uRAD SMART RADAR SENSOR

Velocity and Distance Control of Multiple Vehicles



USER MANUAL

Product

Hardware: uRAD Smart Radar Sensor v2.0

Firmware: Velocity and distance control of multiple vehicles v3.0

Manufacturer

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1. PRODUCT DESCRIPTION

Technical Specifications

RF parameters	
Frequency	60 – 64 GHz (uRAD Industrial)
Modulation	FMCW
Emitting power	15 dBm
Field of view	160º

Power supply	
Voltage	8 – 42V DC
Consumption	2 W

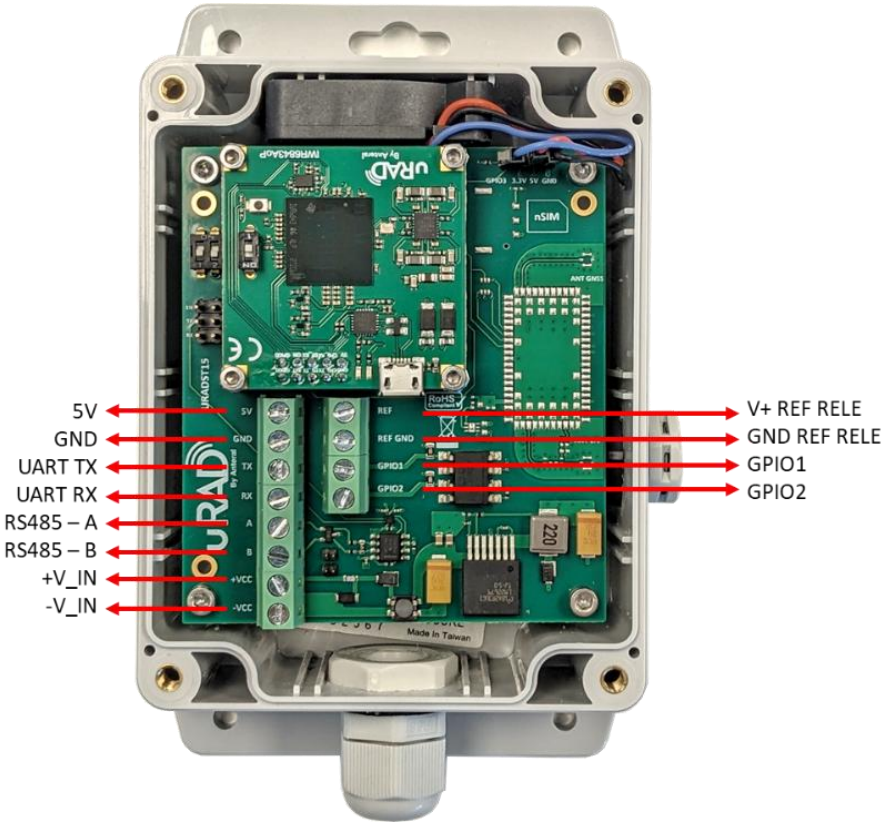
Mechanical parameters	
PCB Dimensions	85 x 76 x 20 mm
PCB Weight	50 g
Dimensions with box	115 x 90 x 65 mm
Weight with box and anchorage	560 g
Box protection	Polycarbonate, IP66, NEMA 1,2,4,4X,12,13, UL-508
Connector	Cable gland
Installation	Box, anchorage and clamps are optional

Other parameters	
Communication interface	RS-485, UART, 2 x GPIO optocoupled Wi-Fi (installation and configuration)
Protocol	Customized (depends on the application)
Core processor	Xtensa dual-core 32-bit, 240 MHz, 8MB Flash
Operating temperature	-20ºC to +80ºC

Performance	
Maximum velocity	180 km/h
Maximum distance	100 m
Lateral distance	±15 m

Components

The device is supplied with or without a case. The user must make the relevant connections on the PCB connector.

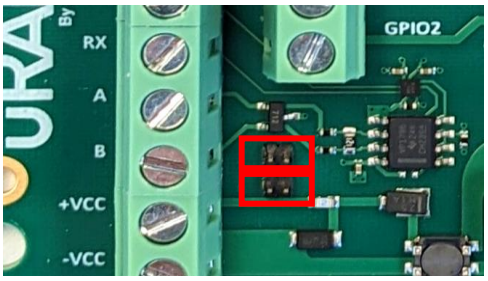


Connections

- +V_IN: Positive DC supply voltage. Must be between +8 and +42 V.
- -V_IN: DC supply voltage ground.
- RS485 – A: Differential line A of the RS-485 interface. 120 Ω terminating resistor. Common-mode voltage up to ±15V
- RS485 – B: Differential line B of the RS-485 interface. 120 Ω terminating resistor. Common-mode voltage up to ±15V
- UART TX: UART transmission lines with TTL voltage 0 – 3.3V.
- UART RX: UART transmission lines with TTL voltage 0 – 3.3V.
- GND: digital ground and 3.3V and 5V voltages.
- 5V: 5V output when powered by +V_IN. The device can also be powered with +5V on this connection.

The data sent via UART and via RS485 is the same. However, the device does not operate in both modes simultaneously. The mode is controlled by short-circuiting or not short-circuiting the two 1x2 1.27 mm male connectors.

- UART: connectors left open, with no jumper between them.
- RS-485: connectors short-circuited with two jumpers.



