Raw Data Capture for XWR6843 Device Using 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 (<u>http://software-dl.ti.com/ra-processors/esd/MMWAVE-</u> <u>STUDIO/latest/exports/mmwave_studio_user_guide.pdf</u>)

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



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Steps



Requirements

- Hardware
 - <u>xWR6843</u> / <u>Carrier board</u>, 5 V / >2.5 A <u>power supply</u>, micro USB cable (cables are part of the kit)
 - <u>DCA1000 EVM</u>, 5 V / >2.5 A <u>power supply</u>, 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





Hardware Setup (1) -Configure Antenna Module



- This step only applies if using the AOPEVM antenna module.
- This information can be found in the ICBOOST users guide at: <u>https://www.ti.com/lit/ug/swru546c/swru546c.pdf</u>
- To use the AOPEVM as an antenna module in conjunction with the ICBOOST carrier card the switches need to be set as shown to route signals from the carrier card through the 60Pin header.



Hardware Setup (1) - Configure xwr6843ISKEVM Rev D

- This step only applies when using the xwr6843ISKEVM RevD antenna module or xwr6843ISK-ODSEVM RevD with ICBOOST carrier board.
- This information can be found in the ICBOOST users guide at: <u>https://www.ti.com/lit/ug/swru546c/swru5</u> <u>46c.pdf</u>
- To use RevD EVM as an antenna module in conjunction with the ICBOOST carrier card, the switches (highlighted in yellow cycle) need to be set as shown to route signals from the carrier card through the 60Pin header.



Hardware setup (2) - Mount Antenna Module

- If using the xwr6843ISK or wr6843ISK-ODS antenna module, both 60Pin connectors will be used.
- If using the standalone module like xwr6843ISK RevD or xwr6843ISK-ODS RevD or AOPEVM module, only the right connector closer to the micro-usb connectors will be connected.
- The mounted modules should appear as shown below.



Hardware setup (3) – switch setting

Please • SW • Sw • SO	e use the /2 setting o itch S1 se P setting o	e left f on the tting c on the	figure to DCA10 on the IC ICBOO	o match 00 board BOOST ST		
			Switch name	Setting when connect with DCA		
			S1.12	ON		
			S1.11	ON		
			S1.10	ON		
			S1.9	OFF		
			S1.8	OFF		
			S1.7	OFF		
			S1.6	OFF		
SOP	Setting		S1.5	ON		
name			S1.4	OFF		
SOP2	OFF		S1.3	ON		
SOP1	ON		S1.2	ON		
SOP0	ON		S1.1	OFF		
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Hardware Setup (4) – xwr6843EVM RevD + DCA1000

· This step only applies when using the xwr6843ISKEVM RevD antenna module Micro USB or xwr6843ISK-ODSEVM RevD without Ethernet Cable **ICBOOST** carrier board. This information can be found in the ICBOOST users guide at: https://www.ti.com/lit/ug/swru546c/swru 546c.pdf To use RevD EVM as an antenna module directly with DCA1000, the switches (highlighted in yellow cycle) Micro USB need to be set as shown. Note that on RevD board, power is supply via USB connector. Switch to "DC JACK 5V IN" 5V, 2.5 A, DC 9 Power Supply **TEXAS INSTRUMENTS**

Hardware setup (4)

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.





- 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.
- Ports (COM & LPT)
 AR-DevPack-EVM-012 (COM57)
 AR-DevPack-EVM-012 (COM58)
 AR-DevPack-EVM-012 (COM59)
 AR-DevPack-EVM-012 (COM60)
 ECP Printer Port (LPT1)
 XDS110 Class Application/User UART (COM4)
 XDS110 Class Auxiliary Data Port (COM3)

Driver setup

- 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 xx xx xx \text{tdi}
- 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

letworking Sharing	Internet Protocol Version 4 (TCP/IPv4) Properties
Connect using:	General
Intel(R) Ethemet Connection 1218-LM This connection uses the following items: QoS Packet Scheduler GoS Packet Scheduler File and Printer Sharing for Microsoft Netw File an	You can get IP settings assigned automatically if your network supports this capability. Otherwise, you need to ask your network administrator for the appropriate IP settings. Obtain an IP address automatically Use the following IP address: IP address: IP address: Subnet mask: Default gateway: Obtain DNS server address automatically Obtain DNS server: Alternate DNS server:
	Validate settings upon exit
OK	OK Cancel



