AGILE SOLUTIONS

SDR STARTER KIT
PC Based SDR System

User Manual

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1. Introduction

Agile Software Radio Peripheral is a PC based software defined radio (SDR) platform for designing wireless communications systems. ASRP boards are developed for research and technology development for wireless communications, including both fixed and mobile, satellite and terrestrial based applications.

ASRP4 from now termed as SDR Starter Kit/board is a 2X2 MIMO SDR Platform or 1X1 SDR Platform with USB 3.0 based Host (PC) interface. The hardware architecture covers 50 MHz to 6 GHz with a channel bandwidth of 200KHz to 56MHz. SDR Starter board comes with driver support for Windows and Linux operating systems. A comprehensive set of demo examples are available for application developers to get started instantly. ASRP boards are integrated directly with MATLAB, SIMULINK, LABVIEW, MS VC++, MS VC# and GNURadio.

SDR Starter Board

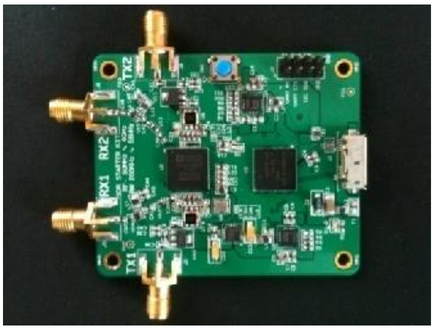


Figure 1: PC Based SDR Platform

SDR Starter kit is USB bus powered and plug and play. It is developed using latest USB 3.0 interface and can stream IQ data upto 320MBytes/Sec in realtime to/from PC making it 80MHz realtime IQ data streaming. SDR Starter kit auto detects USB ports for its compatibility. It works seamlessly with USB 2.0 ports as well.

Below are set of possibilities which can be exercised on SDR Starter kit

Type	Possibilities
Single Carrier	**AM, PM, FM, BPSK, QPSK, QAM, MSK, other variants and higher modulation schemes**
Multi Carrier	**OFDM, OFDMA, SC-FDMA, MC-CDMA**
Multi Antenna	**MIMO, Beam forming, SDMA, Spatial Diversity and Multiplexing**
Communication standards	**3GPP** **CDMA2000, TD SCDMA, 1xEVDO, WCDMA, GSM, LTE** **IEEE** **WIMAX 16a,16d,16e** **802.11a/b/g/n, HIPERLAN** **802.15.4 (ZigBee), Bluetooth, RFID** **Broadcast Technology** **DVB(set top box), DAB (world space)**
Others	**Radar, SIGINT, COMINT, MILCOM**

Table 1*:* Set of Possibilities exercised on SDR Starter kit

2. SDR Starter Kit Features

- **RF Tuning Range 50MHz to 6GHz with resolution 1 Hz.**
    - This frequency range covers almost 80% of the spectrum utilised by all the wireless applications.

- **Tuneable Baseband Sampling frequency from 200KHz to 56MHz.**
    - This feature helps to cut down the arbitrary sampling rate converters in the signal chain.

- **Onboard Tuneable Clock provides 0.025PPM accuracy and comes with factory calibration.**
    - This provides onboard GPS disciplined clock which very useful for wireless Base Station development.

- **Frequency Hopping with <100us provides a great solution for defense application**

- **EVM of less than 3% which means high performance RF transceiver providing near Ideal to High end Test and Measurement equipment and also supports most of the higher order modulation schemes.**

- **USB 3.0 interface which provides streaming IQ Data upto 80MSPS to/from PC which brings high bandwidth application development support**

- **PC Based 2X2 MIMO SDR Platform**

- **Tuneable Channel Bandwidth 200KHz to 56Mhz**

- **Direct RF Signal Transmission and Reception from MATLAB, LABVIEW, VC++, VC#, C and GNURadio**

- **Its terminal Software suite provides a simple plug and play interface for leading algorithm design and development IDE's like MATLAB, LABVIEW, VC++, VC#, C and GNURadio**

2.1. Super Rich Features of SDR Starter Kit

SDR Starter Kit has got inbuilt AGC which brings an ultimate solution for near/far field problems. The built in AGC can be tuned for FAST/SLOW attack mode depending upon the application requirement. Because of this wonderful feature, an impossible realtime AGC control loop for the applications running on desktops will now be able have this feature.

It has onboard 128 TAP FIR filter both for transmit and receive chain which reduces the burden of the host PC for implementing last block of the signal chain for any wireless application. This greatly improves overall over system performance of the application development.

3. Hardware Specifications

- **RF 2 × 2 transceiver with integrated 12-bit DACs and ADCs**
- **RF Tuning Range: 50MHz to 6.0 GHz**
- **Programmable Sampling Rates from 200KHz to 64MHz**
- **Onboard configurable PLL's for synchronized clocking for all the Tx and RX paths**
- **Built-in LO generation from 47MHz to 6GHz**
- **Programmable Lowpass filters for both Tx and Rx chains**
- **Tuneable Crystal 26MHz, with 25 PPb accuracy**
- **Supports TDD operation**
- **Tuneable channel bandwidth: <200 kHz to 56 MHz**
- **Dual receivers: 2 single-ended inputs on SMA with 50 Ohms**
- **Dual transmitters: 2 Single outputs on SMA with 50 Ohms**
- **Superior receiver sensitivity with a noise figure of 7 dB at 800 MHz local oscillator (LO)**
- **RX gain control: 0 dB to 70 dB**
  - Real-time monitor and control signals for manual gain
  - Independent automatic gain control
- **Highly linear broadband transmitter**
- **TX EVM: ≤−40 dB**
- **TX noise: ≤−150 dBm/Hz noise floor**
- **Integrated fractional-N synthesizers**
- **DC offset cancellation feature**
- **76 dB Receiver gain control with 0.5dB step**
- **60 dB Transmitter gain control with 0.5dB step**
- **Maximum Power output 0dBm(Single Tone +8dBm)**
- **Noise figure ~6dB**
- **TDD and FDD support**
- **I2C and UART interface**

4. Packing List

Please check that the following items are in the package sent to you and contact Agile Solutions if any items are missing:

- SDR Starter Board in anti-static bag
- USB 3.0 cable
- 2 Antennas in 2.4GHz ISM Band

5. System Requirements

Please ensure the following system requirements in order to start using SDR Starter system

- Host computer with USB 3.0/2.0 ports and running any of the Windows (XP, Vista, Windows 7, Windows 8) operating system.
- Development Software
  - MATLAB: Any 32bit version from 2008a to 2014a or
  - LabView: 32bit version from 2013 or
  - Visual Studio 2008 to 2013

6. Hardware Setup

Ideally all these installation operations should be performed in an anti-static environment with an anti-static workbench and antistatic wrist-straps. Alternatively if this is not possible you should earth yourself regularly during installation by touching an unpainted earthed metal surface.

Place the board on a flat surface close enough to the host PC so that the USB cable reaches between them

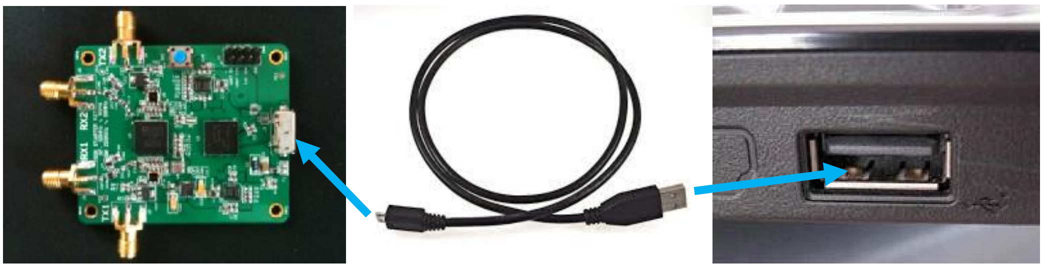


Figure 2: Hardware Plug-in setup

Plug the one side of the USB cable into SDR Starter Board and other side to the PC as shown in the above figure

7. ASRP4 LICENSE INSTALLATION

Every SDR Starter Kit comes with License Key inorder to work with the hardware. This License Key is provided as License.txt. This License file should be placed as “c:\ASRP4License\License.txt”.

