

mmWave Studio GUI User Guide

This document outlines the mmWaveStudio Graphical User Interface details and instructions for software start up. Operating procedures for Radar API and Post-Processing utility is also explained briefly in this user's guide.

Table of Contents

List of Figures	2
1 Introduction.....	4
2 mmWaveStudio Installation and Startup	4
2.1 Installation.....	4
2.2 Startup	5
2.3 USB Interface and Drivers	6
3 Using the DCA1000 EVM	9
3.1 Using DCA1000 CLI utility	9
3.2 Updating the DCA1000 FPGA Binary	9
3.3 Raw ADC data capture	9
4 mmWaveStudio User Interface	10
4.1 Menu Bar	11
4.1.1 File Menu	11
4.1.2 View Menu	11
4.1.3 Tools Menu	11
4.1.4 ToolBars Menu.....	12
4.1.5 Window Menu	13
4.1.6 Help Menu.....	13
4.2 Radar API Window.....	13
4.2.1 Connection.....	14
4.2.2 Device Control & DeviceControl 1	15
4.2.3 Sensor Config & Sensor Config 1	15
4.2.4 Monitor Config.....	16
4.2.5 RFEval	17
4.2.6 JSON Import Export.....	18
4.2.7 Misc.....	18
4.3 Output Window	18
4.4 LUA Shell	19
5 Automation/Scripting	20
6 Radar API Tab Operations	20
6.1 Connection Tab.....	20
6.1.1 Board Control Operations	22
6.1.2 RS232 Operations	23

6.1.3	Firmware Download	24
6.1.4	SPI Connection & FEC Power Up	25
6.2	Device Control Tab	26
6.3	Sensor Config Tab	27
6.4	Monitor Config Tab	28
6.5	RFEval	28
6.6	JSON Import Export	29
6.7	Misc	29
7	APIs Programming sequence	30
8	Radar post processing	30
8.1	List of plots	31
8.1.1	Basic plots	31
8.1.2	CQ plots (chirp quality metrics)	34
8.1.3	Characterization plots	34
8.2	Channel select	36
8.3	Frame /Profile /Chirp sliders	36
8.4	Information sidebar	36
8.4.1	Programmed parameters	37
8.4.2	Calculated parameters	37
8.4.3	Detection results	38
8.5	Play	38
8.6	Miscellaneous options	38
8.6.1	Detection	38
8.6.2	FFT processing settings	39
8.6.3	Miscellaneous	40
8.6.4	Time domain options	40
8.6.5	More miscellaneous options	40
8.7	Notes on Setting up PostProc for Characterization	41
8.8	Standalone processing (post processing done in a different session from configuration and capture)	41
9	Controlling mmWaveStudio from Matlab	43
10	Automation using LUA	45
10.1	Sample Lua script for automation	45

List of Figures

Figure 2.1.	mmWaveStudio startup error message	6
Figure 2.2.	Device Manager (Other Devices)	7
Figure 2.3	FTDI driver update	7
Figure 2.4.	Device Manager (USB Serial Port)	8
Figure 2.5.	DCA1000 COM Ports	8
Figure 2.6.	xWRLx432 EVM USB Enumeration	9
Figure 4.1.	mmWaveStudio Main Window	11
Figure 4.2.	Config ToolBar	12
Figure 4.3.	Edit Button	12
Figure 4.4.	Button Config	13
Figure 4.5.	Edit User Defined Script	13
Figure 4.6.	Radar API Window	14

Figure 4.7. Output Window Docking	18
Figure 4.8. Output Window Log	19
Figure 4.9. LUA Shell window.....	19
Figure 5.1. Command creation	20
Figure 5.2. LUA Script execution	20
Figure 6.1. Connect Tab	21
Figure 6.2. SOP Control.....	23
Figure 6.3. Serial Port Control and selecting the COM port for RS232 operations	23
Figure 6.4. Firmware Download.....	24
Figure 6.5. Firmware Download Progress	25
Figure 8.1. PostProc Basic	30
Figure 8.2. 2D FFT Profile.....	32
Figure 8.3. Range Angle plot	32
Figure 8.4. Detection and Angle Estimation results	33
Figure 8.5. Chirp Config Picture.....	33
Figure 8.6. 1D FFT Profile.....	34
Figure 8.7. Time domain plot	34
Figure 8.8. Phase Stability	35
Figure 8.9. Amplitude stability.....	35
Figure 8.10. Zero-velocity bin vs High velocity bin.	36
Figure 8.11. Channel select	36
Figure 8.12. Sliders	36
Figure 8.13. Information sidebar	37
Figure 8.14. Play	38
Figure 8.15. Miscellaneous options	38

1 Introduction

The mmWaveStudio GUI is designed to characterize and evaluate the TI Radar devices. The mmWave device is configured and controlled from the mmWaveStudio by sending mmWave DFP API commands to the device over SPI. ADC data is captured using DCA1000 EVM board and the data is processed in Matlab and the results are displayed in the GUI.

mmWaveStudio GUI utilizes C DLL and a set of API's to communicate from the GUI to the device through FTDI FT4232H device. The FT4232H is a USB 2.0 Hi-Speed (480 Mb/s) to UART IC. It has the capability of being configured in a variety of industry standard serial or parallel interfaces. The FT4232H features 4 UARTs. Two of these have an option to independently configure an MPSSE engine; this allows the FT4232H to operate as two UART/bit-bang ports plus two MPSSE engines used to emulate JTAG, SPI, I2C, bit-bang or other synchronous serial modes.

This mmWave Studio is designed to support TI third generation low power and low cost radar devices like xWRL6432 and xWRL1432. The mmWave DFP APIs for these devices are brand new and this version of Studio supports only these 3rd generation device APIs.

Key features of the mmWaveStudio GUI are

- Board Control (SOP Change, Reset Control)
- RS232 connection to device
- Firmware download over the RS232 interface in Development mode
- Configuring the TI Radar device using the Radar API commands
- Interaction with DCA1000 EVM for raw ADC data capture
- Post-Processing of ADC data and visualization of the processed data

Refer to DCA1000 EVM Capture Card User's Guide ([SPRUJ4](#)) for more information regarding the usage aspect of DCA1000 EVM.

2 mmWaveStudio Installation and Startup

2.1 Installation

The following software should be installed before starting the mmWaveStudio

1. Install mmWaveStudio from the installer package
2. Install 32-bit Matlab Runtime Engine (Version 8.5.1): It is used to run the Post-Processing utility within mmWaveStudio.
https://in.mathworks.com/supportfiles/downloads/R2015a/deployment_files/R2015aSP1/installers/win32/MCR_R2015aSP1_win32_installer.exe

NOTE: Please make sure the Matlab Runtime Engine installed is exactly same as 32-bit Version 8.5.1

3. If required (read below note), install FTDI Drivers: FTDI USB Driver ([mmwave_studio_<ver>\mmWaveStudio\ftdi](#)) necessary to work with Radar device is installed. See section 2.3 for FTDI driver installation.

NOTE: FTDI drivers will be installed automatically at the end of mmwavestudio installation. The step 3 is only required if the automatic FTDI installation fails.

4. Install Microsoft Visual C++ 2013 Redistributable package if using a Windows 10 machine from the link <https://support.microsoft.com/en-us/help/3179560>

2.2 Startup

1. After the installation is complete, the GUI executable and associated files will reside in the following directory: C:\ti\mmwave_studio_<ver>\mmWaveStudio
2. Power up the DCA1000 EVM and the xWRLx432 BOOST-EVM.

NOTE: Make sure the above combination of DCA1000 and AWR BOOST-EVM are connected to the PC while opening mmWaveStudio for the first time.

3. To start the GUI, click on the file called "mmWaveStudio.exe", located under C:\ti\mmwave_studio_<ver>\mmWaveStudio\RunTime folder.

NOTE: mmWave Studio should to be started in Administrator Mode

NOTE: If mmWave Studio shortcut has been created already, update the shortcut to the new installation path.

NOTE: If you see the error message as shown in [FIGURE 1](#) during opening mmWaveStudio in its output window, follow the steps mentioned below to solve this

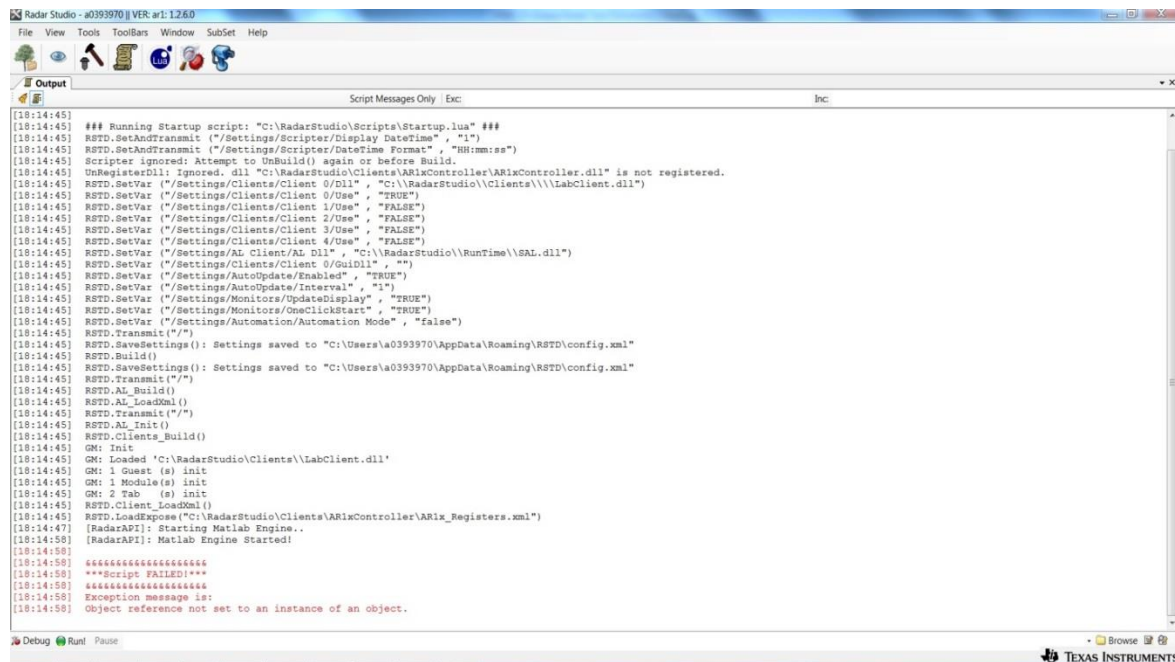


Figure 2.1. mmWaveStudio startup error message

- Install the FTDI drivers again while DCA1000 board is connected through USB
- Re-launch the mmWaveStudio GUI

2.3 USB Interface and Drivers

Once the USB is connected to the xWRLx432 DCA1000 EVM, ensure to install the FTDI USB Drivers ([mmwave_studio_<ver>ftdi](#)). After completion of the driver installation, COM ports will be available in Windows Device Manager as shown in [FIGURE 2.6](#).

In case ftdi device is not coming under COM Ports in device manager follow the steps below :

- If the ftdi devices are coming under USB Devices:
 - Right click on the device and do Uninstall device, then check the delete associated driver option and proceed. this should delete any ftdi related drivers (need to do this for each ports A,B,C,D)
 - Now go to Studio/ftdi/ and launch dpinst64.exe to install the ftdi drivers.
 - Disconnect and connect the device again, the ftdi ports should appear under COM Ports in device manager
- If ftdi devices are coming under other devices it means there is no ftdi driver installed:
 - Go to Studio/ftdi/ and launch dpinst64.exe to install the ftdi drivers.
 - Disconnect and connect the device again, the ftdi ports should appear under COM Ports in device manager

Once xWRLx432 EVM is connected to the DCA1000 EVM, connect DCA1000 to PC using the USB cable provided and connect the power cable. Once done, there should be 4 additional COM Ports as shown in Figure 2.5

When the DCA1000 EVM is connected for the first time to the PC, Windows maybe not be able to recognize the device and would come up as 'Other devices' in device manager as shown in Figure 2.2

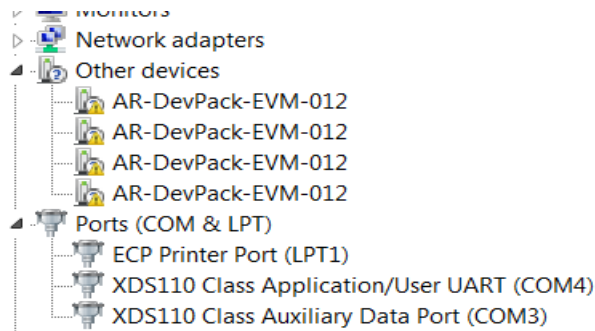


Figure 2.2. Device Manager (Other Devices)

In Windows device manager, right-click on these devices and update the drivers by pointing to the location of the FTDI driver as show in Figure 2.3

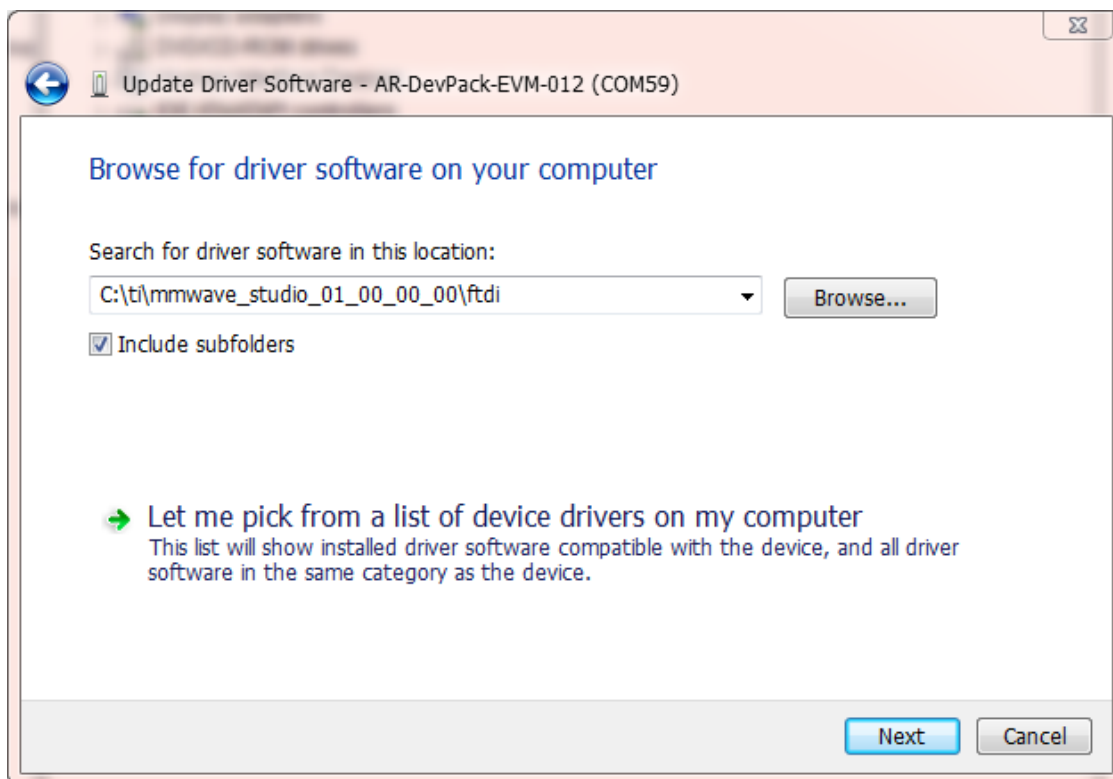


Figure 2.3 FTDI driver update

This must be done for all four COM ports. If after updating the FTDI driver, device manager still doesn't show 4 new COM Ports, as shown in Figure 2.4, you would need to update the FTDI driver once again.

