Application Brief

mmWave Radar For eBike and Scooter Safety Applications

Zahid Sheikh

Given the popularity of micro mobility devices such as eBike and scooters, rider safety has become a critical need. By being aware of the surroundings, riders can take necessary defensive measures to avoid collisions. mmWave radar can sense and provide relevant information to the riders in real time such as detecting an approaching car from behind and alerting the rider. Additionally, mmWave radar can trigger preemptive actions like blinking tail lights of eBike to get approaching car drivers attention to prevent accidents from happening. This article focuses on how mmWave radar devices can be used for these applications.

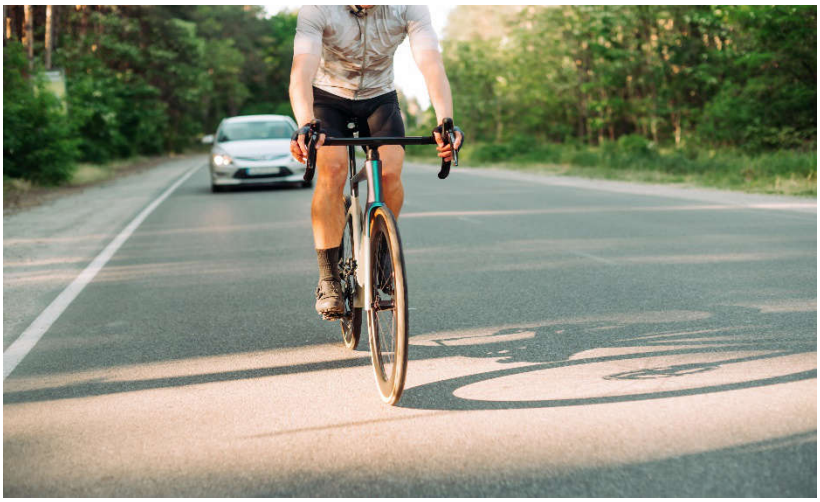

Figure 1. mmWave Radar For eBike and Scooter Safety Applications

What is mmWave Radar

Millimeter wave (mmWave) radar is a special class of radar technology that operates in millimeter band (30GHz to 300GHz) and typically from 57-64GHz or 76–81GHz. These higher frequency ranges with shorter wavelength allow for higher resolution and accuracy. mmWave radar functions by transmitting high-frequency electromagnetic waves that are reflected by objects in the radars path. Receiver circuits in the radar system capture the reflected signals and digitize these for processing to determine the range, velocity and angle of the objects with respect to radar.

With more accurate measurements, mmWave radar improves the overall performance of a system and are successfully used in many applications such as:

- Autonomous vehicles: mmWave radar is used in self-driving cars to detect and track objects, such as pedestrians, other vehicles, and road signs
- Drones: mmWave radar is used in drones to detect and track objects, such as power transmission lines, people, and other drones
- Surveillance: mmWave radar is used in surveillance systems to detect and track people and objects in a given area
- Industrial automation: mmWave radar is used in industrial automation to detect and track objects, such as robots and machines

Why mmWave Radar in eBikes

For outdoor conditions you need the technology that can work in difficult weather conditions such as darkness, fog and dust. Whereas camera and other sensors struggle in low visibility conditions, mmWave radar-based detection systems can be designed to work reliably under these challenging conditions since radar signals can penetrate through fog and dust to detect objects.

The Frequency Modulated Continuous Wave (FMCW) technology that Texas Instruments mmWave radar devices employ, can be used to transmit customized signal chirps for achieving longer detection ranges and higher speeds which are essential for these applications to be effective. Additionally, FMCW based mmWave radar can reject the data that is irrelevant such as detections from stationary vehicles and objects that are moving away from the rider using dynamic clutter removal. This in turn helps to reduce false alarms, improve reliability and enhance user experience.

