Technical Article

# Achieving 4D radar imaging with a single-chip, 8-by-8 cascadable transceiver

*Rogerio Almeida, Gerold Joseph Dhanabalan*


## Summary

This article explores how single-chip, 8-by-8 radar transceivers like the AWR2188 enable advanced 4D imaging radar for autonomous vehicles. 4D radar adds vertical angle measurement to detect object height, improving accuracy in ADAS. These devices also support satellite radar architectures where distributed sensors stream raw data to a central processor for simplified system design and more comprehensive radar coverage of the vehicle.


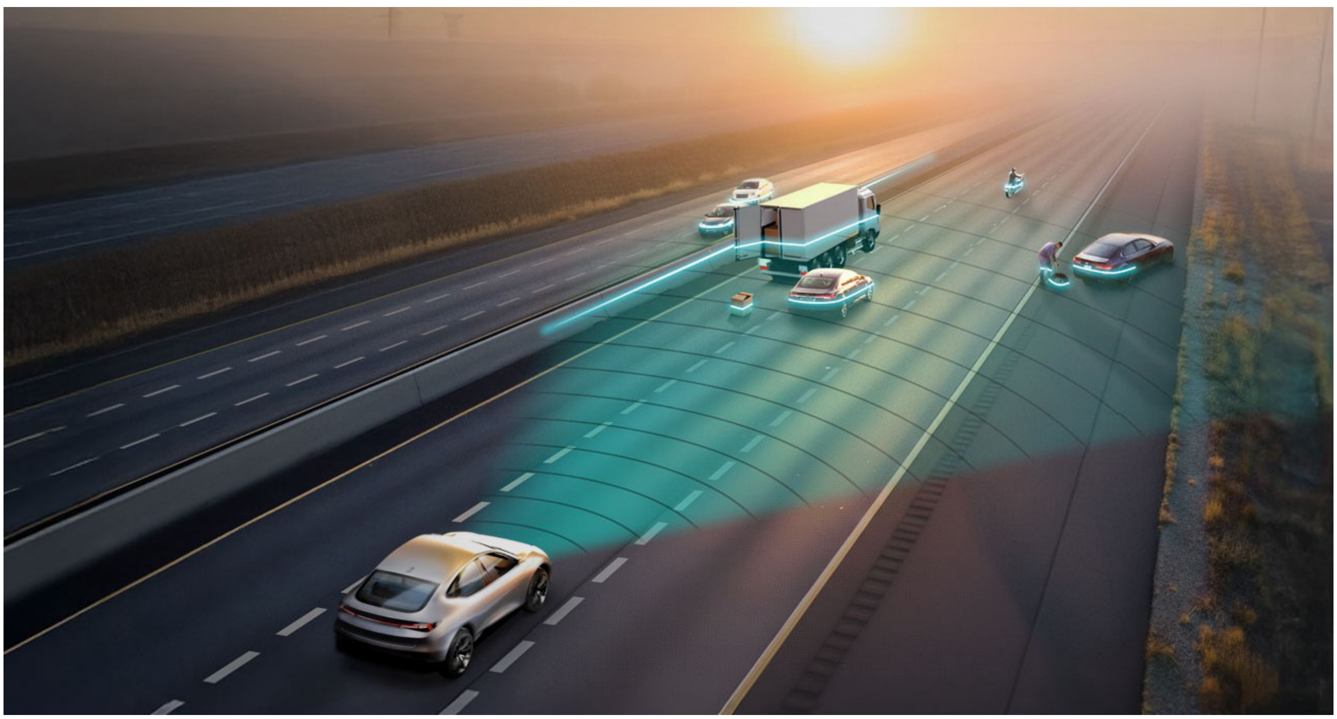

**Figure 1. 4D imaging radar provides high-resolution data including height of objects on the road**

### Introduction

Unlocking the potential of autonomous driving features requires that advanced driver assistance systems (ADAS) can reliably gather highly detailed, streaming environmental data, including proximity to other objects, the types of objects (other cars, people, obstacles) around and in front of the car, and how fast the car is moving.

Radar continues to be a foundational technology that enables ADAS to better perceive and react to a vehicle's surroundings, especially in adverse weather conditions that limit both a driver's visual acuity as well as the accuracy of vision- and light-based sensors.

