# Installation guide for presence detection solution

## using XENSIV™ BGT60TR13C radar SoM board (KIT_60TR13C_EMBEDD_UNL)

## About this document

### Scope and purpose

This user guide serves the purpose of providing a detailed guide on the installation process of the XENSIV™ BGT60TR13C system-on-module (SoM) for presence detection. It covers the radar setup and mounting procedures, ensuring the correct radar installation. Additionally, it highlights potential problems that can arise in the installation environment.

### Intended audience

The intended audience for this document are design engineers, technicians, and developers of electronic systems working with the XENSIV™ BGT60TR13C SoM board (KIT_60TR13C_EMBEDD_UNL) for presence detection solutions.

*Note:* *For hardware and software support, please reach out to our module partners Jorjin Technologies Inc. [3].*

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# 1 Introduction

Developing a comprehensive planning strategy is crucial for the successful installation of radars in a given area. It is recommended to consider several factors for ensuring optimal coverage and reliable performance.

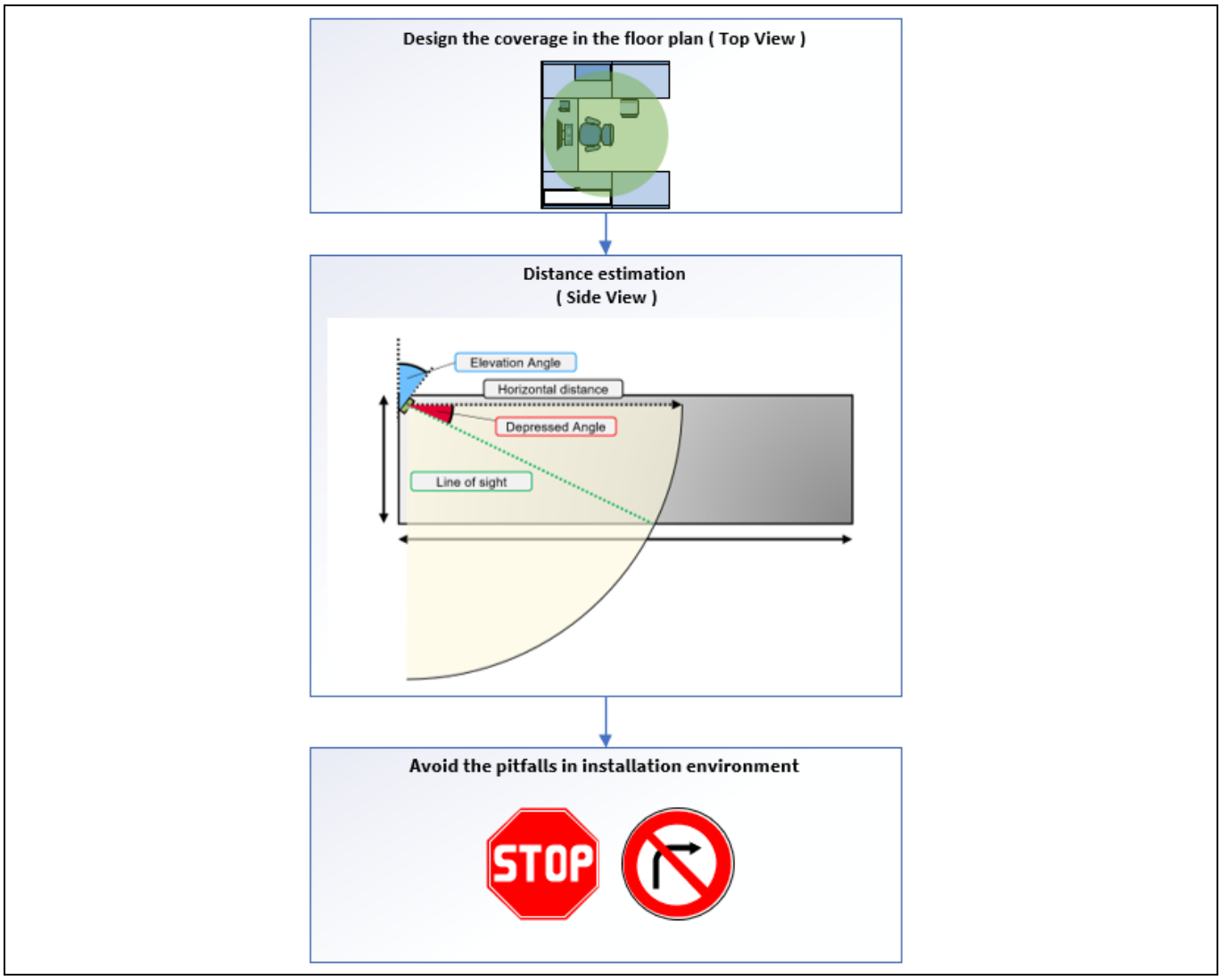



**Figure 1 Planning strategy flowchart**

Consider the following aspects during the planning process:

- **Design the floor plan coverage** to determine the number of radars required for the area. Consider the radar configuration, placement, and mounting position parameters.
- **Use a side view** to analyze the estimated covered distance. The elevation angle of each radar is set to 45 degrees to achieve optimal sensitivity. Due to the tilted angle, the line of sight from the radar to the floor is shorter than the horizontal distance. Estimate the distance using a side view can help the manufacturer predefine the suitable detection distance.
- **Check for problems in the installation environment** that could cause unstable presence detection. Small vibrations of objects can easily trigger false alarms. These vibrations can be quantified using micro values in calibration mode. Take care to avoid these issues.

# 2 Design the coverage using a floor plan

## 2.1 Radar setup and mounting

To install the radar module, position it on the wall at an elevation angle of 45 degrees, as shown in Figure 2. The radar module provides coverage of approximately 90 degrees on both the E-plane and H-plane.

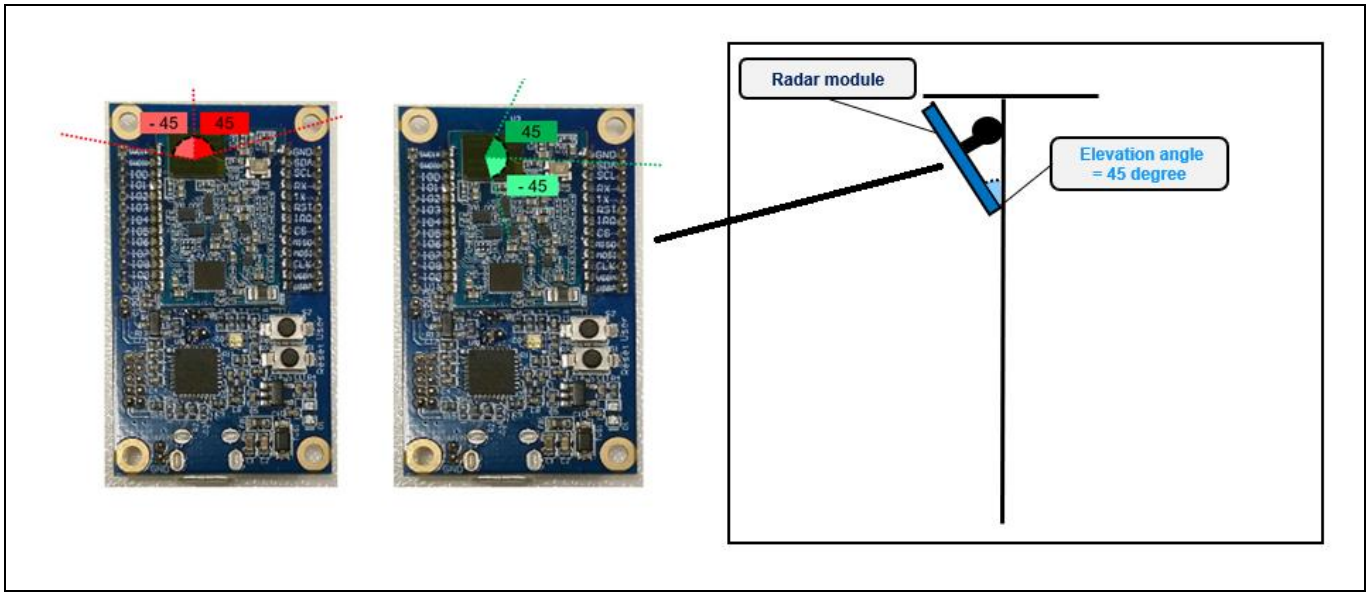



**Figure 2 Elevation angle setup and radar position**

The coverage area can be visualized as a cone shape with a hemisphere attached at the end. The height of the cone is determined by the maximum detection range setting, which can be set within a range of 1 m to 5 m.

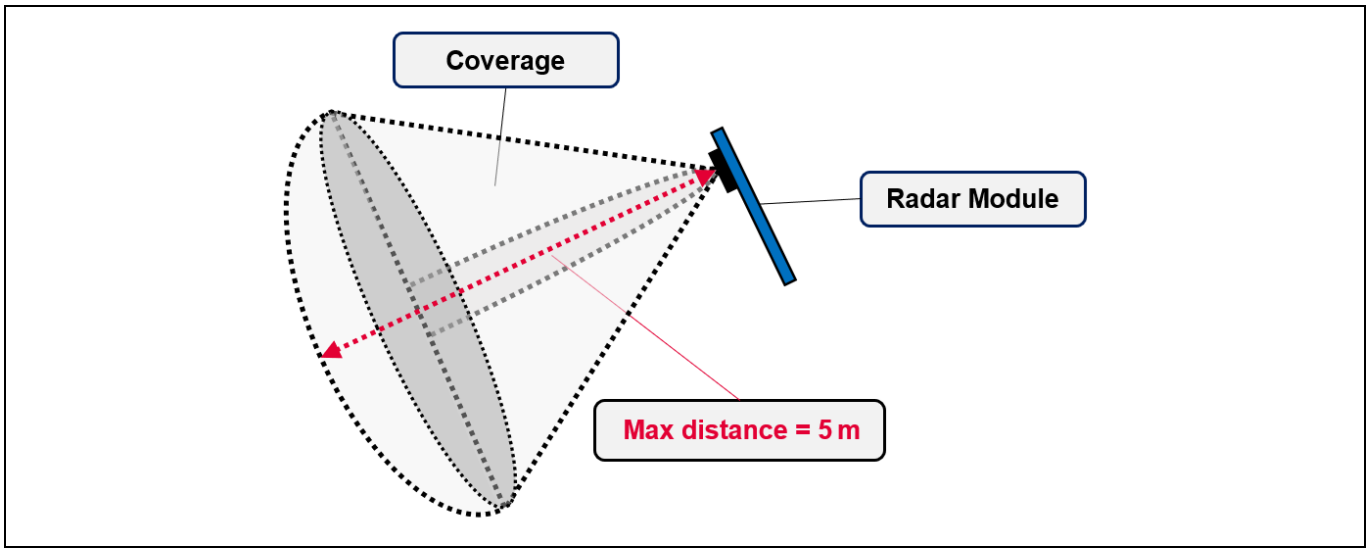



**Figure 3 Radar coverage – inside view**

When viewed from the top, the coverage area forms a 90-degree arc. The radius of this arc is determined by the maximum detection range setting (5 m in this example).

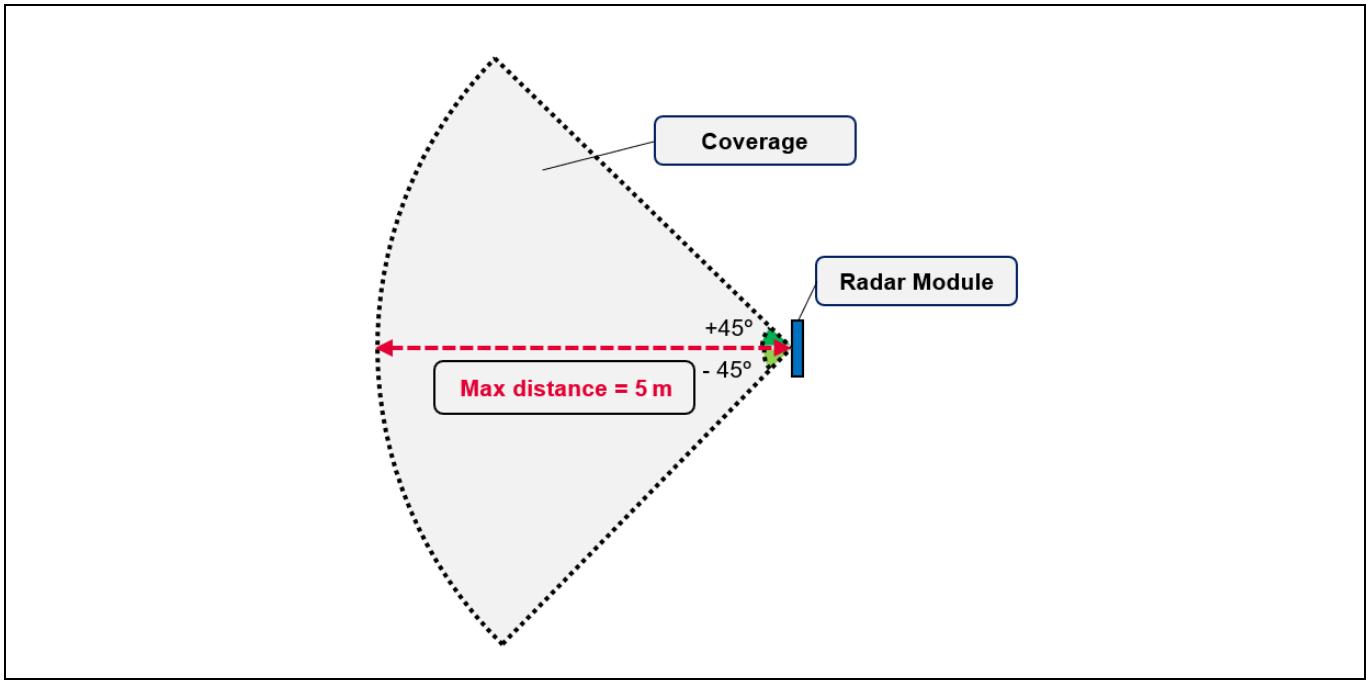



**Figure 4 Radar coverage – top view**

## 2.2 Example of radar installation in a room

The number of radars required to cover the floor plan is determined by the size of the room. In this example, two types of rooms are illustrated to demonstrate this concept.

