Design Guide: TIDEP-01021

Beamsteering for Corner Radar Reference Design

Description

This reference design provides a foundation for a blind spot detection (BSD), cross traffic alert (CTA), lane change assist (LCA), and traffic jam assist (TJA) applications using the AWR1843 evaluation module (EVM). This design allows the estimation (in the azimuthal and elevation plane), tracking of the position (in the azimuthal plane), and the velocity of objects in its field of view for up to 150 m. This design also allows TX beamforming by turning on all of the 3TX operations simultaneously. Beamsteering is also supported by using the 6-bit TX phase shifter to steer the beam toward different angles in the azimuthal direction.

Resources

TIDEP-01021	Design Folder
AWR1843	Product Folder
TCAN1042HGV-Q1	Product Folder
TMP112	Product Folder
LP87702-Q1	Product Folder

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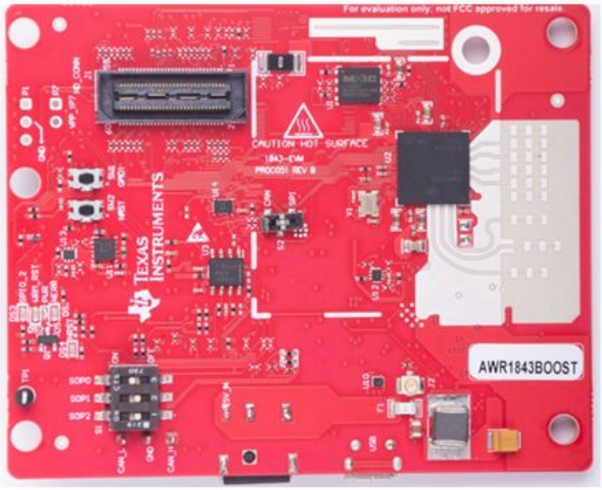
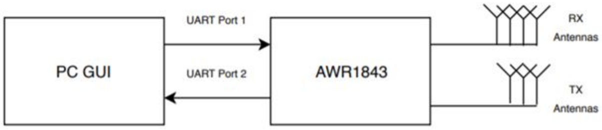
Features

- Single-chip radar for BSD, LCA, TJA and SRR applications
- 150-m detection range (such as cars and trucks)
- Range resolution of 4.3 cm for less than 30-m range and 35-75 cm beyond 30 m
- Clustering and tracking on the detected outputs
- ±60º azimuth FoV with approximately 15º resolution
- 3TX simultaneous operation for TX beamforming
- Range and Doppler FFT processing using on-chip Hardware Accelerator (HWA)
- Use of TX phase shifter for beamsteering

Applications

- Lane change assist (LCA)
- Autonomous parking
- Cross traffic alert (CTA)
- Blind spot detection (BSD)
- Traffic jam assist (TJA)





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1 System Description

Autonomous control of a vehicle provides quality-of-life and safety benefits that help make the relatively mundane act of driving safer and less difficult. The quality-of-life features include the ability of a vehicle to park itself or to determine whether a lane change is possible. Features also include blind spot detection, where a vehicle monitors the road area behind and next to it to warn if there is no gap in traffic. Implementing these technologies requires a variety of sensors to detect obstacles in the environment and track their velocities and positions over time.

1.1 Why Radar?

Frequency modulated continuous wave (FMCW) radars allow the accurate measurement of distances and relative velocities of obstacles and other vehicles. Therefore, radars are useful sensors for many of the quality-of-life and car safety applications. An important advantage of radar over camera and LIDAR-based systems is that radars are relatively immune to environmental conditions (such as the effects of rain, dust, smoke, and glare). Because FMCW radars transmit a specific signal (called a chirp) and process the reflections, they can work in complete darkness or in bright daylight. When compared with ultrasound, radars typically have a much longer range, and the time of transit of a radar signal is much smaller than that of an ultrasound signal. Hence the radar is likely to report dynamic scenes more accurately.

1.2 Beamsteering for Corner Radar Design

This design is an introductory application that is configured for both ultra-short range radar (USRR) and short-range radar (SRR) applications. It is capable of detecting as many as 200 objects and track up to 24 of them at distances as high as 150 meters (or 490 feet), traveling as fast as 140 kmph (~90 mph). In this application, the AWR1843 is configured to be a multi-mode radar, meaning that while it tracks objects at 150 m, it can also generate a rich point cloud of objects at 30 m. If both cars are at 150 m, smaller obstacles at 30 m can be detected.

This design can therefore be used as a starting point to design a stand-alone sensor for a variety of SRR automotive applications. A range of more than 150 m can be achieved with the design of an antenna with higher gain than the one included in the AWR1843BOOSTEVM.

1.3 Key System Specifications

There are two different sets of specifications as this design is a multi-mode radar. The first is the specification, which can be used for BSD, LCA, and TJA and corresponds to the configuration that achieves a maximum range of 150 m. The second is a USRR specification which corresponds to the configuration for 30 m.

Table 1. Key System Specifications

PARAMETER	SPECIFICATIONS	DETAILS
Maximum range	15 0m (BSD ,LCA, TJA), 30 m (USRR)	This represents the maximum distance that the radar can detect an object representing a radar cross section(RCS) of approximately 10 m^2. This is achieved at bore sight.
Range resolution	78 cm (BSD, LCA, TJA), 4.3 cm (USRR)	Range resolution is the ability of a radar system to distinguish two closely spaced objects as separate objects rather than as single object.
Maximum velocity	144 kmph (BSD, LCA, TJA), 36 kmph (USRR)	This is the native maximum velocity obtained using a two-dimensional FFT on the frame data. This specification will be improved over time by showing how higher-level algorithms can extend the maximum measurable velocity beyond this limit.
Velocity resolution	0.52 m/s (BSD, LCA, TJA), 0.32 m/s (USRR)	This parameter represents the capability of the radar sensor to distinguish between two or more objects at the same range but moving with different velocities.