Innovations in radar technology such as 4D imaging radar, which enables high-resolution sensing while adding vertical angle measurement, along with satellite radar configurations, are accelerating industry progress to higher levels of vehicle autonomy as categorized by the Society of Automotive Engineers.

These innovations and the single-chip radar transceivers that enable them are simplifying implementations of comprehensive, high-resolution radar sensing for better accuracy when tracking and discerning nearby or approaching objects.

### What is 4D radar and what is its impact on vehicle autonomy?

Automotive radar systems typically use short- and medium-range radar sensors at the front and rear corners of a vehicle for blind-spot detection, lane-keeping assistance, and front and rear cross-traffic alerts. Long-range radar sensors located at the front of the vehicle handle autonomous emergency braking and adaptive cruise control. 4D imaging radar extends the capabilities of 3D radar (shown in Table 1) by adding vertical angle measurements, allowing vehicles to detect the height of structures such as bridges and tunnels.

**Table 1. Core functions of traditional automotive radar systems**

| Function | Description |
|---|---|
| Distance measurement | Enables safe following distances through range measurements |
| Velocity detection | Uses the Doppler shift to track the relative speed of moving objects |
| Angular resolution | Determines the relative location of objects |
| Multiobject tracking | Supports the simultaneous tracking of vehicles, pedestrians and cyclists |

When combined with distance, horizontal location and velocity data, ADAS features can detect objects and distinguish between road debris, obstacles, vehicles, the road surface, pedestrians or even a person crouched next to a vehicle changing a tire. These sensing capabilities create a high-resolution visualization of objects around a vehicle (Figure 1).

Along with extending the range of object detection, 4D imaging radar also improves accuracy. Unlike lidar or cameras, 4D imaging radar relies on echolocation, which uses radio waves to determine the location, speed and shape of objects in order to monitor environmental and vehicle conditions. Because radio waves have longer wavelengths that can penetrate through particles such as rain, fog and dust, 4D imaging radar has better performance than lidar or cameras in adverse conditions with poor visibility.

4D imaging radar obtains data from a multiple-input, multiple-output antenna array that facilitates high-resolution mapping. With many antennas transmitting signals to targets within the surrounding environment and receiving signals reflected by those targets, the antenna array generates point-cloud data that translates to improved environmental modeling and object classification.

### How do single-chip, 8-by-8 radar chips simplify 4D radar design?

Implementing 4D imaging radar presents significant challenges for automotive original equipment manufacturers (OEMs). Traditional radar systems often require cascading multiple chips to achieve the necessary antenna array size and channel count for high-resolution imaging, increasing system complexity, power consumption and cost. This integration also requires more thermal management and larger printed circuit board footprints, complicating vehicle design and manufacturing.

For example, implementing an 8-by-8 configuration with 4-by-4 transceivers would require two cascaded 4-by-4 transceivers along with PMICs, additional peripherals and a larger board to route the two ICs. This increases overall system complexity, power consumption and system cost. A single-chip AWR2188 transceiver can enable this configuration by itself while also allowing for scalability up to 32-by-32 with only four 8-by-8 devices cascaded together, significantly reducing system complexity.

Figure 2 shows how AWR2188 transceivers can be cascaded from an 8-by-8 configuration to 16-by-16, 24-by-24 and 32-by-32 configurations. This high level of scalability enables Tier 1 automotive suppliers and OEMs to meet consumer demand for improved functionality and greater autonomy.

