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for better quality of experience

MAXIMIZE SENSING ACCURACY USING RADAR

Ideal for Everyday Applications with Advanced Calibration Features for Preventing Detection Errors

Application Note

Overview

A sensor device that triggers a certain function when an object is either present or not may sound simple. But in reality, there are numerous factors to consider in order to avoid false positive readings or detection errors. These can include failure to detect object presence and false positives when the sensor mistakenly senses a presence within the alert zone even when there is no actual object

Use Cases

In this article, we will examine various scenarios and analyze how RADAR sensing is applied and the advantages associated with its use.

Distance Measurement

Distance measurement is an added advantage when power conservation is concerned, particularly with battery operated sensing devices. RADAR offers multiple zone-based settings. What this means is that specific distance can be pre-calibrated so that the sensor, when combined with an MCU, can remain at a sleep/stand-by mode and become activated once an object/person enters into the specified zone and distance. This saves energy and is especially beneficial because image recordings can consume enormous amount of power if they are running all the time. Having the distance calibrated in advance, RADAR integrated with camera - allows the camera to remain idle and starts video recording once an object enters into the defined area.

Angle Entry Detection

Having the angular measurement capability can add an extra level of security. Most motion sensors are designed to detect objects entering the Field of View (FOV) but the kind of data they are able to generate can make a big difference in the interpretation of that data. The commonly used Passive Infrared (PIR) sensor is only able to trigger simple actions such as objects coming in and out of the FOV – aka "the sensing zone". However, with RADAR, additional data can be captured, such as the angle of entry, as well as recorded images when combined with a camera.