1. In “C” drive create a folder named ASRP4License and

2. Copy the License.txt file into this new folder

The ASRP4 drivers will check for the license file in this path and validates the same. All the ASRP4 drivers will fail to work if this License file is missing or corrupt.

8. USB Drivers Installation

SDR Starter Kit is supplied with USB Drivers for all operating systems. Please follow the instructions below to install the USB drivers. This installation is required only once for the first time. After successful installation of the USB Drivers, all the SDR Starter Kit API software will be able to communicate with the Hardware.

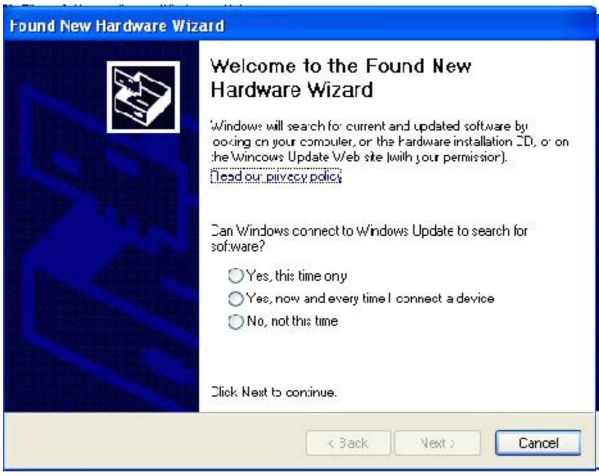
8.1. Installation of PC USB Drivers for Windows XP

PC USB Drivers are required for communicating to SDR Starter board from the PC. Below is the list of files for getting started working with SDR Starter kit.

cyusb3.sys, cyusb3.inf, WdfCoInstaller01009.dll

These drivers need to be installed on the PC where SDR Starter boards needs to be connected. When SDR Starter board is connected for the first time on the USB port of the PC, a window will pop up asking for the USB drivers.

Please browse to the path of USB Driver folder and complete the steps in installation wizard. Below are the figures showing the USB driver installation for SDR Starter Kit.



Found New Hardware Wizard

Welcome to the Found New Hardware Wizard

Windows will search for current and updated software by looking on your computer, on the hardware installation CD, or on the Windows Update Web site (with your permission).

Read our privacy policy

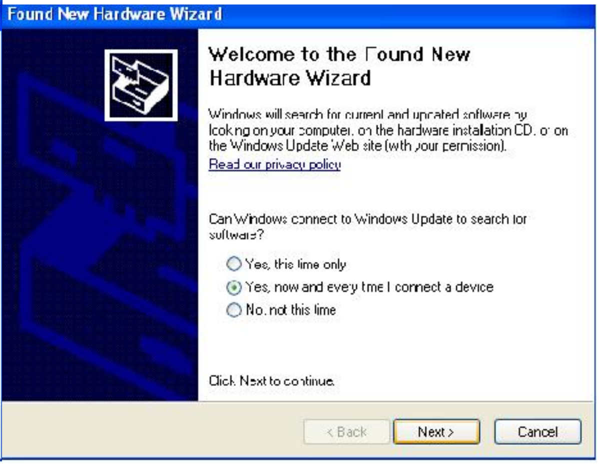
Can Windows connect to Windows Update to search for software?

○ Yes, this time only

○ Yes, now and every time I connect a device

○ No, not this time

Click Next to continue.



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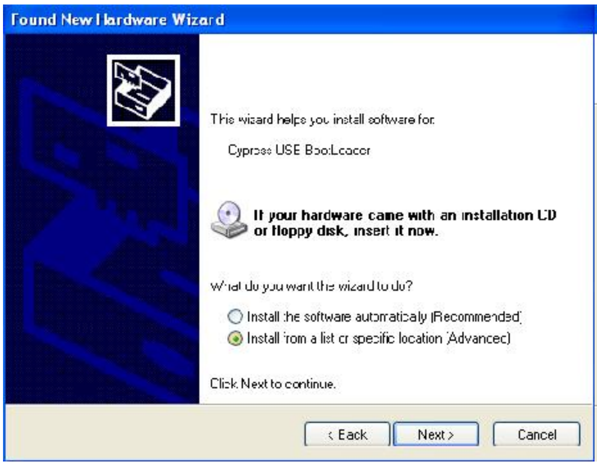
○ Yes, this time only

● Yes, now and every time I connect a device

○ No, not this time

Click Next to continue.



Found New Hardware Wizard

This wizard helps you install software for:

Cypress USB BootLoader

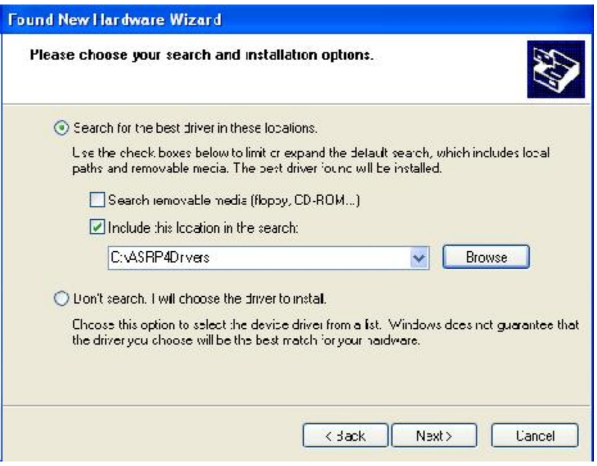
If your hardware came with an installation CD or floppy disk, insert it now.

What do you want the wizard to do?

○ Install the software automatically (Recommended)

● Install from a list or specific location (Advanced)

Click Next to continue.



Found New Hardware Wizard

Please choose your search and installation options.

● Search for the best driver in these locations.

Use the check boxes below to limit or expand the default search, which includes local paths and removable media. The best driver found will be installed.

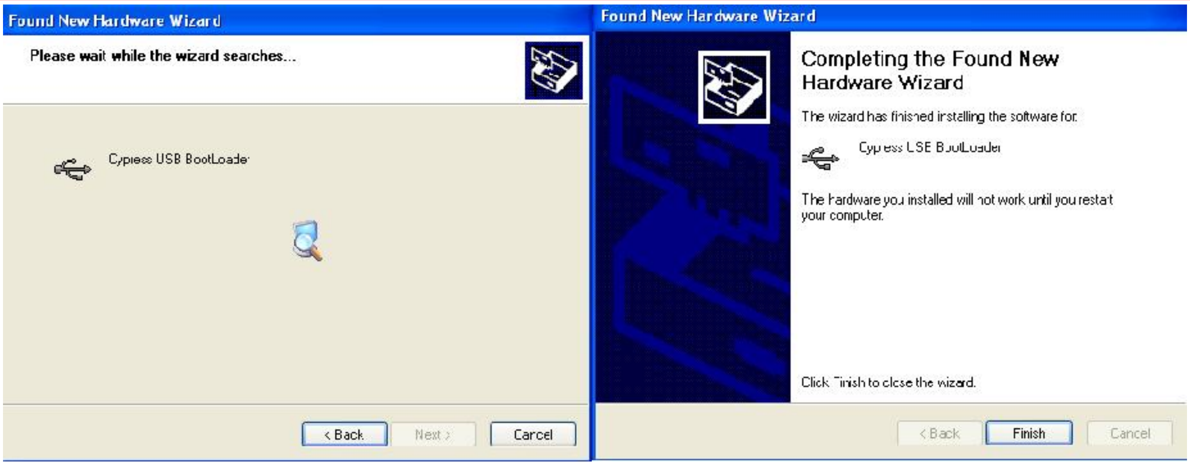
□ Search removable media (floppy, CD-ROM...)

☑ Include this location in the search:

C:\ASRP4Drivers

○ Don't search. I will choose the driver to install.

