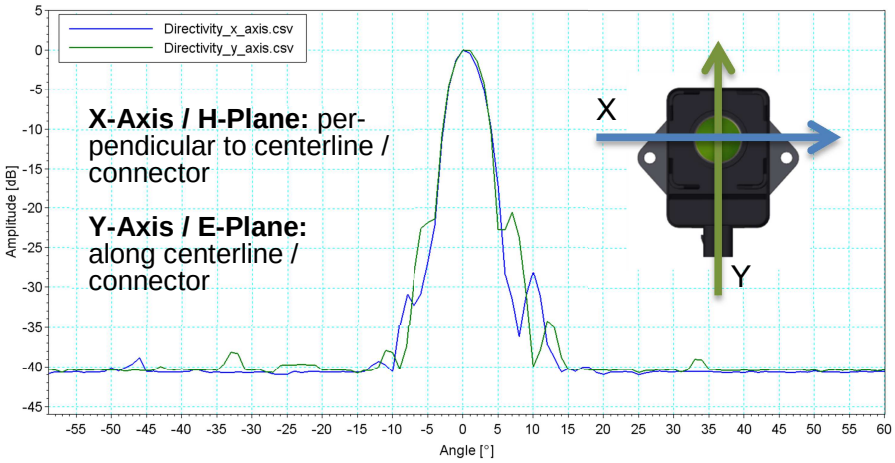



**Fig 5** Typical Directional Sensitivity of Sensor

Baumer recommends to limit intrusion of, in particular non-stationary, objects, into a rotational cone of approx. 60…70° from the lens. Integr ation testing must be done to ensure that the integration with available free space does not have impact on the measurement. It is known that dangling wires, cables, hoses, water droplets may be picked up.

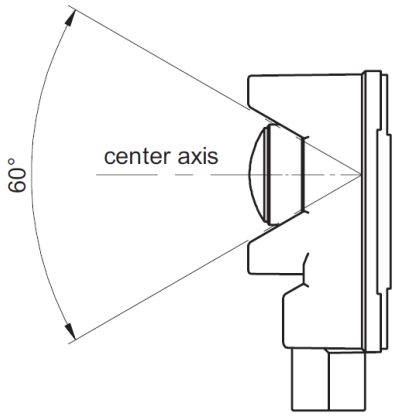



**Fig 6** Recommended Free Space

**NOTE**
Non stationary objects in the near range may be picked up by the sensor even outside the main directional sensitivity cone. The recommended free space should be kept free from moving objects.

## 2.2 Targets and Measurement

### *2.2.1 Reference Target*

All data sheet specifications are based on a low-reflectance target (a wood panel with dimensions 1200mm by 1700mm). This is to simulate the low reflectance of natural objects while avoiding distance ambiguities. The measurement with radar is an intrinsically statistical process when measuring on ground and / or crop which are highly structured targets. Great care has been taken to design a robust signal processing to extract ground and crop distance. Nevertheless integration testing is essential in the application. The correlation between sensor output and the definition of the crop distance must be determined by testing. The zero point for the measurement is on the tip of the lens.

**NOTE**
The correlation between ground & canopy distance with actual targets must be determined for every application.

### *2.2.2 Structured application environment targets and stationary situations*

When measuring on a structured surface (such as soil) the measured distance will be averaged over the whole area covered by the sensor opening angle (“directionality”). In static situations distances with a strong reflection will be favoured. When moving over the structured object statistics will avoid these strong reflections at distinct distances and the ground distance can be determined well. Nevertheless the structure of the surface of the soil will be reflected in the measured distances.

The next figure shows that a multitude of strong reflections are possible within the opening angle of the sensor (blue dots). The output distances may shift over time, due to slight changes in position due to vibration and changed radar wave interference. Causes may be shifting of leaves in the wind, vibration and movement of the implement, and so on. The distance values must be filtered appropriately to avoid erratic movement of implements in these situations and avoid unpredictable movement for bystanders.