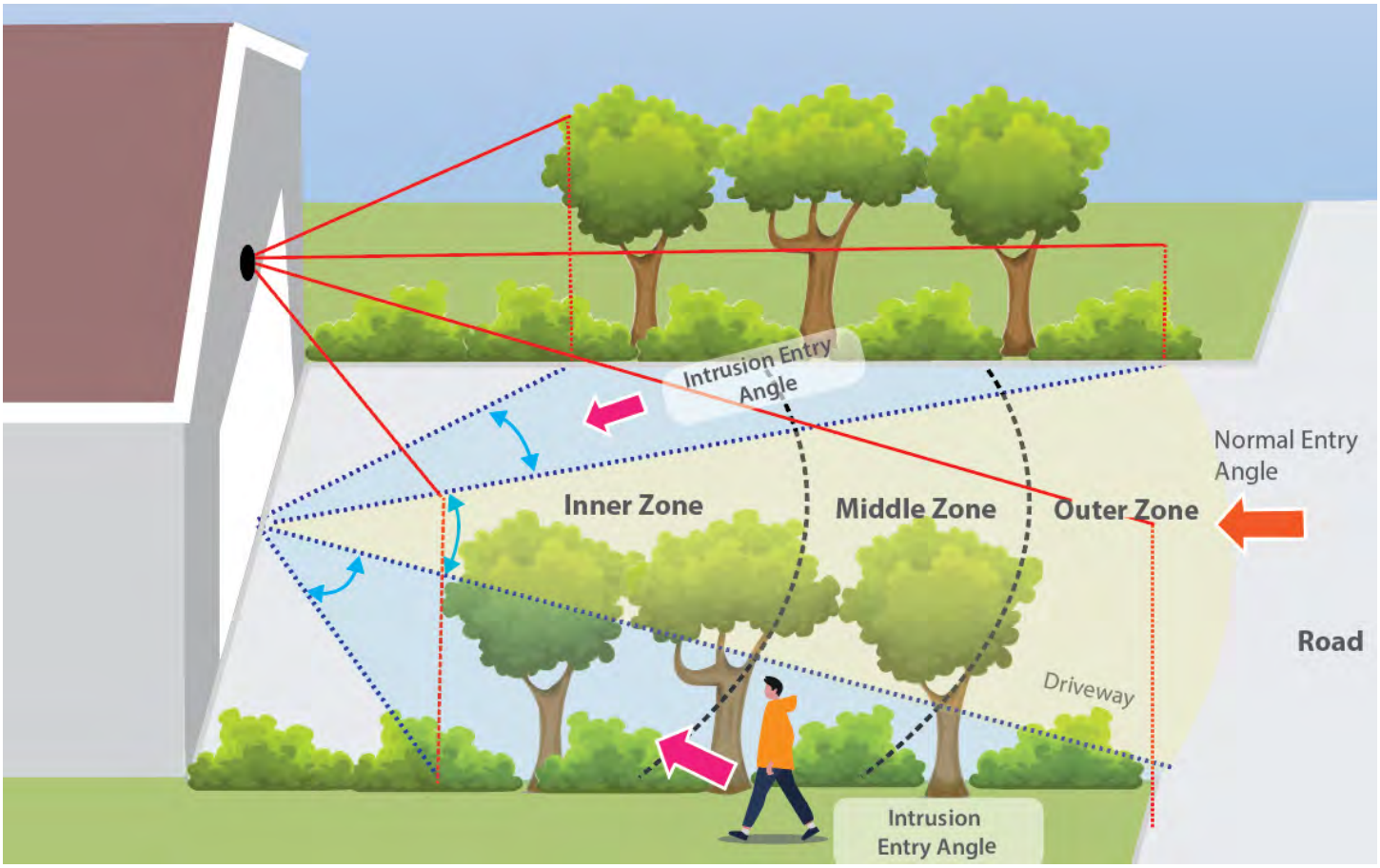


Figure 1. The diagram illustrates how the angle entry and distance measurement with zone set up can be utilized by the unique properties of RADAR sensor.

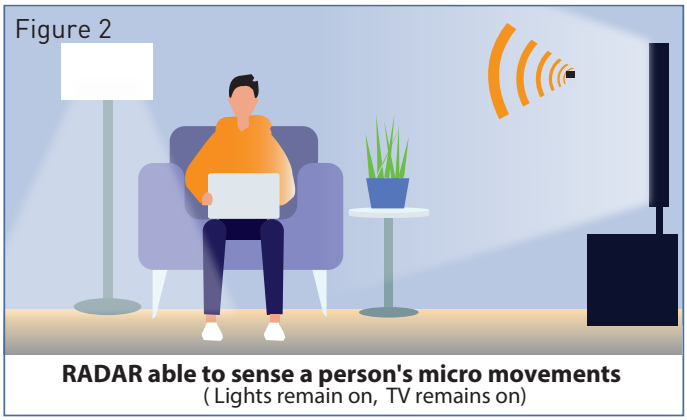
Large Movement Detection

Large movement can be defined as relatively large displacement of an object and usually involves a displacement measured in feet and not in inches. Applications used in large movement detection include tracking number of people in and out of a building or counting the number of vehicles in and out of a garage within the allowable range. RADAR, in addition to having a wide range of advantages mentioned earlier, makes it a far more favorable technology for large movement detection. It minimizes power usage, reduces false alarms with defined distance, and provides added intelligence with angle-of-entry data.

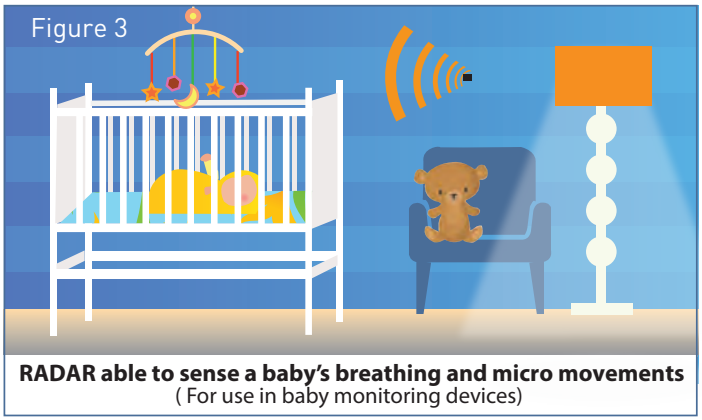
Micro Movement Detection

Micro movement is especially important for in-home control applications (Figure 2 & 3). In earlier sensor technology such as PIR, micro movement detection does not exist, as it relies on large movement for object detection and a pre-set timer to control the light fixtures. This kind of control often causes the lights to inadvertently turn off even when a space is occupied by people who aren't moving much. Micro movement detection can effectively control a wide variety of home fixtures and devices.