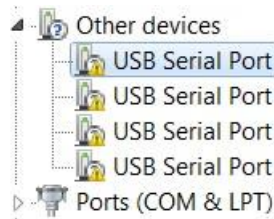


Figure 2.4. Device Manager (USB Serial Port)

When all four COM ports are installed, the device manager recognizes these devices and indicates the COM port numbers, as shown in Figure 2.5

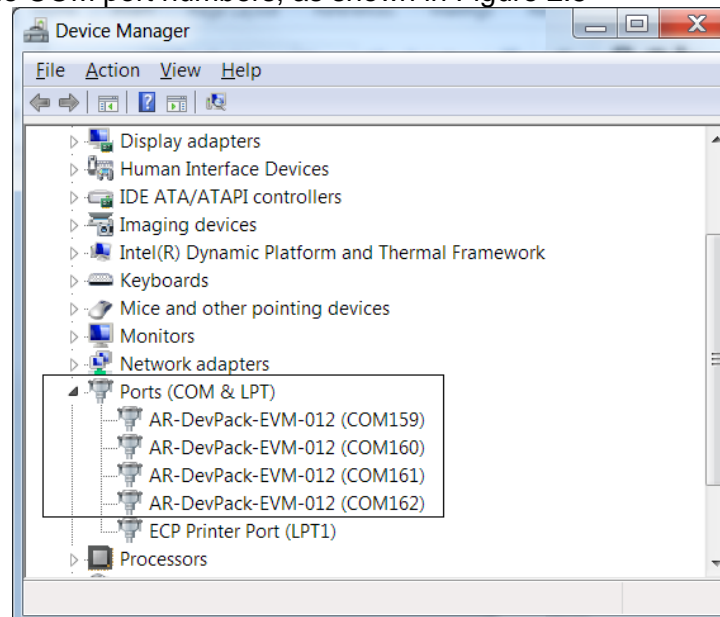


Figure 2.5. DCA1000 COM Ports

Next connect the USB cable from the xWRLx432 EVM to the PC. 2 COM ports will be enumerated with name XDS110. The mmWaveStudio should be connected to COM port numbered alongside the name XDS110 Class Application/User UART. In the following example, it is COM11. For more details, please refer to xWRLx432 EVM User Guide.

NOTE: To update XDS110 USB driver, download and install XDS emulator software from this link [http://processors.wiki.ti.com/index.php/XDS_Emulation_Software_Package]

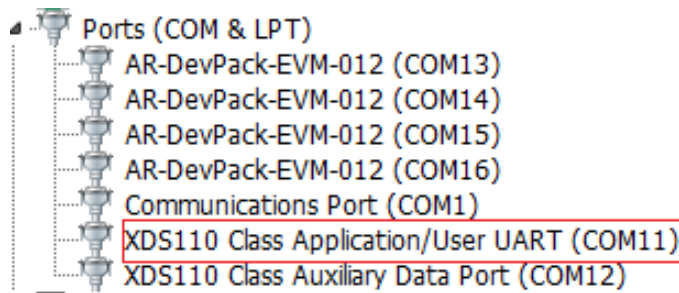


Figure 2.6. xWRLx432 EVM USB Enumeration

3 Using the DCA1000 EVM

The DCA1000 EVM receives the LVDS data from xWRLx432 device and transfers the raw ADC data to the target PC via the Ethernet interface. The default destination Ethernet port address configured in the DCA1000 EVM is 192.168.33.30 and socket number is 4098. User has to ensure that target PC is set with this IP address to receive the raw ADC data from the DCA1000 EVM.

NOTE: System Firewall on Host machine can sometime prevent the Ethernet connection to DCA1000 board. Ensure that the firewall allows the Ethernet port access to mmWaveStudio.

3.1 Using DCA1000 CLI utility

The latest version of Studio contains a DCA1000 CLI utility, which allows controlling the DCA1000EVM over command line (without using the mmWaveStudio GUI). Internally, mmWaveStudio GUI uses the same utility for all communication with DCA1000EVM.

For instructions on using the DCA1000 CLI, refer Section 3 of the user guide present at *“ReferenceCode\DCA1000\Docs\TI_DCA1000EVM_CLI_Software_UserGuide.pdf”*

3.2 Updating the DCA1000 FPGA Binary

The latest version of Studio contains a FPGA binary (version 2.9) present at *“PlatformBinaries\DCA1000FPGA”* folder.

Instructions on flashing the FPGA binary onto the DCA1000 can be found at (Section 9 from the document <https://www.ti.com/lit/ug/spruij4a/spruij4a.pdf>)

3.3 Raw ADC data capture

The LVDS data captured by the DCA1000 EVM is packetized and transferred over the Ethernet interface as UDP datagrams. These UDP datagrams are received by the target PC and it is written into file on the target PC. These UDP data grams contains meta data like packet sequence number, number of data bytes received until now which helps in

determining if there were any packets which were not received in order or if there were any packets which were dropped.

The file name to store the raw ADC data is given by the user in the SensorConfig Tab. The DCA1000 EVM appends “Raw_n” to the file name given by the user. After 1 GB of capture, the DCA1000 EVM will start capturing the data into another file. Each subsequent file will have the test “Raw_n” appended to the user given filename where n is a number starting from 0. For example, if the user given filename is adc_data.bin, after the capture, user will see adc_data_Raw_0.bin, adc_data_Raw_1.bin etc. files in the mmWaveStudio\PostProc (default location of the raw ADC data files) folder.

NOTE: In the previous versions of mmWaveStudio, it was necessary to run Packet Reorder utility once the raw data is captured from DCA1000 before post processing of the data using Matlab. In this version and in subsequent versions of mmWaveStudio, it is not necessary to run the Packet Reorder utility as the data obtained from the DCA1000 is already ordered and can directly be used for post processing.

The change is in the .dll file. No FPGA update is needed. Both adc_data_Raw_0.bin and adc_data.bin are reordered already and ready for post processing.

4 mmWaveStudio User Interface

Invoke mmWaveStudio.exe from C:\ti\mmwave_studio_<ver>\mmWaveStudio\RunTime\mmWaveStudio.exe. When the mmWaveStudio GUI software is started, the initial setup screen appears and the main window appears as shown in

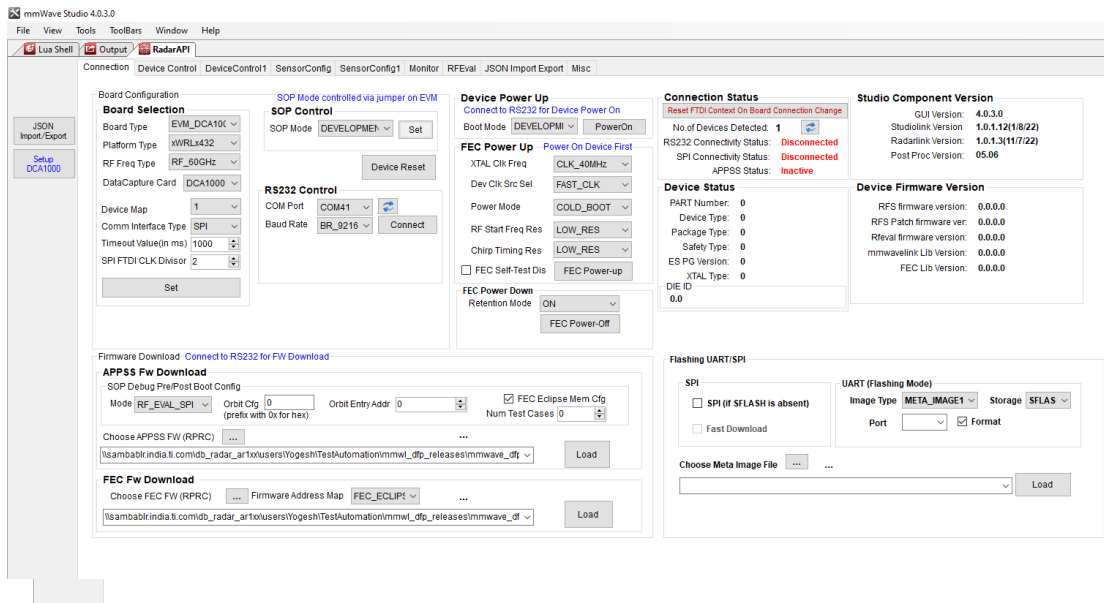


FIGURE 4.1. The GUI version is reported in the upper left corner of the GUI.

NOTE: If Matlab RunTime 8.5.1 is not installed prior to mmWave Studio invocation, error will be displayed saying Matlab Runtime engine is not installed

The mmWave Studio Main window has the following sections:

- Radar API Window
- Output Window and Lua Shell

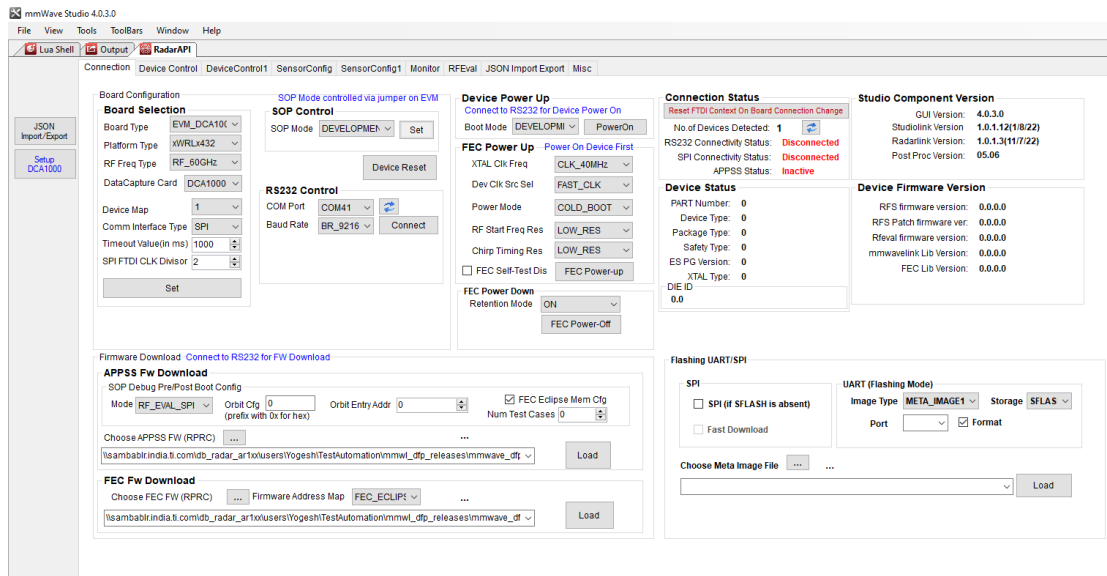


Figure 4.1. mmWaveStudio Main Window

Each of the above sections is described in detail in the forthcoming sections.

4.1 Menu Bar

The mmWaveStudio Main window has the following options in the Menu bar

4.1.1 File Menu

Exit: Exits the application and saves the setup (all current API configurations are stored locally in the PC which can be loaded back again).

Exit without saving layout: Exits without saving the current application setup.

4.1.2 View Menu

- The View menu opens the output window and LUA Shell window
- It also shows and hides toolbars and the status bar.

4.1.3 Tools Menu

Lock layout: Locks and unlocks the current layout. Once the layout is locked, the windows cannot be moved around.

Register DLLs to LUA: Using this option, any module developed in either C/LUA/C# can be loaded as a DLL. The APIs available (exposed) in the module can be called through LUA Shell. Refer to MSDN and LUA Help for creating libraries to be callable by LUA.

4.1.4 ToolBars Menu

Using this option, user can create shortcut buttons to associate frequent used actions in the form of LUA scripts. The below procedure details creating user defined button using the ToolBars menu.

1. Click **New**. The following dialog appears as shown in

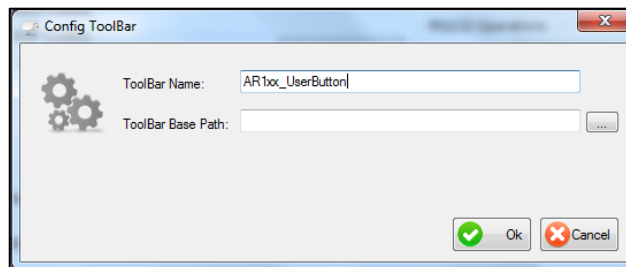


Figure 4.2. Config ToolBar

ToolBar Name – Sets the name for the ToolBar.

ToolBar Base Path – (optional) Defines a base path to search for the scripts which will be called via the toolbar's buttons.

NOTE: Each Toolbar's configuration is saved in an XML file under %AppData%\RSTD\ToolBars folder

2. Set the ToolBar Name and click the OK button.
3. Click on the <new> button in the newly created toolbar.

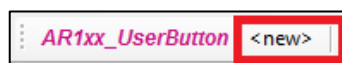


Figure 4.3. Edit Button

4. This opens the User Button Configuration window

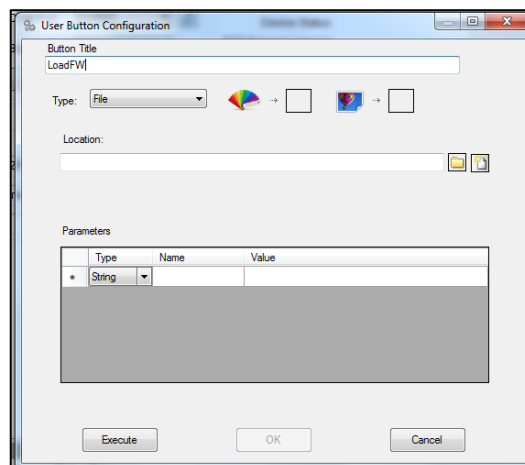


Figure 4.4. Button Config

5. Fill in the **Button Title** with a name for the button, and **Location** with the full path of the script you wish to run and click the **OK** button.
6. Clicking on the newly created button will execute the script it references.
7. Right-clicking on it will open a menu dialog with several options.

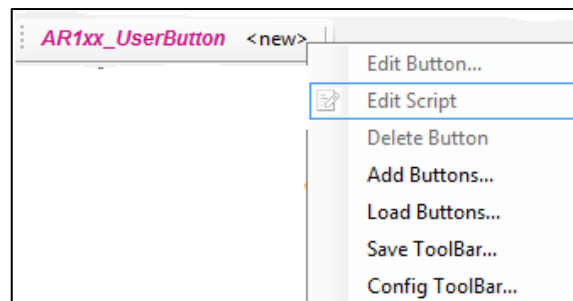


Figure 4.5. Edit User Defined Script

- **Edit Button** - Change the button's settings.
- **Edit Script** – Open the referenced script in your default text editor.
- **Debug Script** – Open the referenced script in the text editor.
- **Delete button** – Delete the user button.
- **Add Buttons** – Add buttons from another toolbar configuration file.
- **Load Buttons** – Load buttons from another toolbar configuration (clears existing buttons)
- **Save Toolbar** – Save the toolbar configuration to selected location (in xml format).
- **Config Toolbar** – Change the toolbar settings.

4.1.5 Window Menu

The Window menu shows open windows in the application.

4.1.6 Help Menu

The Help menu shows information about the current version of the application.

4.2 Radar API Window

As soon as the mmWaveStudio GUI is opened, the Radar API window appears as shown in [FIGURE 4.6](#). Radar API Window is the primary tab through which the mmWave device's functionality can be verified. Also, the mmWave device is configured and controlled from the mmWaveStudio by sending commands to XWRLx432 device over SPI by interfacing through C DLL. Once the ADC data is captured using DCA1000

board, the post processing is done and plots are available in the GUI by interfacing with Matlab DLL.