**CAUTION**
The superordinate controller instance must filter the sensor signal to avoid erratic implement movement.

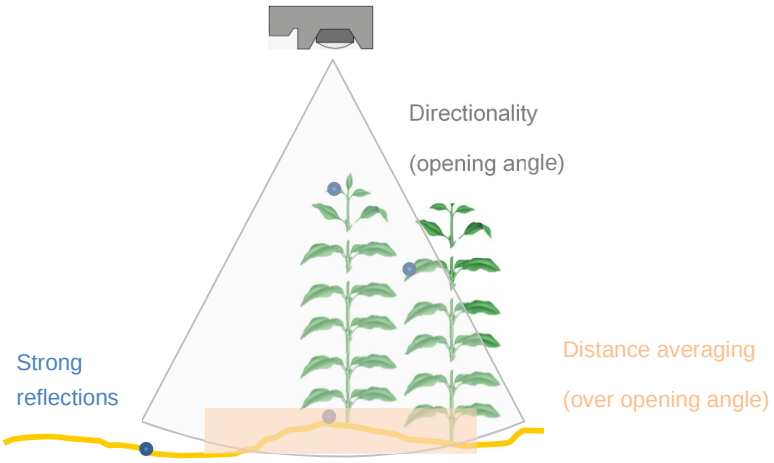



**Fig 7** Shifting reflections in a stationary situation

### *2.2.3 On Vehicle Calibration*

In a stationary situation (vehicle is not moving) while measuring on structured surfaces (such as soil) the output distances may shift over time, due to slight changes in position due to vibration and varying radar wave interference. For on-machine calibration purposes a flat surface of adequate size (e.g. larger than 1200mm by 1200mm) with good radar reflection, and with its geometric centre lined up with the sensor centre axis must be used to avoid this effect and ensure a stable calibration procedure.

**NOTE**
For distance calibration on a vehicle a defined target must be used.

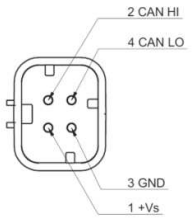
## 2.3 Electrical Integration

The sensor can be used on direct vehicle power for 12VDC nominal voltage systems, and 24VDC nominal voltage systems in the range +VS = 9VDC … 32VDC. A centralized load dump suppression (35V at 12VDC, and 58V at 24VDC nominal voltage respectively) is required. The product shall not be used in the direct control and modification of the state of function of the machine. Please refer to the data sheet for information regarding operation during the engine start phase, and further technical details. Prior to electrical connection of the product the system must be down and not live. Do not exceed permissible bending radius of the cable. The device shall be appropriately protected by an external R/C or fuse. In an industrial environment the device shall be protected by an external R/C or listed fuse, rated max. 100W/Vp or max. 5A below 20VDC, and a UL class 2 power supply be used.

**Tab 3** Connector Pin-Out

| | |
|---|---|
| Connection type | Ampseal 16 4P (776536-1) |
| Mating connector | Ampseal 16 4P (776524-1) |

| Pin | Code | Description |
|---|---|---|
| 1 | +Vs | Positive Supply voltage (12VDC / 24VDC nominal) |
| 2 | CAN HI | CAN High |
| 3 | GND | Ground (supply voltage) |
| 4 | CAN LO | CAN Low |




This product may be used on vehicle power fulfilling these requirements:

**Tab 4** Vehicle Power Electrical Transients

| Test pulse (ISO 7637-2, ISO 16750-2) | 1 | 2a | 2b | 3a | 3b | 4 | 5b |
|---|---|---|---|---|---|---|---|
| Severity level | IV | III | IV | III | III | III | -- |
| Functional status (12 VDC vehicle power) | C | A | C | A | A | C | A |
| Functional status (24 VDC vehicle power) | C | A | C | A | A | C | A |

For test installations a cable with the order code 11213075 (ZCABL-ALL.AMP0300) may be used.

**CAUTION**
The product shall not be used in the direct control and modification of the state of function of the machine.

**CAUTION**
The product shall not be operated during engine start phase.

**ATTENTION**
The product shall not be used on machines without centralized load dump suppression.

**ATTENTION**
The product shall be appropriately protected by an extern fuse or R/C.

**NOTE**
For test installations a cable with the order code 11213075 (ZCABL-ALL.AMP0300) may be used.

## 2.4 Visual Diagnostic

High luminosity LEDs provide quick feedback on the operational status of the sensor. The LEDs are positioned behind the radar lens and may be observed even under bright ambient light. The following table indicates sensor status and LED blink codes.