The device has two “cold” or relay outputs via an optocoupler. It is necessary to apply the desired voltages of these outputs to the connections.

- V+ REF RELAY: positive reference voltage for the optocoupled outputs. Maximum voltage 35V.
- GND REF RELAY: negative voltage or reference ground for the optocoupled outputs.
- GPIO1: Optocoupled output that is activated according to the programmed function.
- GPIO2: Optocoupled output that is activated according to the programmed function.

For example, you can connect (V+ REF RELAY <-> 5 V) and (GND REF RELAY <-> GND) to have outputs between 0 – 5V.





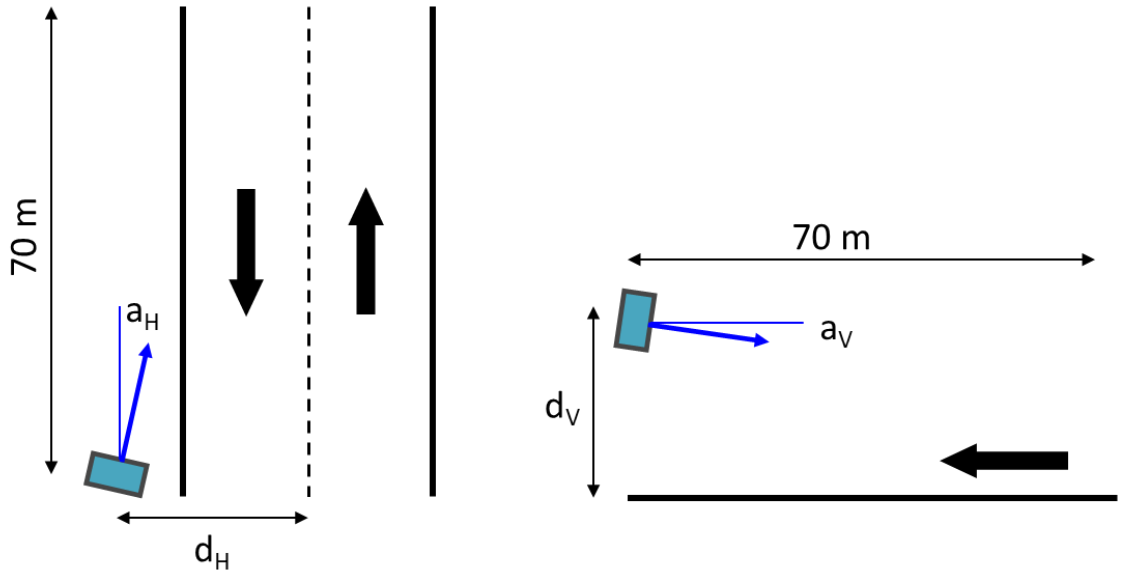
An optional mounting structure can be purchased to install the device outdoors on cylindrical columns. The central joint has a screw that allows fixing the necessary tilt angle during installation. Clamps are also included with the structure.

2. DEVICE PLACEMENT

The device must be placed so that the micro-USB connector is facing downwards.

The device can be placed on the side of the road at a slight angle so that the radar generally points to the centre of the road at a distance of about 70 meters. It can be placed on either the left or right side of the road.

Depending on the horizontal distance from the road and the placement height, the horizontal and vertical inclinations must be as follows.



$$a_H = \tan^{-1}\frac{d_H}{70}$$

$$a_V = \tan^{-1}\frac{d_V}{70}$$

Similarly, the device can be placed above the roadway, on porticos, walkways, traffic lights. The recommendation is the same, aim at the centre of the roadway at a distance of 70 meters.

3. START-UP

The device creates a hidden Wi-Fi network that allows the user to connect with a computer or mobile device to perform various tasks:

- Configure installation parameters.
- View detections in real time.
- Configure Wi-Fi network credentials.
- Update the device firmware.

The SSID is hidden, so you must search for it manually. Since the network access parameters are standardized for all devices, updating the credentials during the first use is a critical security step. This ensures compliance with device protection standards and prevents unauthorized access.

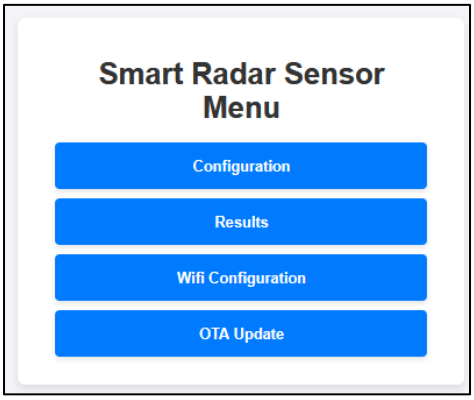
The factory credentials are:

