mmWave Sensor Raw Data Capture Using the DCA1000 Board and mmWave Studio

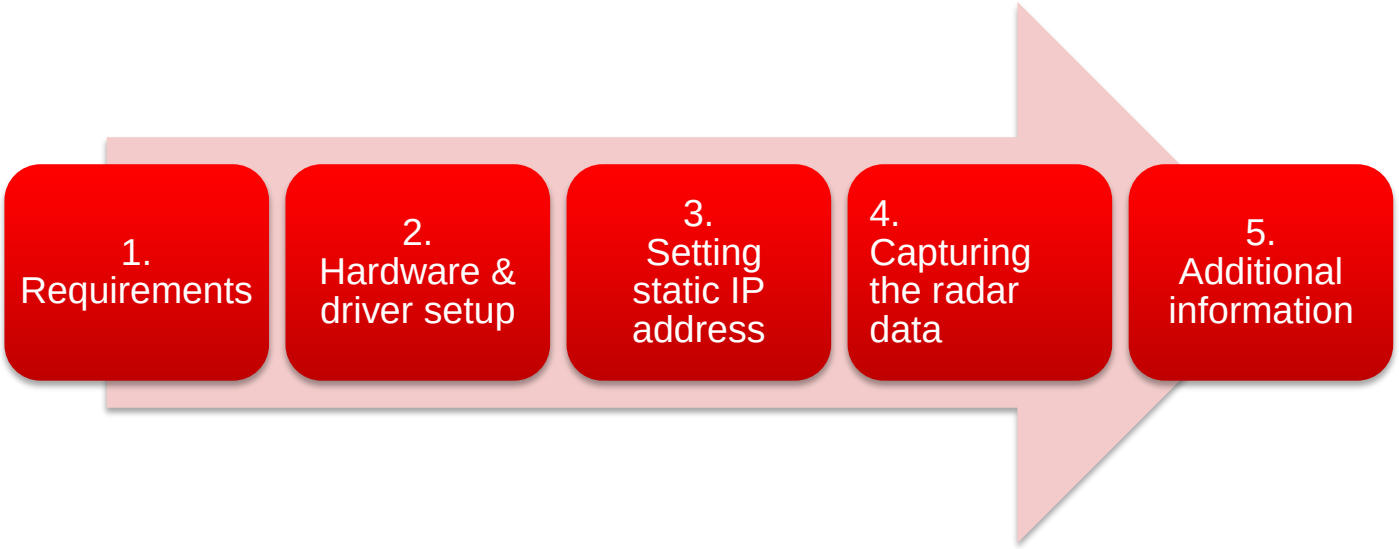
Scope of the training

This training will help you getting started on capture raw ADC data from TI's mmwave sensor devices using the DCA1000 capture card and mmwave studio tool used to configure the mmwave front end.

Once you get started you can refer to the mmwave studio user guide (http://software-dl.ti.com/ra-processors/esd/MMWAVE-STUDIO/latest/exports/mmwave_studio_user_guide.pdf)

and DCA1000 user guide (http://www.ti.com/lit/pdf/spruij4) for more advanced options.