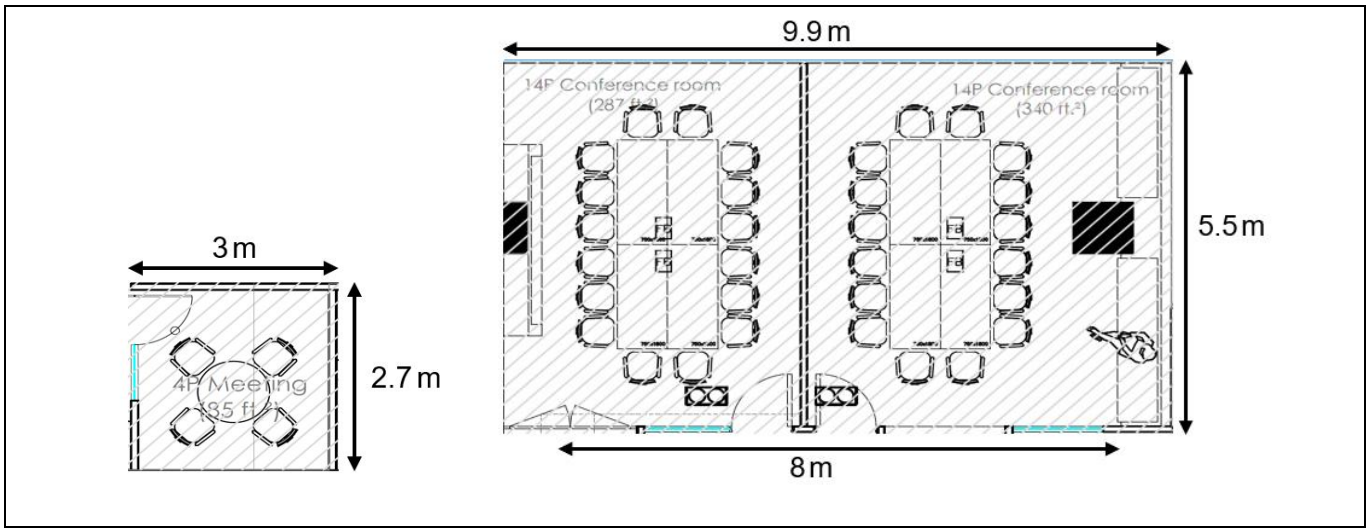



**Figure 5 Analyze the floor plan**

In Figure 6, a small room measuring 3 m × 2.7 m × 2.5 m (l × b × h) is shown. As both the width and length of the room are smaller than the maximum coverage distance of 5 m, only one radar is required to cover the entire room area. In this example, the radar is installed in the corner, with a maximum range set to 2.5 m. Additionally, some margins are left to prevent any disturbance caused by the presence of a curtain.

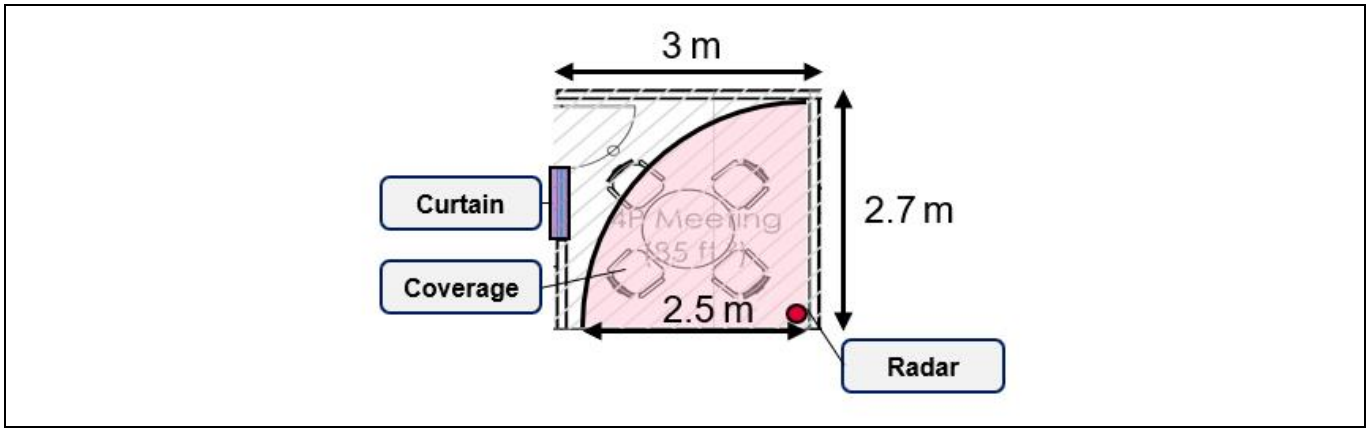



**Figure 6 Radar setup in a small room**

To ensure accurate detection and avoid false alarms caused by the curtain, the radar is mounted on the wall at a height of 2.3 m with a 45-degree elevation angle. A 0.5 m gap is maintained between the curtain and the coverage area. This gap helps prevent any interference or false alarms triggered by the curtain, ensuring reliable detection results.

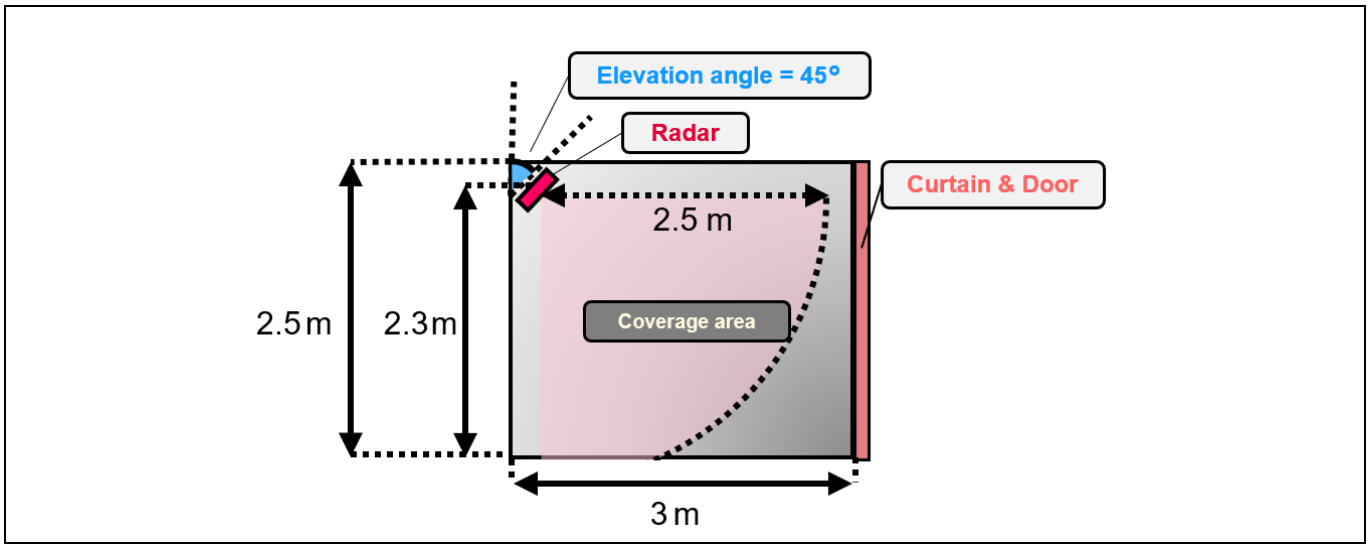



**Figure 7 Radar setup in a small room – side view**

Figure 8 illustrates a large meeting room measuring 9.9 m × 5.5 m × 2.8 m (l × b × h). As the length of the room exceeds the maximum coverage distance of 5 m, three radars are utilized to cover the entire area. To prevent disturbance from curtain movement, the radars are installed at opposite sides of the curtain. Each radar is set to the maximum range of 5 m.

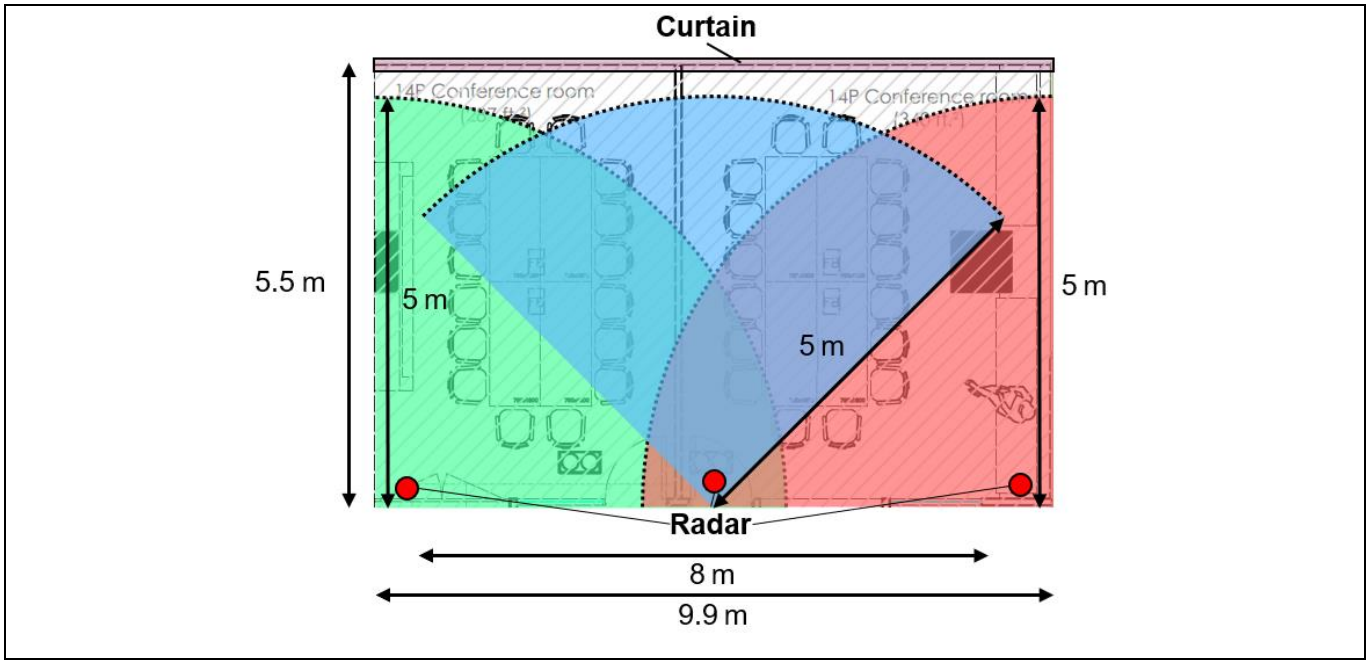



**Figure 8 Radar setup in a large room**

The three radars are mounted on the wall at a height of 2.6 m with a 45-degree elevation angle. To prevent false alarms caused by curtain movement, a 0.5 m gap is maintained between the curtain and the coverage area.

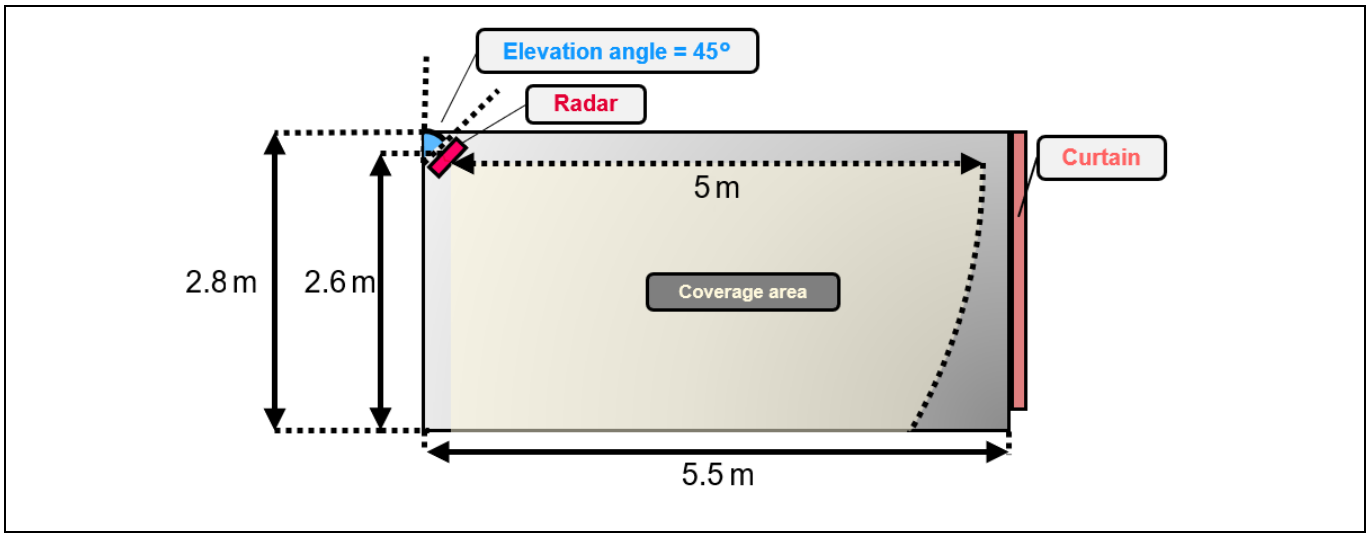



**Figure 9 Radar setup in a large room – side view**

## 2.3 Steps to design floor plan coverage

This section describes a step-by-step guide for designing the radar configuration to determine the covered range. Microsoft PowerPoint is used as the tool for estimation. Following is an example design flow with a scale of 1:100, where 1 cm represents 1 m.