Choose this option to select the device driver from a list. Windows does not guarantee that the driver you choose will be the best match for your hardware.



Found New Hardware Wizard

Please wait while the wizard searches...

Cypress USB BootLoader

Found New Hardware Wizard

Completing the Found New Hardware Wizard

The wizard has finished installing the software for:

Cypress USB BootLoader

The hardware you installed will not work until you restart your computer.

Click Finish to close the wizard.

Figure 3: USB driver installation wizard

8.2 Installation of PC USB Drivers for Windows 8

PC USB Drivers are required for communicating to SDR Starter board from the PC. Below is the list of files for getting started working with SDR Starter kit.

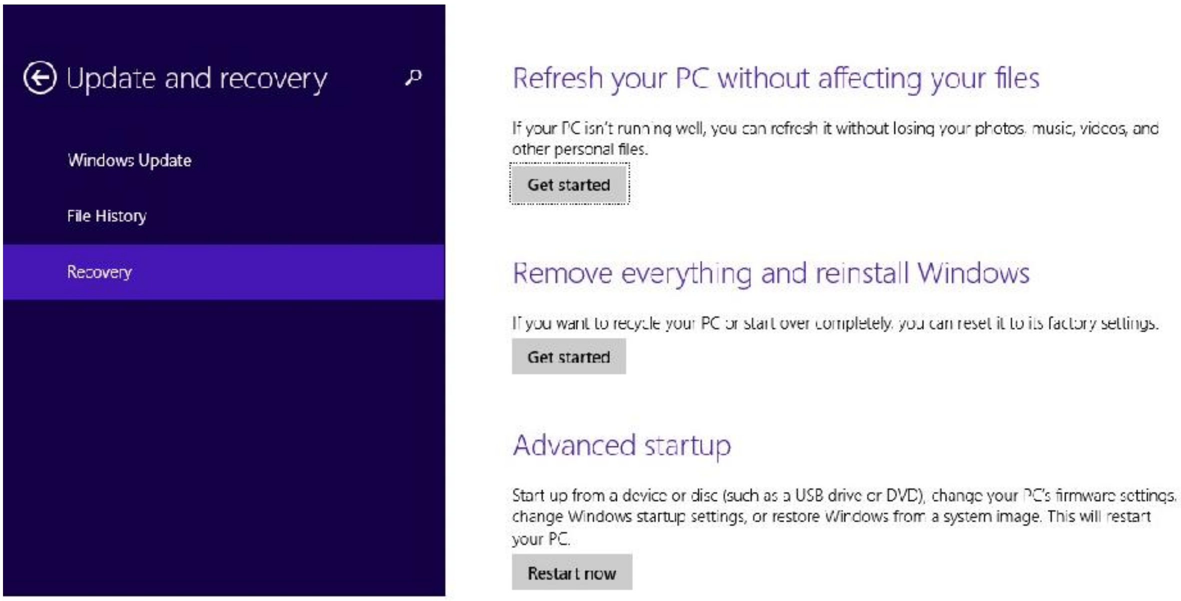
cyusb3.sys, cyusb3.inf, WdfCoInstaller01009.dll

These drivers need to be installed on the PC where SDR Starter boards needs to be connected.

NOTE: BEFORE PROCEEDING FOR INSTALLING USB DRIVERS, WINDOWS USB DRIVER SIGNATURE ENFORCEMENT NEEDS TO BE DISABLED. PLEASE FOLLOW THE INSTRUCTION BELOW TO DISABLE WINDOWS DRIVER SIGNATURE ENFORCEMENT.

WINDOWS DRIVER SIGNATURE DISABLING

1. Press Windows+C to get the Windows Charms on right side of Display
2. Search for "Recovery" keyword
3. Select **"Recovery Options"**



Refresh your PC without affecting your files

If your PC isn't running well, you can refresh it without losing your photos, music, videos, and other personal files.

Remove everything and reinstall Windows

If you want to recycle your PC or start over completely, you can reset it to its factory settings.

Advanced startup

Start up from a device or disc (such as a USB drive or DVD), change your PC's firmware settings, change Windows startup settings, or restore Windows from a system image. This will restart your PC.

Figure 4: Windows 8.1 Advanced Recovery Option

4. Goto Advanced Startup and Restart
5. **After Restart, Goto Troubleshoot->Advanced Options->Startup Settings and Restart again**
6. **After Restart, press F7. This will disable the USB Driver Signature enforcement and restarts the PC again.**

Installation of USB Drivers

1. Connect the SDR Starter Board to PC
2. Goto Device Manager

a. Right click on the Computer

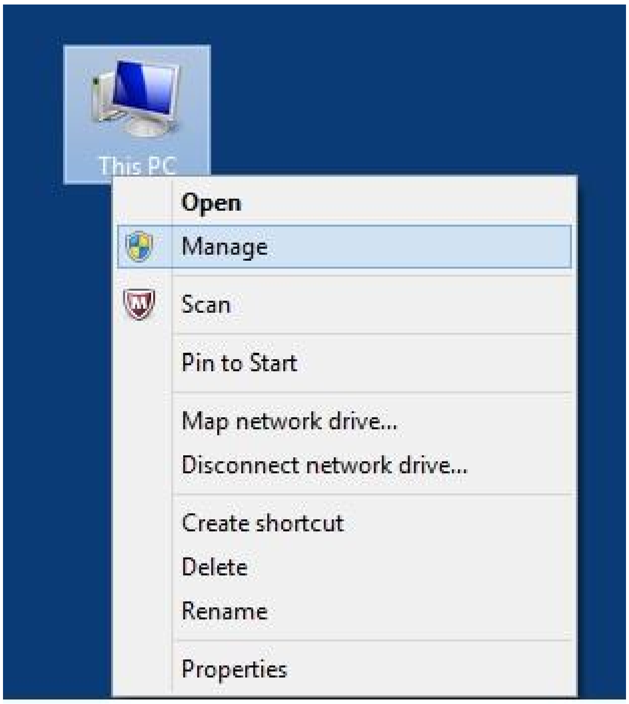


Figure 5: Right click options

b. Select “Manage”

