



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

# IJRSET

International Journal of Innovative Research in  
**SCIENCE | ENGINEERING | TECHNOLOGY**

# INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 11, Issue 3, March 2022

**ISSN** INTERNATIONAL  
STANDARD  
SERIAL  
NUMBER  
INDIA

Impact Factor: 7.569

9940 572 462

6381 907 438

[ijirset@gmail.com](mailto:ijirset@gmail.com)

[www.ijirset.com](http://www.ijirset.com)



# Tunnel Detection with mmWave RADAR

Aniket Bansod

Design Engineer, Department of Electronics Research Centre, Tata technologies Ltd, Pune, Maharashtra, India

**ABSTRACT:** Recently, as the traffic environment and transportation have been improved, the number of tunnels interconnecting cities and roads has increased accordingly. However, such an increase in the use of transportation infrastructure also causes traffic and safety management problems such as vehicle accidents and traffic jams. To exploit these issues, many object detection algorithms and methods help us to reduce the number of accidents. But how to determine the best method??? MmWave Radar and Tunnel detection algorithm is an innovative thing that can detect surrounding objects in a wide range. To track, monitor, and manage vehicle traffic on the roads as well as driving assistance, Radar technology plays a critical role. The proposed system can perform real-time distributed data processing of the target vehicles by providing independent queues for each object of information that is incoming from the receiver of radar. This paper discusses the benefits of lightweight, accurate, robustness of mmWave radar and Tunnel detection algorithm. This will help vehicle drivers to detect and avoid tunnels, overhead barriers, and any obstacles in their path which cause accidents. Tunnel detection techniques will improve standards of the automotive industry and the leading world towards Safe and Secure driving objectives.

**KEYWORDS:** mmWave RADAR; Intelligent Transportation System (ITS); Blind-spot detection (BSD Lane-change assist (LCA); Front/rear cross-traffic alert (F/RCTA); Frequency Modulate Continuous Wave (FMCW); Tunnel Detection Algorithm (TDA).

## I. INTRODUCTION

The automotive industry is developing rapidly in terms of innovation and technology advancements in AI algorithms and smart sensors. Automakers focus on Safe and autonomous vehicles with a range of diverse technologies to keep up with ever-growing consumer demand. Due to this technological advancement, lots of new challenges are creating more pressure on manufacturers. Such an increase in traffic, accidents due to over-speeding and Out of control vehicles. As per statistics, India tops the world in road crash deaths and injuries, the country approximately accounts for about 4.5 lakh road crashes per annum, in which 1.5 lakh people die every year; about 75 or more percent of these crashes are related to human error.

Therefore, this program is projected to:

- Reduce human errors while driving by using robust technology.
- Detect and Assist the driver about a possible collision.
- Tunnel detection for drivers of overloaded Vehicles.
- Overhead barrier detection for a vehicle.

To reduce the number of car accidents as close to zero as possible, there are many technologies are available for sensing vehicle traffic like LiDAR, radar, ultrasonic and infrared sensors, scanners. Among these sensors, the mmWave radar sensor guarantees a robust performance for vehicle localization especially in bad weather conditions (e.g., rain, snow, smoke, clouds). In addition, radar systems are less affected by illumination, while the camera and laser sensors suffer from performance degradations due to low illumination (e.g., at night). With the help of radar sensors, it can be used in vehicle detecting and traffic monitoring purpose.

This paper introduces the use of the Tunnel Detection Algorithm using Millimeter Wave Radar by taking reference from the following articles. A mmWave system operating at 76–81 GHz (corresponding wavelength of about 4 mm), will have the ability to detect movements that are as small as a fraction of a millimeter by transmitting electromagnetic signals that are reflected by objects, including people and animals[1]. Upon reaching the originating point, these reflections (returned signals) are used to calculate the range, velocity, and angle of the detected object. The use of mmWave emissions permits the use of very small antennas, enabling integration within the sensing unit and greater system miniaturization. As a result, compact mmWave sensors can be easily mounted where they are needed [2].

## II. DRIVE SAFER WITH MmWAVE RADAR-THE BENEFITS

Due to the use of wider bandwidth and 4mm wavelength, automotive radar is the most reliable technology for detecting object distance (range) and motion, including velocity and angle in almost every condition [3]. This is to drive benefits across all functional areas and include resource efficiencies, Research & Development cost savings, serviceability efficiency, etc.