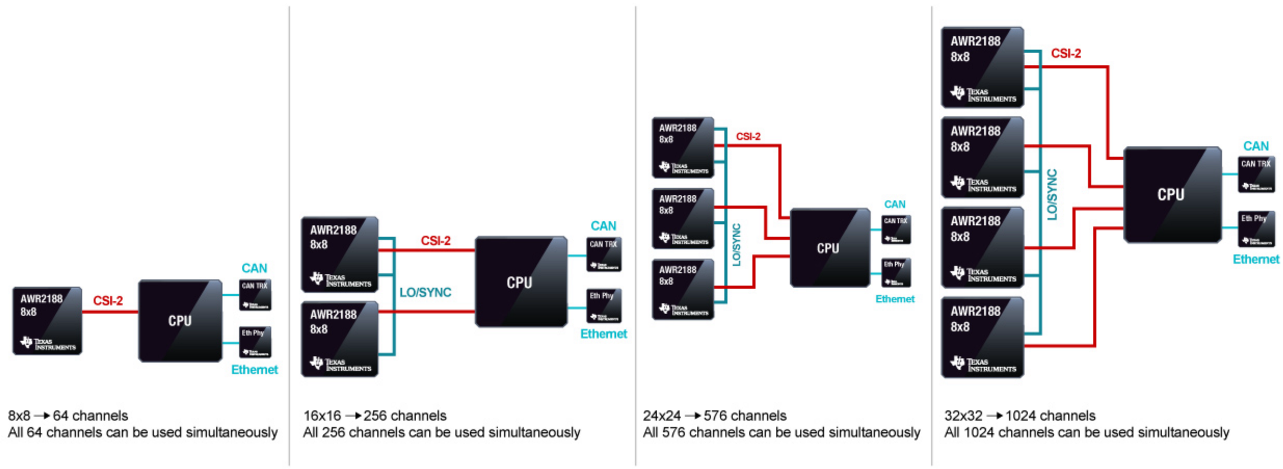


**Figure 2. Cascadable configurations from 8-by-8 to 32-by-32 with AWR2188 4D radar transceivers**

Cascading these devices helps designers achieve even higher performance and more accurate long-range object detection at >350m (as shown in Figure 3), while also providing a scalable development path, from cost-effective stand-alone implementations to premium radar systems.

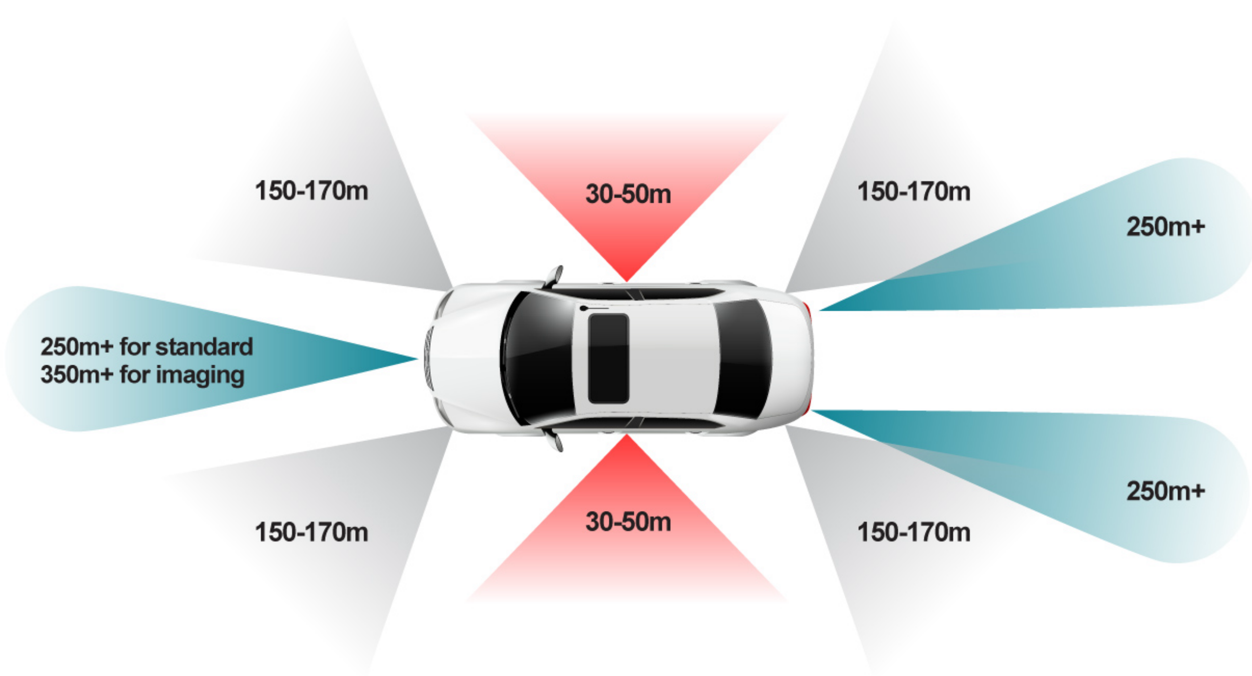


**Figure 3. 4D imaging radar improves coverage**

### How single-chip, 8-by-8 radar transceivers support satellite radar architectures

To support sophisticated ADAS features, automotive radar is evolving from traditional edge radar architecture, where data is processed at each sensor, to satellite radar architecture, where radar transceivers around the vehicle provide raw data for processing by a central electronics control unit (ECU).

