Design/Practical Experience [EEN2020]
Department of Electrical Engineering

Final Report

Academic Year:2021-2022
Semester: 1

Date of Submission of Report: 27-Nov-2021

1. **Name of the Student:** PAMBALI JITHENDRA
   Roll Number: B19EE060
2. **Title of the Project:** VEHICLE SEAT OCCUPANCY DETECTION USING TI MILLIMETER WAVE RADAR SENSOR.
3. **Project Category:** 3
4. **Targeted Deliverables:**
   a) Software program for occupancy detection (e.g., MATLAB code)
   b) Hardware integration and demonstration of the system along with software

Objective:-

The aim of this project is Vehicle Seat-Occupancy Detection based on a PCR (Pulsed Coherent Radar) at the unlicensed 60 GHz ISM band. The radar can measure distances with a sub-millimeter resolution by calculating the time elapsed between transmission and reception of the reflected signal. Therefore, the system can detect the presence of living things occupying the seat, by measuring small movements of the body, produced by breathing and other causes. In consequence, the system not only detects the seat occupancy, but also the breathing rate, which could be estimated from the amplitude peaks after filtering and removing the noise. Also, there is no interference with the existing and widely used radio system, because most of the communication systems are working at low frequencies, and specifically, automotive radars are operating at 24 GHz and 77GHz bands. So, the mm-Wave pulsed coherent radar would be a very promising candidate to implement a seat occupancy detection system and to monitor the driver's vital signs like breathing rate.

There are many other methods for seat occupancy detection that have been implemented in previous literature. Some of the examples are -

- Using Pressure sensors
- Using Face detection using cameras
- Using Infrared Cameras

But all the above detection systems have some major drawbacks, with a very high chance false alarm.

- For pressure sensors, they detect even when some luggage or some other weight on the seats, they interpret as humans.
- For face detection, the cameras won't be able to recognize in low lights.
- For infrared cameras, it won't be able to detect humans when the cabin is warm enough and it is very costly also.

But all of these drawbacks won't be seen in this mm-Wave pulsed coherent radars-based seat occupancy detection system, as we are monitoring both the breathing rate (vital signs) and small movement introduced by a human body. The vital signs detection technique using millimeter-wave radar is especially based on the doppler frequency shifting phenomenon of EM waves, exploits the ability of detection of micro-doppler phase shift induced by the chest and heart movements. In addition to the micro-doppler signature detection, FMCW radars can also determine the range of multiple persons and even the angle using beamforming techniques with a multichannel front-end.

SYSTEM FEATURE AND THEORETICAL BACKGROUND

The radar is characterized by its accuracy in millimeter range and low power consumption. It can measure ranges between 60 to 2000 mm for an RCS of -21 dBm (sphere of radius r D= 50 mm), having a continuous sweep update frequency configurable up to 1500 Hz. The Half Power Beam Width (HPBW) of the antenna is 40 and 80 degrees in E-plane and H-plane, respectively. It is a modulated wavelet at the carrier frequency (fc D 60 GHz).

The interval between pulses is determined by the PRF that is equal to 13 MHz. The duration of the wavelet (*PULSE*) can be configured between a set of five values. The transmitter's effective isotropic radiated power (EIRP) is 10 dBm. The typical range resolution is on the order of 0.5 mm.

Isolation between transmitter and receiver must be very high for a radar system. For this radar system, the leakage between the transmitter and the receiver limits the minimum detection distance to about 6 cm for the minimum pulse length. The system relies on the transmission of coherent phase pulses. Therefore, the received signals from multiple pulses are combined to improve the signal-to-noise ratio (SNR), thus enhancing the visibility of the object.