- SSID: uRAD_SmartTraffic
- Password: uRAD_SmartTraffic

Once connected to the device's Wi-Fi network, access the following address using the browser:

http://192.168.4.1/

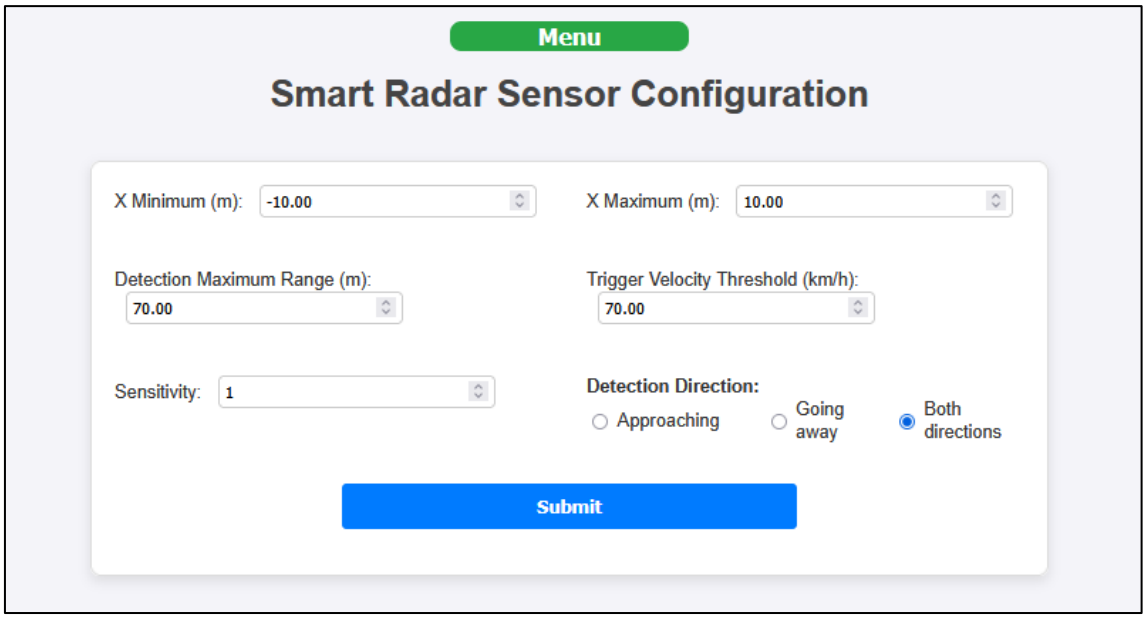
You will access the following main screen where you can also access the different functions.



For security reasons, after 10 minutes, the device stops creating the Wi-Fi access point if no one connects to it. To recreate the access point, the device must be restarted.

Configuration Parameters

From the main tab, clicking the Configuration button redirects to the address http://192.168.4.1/config, which opens the tab for configuring the setup parameters.



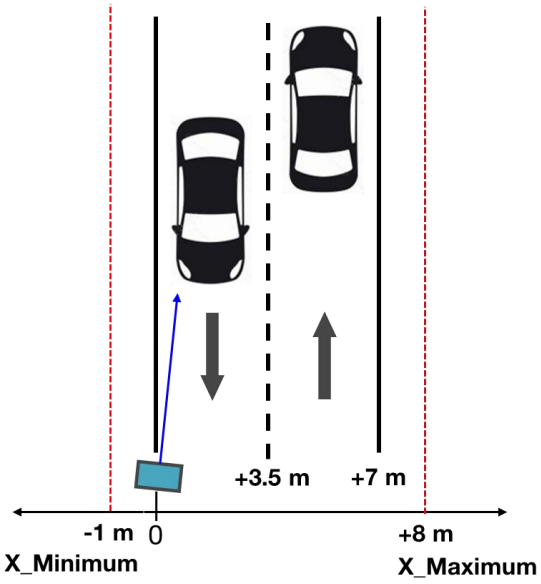
The display shows the configuration parameters saved in the device's permanent memory. To apply any changes, click the Submit button. At power-up or at each restart, the device loads the values saved in the permanent memory.

The configuration parameters are as follows:

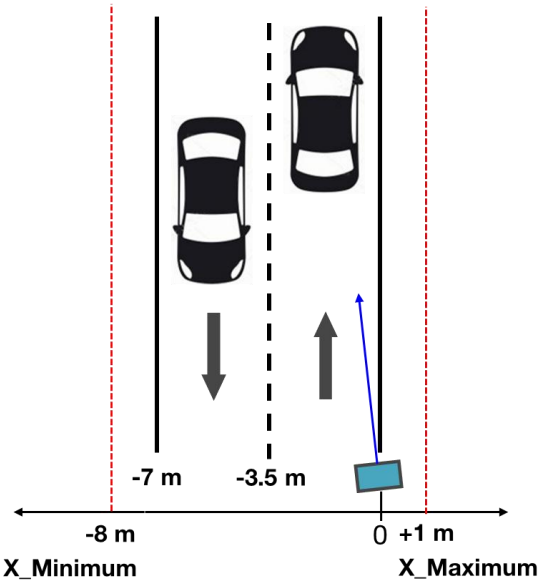
- X Minimum (m): minimum distance in meters in the horizontal direction that you want to consider to detect vehicles. It is advisable to give 1 extra meter of margin.
- X Maximum (m): maximum distance in meters in the horizontal direction that you want to consider to detect vehicles. It is advisable to give 1 extra meter of margin.
- Detection Maximum Range (m): maximum distance in meters at which vehicles begin to be detected.
- Trigger Velocity Threshold (km/h): This parameter sets the velocity limit in km/h above which a detected vehicle triggers the output signals. If the detected velocity exceeds this limit, the GPIO1 signal is set to a high level for positive velocities, and the GPIO2 signal is set to a high level for negative velocities.
- Sensitivity: Allows the sensitivity to be adjusted across 5 values. 1 is the most sensitive setting and 5 is the least sensitive.
- Detection Direction: allows the user to detect only vehicles approaching the radar, going away from the radar or in both directions.