Steps

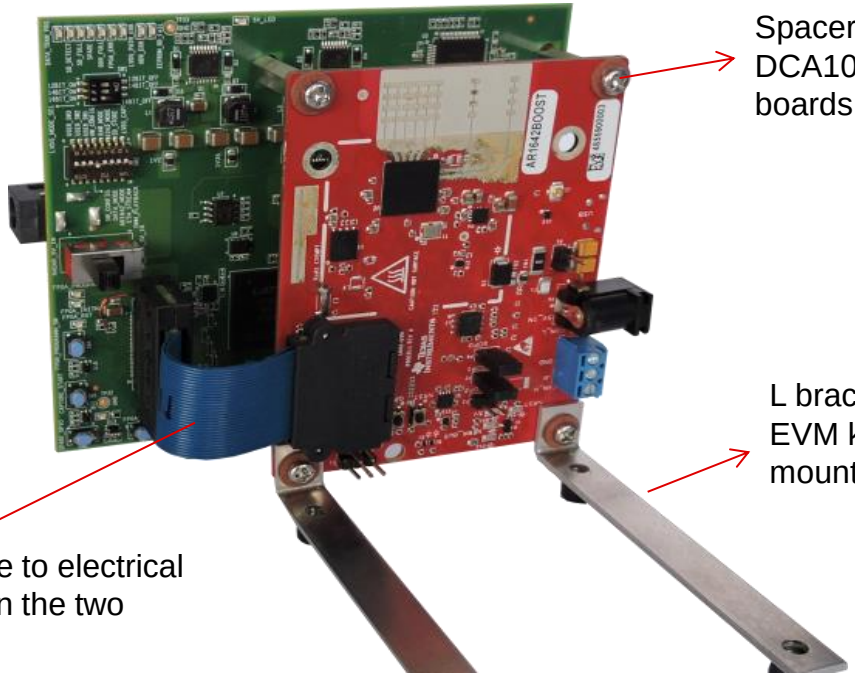

1. Requirements
2. Hardware & driver setup
3. Setting static IP address
4. Capturing the radar data
5. Additional information

Requirements

- Hardware
  - xWR1243 / xWR1443/ xWR1642 EVM, 5 V / >2.5 A power supply, micro USB cable (cables are part of the kit)
  - DCA1000 EVM, 5 V / >2 A power supply, micro USB cable, RJ45 Ethernet cable, 60pin Samtec cable (cables are part of the kit)
- Software
  - mmWave Studio
  - Matlab Runtime Engine v8.5.1
  - If you do not have Code Composer Studio v7.1 or higher installed:
    - XDS Emulation Software Package v6.0.579.0 or higher
- The above links are in clear at the end of this presentation.

Hardware setup (1)

- Connect the mmwave EVM and DCA1000 as shown below. All components are part of the kit:



Spacers available in the DCA1000 kit to assemble the two boards together.

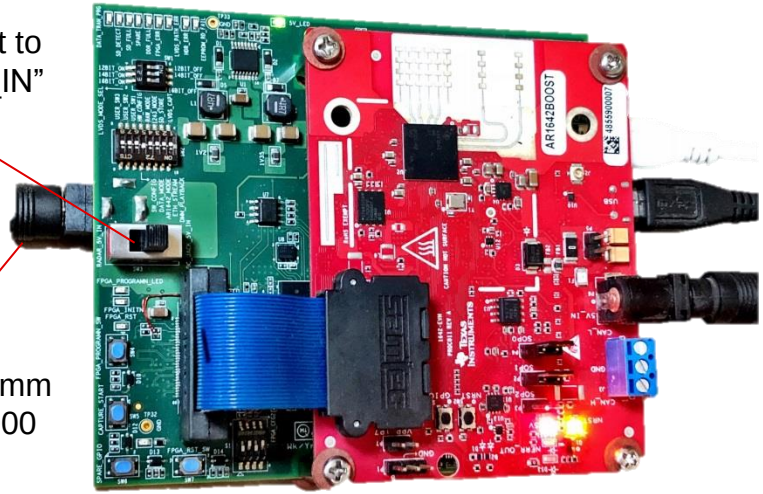
L brackets available in the xWR EVM kit to enable vertical mounting of the sensor

60 pin samtec cable to electrical connection between the two boards.

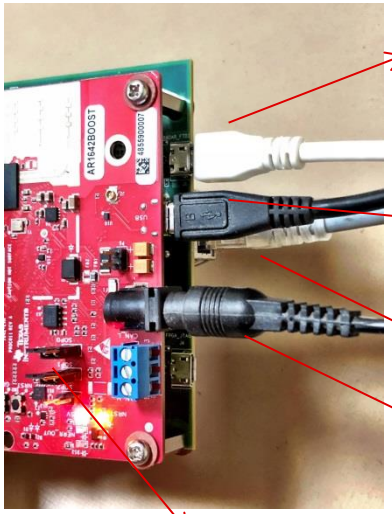
Hardware setup (2)

The DCA1000 and the xWR EVM are powered with 5 V, 2.5 A supplies. Micro USB cable an Ethernet cables are connected for PC interface. The SOP mode is set to SOP mode 2 for mmwave studio interface.