Using the knowledge of algorithms mentioned in this paper, we have tried to implement and understand the mm-Wave Software Development Kit (SDK). For this, we have taken the AWR6843ISK circuit board. We are going to use some tools for detecting the occupancy and breathing rate monitoring from Texas Instruments such as:

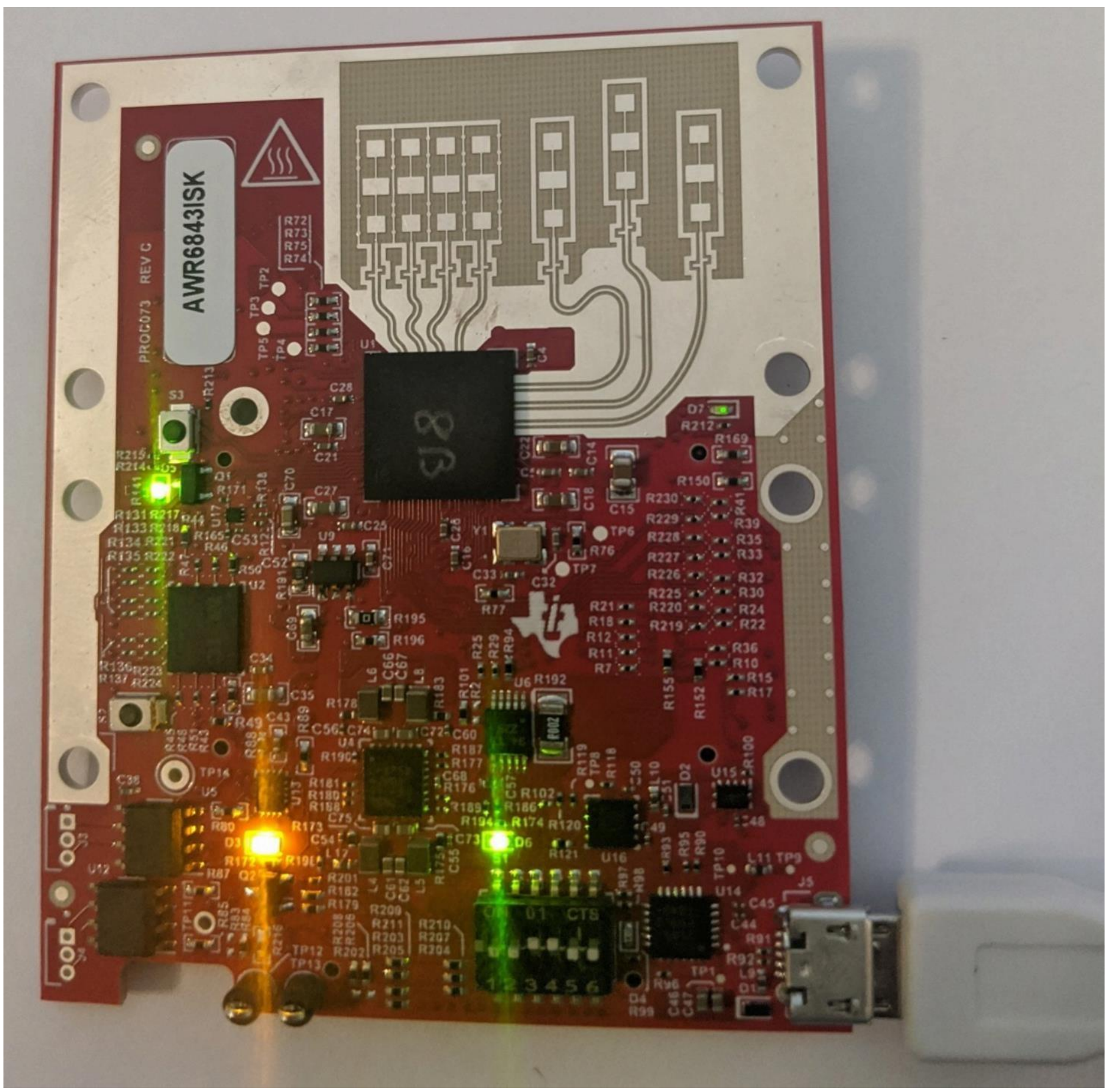
- Code Composer Studio (CCS)
- Uni-flash
- mm-Wave Demo Visualizer

