# *MANUAL FOR THE RADAR MODULE IN PUCK RADAR*

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Version

| Version | Date | By | Description |
|---|---|---|---|
| 0.9 | 2025-01-02 | MPn | NEW. Based on SweloT 1.5.2 |
| 0.9.1 | 2025-01-22 | Knut | NEW. Based on SweloT 1.5.2 |
| 0.9.2 | 2025-01-22 | Knut | NEW. Based on SweloT 2.2.1-12… |

# INTRODUCTION

This document describes how to start and configure the radar module in the Puck Radar device.

~~There are two security modes using the units, unsecure, the app is used to set parameters in the unit or secure, meaning the settings in the unit can't be changed without the user been authorized and the message to the unit signed with a unique unit-~~

key. The user and the device need to be registered in the SweloT Device Management system to keep the private keys safe, see section 3.

# CONFIGURATION

The commands & settings are applied using a mobile app or OTA over LoRaWAN.

## Commands

To communicate with device radar unit, use the commands in the table. The use of the commands is explained below.

| Command | Parameters | Description |
|---|---|---|
| version | | Returns current radar module firmware version |
| factory | | Resets all radar module settings to factory default |
| Mac | | Returns the radar module mac address |
| restart | | Restarts the radar module |
| sys:? | | Returns the system parameters, see section 4 |
| sys:[params] | see section 3.1 | Sets system parameters |
| x:? | | Returns the Methos parameters, see section 4 |
| x:[params] | see section 3.1 | Sets one or several settings for Method x |

## Settings

The position in the settings string determines which parameter the value belongs to.

There are two categories of parameters, generic parameters related to the **system** (sys), e.g.

- Selection of Method
- Bluetooth parameters
- Enabling the radar
- Etc

and parameters related to a selected Method (e.g. method 5 for parking), e.g.

- Measurement cycle
- Range

- Sensitivity level
- Etc.

For detailed information see section 3.1 System and Method parameters

**Example. Activate and deactivate the Radar**

It is possible to change a single parameter by omitting all parameters except the one to change as in this example to activate the sensor scan:

Activate

sys:,,,,,1

Deactivate

sys:,,,,,0

**Method settings**

The settings for different Methods can vary but the current settings can always be shown by using the ":?" option.

**Response**

All commands will return a string in which the first position indicates whether the operation was successful or not. A '=' means success and '*' means error.

**Example**

sys:3

sys:5,250,5,0,8,0

3:60

The first command will activate method 3. The second command will update all system parameters. The third command will change the measurement cycle for method 3 to 60 seconds. the number of samples setting (second in the list) is changed for method 0.

# METHODS

3: Well method.
The method will return the echo (distance and amplitude) at the largest distance within the measurement range and above the sensitivity level. Well suited for applications where it could be assumed that the echo at the largest distance is the correct object to measure. Any echo at closer distance will be neglected.

Examples of applications suited for the well method includes:

- Wells
- Septic tanks
- Snow level (Snow level = Distance to ground – Distance to snow)
- Water level (Water level = Reference ground level – Distance to water)

The method may return false values if the dominating radar echo originates from an unintended radar path such:

1. Radar reflections in the sidewall.
2. Radar echoes reflected in the sensor, the sensor mounting or any lid/construction above the sensor.
3. Radar echoes from the actual bottom of the well.

See picture 1 below.

Determine carefully the mounting position and range of your measurement to minimize the occurrence of false echoes. E.g.
- "Length of Range" < Distance from Puck Radar to the bottom of the well - 10 cm.
- Distance to the highest possible water level in the well should preferably be larger then ("Start of Range" + "Length of Range" )/2
- Position the device to avoid reflections in the side walls as in the left picture below.
- Pay attention to the environment around and above the device to minimize that the radar is reflected and bounces back. Avoid large reflective materials (metal etc).

In most cases, Pucl Radar with the narrow lens will perform better for these applications.
A radar beam forming lid with a round aperture can be purchased from Sensative to further the width of the radar beam and used with the Puck Radar narrow lens.