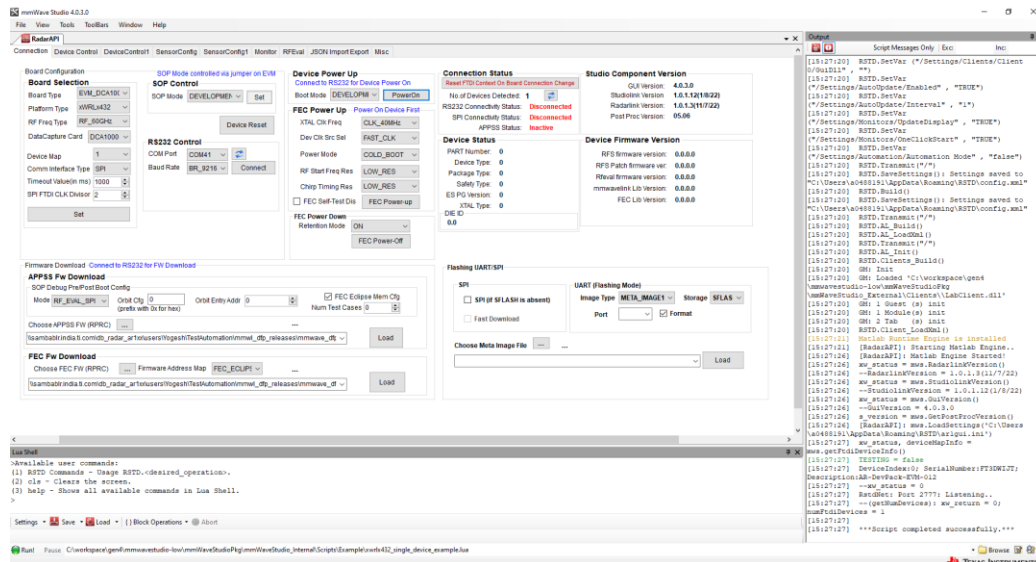


Figure 4.6. Radar API Window

In the Radar API window, the following tabs are available for communication with the Radar Device. For more information on these APIs, refer [mmwave_studio<version>\docs\mmwave_studio_lua_api_documentation.pdf](https://www.ti.com/lit/zip/mmwave_studio_docs/mmwave_studio_lua_api_documentation.pdf)

4.2.1 Connection

- mws.GuiVersion
- mws.StudiolinkVersion
- mws.RadarlinkVersion
- mws.selectBDType
- mws.selectComIfType
- mws.sopControl
- mws.nReset
- mws.GpioControl
- mws.rs232Config
- mws.sopDebugFwPreBootCfg
- mws.fwRprcDownload
- mws.sopDebugFwPostBootCfg
- mws.devicePowerup

- mws.fecDevicePowerOn
- mws.fecDevicePowerOff

4.2.2 Device Control & DeviceControl 1

- mws.fecDfpVerGet
- mws.fecRfPwrOnOff
- mws.fecGpadcMeasCfg
- mws.fecGpadcMeasTrig
- mws.fecDevClkctrl
- mws.fecRdifctrl
- mws.fecTempcMeasCfg
- mws.fecTempMeasTrig
- mws.fecRfsDbgCtrl
- mws.fecRfBootCal
- mws.fecRfRuntimeCal
- mws.fecRfCalDataGet
- mws.fecRfCalDataSet
- mws.fecRfClkBwCfg
- mws.fecDevStatusGet
- mws.fecRfStatusGet
- mws.fecRfFaultStatusGet
- mws.fecDieldGet
- mws.fecRxTxCalDataGet
- mws.fecRxTxCalDataSet

4.2.3 Sensor Config & Sensor Config 1

- mws.sensChirpPfComnCfg
- mws.sensChirpPfTimeCfg
- mws.sensFrameCfg
- mws.sensorStart
- mws.sensorStop
- mws.sensLoopBackCfg

- mws.sensLoopBackEna
- mws.monDbgPdMeas
- mws.monDbgTxPwrMeas
- mws.monLivSynthFreqCfg
- mws.monLivRxSatCfg
- mws.StartMatlabPostProc
- mws.sensChirpPfComnCfgGet
- mws.sensChirpPfTimeCfgGet
- mws.sensPerChirpLut
- mws.sensPerChirpCfg
- mws.sensPerChirpCfgGet
- mws.sensPerChirpCtrl
- mws.sensPerChirpCtrlGet
- mws.sensFrameCfgGet
- mws.sensorStsGet
- mws.sensDynPwrSaveDis
- mws.sensDynPwrSaveStsGet
- mws.captureCardEthernetCfg
- mws.captureCardModeCfg
- mws.getCaptureCardFPGAVersion
- mws.captureCardCfgResetFPGA
- mws.captureCardStartRecord
- mws.captureCardStopRecord
- mws.captureCardDisconnect

4.2.4 Monitor Config

- mws.monEnableTrig
- mws.monDbgPdMeas
- mws.monDbgTxPwrMeas
- mws.monLivSynthFreqCfg
- mws.monLivRxSatCfg
- mws.monLivRxSatRspGet

- mws.monPllCtrlVltCfg
- mws.monTxNRxLbCfg
- mws.monTxNPwrCfg
- mws.monTxNBbCfg
- mws.monTxNDcSigCfg
- mws.monRxHpfDcSigCfg
- mws.monPmClkDcSigCfg
- mws.monLivSynthFreqRspGet
- mws.monPllCtrlVltRspGet
- mws.monTxNRxLbRspGet
- mws.monTxNPwrRspGet
- mws.monTxNBbRspGet
- mws.monTxNDcSigRspGet
- mws.monRxHpfDcSigRspGet
- mws.monPmClkDcSigRspGet

4.2.5 RFEval

- mws.rfEvalMemRead
- mws.rfEvalMemWrite
- mws.rfEvalRegRead
- mws.rfEvalRegWrite
- mws.rfEvalRfsCmd
- mws.rfEvalDevAppStsGet
- mws.rfEvalDevAppCfg
- mws.rfEvalAtelnit
- mws.readRegisterField
- mws.writeRegisterField
- mws.readRegisterByName
- mws.writeRegisterByName
- mws.readRegister
- mws.writeRegister
- mws.memBlockRead

- mws.memBlockWrite

4.2.6 JSON Import Export

4.2.7 Misc

- mws.sensConvFreqToCode
- mws.sensConvTimeToCode
- mws.sensConvSlopeToCode
- mws.sensConvFtPeriodToCode
- mws.DisableConseLog

4.3 Output Window

The mmWaveStudio GUI components are dockable. Click View from the Menu bar, select output option. The output window also appears along with the main window. Select the output tab and drag to the section where you wish to dock. The output window docking is shown in the [FIGURE 4.7](#).

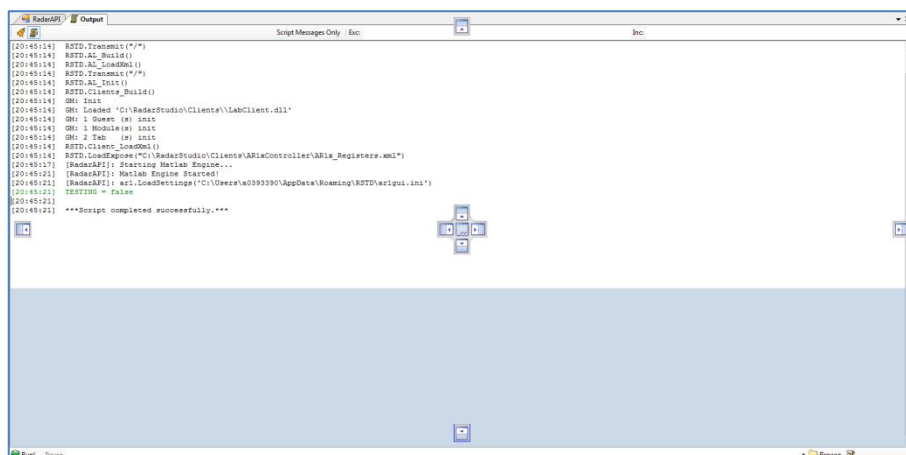


Figure 4.7. Output Window Docking

- The Output Window captures the user initiated actions along with timestamp.
- Both the logs and the script commands are available in the Output window.
- The script commands can be used to create custom LUA scripts and later run from the Run toolbar
- Also, upon an error or if the application is not responding, the error logs can be accessed by Right Clicking on the Output window.

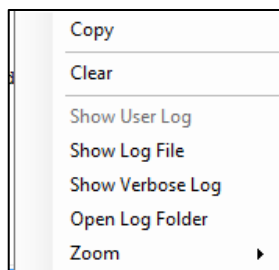


Figure 4.8. Output Window Log

4.4 LUA Shell

LUA Shell is used to execute LUA script commands, perform LUA operations. Click **View → LUA Shell** in the mmWaveStudio main window. The LUA Shell window appears as follows:

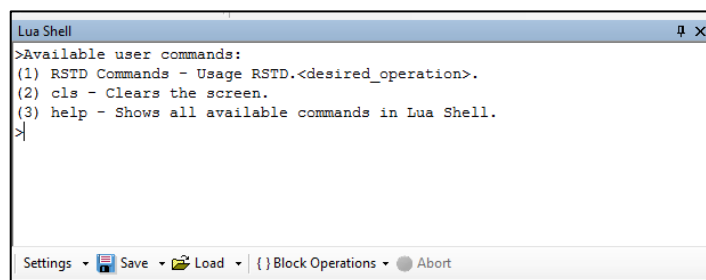


Figure 4.9. LUA Shell window

1. Running “help ar1” in the Lua Shell will list the functions contained under the ar1 module specific to Radar.
2. Running “help RSTD” in the Lua Shell will list the functions contained under the mmWaveStudio module.
3. Pressing Escape key - while the mouse cursor is on the last line deletes this line (last line only)
4. Running the ‘help’ command on each function name will display information on that function (e.g. “help ar1.Connect”)

NOTE: The LUA shell supports auto-completion with the tab key.

History command – Typing history command in the LUA Shell prompt shows all the commands being used by the user in current LUA Shell. By pressing Up-Arrow (↑) and Down-Arrow (↓), the recent commands can be accessed.

5 Automation/Scripting

The mmWave Studio exposes LUA API functions to interface with device, which can be used to test predefined sequences and automate functionality on the device. All these functions can be found under the mws module.

1. Whenever a command is issued in the GUI window, the equivalent script commands can be taken from the Output window and formed an automation script. For example, In the Static Config tab, when Channel and ADC Config command is sent, in the Output window, the script command is logged.



Figure 5.1. Command creation

2. The script commands start with 'mws'. The commands can be saved as a LUA file and used for automation.
3. To execute the LUA scripts, Browse and Select the script file and click Run

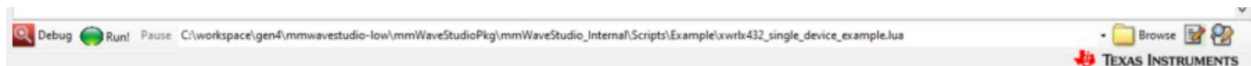


Figure 5.2. LUA Script execution

For more information on LUA Scripting language, please refer to:
<http://lua-users.org/wiki/> - The Lua wiki (See the Lua Directory inside for Lua tutorials)
<http://www.lua.org/manual/5.1/manual.html> - Lua official Reference Manual

6 Radar API Tab Operations

The following sections briefly describe the operations in each tab of RadarAPI window

6.1 Connection Tab

When the mmWaveStudio is invoked, the Connect Tab appears as shown in [FIGURE 6.1](#).

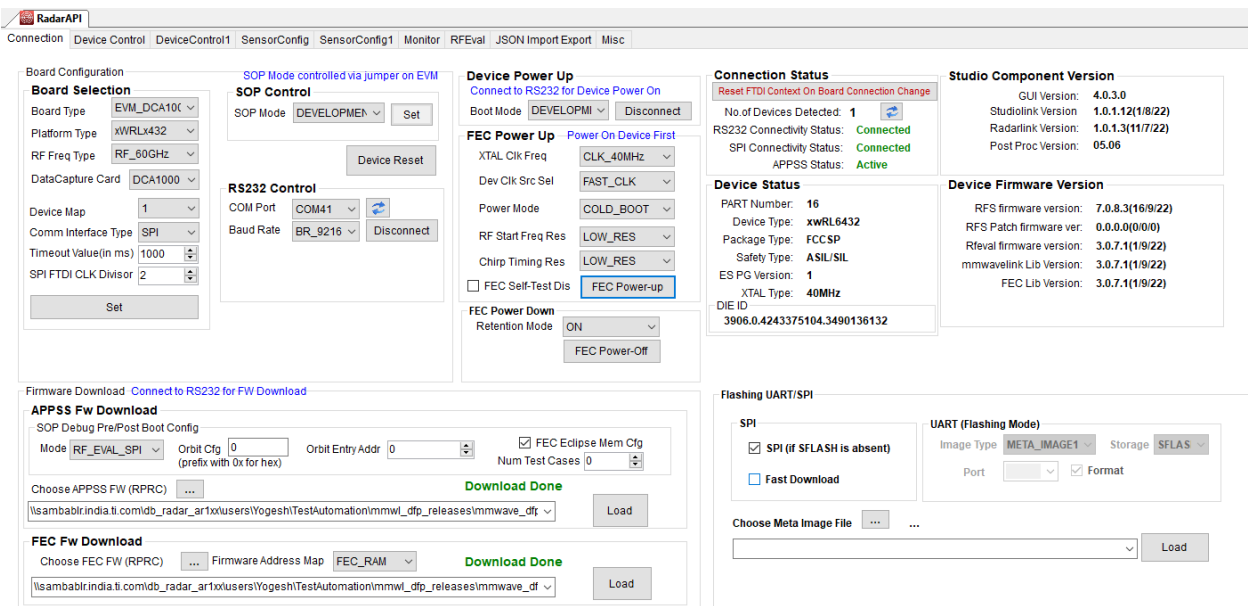



Figure 6.1. Connect Tab

Using this tab, user can perform

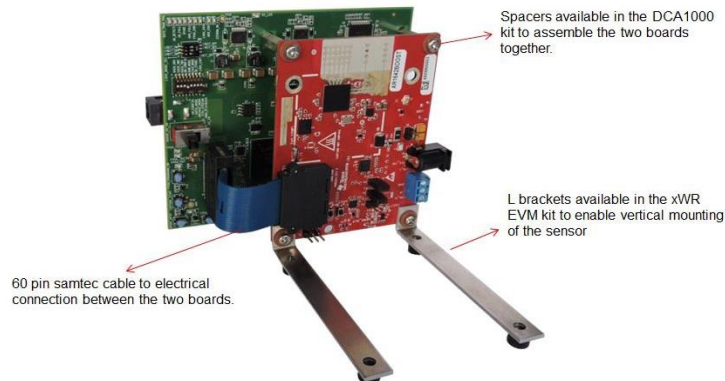
- Board control operations
- RS232 Operations
- Connectivity Status and content versions
- Firmware Download (RS232/SPI/UART)
- SPI Connection
- FEC Power On/Off

CAUTION:

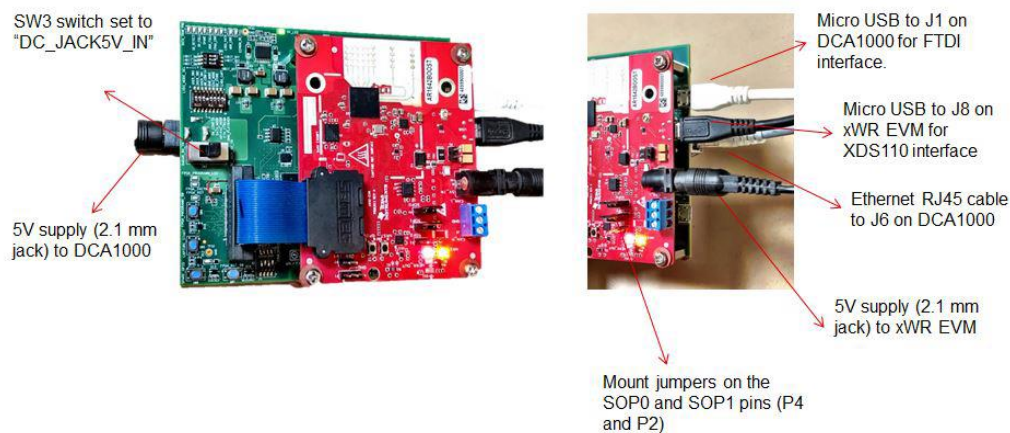
Before starting with any action on mmWaveStudio please make sure that GUI detects the device connected to PC. Value of 'No of devices detected' should not be 0 else click on  to refresh. In case number of devices detected is 0 go through [USB Interface and Drivers](#) section to make sure correct drivers are installed and FTDI ports are coming under COM Ports in device manager.

6.1.1 Board Control Operations

mmWaveStudio does board control operation of XWRLx432 device through FTDI ports on DCA100.



Hardware Connection: DCA1000 With xWR mmWave Sensor EVMs



Data and Supply Cable Connections

(Refer to [mmwave_studio<version>\docs\DCA1000_Quick_Start_Guide.pdf](#) for more detail)

Board Selection

Configure the Board and Communication interface.