c. Select “Device Manager” from Left Pane

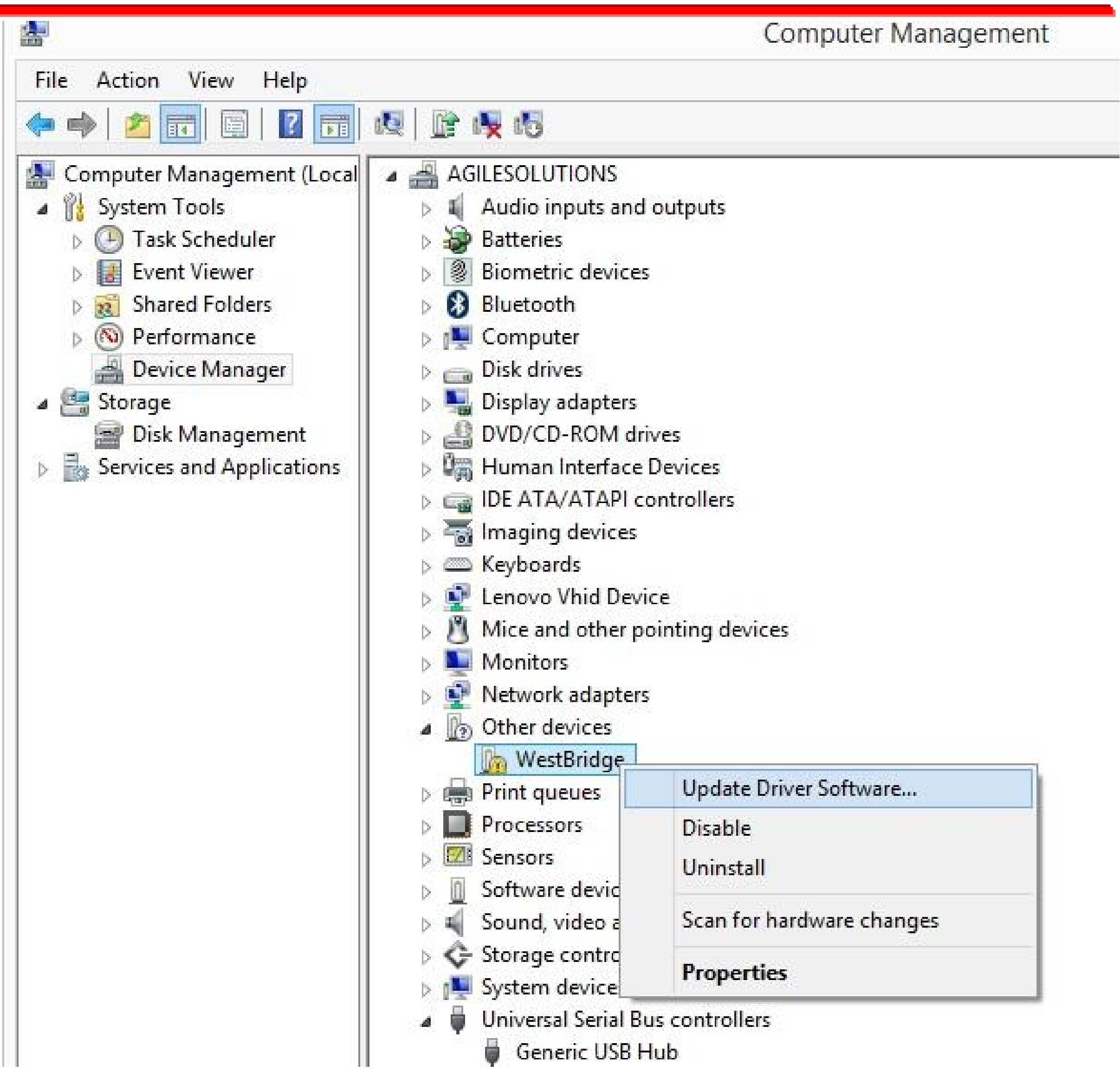
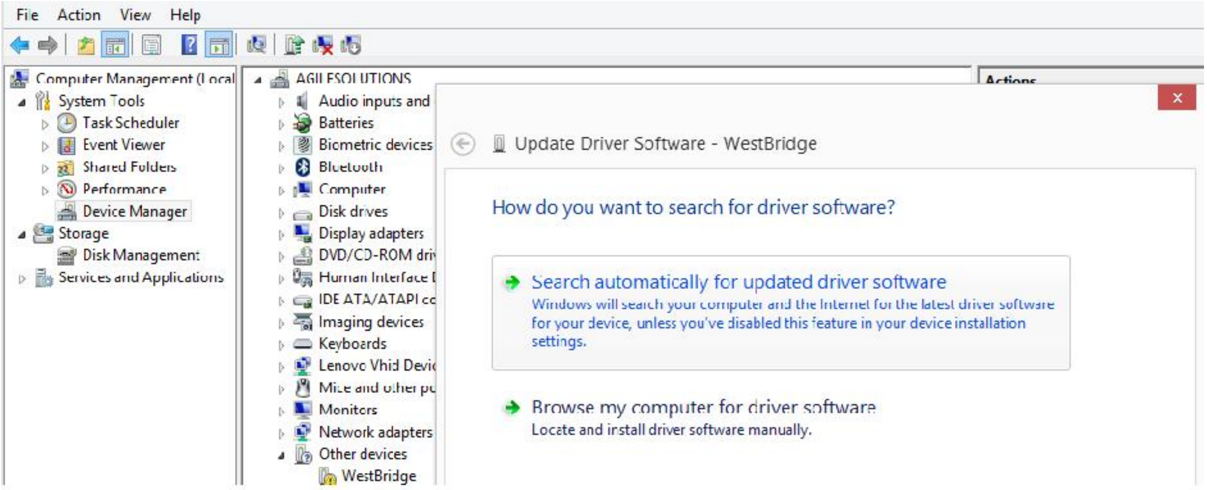


Figure 6: Device Manager List

Now, the Device Manager will be listing the Connected SDR Starter Board as “Westbridge”.

1. Right Click on the “Westbridge” and select properties

2. Click on Update Driver Software and Select first option. This will take several minutes to update USB drivers in the system. Please make sure the PC is connected to Internet. After this process completes and still the USB drivers are **NOT INSTALLED**



Update Driver Software - WestBridge

How do you want to search for driver software?

Search automatically for updated driver software
Windows will search your computer and the Internet for the latest driver software for your device, unless you've disabled this feature in your device installation settings.

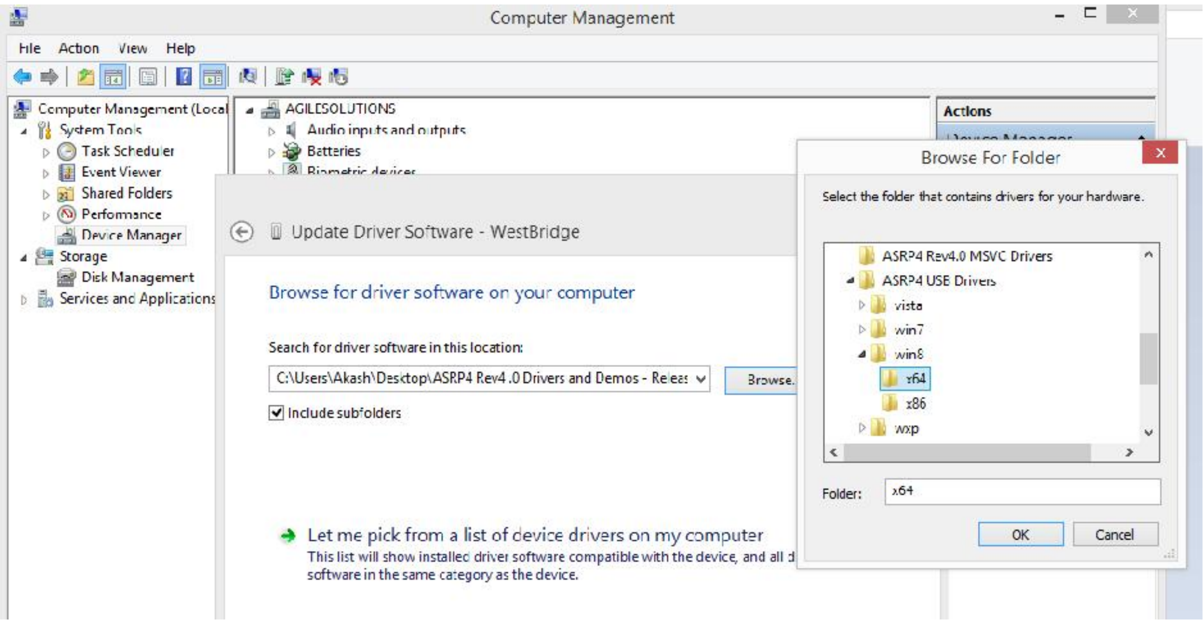
Browse my computer for driver software
Locate and install driver software manually.

Figure 7: Selecting first option for Driver Update

3. **Restart the PC**

4. **Goto Device manager again and select update driver software for “Westbridge”**

5. **This time Select second option and browse to the SDR Starter Kit USB Drivers folder. Select the respective USB driver Folder as per the Operating System.**



Update Driver Software - WestBridge

Browse for driver software on your computer

Search for driver software in this location:

C:\Users\Akash\Desktop\ASRP4 Rev4.0 Drivers and Demos - Releas

Browse...

☑ Include subfolders

Let me pick from a list of device drivers on my computer
This list will show installed driver software compatible with the device, and all d software in the same category as the device.