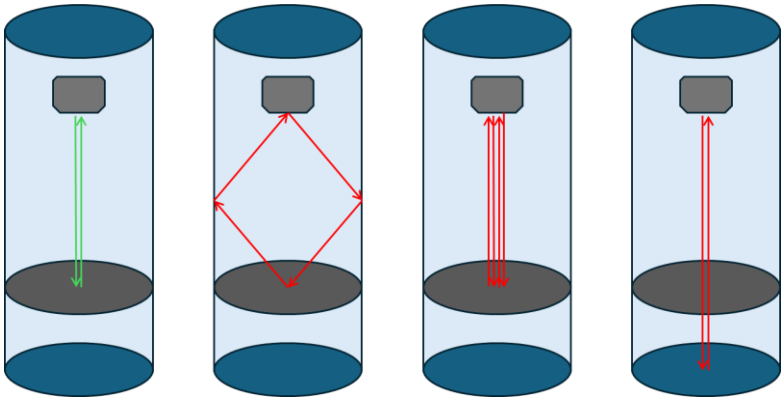

*Figure 1. Radar paths. Green shows the radar path to correctly measure the distance to the water level. Green shows the radar path to correctly measure the distance to the water level while the others show side reflections, double bounces and reflections of the bottom.*

Lägg till Median och adaptiv – beskrivningar

4: Bin method

The bin method will return the amplitude of the radar signal echo and the distance to the closest object with a radar echo amplitude above the threshold level. The method is well suited for detecting when it is time to empty a waste bin.

Puck Radar with a narrow lens is usually more suitable for bin applications.

Note that this method is very sensitive to echoes from any close objects. Very small echoes can be handled by increasing the threshold level. Random echoes in the near proximity like raindrops can be filtered out by increasing the average factor.

The sensor could be mounted above the waste bin to detect when it is full by measuring the distance to the nearest object with a reflection amplitude above the threshold level.

The sensor could also be mounted on one of the side walls of the container such that the radar signal is directed across the container top segment and objects in the container will reflect the radar signal when they reach the level of that top segment. A radar beam forming lid with a horizontal aperture can be purchased from Sensative to create a wide, but thin, radar beam detecting any waste object reaching the top of the waste bin with a better precision.

5: Parking method

The parking method will detect the largest radar signal echo within the defined measurement range and above the defined threshold. The method is well suited for detecting the presence of a large object such as a vehicle in a well-defined area. Normal or narrow lens should be selected based on the width of the area to cover. The beam forming lid could be used to further narrow the area to monitor.

Varför kan man inte ställa in känsligheten?

6: Seating method

NEED HELP to describe this method

The seating method will return the distance and amplitude at the largest radar signal echo within the defined measurement range and above the defined threshold. The metod also report If the seat is considered occupied or free. The state of occupied change from occupied to free and vice versa, when a configurable number of consecutive measurements show the same result. The number of consecutive measurements is configurable separate for each direction.

Puck Radar with narrow lens is usually most suitable for seating applications.

The detection works best in a setup where obstacles around the seat are defined, e.g. cars, buses and trains. Mount the Puch sensor and finetune the distance and threshold to get a firm detection in a representative seat. Adjust the parameter value to switch

between occupied and free seats, to filter out temporary events and further improve the reliability of the measurement.