SW3 switch set to “DC_JACK5V_IN”



5V supply (2.1 mm jack) to DCA1000



Micro USB to J1 on DCA1000 for FTDI interface.

Micro USB to J8 on xWR EVM for XDS110 interface

Ethernet RJ45 cable to J6 on DCA1000

5V supply (2.1 mm jack) to xWR EVM

Mount jumpers on the SOP0 and SOP1 pins (P4 and P2)

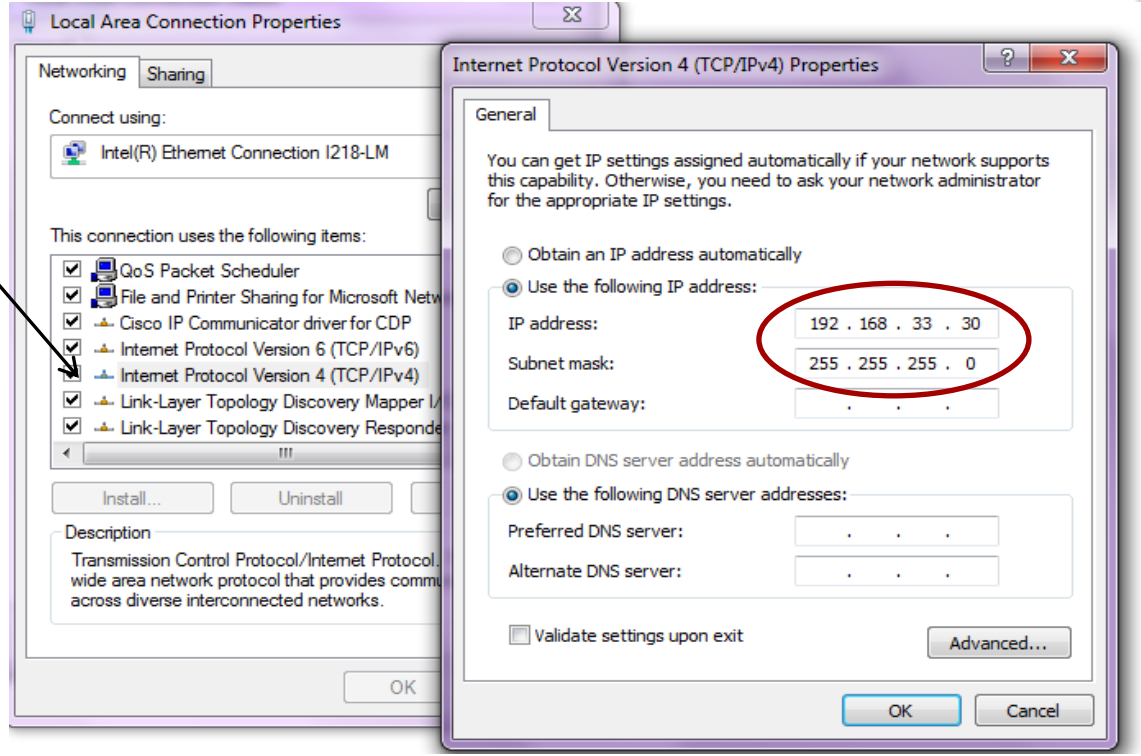
FTDI and XDS driver (1)

- If you do not have Code Composer Studio v7.1 or higher installed:
  - Install the XDS Emulation Software Package.
- Connect the DCA1000 and the EVM to your PC through USB cables and power.
- In the Windows Device Manager, the COM ports should appear as this when their drivers are installed:

- The FTDI device ports of the DCA1000 board will appear with a yellow label when the driver is not installed
  - In this case, right-click on this symbol, select “Update Driver Software”, “Browse my computer for driver software”, select the below directory, and tick “Include subfolders”. ~\mmwave_studio_01_00_00_00\ftdi
  - This needs to be done for each of the 4 ports. In some cases you might need to do it twice for the 1st port or each of the 4 ports.

