

Module Design Makes 60GHz mmWave Radar Simple to Use

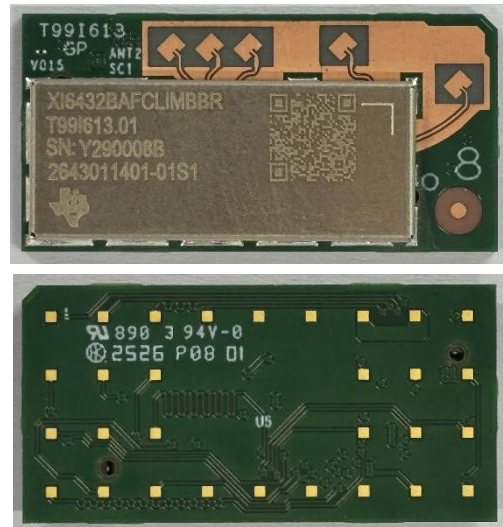


Introduction

The emergence of compact, low-power millimeter-wave radar has opened new possibilities for intelligent sensing across appliances, smart buildings, industrial automation, and IoT devices. Yet, for many years, the complexity of mmWave system design—ranging from RF layout and antenna tuning to signal processing and regulatory certification—placed this technology out of reach for most developers. Texas Instruments' IWRL6432WMOD module transforms this dynamic by offering a radar design that is not only powerful and highly integrated but also easy to use.

The IWRL6432WMOD is built around the IWRL6432W radar SoC, a device that integrates the FMCW transceiver, baseband processing, ADCs, and an M4 processor running Motion and Presence Detection processing engine. Surrounding this SoC is a carefully engineered module that includes a pre-tuned 60 GHz antenna array, on-board power regulation, QSPI flash memory, and a 40MHz crystal, all packaged in a compact 31mm × 15mm footprint. This level of integration eliminates the need for specialized RF expertise, allowing developers to focus on application-level functionality rather than low-level radar engineering.

The ease of use of the module is further enhanced by dual-mode architecture, which supports both autonomous operation—requiring no host processor—and host-controlled operation for advanced applications. Combined with TI's mmWaveULink API and the Module Visualizer GUI, the IWRL6432WMOD provides a complete ecosystem that significantly simplifies development. This article explores the architecture of the module, software environment, regulatory compliance and real-world use cases, with an emphasis on how each design choice contributes to developer-friendly experience.



Human Presence Detection Use Case

The most common application of the IWRL6432WMOD is human presence detection. The module can detect stationary or moving individuals at distances up to 15 meters, even in complete darkness or through obstructions like glass or plastic. This makes it preferred for smart lighting, HVAC control, and security systems.

Unlike passive infrared (PIR) sensors, which rely on line-of-sight and motion, mmWave radar can detect micro-movements such as breathing, enabling reliable detection even when occupants are sitting still. The module's angular resolution also allows for enabling more intelligent automation.

Smart Home Automation

The module can serve as the sensing backbone for smart home systems, enabling context-aware automation. For instance, it can trigger lights when someone enters a room, adjust thermostats based on occupancy, or alert homeowners to unexpected motion.

Its immunity to lighting conditions and ability to detect presence through obstructions make it more reliable than traditional sensors in many scenarios.

Occupancy Detection in Smart Buildings

In commercial buildings, accurate occupancy data is essential for optimizing energy usage and space utilization. The IWRL6432WMOD can be deployed in conference rooms, open offices, and restrooms to detect occupants in real time.

By integrating multiple modules and aggregating their data, building management systems can make informed decisions about lighting, HVAC, and cleaning schedules. The module's low power consumption and small size make it easy to install in ceilings, walls, or fixtures without impacting aesthetics.

Fully Integrated Radar Subsystem

The IWRL6432WMOD is designed as a self-contained radar subsystem that requires minimal external components. The heart of the module is the IWRL6432W SoC, which integrates the FMCW radar transceiver, digital signal processing pipeline, and application-level firmware. This SoC handles chirp generation, RF transmission, reception, analog-to-digital conversion, and the initial stages of signal processing, including FFTs and clustering. By embedding these functions directly into the module, TI eliminates the need for developers to design or tune RF circuitry, which is traditionally one of the most challenging aspects of mmWave development.

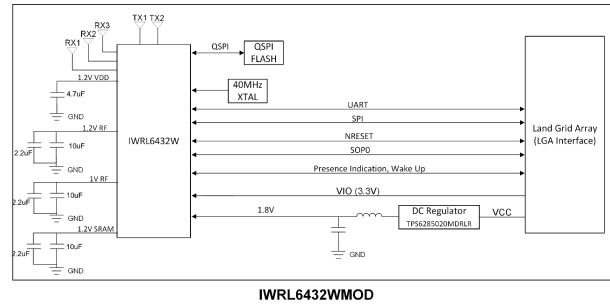
Surrounding the SoC is a set of carefully selected components that support reliable operation. The module includes a 40 MHz crystal oscillator, ensuring stable frequency generation for the radar's PLL. It also integrates a power distribution network that converts the external 3.3V supply into the internal 1.8V and RF-specific rails required by the SoC. This internal regulation simplifies power-supply design and reduces noise sensitivity, which is critical for high-frequency radar systems.

The module also incorporates QSPI flash memory, which stores configuration data for autonomous mode. This allows the radar to boot directly into a pre-configured sensing profile without requiring a host processor to send configuration commands at startup. The presence of on-module flash is a key contributor to the module's ease of use, enabling plug-and-play operation in many applications.

The internal structure of the module can be visualized as a set of interconnected subsystems, each serving a specific role in the radar pipeline. At the center is the IWRL6432W SoC, which interfaces with the antenna array, power network, and QSPI flash. The antenna array consists of three receive antennas arranged horizontally and two transmit antennas

arranged vertically. This configuration forms a virtual antenna array with six azimuth elements and two elevation elements, enabling 3D sensing with an azimuth resolution of approximately 19 degrees.