When the device is turned on or restarted, it automatically starts measuring with the saved settings.

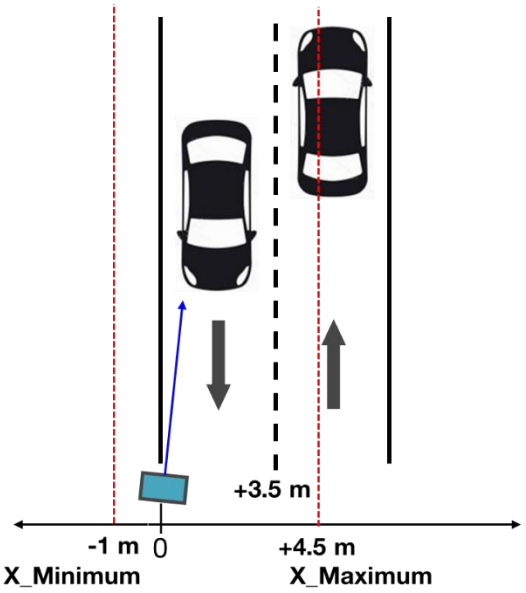
Take a look at the following use case examples.



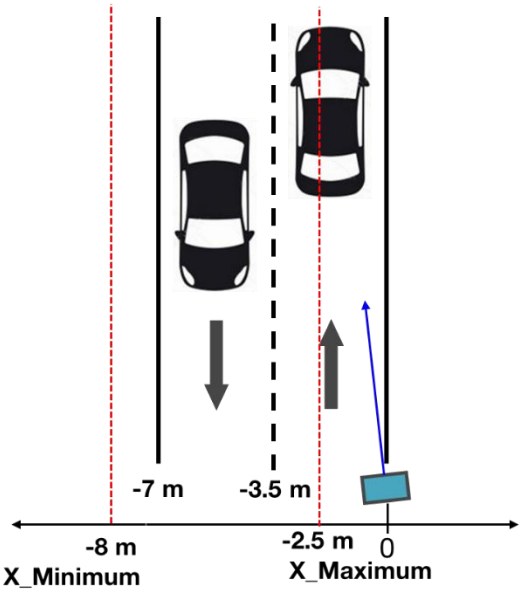
X Minimum = -1
X Maximum = +8
Both directions



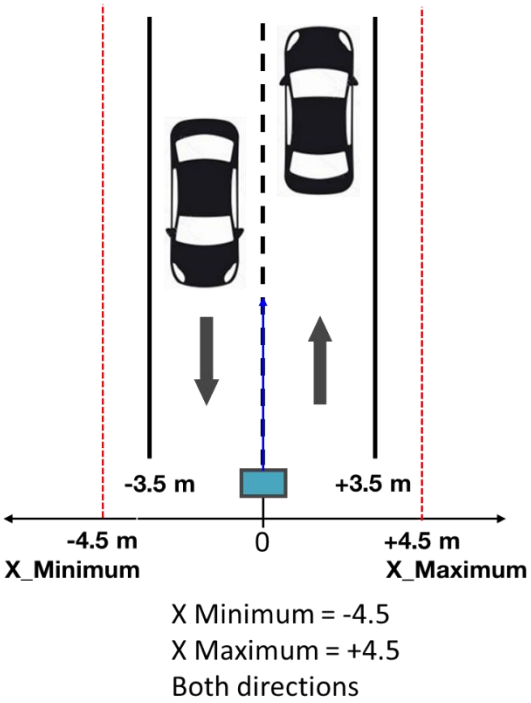
X Minimum = -8
X Maximum = +1
Both directions



X Minimum = -1
X Maximum = +4.5
Approaching

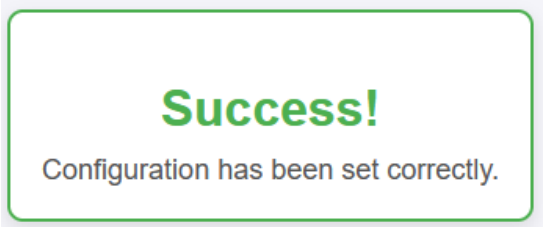


X Minimum = -8
X Maximum = -2.5
Approaching



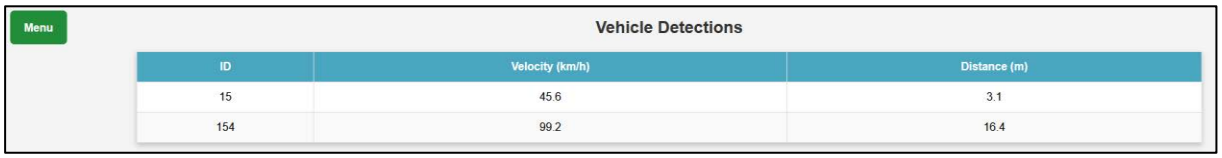
To apply any changes, click the Submit button.

If the changes have been applied successfully, a confirmation message appears.