1. Draw a block at a 1:100 scale and place the floor plan inside the block.

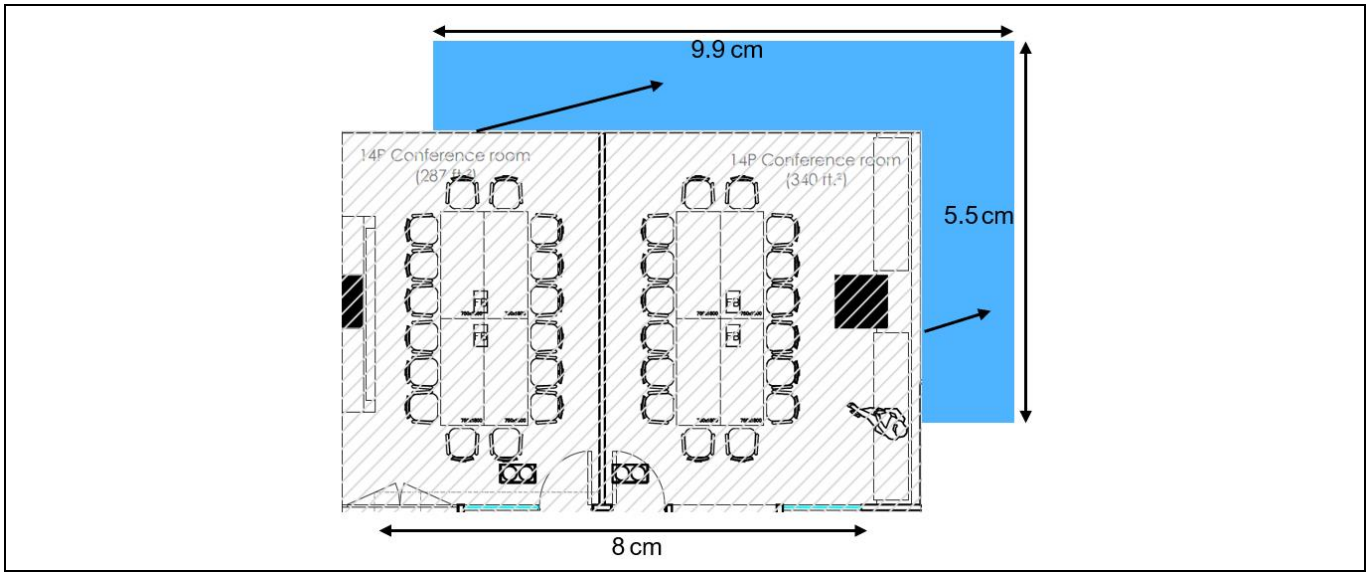



**Figure 10 Floor plan measurement**

2. Select **Shapes** and choose **Arc** to create the radar detection area. Set the angle of the arc to 90 degrees.

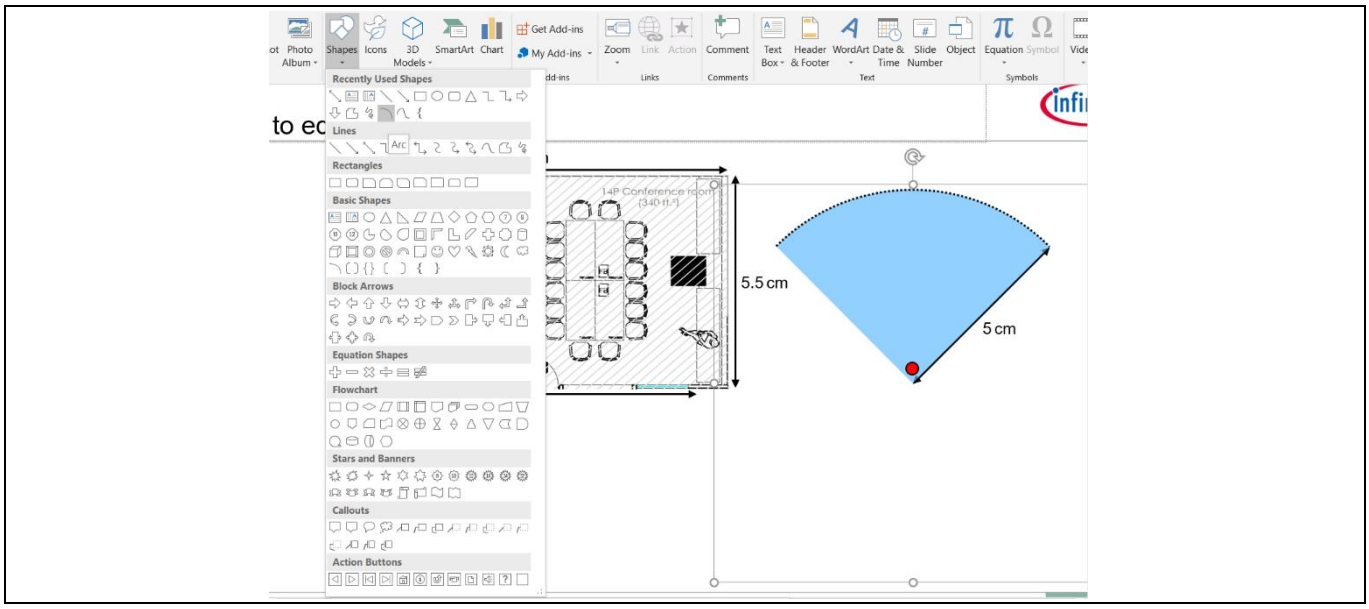



**Figure 11 Radar coverage shape creation**

3. Right-click on the arc and select **Size and Position**. Set the height and width (diameter) to 10 cm, which represents the required detection distance of the radar in real space (5 m).

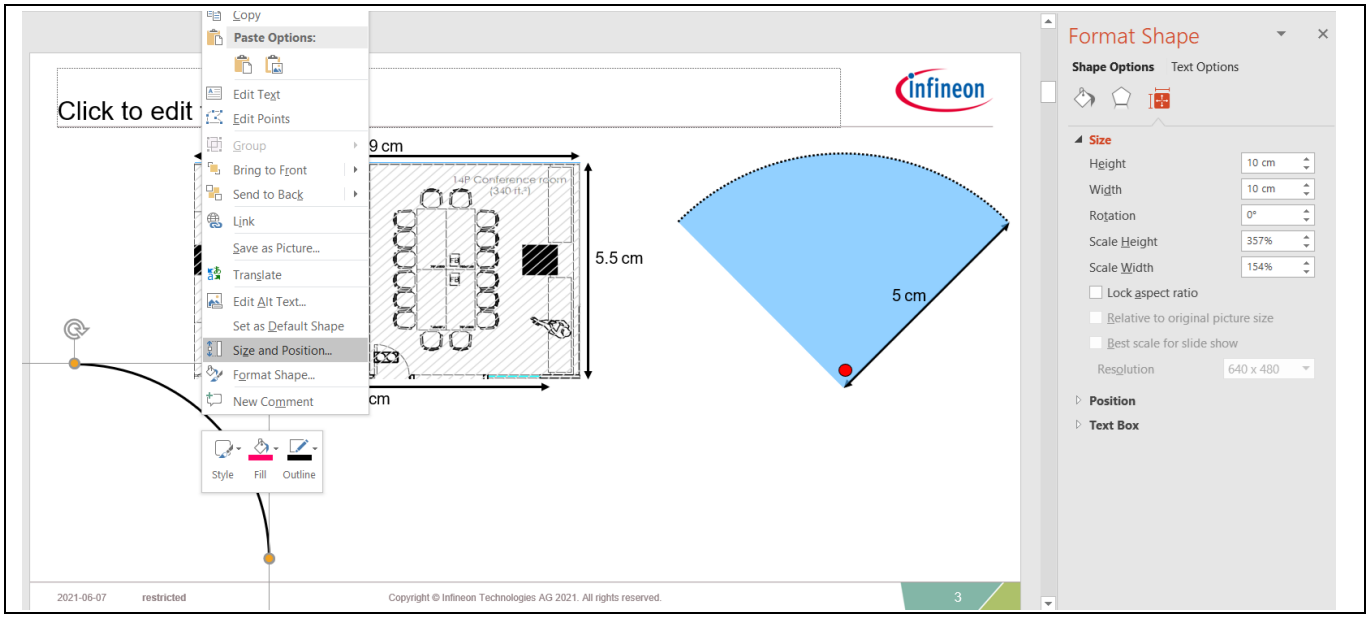



**Figure 12 Radar coverage shape creation**

4. Right-click on the arc and choose **Solid fill**. Select a color to fill the arc and set the transparency to 50 percent. This arc area represents the coverage area of the radar.

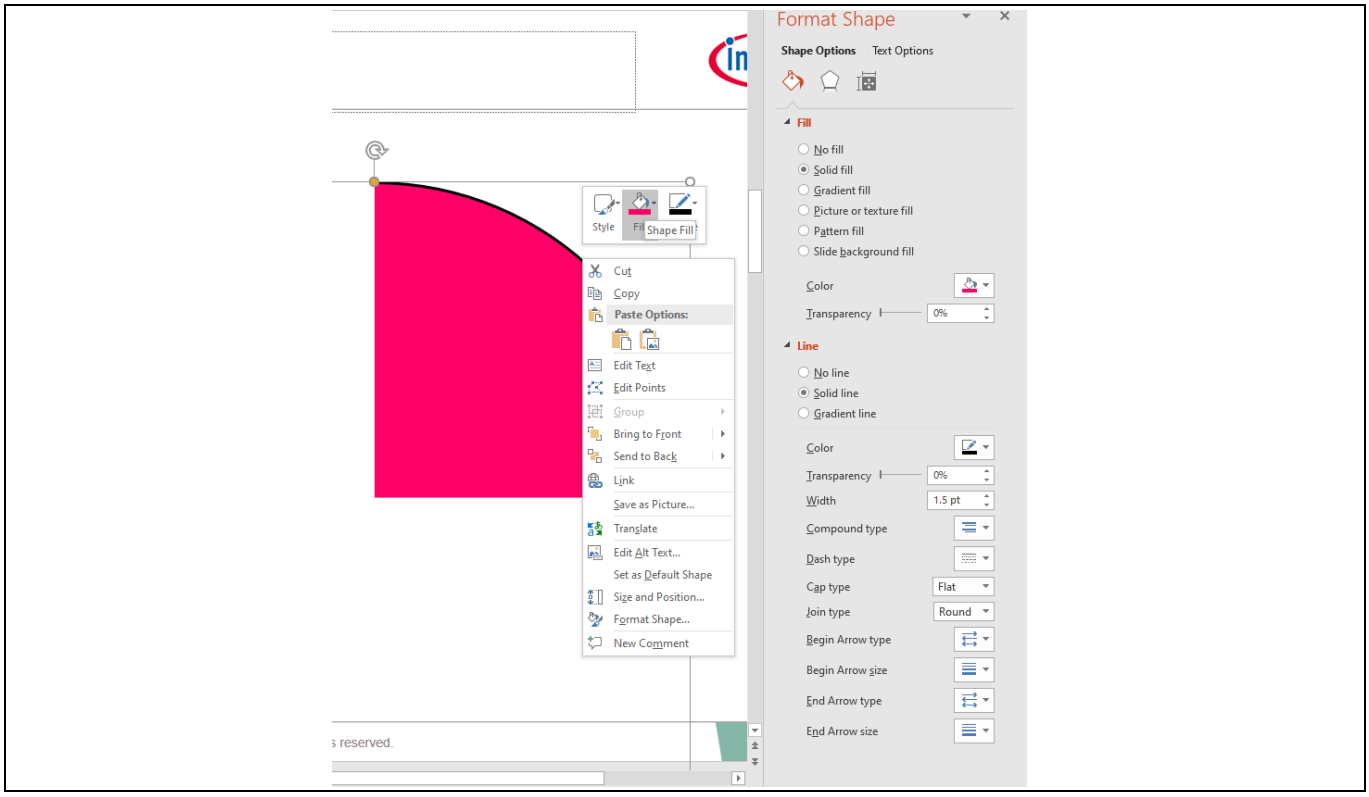



**Figure 13 Radar coverage shape setting**

5. Place the arc area on the desired position.

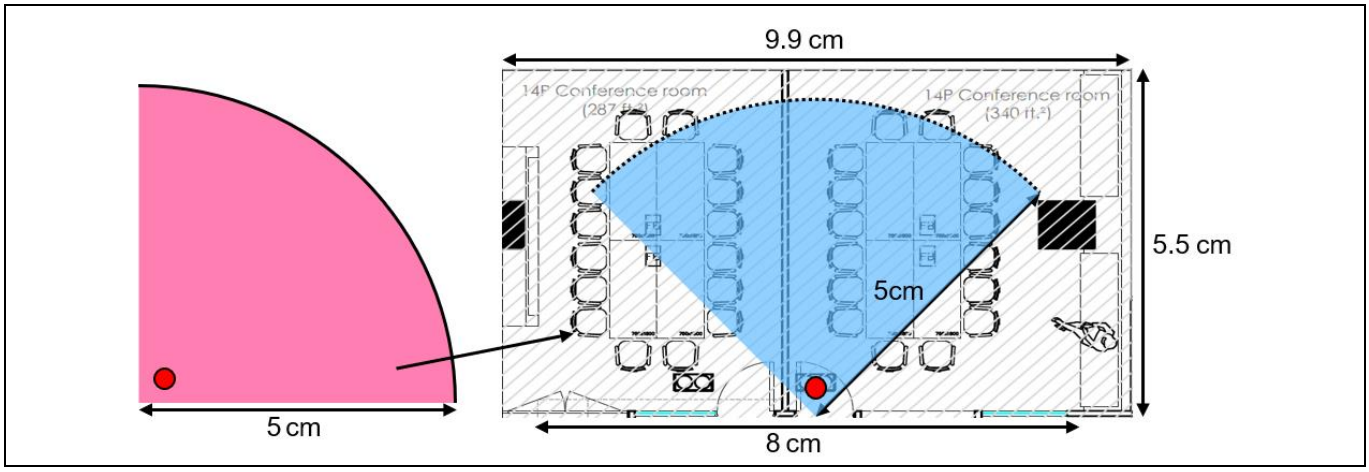



**Figure 14 Radar coverage in floor plan**

6. Repeat Step 5 to complete the setup.

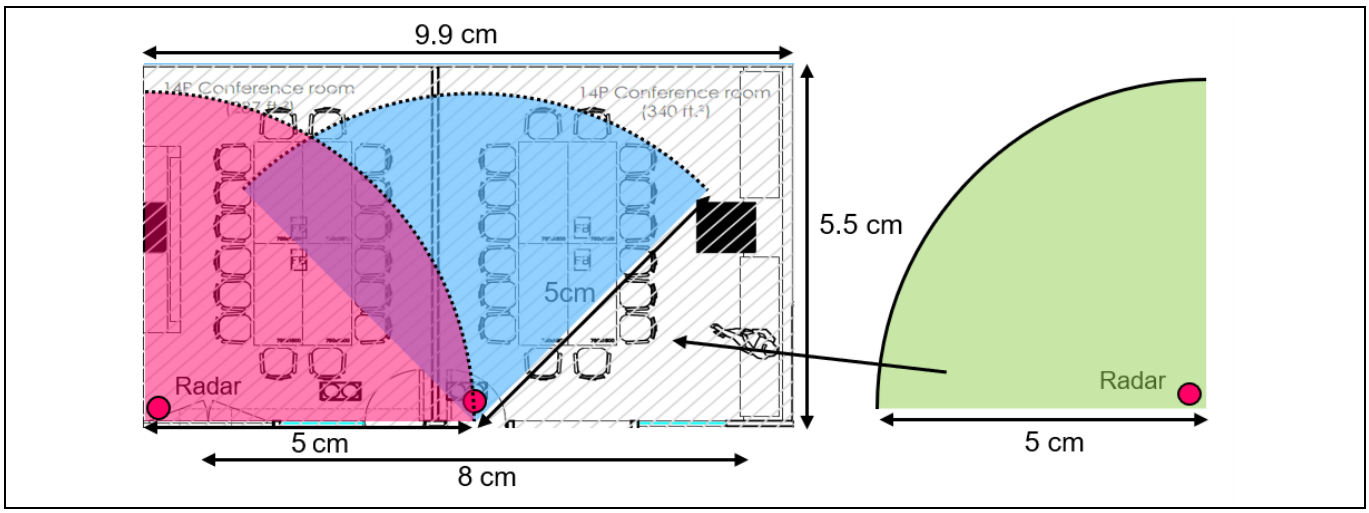



**Figure 15 Multiple radar coverage in floor plan**

## 2.4 Distance estimation – side view

This section shows how to estimate the covered distance using a side view. Microsoft PowerPoint is used as the tool for the estimation. The example setup and estimation are the same as described in Section 2.3. The area of the shape is at a scale of 1:100.