**Tab 5** Status Mapping (Visual Diagnostic)

| Status | Code |
|---|---|
| Sensor fully operational (object detected) | 100ms Green LED ON<br>400ms LED OFF |
| Sensor fully operational, (no object detected) | Green LED as above, with additional<br>100ms Yellow LED ON in “LED OFF” interval |
| Hardware fault | 50ms Red LED ON<br>50ms LED OFF |
| CAN Bus Off (malfunction) | 50ms Magenta LED ON<br>150ms LED OFF |
| Address claim failed | 50ms Magenta LED ON<br>50ms LED OFF |
| Waiting for Master ECU address claim | 500ms Magenta LED ON<br>500ms LED OFF |
| Other | Blue LED |



## 2.5 CAN Interface (Physical Layer)

The CAN physical layer is according to SAE J1939-15 (reduced physical layer). Some base parameters are shown in the table below.

**Tab 6** CAN Interface

| Parameter | Value |
|---|---|
| Bus Speed | 250 kbit / sec (1) |
| Bus Termination | External termination |
| Bus Voltage | 5V |
| Wiring | Unshielded twisted pair (UTP) |
| Cable impedance | 120 Ohm (+/- 10%) |

(1) may be customized to 500 kbit/sec for customer specific versions.

The bus termination resistor is not included in the device. The bus setup is shown in the figure below:

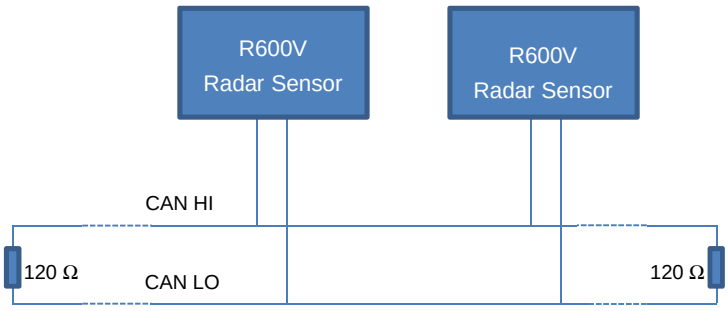



**Fig 8** CAN connection setup diagram

For further information please refer to the CAN Protocol chapter.

# 3 CAN Protocol

The physical layer of the 2-wire interface is specified according to SAE J1939-15. The wires are protected against short-circuit.

The implementation of the protocol stack follows the SAE J1939 standards and is visualized in the OSI network model as follows:

**Tab 7** SAE J1939 in the OSI reference model

| OSI Layer | Implementation | Network Management |
|---|---|---|
| Application Layer | SAE J1939-71 (Vehicle)<br>SAE J1939-73 (Diagnostic) | SAE J1939-81 |
| Presentation | N/A | |
| Session | N/A | |
| Transportation Layer | SAE J1939-21<br>(Data Link Layer) | |
| Network Layer | SAE J1939-31 | |
| Data Link Layer | SAE J1939-21 | |
| Physical Layer | SAE J1939-14<br>SAE J1939-15 | |

Not all functions listed in the referenced standards have been implemented. The following chapters explain the extent and implemented functions.

DBC files can be downloaded from the respective product page on *www.baumer.com*.

## 3.1 ISO Name

| | |
|---|---|
| Manufacturer code | 343 (Baumer Group) |
| ECU instance | 0 |
| Function instance | 0 for R600V.DAE0-11188367<br>1 for R600V.DAE0-11209335 |
| Function | 0 |
| System | 0 |
| System instance | 0 |
| Industry group | 2 |
| Arbitration Capable | 1 |

## 3.2 Device address

### *3.2.1 Commanded address (PGN 0xFED8)*

Supported

### *3.2.2 Address Claim*

The device is arbitrary address capable.

Address range: 0x80...0xCF

Default address: 0x80

### *3.2.3 Address resolution sequence*

After reset, the device performs the following start-up sequence:

1. After initialization, send “request for address claimed” message (PGN 0xEE00)
    a. At initialization, initialize the radar sensor sort table with the own ISO name only
    b. Send a request for address claimed. This causes other devices on the bus to claim their addresses
2. Wait 1250 ms. During this time, incoming address claims are evaluated and the own device address is modified accordingly if necessary (e.g. when more than one radar sensors are present on the bus)
3. Send “address claimed” message
    a. Claim the own address, which is derived from the sort table. Address = 0x80 + index of own device name in table (2)
4. Wait 250 ms and handle address collisions.
5. Start transmitting the cyclic ground & canopy message.