Refer: mws.selectBDType, mws.selectComIfType

SOP Control

NOTE: When using a DCA1000 EVM, use the jumpers on the XWRLx432 BOOST to control the SOP settings.

The XWRLx432 device implements a sense-on-power (SOP) scheme to determine the device operation mode. The device can be configured to power up in one of the three following modes:

- SOP Development Mode. This mode should be used for RF evaluation.
 - Set SOP Development Mode. For characterization and evaluation of XWRLx432 devices, always use SOP Development mode
 - Connect over RS232
 - Perform APPSS & FEC Firmware Download
 - Perform SPI Connect
 - Issue API to the device

Once the USB connections to the board is intact, Select the SOP Mode(In case of evm use jumpers to set sop mode on board) and Click Set button. For SOP setting to be effective, reset the device.



Figure 6.2. SOP Control

6.1.2 RS232 Operations

The serial port mode provides a direct PC connection of the XWRLx432 device through the RS232 interface through the XDS110-USB interface. This mode allows firmware download and enables the device for characterization purposes. The serial port mode is also the default debug option on the Windows platform used to operate the device in TX and RX mode and using the read/write registers.

Once the SOP Mode is set, select the COM Port enumerated as 'XDS110 Class Application/User UART' for RS232 operations and click **Connect** button. The XDS110 port enumerates two ports as explained in USB interfaces and drivers section.

NOTE: Use the default Baud Rate of 921600 bps.

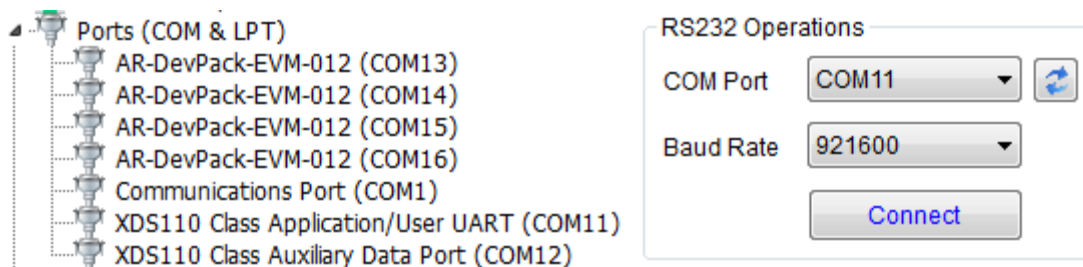


Figure 6.3. Serial Port Control and selecting the COM port for RS232 operations

Since the default baud rate configured in the device is 115200 bps, mmWaveStudio attempts to connect in 115200 baud rate, and then configures the RS232 module to re-establish connection in 921600 baud rate.

Device status is get updated on same tab upon successful RS232 connection.

6.1.3 Firmware Download

The XWRLx432 firmware images are downloaded by the mmWaveStudio to the XWRLx432 device in SOP Development mode. The development mode provides a debug connection to the device using the dedicated RS232 interface such as writing and reading registers.

Refer mmWave DFP package for latest FEC and APPSS rprc image files. DFP is part of mmWave SDK package.

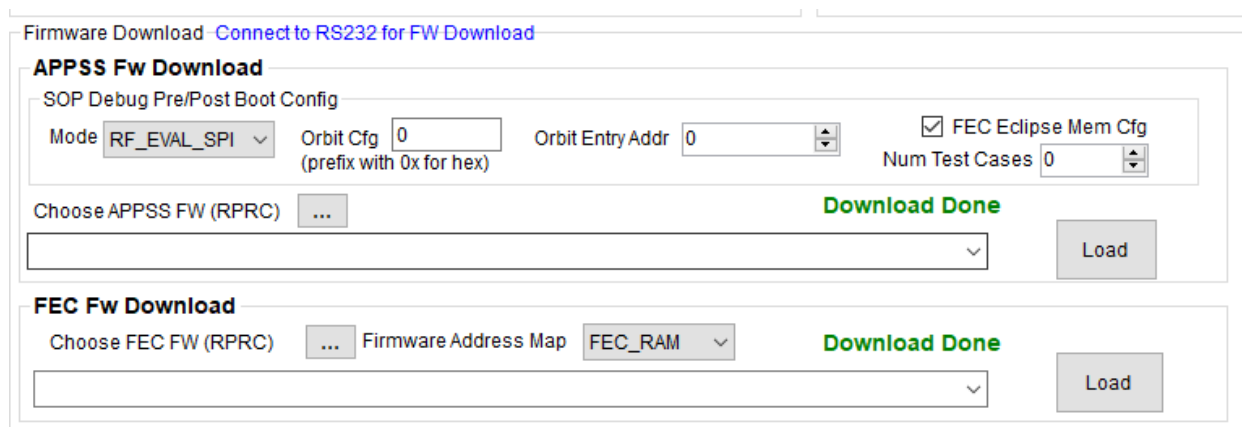



Figure 6.4. Firmware Download

The firmware download steps are as follows:

4. Select SOP Development Mode (SOP selection is not needed when using DCA1000 EVM. User has to set the jumpers on xWRLx432 BOOST to set the device in SOP mode.
5. Connect over RS232
6. Refer mws.sopDebugFwPreBootCfg and mws.sopDebugFwPostBootCfg for boot related configurations for SOP development mode
7. In the Firmware Download area of the Connect tab, set the FECSS and APPSS firmware. Click the  button and browse to the location of the file
8. Click Load next to the APPSS & FEC firmware. The mmWaveStudio application begins downloading the firmware files entered in the previous steps. Refer mws.fwRprcDownload for download options configuration.

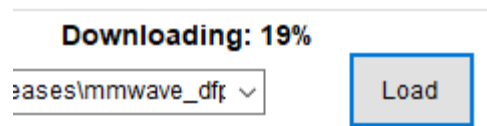


Figure 6.5. Firmware Download Progress

9. Once the FEC firmware download is complete, click Load next to the APPSS firmware update.

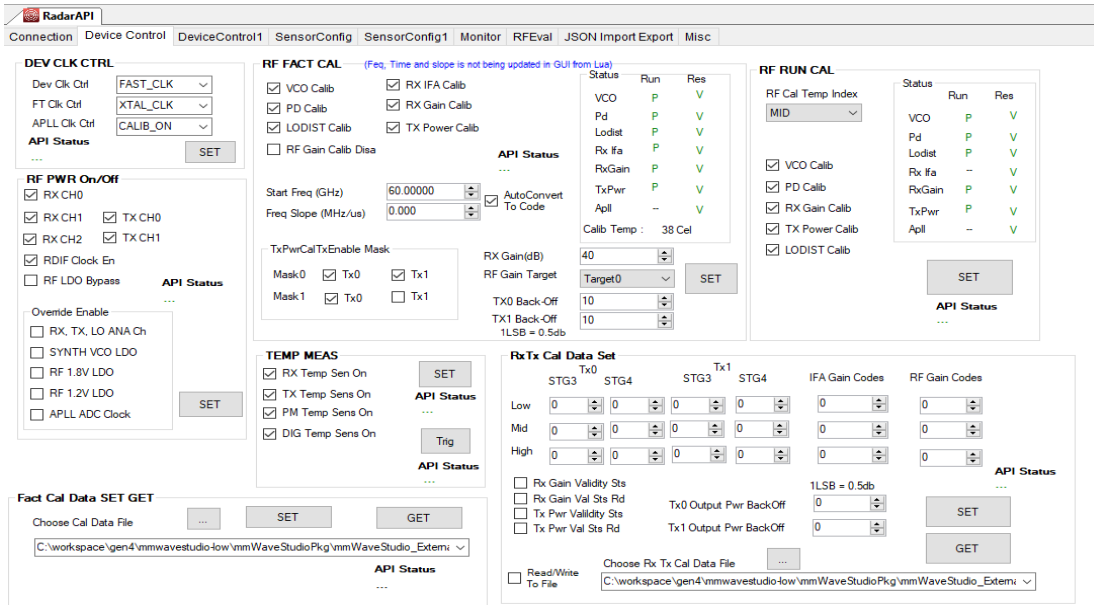
6.1.4 SPI Connection & FEC Power Up

The mmWave radar device communicates with the external host processor using the SPI interface. The mmWave device is configured and controlled from the external host processor by sending commands to mmWave device over SPI.

1. Once the APPSS firmware download is complete, Device Power On for SPI Connection.
2. The PowerOn button becomes Disconnect indicating a success. If Device Power On does not succeed you may need to erase the serial flash and try again using the Uniflash tool.
3. Once SPI Connection is successful, Click FEC PowerUp button. This command initiates FEC power up. Now, the user can issue commands to the device over SPI Communication interface.
4. On Successful device Power Up, Rfeval version will get updated in Firmware Status Section
5. On Successful FEC Power Up RFS, mmwavelink and fecsslib version will get updated in Firmware Status Section

6.2 Device Control Tab

These tabs contain Device Control DFP APIs. Refer to lua documentation [mmwave_studio<version>\docs\mmwave_studio_lua_api_documentation.pdf](#) for API parameter details.



RadarAPI

Connection | **Device Control** | DeviceControl1 | SensorConfig | SensorConfig1 | Monitor | RFEval | JSON Import Export | Misc

DEV CLK CTRL

Dev Clk Ctrl: FAST_CLK
FT Clk Ctrl: XTAL_CLK
APLL Clk Ctrl: CALIB_ON
API Status: ... SET

RF PWR On/Off

☒ RX CH0
☒ RX CH1 ☒ TX CH0
☒ RX CH2 ☒ TX CH1
☒ RDIF Clock En
☐ RF LDO Bypass
API Status: ...
Override Enable
☐ RX, TX, LO ANA Ch
☐ SYNTH VCO LDO
☐ RF 1.8V LDO
☐ RF 1.2V LDO
☐ APLL ADC Clock
SET

RF FACT CAL (Freq, Time and slope is not being updated in GUI from Lua)

☒ VCO Calib ☒ RX IFA Calib
☒ PD Calib ☒ RX Gain Calib
☒ LODIST Calib ☒ TX Power Calib
☐ RF Gain Calib Disa
API Status: ...
Start Freq (GHz): 60.00000
Freq Slope (MHz/us): 0.000
AutoConvert To Code
TxPwrCalTxEnable Mask
Mask0: ☒ Tx0 ☒ Tx1
Mask1: ☒ Tx0 ☐ Tx1
RX Gain(dB): 40
RF Gain Target: Target0
TX0 Back-Off: 10
TX1 Back-Off: 10
1LSB = 0.5db
Calb Temp: 38 Cel
SET

RF RUN CAL

RF Cal Temp Index: MID
☒ VCO Calib
☒ PD Calib
☒ RX Gain Calib
☒ TX Power Calib
☒ LODIST Calib
API Status: ... SET

TEMP MEAS

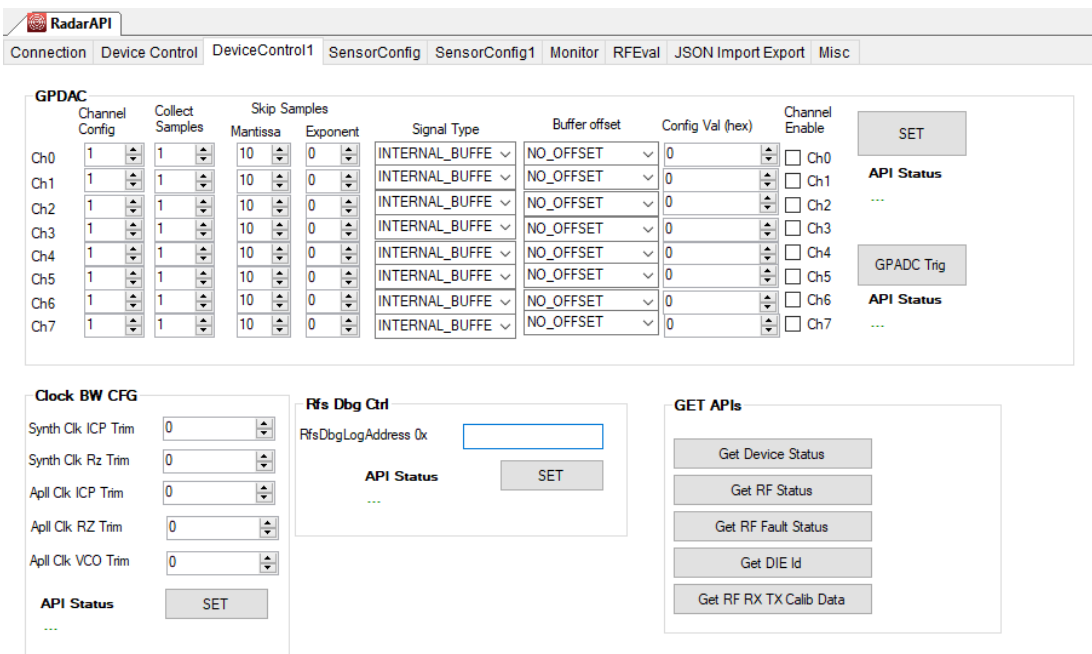
☒ RX Temp Sen On
☒ TX Temp Sens On
☒ PM Temp Sens On
☒ DIG Temp Sens On
API Status: ... SET
Trig
API Status: ...

RxTx Cal Data Set

STG3 STG4 STG3 STG4 IFA Gain Codes RF Gain Codes
Low 0 0 0 0 0 0
Mid 0 0 0 0 0 0
High 0 0 0 0 0 0
API Status: ...
☐ Rx Gain Validity Sts
☐ Rx Gain Val Sts Rd
☐ Tx Pwr Validity Sts
☐ Tx Pwr Val Sts Rd
Tx0 Output Pwr BackOff: 0
Tx1 Output Pwr BackOff: 0
1LSB = 0.5db
SET
GET
Choose Rx Tx Cal Data File: C:\workspace\gen4\mmwavestudio-low\mmWaveStudioPkg\mmWaveStudio_Extm
Read/Write To File: C:\workspace\gen4\mmwavestudio-low\mmWaveStudioPkg\mmWaveStudio_Extm

Fact Cal Data SET GET

Choose Cal Data File: ... SET GET
C:\workspace\gen4\mmwavestudio-low\mmWaveStudioPkg\mmWaveStudio_Extm
API Status: ...



RadarAPI

Connection | **Device Control** | DeviceControl1 | SensorConfig | SensorConfig1 | Monitor | RFEval | JSON Import Export | Misc

GPADC

Channel	Channel Config	Collect Samples	Skip Samples	Signal Type	Buffer offset	Config Val (hex)	Channel Enable
Ch0	1	1	10	INTERNAL_BUFFERE	NO_OFFSET	0	<input type="checkbox"/> Ch0
Ch1	1	1	10	INTERNAL_BUFFERE	NO_OFFSET	0	<input type="checkbox"/> Ch1
Ch2	1	1	10	INTERNAL_BUFFERE	NO_OFFSET	0	<input type="checkbox"/> Ch2
Ch3	1	1	10	INTERNAL_BUFFERE	NO_OFFSET	0	<input type="checkbox"/> Ch3
Ch4	1	1	10	INTERNAL_BUFFERE	NO_OFFSET	0	<input type="checkbox"/> Ch4
Ch5	1	1	10	INTERNAL_BUFFERE	NO_OFFSET	0	<input type="checkbox"/> Ch5
Ch6	1	1	10	INTERNAL_BUFFERE	NO_OFFSET	0	<input type="checkbox"/> Ch6
Ch7	1	1	10	INTERNAL_BUFFERE	NO_OFFSET	0	<input type="checkbox"/> Ch7

GPADC Trig
API Status: ...