Through the distributed configuration of satellite architecture, the central ECU can more easily build a comprehensive environmental view, minimizing coverage gaps rather than processing that data at the edge, as in a traditional edge radar configuration.

In a satellite architecture, the central ECU minimizes latency through its high level of computing resources, allowing the vehicle to respond faster to sensor data.

Modern sensor integration is increasingly using artificial intelligence and machine learning frameworks to combine data from multiple input sources such as imaging systems and radar sensors in order to enhance system performance through minimally processed or raw sensor inputs. Transmitting unfiltered data streams to the CPU creates opportunities for software-based product differentiation across vehicle fleets and operational adaptability that is unattainable with traditional architectures.

The AWR2188 supports both architectures and was designed to integrate with an ecosystem of industry-leading processors, helping designers more easily adopt satellite radar as they design for higher levels of autonomy. Figure 4 is a block diagram of a satellite architecture using AWR2188 sensors.

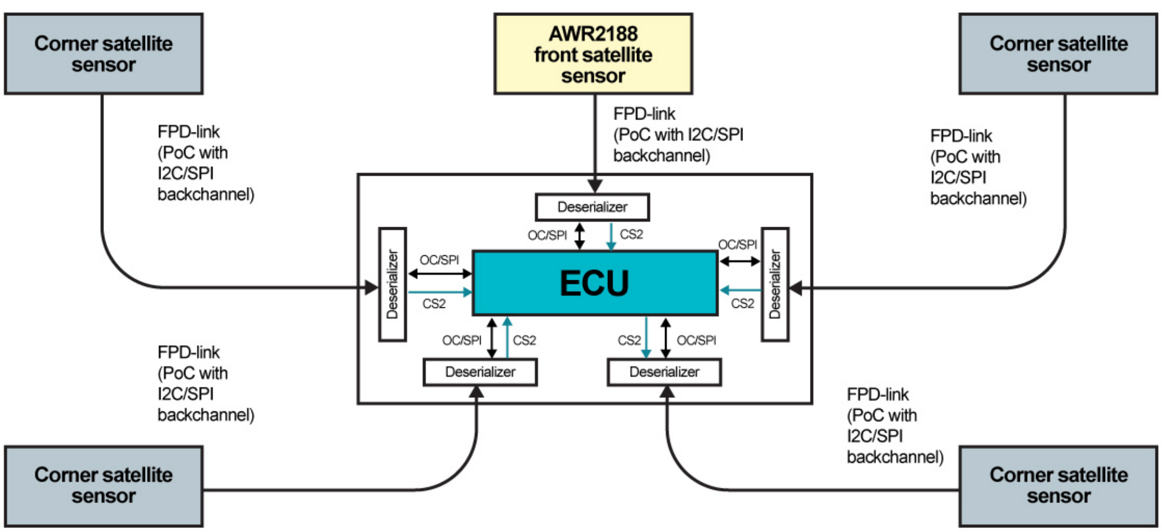


**Figure 4. Block diagram of satellite radar architecture**

### Conclusion

By enhancing the view of the world around us, we can take another step toward a future of more responsive, safer and autonomous driving experiences. To better understand surroundings, modern vehicles use a combination of sensing modalities to empower ADAS features.

4D imaging radar transceivers like the AWR2188 provide the RF performance, channel count and cascadability needed to support the evolution from edge to satellite radar applications.

### Additional resources

- Get started with the design guide, "Single-Chip mmWave Streaming Radar Reference Design for Automotive Front Radar."
- Learn about satellite architecture in the technical article, "Are you ready for the emerging automotive radar satellite architecture?"

### Trademarks

All trademarks are the property of their respective owners.