Features

For eBikes and micro mobility devices, mmWave radar can be used to develop various features, including:

- **Collision avoidance**: mmWave radar can detect obstacles, such as pedestrians, cars, or other eBike, and alert the rider to potential collisions
- **Blind Spot Monitoring**: mmWave radar can detect approaching vehicles from behind or a blocked view and alert the rider
- **Speed limit detection**: mmWave radar can measure ground speed and alert the rider
- **Object detection**: mmWave radar can detect objects, such as debris, on the road and alert the rider to potential hazards

Frequency Bands

Regional and regulatory requirements mandate use of either 60GHz or 77GHz radar. At these frequencies mmWave radar offers improved sensing performance characteristics such as:

- **Higher resolution and accuracy:** mmWave radar can detect objects with a higher resolution, which means the radar can distinguish between smaller objects and provide more accurate distance and velocity measurements
- **Shorter wavelength:** The shorter wavelength of mmWave radar (typically 4mm and 5mm at 77GHz and 60GHz bands) allows for higher resolution and more precise measurements
- **Faster detections and tracking:** mmWave radar can operate at higher speeds, making mmWave radar designed for applications that require fast detection and tracking, such as eBikes, scooters and approaching vehicles

To meet the regulatory requirements for different applications and end equipment, Texas Instruments offers a rich portfolio of mmWave radar designs with pin to pin compatible devices in both bands. For example:

- IWR6843 (57GHz to 64GHz), IWR1843 (76GHz to 81GHz)
- IWRL6432 (57GHz to 64GHz), IWRL1432 (76GHz to 81GHz)

Cost and Design Size

mmWave radar based designs can be designed in a very cost-effective way to meet the budget targets. By selecting a highly integrated device such as IWRL1432, designers can take advantage of system on a chip approach to keep the BOM cost lower as well achieve simplicity of design.

IWRL1432 device is offered in 6.45mm x 6.45mm package size. This device integrates an RF front-end, synthesizer, hardware accelerator and on-chip micro controller to carry out radar computations and signal processing on-chip. Higher level of integration in IWRL1432 device makes product designs much simpler as the burdens for interconnecting and using external resources for processing are eliminated. The higher integration also results in reduced product BOM cost and helps to keep the design size compact for meeting the form factor requirements.

The low power device architecture of IWRL1432 allows for longer battery life which is highly desired for end equipment applications. Device is functional safety complaint with IEC 61508 SIL-2 certification making IWRL1432 designed for applications such as eBikes and scooters.

Range Requirements

For safety, e-bike riders require Blind Spot Detection (BSD) with a longer detection range for design to be effective. Generally, design specifications require 100 meters or more detection range to alert the riders and drivers of the approaching vehicles. This entails specific antenna designs to provide higher gain needed to meet the link budget requirements for round trip of transmitting the signal and receiving the echo back.

To meet these needs TI has developed an example reference designs based on IWRL1432 device. The design can be reviewed and evaluation board can be ordered using the part number: **IWRL1432BOOST–BSD EVM**. Key features of this design are:

- Easy-to-use 77GHz mmWave sensor evaluation kit (76-81GHz mmWave sensor)
- High-performance antenna system based on ROGERS RO3003 PCB substrate
- 3 receive (RX) 2 transmit (TX) antenna with greater than 120 meters range
- 90° azimuth field of view (FoV) and 20° elevation FoV
- USB powered, discrete DCDC power management design, onboard capability for power-consumption monitoring
- Access to point cloud data over USB
- 60-pin high-speed interface for host-controlling interface, direct interface with DCA1000 and MCU LaunchPad™ development kit

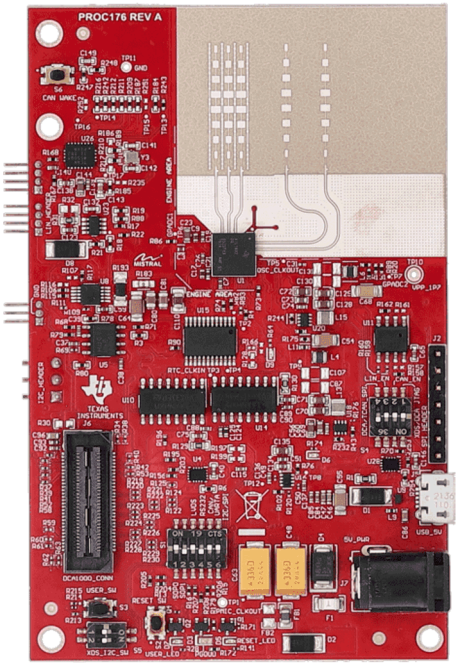

Figure 2. IWR1432BOOST-BSD Evaluation Module (EVM)

Bike Radar Demo

To showcase the applications and functionality, a demo using IWRL1432 device and BSD reference design has been developed. IWRL1432BOOST-BSD board is mounted on the back of bike and testing has been carried out with various scenarios, ranges and lighting conditions. Demo can be viewed on the link provided.