PARAMETERS

## System and Method parameters

| Method | Command | Parameter name | Type | Default | Max | Min | Available for end-users | Warning value | Warning text | Help text |
|---|---|---|---|---|---|---|---|---|---|---|
| **System** | **sys:** | | | | | | | | | |
| | | Selected Method | integer | 0 | 6 | 0 | Yes | | | The current selected method |
| | | Advertisement Interval (ms) | integer | 1000 | | | No | | | System parameters - do not change |
| | | Advertisement timeout (s) | integer | 10 | | | No | | | System parameters - do not change |
| | | 2.4 GHz radio protocol mode | integer | 0 | 2 | 0 | Yes | | Setting = 2 (Long range only) is not supported by mobile phones and should normally not be selected! | 0 = Normal range, 1 = Alternating normal range / long range, 2 = Long range only |
| | | Tx power | integer | 8 | | | No | | | System parameters - do not change |
| | | Radar on | boolean | 0 | 1 | 0 | Yes | | | Turn radar off=0 / on=1 |
| | | Network configuration | integer | 1 | 3 | 1 | No | 2 | If 2 is selected, wake up the 2.4 GHz RF with an NFC wake up (position an NFC enabled mobile phone in close proximity above Puck Radar until the phone vibrates) | 1= 2.4 GHz RF, 2= LoRaWAN, 3= 2.4 GHz & LoRaWAN. |
| | | Send on Change | boolean | 0 | | | no | --- | --- | - Not implemented - |
| | | Periodic advertisement of 2.4 GHz RF signal (s) | Integer | 0 | | | Yes | | | Time between periodic advertisements in addition to those that occur during measurement. If this is greater than zero and less than the interval for the current method, advertising is started with this periodicity. Default value is zero. |
| | | Timeout of the 2.4 GHz RF signal periodic advertisement (s) | integer | 10 | | | | | | Specifies how long the advertisement should be active in the case of periodic advertisement. The periodic advertisement will always be done using the normal 2.4 GHz range.<br>This also applies to the advertising that starts on cold start. |
| | | Timeout of the 2.4 GHz RF signal advertisement after a detected NFC signal (s) | integer | 20 | | | No | | | Specifies how long, in seconds, it is announced after an NFC signal is detected. |
| | | Secure Mode for LoRa interface | boolean | 0 | | | No | | | Specifies how long, in seconds, to wait after cold start before communicating with the LoRaWAN module. |
| | | Distance in mm for Lora | boolean | 0 | | | No | | | - Not implemented - |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Well** | **3:** | | | | | | | | | |
| | | Measurement cycle (s) | integer | 60 | ? | ? | Yes | | | The time between each radar measurement |
| | | HW acceleration average samples | integer | 30 | 1? | ? | No | | | Number of radar measurements in a single radar scan. Increased value will reduce noise. This may improve the radar precision but will decrease battery length. |
| | | Start of range (m) | float | 0.200 | ? | ? | Yes | | | Start of range + Length of range = maximum 5 meter. The start and end values will be rounded to the closest measurement point available. |
| | | Length of range (m) | float | 4.800 | ? | ? | Yes | | | Start of range + Length of range = maximum 5 meter. The start and end values will be rounded to the closest measurement point available. |
| | | Average factor | float | 1.00 | 1? | ? | No | | | Number of radar scans in a single measurement cycle. Should normally be 1 but can be increased to handle rain/snow or a moving water surface to establish a more stable measurement.<br>NOTE: The average factor will decrease the battery life with the same factor. Battery life is ¼ if the average factor is changed to 4. |
| | | Sensitivity level (unit?) | float | 0.650 | ? | ? | Yes | | | Increase the sensitivity level if Puck Radar often fails to detect an object within the defined range<br>(reporting distance 0).<br>Decrease the sensitivity level if Puck radar often reports echoes from incorrect radar paths (fig. 1) |
| | | cfar threshold guard | float | 0.200 | 0.2 | 0.01 | No | | | - System parameter, do not change - |
| | | cfar threshold window | float | 0.090 | 0.2 | 0.01 | No | | | Measurement point window in meter Explain better! Mäts varje punkt +/- 9/4.5 cm? Måste man då ha max range = botten -10/5 cm? |
| | | Offset | integer | 0 | | | No | | | - Not implemented - |