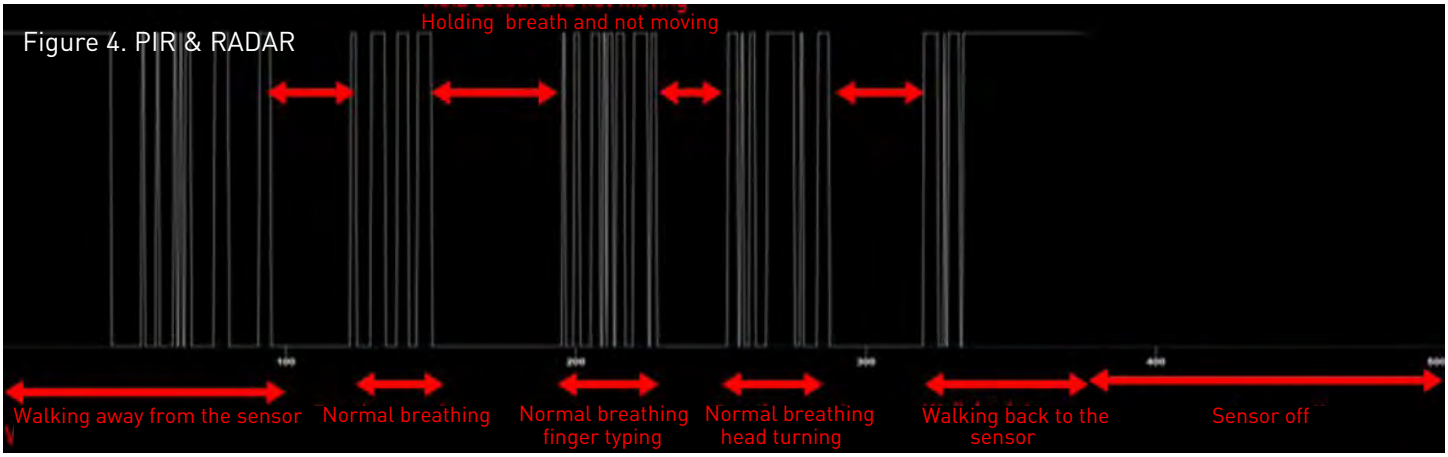
The two figures below (Figures 4 & 5) illustrate the micro and large movement detection. Large movement like walking, sit down movements are being detected by both PIR and RADAR (Figure 4). While the micro movement are only detected by RADAR (Figure 5).

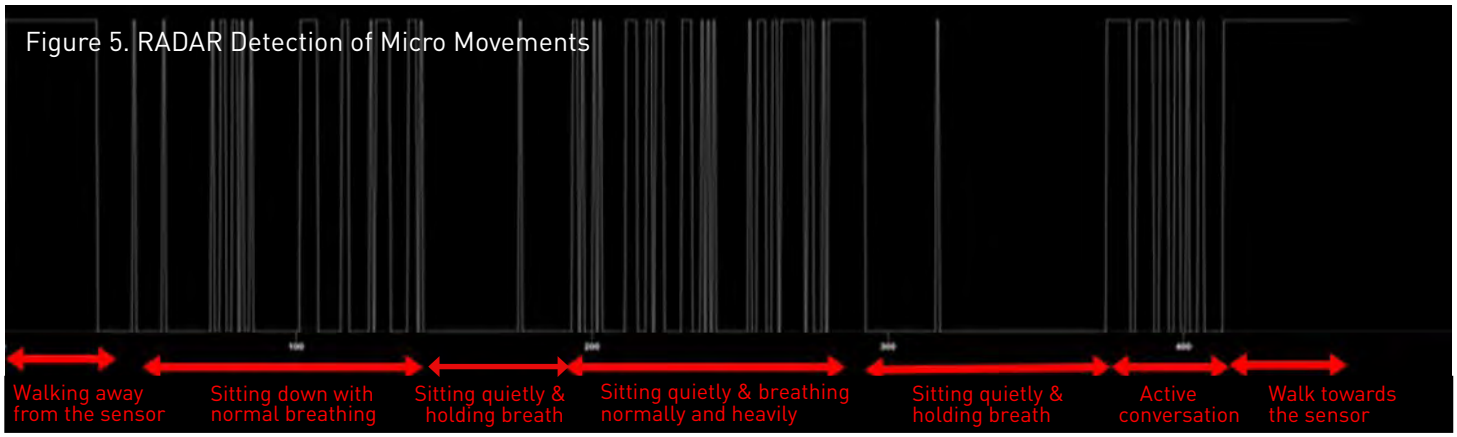


RADAR able to sense a person's micro movements
(Lights remain on, TV remains on)