- mm-Wave Demos

This reference design demonstrates the use of the AWR6843 60GHz single-chip mm-Wave sensor with integrated DSP, as a Vehicle Occupant Detection (VOD) and Child Presence Detection (CPD) Sensor enabling the detection of life forms in a vehicle. This design provides a reference processing chain that runs on the C674x DSP, enabling the generation of a heat map to detect life forms in a Field of View (FOV) of ±60 degrees.

AWR6843ISK (Top view)

So, after getting some knowledge regarding the theory, we now will start working with the hardware and the software.



6) Procedure:

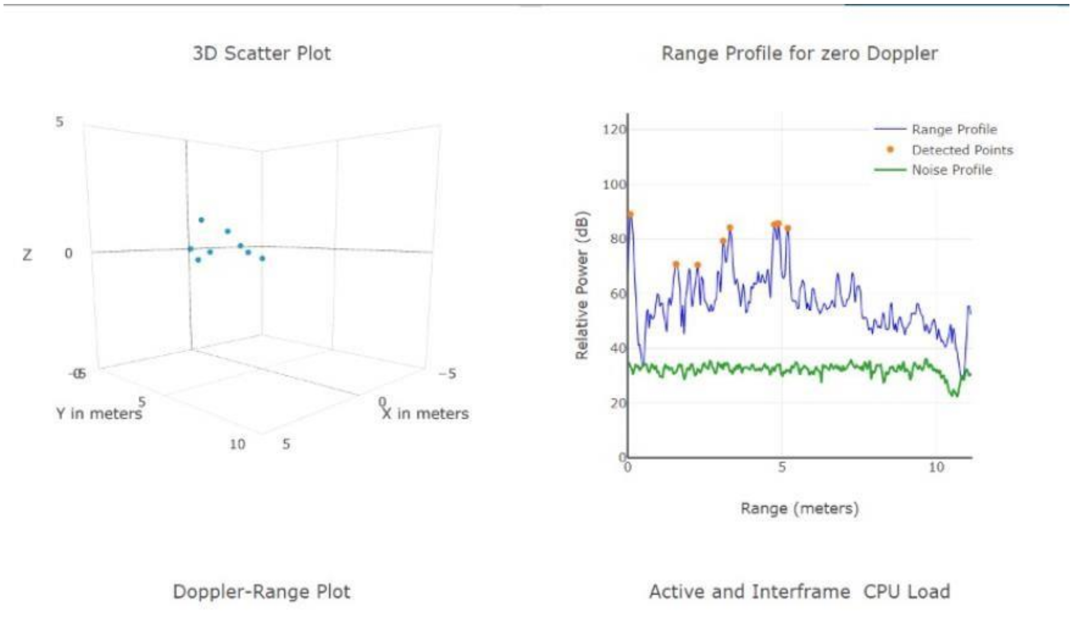
- Install mmwave_industrial_toolbox_4_9_0, mmwave_sdk_03_05_00_04, Uniflash(latest version), mmwave_automotive_toolbox_3_4_0 .
- Install Silicon Labs drivers (Dual CP2105 USB to UART Bridge: Enhanced COM Port, Dual CP2105 USB to UART Bridge: Standard COM Port) for connecting the board.
- Next, Connect the **AWR6843ISK** evaluation module kit to the PC using the micro USB cable and then attach the board to the tripod stand and make the necessary setup.
- Put the EVM in flashing mode and power cycle the device.
- Open Uniflash Software and select the AWR6843 board.
- Once the device is selected, go to Settings and Utilities and change the COM Port number with the Enhanced COM Port number.
- Go to program, browse the META IMAGE for running the bin file at the following location, "C:\ti\mmwave_automotive_toolbox_3_4_0\labs\incabinsensing\occupancy_plus_vital_signs\prebuilt_binaries\vod_vital_signs_68xx.bin".
- Once the meta image has been selected, then perform the action, "Load Image".
- After successful loading of the bin file, put the EVM into functional mode.
- Then go to the location, "C:\ti\mmwave_automotive_toolbox_3_4_0\labs\incabinsensing\occupancy_plus_vital_signs\gui\vod_vital_signs" and run the Matlab code file.
- After the MatLab opens, in the console window type the following command, "vod_vital_signs (Standard COM port Number) (Enhanced COM port Number) ..\chirp_configs\vod_vs_68xx_10fps.cfg_10fps" and press Enter.
- Now one can observe several commands running in the console window and once the command "**Sensor Start**" comes, it means that everything is functioning properly and 2 tabs should open, One is a java application named "Texas Instruments - Occupancy Detection Demo Visualization" for showing the occupancy and another named as "Figure 2" for monitoring the vital signs.