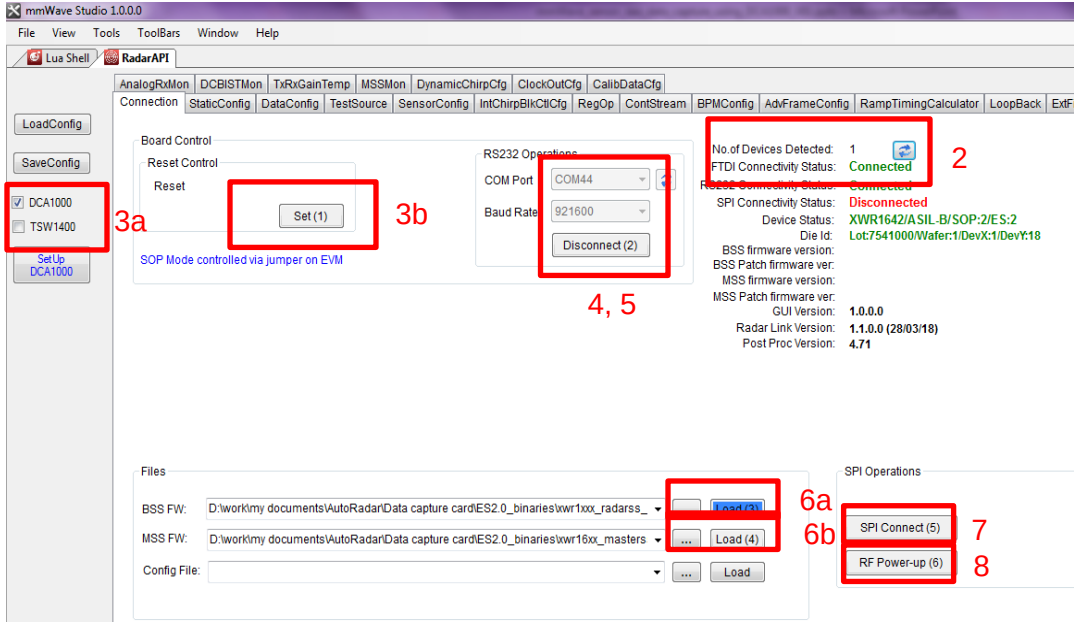
Setting static IP address

- Connect the Ethernet cable between the DCA1000 and the PC.
- In the PC local area network properties select TCP/IPv4.
- Set static IP address of 192.168.33.30.
- Subnet mask as 2555.255.255.0



Capturing the radar data (1)

1. Run mmwave Studio from the installation location (~\mmwave_studio_<ver>\mmWaveStudio\RunTime\mmWaveStudio.exe). You can also create a short for easy access.
2. The Connection window should show up with FTDI Connectivity highlighted in green. If in red, install the FTDI drivers (see section 2).
3. Select ‘DCA1000’ and click on ‘set’ (in reset control)
4. Select the Application/User port number, Baud rate 115200.
5. Click ‘Connect’. The RS232 Connectivity should turn to ‘Disconnect’. The Device status should show based on the radar device used.

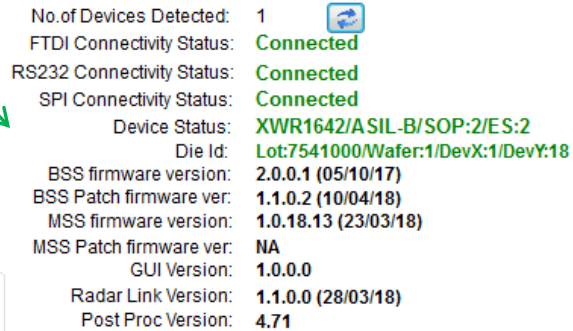


Note that the tool guides you with the button sequence by highlighting it in BLUE

Capturing the radar data (2)

6. In the mmwave Studio Connection tab, load the appropriate BSS (radarss.bin) , then MSS firmware (Masterss.bin) from the “~\mmwave_studio_<ver>\rf_eval_firmware” folder. The binary is based on the device variant being used (1243/1443/1642) and the silicon PG version being used (ES1.0, ES2.0, ES3.0).