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3. Setting static IP address

Capturing the radar data (4.1)



Capturing the radar data

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- Run mmWave Studio from the installation location (~\mmwave_studio_<ver>\mmWaveS tudio\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).

nection StaticC	onfig DataConfig TestS	alloDataCtg In ource Sensor(onfig IntChirpBlkCtlCfg	RegOp ContStream BPMCo	onfig AdvFrameCor	fig RampTimingCalculator	LoopBack
Board Control Reset Control Reset	Set (1)	RS232 Oper COM Port Baud Rate	com4 v ¢ 115200 v Connect (2)	No. of Devices Detected FTDI Connectivity Status RS232 Connectivity Status: SPI Connectivity Status: Device Status: Die Id: BSS firmware version	1 Connected Disconnected		
	Operating Frequency 60 GHz 77 GHz	Device V O XW O XW O XW	ariant R12xx O xWR6843 R14xx O xWR1843 R16xx	BSS Patch firmware ver: MSS firmware version: MSS Patch firmware ver: GUI Version: Radar Link Version: Post Proc Version:	2.1.1.0 2.0.9.0 (31/07/19) 4.86		
iles BSS FW: C:10	Nmmwave_studio_02_01_	01_00\mmWave	Studio\Scripts\.\.\rf_eval	firmware\radar v Loa	id (3)	SPI Operations SPI Connect (5)	

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



Capturing the radar data (4.2)

- 1. "Reset Control" click 'Set(1)'
- 2. **"RS232 Operations**" Select the COM port listed in device manager as Application/User port number, Baud rate 115200.
- 3. Click 'Connect'. The RS232 Connectivity should turn to 'Disconnect'. The Device status should show based on the radar device used.

Hanager File Action View Help			5
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 Network adapters Ports (COM & LPT) AR-DevPack-EVM-012 (COM33) AR-DevPack-EVM-012 (COM34) AR-DevPack-EVM-012 (COM35) AR-DevPack-EVM-012 (COM36) Intel(R) Active Management Technolo XDS110 Class Application/User UART (gy - SOL COM4)	(COM3)	



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



Capturing the radar data (4.2.2)

- 1. This page only applied to the AOP device.
- 2. In the case of AOP device, after reset and RS232 connection, the device name is not automatically detected. User has to program the "operation frequency" and "device variant" manually. And the order matters.

Uua Shell 😹 RadarAPI			
MSSMon DynamicChirpCfg ClockOutCfg C	alibDataCfg Import_Export	Dania Castoleane DBUG	afe Ad France Confee DemoTimics Coloridat
Board Control Reset Control Reset Set (1) SOP Mode controlled via jumper on EVM	RS232 Operations COM Port COM4 ~ 2 Baud Rate 115200 Disconnect (2)	No.of Devices Detected: FTDI Connectivity Status: RS232 Connectivity Status: SPI Connectivity Status: Device Status: Die Id: BSS firmware version: BSS Patch firmware version:	1 Connected Connected Disconnected UnDetDe/QM/SOP:2/E S:2 Lot:3929529/Wafer:19/DevX:6/DevY:11
Operating Frequency 60 GHz 77 GHz	Device Variant XWR12xx XWR6843 XWR14xx XWR1843 XWR16xx 2	MSS Patch firmware ver: GUI Version: Radar Link Version: Post Proc Version:	2.1.1.0 2.0.9.0 (31/07/19) 4.86

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



Capturing the radar data (4.3)

- "Files" 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 (1243/1443/1642/6843)
- 2. The silicon PG version being (ES1.0, ES2.0, ES3.0) supported by the firmware is listed in the radar studio release notes. The firmware for an older PG version can be found in the older version of the radar studio.
- 3. **"SPI Operations**" Click 'SPI Connect(5)' then 'RF Power-up(6)'
- 4. Once the firmware is loaded, the firmware and patch versions are displayed.