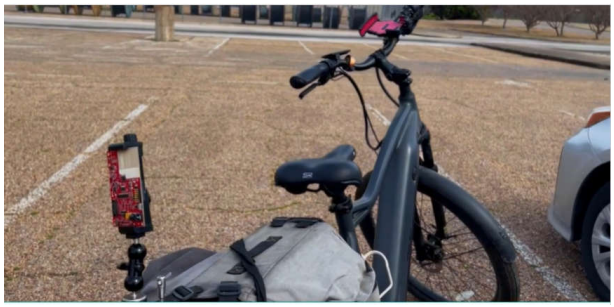

Figure 3. IWRL1432BOOST-BSD EVM Mounted on the eBike

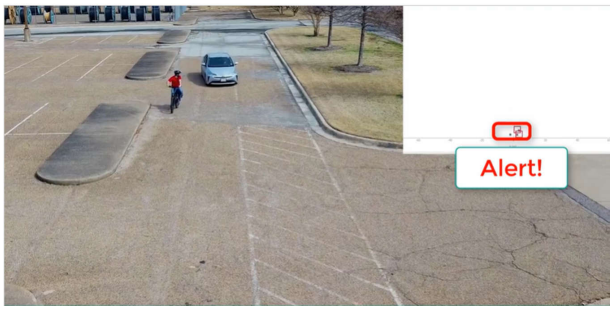

Figure 4. Radar Alerts Approaching Car

True Ground Speed

True ground speed can be measured using mmWave radar which provides a robust design in all weather and muddy conditions. This adds reliability while reducing the component cost associated with traditional methods for speed measurement. In the demo shown in the above link, radar **IWRL1432BOOST–BSD EVM** has been placed at 45 deg (pointed down) for speed measurements up to 40m/s (90mph) and 120m+ range detections.

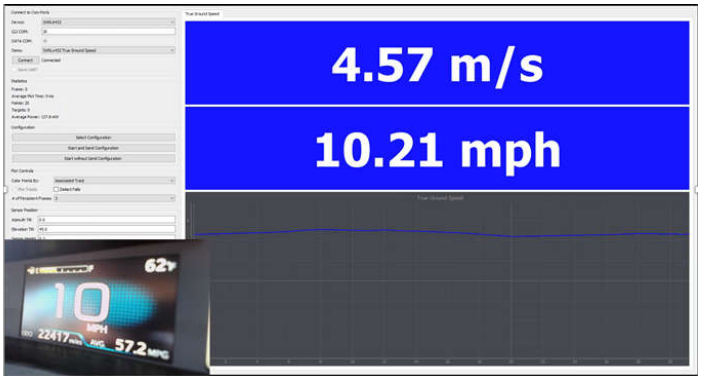

Figure 5. True Ground Speed Measurement With mmWave Radar

Conclusion

There are several benefits of mmWave radar in bikes, eBike, and micro mobility designs where the design enhances safety and adds intelligent sensing. Radar can sense vehicles approaching from >120 meters away and warn drivers and riders to avoid potential accidents. mmWave radar presents advantages uniquely tailored to demanding environments, including:

- **Improved safety**: mmWave radar can help prevent accidents by detecting obstacles and alerting the rider to potential hazards
- **Integration with other sensors**: mmWave radar can be integrated with other sensors, such as cameras to provide a more comprehensive view of the surroundings
- **Enhanced rider experience**: mmWave radar can provide a more comfortable and confident riding experience by automating certain tasks, reducing stress and anxiety
- **All-weather reliability**: delivering consistent performance in rain, fog, snow, dust, and other challenging environmental conditions
- **Adaptive functionality**: Texas Instruments offers a broad portfolio of mmWave radar devices and customizable software designs to meet the needs of different end equipment and diverse applications

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Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265