7. Once the firmware are loading the firmware and patch versions are displayed.

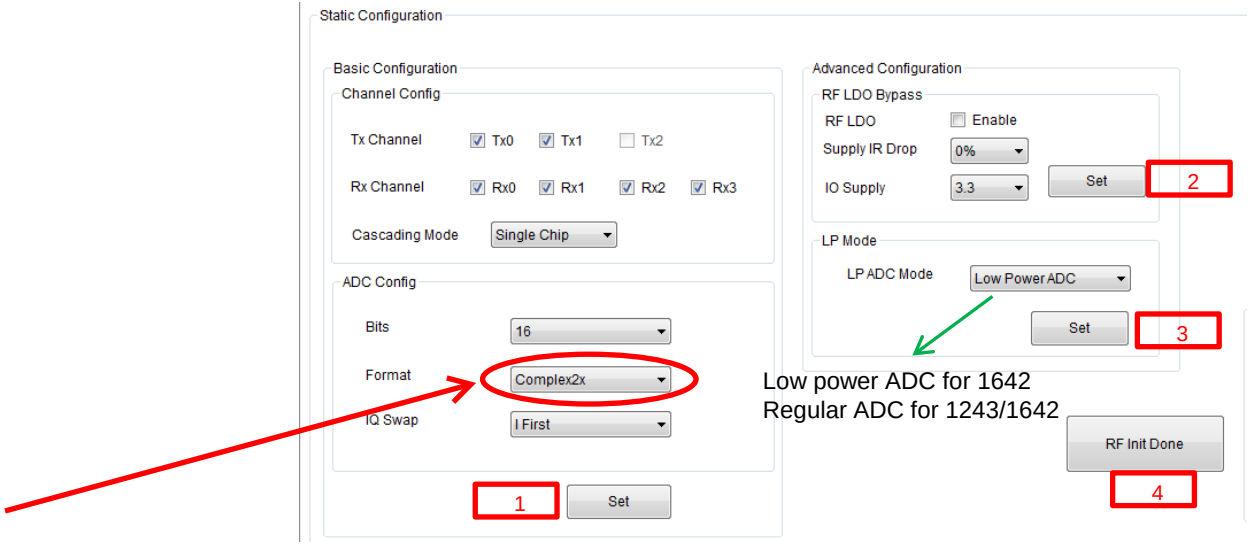


8. Next Click the SPI Connect button. The SPI Connect button becomes SPI Disconnect indicating a success.

9. Next Click the RF Power up button

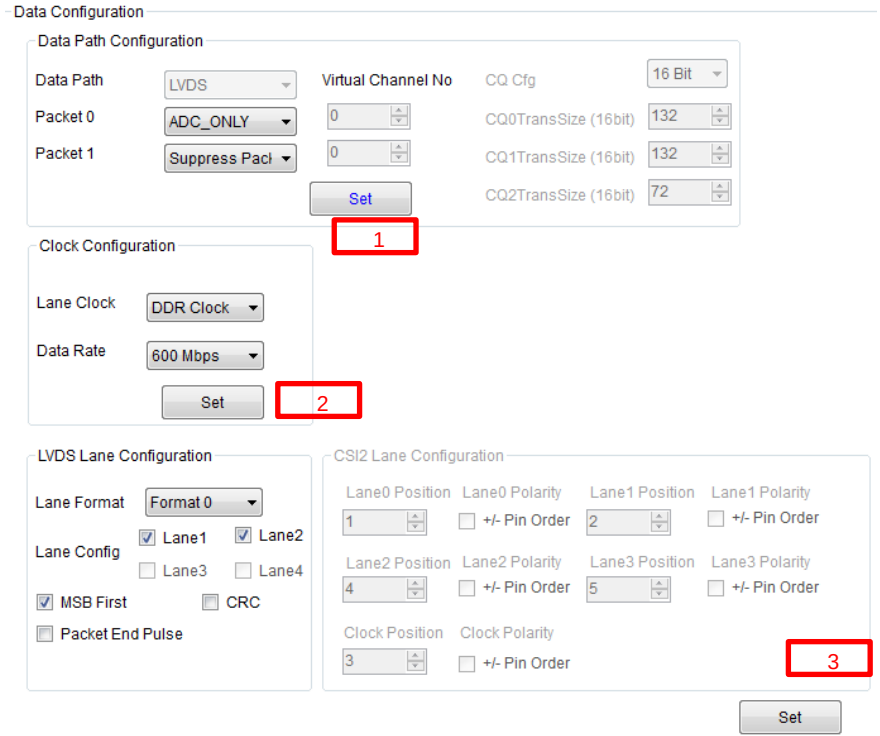
Capturing the radar data (3)