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



Capturing the radar data (4.4)

- StaticConfig tab:
 - Select the desired TX and RX channels that you would want to use. In ADC Config, select desired ADC configuration and click SET
 - 2. If board is 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 'Regular ADC' mode
 - 4. Click the RF Init Done button.

		Advanced Configuration
hannel Config		RF LDO Bypass
Tx Channel 🗹 Ty	0 🗹 Tx1 🗹 Tx2	RF LDO Bypass Enable
Py Channel		PALDO I/P Disable
		Supply IR Drop 0% ~
Cascading Mode S	ingle Chip 🛛 🗸	IO Supply 3.3 V Set
CasCading PinOut Cfg		LP Mode
CIkOut Master Dis	SyncOut Master Dis	LP ADC Mode Regular ADC ~
ClkOut Slave Ena	SyncOut Slave Ena	
INTLO Master Ena	OSCCIkOut Master Dis	Set
DC Config		
Bits	16 ~	Radar Miscellaneous Control
Full Scale		
Reduction Factor	•	Per Chirp Phase Shifter En 5 RF Init Done
Format	Complex2x ~	
		Set

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Capturing the radar data (4.5)

- 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.

Data Path LVDS Virtual Channel No CQ Cfg: 16 Bit + Packet 0 ADC_ONLY + 0 CQOTransSize (16bit) 132 + 0 CQTransSize (16bit) 132 + Clock Configuration Lane Clock Data Rate 600 Mbps + 2 LVDS Lane Configuration Lane Format Lane1 Lane2 Lane3 Lane4 MSB First CRC Packet End Pulse Clock Position Lane0 Polarity Lane1 Position Lane1 Polarity Lane2 Polarity Lane3 Polarity Lane3		uration				Francisco	
Packet 0 ADC_ONLY Packet 1 Suppress Pack COUTransSize (16bit) 132 COUTRANS C	Data Path	LVDS -	Virtual Channel No	CQ Cfg		16 Bit	*
Packet 1 Suppress Pack CQ1TransSize (16bit) 132 Set 1 CQ2TransSize (16bit) 72 Clock Configuration Lane Clock DDR Clock Data Rate 600 Mbps Set 2 LVDS Lane Configuration Lane Format Format CSI2 Lane Configuration Lane Config Lane 3 Lane4 M MSB First CRC Packet End Pulse CSI2 Clock Position Clock Polarity Set +/- Pin Order Clock Polarity Set +/- Pin Order +/- Pin Order Clock Position Clock Polarity Set +/- Pin Order +/- Pin Order +/- Pin Order Clock Position Clock Polarity Set +/- Pin Order +/- Pin Order Clock Polarity Set +/- Pin Order Clock Polarity Set +/- Pin Order +/- Pin Order Clock Polarity Set +/- Pin Order +/- Pin Order Clock Polarity Set	Packet 0	ADC_ONLY -	0	CQ0TransSize	(16bit)	132	A. V
Set 1 CO2TransSize (16bit) 72 Clock Configuration Lane Clock DDR Clock Data Rate 600 Mbps 600 Mbps Set 2 LVDS Lane Configuration Lane Format Format 0 Lane1 I Lane2 Lane3 Lane4 Lane4 +/- Pin Order MSB First CRC CRC Cock Position Packet End Pulse Clock Position	Packet 1	Suppress Pack 👻	0	CQ1TransSize	(16bit)	132	
Clock Configuration Lane Clock DDR Clock Data Rate 600 Mbps Set 2 LVDS Lane Configuration Lane Format Format I I I Lane2 Lane Config Lane3 Lane4 MSB First RCRC Packet End Pulse Clock Position Clock Polarity Lane1 Polarity Lane2 Polarity Lane3 Polarity Plane4 Pulse Plane4 P			Set	CQ2TransSize	(16bit)	72	
Lane Format Format 0 Lane Format Format 0 Lane Format Image: Construction in the second s	Lane Clock D	DDR Clock					
Lane Config Lane 2 Lane 2 MSB First CRC Packet End Pulse Clock Position Clock Polarity 3 +/- Pin Order 2 +/- Pin Order +/- Pin Order 5 +/- Pin Order	LVDS Lane Config	guration	- CSI2 Lane Configu	iration			
Lane3 Lane4 MSB First CRC Packet End Pulse Clock Position Clock Position Clock Polarity Lane3 +/- Pin Order State +/- Pin Order	LVDS Lane Config Lane Format Fo	guration	- CSI2 Lane Configu Lane0 Position	uration Lane0 Polarity	Lane1 F	osition	Lane1 Polarity
MSB First CRC Packet End Pulse Clock Position Clock Position Clock Polarity 3 +/- Pin Order	LVDS Lane Config Lane Format	guration ormat 0 🔹 Lane1 💟 Lane2	CSI2 Lane Configu Lane0 Position	iration Lane0 Polarity] +/- Pin Order	Lane1 F	Position	Lane1 Polarity
Packet End Pulse Clock Position Clock Polarity 3 +/- Pin Order	LVDS Lane Config Lane Format F Lane Config	guration format 0 Lane1 Lane2 Lane3 Lane4	CSI2 Lane Configu Lane0 Position	Lane0 Polarity +/- Pin Order Lane2 Polarity +/- Pin Order	Lane1 F 2 Lane3 P	osition	Lane 1 Polarity +/- Pin Order Lane 3 Polarity +/- Pin Order
3 👘 +/- Pin Order	LVDS Lane Config Lane Format F Lane Config MSB First	ormat 0 Lane1 Lane2 Lane3 Lane4 CRC	CSI2 Lane Configu Lane0 Position 1 * [Lane2 Position 4 * [uration Lane0 Polarity +/- Pin Order Lane2 Polarity +/- Pin Order	Lane1 F 2 Lane3 P 5	Position	Lane 1 Polarity +/- Pin Order Lane 3 Polarity +/- Pin Order
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4 Capturing the radar data