Results Visualization

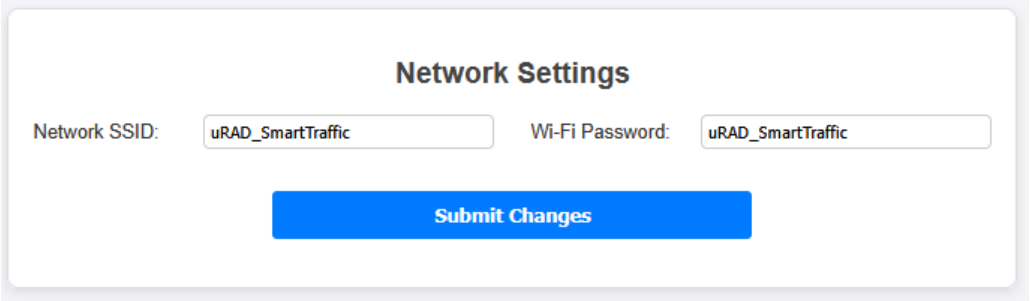
From the main tab, clicking the Show Results button redirects to http://192.168.4.1/results, which opens the tab where real-time detections can be viewed.



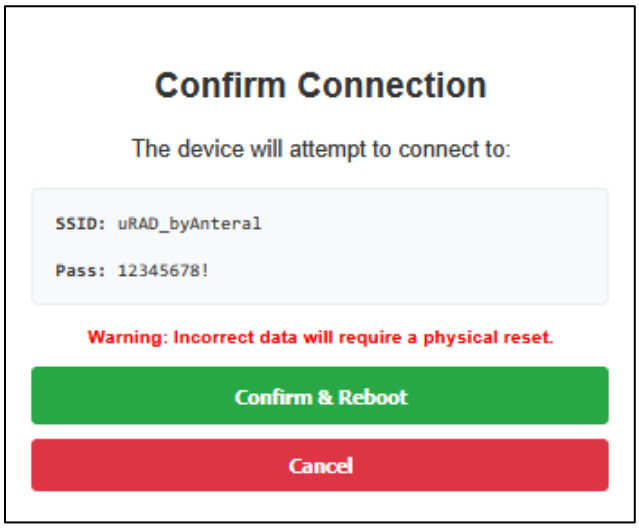
This tab allows users to verify the proper functioning of the device.

Network Credentials Configuration

From the main tab, by clicking the Wifi Configuration button, you can access the address http://192.168.4.1/configwifi, which displays the page where Wi-Fi credentials can be modified.



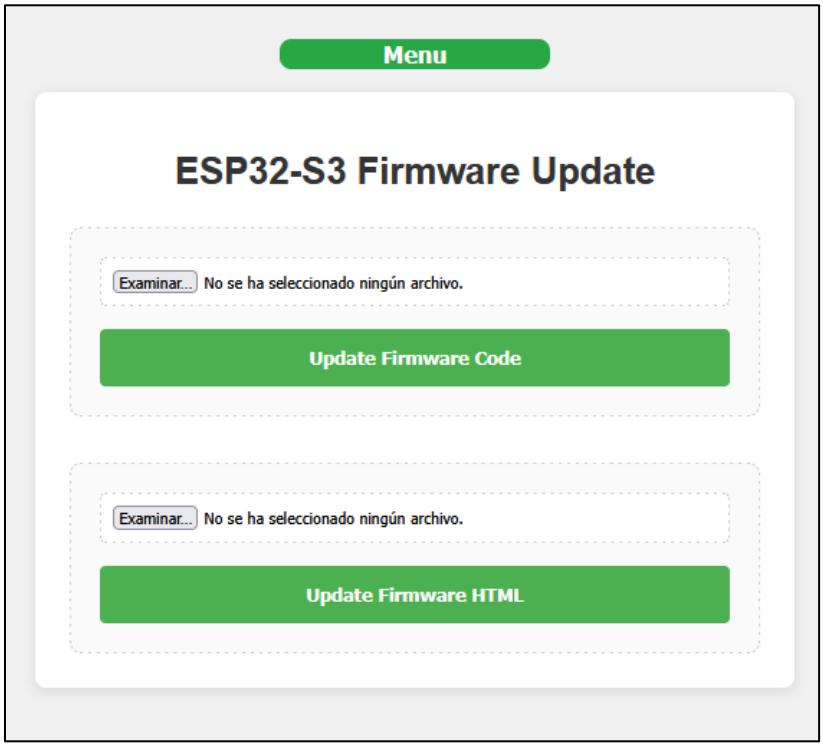
Through this interface, you can define a new SSID (Network Name) and a new Password for the device's access point. Once the data is entered and you click the Submit Changes button, the system will display a confirmation screen to verify that the entered characters are correct.



ATTENTION: This procedure is irreversible via remote access. Since the SSID operates in hidden mode, any typing error in the network name or the loss of the new password will prevent future access to the device. In the event of losing access due to incorrect credentials, technical intervention will be required to perform a physical firmware flash.

Upload New Firmware

From the main tab, clicking the OTA Update button redirects to http://192.168.4.1/update, which opens the tab for uploading new firmware to the device.



The update window displays two different options:

- Update Firmware Code: Updates the device's internal program; i.e., the firmware that controls the radar's operation.
- Update Firmware HTML: Updates only the web interface (what is displayed in the browser).

When an update is required, the specific option that needs to be updated will be indicated.

4. OPERATION

Communication protocol

Communication is done through the device's Serial connector and is configured as follows:

- Baud rate: 115200 bps
- Format: 8 data bits and 1 stop bit
- Parity: None
- Packet Base: Base 0
- Byte encoding: Big Endian
- Voltage: TTL 0 – 3.3 V (UART); Differential half-duplex with common-mode voltage up to ±15V (RS485).