- In the Radar Studio Static Config tab, do the below:
  1. Select the desired TX and RX channels. In ADC Config, select desired AD configuration and click SET
  2. If the board provided 1V RF supply Enable the RF LDO Bypass, if its 1.3V leave it unchecked. Click the Advanced Configuration Set button.
  3. LP mode- ‘Select Low power ADC’ mode for 1642 and ‘Regular ADC’ mode for 1243/1443
  4. Click the RF Init Done button.



Capturing the radar data (4)

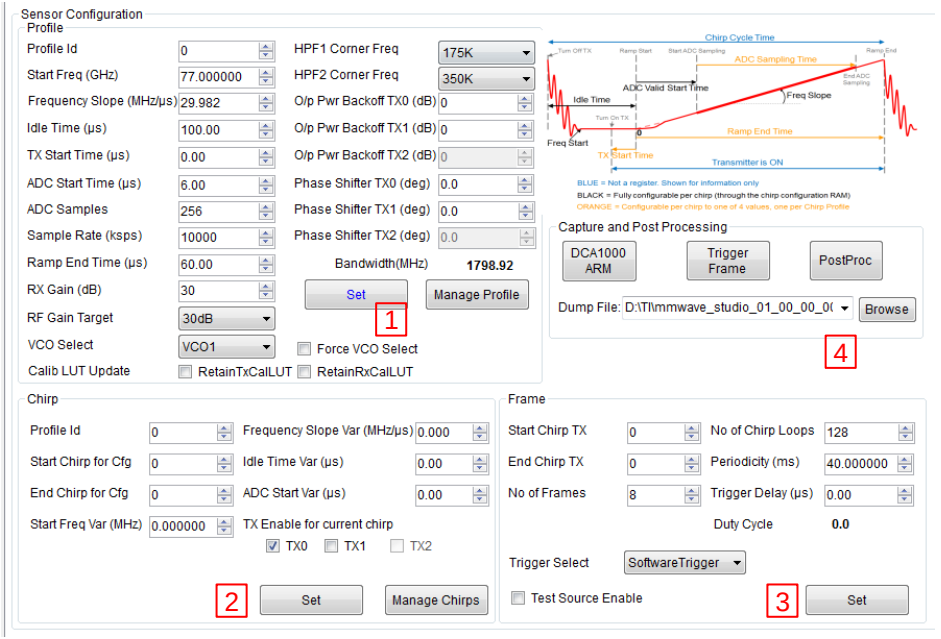
1. In the DataConfig tab, select the data path config (ADC only) and click Set button.
2. Select the clock rate and click set.
3. Select the LVDS lanes and click set.
   Note that DCA1000 always captures 2 LVDS lanes for 1642 and 4 LVDS lanes for 1243/1443 devices.