Clock BW CFG

Synth Clk ICP Trim: 0
Synth Clk Rz Trim: 0
Appl Clk ICP Trim: 0
Appl Clk RZ Trim: 0
Appl Clk VCO Trim: 0
API Status: ... SET

Rfs Dbg Ctrl

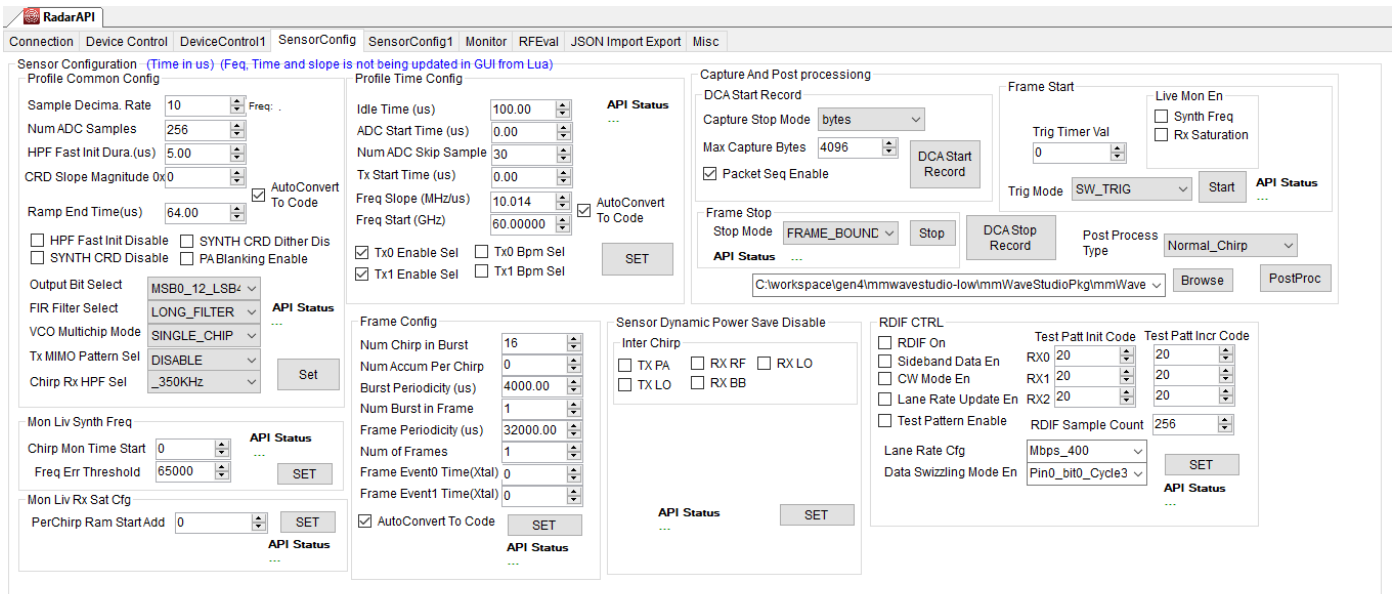
RfsDbgLogAddress 0x:
API Status: ... SET

GET APIs

Get Device Status
Get RF Status
Get RF Fault Status
Get DIE Id
Get RF RX TX Calib Data

6.3 Sensor Config Tab

These tabs contain Sensor Control DFP APIs. Refer to lua documentation [mmwave_studio<version>\docs\mmwave_studio_lua_api_documentation.pdf](#) for API parameter details.



RadarAPI

Connection Device Control DeviceControl1 SensorConfig SensorConfig1 Monitor RFEval JSON Import Export Misc

Sensor Configuration (Time in us) (Freq, Time and slope is not being updated in GUI from Lua)

Profile Common Config

Sample Decima. Rate: 10 Freq: .

NumADC Samples: 256

HPF Fast Init Dura(us): 5.00

CRD Slope Magnitude 0x0

Ramp End Time(us): 64.00

AutoConvert To Code

HPF Fast Init Disable

SYNTH CRD Dither Dis

SYNTH CRD Disable

PA Blanking Enable

Output Bit Select: MSB0_12_LSB4

FIR Filter Select: LONG_FILTER

VCO Multichip Mode: SINGLE_CHIP

Tx MIMO Pattern Sel: DISABLE

Chirp Rx HPF Sel: _350KHz

API Status

Mon Liv Syn Freq

Chirp Mon Time Start: 0

Freq Err Threshold: 65000

API Status

Mon Liv Rx Sat Cfg

PerChirp Ram StartAdd: 0

API Status

Profile Time Config

Idle Time (us): 100.00

ADC Start Time (us): 0.00

NumADC Skip Sample: 30

Tx Start Time (us): 0.00

Freq Slope (MHz/us): 10.014

Freq Start (GHz): 60.00000

AutoConvert To Code

Tx0 Enable Sel

Tx0 Bpm Sel

Tx1 Enable Sel

Tx1 Bpm Sel

API Status

Frame Config

Num Chirp in Burst: 16

Num Accum Per Chirp: 0

Burst Periodicity (us): 4000.00

Num Burst in Frame: 1

Frame Periodicity (us): 32000.00

Num of Frames: 1

Frame Event0 Time(Xtal): 0

Frame Event1 Time(Xtal): 0

AutoConvert To Code

API Status

Sensor Dynamic Power Save Disable

Inter Chirp

TX PA

RX RF

RX LO

TX LO

RX BB

API Status

Capture And Post processing

DCA Start Record

Capture Stop Mode: bytes

Max Capture Bytes: 4096

Packet Seq Enable

DCA Start Record

Frame Start

Trig Timer Val: 0

Trig Mode: SW_TRIG

Start

API Status

Live Mon En

Synth Freq

Rx Saturation

Frame Stop

Stop Mode: FRAME_BOUND

Stop

DCA Stop Record

Post Process Type: Normal_Chirp

API Status

C:\workspace\gen4\mmwavestudio-low\mmWaveStudioPkg\mmWave

Browse

PostProc

RDIF CTRL

RDIF On

Sideband Data En

CW Mode En

Lane Rate Update En

Test Pattern Enable

Lane Rate Cfg: Mbps_400

Data Swizzling Mode En

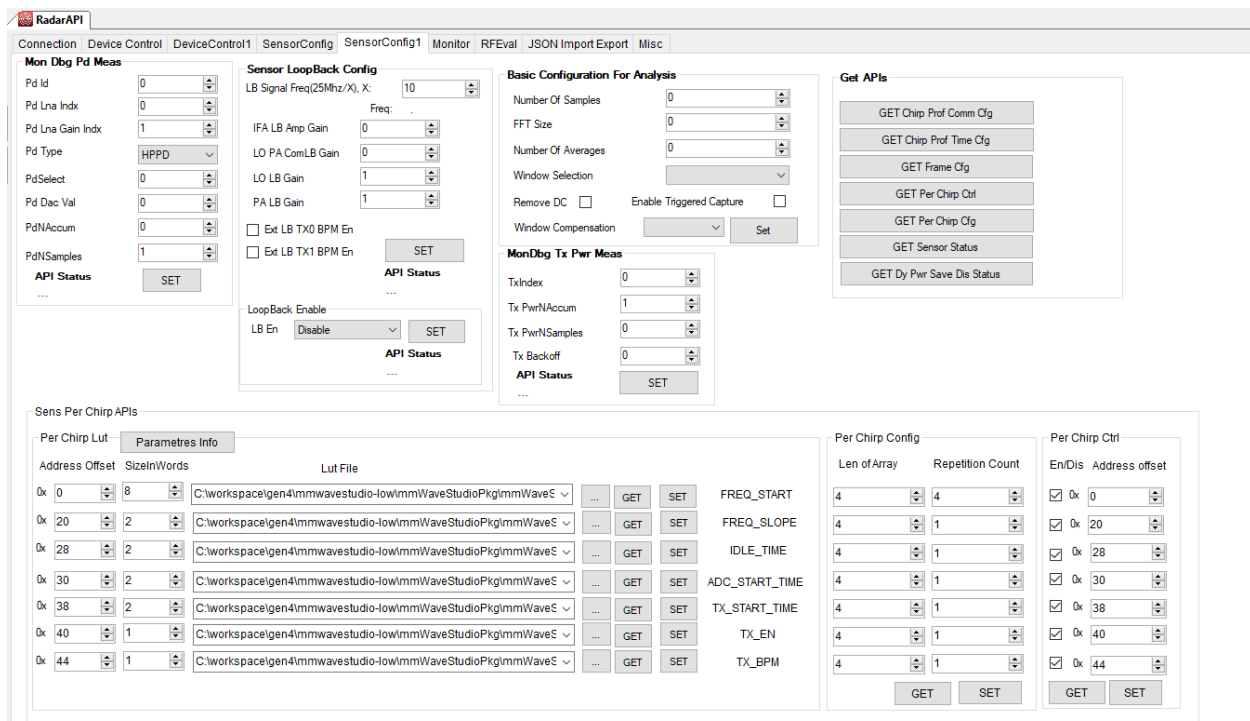
Test Patt Init Code: RX0 20

Test Patt Incr Code: RX1 20

RDIF Sample Count: 256

SET

API Status



RadarAPI

Connection Device Control DeviceControl1 SensorConfig SensorConfig1 Monitor RFEval JSON Import Export Misc

Mon Dbg Pd Meas

Pd Id: 0

Pd Lna Indx: 0

Pd Lna Gain Indx: 1

Pd Type: HPPD

Pd Select: 0

Pd Dac Val: 0

PdNAccum: 0

PdNSamples: 1

API Status

SET

Sensor LoopBack Config

LB Signal Freq(25Mhz/X): 10

Freq: .

IFA LB Amp Gain: 0

LO PA ComLB Gain: 0

LO LB Gain: 1

PA LB Gain: 1

Ext LB TX0 BPM En

Ext LB TX1 BPM En

API Status

SET

LoopBack Enable

LB En: Disable

API Status

Basic Configuration For Analysis

Number Of Samples: 0

FFT Size: 0

Number Of Averages: 0

Window Selection

Remove DC

Enable Triggered Capture

Window Compensation

Set

Mon Dbg Tx Pwr Meas

TxIndex: 0

Tx PwrNAccum: 1

Tx PwrNSamples: 0

Tx Backoff: 0

API Status

SET

Sens Per Chirp APIs

Per Chirp Lut

Parameters Info

Address Offset

SizeInWords

Lut File

0x 0 8 C:\workspace\gen4\mmwavestudio-low\mmWaveStudioPkg\mmWaveS

GET SET

FREQ_START

0x 20 2 C:\workspace\gen4\mmwavestudio-low\mmWaveStudioPkg\mmWaveS

GET SET

FREQ_SLOPE

0x 28 2 C:\workspace\gen4\mmwavestudio-low\mmWaveStudioPkg\mmWaveS

GET SET

IDLE_TIME

0x 30 2 C:\workspace\gen4\mmwavestudio-low\mmWaveStudioPkg\mmWaveS

GET SET

ADC_START_TIME

0x 38 2 C:\workspace\gen4\mmwavestudio-low\mmWaveStudioPkg\mmWaveS

GET SET

TX_START_TIME

0x 40 1 C:\workspace\gen4\mmwavestudio-low\mmWaveStudioPkg\mmWaveS

GET SET

TX_EN

0x 44 1 C:\workspace\gen4\mmwavestudio-low\mmWaveStudioPkg\mmWaveS

GET SET

TX_BPM

Per Chirp Config

Len of Array

Repetition Count

EnDis

Address offset

4 4

4 1

4 1

4 1

4 1

4 1

4 1

GET SET

Per Chirp Ctrl

EnDis

Address offset

0x 0

0x 20

0x 28

0x 30

0x 38

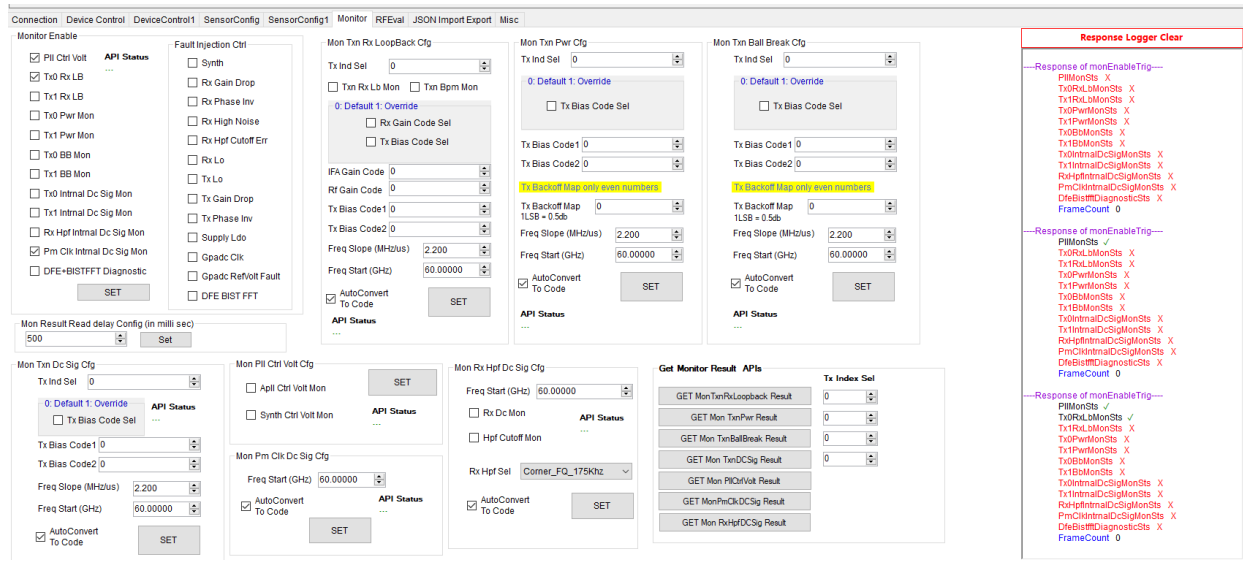
0x 40

0x 44

GET SET

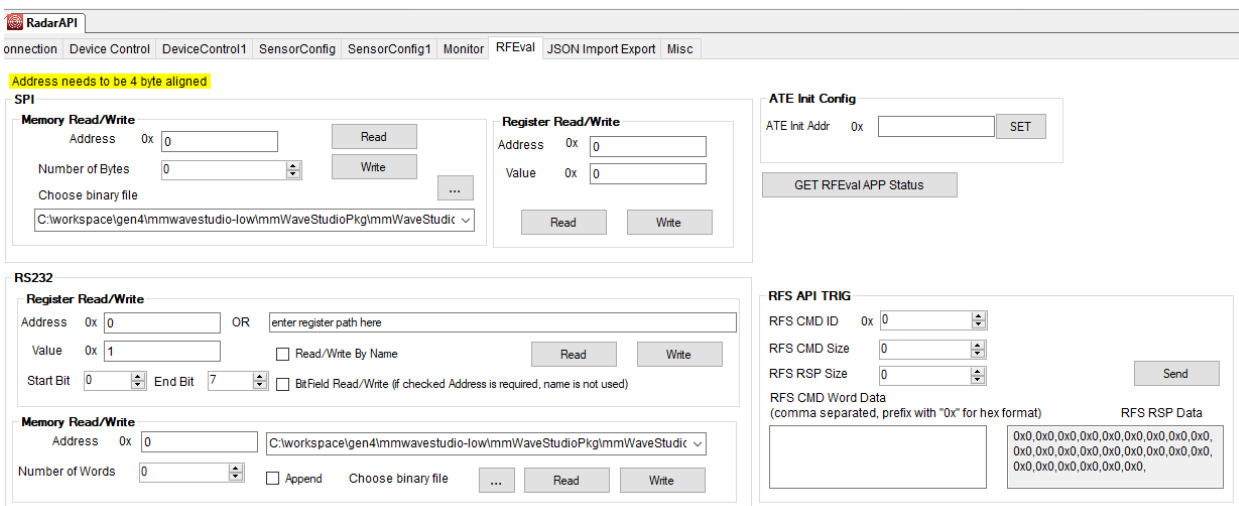
6.4 Monitor Config Tab

These tabs contain Monitor DFP APIs. Refer to lua documentation [mmwave_studio<version>\docs\mmwave_studio_lua_api_documentation.pdf](#) for API parameter details.



6.5 RFEval

These tabs contain Register/Memory Read/Write APIs over RS232/SPI and RFEval Custom Commands. Refer to lua documentation [mmwave_studio<version>\docs\mmwave_studio_lua_api_documentation.pdf](#) for API parameter details.



6.6 JSON Import Export

Use this tab to save GUI configuration into a json file. This file can be used to import configuration into GUI.