Detection Readings

The device transmits the list of detected vehicles, along with their velocities and distances, every 0.1 seconds. Positive and negative velocities correspond to vehicles moving away from and approaching the device, respectively.

At each instance, a packet is sent with the following structure:

Name	Header		Packet length	Number of vehicles	Info vehicle 1	Info vehicle N	Checksum	Tail	
Length	2 bytes		1 byte	1 byte	10 bytes	10 bytes	2 bytes	2 bytes	
Constant value	117	82						65	68

The Header and Tail fields always have constant values. The Packet length field represents the total number of bytes in the packet. The Checksum value is the sum of all bytes in the packet.

After the Number of vehicles field, the information for the N vehicles is included.

For each vehicle, the following data is provided:

- Identifier: a unique identifier with a maximum value of 65000 (it resets to 0 afterward).
- Velocity: measured in km/h.
- Distance: the distance of the vehicle relative to the radar.

When a vehicle reaches 10 meters, the transmitted velocity remains constant until the vehicle passes the radar. This is because velocity measurement becomes less

accurate due to the radar's pointing angle. The distance measurement remains accurate up to 10 meters, and from 10 meters to 0 meters, the distance is estimated based on the vehicle’s velocity.

The format of the information per vehicle is as follows:

Name	ID	Velocity	Distance
Length	2 bytes	4 bytes	4 bytes
Type	Unsigned short	Float	Float

Detection Readings Example

Two vehicles are detected.

- The first one is detected at a velocity of 25.6 km/h at a distance of 31.9 m.
- The second one is detected at a velocity of -40.5 km/h at a distance of 15.4 m.

The packet format is as follows:

Name	Header		Packet length	Number of vehicles	Vehicle ID 1		Speed vehicle 1			
Desired value	117	82	28	2	270		25.60			
Value in bytes	117	82	28	2	1	14	65	204	204	205

Name	Vehicle distance 1				ID Vehicle 2		Speed vehicle 2				Vehicle distance 2			
Desired value	31.9				271		-40.5				15.4			
Value in bytes	65	255	51	51	1	15	194	34	0	0	65	118	102	102

Name	Checksum		Tail	
Desired value	2108		65	68
Value in bytes	8	60	65	68

Additionally, the device sets GPIO1 high when the detected positive velocity (vehicles moving away) exceeds the velocity limit set in the configuration and sets

GPIO2 high when the detected negative velocity (vehicles approaching) exceeds (in absolute value) the velocity limit set in the configuration. The velocity limit value is the same for both directions of travel.

Configuration Using Commands

In addition to configuring parameters using the web interface, it is possible to adjust the various parameters through the device's serial communication, following the same communication model used to transmit vehicle detections.

The parameter configuration packet always has a fixed length of 13 bytes with the following format:

Name	Header		Packet length	Action code	Action value	Checksum	Tail	
Length	2 bytes		1 byte	2 bytes	4 bytes	2 bytes	2 bytes	
Constant value	124	75	13				65	68

The Header, Packet Length, and Tail fields always contain constant values. It is important to note that the header values differs from those in the vehicle detection packets; this distinction specifically identifies the packet as a configuration change action.

The Checksum value is the sum of all bytes in the packet.

If the action to be performed has a defined scale factor, the desired value must be multiplied by this factor before including it in the packet's byte field. For example, to set the x_min value to 8.1, the value 81 must be sent.

The response packet always has a fixed length of 7 bytes, using the following format:

Name	Header		Response Code	Checksum	Tail	
Length	2 bytes		1 byte	2 bytes	2 bytes	
Constant value	124	75			65	68

The response code will be 0 if the action was processed successfully, and non-zero in the event of an invalid request (action value out of the permitted range, non-existent action code, etc.).

Error Codes:

- 1 = Invalid CRC.
- 2 = Invalid action code.
- 3 = Action value out of range.

Control and Configuration Actions

1. Radar start

Description	Initializes the radar
Code	0
Possible Values	1
Default Value	The radar initializes when the device starts

2. Radar stop

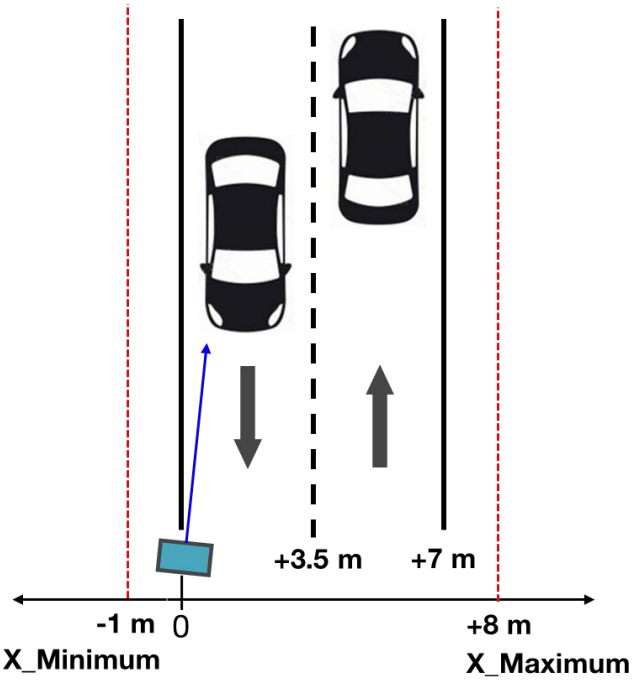
Description	Stops the radar
Code	1
Possible Values	1
Default Value	The radar initializes when the device starts