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Capturing the radar data (4.6)

- 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 path name.

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

Profile Id	0	-	HPF1 Corner Freq	17	'5K	~	fum DETX	Hamp Diart	Stert ADIC 8	ADC Sampling Time	Samp 6	had
Start Freq (GHz)	60.250000	\$	HPF2 Corner Freq	35	юк	~	4	ADCAME	Church		EndADC Sampling	1
Frequency Slope (MHz/µ	s) 29.982	\$	O/p Pwr Backoff TX0 (dB) 0		÷	Idle Tim			Freq Si	lope V	١.
Idle Time (µs)	100.00	\$	O/p Pwr Backoff TX1 (dB) 0		\$	1h-	I O		Ramp End Time	1	V
TX Start Time (µs)	0.00	-	O/p Pwr Backoff TX2 (dB) 0		*	Freg Start	X Start Time		Transmitter is ON		
ADC Start Time (µs)	6.00	-	Phase Shifter TX0 (de	g) 0.0	000	-	BLUE :	Not a register. S	Shown for	information only		
ADC Samples	256	-	Phase Shifter TX1 (de	g) 0.0	000	-	ORANE	DE - Configurabl	e per chirp	to one of 4 values, one per Ch	np Profile	
Comple Date (kene)	10000		Phase Shifter TX2 (de	a) 0 (00		Capture	and Post I	Proces	sing		
Sample Rate (Rsps)	10000		A Production of the product of the second of the second second	- V.S	100		1 0.000 07 000 000	2022/02/02/01		12 (CAR) - 12 (CAR)		
Ramp End Time (µs)	60.00	\$	Bandwidth(MH	Iz)	1798	.92	DCA1	000 M		Trigger Frame	PostProc	
Ramp End Time (µs) RX Gain (dB)	60.00 30	÷	Bandwidth(MH	Iz) Mar	1798. 1age Pr	.92 ofile	DCA1 AR	000 M		Trigger Frame	PostProc	
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Capturing the radar data (4.7)



- Select 'DCA1000' and click on 'SetUp DCA1000'
- 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 in case the connection fails make sure the static IP is set correctly, Ethernet cable is plugged in correctly, WIFI is disabled and the ports 4096 and 4098 are accessible in the PC used, i.e. there is no firewall blocking the ports.