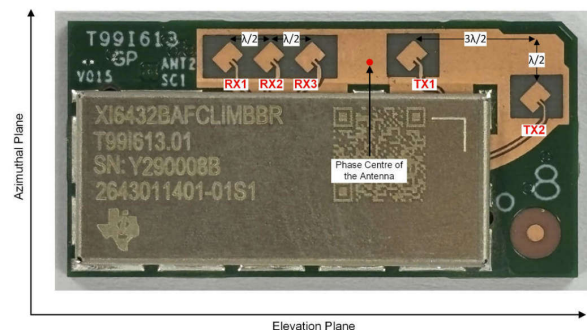
The SoC communicates with external devices through a 4-wire SPI interface, which supports configuration commands, point-cloud data transfer, and status reporting. Additional GPIOs provide functions such as PRESENCE_DETECT, WAKE_UP, SPI_BUSY, and nRESET allowing the module to integrate seamlessly into both simple and complex systems.

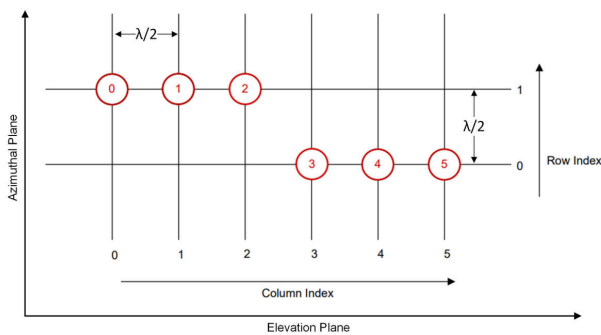


Antenna Geometry and Virtual Array

The module uses a 2D antenna array that supports both azimuth and elevation angle estimation. The three RX antennas are arranged in a horizontal line, while the two TX antennas are vertically offset. This arrangement creates a virtual array through MIMO techniques, effectively multiplying the number of antenna elements without increasing physical size.

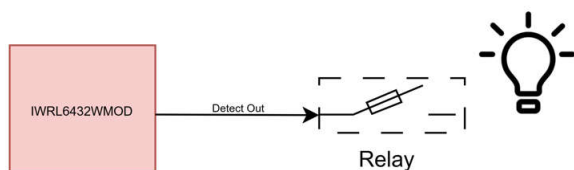
This virtual array enables the radar to detect not only the distance and velocity of objects but also their angular position in both horizontal and vertical planes. The result is a compact module capable of full 3D sensing, suitable for applications such as occupancy detection, gesture recognition, and object tracking. Importantly, developers do not need to understand or manipulate the antenna geometry; the module's firmware and APIs handle all necessary signal processing.



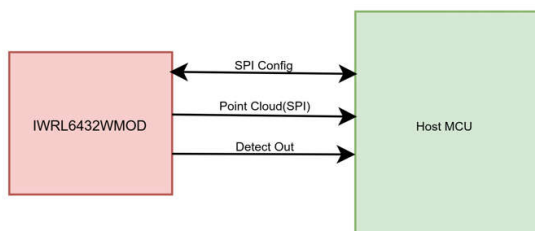


Software Operating Modes Designed for Simplicity

The IWRL6432WMOD supports two primary modes of operation: autonomous mode and host-controlled mode. In autonomous mode, the module boots from internal flash and begins sensing immediately, outputting presence detection via a GPIO pin. This mode is preferred for low-power applications where no host processor is available or desired.



In host-controlled mode, the module communicates with an external microcontroller via SPI. Developers can use the mmWaveULink API to configure sensing parameters, retrieve point-cloud data, and manage power states. This mode provides maximum flexibility and is designed for applications requiring dynamic configuration or advanced data processing.



Regulatory Compliance

The regulatory bodies in different regions of the world define the 60GHz mmWave operation in terms of :

- Frequency range allowed
- Power limits (EIRP and power density)
- Use-case restrictions (indoor vs outdoor)
- Certification and testing procedures

Region	Frequency Range	Specification Limits	Usecase and Restriction
United States (FCC - Part 15.255)	57–71GHz	40dBm EIRP	Indoor preferred; outdoor allowed with limits
Europe (ETSI EN 305 550, RED compliance)	57–66GHz	40dBm EIRP, 13 dBm/MHz density	Indoor use only (currently)
Japan (JRL)	59–66GHz	~40dBm EIRP	Requires MIC approval
China	57–64GHz (licensed)	Restricted	Limited use; regulation evolving
Others (Korea, India)	Varies	Varies	Unclear or evolving

Traditional RF certification can take 3-6 months or longer, delaying product launch and competitive advantage. IWRL6432WMOD eliminate this bottleneck, reducing development cycle by months and help in accelerated Time-to-Market. Certification costs range from \$50,000-\$150,000 per region when factoring in testing fees, engineering time, and potential re-testing for failures. IWRL6432WMOD dramatically reduce these expenses. While there is still need for system-level compliance testing, the most challenging and expensive RF component testing is already complete.

Most regulatory authorities allow modular certification approaches, where certified modules maintain their certification status when properly integrated. This means product technical documentation can reference the module's existing certifications while focusing on the system-level implementation.

The Modular Approval (MA) of IWRL6432WMOD offer a proven path to faster deployment while significantly reducing certification costs and technical risks. IWRL6432WMOD are complete RF designs that have already passed regulatory testing and obtained certifications from major authorities including FCC (United States), RED(Europe) and JRL(Japan). These modules come with certified RF performance, allowing you to integrate proven technology directly into the product without starting the certification process from scratch.

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