Typical measurable benefits from MmWave RADAR include a wide range of improvements, such as:

- Primary radar applications can be broadly grouped or cascaded into corner radars and front radars. Therefore, include complete 360-degree coverage around the vehicle. Based on this it can be used in various applications.
- It is suitable for 12V, 24V, and 48V EV, CV, and PV platforms, and active power consumption is 0.5-1.5W.
- It has a higher resolution. And the maximum supported range is 150m
- As it consists of high-end microcontrollers like DSP and MCU with CAN-FD protocol and mmWave sensors which can be used for adding intelligent algorithms like Tunnel Detection. As well as transmitter signal signature and configuration can be modified according to external conditions.
- MmWave RADAR can also be used in the following Applications as mentioned in Fig 1:-
  - Blind-spot detection (BSD).
  - Lane-change assist (LCA).
  - Front/rear cross-traffic alert (F/RCTA).
  - Autonomous emergency braking (AEB).
  - Adaptive cruise control (ACC).

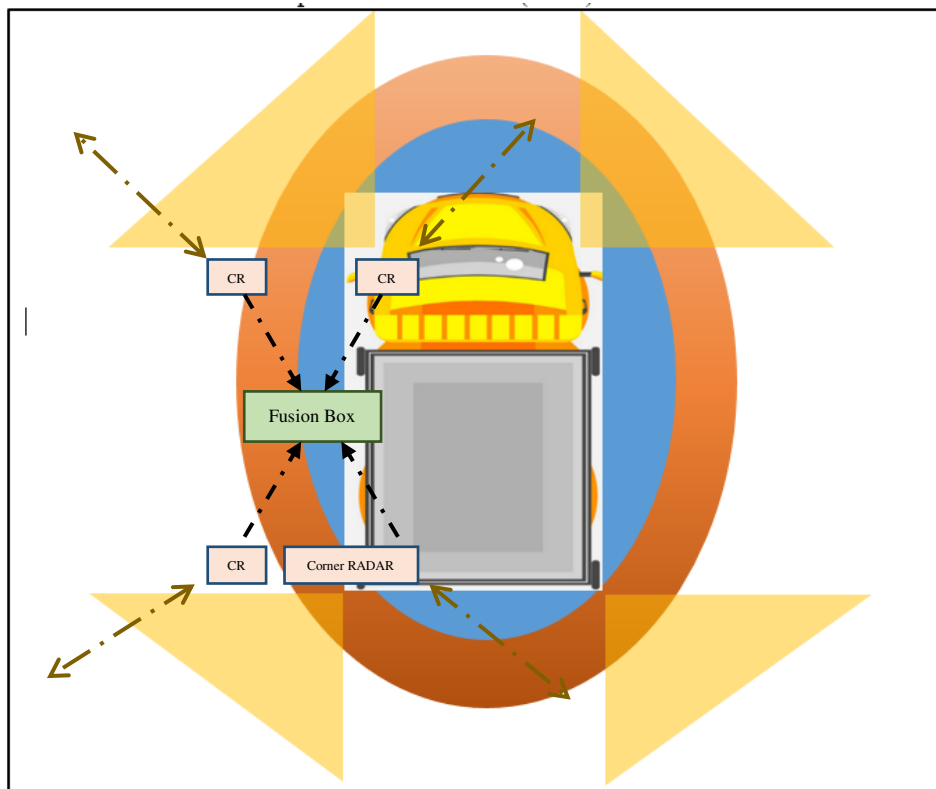
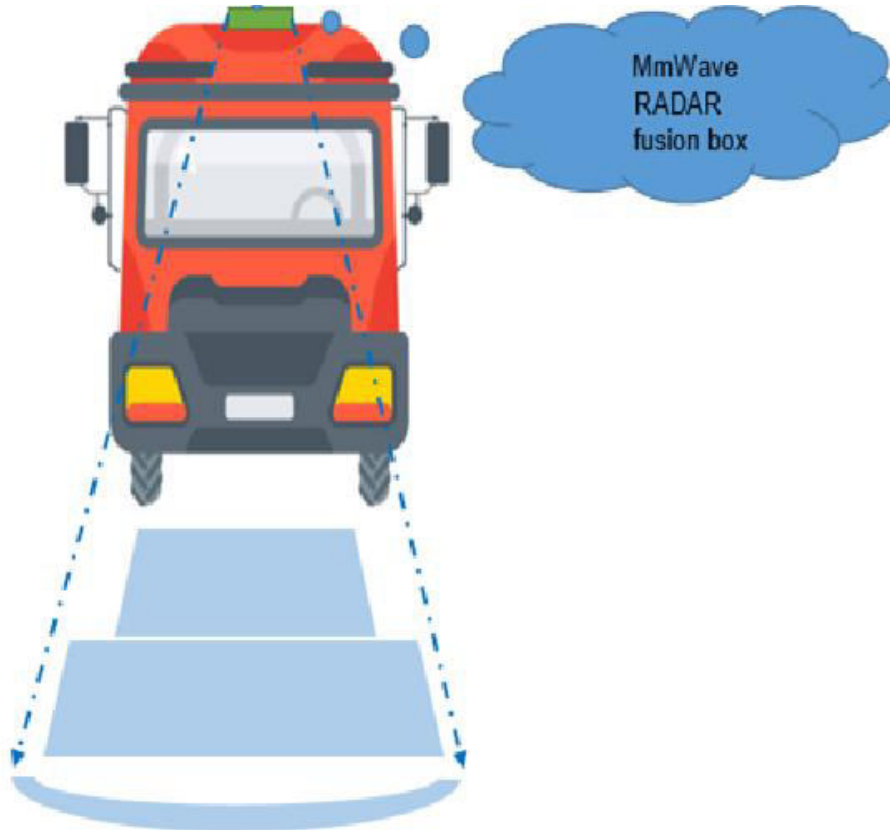