2 System Overview

2.1 Block Diagram

Figure 1. BSD, LCA, TJA System Block Diagram

2.2 Highlighted Products

2.2.1 AWR1843 Single-Chip Radar Solution

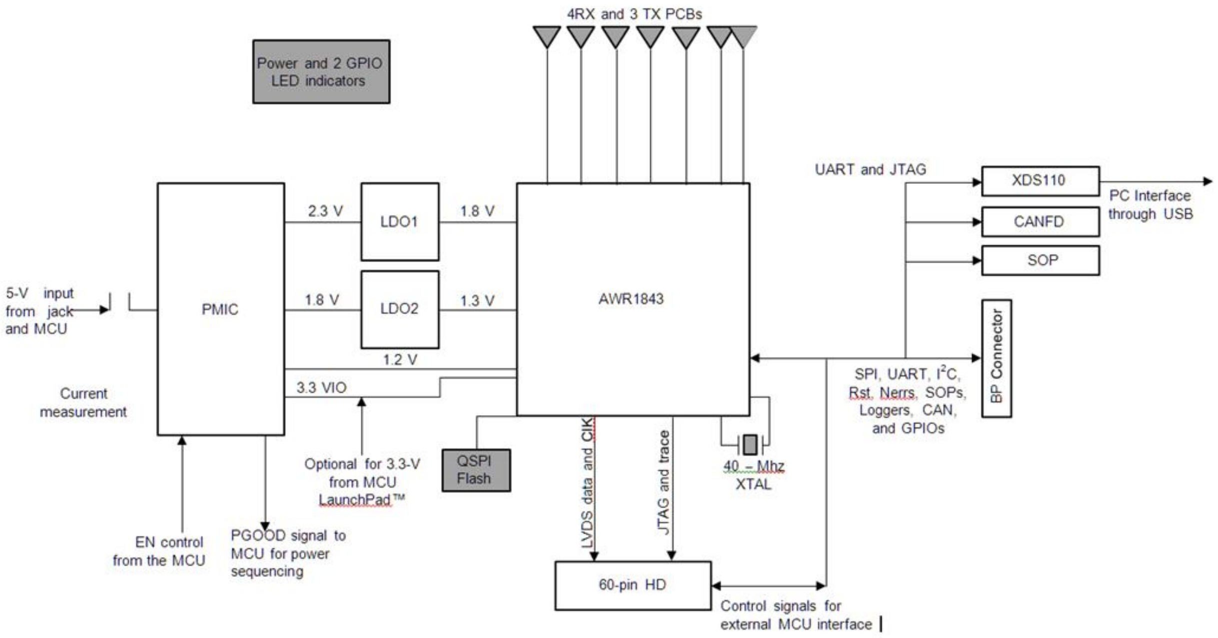
The AWR1843 is an integrated single-chip, frequency modulated continuous wave (FMCW) sensor capable of operation in the 76- to 81-GHz frequency band. The device is built with TI's low-power, 45-nm radio frequency complementary metal-oxide semiconductor (RFCMOS) processor and enables unprecedented levels of analog and digital integration in an extremely small form factor. The device has four receivers and three transmitters with a closed-loop phase-locked loop (PLL) for precise and linear chirp synthesis. The sensor includes a built-in radio processor (BIST) for RF calibration and safety monitoring. Based on complex baseband architecture, the sensor device supports an IF bandwidth of 10 MHz with reconfigurable output sampling rates. The presence of the Arm® Cortex® R4F and TI's C674x DSP (fixed and floating point) along with 2 MB of on-chip RAM enables high-level algorithm development.

2.2.2 AWR1843BOOST Features

The AWR1843BOOST has the following features:

- AWR1843 radar device
- Power management circuit to provide all of the required supply rails from a single, 5-V input
- Three onboard TX antennas and four RX antennas
- Onboard XDS110 that provides a JTAG interface, UART1 for loading the radar configuration on the AWR1843 device, and UART2 to send the object data back to the PC

Figure 2. AWR1843BOOST Block Diagram



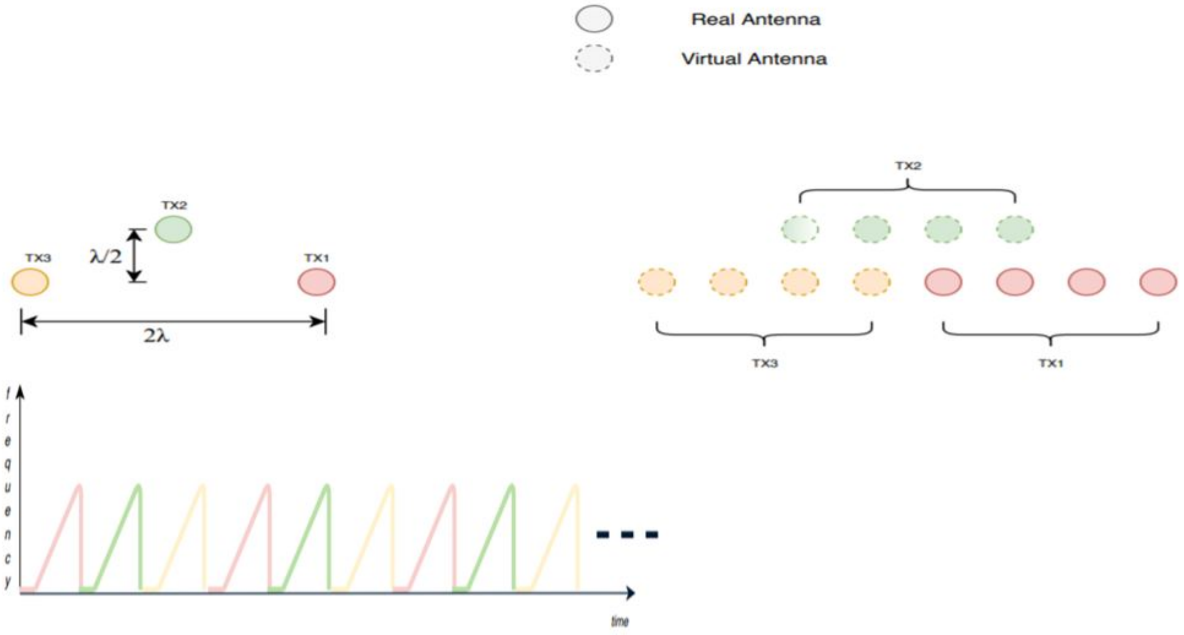
For more details on the hardware, see the *AWR1843 single-chip 76-GHz to 81-GHz automotive radar sensor evaluation module*. The schematics and design database can be found in the following files: *AWR1843BOOST Design Database* and *AWR1843BOOST Schematic, Assembly, and BOM*.