JSON Load-Save

Pick Json File

...

C:\workspace\gen4\mmwavestudio-low\mmWaveStudioPkg\mmWaveStudio_Internal\RunTime\..USONSam; ▼

Export

Pick Json File

...

C:\workspace\gen4\mmwavestudio-low\mmWaveStudioPkg\mmWaveStudio_Internal\RunTime\..USONSam; ▼

Import

6.7 Misc

This Tab Contains Conversion APIs and some other debug features like:

1. Enable/Disable log print in console
2. Update a custom text box from lua script

RadarAPI

Connection

Device Control

DeviceControl1

SensorConfig

SensorConfig1

Monitor

RFEval

JSON Import Export

Misc

Freq To Code(in MHz)

0.00000

Freq To Code

60GHz

77GHz

High Res

0

Low Res

0

Ft Period to Code(in us)

0.00

Ft Period To Code

XTAL Freq

CLK_40MHz ▼

Code

0

Enable/Disable Console Logging

(This Doesn't affect trace file logs)

Disable API Logs(error will be logged)

Disable All Logs

Enable All Logs

Time to Code(in us)

0.00

Time To Code

High

0

Low

0

Configurable Text Box

Write using lua API:

mws.setCustomText("text", append)

Slope to Code(in MHz/us)

0.000

Slope To Code

60GHz

0

77GHz

0

7 APIs Programming sequence

Refer the LUA documentation ([mmwave_studio<version>\docs\mmwave_studio_lua_api_documentation.pdf](#)) for API programming sequences under section “API Programming Sequence”.

8 Radar post processing

The radar post processing (or PostProc) tool is used to visualize the adc data collected on the PC. It works using two inputs - the first is the raw LVDS capture (stored as .bin file) and the second is the sequence of APIs that were used to program the radar device (stored as .log file). Using these two sources of information, PostProc is able to interpret the data that the radar device collects and provide meaningful plots.

Note that mmWaveStudio automatically provides the dump file, and the sequence of APIs to the Matlab PostProc tool. So there is no need to manually provide these two inputs.

The following image shows how PostProc looks (with annotations) when you launch it first:

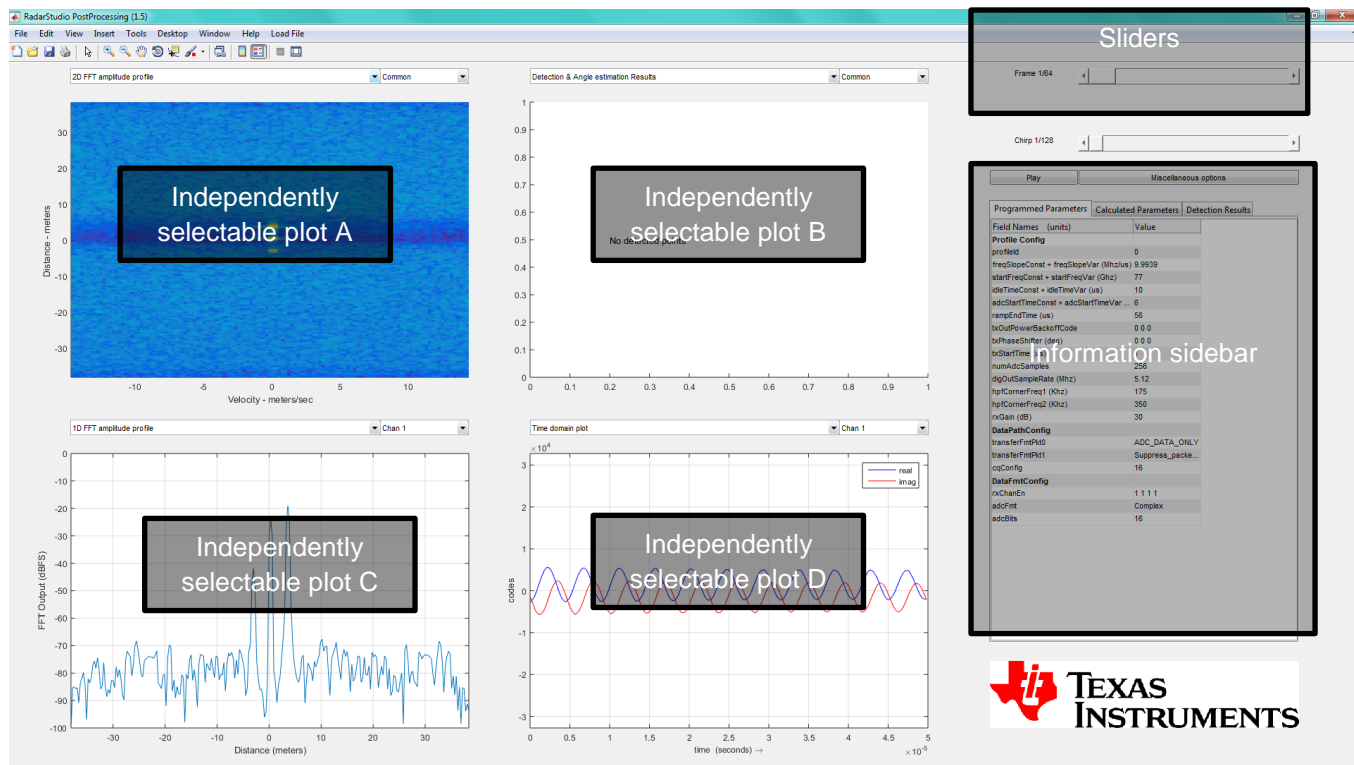


Figure 8.1. PostProc Basic

There are four different independently selectable plots. Each of these plots can be configured to different channels and different kinds of plots. Some of these plots are valid for all channels and some are simply a common measurement for all channels.

Some plots are per-chirp and others are per frame. Each optionally is described later in the 'List of plots' section.

There is a set of sliders (on the top-right) that allow one to move around in the captured scenario, and display any frame, as well any of the chirps of the frame. If you are using the advanced frame configuration, the sub-frames, the bursts, the burst-loops are also individually selectable using the sliders.

Below the sliders, are two buttons, the 'play' button 'plays' the captured scenario, moving through each frame and updating the plots. 'Playing' through a captured scenario is a good way to see and correlate the captured scenario with what the different plots show, and see if there are issues.

While the default plots are a useful way to understand the radar data, some modification (to the plots) is sometimes required. So a number of 'less-common' options to modify the different plots are provided in a separate menu. This menu can be accessed using the 'Miscellaneous options' button.

Finally, below the 'Play' and 'Miscellaneous options' buttons is series of spreadsheets which provide the important parameters that were used to plot these graphs.

NOTE:

1. The Studio PostProc visualizer only supports data captured using RDIF Data Swizzling Mode 2 ("Pin0_bit0_Cycle3" in GUI).
2. If capture size exceeds 1GB, DCA Capture CLI splits the captured data into multiple files of size ≤ 1 GB. PostProc only processes first file from these generated files. Hence only maximum of 1 GB data can be used for radar Post Processing.

8.1 List of plots

Note: This list will be updated as more capability is added to PostProc.

8.1.1 Basic plots

8.1.1.1 2D FFT profile

The Range-velocity 'mesh' graph computed by performing a 2D-FFT of one frame of the captured scenario is shown in this plot. The x-axis shows the velocity (in meters/second) and the y-axis shows the range (in meters). Strong-reflectors are shown in brighter colours, and the noise floor is shown in dark blue.

The 2D output of each channel can be independently selected using the channel selector. If the 'common' option is selected in the channel selector, then the non-coherent-sum of the 2D FFT output across channels is plotted.

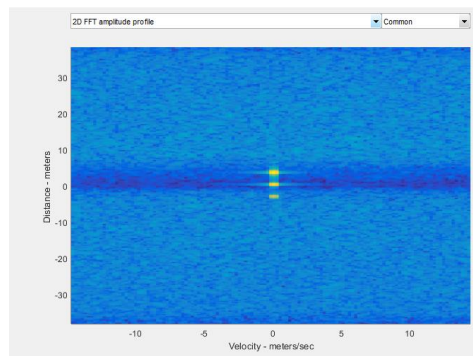


Figure 8.2. 2D FFT Profile

8.1.1.2 Range Angle plot

This plot shows a top-down view of the range-angle mesh. Targets are shown in brighter colours. The processing assumes a 1-Tx 4-Rx antenna configuration, with all 4 Rx antennas lying on the same plane (separated by $\lambda/2$, where λ is the starting wavelength of the FMCW ramp).

No calibration is performed in this step. Note that since only 4 antennas are used in the 3rd dimension processing, only a crude estimation of the angles are possible.

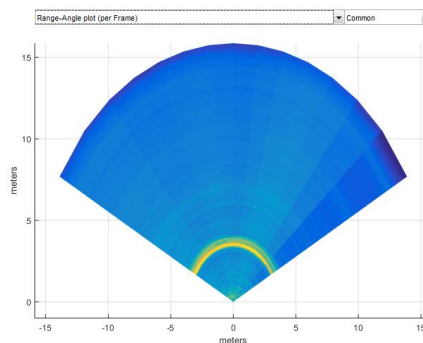


Figure 8.3. Range Angle plot

8.1.1.3 Detection and Angle estimation Results

A simple 2D-CFAR-CA (Constant false alarm – cell averaging) algorithm is used to detect targets in the scene. The parameters of the CFAR can be modified in the 'Miscellaneous Options' menu.

Targets are shown as coloured dots.

- Red dots indicate that the target has negative velocity,
- Green dots imply zero velocity
- Blue dots indicate positive velocity.

As in the range-angle plot, the antenna configuration assumes 4-Rx antennas separated by $\lambda/2$ organised as a linear array, the third dimension processing is simply a 3D-FFT followed by a peak search. Hence only a single target is detected per range-velocity bin.

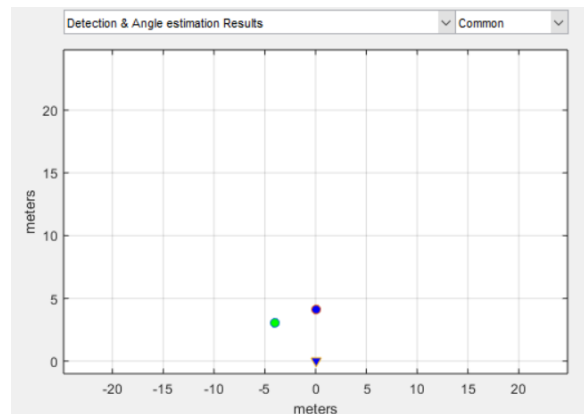


Figure 8.4. Detection and Angle Estimation results

8.1.1.4 Chirp Config Picture

This is a graphical depiction of the chirps that have been configured on the device. The x-axis is time (in seconds), and the y-axis is the ramp frequency. Using the 'miscellaneous options' menu, the plot can be modified to show all the chirps of a complete frame.

Since the chirp is common to all the rx channels on the device, only 'common' option is allowed on the channel selection dropdown.

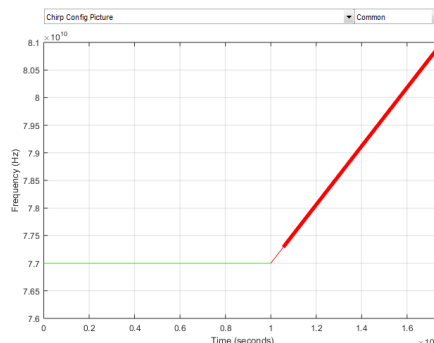


Figure 8.5. Chirp Config Picture

8.1.1.5 1D FFT amplitude profile

This is the '1D-FFT' amplitude profile. The x-axis can be configured (using the 'miscellaneous options' menu) to be in meters or in Hz (IF frequency) or in samples. The y-axis is given in dBFS.

Also, in the 'miscellaneous options' menu are options to do 'non-coherent' sum across chirps (per frame) and across antennas, as well as options to select the window (by default the Hann window is used).

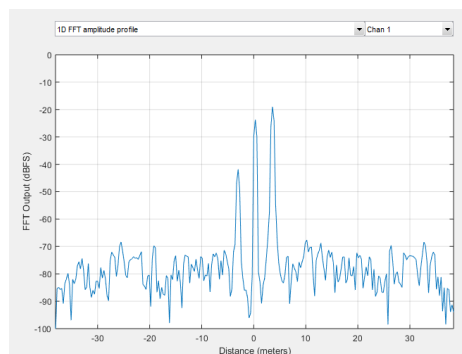


Figure 8.6. 1D FFT Profile

8.1.1.6 Time domain plot

This plot has the 'Raw ADC data' per chirp is plotted. The x-axis can be either time or 'instantaneous ramp frequency' or 'sample number'. The y-axis is in either ADC codes or in (1/full-scale).

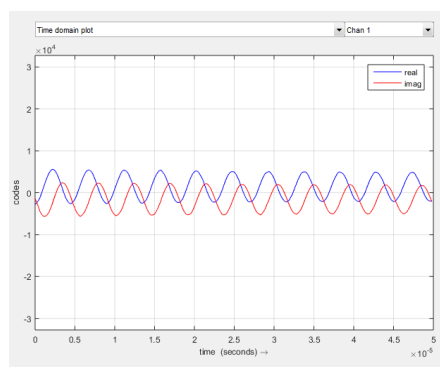


Figure 8.7. Time domain plot

8.1.2 CQ plots (chirp quality metrics)

Chirp quality metrics are used to identify regions of a chirp affected by interference. It is still under development. The metrics used are namely

1. ADC/IF Saturation Indicator

8.1.3 Characterization plots

8.1.3.1 Phase stability across chirps

Phase stability is an important concern when measuring vibration frequency, and also in low velocity measurement. This plot shows the phase (of the strongest reflector) as a function of the chirps of a frame. The x-axis is in 'chirp number' and the y-axis is in degrees. Note that the y-axis label also tells where the strongest reflector is present (in meters).

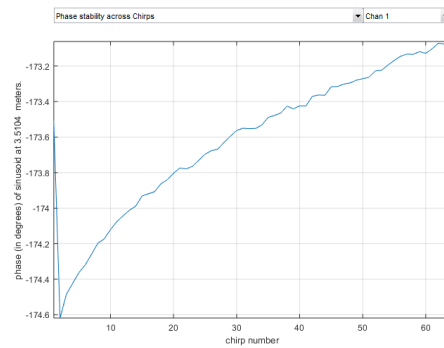


Figure 8.8. Phase Stability

8.1.3.2 Amplitude stability across chirps

Amplitude stability is a good measure of how stable the transmit power is across a Frame. This plot shows the amplitude of the strongest tone in the chirp. The position of the strongest reflector (in meters) is shown in the y-axis label.

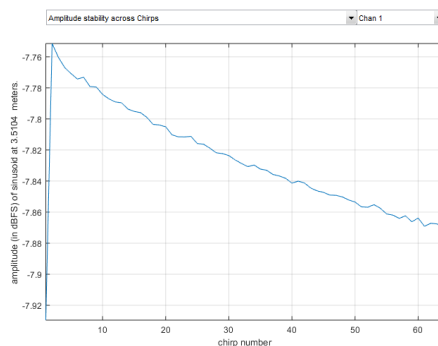


Figure 8.9. Amplitude stability

8.1.3.3 Zero-velocity bin vs High velocity bin

In a stationary scene, all energy from reflectors will be concentrated on the zero-velocity range bins. High-velocity range-bins will essentially be showing the thermal noise floor. This plot displays the Zero-velocity and the High velocity bins for an easy estimate of the SNR.

The 'high velocity bin' graph is generated from the '2D-FFT' by averaging the velocity bins from ' $\max_{velocity}/2$ ' to ' $\max_{velocity}$ ' and ' $-\max_{velocity}/2$ ' to ' $-\max_{velocity}$ '.

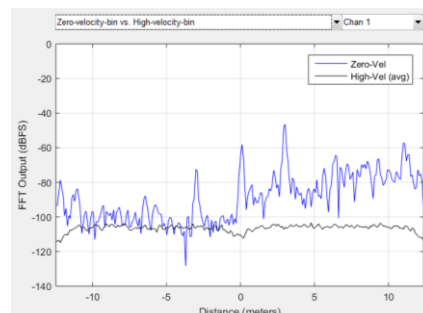


Figure 8.10. Zero-velocity bin vs High velocity bin.