RADAR able to sense a baby's breathing and micro movements
(For use in baby monitoring devices)





Factors Caused by Temperature Changes and Movements from Inanimate Objects

Home Electronics

Home applications such as portable fans, ceiling fans or portable heaters can trigger false presence detection due to the movement of the rotating fan blades and air flow. To achieve optimal sensing accuracy, an added algorithm is required.

A RADAR sensor has the option to remove such so-called "background noise". As part of the calibration process, devices can be configured in advanced to identify the 'on' and 'off' signatures from various home electronics, and factor that data into its functional behavior.

For instance, calibration is done to include all home electronics as add-on fixtures while they are in operation and the sensor will identify the signal differences by considering the data set as part of the background so that any movement generated by the add-on fixtures will not trigger movement detection. Figure 6 below illustrates the calibrated range where the RADAR sensor accounts for "background noise" during the sensor calibration process.

On the other hand, sensor calibration can be performed while the add-on fixtures are in non-operation mode and the 'off' signature is eliminated as part of the background signature. In such a case, the RADAR sensor did not trigger any response when detecting movement from the fixture.

Figure 6. RADAR Sensor detects backround noise

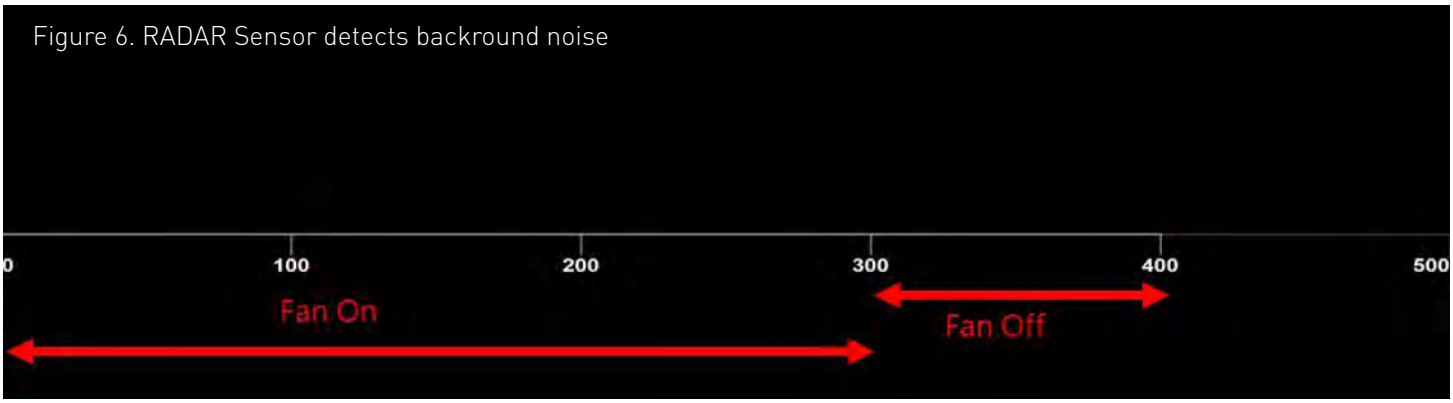
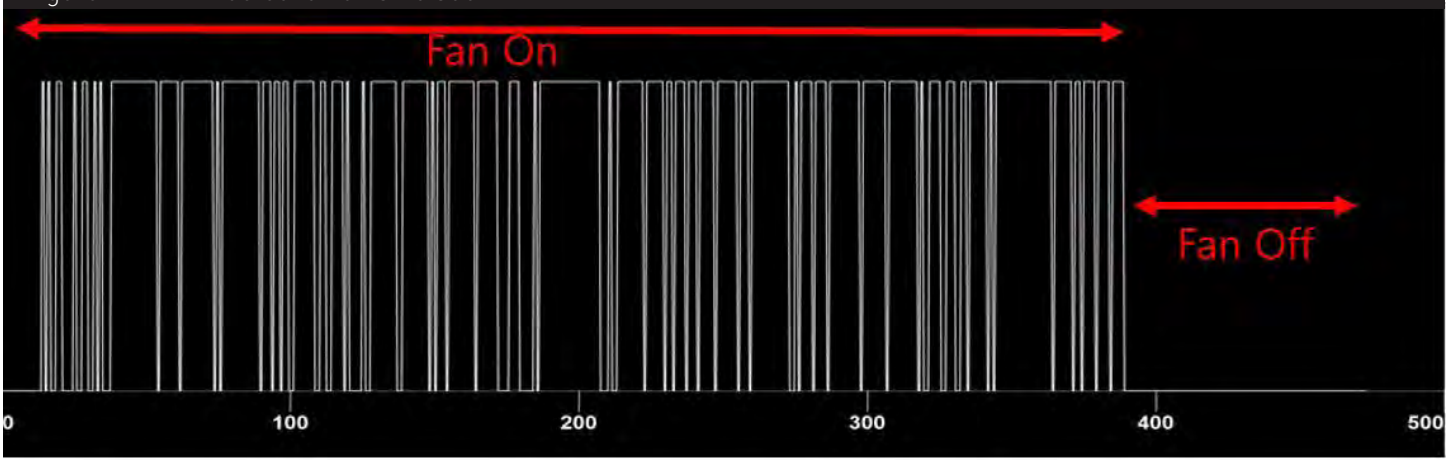