1. Draw a 1:100 scale block to simulate the space of the side view. The height and length of the space are 2.8 m and 9.9 m, respectively. Place the radar block in the top left corner. The elevation angle of the radar is set as 45 degrees.

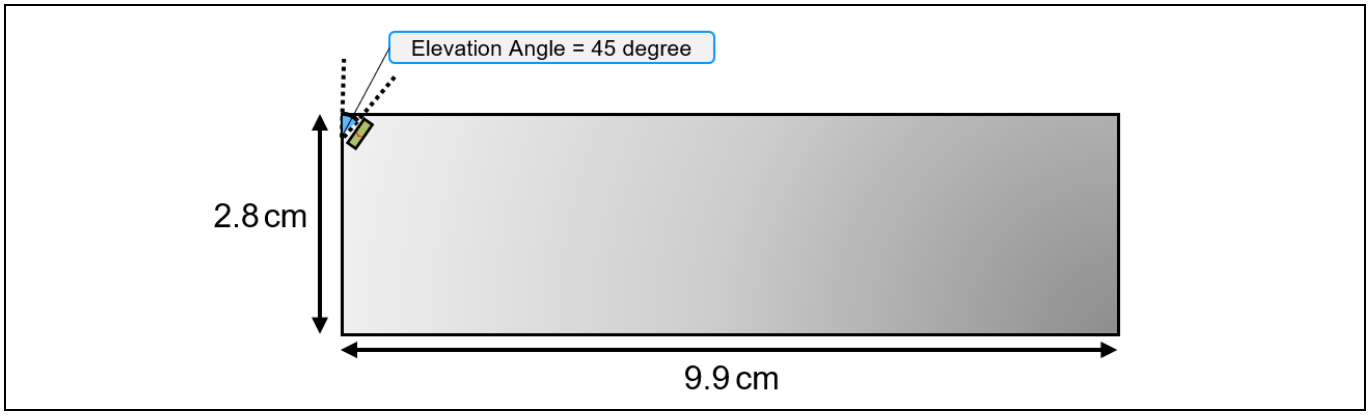



**Figure 16 Floor plan creation**

2. Create a 90-degree arc to represent the radar coverage area. Set the height and width (diameter) to 10 cm.

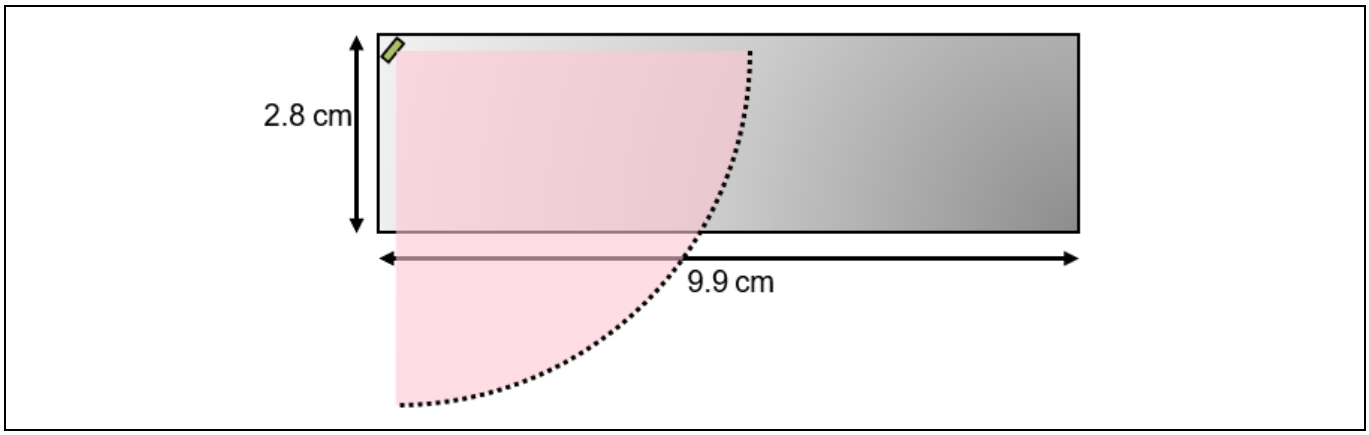



**Figure 17 Add radar coverage**

3. Draw a rectangle with 0.5 cm height to place on the coverage area. Extend the length of the rectangle until it touches the arc edge. Figure 18 shows examples of the rectangle, labeled A and B.

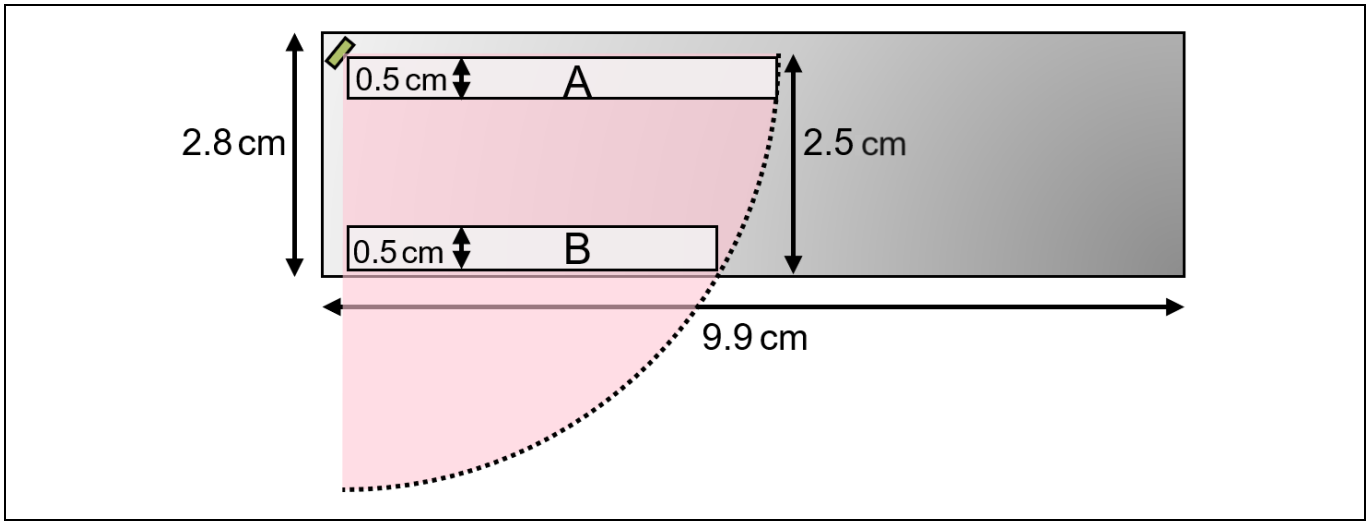



**Figure 18 Coverage measurement**

4. Right-click the rectangle and select **Size and Position** to see the scaled distance.

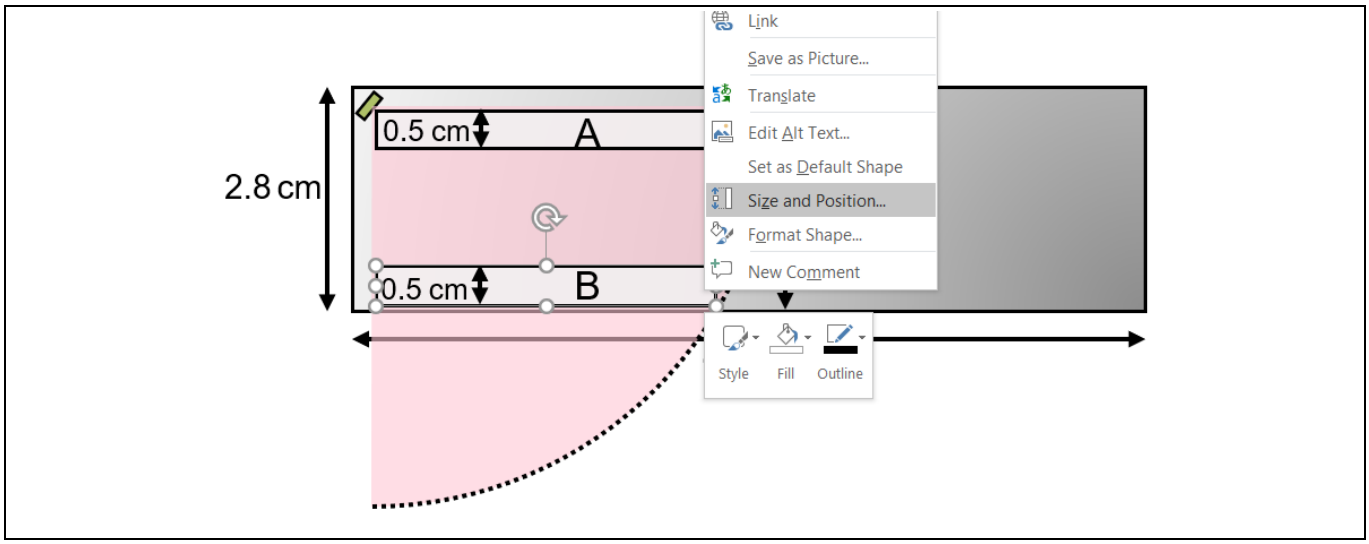



**Figure 19 Read the width of the rectangle**

5. Read the width value under **Format Shape**. The cover length is 4.32 cm, in this example, which represents 4.32 m.

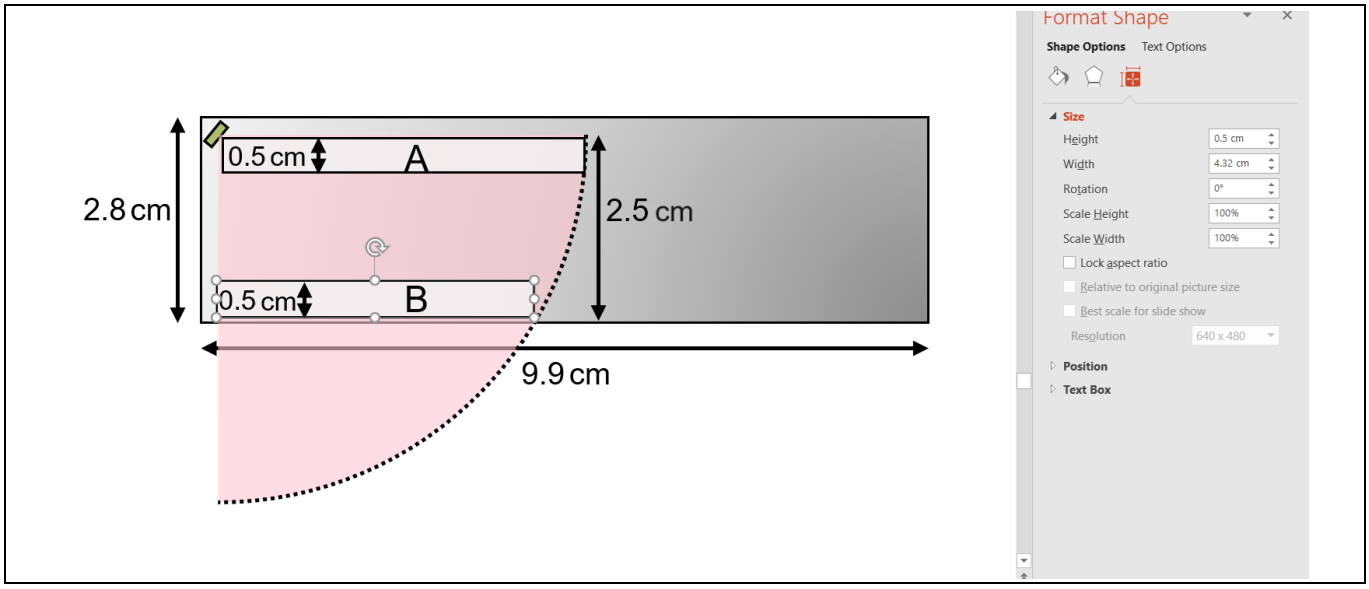



**Figure 20 Length of the rectangle**

## 2.5 Example setup – small room

This example considers a small room of 3.5 m × 3.5 m × 3.5 m (l × b × h), with a curtain on one side. To avoid detecting vibration from the curtain, the maximum range setting should not exceed 3 m, such that there is at least a 0.5 m buffer between the maximum coverage area and the curtain. As the coverage area is an arc, part of the room will not be covered.