8.2 Channel select

Some of these plots use all the Rx antennas to create the plot (1a, 1b, 1c, 2a, 2b, 2c), some have a per Rx measurement (1e, 1f, 3a, 3b), some aren't associated with the Rx plot (1d).

For measurements that are associated with a particular Rx, the channel select option can be used to select the channel whose measurement is to be shown.

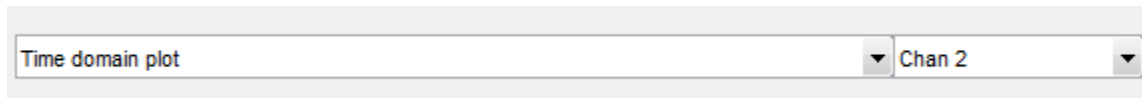


Figure 8.11. Channel select

PostProc will automatically select the first channel when changing from a common measurement to a per-channel measurement and vice-versa.

8.3 Frame /Profile /Chirp sliders

These slides allow exploring the different frames of the ADC dump. Within a frame, the different chirps can also be selected. If multiple 'chirp config' are selected as part of the frame, each is shown separately in the profile slider. Note that if the Advanced Frame Config is used, additional sliders will appear to allow the selection of 'sub-frames', 'bursts', 'burst-loops' which are configurable only through the Advanced Frame Config.

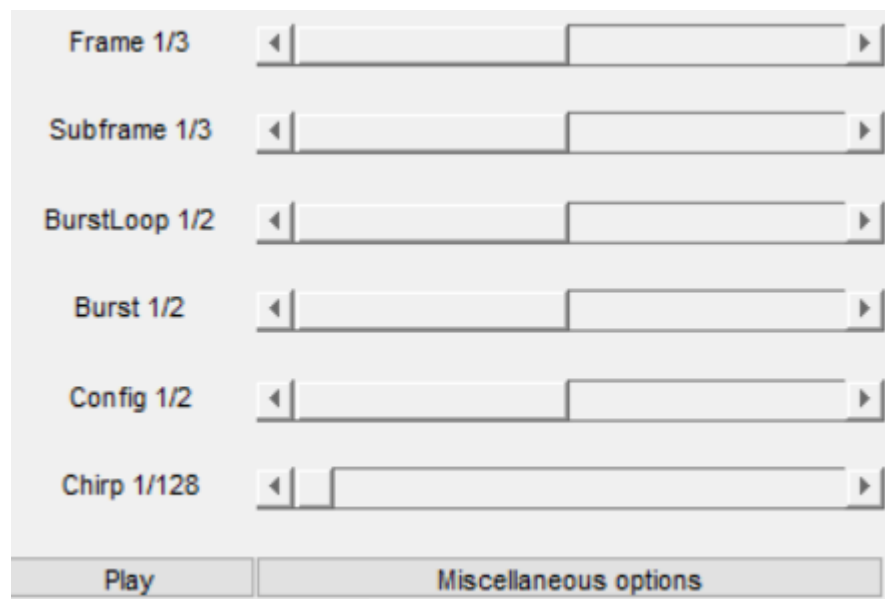


Figure 8.12. Sliders

8.4 Information sidebar

The sidebar has (as of now) three separate tabs.

Programmed Parameters		Calculated Parameters	Detection Results
Field Names (units)	Value		
Profile Config			
profileId	0		
freqSlopeConst + freqSlopeVar (Mhz/us)	29.9817		
startFreqConst + startFreqVar (Ghz)	77		
idleTimeConst + idleTimeVar (us)	100		
adcStartTimeConst + adcStartTimeVar ...	6		
rampEndTime (us)	60		
txOutPowerBackoffCode	0 0 0		
txPhaseShifter (deg)	0 0 0		
txStartTime (us)	0		
numAdcSamples	256		
digOutSampleRate (Mhz)	10		
hpfCornerFreq1 (Khz)	175		
hpfCornerFreq2 (Khz)	350		
rxGain (dB)	30		
DataPathConfig			
transferFmtPkt0	ADC_DATA_ONLY		
transferFmtPkt1	Suppress_packe...		
cqConfig	16		
DataFmtConfig			
rxChanEn	1 1 1 1		
adcFmt	Complex		
adcBits	16		
Chirp Config			
txEnable	1 0 0		

Figure 8.13. Information sidebar

These tabs are explained in the subsequent subsections.

NOTE: Chirp parameters programmed via the Sensor Per Chirp APIs are not reflected in the Studio PostProc visualizer information sidebar.

8.4.1 Programmed parameters

This gives a short list of the parameters that were programmed using the APIs. This is the data that the post-proc tool uses to analyse the data.

8.4.2 Calculated parameters

This is a useful list of parameters that are calculated using the programmed parameters. They include

- True start frequency ramp. The programmed start frequency doesn't take into account the ADC start time. When the ADC start time is taken into consideration, the true start of the ramp happens a few microseconds after the programmed start.

- b. Bandwidth. The bandwidth provided here correctly takes into account the ADC start time and the number of samples to be collected.
- c. Range resolution
- d. Velocity resolution

8.4.3 Detection results

Up to five detected measurements are shown, along with their SNR, velocities and ranges.

8.5 Play

If the ADC data has multiple frames, the play button plays through the frames one by one, allowing one to see the evolution of the scene.

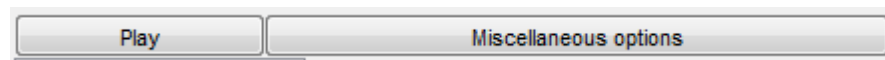


Figure 8.14. Play

8.6 Miscellaneous options

This window holds a list of options to modify and alter the plots. Options are organised in different 'boxes', with each box corresponding to a particular type of plot. The current 'boxes' are.

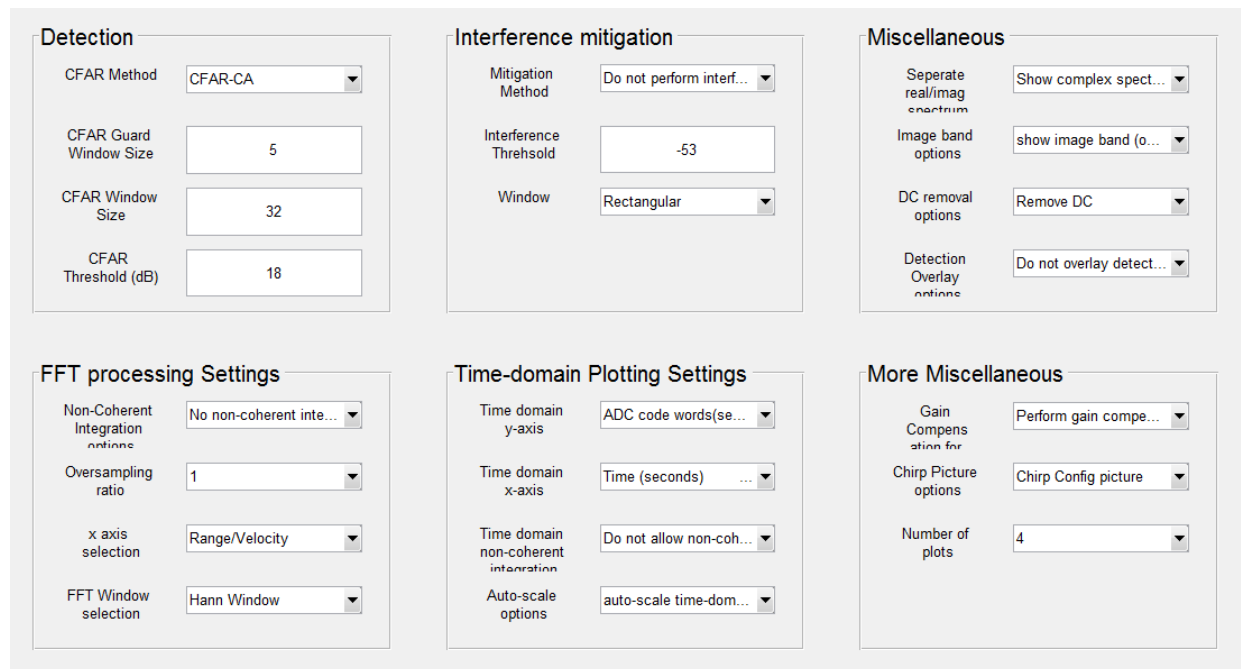


Figure 8.15. Miscellaneous options

8.6.1 Detection

The detection algorithm is 2D-CFAR-CA.

- a. **CFAR method.** There are three different variants of CFAR that can be selected.
 - i. CFAR-CA computes the noise floor considering samples that lie in a window that spans both sides of the CUT (cell under test). The noise floor is simply the mean of the energy in that window.
 - ii. CFAR-CA-SO selects the 'smaller of' (hence -SO) the noise-floor computed using samples that lie on left-side of the CUT and the noise floor computed using samples that lie on the right of the CUT.
 - iii. CFAR-CA-GO selects the 'greater of' (hence -GO) the noise-floor computed using samples that lie on left-side of the CUT and the noise floor computed using samples that lie on the right of the CUT.
- b. **CFAR guard-window size.** The guard window is used to reduce the effect of adjacent targets (or leakage) when measuring the noise floor. Essentially the samples that lie within the guard-window are omitted from the computation of the noise-floor.
- c. **CFAR window size.** The size of the window determines the number of samples that are used to compute the noise-floor. The larger the window size, the better the noise floor estimate. However, the larger the window, the more probable that multiple targets will occur in the same window and result in a raised noise floor.
- d. **CFAR Threshold.** Once the noise floor has been computed, it is compared against the CUT. If the CUT is greater than the noise-floor by the CFAR threshold, then CUT is declared as a valid target. Reducing the detection threshold will help increase the number of detected targets.

8.6.2 *FFT processing settings*

- a. **Non-coherent Integration options.** Allow non-coherent integration across chirps and across chirps and antennas for the '1D FFT amplitude plots' and the 'time domain plots'. Allowing non-coherent integration improves the 'look' of the noise floor (in the '1D FFT amplitude profile'), and shows the envelope of complex signals in the time domain plot.
- b. **Oversampling ratios.** Setting the 'oversampling ratio' higher than one creates zero-padded FFTs which improve bin-resolution (Note : zero-padding is done only in range not in velocity). Be aware that setting larger oversampling ratios, require proportionally more RAM to compute the FFT and also to display it.
- c. **x-axis selection.** Changes the x-axis from meters (default) to hz. This is useful when doing looking at the IF spectrum, as opposed to an actual target.
- d. **FFT-window selection.** Different FFT windows have different uses. By default we use the Hann window, which has a reasonable tradeoff between main lobe expansion and suppression of side-lobes. There are three other options, no-window (no energy loss, least main lobe expansion, no suppression of side lobes), and Blackman-Harris (high main lobe expansion, better suppression of side lobes (as compared to Hann)) and flat-top window (primarily used in characterization).

8.6.3 Miscellaneous

- a. **Separate real/imag.** In the '1-D FFT amplitude profile' plot optionally separate the imaginary and real parts of the FFT.
- b. **Image band options.** In the 'complex 2X' mode, the image band (i.e. negative frequencies) is visible. However, since no target can lie 'behind' the radar, the image band is of no interest in field tests. It is only useful in interference detection, and in monitoring.
- c. **DC removal option.** This option can remove DC on a per-frame basis. By default DC is removed as it will result in cleaner images.
- d. **Detection overlay options.** Allow the detection results to be displayed over the '2D FFT profile' plot, and the range-angle plot.

8.6.4 Time domain options

- e. **Time domain x-axis.** The x-axis can be changed from time (seconds) to 'instantaneous ramp frequency' (Hz) or 'sample number'.
- f. **Time domain y-axis.** The y-axis can be changed from ADC codewords to 1/fullscale.
- g. **Time domain non-coherent integration options.** In conjunction with non-coherent integration options can construct the envelope of a complex time domain signal by computing $\sqrt{I^2 + Q^2}$
- h. **Auto scale options.** The y-axis can be optionally allowed to auto-scale. This is useful for cases where the ADC swing is very low.

8.6.5 More miscellaneous options

- a. **Window compensation options.** Applying a window prior to FFT causes a change in the absolute output level of the FFT (This change is called the windowing loss). These set of options allow two different methods of compensating for the windowing loss – Gain-compensation or Energy-compensation.

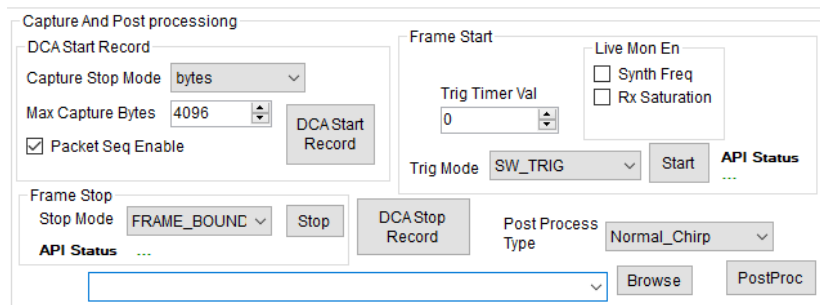
Both methods differ only in the compensation factor. When using Gain-compensation the each fft output is divided by a factor given by $\sum_{i=0}^{N-1} w_i / N$.
When using Energy-compensation the factor is given by $rms([w_0 \ w_1 \ ... \ w_{N-1}])$.
- b. **Chirp picture options.** This option selects between different plots in the 'Chirp Picture'. For example a 'single chirp's picture' can be plotted or a 'complete frame's worth of chirps' can be plotted.
- c. **Number of plots.** By default 4 plots are shown on the main window. This dropdown can change that to 1, 2, 4, or 9 independently configurable plots.

8.7 Notes on Setting up PostProc for Characterization

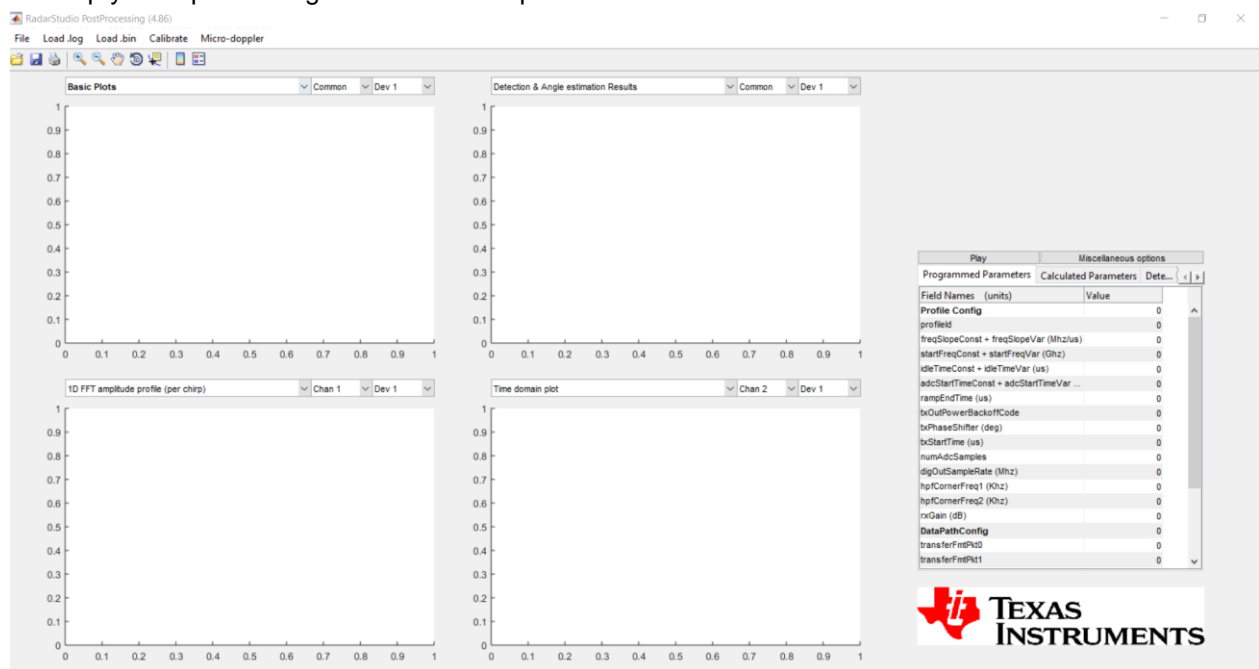
The tool is 'by default' configured for characterization so no changes need to be done. There is no reason to access the 'miscellaneous options' menu.