Fig 1:-Truck with RADAR fusion box

### III. RIGHT SPECIFICATIONS FOR RIGHT APPLICATIONS

Figure 2 is a block diagram of a mmWave radar fusion box mounted on a truck showing a single representative TX chain and RX chain. As there are multiple types RADAR is present in the market with a variety of features. Their specifications and selection criteria depend on their applications. To choose the best among them application developers need to know about specifications and their performance under different conditions. As mmWave RADAR has upper hands over other automotive RADARs which are available in the market. Specifications of mmWave RADAR are as follow:-



*Fig: 2:-mmWave RADAR mounted on a truck*

- **Object Detection Accuracy:** -RADAR's accuracy depends on the transmitter, especially on the slope and linearity of the frequency drift. Transmit (Tx) signal whose frequency-changing linearly with time is also known as "sweep in frequency" or "chirp" [4]. As a local oscillator used for transmitting chirp, it gives great flexibility to the developer to configure parameters like frequency slope, sweep bandwidth, and transmit multiple chirp configurations in TX signal. As it is operating in the wide frequency band and 4mm wavelength, its resolution goes up to 2cm.
- **Versatile intelligence:** -As it is using Digital Signal Processor [5], as shown in Fig 3 below. To increase accuracy and robustness Tunnel and overhead barrier detection algorithms were added to it. DSP and TDA can sense external conditions and adapt themselves to that condition due to the intelligence algorithm available in them. E.g. if radar sensors are mounted on top of the vehicle and rain starts, at that time, the transmitter will change its chirp configuration parameters and signature according to the Signal to Noise Ratio. Because of an intelligent algorithm, mmWave RADAR can be adaptable to any condition.