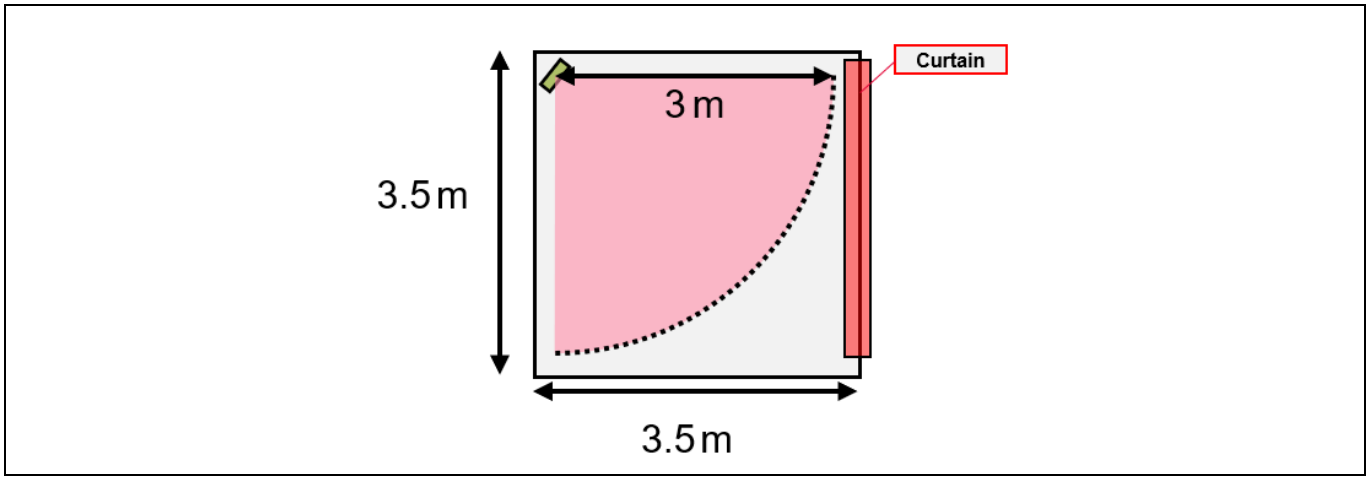



**Figure 21 Side of view – small room**

# 3 Micro and macro detection and setup

Given the radar's sensitivity to slight movements, it is important to consider potential sources of vibration, such as air conditioners and curtains, as they can significantly impact the detection performance. Ensure to take special precautions during the radar installation in such cases to ensure optimal functionality.

In presence detection solutions, both macro and micro detection modes can be utilized to cater to different needs and requirements.

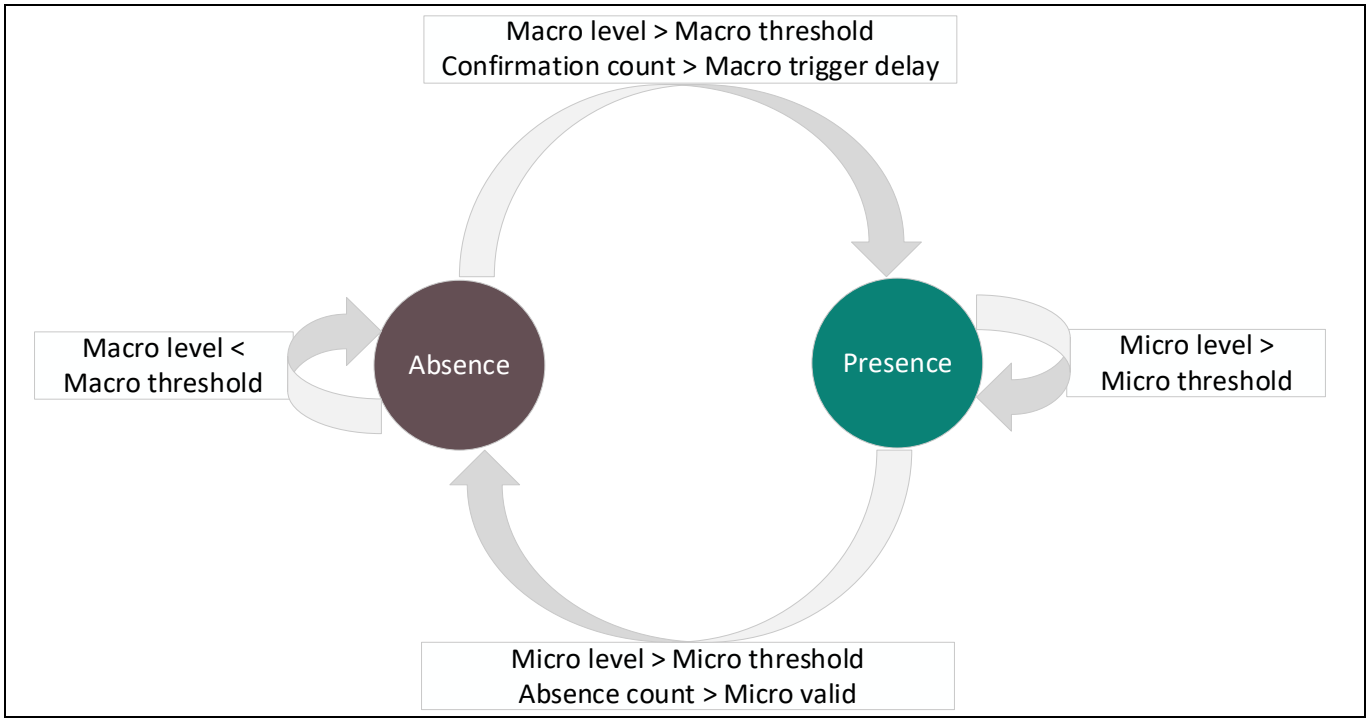



**Figure 22 Presence detection state diagram**

During absence of state detection, the system primarily evaluates the macro level. If the macro level surpasses the specified macro threshold, the state transitions from absence to presence. Once in the presence state, the system continuously monitors the micro level. As long as the micro level remains above the designated micro threshold, the state remains in the presence state. However, if the micro level drops below the micro threshold, the state reverts back to absence.

Vibrating objects in the detection area can keep the micro value high, preventing the system from switching to the absence state when there is no one present.

## 3.1 Procedures of macro and micro-level recording

To record and save the micro detection value over time, the calibration mode provides the necessary functionality. Perform these steps for recording:

1. Download and extract BGT60TR13C Config Tool to install the Infineon_BGT60TR13C_Embedd_ConfigTool.
2. Navigate to *\Infineon_RadarFF_ConfigTool\Infineon_BGT60TR13C_Embedd_Presence_ConfigTool*, run the *IFX_BGT60TR13C_Embedd_MCU4_Module_Config_vx.x.x_build-xxxxxx.exe* tool to select the radar COM port and press **Connect**.