2.3 System Design Theory — Chirp Configuration

2.3.1 Antenna Configuration

This design uses four receivers and the three transmitters in two different chirp configurations. The first configuration (BSD, LCA, and TJA) uses a simple non-MIMO configuration with TX1, TX2, and TX3 transmitting simultaneously. The second USRR uses a time division multiplexed MIMO configuration (that is, alternate chirps in a frame transition TX1, TX2, and TX3 respectively). The multiple-input-multiple-output (MIMO) configuration synthesizes an array of twelve virtual RX antennas, as shown in Equation 1. This technique improves the angle resolution by a factor of three (compared to a single TX configuration).

Figure 3. MIMO Antenna Configuration



2.3.2 Chirp Configuration and System Performance

To achieve the specific BSD, LCA, and TJA, use a case with a visibility range of approximately 150 m and memory availability of the AWR1843. The chirp configuration shown in Table 2 is used.

Table 2. Chirp Configuration

PARAMETER	SPECIFICATIONS
Idle time (µs)	5 (BSD, LCA, TJA), 7 (USRR)
ADC start time (µs)	4.8 (BSD, LCA, TJA), 5 (USRR)
Ramp end time (µs)	60 (BSD, LCA, TJA), 87.3 (USRR)
Number of ADC samples	256 (BSD, LCA, TJA), 512 (USRR)
Frequency slope (MHz/µs)	4 (BSD, LCA, TJA), 42 (USRR)
ADC sampling frequency (ksps)	4652 (BSD, LCA, TJA), 6250 (USRR)
MIMO (1→yes)	0 (BSD, LCA, TJA), 1 (USRR)
Number of chirps per profile	256 (BSD, LCA, TJA), 64 (USRR)
Effective chirp time (usec)	55 (BSD, LCA, TJA), 82 (USRR)
Bandwidth (MHz)	240 (BSD, LCA, TJA), 3456 (USRR)
Frame length (ms)	16.6 (BSD, LCA, TJA), 6.03 (USRR)

The Table 2 configuration is selected to achieve the system performance shown in Table 3.

The primary goal was to achieve a maximum distance of approximately 150 m. The product of the frequency slope and the maximum distance is limited by the available IF bandwidth (10 MHz for the AWR1843). Thus, a maximum distance of 150 m locks down the frequency slope of the chirp to approximately 4 MHz/µs. The choice of the chirp periodicity is a trade-off between range resolution and maximum velocity. This design uses a range-resolution of approximately 0.78 m, which leaves a native maximum velocity of about 55 kmph. For details on the connection between the system performance and the chirp parameters, see the *Programming Chirp Parameters in TI Radar Devices application report*. Through high-level algorithms, the maximum unambiguous velocity that can be detected is as high as 144 kmph.

A larger maximum distance translates to a lower range resolution due to limitations on both the L3 memory and the IF bandwidth. A useful technique to work around this trade-off is to have multiple configurations with each tailored for a specific viewing range. For example, it is typical to have the BSD, LCA, and TJA radar alternate between two modes: a low-resolution mode targeting a larger maximum distance (such as 150 m with 0.75-m resolution) and a high-resolution mode targeting a shorter distance (such as 30 m with 4-cm resolution). This multi-mode capability is implemented in the current BSD, LCA, and TJA design. Table 3 shows the USRR specifications.

Table 3. System Performance Parameters

PARAMETER	SPECIFICATIONS
Range resolution (m)	0.75 (BSD, LCA, TJA), 0.043 (USRR)
Maximum distance (m)	150 (BSD, LCA, TJA), 30 (USRR)
Maximum velocity (kmph)	144 (BSD, LCA, TJA), 36 (USRR)

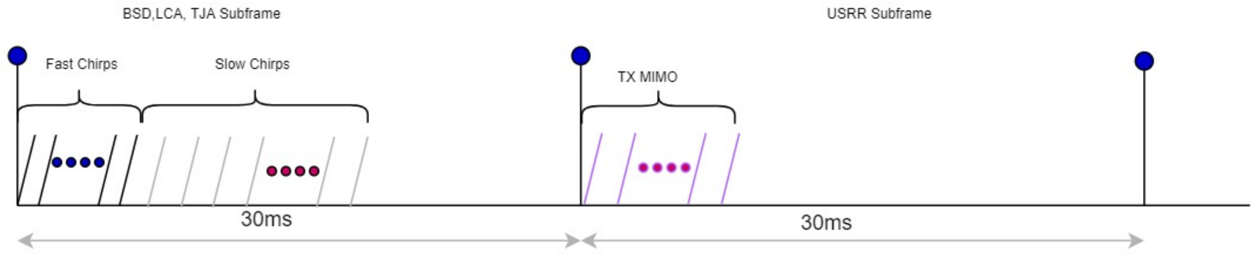
2.3.3 Configuration Profile

To meet the requirements of both USRR and BSD, LCA, and TJA, this design makes use of the advanced frame configuration API of the AWR1843 device. This API allows the construction of a frame consisting of multiple subframes with each subframe being tuned to a particular application. Such a design is referred to as a multi-mode radar. Each of these subframes are tuned to one application. In the case of the BSD, LCA, and TJA design, two subframes are used. One subframe is dedicated to the USRR context and the other to the BSD, LCA, and TJA context.

The frame configuration uses the advanced frame configuration API to generate two separate subframes – the BSD, LCA, and TJA subframe and the USRR subframe. The subframes are named after their principle design requirement.

Figure 4 shows the frame configuration.

Figure 4. Frame Configuration



The BSD, LCA, and TJA subframe consists of two kinds of chirps: fast chirps and slow chirps. Both fast and slow chirps have the same slope, however, the slow chirp has a slightly higher chirp repeat periodicity than the fast chirp. Slow chirps, when processed after 2D FFT, will have a lower maximum unambiguous velocity compared to the fast chirps. The fast and slow chirps do not alternate. Instead, the fast chirp is repeated a certain number of times, followed by the slow chirp which is again repeated an equal number of times.