8.8 Standalone processing (post processing done in a different session from configuration and capture)

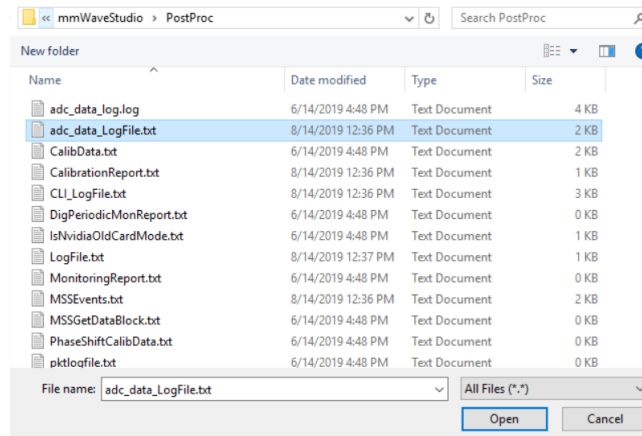
- This is particularly useful when the data is already captured from a previous session and the user just needs to post process the data using Studio.
- Go to the "Sensor Config" tab directly once Studio is opened.
- Provide an empty path (like in the screenshot below) and click on "PostProc" button.



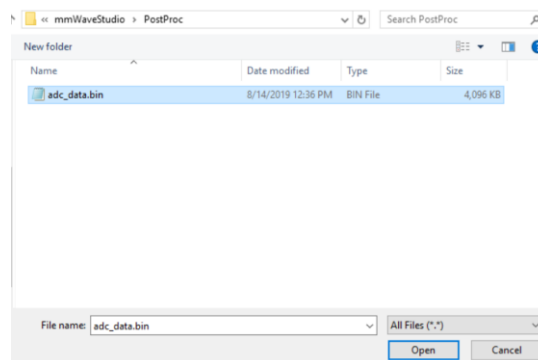
- An empty Post processing window will be opened



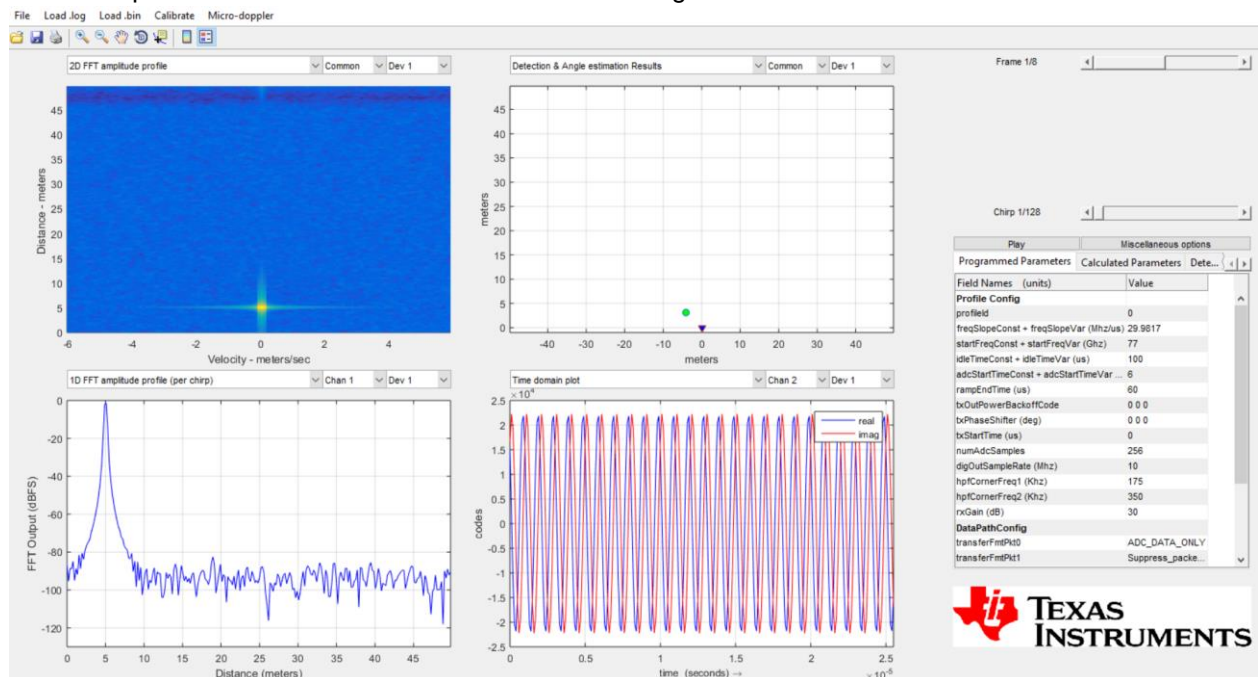
- Click on “Load .log” on the toolbar and select the corresponding log file.



- Click on “Load .bin” on the toolbar and select the corresponding bin file.



- The basic plots will be obtained for the bin file and the log file selected



9 Controlling mmWaveStudio from Matlab

1. From mmWaveStudio's Lua Shell, call the RSTD.NetStart() command

This command starts a listening server on port 2777 by default.

(you can also add this command to "C:\ti\mmwave_studio_01_00_00_01\mmWaveStudio\Scripts\Startup.lua" so that it is called automatically)

2. There are two Matlab scripts shown below. Copy them and create scripts with names RSTD_Interface_Example.m and Init_RSTD_Connection.m. You can modify the path to the RtttNetClientAPI.dll in RSTD_Interface_Example.m, and then call the RSTD_Interface_Example from Matlab. This script demonstrates how to connect to mmWaveStudio from Matlab and allow Lua commands to be sent to mmWaveStudio. The script internally calls Init_RSTD_Connection.m to establish the connection to port 2777, and then displays a green message in the mmWaveStudio Output window.

See lines 41-47 in Init_RSTD_Connection.m for an example of sending a single Lua Command. Basically, you construct the Lua command as a string in Matlab and pass it to the RtttNetClientAPI.RtttNetClient.SendCommand API. Also see commented lines 12-15 in RSTD_Interface_Example.m for an example on how to get mmWaveStudio to run an external Lua Script.

RSTD_Interface_Example.m

```
%% RSTD Interface Example.m
1  addpath(genpath('.\'))
2
3  % Initialize mmWaveStudio .NET connection
4  RSTD_DLL_Path =
    'C:\ti\mmwave_studio_01_00_00_01\mmWaveStudio\Clients\RtttNetClientControl
    ler\RtttNetClientAPI.dll';
5
6  ErrStatus = Init_RSTD_Connection(RSTD_DLL_Path);
7  if (ErrStatus ~= 30000)
8      disp('Error inside Init_RSTD_Connection');
9      return;
10 end
11
12 %Example Lua Command
13 %strFilename =
    'C:\ti\mmwave_studio_01_00_00_01\mmWaveStudio\Scripts\Example_script_
    AllDevices.lua';
14 %Lua_String = sprintf('dofile("%s")',strFilename);
15 %ErrStatus =RtttNetClientAPI.RtttNetClient.SendCommand(Lua_String);
```

Init_RSTD_Connection.m

```

%% Init_RSTD_Connection.m
1 function ErrStatus = Init_RSTD_Connection(RSTD_DLL_Path)
2 %This script establishes the connection with mmWaveStudio software
3 % Pre-requisites:
4 % Type RSTD.NetStart() in mmWaveStudio Luashell before running the script.
  This would open port 2777
5 % Returns 30000 if no error.
6 if (strcmp(which('RtttNetClientAPI.RtttNetClient.IsConnected'),'')) %First
  time the code is run after opening MATLAB
7     disp('Adding RSTD Assembly');
8     RSTD_Assembly = NET.addAssembly(RSTD_DLL_Path);
9     if ~strcmp(RSTD_Assembly.Classes{1},'RtttNetClientAPI.RtttClient')
10         disp('RSTD Assembly not loaded correctly. Check DLL path');
11         ErrStatus = -10;
12         return
13     end
14     Init_RSTD_Connection = 1;
15 elseif ~RtttNetClientAPI.RtttNetClient.IsConnected() %Not the first time but
  port is disconnected
16 % Reason:
17 % Init will reset the value of Isconnected. Hence Isconnected should be
  checked before Init
18 % However, Isconnected returns null for the 1st time after opening MATLAB
  (since init was never called before)
19     Init_RSTD_Connection = 1;
20 else
21     Init_RSTD_Connection = 0;
22 end
23
24 if Init_RSTD_Connection
25     disp('Initializing RSTD client');
26     ErrStatus = RtttNetClientAPI.RtttNetClient.Init();
27     if (ErrStatus ~= 0)
28         disp('Unable to initialize NetClient DLL');
29         return;
30     end
31     disp('Connecting to RSTD client');
32     ErrStatus = RtttNetClientAPI.RtttNetClient.Connect('127.0.0.1',2777);
33     if (ErrStatus ~= 0)
34         disp('Unable to connect to mmWaveStudio');
35         disp('Reopen port in mmWaveStudio. Type RSTD.NetClose() followed
  by RSTD.NetStart()')
36         return;
37     end
38     pause(1);%Wait for 1sec. NOT a MUST have.
39 end
40
41 disp('Sending test message to RSTD');
42 Lua_String = 'WriteToLog("Running script from MATLAB\n", "green")';
43 ErrStatus = RtttNetClientAPI.RtttNetClient.SendCommand(Lua_String);
44 if (ErrStatus ~= 30000)

```

```
45     disp('mmWaveStudio Connection Failed');
46 end
47 disp('Test message success');
48 end
```

10 Automation using LUA

mmWaveStudio allows a Lua script to be executed through command line (it will open the GUI). Below steps explain the procedure

1. Navigate to the Runtime folder where mmWaveStudio executable is present.
2. Open the command prompt and type

mmWaveStudio.exe /lua <path to the Lua script>

10.1 Sample Lua script for automation

A sample Lua script named “Automation.lua” is present at the Scripts directory for reference.

In order to execute the script, the command to be provided is as follows:

```
C:\ti\mmwave_studio_02_01_00_00\mmWaveStudio\RunTime>mmWaveStudio.exe /lua ..\Scripts\Automation.lua
```

- Every Lua script that needs to be executed should have the startup portion as shown below

```
----- STARTUP -----
----- DO NOT MODIFY THIS SECTION -----

-- mmwavestudio installation path
RSTD_PATH = RSTD.GetRstdPath()

-- Declare the loading function
dofile(RSTD_PATH .. "\\Scripts\\Startup.lua")
```

- The sample script shows how to do a basic capture using the DCA1000 EVM. The script can be extended for custom usage.

```

----- CONFIGURATIONS -----
-- Use "DCA1000" for working with DCA1000
capture_device = "DCA1000"

-- SOP mode
SOP_mode      = 2

-- RS232 connection baud rate
baudrate      = 921600
-- RS232 COM Port number
uart_com_port = 4
-- Timeout in ms
timeout       = 1000

-- BSS firmware
bss_path      = "C:\\ti\\mmwave_studio_02_01_00_00\\rf_eval_firmware\\radarss\\xwrl2xx_xwrl4xx_radarss.bin"
-- MSS firmware
mss_path      = "C:\\ti\\mmwave_studio_02_01_00_00\\rf_eval_firmware\\masterss\\xwrl2xx_xwrl4xx_masterss.bin"

adc_data_path = "C:\\ti\\mmwave_studio_02_01_00_00\\mmWaveStudio\\PostProc\\test_data.bin"

```

- a. The capture device should be specified as "DCA1000".
- b. The SOP mode has to be chosen appropriately. In this example, SOP2 is chosen.
- c. The COM port and the baud rate should be chosen appropriately. COM port can be obtained through device manager.



- d. The BSS and the MSS firmware paths.
 - e. ADC file path for the capture.
- Once the basic connection tab configuration is done, the device is configured done until the frame configuration.
 - The DCA1000 capture card is setup and the device starts framing.
 - The captured data is stored at the mentioned ADC file path.
 - Once the API's are executed, the script exits with the closure of mmWaveStudio GUI.

```

----- Exit MMwave Studio -----
os.exit()

```

IMPORTANT NOTICE

Texas Instruments Incorporated ("TI") technical, application or other design advice, services or information, including, but not limited to, reference designs and materials relating to evaluation modules, (collectively, "TI Resources") are intended to assist designers who are developing applications that incorporate TI products; by downloading, accessing or using any particular TI Resource in any way, you (individually or, if you are acting on behalf of a company, your company) agree to use it solely for this purpose and subject to the terms of this Notice.

TI's provision of TI Resources does not expand or otherwise alter TI's applicable published warranties or warranty disclaimers for TI products, and no additional obligations or liabilities arise from TI providing such TI Resources. TI reserves the right to make corrections, enhancements, improvements and other changes to its TI Resources.

You understand and agree that you remain responsible for using your independent analysis, evaluation and judgment in designing your applications and that you have full and exclusive responsibility to assure the safety of your applications and compliance of your applications (and of all TI products used in or for your applications) with all applicable regulations, laws and other applicable requirements. You represent that, with respect to your applications, you have all the necessary expertise to create and implement safeguards that (1) anticipate dangerous consequences of failures, (2) monitor failures and their consequences, and (3) lessen the likelihood of failures that might cause harm and take appropriate actions. You agree that prior to using or distributing any applications that include TI products, you will thoroughly test such applications and the functionality of such TI products as used in such applications. TI has not conducted any testing other than that specifically described in the published documentation for a particular TI Resource.

You are authorized to use, copy and modify any individual TI Resource only in connection with the development of applications that include the TI product(s) identified in such TI Resource. NO OTHER LICENSE, EXPRESS OR IMPLIED, BY ESTOPPEL OR OTHERWISE TO ANY OTHER TI INTELLECTUAL PROPERTY RIGHT, AND NO LICENSE TO ANY TECHNOLOGY OR INTELLECTUAL PROPERTY RIGHT OF TI OR ANY THIRD PARTY IS GRANTED HEREIN, including but not limited to any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information regarding or referencing third-party products or services does not constitute a license to use such products or services, or a warranty or endorsement thereof. Use of TI Resources may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

TI RESOURCES ARE PROVIDED "AS IS" AND WITH ALL FAULTS. TI DISCLAIMS ALL OTHER WARRANTIES OR REPRESENTATIONS, EXPRESS OR IMPLIED, REGARDING TI RESOURCES OR USE THEREOF, INCLUDING BUT NOT LIMITED TO ACCURACY OR COMPLETENESS, TITLE, ANY EPIDEMIC FAILURE WARRANTY AND ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, AND NON-INFRINGEMENT OF ANY THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

TI SHALL NOT BE LIABLE FOR AND SHALL NOT DEFEND OR INDEMNIFY YOU AGAINST ANY CLAIM, INCLUDING BUT NOT LIMITED TO ANY INFRINGEMENT CLAIM THAT RELATES TO OR IS BASED ON ANY COMBINATION OF PRODUCTS EVEN IF DESCRIBED IN TI RESOURCES OR OTHERWISE. IN NO EVENT SHALL TI BE LIABLE FOR ANY ACTUAL, DIRECT, SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF TI RESOURCES OR USE THEREOF, AND REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

You agree to fully indemnify TI and its representatives against any damages, costs, losses, and/or liabilities arising out of your noncompliance with the terms and provisions of this Notice.

This Notice applies to TI Resources. Additional terms apply to the use and purchase of certain types of materials, TI products and services. These include; without limitation, TI's standard terms for semiconductor products (<http://www.ti.com/sc/docs/stdterms.htm>), evaluation modules, and samples (<http://www.ti.com/sc/docs/sampterm.htm>).

This software product may be used to configure the TI mmWave device outside regional regulations for RF emissions. Users are responsible for understanding local RF emission regulations and operating the product within those regulations.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265

Copyright © 2022, Texas Instruments Incorporated