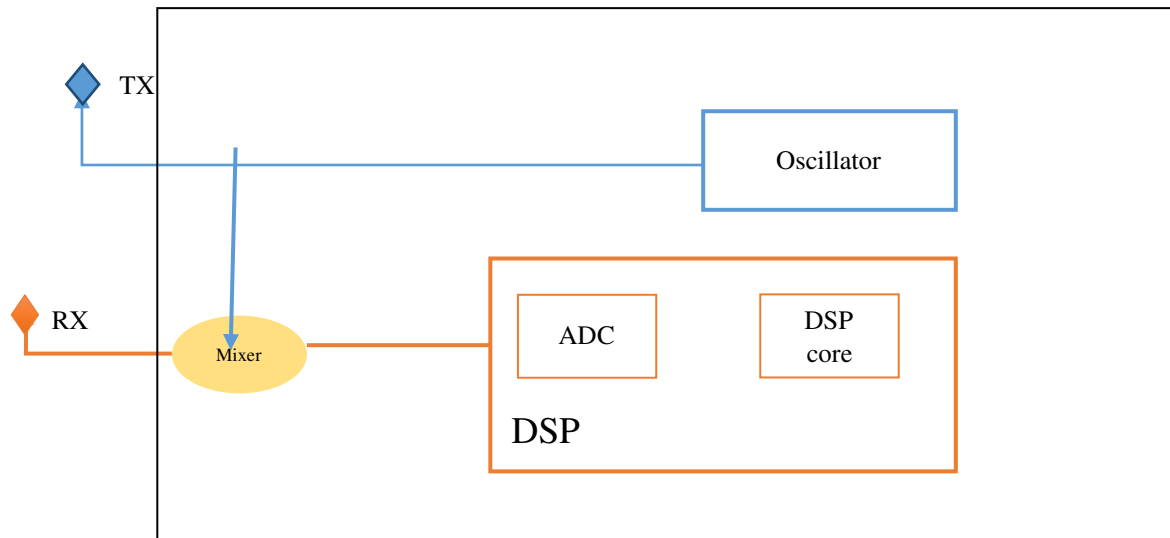


Fig3: Block diagram of mmWave Radar

- **Small in Size and Low Power:** -mmWave RADAR active power consumption is 0.5 to 1.5W with MCU and DSP capabilities available. It uses CMOS technology and best-in-class power management technique to enable low power consumption and small size which plays the main role in energy-efficient vehicles [6].
- **Environmental Condition:** -Conditions such as Sunny, smoke/gas, High temperature affect the functioning of Ultrasonic RADAR, LIDAR. Their performance reduces due to these environmental conditions. On other hand, mmWave performance is always better than these RADARs.
- **Target Characteristics:** -Transparent surface, Liquid/fluid, Irregular shape, Soft surface are major factors on which the selection of RADAR mostly depends. Ultrasonic RADAR cannot perform well on Soft surface and LIDAR fail to detect transparent surface. But mmWave RADAR performs well on every target as compared to Ultrasonic RADAR and LIDAR.

#### IV. PINPOINTING RIGHT TECHNOLOGY FOR RIGHT APPLICATION

**Tunnel Detection:** -While driving a loaded big truck as seen in below figure 4, it seems a big task for a driver. When the tunnel arrives, many times drivers are unable to predict the height of the tunnel, and accidents happen. But truck that is updated with mmWave sensor and Tunnel detection algorithm helps the driver to predict the height of the tunnel and take decisions while entering into a tunnel. It also helps drivers while driving in foggy, smoky conditions. It can detect a static and moving object from 10m to 150m. Below figure 4 illustrates the use of it as a satellite sensor mounted at four corners of a vehicle, feeding raw-detected objects to a radar fusion box. After receiving data at Analog to Digital Converter, it will convert analog data into digitized signal and send to DSP for further processing which is explained below in Scenario1.