Capturing the radar data (5)

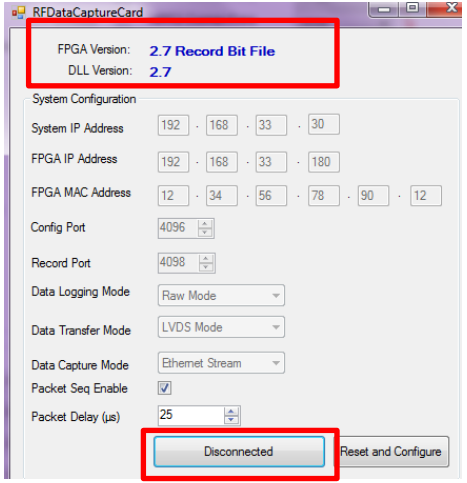
1. In the SensorConfig tab select the required Profile configuration. These define the FMCW chirp profile.
2. Select the chirp configuration .
3. Select the frame configuration .
4. Select the Dump file pathname.

For more details on selecting the values for profile , chirp and frame configuration refer to the app note "Programming Chirp Parameters in TI Radar Devices"



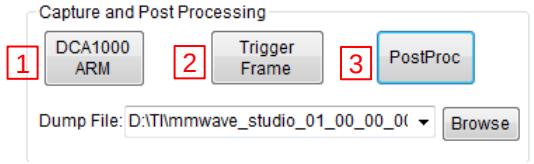
Capturing the radar data (6)

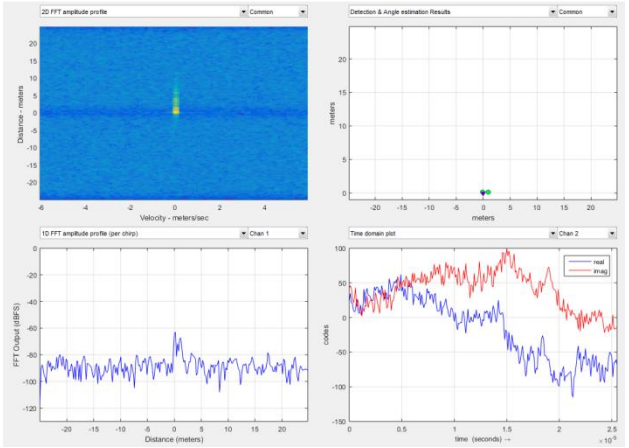
- Click the button: “SetUp DCA1000” on the left half of the panel.
- Click on “Connect, Reset and configure”. This would establish the Ethernet connection and display the FPGA versions. Verify that the FPGA version is correct.
- Note that incase the connection fails make sure the static IP is set correctly, Ethernet cable is plugged in correctly and the ports 4096 and 4098 are accessible in the PC used, ie there is no firewall blocking the ports.



Capturing the radar data (7)

- Click on DCA1000 ARM and then Trigger Frame. At this point the radar starts sending out ADC data and DCA1000 stars capturing it.
- Once the capture is complete , click on ‘Post Proc’.
- At this point the .bin file specified in the “Dump File” dialog box is created and the captured data is processed.
- The post processing utility displays the FFT, time domain and other analyses plots
- For details on the post processing analyses options and file formats refer the mmwave studio user guide.





Additional information

- Data capture flow.
- xWR1243/1443 and xWR1642 file format
- Useful links

Data file format (1)

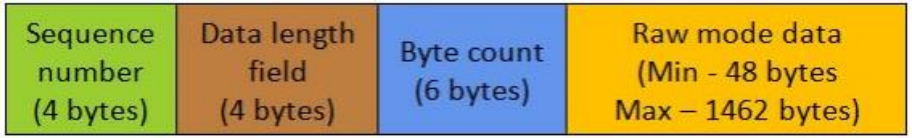
- Configuration:
  - n LVDS Lanes, complex data, n channels, chirping/continuous streaming mode
- Notation:
  - RxkIn: The n^{th} in-phase sample corresponding to k^{th} RX channel.
  - RxkQn: The n^{th} quadrature-phase sample corresponding to k^{th} RX channel.
  - N: The number of samples per chirp.
- Note that since the data is captured using a UDP protocol over Ethernet interface , there could be occasional packets drops. The data from the dropped packets is filled with zeros in the file and can be ignored for analyses.