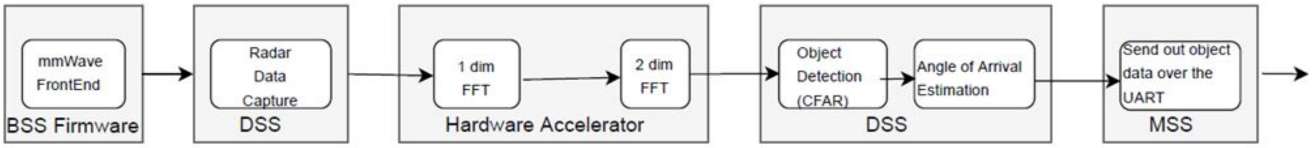
The purpose of this chirp design is to use the two separate estimations of target velocity from the fast chirp and the slow chirp along with the Chinese remainder theorem to generate a consistent velocity estimate with a much higher maximum-velocity limit.

The USRR subframe consists of three alternating chirps. Each chirp uses one of the three TXs available on the AWR1843. Combined processing of this subframe allows the generation of a virtual Rx array of 8 Rx antennas, which consequently have better angular resolution (~14.32 degrees in azimuthal direction). This is not correct because all of the TX antennae are not in the same line as the 4 Rx antenna array.

2.3.4 Data Path

The block diagram in Figure 5 shows the processing data path to the BSD, LCA, and TJA application.

Figure 5. BSD, LCA, and TJA Data Path or Processing Chain



2.3.5 Chirp Timing

Figure 6 shows the timing of the chirps and subsequent processing in the system.

Figure 6. Top Level Data Path Timing

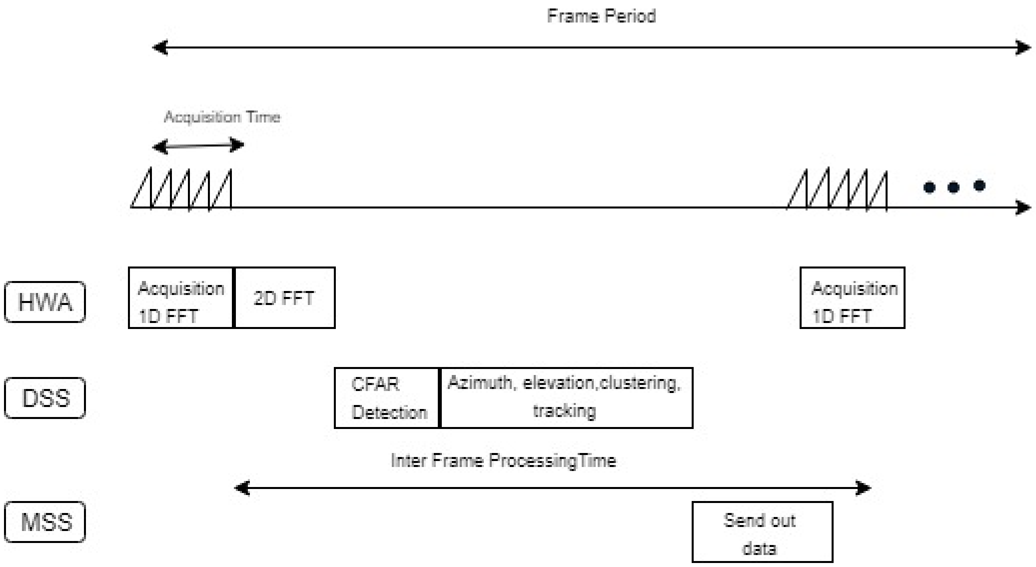


Figure 6 also shows the data path processing, which is described as follows.

The RF front end is configured by the BIST subsystem (BSS). The raw data obtained from the various front-end channels is taken by the radar hardware accelerator (HWA) for processing.

- Processing during the chirps as seen in Figure 5 consists of:
  - 1D (range) FFT processing performed by the hardware accelerator that takes input from multiple receive antennae from the ADC buffer for every chirp (corresponding to the chirping pattern on the transmit antenna)
  - Transferring transposed output into the L3 RAM by Enhanced Direct Memory Access (EDMA)
- Processing during the idle or cool down period of the RF circuitry following the chirps until the next chirping period, shown as *inter frame processing time* in Figure 6. This processing consists of:
  - 2D (velocity) FFT processing performed by hardware accelerator that takes input from 1D output in L3 RAM and performs FFT to give a (range, velocity) matrix in the L3 RAM.
  - Taking data from the L3 RAM into the C674x DSP to perform CFAR detection in Doppler direction. CFAR detection in range direction uses the mmWave library. The rest of the processing continues in the DSP.
  - Peak grouping (for both Doppler and range) for the BSD, LCA, and TJA subframe, for Doppler and for the USRR subframe.
  - Direction of arrival (azimuth) estimation to map the X-Y location of object. The elevation is estimated to map the Y-Z location of the object.
  - Additional pruning based on the SNR and the 2D-FFT magnitude of the object to avoid ground clutter.
  - Clustering of detected objects using the dBScan algorithm for both BSD, LCA, and TJA and USRR.
  - Tracking of clusters using an extended Kalman filter for the BSD, LCA, and TJA.

For more details on the application flow and processing, see the *mmWave software development kit (SDK)*.

Clustering

Clustering is performed using the dBscan algorithm, which is applied on the detected objects of both the SRR and the USRR subframes. The output of the clustering algorithm is the mean location of a cluster and its dimensions assuming that the cluster is a rectangle.

For the USRR subframe, the clustering output is sent as is to the graphical user interface (GUI). USRR clusters allow the grouping of dense point clouds to form rectangles. In cross-traffic scenarios, these clusters can be used to identify vehicles crossing the field of vision (FoV) of the radar.

For the SRR algorithm, the clustering output is used as the basis for the input to the tracking algorithm. The strongest object in the cluster is provided as the representative object to the tracking algorithm. The intention here is essentially to reduce the number of objects provided to the tracking algorithm and introduce hysteresis so that the trackers only track strong reflectors and do not switch between adjacent reflectors.