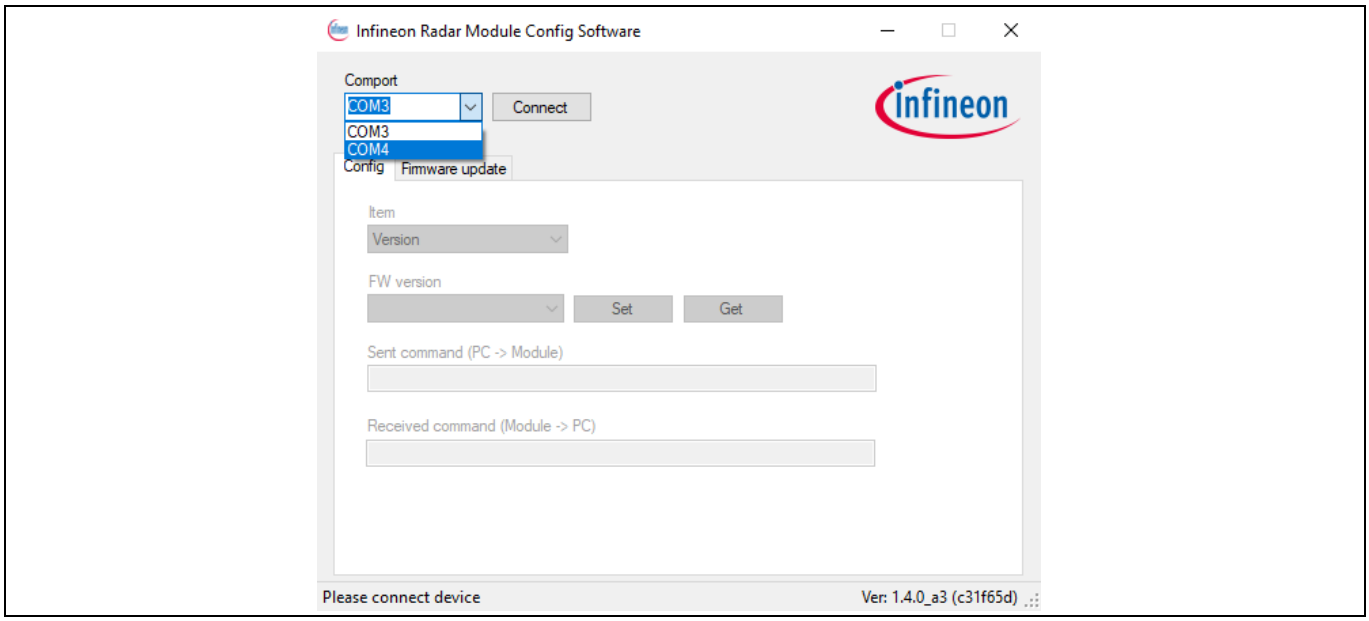



**Figure 23 Radar config tool**

3. Select **Reset config** and press **Set**.

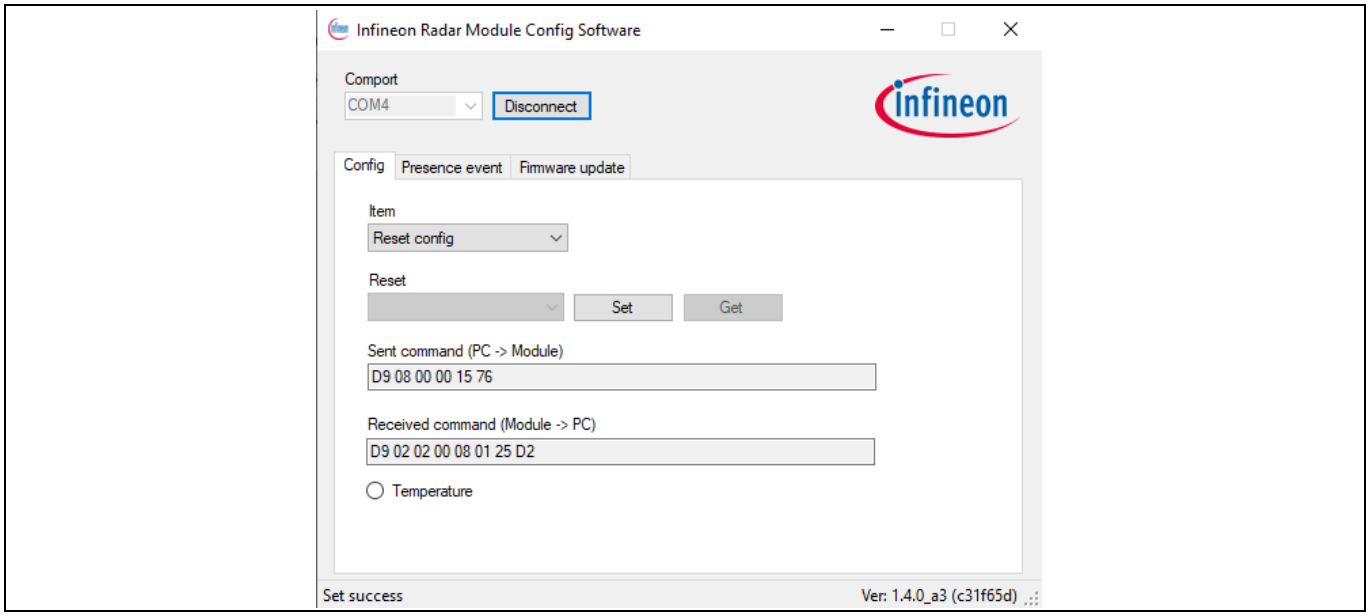



**Figure 24 Reset radar config**

4. Select **Calibration mode**, select **Enable**, and then press **Set**.

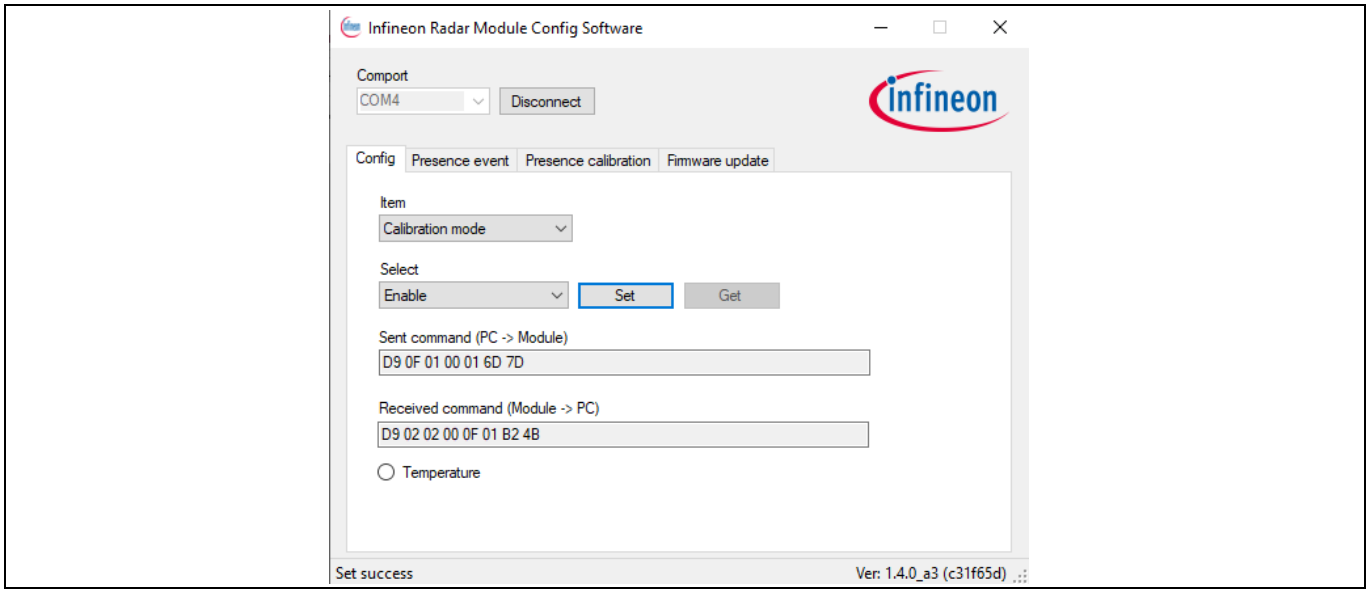



**Figure 25 Enable calibration mode**

5. Select the **Calibration rate**, choose **4**, and then press **Set**.

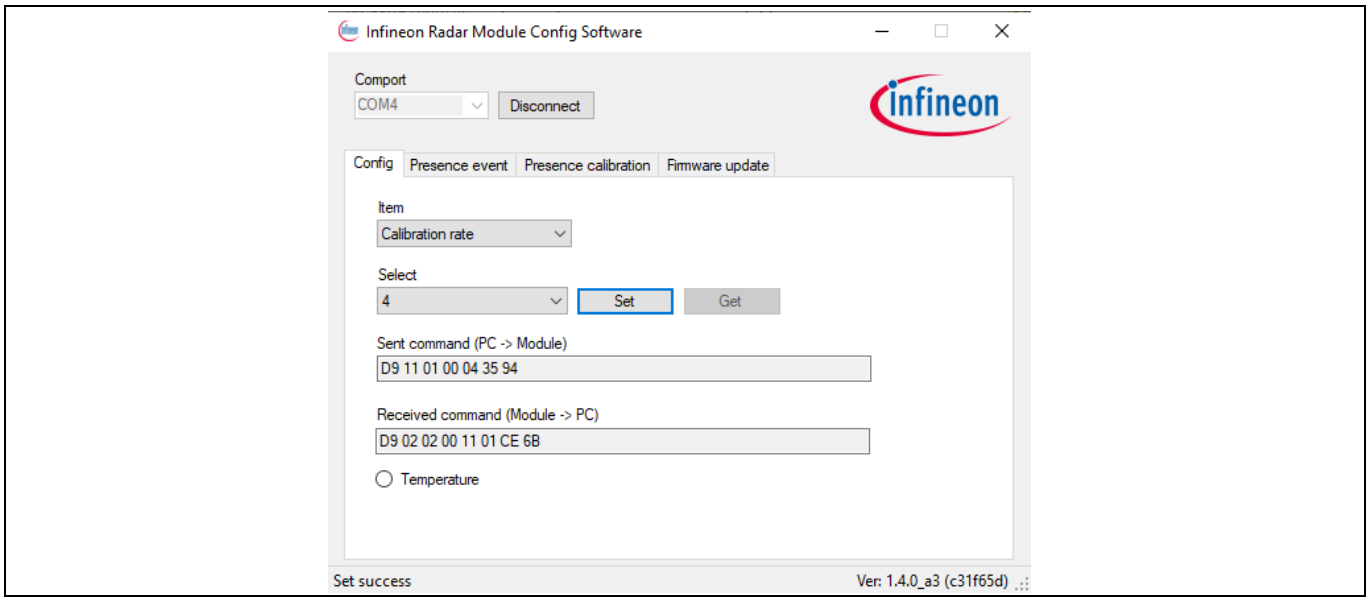



**Figure 26 Set calibration rate**

6. Select **Max range**, **5.0** from **Distance (m)** dropdown, and then press **Set**.

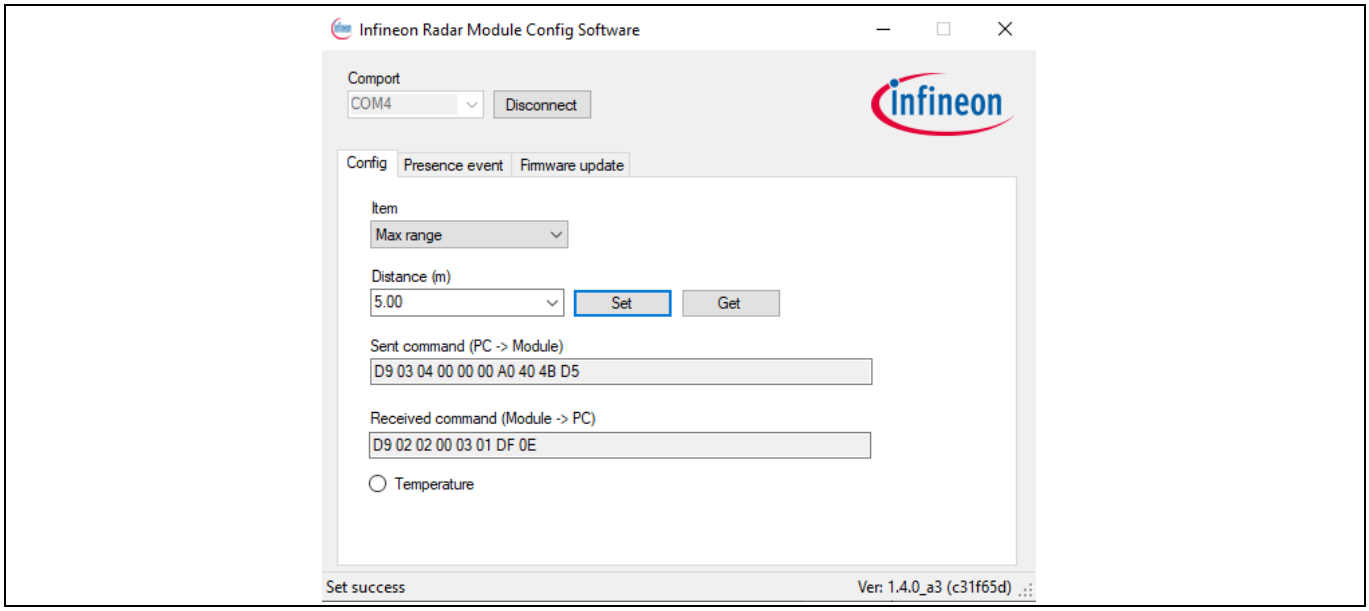



**Figure 27 Set maximum range**

7. Select **Detect mode**, select **Macro and micro**, and then press **Set**.

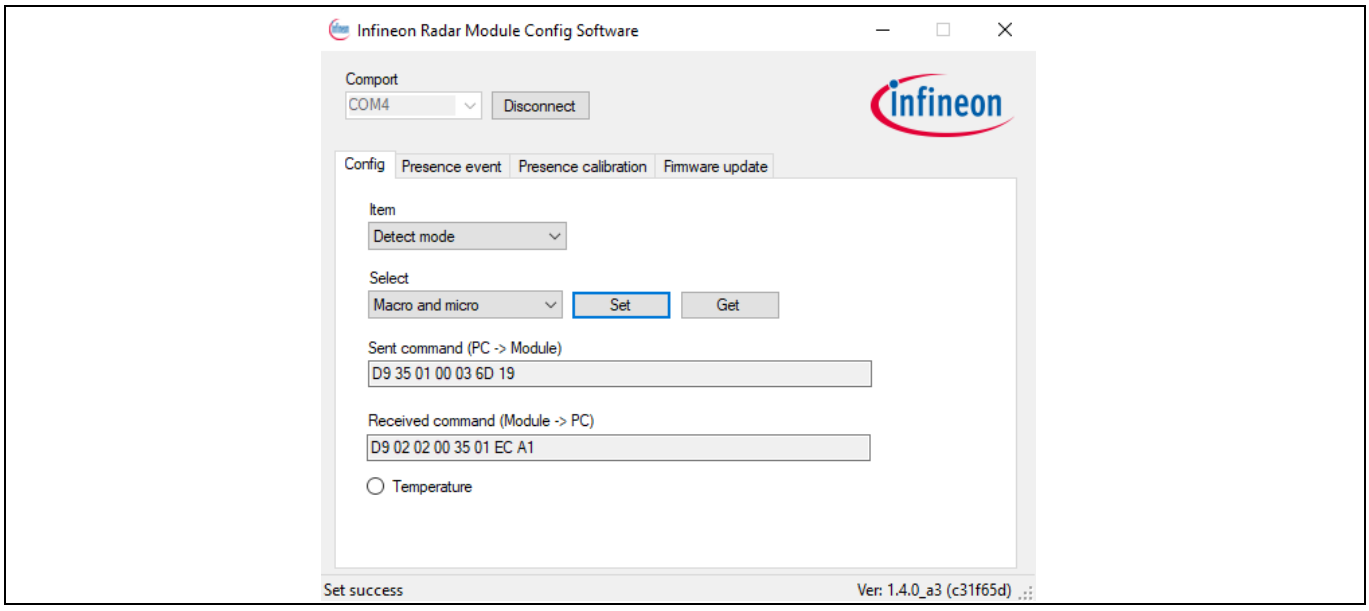



**Figure 28 Set detect range**

8. Select the **Presence calibration** tab. Check **save to file** at bottom right.

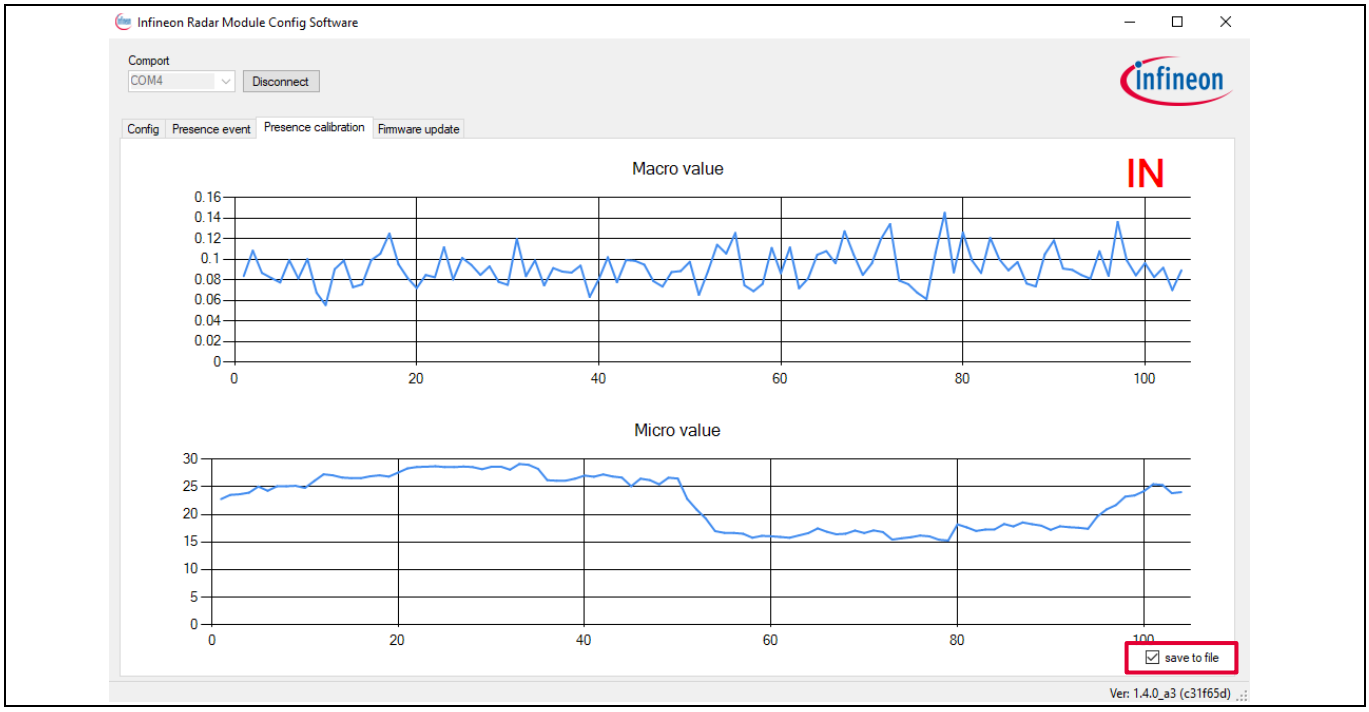



**Figure 29 Save macro and micro to a file**

9. Upon completion, a .csv file will be generated in the current directory.

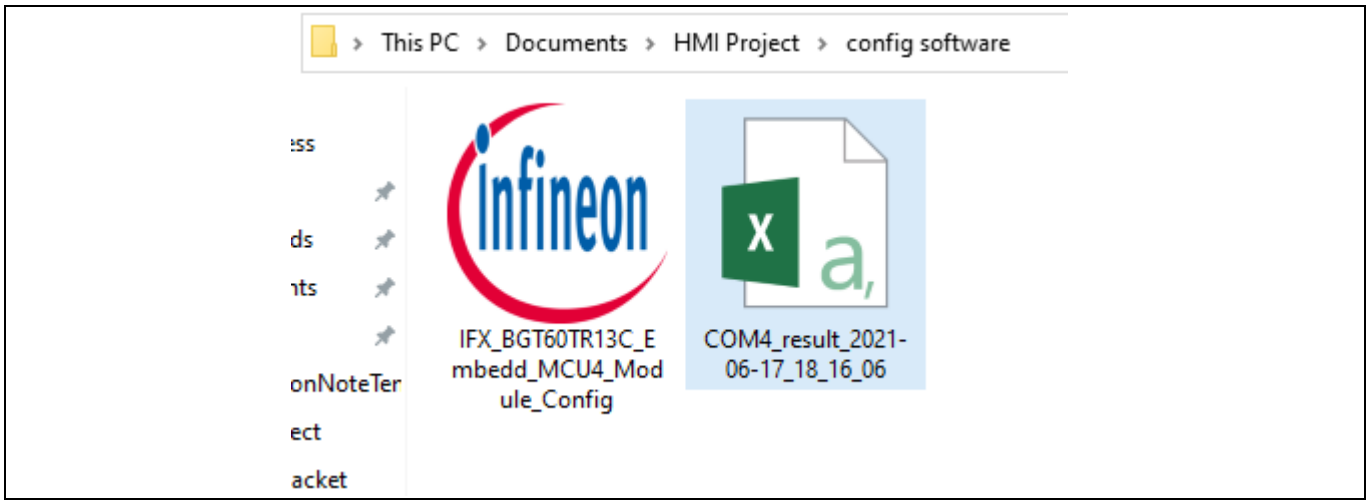
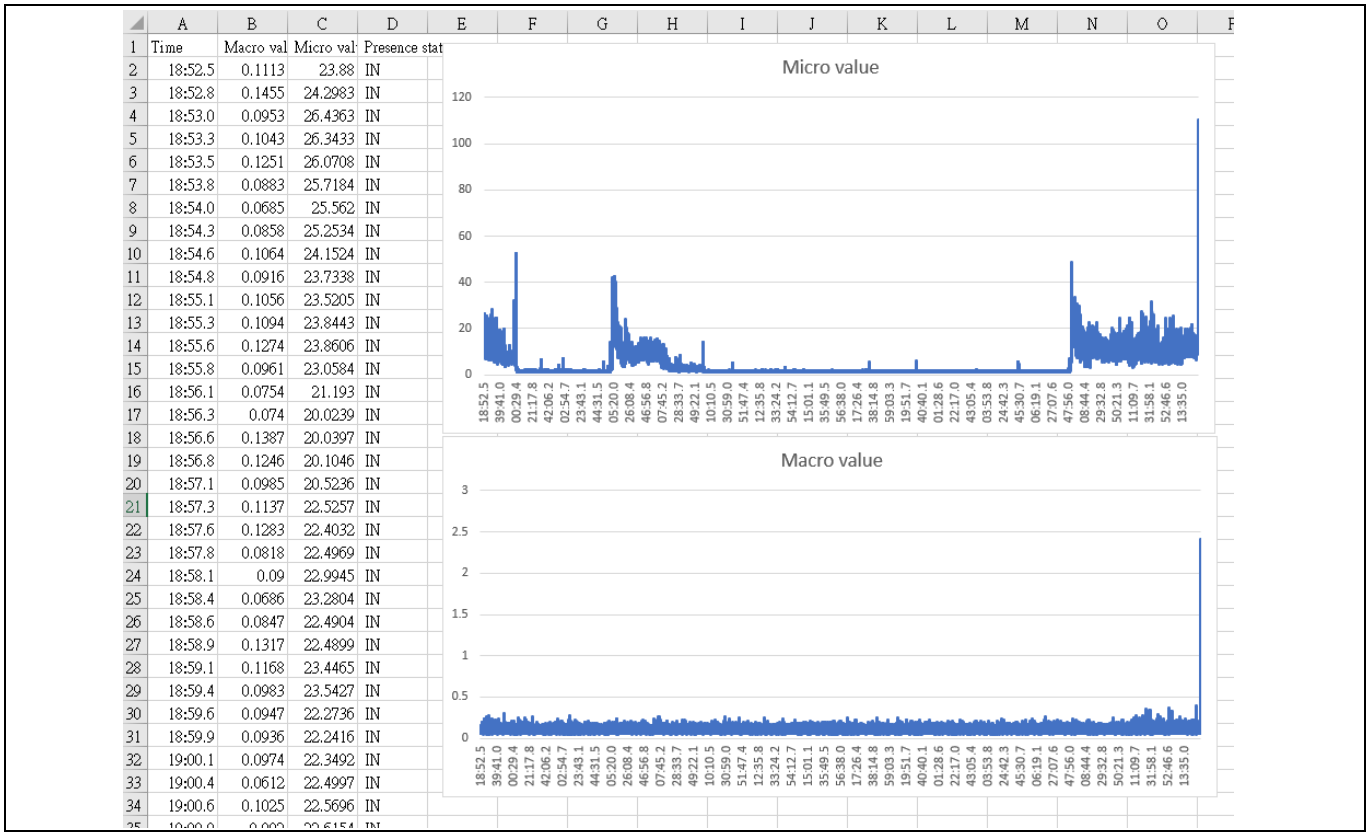



**Figure 30 Recording file**

10. Open the recording file in Excel and create graphs to visualize the macro and micro values over time.




| | A | B | C | D |
|---|---|---|---|---|
| 1 | Time | Macro val | Micro val | Presence stat |
| 2 | 18:52.5 | 0.1113 | 23.88 | IN |
| 3 | 18:52.8 | 0.1455 | 24.2983 | IN |
| 4 | 18:53.0 | 0.0953 | 26.4363 | IN |
| 5 | 18:53.3 | 0.1043 | 26.3433 | IN |
| 6 | 18:53.5 | 0.1251 | 26.0708 | IN |
| 7 | 18:53.8 | 0.0883 | 25.7184 | IN |
| 8 | 18:54.0 | 0.0685 | 25.562 | IN |
| 9 | 18:54.3 | 0.0858 | 25.2534 | IN |
| 10 | 18:54.6 | 0.1064 | 24.1524 | IN |