Figure 7. RADAR detection of fan blade



The figure above illustrates the detection of the fan blade movement when a static background is used for calibration.

Plants and Trees

False sensor detection is often caused by movements from plants created by air current caused by home appliances such as air conditioner (A/C) units, heaters, fans or other in-home devices.

A typical scenario is when the A/C or heater turn on in the middle of the night, causing the home control sensor to detect movement from a household plant, which triggers the light to be switched on as if someone is present in the room. Although PIR can detect this kind of movement, it will require extra development effort to eliminate such unwanted false positive readings. A sample test performed indicated that the PIR motion detect result is not very reliable when detecting plant movement. See PIR result below (Figure 8).

Such kind of unwanted background movement can be eliminated by running the RADAR calibration with plant while in motion.(Figure 9).

Another area to consider when designing a product is to factor in all possible elements in its surroundings that might cause an inaccurate reading. Trees, shrubs and various decorative or garden ornaments like windchimes or pin-wheels may create movement during a windy day; this will trigger the security device to create a false positive that is undesirable in any security system.

Due to the unpredictability in dealing a wide range of environmental conditions, a complex algorithm is required to minimize such false positive readings. The great advantage of using a RADAR sensor is that it does not require the need to develop complex algorithms for each element considered. RADAR will simply calibrate the sensor to include all kinds of movements, independent of what they are.