Data capture flow

The data over Ethernet saved in files with headers

ADC data parsed by mmwave studio

- The files are split after ~1GB size and stored in the “mmwave_studio_<ver> \mmWaveStudio\PostProc” folder
- The file names are “adc_data_Raw_0.bin” , “adc_data_Raw_1.bin “ and so on for subsequent files.
- This file content is in the form of ethernet packets with the below format



or UDP packet number	#of bytes in the packet	Total byte count of ADC data transferred upto this packet	Raw data captured from LVDS interface

- Mmwave studio pick up only first stored “adc_data_Raw_0.bin”.
- The headers etc. are removed, missing packets or out of orders are detected using sequence number.
- Any missing packets are replaced with “zeros” in the file. The length of zeros is detected by the byte count of the next packet.
- The raw ADC data is then written back to “adc_data.bin” file.

Data file format (2)

1243/1443 interleaved format- complex 4channel

Chirp1	RX0I0	RX1I0	RX2I0	RX3I0
	RX0Q0	RX1Q1	RX2Q2	RX3Q3
	RX0I1	RX1I1	RX2I1	RX3I1
	RX0Q1	RX1Q1	RX2Q1	RX3Q1
	….			
	RX0IN-1	RX1IN-1	RX2IN-1	RX3IN-1
	RX0QN-1	RX1QN-1	RX2QN-1	RX3QN-1
Chirp2	RX0I0	RX1I0	RX2I0	RX3I0
	RX0Q0	RX1Q1	RX2Q2	RX3Q3
	RX0I1	RX1I1	RX2I1	RX3I1
	RX0Q1	RX1Q1	RX2Q1	RX3Q1
	….			
	RX0IN-1	RX1IN-1	RX2IN-1	RX3IN-1
	RX0QN-1	RX1QN-1	RX2QN-1	RX3QN-1

1642 non- interleaved format- complex 4 channel

Chirp1	RX0I0	RX0I1	RX0Q0	RX0Q1
	RX0I2	RX0I3	RX0Q2	RX0Q3
	….			
	RX1I0	RX1I1	RX1Q0	RX1Q1
	RX1I2	RX1I3	RX1Q2	RX1Q3
	….			
	RX3I0	RX3I1	RX3Q0	RX3Q1
	RX3I2	RX3I3	RX3Q2	RX3Q3
Chirp2	RX0I0	RX0I1	RX0Q0	RX0Q1
	RX0I2	RX0I3	RX0Q2	RX0Q3
	….			
	RX1I0	RX1I1	RX1Q0	RX1Q1
	RX1I2	RX1I3	RX1Q2	RX1Q3
	….			
	RX3I0	RX3I1	RX3Q0	RX3Q1
	RX3I2	RX3I3	RX3Q2	RX3Q3

- From mmwave studio the raw ADC data (without any headers) is stored in the file name provided sensor config window.
- The data format remains unchanged in the ‘continuous streaming’ mode where one can think of the data collected as belonging to a single large chirp.
- For more details on file format refer to the mmwave studio user guide and the **xWR1xxx ADC Raw Data Capture** app note.

Useful links

- Online support https://e2e.ti.com/support/sensor/mmwave_sensors
- mmWave Studio http://www.ti.com/tool/MMWAVE-STUDIO
- mmWave studio user guide http://software-dl.ti.com/ra-processors/esd/MMWAVE-STUDIO/latest/exports/mmwave_studio_user_guide.pdf
- DCA1000 http://www.ti.com/tool/DCA1000EVM
- XDS Emulation Software http://processors.wiki.ti.com/index.php/XDS_Emulation_Software_Package
- Matlab runtime https://www.mathworks.com/supportfiles/downloads/R2015a/deployment_files/R2015aSP1/installers/win32/MCR_R2015aSP1_win32_installer.exe
- Example power supply https://www.digikey.com/product-detail/en/cuiinc/SMI36-5-V-P5/102-3589-ND/5415060