Browse For Folder

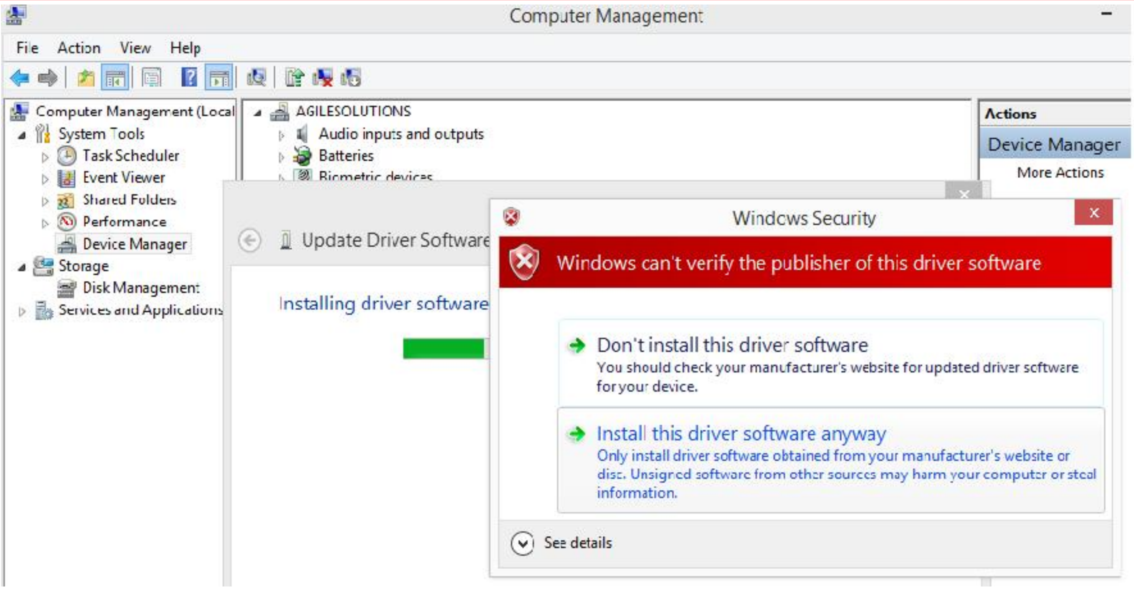
Select the folder that contains drivers for your hardware.

Folder: x64

OK Cancel

Figure 8: Selecting second option for Driver Update

6. **Click Next. Complete the Installation process.**



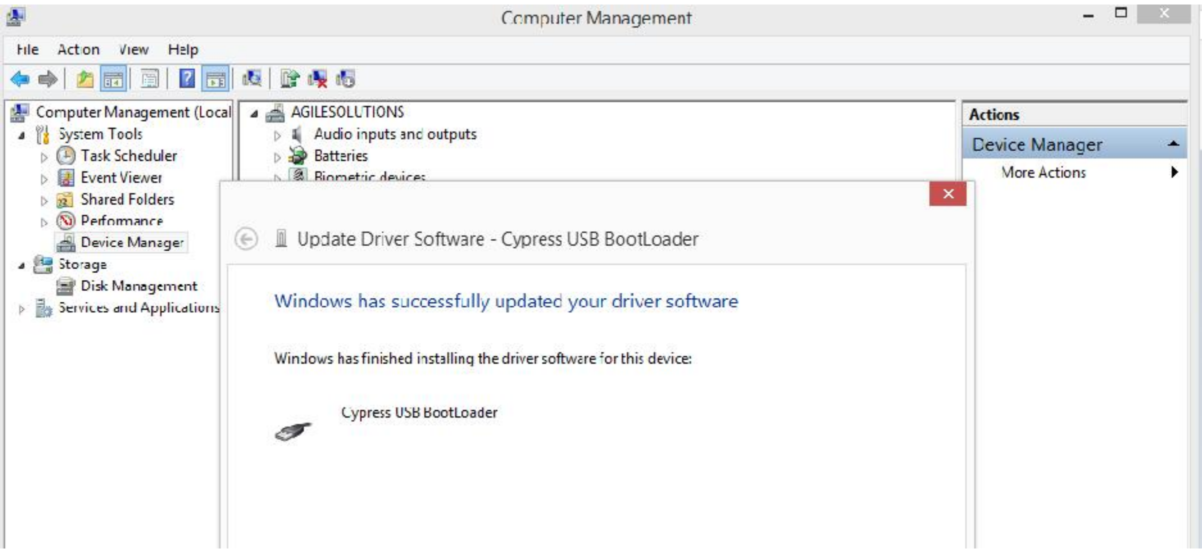
Installing driver software

Windows can't verify the publisher of this driver software

Don't install this driver software
You should check your manufacturer's website for updated driver software for your device.

Install this driver software anyway
Only install driver software obtained from your manufacturer's website or disc. Unsigned software from other sources may harm your computer or steal information.

Figure 9: Installation of Driver Software



Update Driver Software - Cypress USB BootLoader

Windows has successfully updated your driver software

Windows has finished installing the driver software for this device:

Cypress USB BootLoader

Figure 10: Completion of Driver Update

7. **Goto Device Manager again and under USB device tree, you should be able to see "Cypress USB Bootloader".**

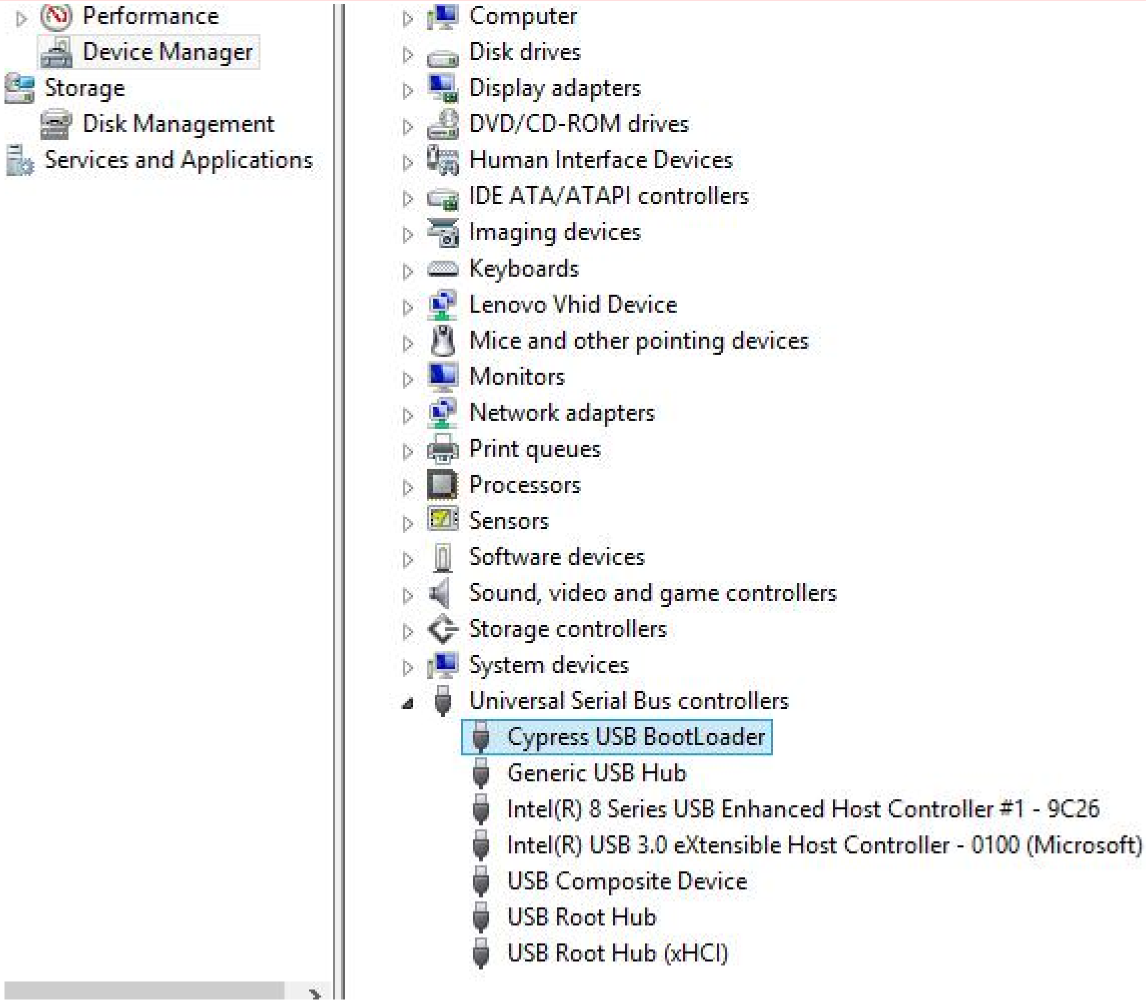


Figure 11: Installed Driver listed in Device Manager

8. **This completes the USB Driver Installation.**

9. SDR Starter Kit Software Libraries

ASRP4 Software’s are available in the form of precompiled DLL’s. They provide API’s for complete set of features supported by ASRP4.