Figure 8. PIR Movement of plant

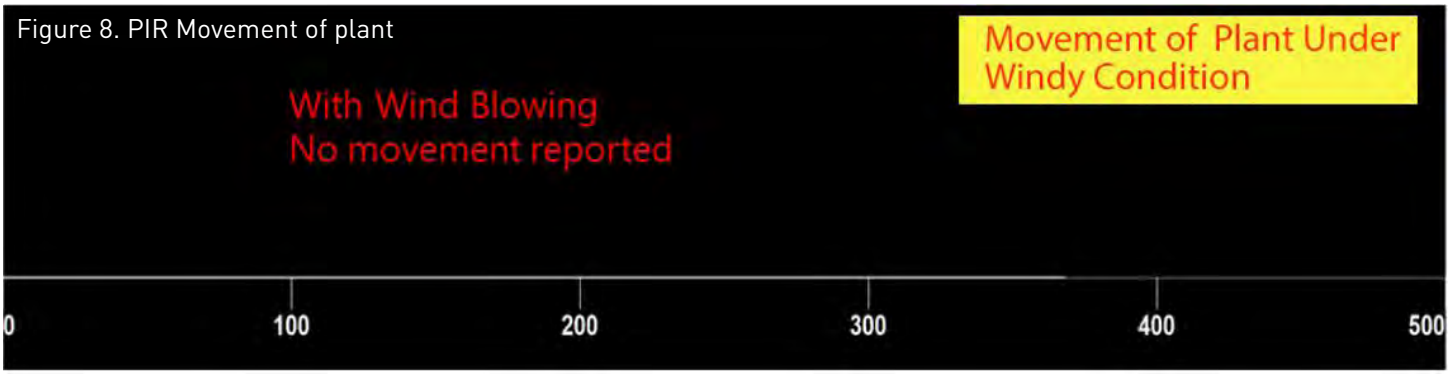


Figure 9. RADAR calibrated to detect plant movement

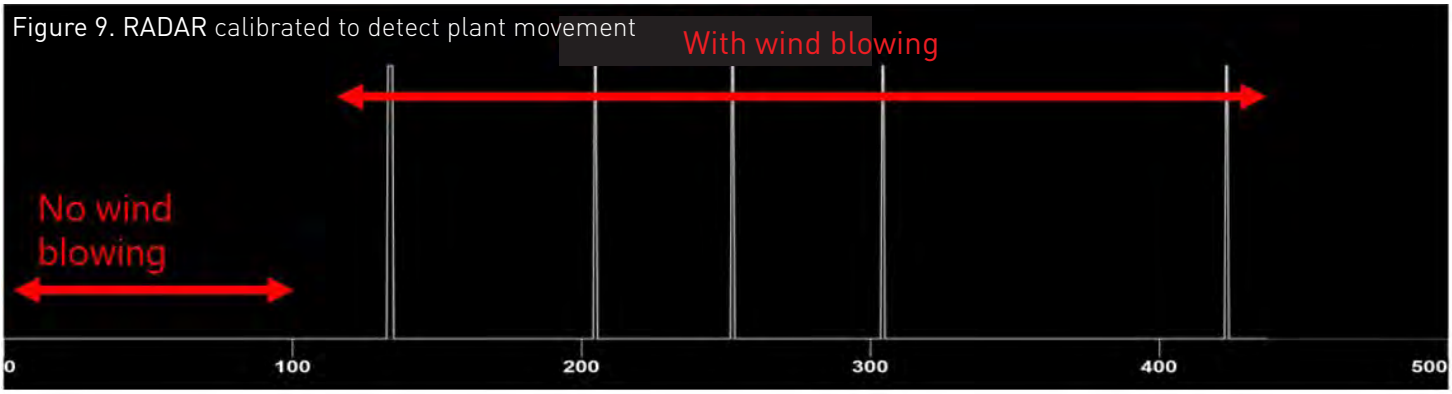


Figure 10. RADAR calibrated to filter out plant movement conditions.

Figure 10 on previous page shows how the sensor calibrates and filters out movement of shrubs under windy conditions. The signature difference helps to eliminate false readings and accurately detects human presence.

Alternatively, (Figure 11) calibration can be done in reverse under windless conditions, allowing a user to choose the sensing options. This kind of flexibility makes RADAR a great sensor choice.

Environmental Conditions and Temperature Fluctuations

A major disadvantage with certain sensing technologies such as PIR is the requirement for having a consistent temperature in its immediate surroundings in order to prevent false positive readings.