| | | Adaptive Range | float | 0 | | | Yes | | | 0 = function off, In other case, measurement initiate from “start of range” to “Lengt of range”, then next measurement will center (Adaptive Range / 2) around last measurement result. If the water level actually was outside the range a second measure will be done with full range to catch the surface. To avoid this to happened increase the “window” meaning higher value on Adaptive Range or a shorter Measurement cycle. |
| | | Median filter | boolean | 1 | | | No | | | Enable Median filter, 0 = function off, 1 = median function on" override CFAR measurement settings and Sensitivity level. Instead, the Median threshold is applied. |
| | | Median threshold | integer | 200 | | | No | | | High threshold, require higher amplitude on echo. |
| | | Median sweep delay | integer | 1000 | | | Yes | | | The value in ms is the delay between each measurment. 0 = no delay |
| | | Profile | integer | 2 | | | Yes | | High value consumes more energy | Specifies the profile, High value provides higher SNR and allows longer distances |
| | | Debug | integer | 0 | | | No | | | Enable debug feature, 0: debug off, 1: debug on, current effect is that amplitude is reported regardless of the echo is above the threshold or not. In case it’s below the distance will be zero. |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Bin 4:** | | | | | | | | | | |
| | | Measurement cycle (s) | integer | 30 | ? | ? | Yes | | | The time between each radar measurement |
| | | HW acceleration average samples | integer | 50 | ? | ? | No | | | Number of radar measurements in a single radar scan. Increased value will reduce noise. This may improve the radar precision but will decrease battery length. |
| | | Start of range (m) | float | 0.150 | ? | ? | Yes | | | Start of range + Length of range = maximum 5 meter. The start and end values will be rounded to the closest measurement point available. |
| | | Length of range (m) | float | 1.000 | ? | ? | Yes | | | Start of range + Length of range = maximum 5 meter. The start and end values will be rounded to the closest measurement point available. |
| | | Threshold level | integer | 290 | ? | ? | Yes | | | Threshold level. Decrease level to detect more. Increase level to get fewer detections.<br>Adjust for different waste materials.<br>Metal waste is very reflective, and the threshold can be increased. Paper is less reflective, and the threshold level may be reduced for a proper performance. |
| **Parking 5:** | | | | | | | | | | |
| | | Measurement cycle (s) | integer | 15 | ? | ? | Yes | | | The time between each radar measurement |
| | | HW acceleration average samples | integer | 10 | ? | ? | No | | | Number of radar measurements in a single radar scan. Increased value will reduce noise. This may improve the radar precision but will decrease battery length. |
| | | Start of range (m) | float | 0.200 | ? | ? | Yes | | | Start of range + Length of range = maximum 5 meter. The start and end values will be rounded to the closest measurement point available. |
| | | Length of range (m) | float | 1.500 | ? | ? | Yes | | | Start of range + Length of range = maximum 5 meter. The start and end values will be rounded to the closest measurement point available. |
| **Seating 6:** | | | | | | | | | | |
| | | Measurement cycle (s) | integer | 30 | ? | ? | Yes | | | The time between each radar measurement |
| | | HW acceleration average samples | integer | 50 | ? | ? | No | | | Number of radar measurements in a single radar scan. Increased value will reduce noise. This may improve the radar precision but will decrease battery length. |
| | | Start of range (m) | float | 0.150 | ? | ? | Yes | | | Start of range + Length of range = maximum 5 meter. The start and end values will be rounded to the closest measurement point available. |
| | | Length of range (m) | float | 1.000 | ? | ? | Yes | | | Start of range + Length of range = maximum 5 meter. The start and end values will be rounded to the closest measurement point available. |
| | | Threshold level | integer | 290 | ? | ? | Yes | | | Threshold level. Decrease level to detect more. Increase level to get fewer detections.<br>Adjust for different environments and distance from the seating/object. |
| | | Offset | | 0 | | | no | | | - Not implemented - |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Required occupied detection | integer | 3 | | | yes | | | Number of consecutive 'occupied' detection needed to change to 'occupied' |
| | | Required free detection | integer | 3 | | | yes | | | Number of consecutive 'free' detection needed to change to 'free' |