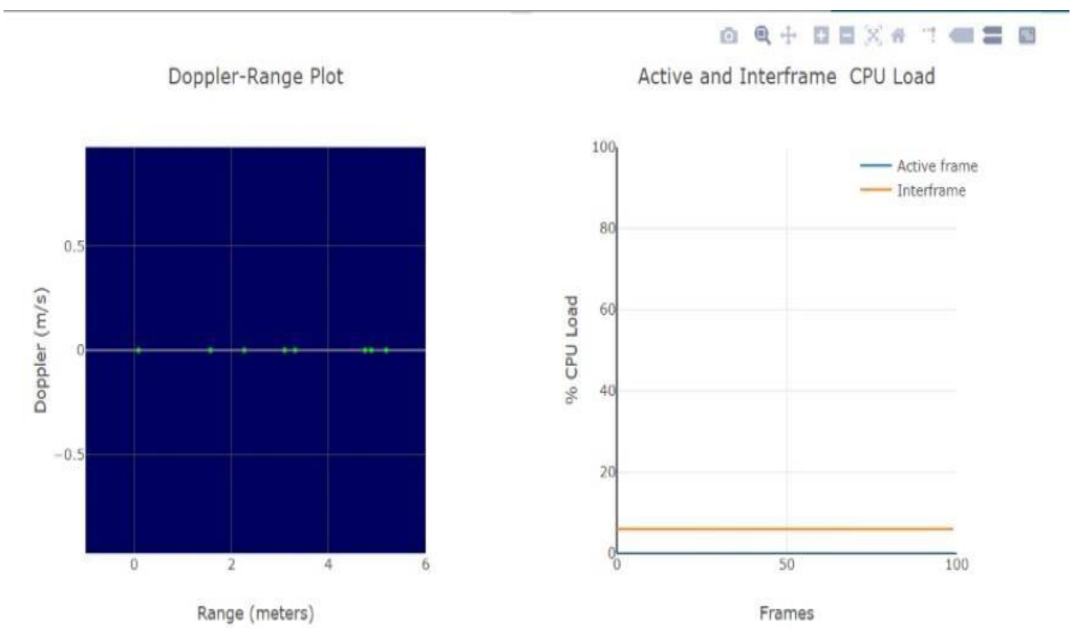
7) Work Done:

• Demonstration of mm-Wave sensor technology for robust detection of life forms (adults, children, pets) in a vehicle.
• Generate presence heat map with a FOV of ±60 degrees.
• Source code for processing and detection based on the mm-Wave software development kit (SDK)
• Based on proven EVM hardware designs, enabling quick time to market and out-of-the-box demonstration.
• Radar front-end and detection configuration fully explained.

8) Results:

1) Out-of-the-box demonstration of mm-Wave Sensor using mm-Wave Visualizer.