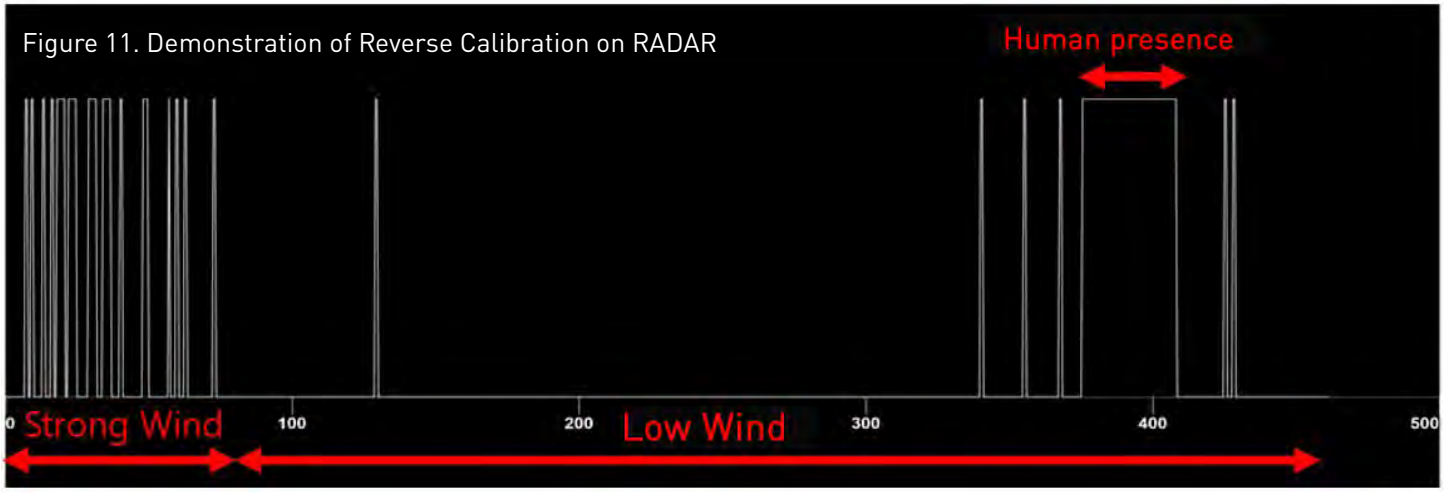
RADAR, unlike PIR, has excellent environmental resistance such as temperature changes caused by rain, wind, snow, heat, etc. Such characteristics make RADAR a suitable sensing technology where environmental factors are of concern. Additionally, and due to its inherent resiliency, the mounting location of RADAR is less restrictive, and may even be completely obscured, with 100 percent functionality, behind solid, non-metallic enclosures.

Summary

Motion sensing technologies differ greatly with varying capabilities. In order to improve sensing accuracy and conserve power usage, complex algorithms and device calibrations are used in order to eliminate false and false-positive readings. When developing a security product, it makes sense for companies to consider real-life, practical use cases to avoid sensing errors and increase the reliability of the security device.

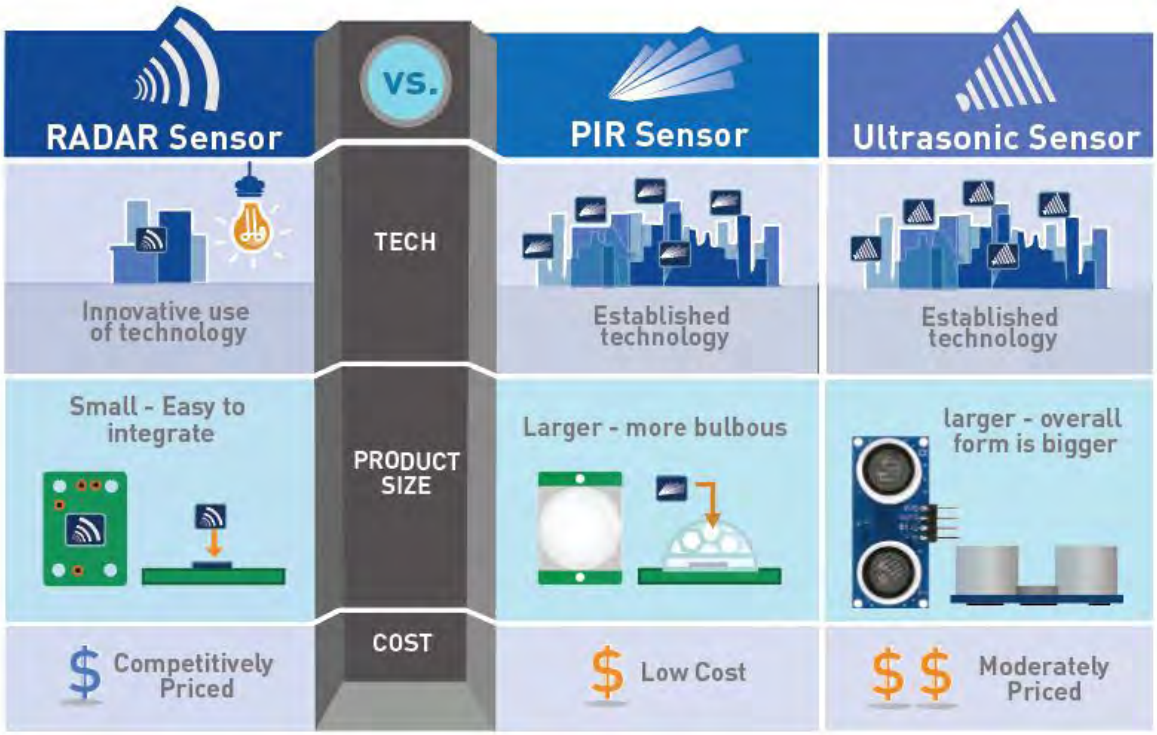
Visit www.socionextus.com/radar to learn more about RADAR sensor solutions from Socionext.