(2) This means that, provided no new sensors are mounted, each sensor will end up with the same device address each time. However, if a new sensor is added to the system, addresses might shift up or down according to the new sort order

## 3.3 Supported PGN (Parameter Group Number)

### *3.3.1 ECU Identification Info*

| | |
|---|---|
| PGN: | 0xFDC5 |
| Direction: | Transmit |
| Transmission rate: | On PGN request only |

### *3.3.2 ECU Software Identification*

| | |
|---|---|
| PGN: | 0xFEDA |
| Direction: | Transmit |
| Transmission rate: | On PGN request only |

### *3.3.3 DM14 Memory access command message*

| | |
|---|---|
| PGN: | 0xD900 |
| Direction: | Receive |
| Transmission rate: | Random |

### *3.3.4 DM15 Memory access reply message*

| | |
|---|---|
| PGN: | 0xD800 |
| Direction: | Transmit |
| Transmission rate: | Reply to DM14 command message |

### *3.3.5 DM16 Memory access binary data*

| | |
|---|---|
| PGN: | 0xD700 |
| Direction: | Transmit/receive |
| Transmission rate: | When needed |

### *3.3.6 Ground & Canopy Message*

| | |
|---|---|
| PGN: | 0xC000 |
| Direction: | Transmit |
| Transmission rate: | 50ms |
| Source address: | Sensor address |
| Destination address: | Broadcast (0xff) |
| Initial delay after start-up sequence: | 200ms |

All values are in little endian format. Bit1 of byte 1 = LSB of first byte

**Tab 8** Ground & Canopy Message

| Start bit | Bits | Offset | Scaling | Description |
|---|---|---|---|---|
| 1 | 2 | 0 | 1 | Sensor status<br>0 = No error<br>1 = Reversible error. (e.g. temperature too high)<br>2 = Irreversible error. Sensor measurement not available |
| 3 | 7 | 0 | 1% | Canopy confidence (3)<br>Value 0…100% (higher confidence = detection of canopy better) |
| 10 | 7 | 0 | 1% | Ground confidence (3)<br>Value 0…100% (higher confidence = detection of ground better) |
| 17 | 16 | 0 | 1mm | Canopy distance |
| 33 | 16 | 0 | 1mm | Ground distance |
| 49 | 16 | 32768 | 1 | Reserved for future use: Value fixed to 0xffff |

(3) The ground and canopy confidence values are independent, relative measures for ground and canopy distance. 80% confidence for ground means something else than 80% for canopy. Signal strength, the number of targets detected, and the history of ground and canopy distance are considered to determine this value. The confidence values are an indication only. Thresholds for decisions made on the controller / system level need to be determined through application testing.

### *3.3.7 Vehicle Speed Message (reserved)*

| | |
|---|---|
| PGN: | 0xC100 |
| PDU Type: | PDU1 |
| Direction: | Receive |
| Reception address: | Broadcast or device address |
| Reception rate: | < 1000ms |

This message may be used in future versions of the product to inform the sensor of the current vehicle speed. This message is optional; the device is able to perform its basic functionality without speed information.

All values are in little endian format. Bit1 of byte 1 = LSB of first byte

**Tab 9** Vehicle Speed Message (future use only)

| Start bit | Bits | Offset | Scaling | Description |
|---|---|---|---|---|
| 1 | 16 | 0 | 1 | Vehicle speed [mm/s] |
| 17 | 1 | 0 | 1 | Sign (0/1 = forward/reverse) |
| 18 | 48 | 0 | 1 | Don't care |

## 3.4 Sensor Configuration

A number of sensor parameters can be read and written over the CAN bus using the J1939 memory access (MA) protocol.

User level for access = 1

Key for access is equal to the seed generated by the device.

All addresses are direct spatial (is pointer)

The access is similar to the SPN space. Each parameter has an individual size.

The tool shall issue a read or write command with a memory length of 1 (one).

In its “proceed” reply, the device returns the actual number of bytes to be used for the transfer.