Tracking

The tracker is a standard Extended Kalman Filter (EKF) with four states (x, y, v_x, v_y) and three inputs (r, v, $\sin(\theta)$) or range, relative velocity, and sin of the azimuth. Compute the associated variances for the inputs using the associated signal-to-noise ratio (SNR) for each input. Use the Cramer-Rao lower bound (CRLB) formula for frequency variance to convert the SNR to a variance. The variance is lower-bounded by the resolution of the various inputs.

While the tracker is standard for an EKF, there are two functions in the tracker that can be modified based on the requirements. The first is the track initialization function (initNewTracker), where the initial parameters of the track are populated. In the SRR design, the assumption is that the velocity of the object is only along the longitudinal axis. As in, a vehicle with a relative velocity is assumed to be traveling towards the radar with $v_x = 0$, and $v_y = v$, which works well in long-range highway traffic but is less effective in cross-traffic situations.

The second function is the data association function (isTargetWithinDataAssociationThresh), which associates new measurements with existing tracks. Association requires assumptions on the movement of objects in the scene, including maximum velocities, directions of motion, accelerations when close to the radar, and so forth.

eDMA configuration

Large-scale data movement between memories is accomplished in the BSD, LCA, and TJA using the EDMA. Using the EDMA is more efficient than using the processor to move data because while the data movement is being completed, the DSP and HWA can continue to process data. The major data transfers necessary include:

- Movement of range FFT output data from the HWA memory to the L3 memory
- Triggering the HWA processing
- Fetching the 1D-FFT data from L3 to HWA input buffer to perform 2D FFT
- Movement of 1D-FFT data from L3 to do angle estimation (after 2D-DFT)

Most of the EDMAs work on a ping-pong buffer, meaning that as the ping buffer is being filled, the pong buffer can be used by the HWA or DSP for processing.

To process the two different subframes, the BSD, LCA, and TJA demo simply doubles the number of assigned EDMAs so that each subframe has its own subset of EDMAs to perform the necessary transfers. This method will not scale as the number of subframes increase, and TI recommends that if more than 3 subframes are to be programmed, reprogram the EDMAs after a frame is processed (as is done in the mmWave SDK demo).

To process the maximum velocity enhancement subframe, the EDMAs listed as 2, 3, and 6 must be changed so that they transfer twice as many chirps.

Memory allocation

The AWR1843 has the following memories:

- L3 RAM of 1024 kB
- L2 RAM of 256 kB
- L1D RAM of 32 kB
- L1P RAM of 32 kB

The R4F has 512 kB of code and data RAM. In the BSD, LCA, and TJA design, the R4F is used only for configuration and for UART/LVDS communication. Its memory consumption and allocation have no effect on the design. The DSP, therefore, is the main consumer of memory and the allocations in it are discussed in the following sections.

Of the 32 KB for L1P RAM and L1D RAM available, half (16 kB) of the L1P RAM and half (16 kB) of the L1D RAM are reserved for code and data storage. The remaining is used as cache. The code stored in L1P is typically algorithms like the FFTs or the CFAR, or some of the kernels of more complex algorithms like clustering and tracking. Storing these in L1 allows faster execution of these kernels as well as saving some space (in this case, ~16 kB) in the remaining memories. The L1D is used as fast ram for certain commonly used buffers.

L2 RAM is used for:

- Code storage
- Data scratch buffers
- State information for the different algorithms
- Configuration information of BSD, LCA, and TJA
- Detection matrix

L3 RAM is used for:

- Single-use initialization code after execution of this memory is overwritten with radar data
- Storing the radar cube

Processing radar signals requires a large number of scratch buffers for each step of the processing stages (3D-FFT, detection, angle estimation, and so forth). The available memory is used efficiently by overlaying the scratch buffers. A scratch buffer used in a previous stage can be re-used in the current stage.

There are two subframes per frame, and both subframes are processed separately and in sequence. Therefore, nearly every scratch buffer memory location can be overlaid between the two. The creation of the scratch buffer pointers for the two subframes is done in MmwDemo_dataPathConfigBuffers.

Maximum velocity disambiguation in BSD, LCA, and TJA subframe

The BSD, LCA, and TJA subframe achieves a maximum unambiguous velocity of 144 kph by using signal-processing techniques that help disambiguate velocity. This method works by using two different estimates of velocity from the two kinds of chirps, fast chirps and slow chirps, transmitted in the BSD, LCA, and TJA subframe. If the two velocity estimates do not agree, then velocity disambiguation is necessary. To disambiguate, it is necessary to rationalize the two velocity measurements and find out the disambiguation factor, k. If the native maximum unambiguous velocity of the fast chirp is v_f , and that of the slow chirp is v_s, then after the disambiguation process, the disambiguated velocity would be $2\ kv_f + v$, where v is the native estimated velocity from the fast chirps.

The disambiguation process works by using the fast chirp velocity to compute different disambiguated velocity hypotheses. This computation works by taking the fast chirp velocity and adding $2\ kv_f$, where $k \in \{-1,0,1\}$ (an unwrapping process on the velocity estimate). These hypotheses are then converted to indices of the slow chirp by finding the equivalent estimated velocities in the slow chirp configuration, essentially undoing the unwrapping using v_s as the maximum unambiguous velocity.

If the index corresponding to one of the hypotheses has significant energy, then that hypothesis is considered to be valid. Disambiguation of up to 3 times of the naive maximum velocity is possible with this method; however, testing has only been done up to 144 kph.

TX beamforming and beamsteering

In the TX beamforming mode, multiple TX channels are transmitting simultaneously and coherently to achieve higher gain and longer range in the main focused field of view. As shown in Figure 7, each TX channel of each device has a 6-bit configurable phase register with a step size of 5.625 degrees. The value of the phase value programed to each TX channel is calculated based on where the main beam should be focused. Due to the coherent gain achieved in BSD, LCA, and TJA (TX beamforming) mode, its detection range is much longer than that achievable in USRR (MIMO) mode.