3. Set minimum X-axis limit

Description	Defines the minimum horizontal distance (in meters) considered for detection
Code	2
Possible Values	-200 to 200
Default Value	-100
Scale Factor	10

4. Set maximum X-axis limit

Description	Defines the maximum horizontal distance (in meters) considered for detection
Code	3
Possible Values	-200 to 200
Default Value	100
Scale Factor	10



In this example, the radar is positioned to the left of the road. The 0 point always corresponds to the radar's position. The configuration is set to 1 meter to the left of the radar (X Minimum = -1) and 8 meters to the right of the radar to monitor both lanes (X Maximum = +8). Due to the scale factor, the values sent via the protocol must be X Minimum = -10 and X Maximum = 80.

It is always recommended to allow a 1-meter margin on each side of the desired monitoring zone.

5. Sensitivity configuration

Description	Configures the sensitivity level
Code	4
Possible Values	1 to 5
Default Value	1

6. Maximum detection distance configuration

Description	Configures the maximum distance (in meters) at which vehicles begin to be detected
Code	5
Possible Values	0 to 1500
Default Value	700
Scale Factor	10

7. Configure GPIO trigger velocity treshold

Description	Configures the velocity limit (in km/h) above which any detected vehicle triggers the GPIO1 and GPIO2 signals to a high level
Code	6
Possible Values	0 to 1500
Default Value	700
Scale Factor	10

8. Modify detection direction

Description	Allows modification of the vehicle detection direction
Code	7
Possible Values	1: Detect only approaching vehicles (Approaching) 2: Detect only vehicles moving away (Going Away) 3: Detect in both directions (Both directions)
Default Value	3

Configuration Write Example

To execute action 3 (setting the maximum X-axis detection distance to 11 meters), the packet to be sent is as follows:

Name	Header		Packet length	Action code		Action value				Checksum		Tail	
Length	2 bytes		1 byte	2 bytes		4 bytes				2 bytes		2 bytes	
Desired Value	124	75	13	3		110				458		65	68
Byte Value	124	75	13	0	3	0	0	0	110	1	202	65	68

If the action is successfully executed, the response packet is:

Name	Header		Response code	Checksum		Tail	
Length	2 bytes		1 byte	2 bytes		2 bytes	
Received Byte Value	124	75	0	1	76	65	68

Reading Configuration Parameters

Just as device configuration can be modified using commands, it is also possible to request the current values of the various parameters.

The request packet format is identical to that of the configuration packets, maintaining the fixed length of 13 bytes and the same field structure. The only difference lies in the Header values, which identify this packet specifically as an information read request.

Name	Header		Packet length	Action code	Action value	Checksum	Tail	
Length	2 bytes		1 byte	2 bytes	4 bytes	2 bytes	2 bytes	
Constant value	120	90	13				65	68

The Action code field must contain the numeric code corresponding to the parameter whose current value is requested. These codes are detailed below. The Action value field is not used in this operation; therefore, it can be set to any value.

Action Code	Requested Value
2	Minimum X-Axis Limit
3	Maximum X-Axis Limit
4	Sensitivity
5	Maximum Detection Distance
6	GPIO Trigger Velocity Treshold
7	Detection Direction

The Checksum value is the sum of all bytes in the packet.

The response packet always has a fixed length of 11 bytes, using the following format. The requested configuration is returned in the Response value field.

The Response value is encoded in the same way as in parameter configuration. Response value indicates 0 if the request is invalid and 1 if it is valid.

Name	Header		Response code	Response value	Checksum	Tail	
Length	2 bytes		1 byte	4 bytes	2 bytes	2 bytes	
Constant Value	120	90				65	68

Reading Configuration Parameter Example

To request the current value of the maximum detection distance, the request packet is as follows:

Name	Header		Packet length	Action code		Action value				Checksum		Tail	
Length	2 bytes		1 byte	2 bytes		4 bytes				2 bytes		2 bytes	
Desired Value	120	90	13	5		0				361		65	68
Byte Value	120	90	13	0	5	0	0	0	0	1	105	65	68

The response packet obtained is as follows:

Name	Header		Response code	Response value				Checksum		Tail	
Length	2 bytes		1 byte	4 bytes				2 bytes		2 bytes	
Byte Value	120	90	1	0	0	3	102	1	193	65	68
Decimal Value	120	90	1	870				449		65	68

5. SAFETY AND HANDLING

This chapter includes important safety and handling information for uRAD device.

Read all safety and handling information below as well as the operating instructions before using uRAD products in order to avoid any injury or damage.

Keep this user guide on hand for future reference.

Important Safety Information



WARNING: Failure to follow these safety instructions could result in fire, electric shock, or other injury or damage.

Proper handling uRAD contains sensitive electronic components. Do not drop, disassemble, crush, bend, deform, puncture, shred, microwave, incinerate, paint, or insert foreign objects into uRAD.