All parameters are volatile, they assume their default values after each reset.

### *3.4.1 Tool ISO name acceptance criteria*

The sensor accepts MA sessions from any tool that fulfils all of the following criteria:

- ISO name Function field = 129
- ISO name Industry group field = 0

### *3.4.2 Adjustable Parameters*

The following parameters are available for adjustment:

**Tab 10** Adjustable Parameters

| Address | Parameter | range | offset | scaling | Default value |
|---|---|---|---|---|---|
| | | **LED settings** | | | |
| 0x07DFAA | Green LED duty cycle | 0..100 | 0 | 1% | N/A (4) |
| 0x07DFAB | Green LED period | 0..255 | 0 | 100ms | N/A (4) |
| 0x07DFAC | Red LED duty cycle | 0..100 | 0 | 1% | N/A (4) |
| 0x07DFAD | Red LED period | 0..255 | 0 | 100ms | N/A (4) |
| 0x07DFAE | Blue LED duty cycle | 0..100 | 0 | 1% | N/A (4) |
| 0x07DFAF | Blue LED period | 0..255 | 0 | 100ms | N/A (4) |
| | | **Measurement Settings** | | | |
| 0x07E388 | Detection range end (5) | 200..6000 | 0 | 1mm | 6000 |
| 0x07E389 | Detection range start (5) | 200..6000 | 0 | 1mm | 200 |
| | | **CAN Settings** | | | |
| 0x07E38A | Data PGN transmit period | 10..1000 | 0 | 1ms | 50 |

(4) LED default values depend on the current state

(5) Detection range can be adjusted to avoid issues with double echo detections.

# 4 Trouble Shooting

**Tab 11** Trouble Shooting Overview

| Failure | Action |
|---|---|
| No function, no LED | Check cables, connections, power supply at pins |
| Function impaired, thick layer of dirt | Clean lens and remove excess water. |
| Mechanical damage to housing and/or lens | Replace part by qualified personnel. |
| Unexplained targets / distance measurement in near range | Check free space (or beyond) for non-stationary objects (such as dangling wires, tubes, water drops on surfaces. |
| Unexplained targets / distance measurement in far range | Check for double reflections, and limit measurement range |
| The LED is blinking red (50ms on / 50ms off) | Hardware fault. Replace part by qualified personnel |
| The LED is blinking magenta | CAN bus error. Check Tab 5 for details. |
| The LED is blinking blue for a long period. | Try a power cycle. If this does not fix the issue replace part by qualified personnel |
| No communication (also magenta blinking) | Check CAN speed (e.g. 250kbit/sec), check 120Ohm termination, |

# 5 Accessories

The following accessories are available for this product

**Tab 12** Accessories

| Art. no. | Description | Type | Comment |
|---|---|---|---|
| 11213075 | ZCABL-ALL.AMP0300 | Connector AMPSEAL 16 with PUR-cable | 3m cable with AMPSEAL connector and fly-leads |

# 6 Appendix

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## 6.3 Definitions and Abbreviations

The following definitions and abbreviations are used throughout this manual

**Tab 13** Definitions and Abbreviations

| Key | Definition |
|---|---|
| CAN | Controller Area Network |
| DAB | Data Sheet |
| DM | Direct Memory |
| ECU | Electronic Control Unit |
| ISO | International Standardization Organization |
| LED | Light Emitting Device |
| MA | Memory Access |
| OEM | Original Equipment Manufacturer |
| OSI | Open Systems Interconnection |
| PDU | Protocol Data Unit |
| PGN | Parameter Group Number |
| SAE | Society of Automotive Engineers |
| TLD | Top Level Drawing |
| VDC | Volt Direct Current |

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# 8 Document Revision History

**Tab 14** Document revision history

| Vers. | Date | Note | Author | Checked | Released |
|---|---|---|---|---|---|
| 0.5 | 29 Oct 2019 | Technical review | wemi | tip, matts, rma, erv | N/A |
| 1.0 | 15 Nov 2019 | Initial Release | wemi | lph, sfri | N/A |
| 1.01 | 28 Nov 2019 | Fix addresses for settings | wemi | N/A | N/A |
| 1.1 | 29 Nov 2019 | Align with other documents | wemi | N/A | N/A |

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