Figure 7. Beamforming Operation in the AWR1843

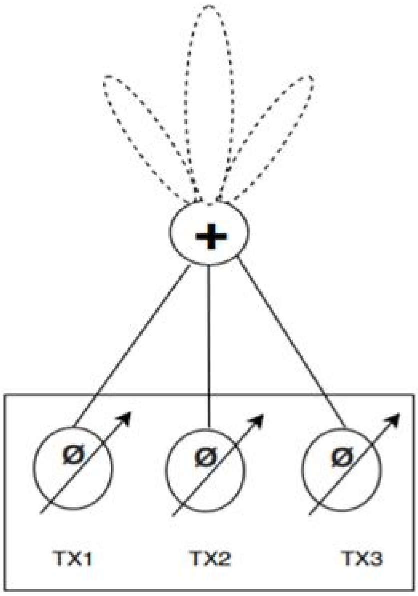
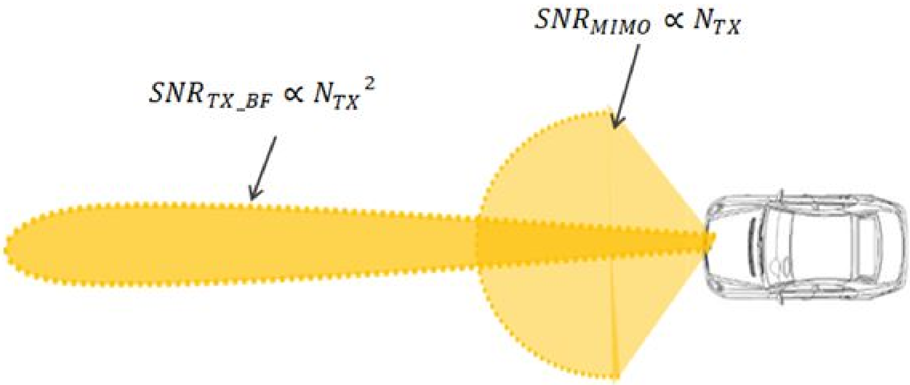


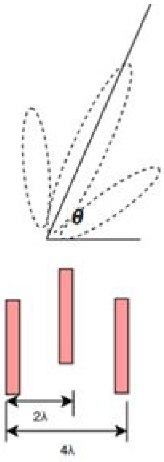
Figure 8. Gain Comparison in BSD, LCA, and TJA and USRR



Phase calculation for beamforming

The amount of phase value to be programed to each TX channel is computed as a function of array factor and target angle.

Figure 9. Beamforming Phase Calculation



$$\vec{\emptyset} = [\emptyset_1 \ \emptyset_2 \ \emptyset_3] = \left[0 \quad 2\pi\frac{d_2}{\lambda}\sin\theta \quad 2\pi\frac{d_3}{\lambda}\sin\theta\right] \qquad d2 = 2\lambda,\ d3 = 4\lambda \tag{1}$$

The ideal phase value is further quantified by the allowed phase step size of 5.625 degrees to calculate the integer value to be programed to the registers.

$$\overrightarrow{\emptyset_{int}} = \lfloor[\emptyset_1 \ \emptyset_2 \ \emptyset_3\ ]/5.625\rfloor \tag{2}$$

As an example, for TI EVM, 3 azimuth TX antennas can be used for beamsteering. If the desired steering angle is 30 degrees, then the phase vector is as shown in Equation 3 in degrees.

$$\vec{\emptyset} = \frac{[0 \quad 4\pi\sin 30^o \quad 8\pi\sin 30^o]}{\pi} * 180 \tag{3}$$

The TX beamforming supports both the per-chirp-based beamsteering and frame-based beamsteering.

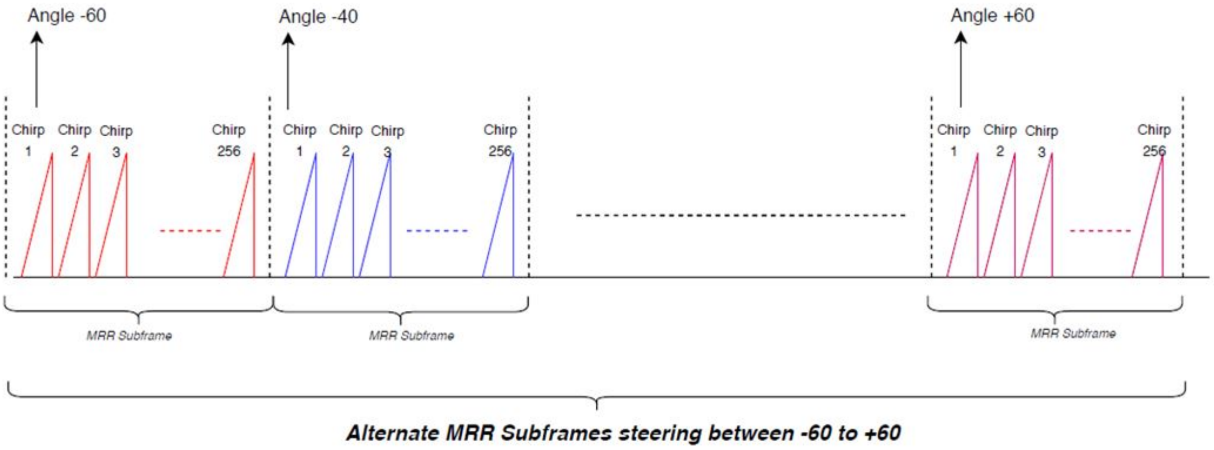
Beamsteering in a BSD, LCA, and TJA design

In this design, the frame-based beamsteering used is where all the chirps in the BSD, LCA, and TJA subframe apply the same value of the phase to the TX phase shifter for that particular angle.

This design provides a reference on how to configure the phase shifters of the TX. In the current design, all of the chirps in the subframe used for the TX beamforming apply the pre-computed phase values for a particular steering angle.

In this design, steering is done between angles -60 to +60 degrees in steps of 20 degrees to scan the entire scene in front of the sensor. To begin with the phase shifter, the value of all of the chirps used in the BSD, LCA, and TJA subframe are configured to phase values corresponding to the -60 degrees and then alternate BSD, LCA, and TJA subframes to apply phase values corresponding to -40, -20, 0, +20,+40, and +60 degrees. Once it reaches the steering angle for +60 degrees, the configuration rolls back to the -60 degrees. Effectively, the entire scan between -60 to +60 degrees takes about ~200 ms. The steering angle and step value are configurable in the demo software provided.