- ASRP4DLL.dll
- ASRP4DLL.h

User needs to just use the respective API’s for configuring and controlling the board. With respective API’s SDR Starter Kit will be ready for acquiring or sending signals in realtime from the PC. Typically MATLAB, Simulink, LabView or Visual Studio can be used for working with Signals.

10. API Library for Microsoft Visual Studio

API function	Description
void InitializeASRP4 (char TxRx, char NumCh);	This function initializes ASRP4. This function needs be called only once after powering up ASRP4. TxRx should be set to one for initializing ASRP4 to Transmitter mode and TxRx should be set to zero for initializing ASRP4 to Receiver mode and NumCh should be set to 1 for one channel and 2 for two channels
void RxIQData (int16 *IDataIn, int16 *QDataIn);	This function streams IQ samples of RF signals from ASRP4 board to PC at defined RF center frequency. This function returns 4096 samples for IData and QData at a time. This function can be called in a loop for continuous reception of signals.
void TxIQData (int16 *IDataOut, int16 *QDataOut);	This function streams IQ samples to ASRP4 board to generate RF signals at defined RF center frequency. This function accepts 4096 samples for IData and QData at a time. This function can be called in a loop for continuous transmission.
double ASRP_Tune_Tx_RF (double RF);	This function Tunes the desired RF center frequency anywhere in the range of 50MHz to 6GHz.
double ASRP_Tune_Rx_RF (double RF);	This function Tunes the desired RF center frequency anywhere in the range of 50MHz to 6GHz.
double ASRP_Tune_Tx_BW (double BW);	This function Tunes the multiple Filters in the Transmitter Signal chain to desired Bandwidth in the range anywhere where between 200KHz to 56MHz.
double ASRP_Tune_Rx_BW (double BW);	This function Tunes the multiple Filters in the Receiver Signal chain to desired Bandwidth in the range anywhere where between 200KHz to 56MHz.
double ASRP_Tune_Tx_SampFreq (double SampFreq);	This function Tunes the desired Sampling Frequency anywhere in the range 200KHz to 56MHz. In to channel mode the maximum sampling frequency cannot be more than 50MHz for each channel.
double ASRP_Tune_Rx_SampFreq (double SampFreq);	This function Tunes the desired Sampling Frequency anywhere in the range 200KHz to 56MHz. In to channel mode the maximum sampling frequency cannot be more than 50MHz for each channel.
double ASRP_Tune_Tx_FIR_En (double FIR_En);	This function Enables or Disables the Interpolating FIR Filter in the transmitter signal chain. This is an onboard 128 Tap FIR filer and can be used for Interpolation and as well for Pulse shaping. The Interpolation factors supported are 1,2 and 4.
double ASRP_Tune_Rx_FIR_En (double FIR_En);	This function Enables or Disables the Decimating FIR Filter in the receiver signal chain. This is an onboard 128 Tap FIR filer and can be used for Decimation and as well for Pulse shaping. The Decimation factors supported are 1,2 and 4.
double ASRP_Tune_Tx_Attn (double Attn);	This function Tunes the desired attenuation level at the transmitter output in range anywhere between 0 dB to 60 dB with step of 0.5dB.
double ASRP_Tune_Rx_GCMode (double GCMode);	This function sets the receiver AGC Mode into Manual or Automatic Mode. In Manual Mode the receiver Tunes the Receiver signal chain gain as per the Manual Gain Value setting. In AGC mode the RSSI is calculated automatically and Gain is continuously adapted to the received signal strength. Under AGC Mode, Fast and Slow attack mode are supported.
double ASRP_Tune_Rx_Gain (double Gain);	This function tunes the Receiver Gain at various stages in the receiver signal chain with total maximum Gain of 76 dB and can varied in the range of 0 dB to 76 dB with step size of 0.5 dB.

Table 2: API Library for Microsoft Visual studio

11. API Library for MATLAB

MATLAB is the powerful IDE for developing algorithms and provides most powerful Signal Processing Libraries which can be used to build communication signal chains in very less time. ASRP4 comes with MATLAB drivers for working with realtime RF signals. Below are the set of MATLAB functions for the ASRP4 board.

API function	Description
Initialize_Transmitter(True);	This function initializes ASRP4. This function needs be called only once after powering up ASRP4.
SetTxRFCenterFrequency (RFCenterFreq_MHz);	This function Tunes the desired RF center frequency anywhere in the range of 50MHz to 6GHz.
SetTxSamplingFrequency (SamplingFreq_Hz);	This function Tunes the desired Sampling Frequency anywhere in the range 200KHz to 56MHz. In to channel mode the maximum sampling frequency cannot be more than 50MHz for each channel.
SetTxChannelBandwidth (ChannelBandwidth_Hz);	This function Tunes the multiple Filters in the Transmitter Signal chain to desired Bandwidth in the range anywhere where between 200KHz to 56MHz.
SetTxPowerAttenuation (TransmitterPowerAttenuation_dB);	This function Tunes the desired attenuation level at the transmitter output in range anywhere between 0 dB to 60 dB with step of 0.5dB.
SetTxFilterEnable (EnableInterpolatingFIRFilter);	This function Enables or Disables the Interpolating FIR Filter in the transmitter signal chain. This is an onboard 128 Tap FIR filer and can be used for Interpolation and as well for Pulse shaping. The Interpolation factors supported are 1,2 and 4.
TxIQData(IData, QData);	This function streams IQ samples to ASRP4 board to generate RF signals at defined RF center frequency. This function accepts 4096 samples of Complex IQData at a time. This function can be called in a loop for continuous transmission.
Initialize_Receiver(True);	This function initializes ASRP4. This function needs be called only once after powering up ASRP4.
SetRxRFCenterFrequency (RFCenterFreq_MHz);	This function Tunes the desired RF center frequency anywhere in the range of 50MHz to 6GHz
SetRxFilterEnable (EnableDecimatingFIRFilter);	This function Enables or Disables the Decimating FIR Filter in the receiver signal chain. This is an onboard 128 Tap FIR filer and can be used for Decimation and as well for Pulse shaping. The Decimation factors supported are 1,2 and 4.
SetRxSamplingFrequency (SamplingFreq_Hz);	This function Tunes the desired Sampling Frequency anywhere in the range 200KHz to 56MHz. In to channel mode the maximum sampling frequency cannot be more than 50MHz for each channel.
SetRxChannelBandwidth (ChannelBandwidth_Hz);	This function Tunes the multiple Filters in the Receiver Signal chain to desired Bandwidth in the range anywhere where between 200KHz to 56MHz.
SetRxGainControlMode (AGC_Mode_Fast_slow_Manual);	This function sets the receiver AGC Mode into Manual or Automatic Mode. In Manual Mode the receiver Tunes the Receiver signal chain gain as per the Manual Gain Value setting. In AGC mode the RSSI is calculated automatically and Gain is continuously adapted to the received signal strength. Under AGC Mode, Fast and Slow attack mode are supported.
SetRxManualGain (ReceiverGain_dB);	This function tunes the Receiver Gain at various stages in the receiver signal chain with total maximum Gain of 76 dB and can varied in the range of 0 dB to 76 dB with step size of 0.5 dB.
RxIQData(IQData);	This function streams IQ samples of RF signals from ASRP4 board to PC at defined RF center frequency. This function returns 4096 samples of Complex IQData at a time. This function can be called in a loop for continuous reception of signals.

