Technical Documentation

Radar vs PIR: selecting the right solution

Background

As radar capabilities advance, the level of information obtainable increases.

Per the image below, radar now provides a more broader range of capabilities which means where previously passive infrared (PIR) may have been the only viable solution, you now need to understand if the advantages radar brings over PIR could benefit your specific application further.

The objective of this material is to take a closer look at both technologies to ensure you chose the technology that will bring most value to your specific requirements.

Image: range of information obtainable from radar

Speed Sensors

Speed/velocity

› Derived from Doppler shift in frequency

N W O S

Range/distance to target

› Derived from measurement of electromagnetic wave

Angle sensor

Angle/direction to target

› Derived from phase difference at the antennas

Position sensor

Position of object

› Derived from FMCW

www.infineon.com/24GHz

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Comparison of some example use cases

Before we move further into the details of two solutions, the chart below lists some of the advantages that radar brings against some of the challenges of PIR.

Use case	Advantages of radar	Challenges of PIR
Indoor lighting	› Increased detection range › Energy efficient by turning lights off automatically › Can be discretely designed behind casing	› Limited range compared to radar › Limited coverage means more sensors required › Unsightly design means PIR needs to be visible
Automatic door	› Detects direction of travel so only opens when necessary › Keeps the building energy efficient through reduced door opening	› Only detects movement, irrespective of person coming into building › Cannot distinguish between people and animals
Smart street lighting	› Increased detection range › Precision object identification › 24GHz works independent of hot weather	› Can be unreliable and impacted in harsh weather conditions › Lack of object identification means false triggers › No directional measurement
Intruder alarm	› Increased detection range › Reduce false alarms › Detection sensitivity is adjustable	› Unsightly design means PIR needs to be visible › Can be unreliable and impacted in harsh weather conditions › Limited range/coverage means more sensors required

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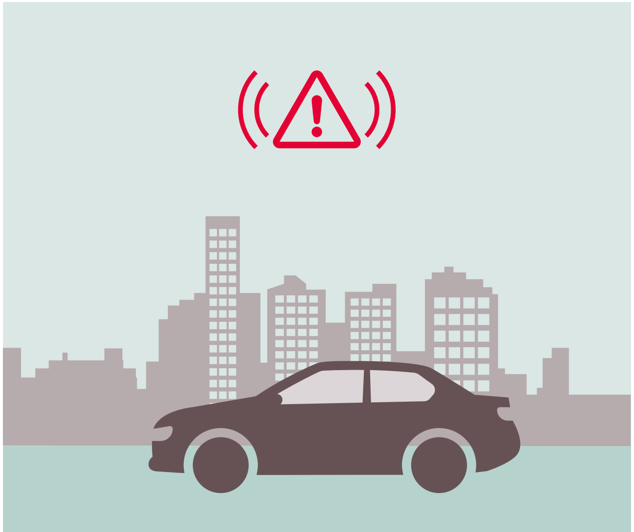
When designing sensor systems for detecting proximity or motion information, designers must consider flexibility and cost of the type of technology they utilize.

Is radar the correct technology for my application? The answer depends on the system requirements with respect to functionality and costs, and to fully answer this question, let's quickly review how each of these sensors behaves. Traditional motion sensors have been designed using PIR. This has been an inexpensive and simple detection of objects using the object's heat signature when the object comes within the range of the sensor. The PIR sensor detects changes in the amount of infrared radiation it sees and converts this change into a voltage. This voltage is compared to a threshold limit to trigger a signal that enables a light or activates an alarm.

Radar uses the Doppler principle to determine the object's motion, speed and even direction, given the complexity of the radar's implementation. For the simple case of object detection, the radar transmits a 24 GHz waveform and reflects off an object that is in the sensor's field of view. This reflected waveform is received by the radar transceiver. The received signal will have a frequency difference referred to as the Doppler frequency. The Doppler frequency is then used to detect movement along with velocity. Depending if the 24GHz transceiver is fed with a Continuous Wave (CW) Doppler or Frequency Modulated CW (FMCW), other parameters of the object can be realized such as distance to the sensor and given an additional antenna, the exact position or coordinates of the object in the field of view.

"Factors such as range, object sensitivity and environmental factors can influence the sensor performance."