Figure 10. Beamsteering Scheme in BSD, LCA, and TJA Reference Design



3 Hardware, Software, Testing Requirements, and Test Results

3.1 Required Hardware and Software

The AWR1843 BoosterPack™ is an easy-to-use evaluation board for the AWR1843 mmWave sensing devices.

The BSD, LCA, and TJA application runs on the AWR1843BOOST EVM and connects to a visualization tool running on a PC connected to the EVM over USB. Details regarding usage of this board can be found in the *AWR1843BOOST and IWR1843BOOST Single-Chip mmWave Sensing Solution User's Guide*. The BSD, LCA, and TJA design is an application built using the mmwaveSDK. As such, it is necessary to install the mmwave SDK from http://www.ti.com/tool/MMWAVE-SDK.

The source code for the BSD, LCA, and TJA design can be found in the mmWave Automotive Toolbox from the TI Resource Explorer. The MMWAVE-SDK version used to build this code is provided in the demo software release notes.

3.1.1 Hardware

The AWR1843 core design includes:

- The AWR1843 device, a single-chip, 77-GHz radar device with an integrated DSP
- Power management network using a low-dropout linear regulator (LDO) and power management integrated circuit (PMIC) DC/DC supply (TPS7A88, TPS7A8101-Q1, and LP87702-Q1)
- The EVM also hosts a device to assist with onboard emulation and UART emulation over a USB link with the PC

3.1.2 Software and GUI

Associated software is hosted on the TI Resource Explorer Automotive Toolbox.

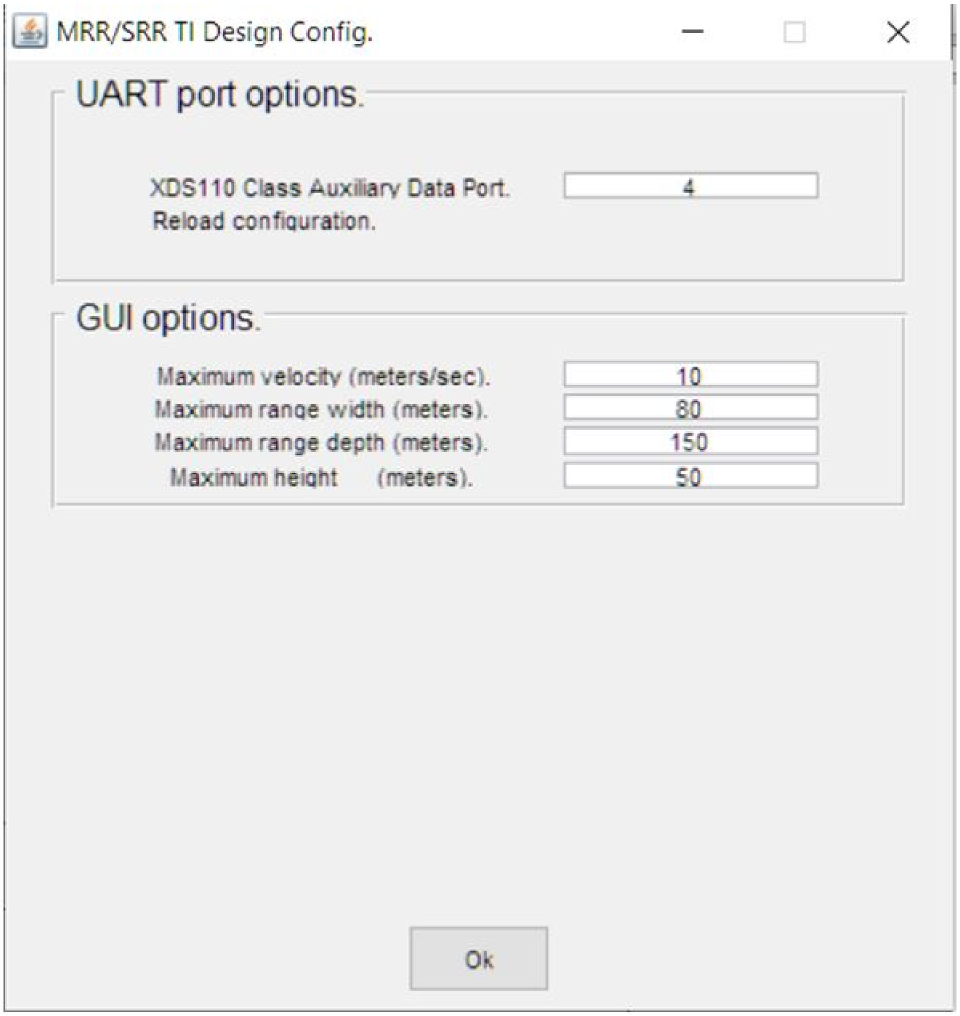
The demo GUI is configured as follows.

The first tab allows the user to configure the demo (see Figure 11). In the first tab (UART port options), UART ports can be configured based on the device manager settings. If the radar is already running, there is no need to load the configuration, so the *reload configuration* is not necessary when restarting the GUI; otherwise, set it to start the radar.

The second tab configures the ranges on the GUI. It only configures the GUI and not the radar.

The final tab has a list of record and replay options that allow recording of and then replaying of UART recordings.