Table 3: API Library for MATLAB

12. SDR Starter Kit Working with MATLAB

SDR Starter Kit API's for MATLAB are compatible with MATLAB versions from MATLAB2008a to MATLAB2014b. Minimum system requirements to work with SDR Starter Kit with MATLAB are any Windows OS and preinstalled MATLAB with PC having 2GB RAM and Intel Core i3/i5/i7 (3Gen/4Gen).

For working with SIMULINK, MATLAB Versions 2003b and above only are supported.

Note: Please note that the SDR Starter Kit Driver API's for MATLAB are precompiled DLL's and require that MATLAB mex compiler is configured. If you are not sure of this Compiler configured for MATLAB then

1. Type "mex -setup" in MATLAB command prompt and select any listed compilers. At the minimum MATLAB comes with LCC compiler and can be used as default compiler.

2. Microsoft VC++ of any version can also be used for default compiler. For setting this compiler see more detailed help in MATLAB documentation.

12.1. Demo Example of Generating a Tone Signal with SDR Starter kit in MATLAB

A Tone Signal can be generated using SDR Starter Kit in MATLAB. It can be done using following steps

- Connect SDR Starter kit to your PC
- Copy the below code into a new MATLAB script and save it
- Set the parameters and run the file
- Now the Tone Signal is being generated

```
MyASRP4 = ASRP4;
NumberOfSamples = 4096;
SamplingFrequency = 1e6;
CarrierFrequency = 40e3;
RFcenterFrequency = 2.4e9;
Bandwidth = 1e6;
TransmitterPowerAttenuation = 0;
EnableInterpolatingFIR = 0;
DAC_Scaling_Factor = 2000;


MyASRP4.Initialize_Transmitter(1);
MyASRP4.SetTxRFCenterFrequency(RFcenterFrequency);
MyASRP4.SetTxSamplingFrequency(SamplingFrequency);
MyASRP4.SetTxChannelBandwidth(Bandwidth);
MyASRP4.SetTxPowerAttenuation(TxPowerAttenuation);
MyASRP4.SetTxFilterEnable(EnableInterpolatingFIR);

TimeVector = 0:(1/SamplingFrequency):(NumberOfSamples/SamplingFrequency);
ToneSignal = exp(-i1*2*pi*CarrierFrequency*TimeVeector)* DAC_Scaling_Factor;

while(1)
  TxIQData(ToneSignal);
end
```

12.2. Demo Example of Generating a QAM-4/16/64 Signals with SDR Starter Kit in MATLAB

A QAM-4/16/64 Signal can be generated using SDR Starter Kit in MATLAB. It can be done using following steps

- Connect SDR Starter kit to your PC
- Copy the below code into a new MATLAB script and save it
- Set the parameters and run the file
- Now the QAM-4/16/64 signal is being generated

```
MyASRP4 = ASRP4;
QAM4 = 4;
QAM16 = 16;
QAM64 = 64;
NumberOfSamples = 4096;
SamplingFrequency = 1e6;
CarrierFrequency = 40e3;
RFcenterFrequency = 2.4e9;
Bandwidth = 1e6;
TransmitterPowerAttenuation = 0;
EnableInterpolatingFIR = 0;
DAC_Scaling_Factor = 2000;


MyASRP4.Initialize_Transmitter(1);
MyASRP4.SetTxRFCenterFrequency(RFcenterFrequency);
MyASRP4.SetTxSamplingFrequency(SamplingFrequency);
MyASRP4.SetTxChannelBandwidth(Bandwidth);
MyASRP4.SetTxPowerAttenuation(TxPowerAttenuation);
MyASRP4.SetTxFilterEnable(EnableInterpolatingFIR);
while(1)
x = randint(NumberOfSamples,1, QAM16);     % Create a signal source.
h = modem.qammod(QAM16);                   % Create a modulator object
y = modulate(h,x)* DAC_Scaling_Factor = 2000;   % Modulate the signal x.
TxIQData(y);
end
```

12.3. Demo Example of Receiving FM Signals with SDR Starter Kit in MATLAB

Live FM Signals can be received using SDR Starter Kit in MATLAB. It can be done using following steps

- Connect SDR Starter kit to your PC
- Copy the below code into a new MATLAB script and save it
- Set the required FM station frequency in RfcenterFrequency and other parameters and run the file
- Now the FM station which has been tuned will be demodulated in realtime and the demodulated signal is played through the speakers.

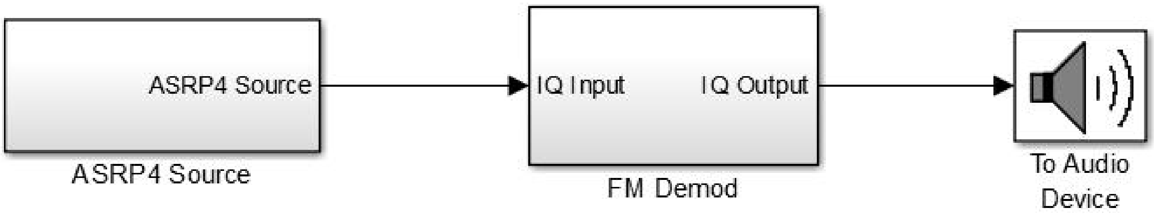
```
SamplingFrequency = 400e3;
RFcenterFrequency = 95e6;
Bandwidth = 500000;
TransmitterPowerAttenuation = 0;
EnableInterpolatingFIR = 1;
AGC_FastAttack = 1;
ManualGain = 76;

MyASRP4 = ASRP4;
MyASRP4.Initialize_Receiver(1);
MyASRP4.SetRxRFCenterFrequency(RFcenterFrequency);
MyASRP4.SetRxFilterEnable(EnableDecimatingFIR);
MyASRP4.SetRxSamplingFrequency(SamplingFrequency);
MyASRP4.SetRxChannelBandwidth(Bandwidth);
MyASRP4.SetRxGainControlMode(AGC_FastAttack);
MyASRP4.SetRxManualGain(ManualGain);

while(1)
   x = RxIQData;
   plot(20*log10(abs(fftshift((fft(x)))))); % spectrum Plot
   BaseBandAudio = diff(unwrap(angle(x))); %FM Demod
   soundsc(BaseBandAudio,400e3,16); % Audio Playback
end
```