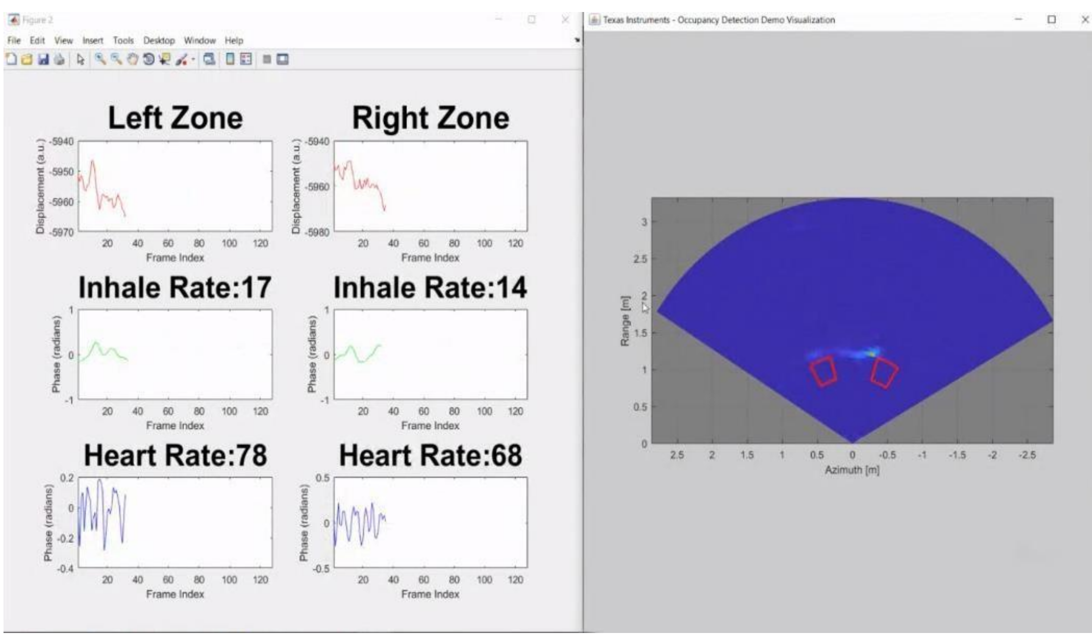




2) Source code for processing and detection of occupancy and vital signs.

3) Heat map of the presence of Occupants and Vital Signs monitoring.

Standing positions of the person



9) Conclusion:

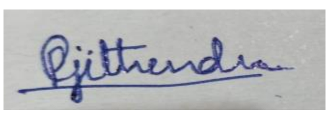
We can conclude from the above results that we were successfully able to run the software program for occupancy detection and vital signs monitoring and we succeeded in integrating the hardware and demonstrating the required plots and heat map. Our target deliverables have been achieved and we are submitting our report for final evaluation.

10) References:

- [60GHz mmWave Sensor EVMs (Rev. D)]
- [AWR6443, AWR6843 Single-Chip 60- to 64-GHz mmWave Sensor datasheet (Rev. C)]
- [Using TI mmWave technology for car interior sensing]
- https://youtu.be/gUu8bUxUOxY
- [User guide of vehicle seat occupancy and Vital Signs]
- [Out of the box demonstration]

11) Declaration: I declare that no part of this report is copied from other sources. All the references are properly cited in this report.

Soumava Mukherjee



Signature of the Student **Signature of the Supervisor**

Supervisor's Recommendation for the Evaluation

Please tick any one of the following

1. The work done is satisfactory, and sufficient time has been spent by the student. The submission by the student should be evaluated in this term.
2. The work is not complete. Continuity Grade should be given to the student. The student would need to be evaluated in the next semester for the same Design Project with me.
3. The work is not satisfactory. There is no need for evaluation. The students should look for another Design Credit Project for the next semester.
4. [Other Comment, if 1-3 are not valid] ______________________________

✓

Soumava Mukherjee

Signature of the Supervisor