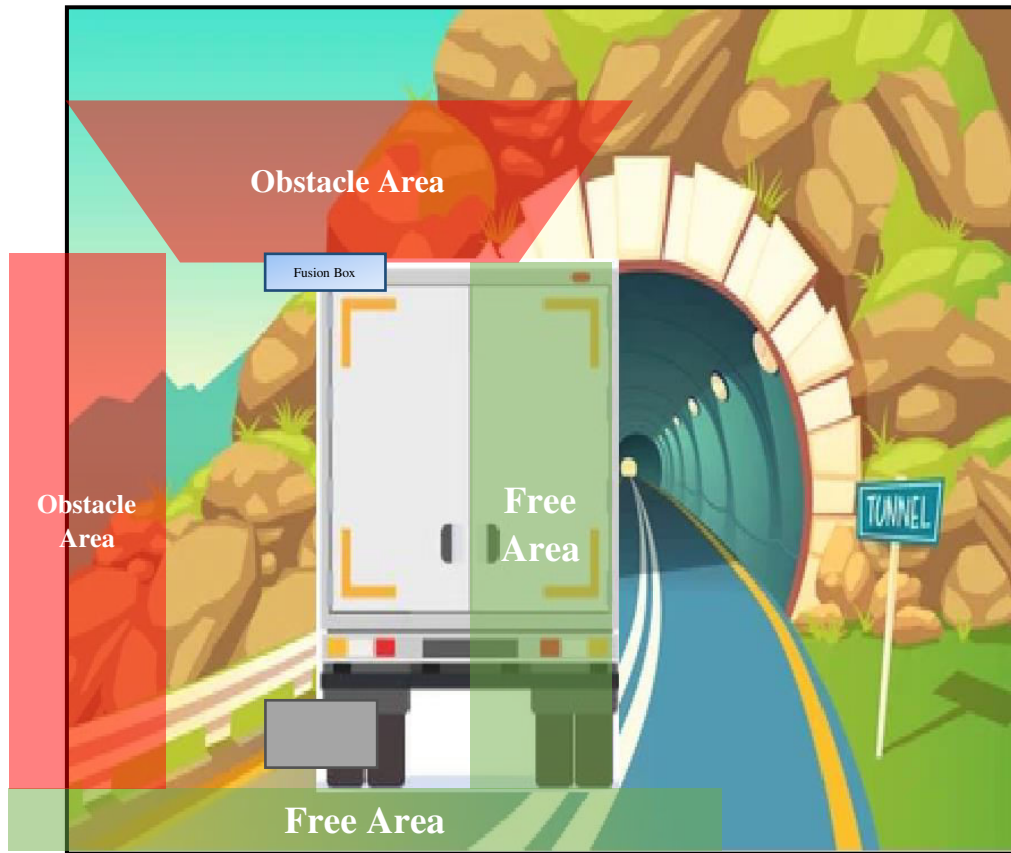


Figure 4:-Tunnel detection with mmWave RADAR

**Scenario 1:** After sending raw data from Corner radars to DSP, the Tunnel detection algorithm performs object detection and angle estimation processing. If the Algorithm detects the tunnel, it will calculate the height and width of a tunnel according to a received signal. And it will compare tunnel height with vehicle height and indicate to a driver. Tunnel detection algorithm will also send data to ECUs over the CAN or CAN-FD interface for necessary action. E.g. Emergency Braking ECU. There are 4 corner RADAR sensors available and All are connected with each other via private CAN bus. Updated truck with mmWave sensor will play a major role while driving at night.

**Scenario 2:** While driving in a city or at a toll gate as shown in figure 5, there are many overhead barriers present to restrict the entry of Heavy vehicles. And the height of these barriers vary, and it becomes accident-prone for heavy vehicles. But using mmWave RADAR and TDA, it can find collision points and divide vehicle surrounding in green and red zones. Because of this, taking decisions for collision avoidance becomes easy for drivers while driving.

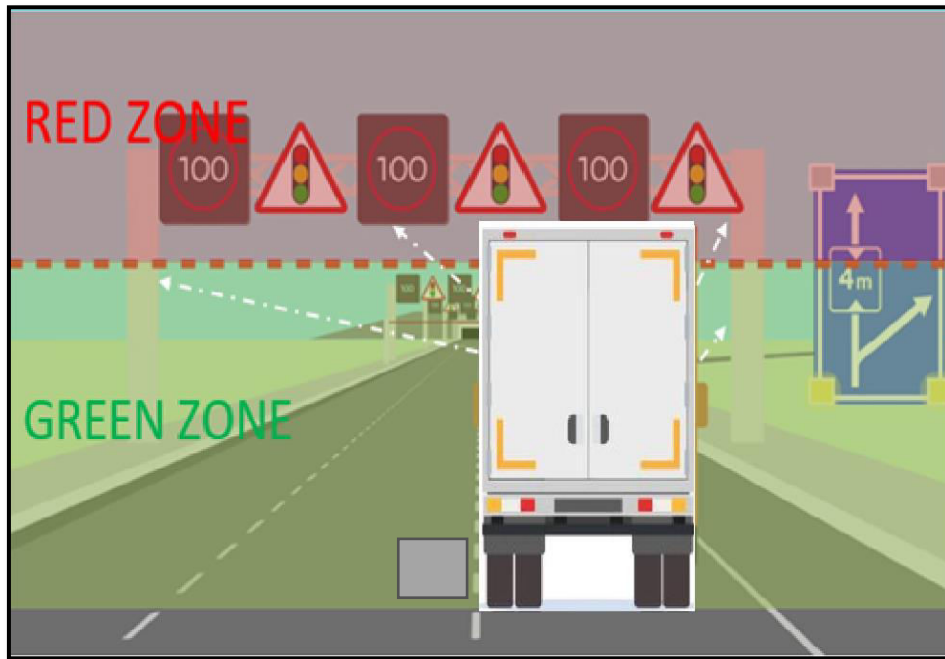


Figure 5:-Uses of mmWave in ADAS Application

By using mmWave Radar, Drivers can get a surrounding sense of Traffic and Blind spot detection. As shown in following figure 6.