| 11 | 18:54.8 | 0.0916 | 23.7338 | IN |
| 12 | 18:55.1 | 0.1056 | 23.5205 | IN |
| 13 | 18:55.3 | 0.1094 | 23.8443 | IN |
| 14 | 18:55.6 | 0.1274 | 23.8606 | IN |
| 15 | 18:55.8 | 0.0961 | 23.0584 | IN |
| 16 | 18:56.1 | 0.0754 | 21.193 | IN |
| 17 | 18:56.3 | 0.074 | 20.0239 | IN |
| 18 | 18:56.6 | 0.1387 | 20.0397 | IN |
| 19 | 18:56.8 | 0.1246 | 20.1046 | IN |
| 20 | 18:57.1 | 0.0985 | 20.5236 | IN |
| 21 | 18:57.3 | 0.1137 | 22.5257 | IN |
| 22 | 18:57.6 | 0.1283 | 22.4032 | IN |
| 23 | 18:57.8 | 0.0818 | 22.4969 | IN |
| 24 | 18:58.1 | 0.09 | 22.9945 | IN |
| 25 | 18:58.4 | 0.0686 | 23.2804 | IN |
| 26 | 18:58.6 | 0.0847 | 22.4904 | IN |
| 27 | 18:58.9 | 0.1317 | 22.4899 | IN |
| 28 | 18:59.1 | 0.1168 | 23.4465 | IN |
| 29 | 18:59.4 | 0.0983 | 23.5427 | IN |
| 30 | 18:59.6 | 0.0947 | 22.2736 | IN |
| 31 | 18:59.9 | 0.0936 | 22.2416 | IN |
| 32 | 19:00.1 | 0.0974 | 22.3492 | IN |
| 33 | 19:00.4 | 0.0612 | 22.4997 | IN |
| 34 | 19:00.6 | 0.1025 | 22.5696 | IN |

**Figure 31 Plot the graph in Excel file**

11. In an empty environment without any moving objects, the macro value will remain low. In this example, the macro threshold can be set to a value of 0.5.

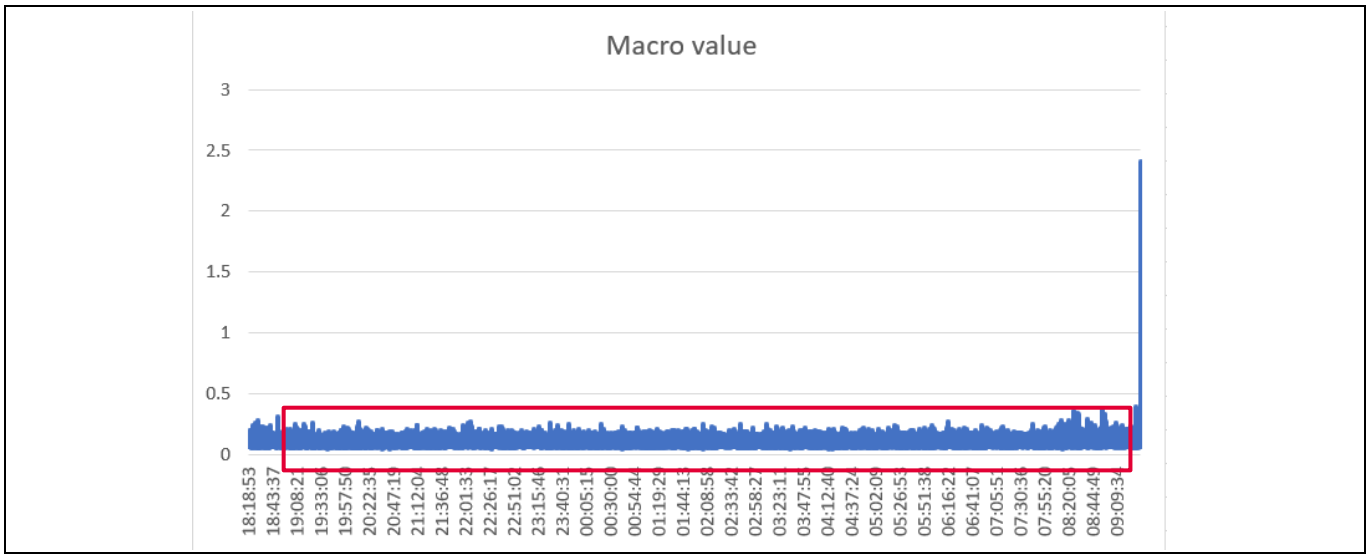



**Figure 32 Plot the graph in Excel file**

12. Select the **Macro threshold**, select **0.5** from the **Value** dropdown, and then press **Set**.

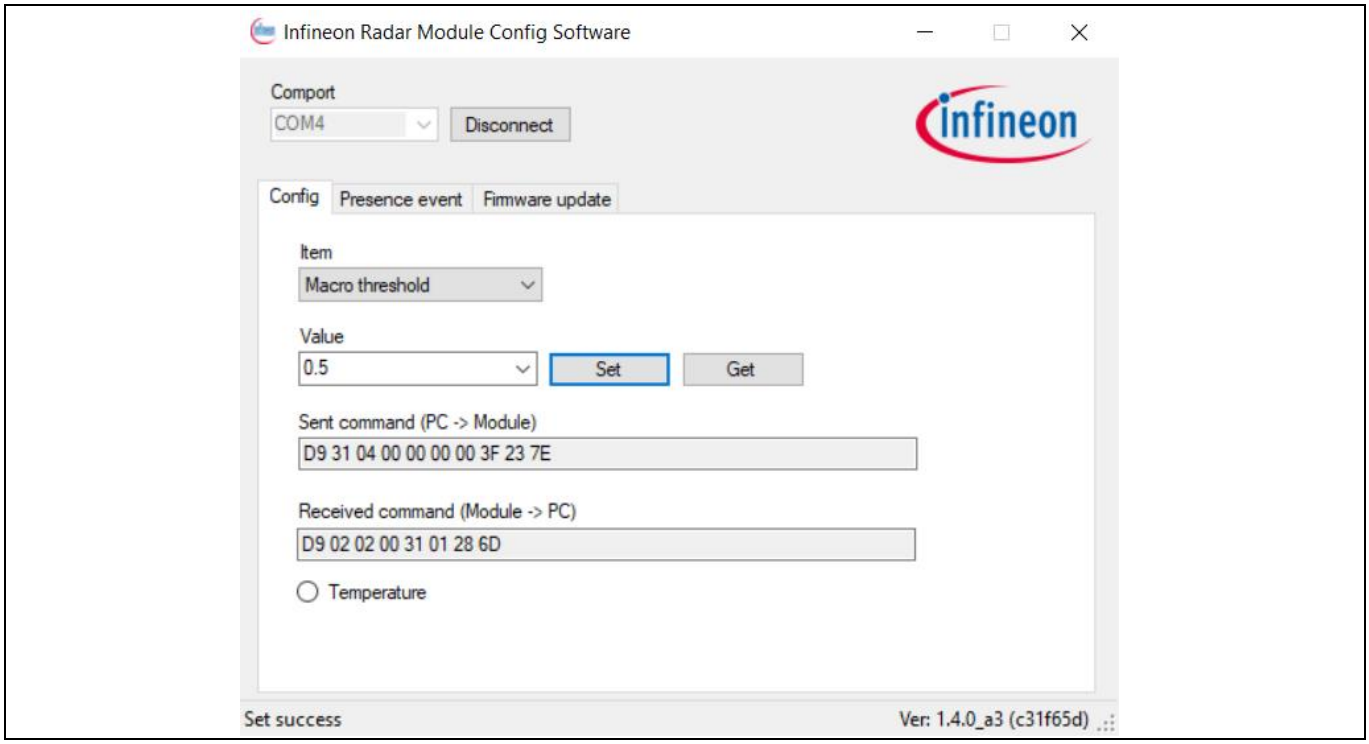



**Figure 33 Set macro threshold**

13. Similar to the macro value, the micro value will remain at a low level when there are no moving objects present in the environment. In this example, the highlighted red region represents the timeframe for an empty environment. Selecting the maximum value within that range as the micro threshold, which is 10.