		-				Job come		in the second	ing risinpri	
aveConfig	Sensor Confiduration	i				-Turn Off TX	Rang Start 51	Chirp Cycle Time	Re	are, tre
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	Data Capture Mode	Ethernet Stream 🛛 🗸			5					
	Packet Seq Enable				Frame					
	Packet Delay (µs)	25			Start C	hirp TX	0	No of Chirp Loops	128	÷
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			_		No of F	rames	8	Trigger Delay (µs)	0.00	1





Capturing the radar data (4.8)

- 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.
- Bellow are some of the Post Proc plots available:
- Range-Angle plot
- Time domain plot
- 2D FFT amplitude profile
- 1D FFT amplitude profile
- Phase stability across Chirps
- Amplitude stability across Chirps
- Noise Cloud plots









Data file format (1)

- Configuration:
 - n LVDS Lanes, complex data, n channels, chirping/continuous streaming mode
- Notation:
 - RxkIn: The nth in-phase sample corresponding to kth RX channel.
 - RxkQn: The nth quadrature-phase sample corresponding to kth 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 file format (2)

Sample binary file produced by mmWave

	95ff	80ff	e3ff	e0ff	7bff	60ff	f1ff	f4ff
2	75ff	79ff	e2ff	fdff	72ff	6eff	1b00	3d00
	48ff	19ff	3d00	4300	e2fe	cafe	0900	f9ff
	b1fe	90fe	d7ff	a8ff	9ffe	bcfe	77ff	4bff
	b7fe	d2fe	38ff	1fff	e3fe	11ff	1eff	2cff
	47ff	34ff	41ff	5cff	4cff	54ff	7cff	6aff
	44ff	2fff	6bff	5cff	Øcff	29ff	20ff	20ff
	2aff	3aff	fdfe	effe	68ff	74ff	11ff	26ff
	87ff	73ff	45ff	35ff	6fff	78ff	3aff	4fff
10	4bff	47ff	29ff	3dff	64ff	5eff	45ff	48ff
11	4aff	4cff	4dff	3aff	4dff	47ff	37ff	37ff
12	38ff	47ff	28ff	38ff	58ff	8cff	2eff	43ff
13	acff	97ff	80ff	9bff	8cff	88ff	9aff	b9ff
14	78ff	5eff	b0ff	99ff	52ff	40ff	98ff	8dff
15	30ff	23ff	85ff	64ff	33ff	40ff	3eff	32ff
16	5cff	77ff	5cff	74ff	57ff	64ff	78ff	89ff
17	62ff	6aff	8fff	83ff	50ff	6aff	68ff	62ff
18	76ff	66ff	75ff	8dff	77ff	52ff	99ff	8eff
19	55ff	43ff	7bff	6cff	37ff	5bff	3fff	3cff
20	7fff	adff	48ff	71ff	cdff	d2ff	9bff	c3ff

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 Additional information

6843 non-interleaved format- complex 4 channel

Chirp 1	Rx010	Rx0I1	Rx0Q0	Rx0Q1	Rx012	Rx013	Rx0Q2	Rx0Q3
	Rx0I4	Rx015	Rx0Q4	Rx0Q5	Rx016	Rx017	Rx0Q6	Rx0Q7
							(
	Rx3IN-4	Rx3IN-3	Rx3QN-4	Rx3QN-3	Rx3IN-2	Rx3IN-1	Rx3QN-2	Rx3QN-1
Chirp 2	Rx010	Rx0I1	Rx0Q0	Rx0Q1	Rx012	Rx 0 I3	Rx0Q1	Rx0Q3
	Rx0I4	Rx 0 15	Rx0Q4	Rx 0 Q5	Rx016	Rx 0 I7	Rx0Q6	Rx0Q7
					•••			
	Rx3IN-4	Rx3IN-3	Rx3QN-4	Rx3QN-3	Rx3IN-2	Rx3IN-1	Rx3QN-2	Rx3QN-1

- 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 <u>Mmwave Radar Device ADC Raw Data Capture</u> app note.



Useful links

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Online support https://e2e.ti.com/support/sensor/mmwave sensors mmWave Studio http://www.ti.com/tool/MMWAVE-STUDIO ICBOOSTER users guide https://www.ti.com/lit/ug/swru546c/swru546c.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_file s/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 https://e2e.ti.com/support/sensors/f/1023/t/872161 DCA1000 Debug handbook



5 Additional information