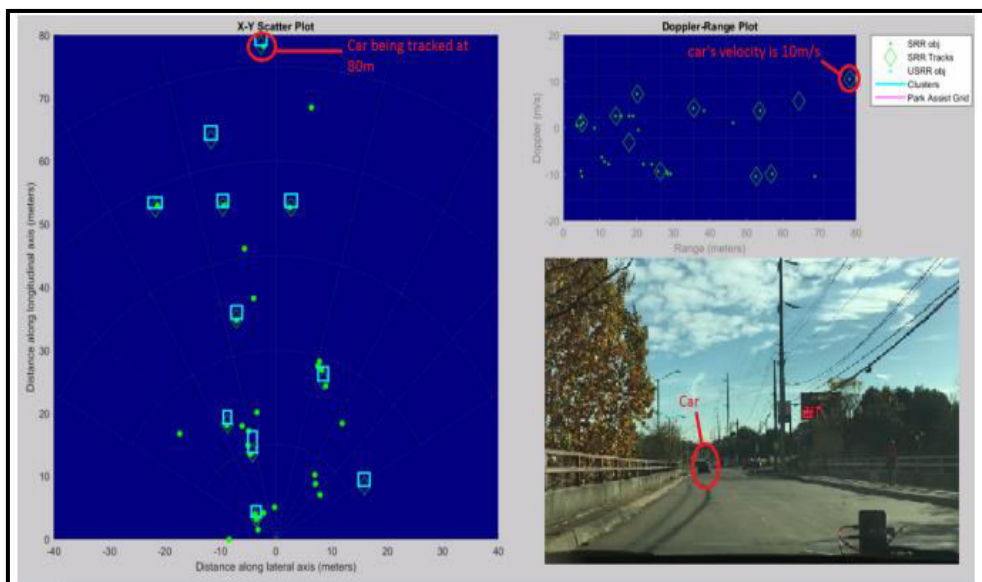


Figure 6:- Tracking of Objects on GUI

## V. CONCLUSIONS

Well-established applications of frequency-modulated continuous-wave (FMCW) mmWave radar in automobiles range from safety to comfort functions– such as blind-spot detection, lane-change assist, automatic cruise control, and park assist. However, there are several other applications of radar Sensors that provide unique advantages. These include:

- Free-space sensing,
- Driver vital-sign monitoring,



- Gesture-based recognition,
- Occupancy detection.

Its performance is independent of ambient light. It can travel through plastic, which enables the sensor mounts behind, such as a car bumper, dashboard, to enhance the solution's aesthetics.

Using mmWave RADAR makes this application extremely unique to the market. The level of integration and small footprint are enabling designers to add new features to existing applications. As the market adapts to ADAS and Autonomous vehicles. Considering the noise-figure improvement, there is no significant penalty in current consumption, since you can trade off the better noise figure against the on/off duty cycle of operation to effectively reduce current consumption.

#### REFERENCES

1. ETSI EN 300 440 V2.2.1 (2018-07). – ‘Radio Equipment to be used in the 1 GHz to 40 GHz frequency range’.
2. Invesco, Cesar and Rao, Sandeep (2017) “The fundamentals of millimeter wave”, Texas Instruments.
3. Jasbir Singh, Brian Ginsburg, Sandeep Rao, Karthik Ramasubramanian (2017), “AWR1xxx mmWave sensor: 76–81-GHz radar-on-chip for short-range radar applications”, Texas Instruments.
4. Dham, Vivek (2017). “Programming Chirp Parameters in TI Radar Devices.” TI application report SWRA553, Texas Instruments.
5. Rao, Sandeep, Jasbir Nayyar, Mingjian Yan, and Brian Johnson (2017). “Introduction to the DSP Subsystem in the AWR16xx.” TI application report SWRA552.
6. Robert Ferguson, Matthieu Chevrier, Alan Rankin, “mmWave radar: Enabling greater intelligent autonomy at the edge”, TI report, May 2017





**Impact Factor:  
7.569**



# INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

 9940 572 462  6381 907 438  [ijirset@gmail.com](mailto:ijirset@gmail.com)



[www.ijirset.com](http://www.ijirset.com)

Scan to save the contact details