Water and wet locations Do not expose any sensitive components of uRAD to water or rain, or handled near washbasins or other wet locations without a proper case. Take care not to spill any food or liquid on uRAD. In case uRAD gets wet, allow it to dry thoroughly before turning it on again. Do not attempt to dry uRAD with an external heat source, such as a microwave oven or hair dryer.

uRAD repairs Never attempt to repair or modify uRAD by yourself. Disassembling may cause damage that is not covered under the warranty. If uRAD is damaged, malfunctions, or comes in contact with liquid, contact us at contact@urad.es .

Radio frequency interference Observe signs and notices that prohibit or restrict the use of radio frequency devices. Emissions from uRAD can negatively affect the operation of other radio frequency equipment operating in the same frequency band. Turn off uRAD when use is prohibited, such as traveling in aircraft, or when asked to do so by authorities.

Important Handling Information



WARNING: Failure to follow these handling instructions could result in damage to uRAD or other property.

Carrying uRAD contains sensitive electronic components. Don't bend, drop or crush it.

Cleaning To clean use a soft lint-free tip and isopropyl alcohol. Dust can be removed with compressed air of low power.

Plugging Never force the connectors or apply excessive pressure because this may cause damage that is not covered under the warranty. Check for obstructions.

Operating Temperature Keeping uRAD within acceptable temperatures. uRAD components operate from -40ºC to 85ºC but we recommend operates uRAD in the range from -20ºC to 65ºC.

Disposal and Recycling Information Your uRAD must be disposed of properly according to local laws and regulations. Because this product contains electrical components, the product must be disposed of separately from household waste. Contact your local authorities to learn about recycling options.

6. PRODUCT WARRANTY

Manufacturing

All components and solder alloys used in this product comply with the RoHS Directive. The RoHS Directive prevents all new electrical and electronic equipment placed on the market in the European Economic Area from containing more than agreed levels of lead, cadmium, mercury, hexavalent chromium, poly-brominated biphenyls (PBB) and poly-brominated diphenyl ethers (PBDE).).

Certification

uRAD Industrial module is CE marked under EU-Type examination certificate n. 803416897303 and fulfills with the corresponding directives:

- RED Article 3.1 (a): Health and Safety of the User

  Test EN 62368-1: 2014 +AC: 2015 Safety

  Test EN 62311:2008 - EMF Human exposure
- RED Article 3.1 (b): Electromagnetic compatibility

  Test EN 301 489-3 V2.1.1 EMC Short-Range Devices SRD
- RED Article 3.2 :Effective use of spectrum allocated

  Test EN 305 550-2 V1.2.1_Radio equip. 40GHz to 246GHz
- Notified body

  EU-Type Examination Certificate RED - NB 2559 (en)
- RoHS

  Test EN 63000: 2018 RoHS documentary assessment

Testing

Each uRAD shield is subject to strict tests to make sure they are not faulty:

- First , it is thoroughly tested for short circuits and open connections.
- Second, it is powered to check there are no over-range voltage.
- Then, the microcontroller is programmed and debugged.
- Finally, the board is plugged in a computer and several test programs are run to check its overall functionality.

Limited Warranty Statement

IMPORTANT: BY USING uRAD PRODUCTS YOU ARE AGREEING TO BE BOUNDED BY THE TERMS OF THIS LIMITED WARRANTY STATEMENT. DO NOT USE YOUR PRODUCTS UNTIL YOU HAVE READ THE TERMS OF THE

WARRANTY. IF YOU DO NOT AGREE TO THE TERMS OF WARRANTY, DO NOT USE THE PRODUCTS AND RETURN THEM. THIS LIMITED WARRANTY IS THE END-USER'S SOLE AND EXCLUSIVE REMEDY AGAINST uRAD, WHERE PERMITTED BY LAW.

1. Warranties

1.1 uRAD warrants that its products will conform to the specifications detailed in the corresponding datasheet. Warranty lasts for 1 year from the date of sale if the shield is bought outside the EU and last for 2 years if bought in the EU. uRAD shall not be liable for any defects that are caused by neglect, misuse or mistreatment, including any products that have been altered or modified in any way by the Customer.

1.2 If any uRAD product fails to conform to the warranty set forth above, uRAD's sole liability shall be to replace or repair such products. uRAD's liability shall be limited to products that are determined by uRAD not to conform to such warranty. If uRAD elects to replace or repair such products, uRAD shall be given a reasonable time to provide replacements. Replaced or repaired products shall be warranted for a new full warranty period.

1.3 The Customer agrees not to use uRAD products for any applications or in any components used in life support devices or to operate nuclear facilities or for use in other mission-critical applications or components where human life or property may be at stake. The Customer acknowledges and agrees that any such use is solely at the Customer's risk, and that the Customer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

1.4 uRAD may provide technical, applications or design advice. The Customer acknowledges and agrees that providing these services shall not expand or otherwise alter uRAD's warranties, as set forth above, and that no additional obligations or liabilities shall arise from uRAD providing such services.

1.5 uRAD disclaims all other warranties, expressed or implied, regarding products, including, but not limited to, any implied warranties of merchantability or fitness for a particular purpose.

1.6 The Customer acknowledges and agrees that the Customer is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning the products and any use of uRAD products in the Customer's applications, not with-standing any applications-related information or support that may be provided by uRAD.

1.7 In no event shall uRAD be liable to the Customer or any third parties for any special, collateral, indirect, punitive, incidental, consequential or exemplary damages in connection with or arising out of the products provided hereunder, regardless of whether uRAD has been advised of the possibility of such damages. This section will survive the termination of the warranty period.

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