Figure 11. Demonstration of Reverse Calibration on RADAR

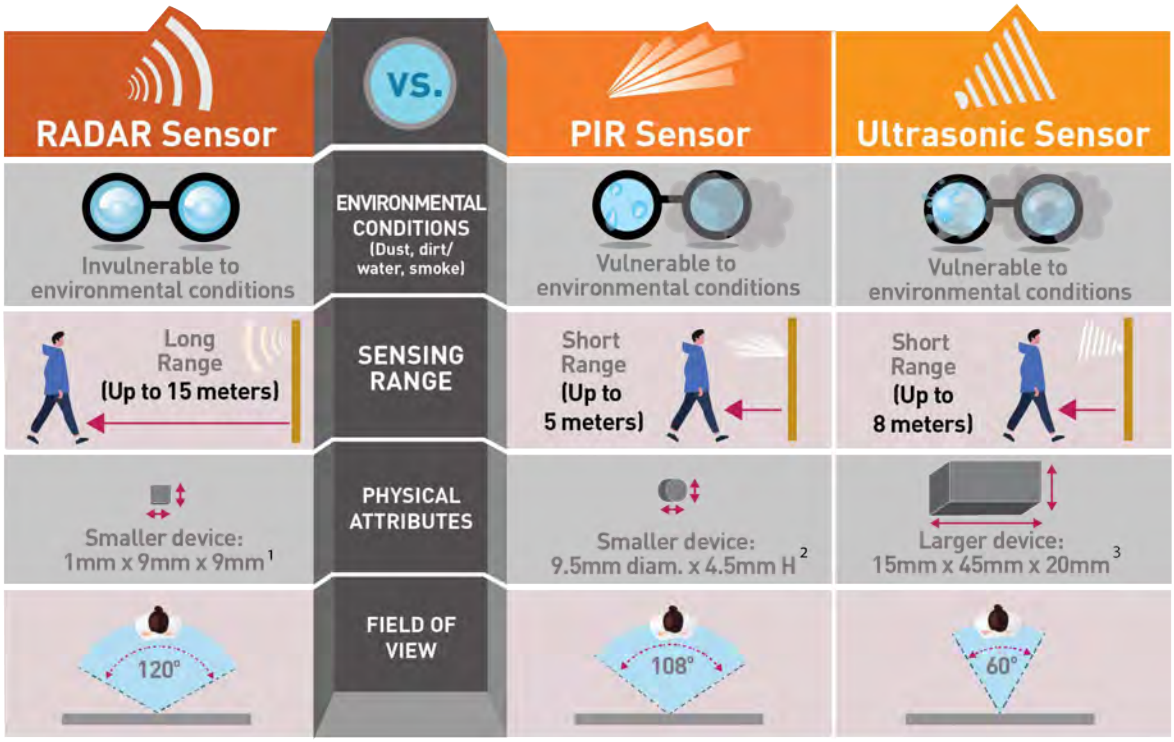


Comparison Graphs of RADAR vs. PIR and Ultrasonic Sensors

Comparable Attributes



Distinctive Attributes



Product dimension referenced:
[1] Socionext SC123x Series 24GHz RADAR Sensor
[2] True Sense Technologies PIR Ceiling Mount Motion Sensor (TS-06)
[3] Ultrasonic Sensor Module (HC-SR04)

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