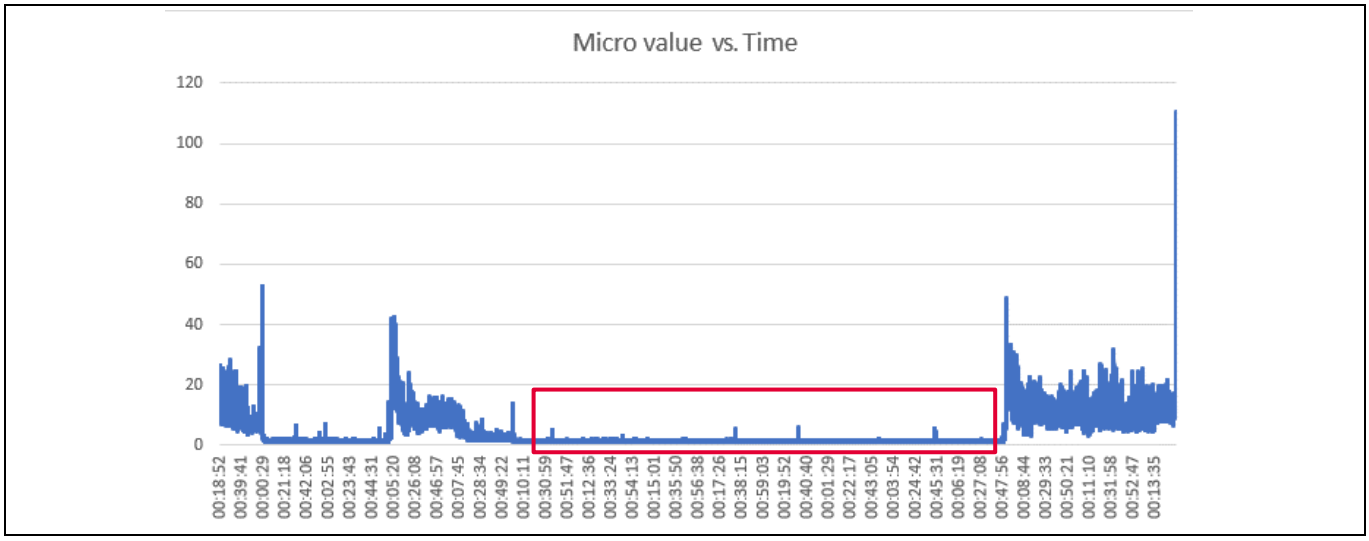



**Figure 34 Analyze micro graph**

14. Select **Micro threshold**, select **10.00** from the **Value** dropdown, and then press **Set**.

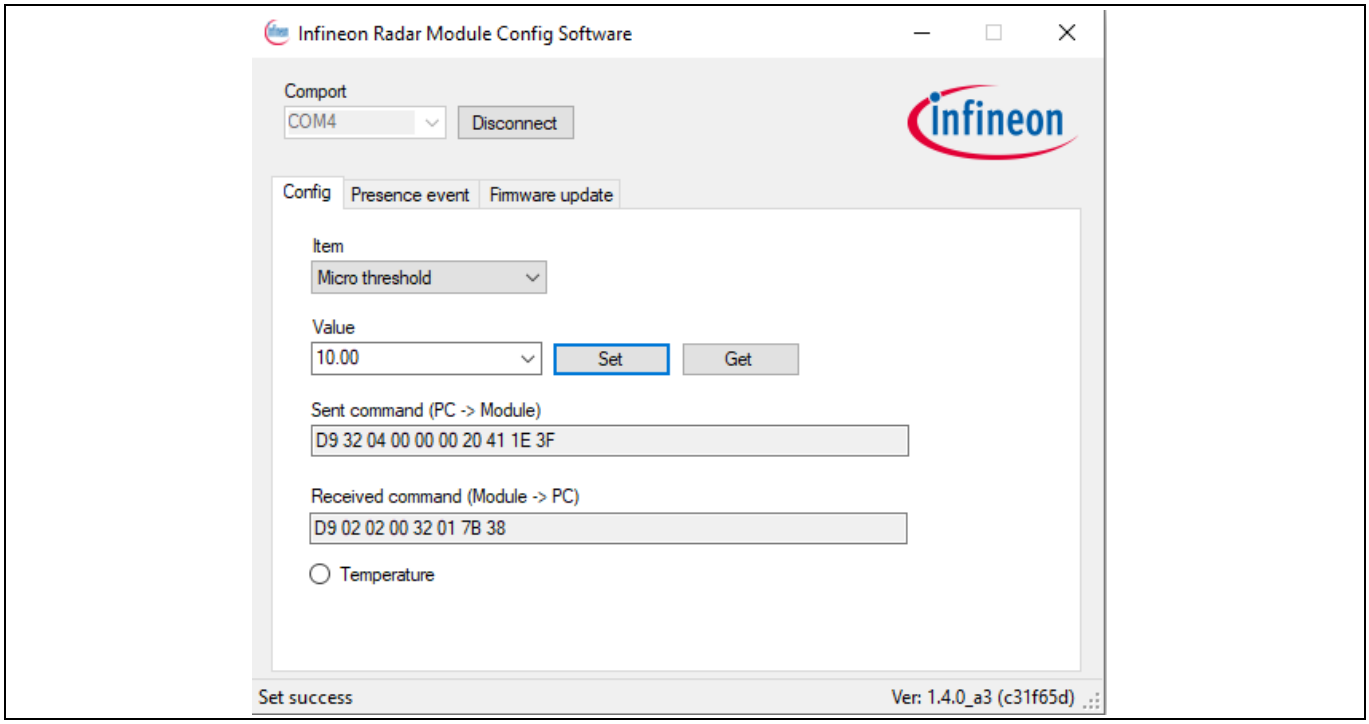



**Figure 35 Set micro threshold**

## 3.2 Abnormal situations

Assuming the macro threshold is set to 0.5 and the micro threshold is set to 10, the presence of a vibrating object will cause the micro value to remain consistently higher than the micro threshold. Consequently, the radar will erroneously remain in the presence state, even when there is no one present in the room.

Figure 36 shows an example scenario where the detection is disrupted by an air conditioner. The black highlighted area represents the duration when the air conditioner is switched on, while the blue highlighted area represents the duration when the air conditioner is turned off.

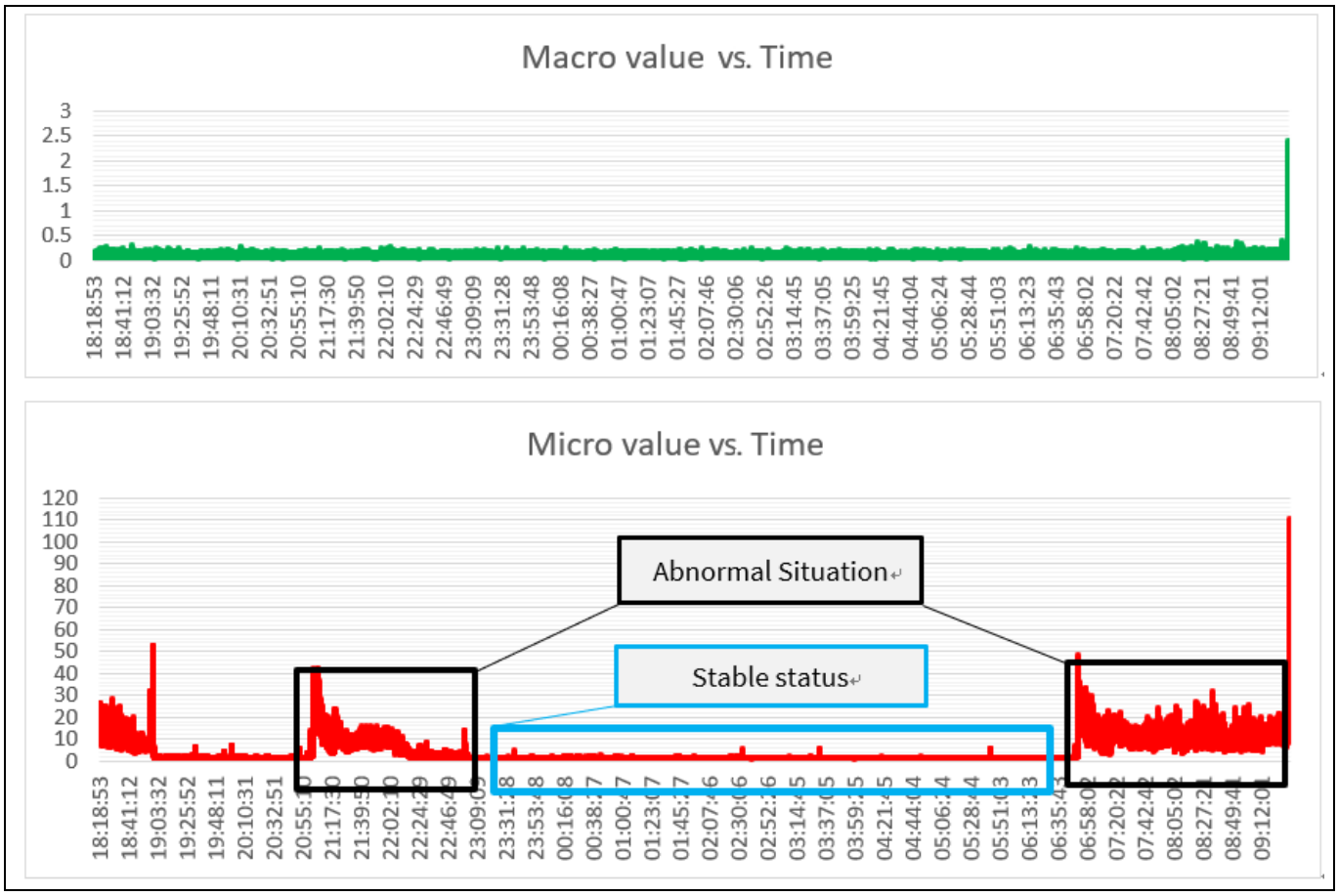



**Figure 36 Micro and macro values with small vibrations**

# 4 Potential problems in the installation environment

As mentioned in Section 3, certain objects like air conditioners can produce vibrations that may impact the performance of radar detection. Be cautious of the following potential issues:

- Hanging lights/tubes
- Curtains
- Radar installed near air conditioners
- IP/CCTV cameras

Figure 37, Figure 38, and Figure 39 provide examples of these potential problems. It is recommended to keep the radar at a distance from these objects and avoid placing them within the radar's detection area.

**Figure 37 Hanging light and curtain**

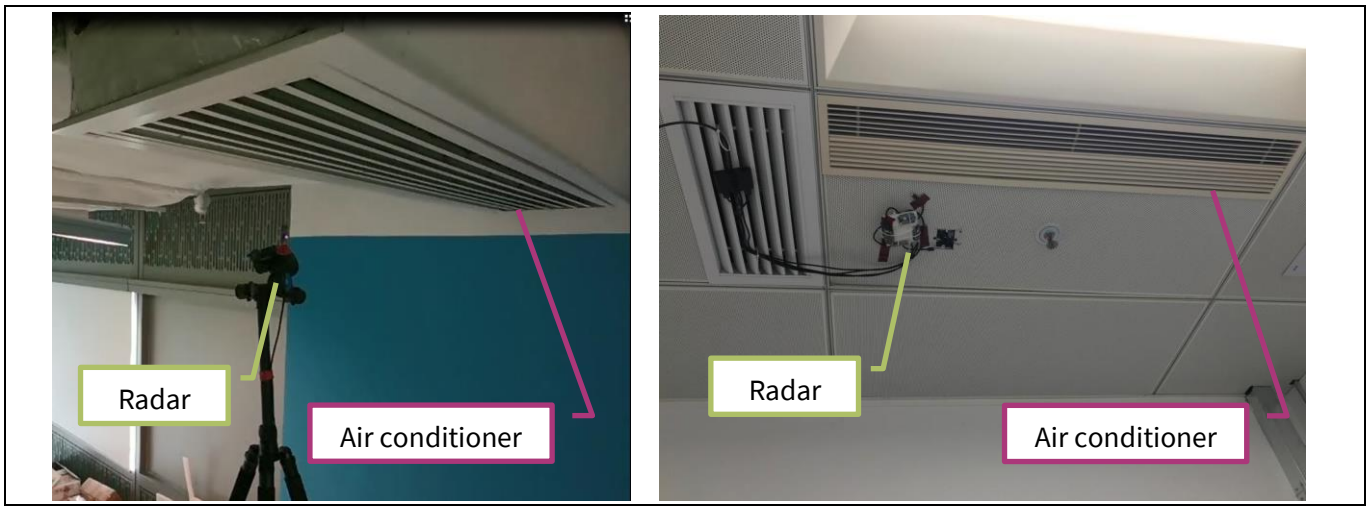



**Figure 38 Air conditioner**

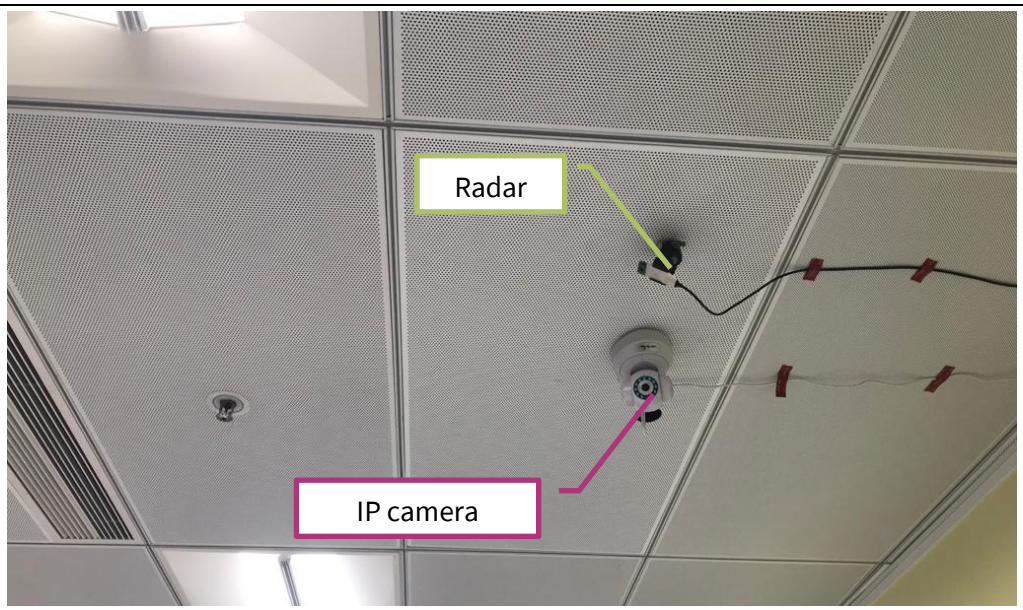



**Figure 39 IP/CCTV camera**

## References

[1] Infineon Technologies AG: *XENSIV™ KIT_CSK_BGT60TR13C board;* Available online

[2] Infineon Technologies AG: *XENSIV™ KIT_CSK_BGT60TR13C user guide;* Available online

[3] Jorjin Technologies Inc.: *MM5D91-00 60GHz mmWave Radar Presence Detection Sensor Module;* Available online

# Revision history

| Document revision | Date | Description of changes |
|---|---|---|
| 1.00 | 2021-07-06 | Initial version |
| 1.10 | 2022-03-02 | Fixed document title and typos. |
| 1.20 | 2024-07-15 | Miscellaneous document cleanup updates |

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