Figure 11. GUI Configuration

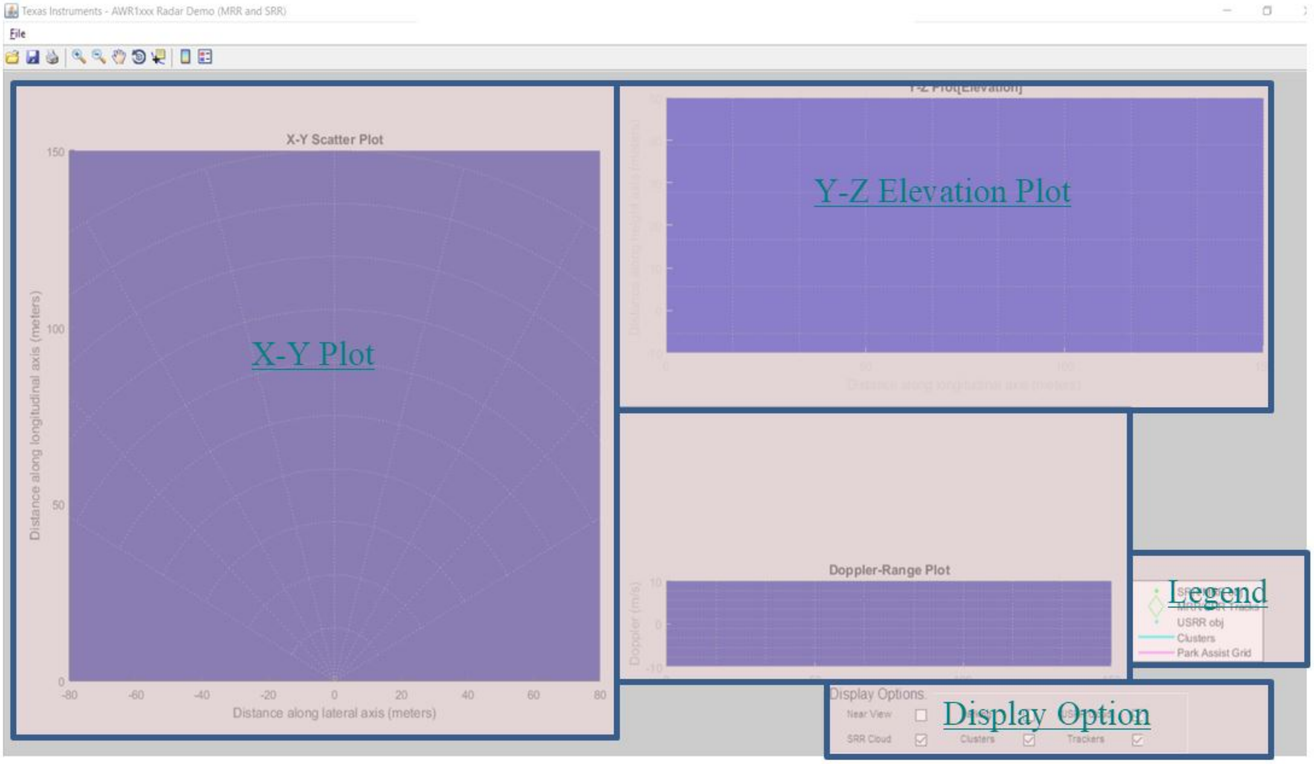


XDS110 Class Auxiliary Data Port. 4
Reload configuration.

Maximum velocity (meters/sec). 10
Maximum range width (meters). 80
Maximum range depth (meters). 150
Maximum height (meters). 50

The default GUI starts as soon as the *OK* button is clicked. See Figure 12 for a screenshot of the GUI with the different components labeled.

Figure 12. GUI



Near View ☐

SRR Cloud ☑ Clusters ☑ Trackers ☑

The MATLAB® GUI consists of five components:

- X-Y scatter plot: Displays the positions of the point clouds, the tracks and the clusters.
- Y-Z plot: Displays the elevation in formation of the detected object.
- Doppler range plot: Displays the Doppler-range coordinates of the point cloud and the clusters.
- Legend: Description of the different kinds of points being displayed on the screen.
- Display options: The features of the BSD, LCA, and TJA design can make the display crowded and sometimes difficult to understand. As such, different types of the point cloud can be enabled and disabled at will during demonstration. For example, during long stretches of open highway, it may be only necessary to see the trackers. In heavy traffic, the USRR cloud would make more sense. In cases where there is cross traffic, the cluster output would generate a better display of the traffic crossing over.

3.2 Testing and Results

3.2.1 Test Setup

The performance of the AWR1843 beamsteering functionality was tested using the demo available in the TI Resource Explorer in the Automotive Toolbox: lab0011_mrr_beamsteering. The demo used the default configuration which scans from -60 deg to +60 deg using a 20-deg step.

The results were compared to the non-beam-steering demo also available in the TI Resource Explorer in the Automotive Toolbox: lab0007_medium_range_radar.

The AWR1843BOOSTEVM was used for the tests.

The sensor was placed on a tripod as shown in Figure 13 at a height of 1.2 m.

The sensor was rotated at the angles provided in Table 4.

Figure 13. Test Setup

3.2.2 Test Results

The results shown in Table 4 correspond to the maximum range detected for mid-size SUVs.

Table 4. Test Results

ANGLE (deg)	MAX RANGE NON BEAMSTEERING (m)	MAX RANGE BEAMSTEERING (m)
0	160	160
+/-5	155	155
+/-10	155	155
+/-15	150	150
+/-20	150	150
+/-25	150	150
+/-30	140	140
+/-40	105	105
+/-50	45	75
+/-60	30	50

4 Design Files

4.1 Schematics

To download the schematics, see the design files at TIDEP-01021.

4.2 Bill of Materials

To download the bill of materials (BOM), see the design files at TIDEP-01021.

4.3 PCB Layout Recommendations

4.3.1 Layout Prints

To download the layer plots, see the design files at TIDEP-01021.

4.4 Altium Project

To download the Altium Designer® project files, see the design files at TIDEP-01021.

4.5 Gerber Files

To download the Gerber files, see the design files at TIDEP-01021.

4.6 Assembly Drawings

To download the assembly drawings, see the design files at TIDEP-01021.

5 Software Files

To download the software files, see the design files at TIDEP-01021.

6 Related Documentation

1. Texas Instruments, *AWR1843BOOST and IWR1843BOOST Single-Chip mmWave Sensing Solution User's Guide*
2. Texas Instruments, *Programming Chirp Parameters in TI Radar Devices Application Report*
3. Texas Instruments, *AWR18xx/16xx/14xx Technical Reference Manual*
4. Texas Instruments, *Programming Chirp Parameters in TI Radar Devices Application Report*
5. Texas Instruments, mmWave SDK User's Guide

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