Getting back to the question of whether radar is best suited for a particular application; the designer must determine critical features versus cost for this design. Factors such as range, object sensitivity and environmental factors can influence the sensor performance.

PIR is inexpensive, although radar technologies are decreasing in cost and are more compact and simple to design. Radar can be as simple as a PIR sensor detecting motion or as complex as an imaging radar where complex algorithms and multiple antennas can render a map of geographic terrain.

Technology comparison

Features	24GHz sensor	Infrared	Ultrasonic	Laser
Application flexibility	Best	Weak	Weak	Weak
Resistance to moisture, dirt and temperature	Best	Weak	Weak	Weak
Speed detection	Best	Weak	Good	Best
Accuracy sensitivity	Best	Weak	Best	Best
Resolution	Best	Weak	Best	Best
Direction capability	Best	Good	Good	Weak
Distance measurement	Best	Good	Weak	Best
Penetration of materials	Best	Weak	Weak	Weak
Size of solution	Best	Best	Best	Weak
Cost	Good	Best	Best	Weak

● Best ● Good ● Weak

Sensor features will dictate technology choice. Is distance important? If so, consider that PIR sensors are roughly 10 meters maximum, and found in places like in-home motion detectors or driveway lights. Radar can range from within 10 meters to over 50 meters depending on the radar signature of the object. This opens the door for radar as a sensing solution for various applications where PIR traditional has limitations. Sensing for outdoor lighting for streets, parking lots or campuses can be extended to cover a larger area depending on the antenna scheme.

As inexpensive as PIR is, there are limitations in performance. For example, the PIR sensor monitors change in the infrared radiation of an object. This means that if the object is stationary, PIR sensors cannot detect the motionless object. Environmental factors also should be considered. If the sensor is intended for an outdoor application; snow, dirt and other outdoor conditions can degrade the performance of the PIR sensor. Heat is a well-known limitation. For example, if the ambient temperature is around 98–99 degrees (F), it will not detect human movement since the body registers 98.6° typically. If an aesthetic design is desired, then consider that PIR requires a plastic radome or cover that is semi-transparent in order for the infrared energy to pass. This cover should be clean from dust or dirt in order to maximize performance. This is more difficult for an outdoor application. There are also issues with false detection when non-human objects come into the sensor’s view.

> “Environmental factors also should be considered…snow, dirt and other outdoor conditions can degrade the performance of the PIR sensor.”

When starting a new sensor design, one may consider an intelligent sensor that has positive tradeoffs that justify some minimal cost increase. The 24GHz radar sensor can be a simple Doppler-based motion detector, and a simple algorithm can determine if the object is coming closer or moving away from the sensor. Even with a Doppler implementation, speed calculation comes for free as the Doppler shift (frequency) can be used to calculate speed. The Doppler shift itself is made available by the radar transceiver to the processing unit where the processor uses this frequency to determine movement. For a slightly more complex implementation, an FMCW scheme would monitor stationary and moving objects as well as track these objects. This allows a radar to also measure range and can update the object’s movement and distance real-time to the user. Design freedom is also an important factor and can include the ability to adjust the field pattern of the sensor as well as the appearance of the sensor to the end users. Radar sensors can be designed aesthetically behind a wall or a fixture so that there is no visible sensor seen. This could be useful for security sensors that can monitor motion behind a wall. Radar sensors can be combined with optical cameras where radar serves as a longer distance activator for the camera.

To experiment with a radar solution and determine if it addresses the needs of their specific application, engineers can obtain different reference designs and development platforms such as those available from Infineon Technologies. The Sense2Go is an example of a simple and compact development platform that can be used for an intelligent motion sensor.

The Sense2Go platform allows the user to implement and test several sensing applications at the 24 GHz ISM band such as Doppler based movement detection, Doppler based direction of movement detection, Doppler based speed estimation and Frequency-Modulated Continuous Wave (FMCW) based distance measurement of stationary targets.

For additional support and information

Collaterals and brochures	› Product briefs › Selection guides › Application brochures › Presentations › Press releases, ads	www.infineon.com/24GHz-Radar
Technical material	› Application notes › Radar FAQ › Technical articles › Simulation models › Datasheets, MCDS files	
Evaluation boards	› Evaluation boards › Demoboards › Reference designs	www.infineon.com/evaluationboards
Videos	› Technical videos › Product information videos	www.infineon.com/mediacenter

Notes

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