13. SDR Starter Kit Working with SIMULINK

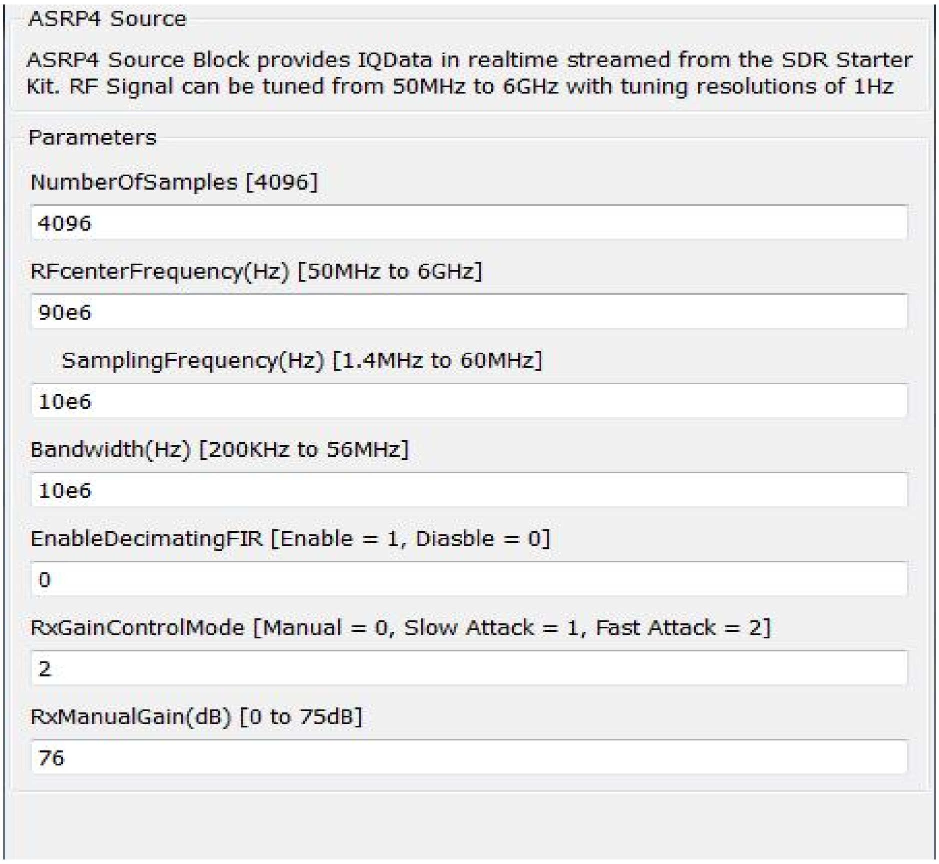
SDR Starter Kit Simulink drivers provide Source and Sink Blocks. These blocks can be used for generating and receiving RF signals from SDR Starter Kit in realtime. ASRP4 Simulink source and Sink Blocks provides a great flexibility to utilize Simulink's vast set of libraries to readily build a wireless communication system without writing a single piece of code. A Signal Generator and Receiver can be be built by just connecting blocks in sequence as can be seen as simple text book representation of any communications systems signal chain.

13.1. ASRP4 Simulink Source Block

ASRP4 Simulink **Source Block** provides stream of Complex IQ Data within Simulink model. This stream of IQData is the digitized waveform of the tuned RF Signal in SDR Starter Kit. This signal can then be further processed using Simulink's vast Library of Signal Processing Blocks.



For configuration and tuning of the SDR Starter Kit, Double Click on Simulink ASRP4 Source Block. This will pop up a Configuration Panel for tuning the SDR Starter Kit.



ASRP4 Source

ASRP4 Source Block provides IQData in realtime streamed from the SDR Starter Kit. RF Signal can be tuned from 50MHz to 6GHz with tuning resolutions of 1Hz

Parameters

NumberOfSamples [4096]

4096

RFcenterFrequency(Hz) [50MHz to 6GHz]

90e6

SamplingFrequency(Hz) [1.4MHz to 60MHz]

10e6

Bandwidth(Hz) [200KHz to 56MHz]

10e6

EnableDecimatingFIR [Enable = 1, Diasble = 0]

0

RxGainControlMode [Manual = 0, Slow Attack = 1, Fast Attack = 2]

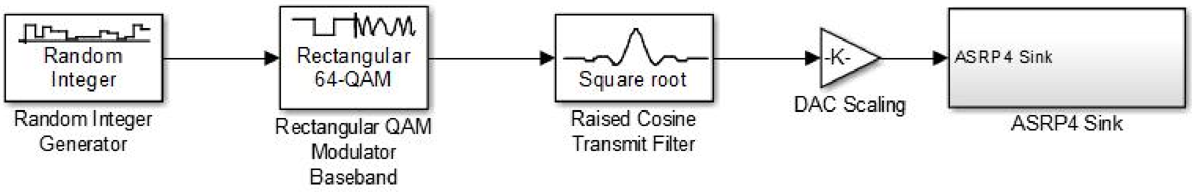
2

RxManualGain(dB) [0 to 75dB]

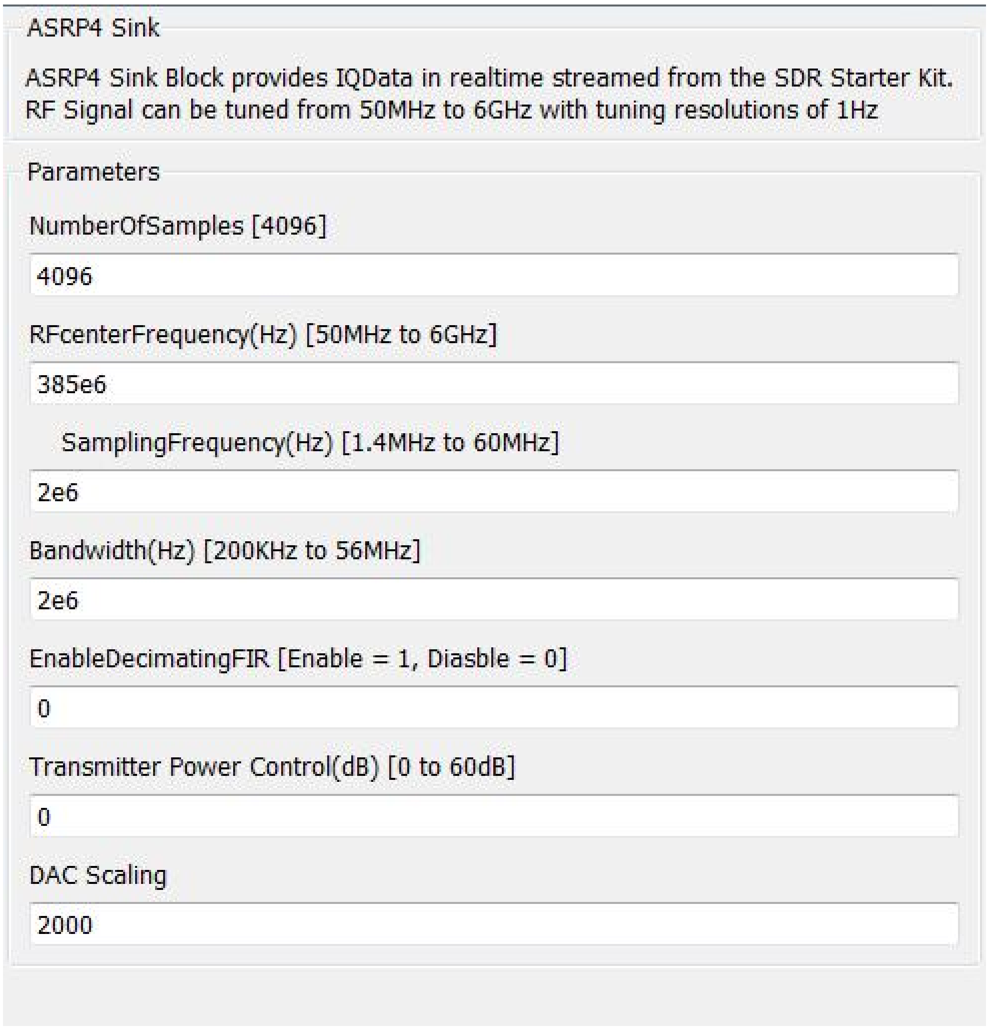
76

ASRP4 Simulink Sink Block

ASRP4 Simulink **Sink Block** accepts stream of Complex IQ Data within Simulink model. This stream of digitized waveform basically IQData is streamed in realtime to SDR Starter Kit and is upconverted and transmitted at desired RF Frequency.



For configuration and tuning of the SDR Starter Kit, Double Click on Simulink ASRP4 Sink Block. This will pop up a Configuration Panel for tuning the SDR Starter Kit.



ASRP4 Sink

ASRP4 Sink Block provides IQData in realtime streamed from the SDR Starter Kit.
RF Signal can be tuned from 50MHz to 6GHz with tuning resolutions of 1Hz

Parameters

NumberOfSamples [4096]
4096

RFcenterFrequency(Hz) [50MHz to 6GHz]
385e6

SamplingFrequency(Hz) [1.4MHz to 60MHz]
2e6

Bandwidth(Hz) [200KHz to 56MHz]
2e6

EnableDecimatingFIR [Enable = 1, Diasble = 0]
0

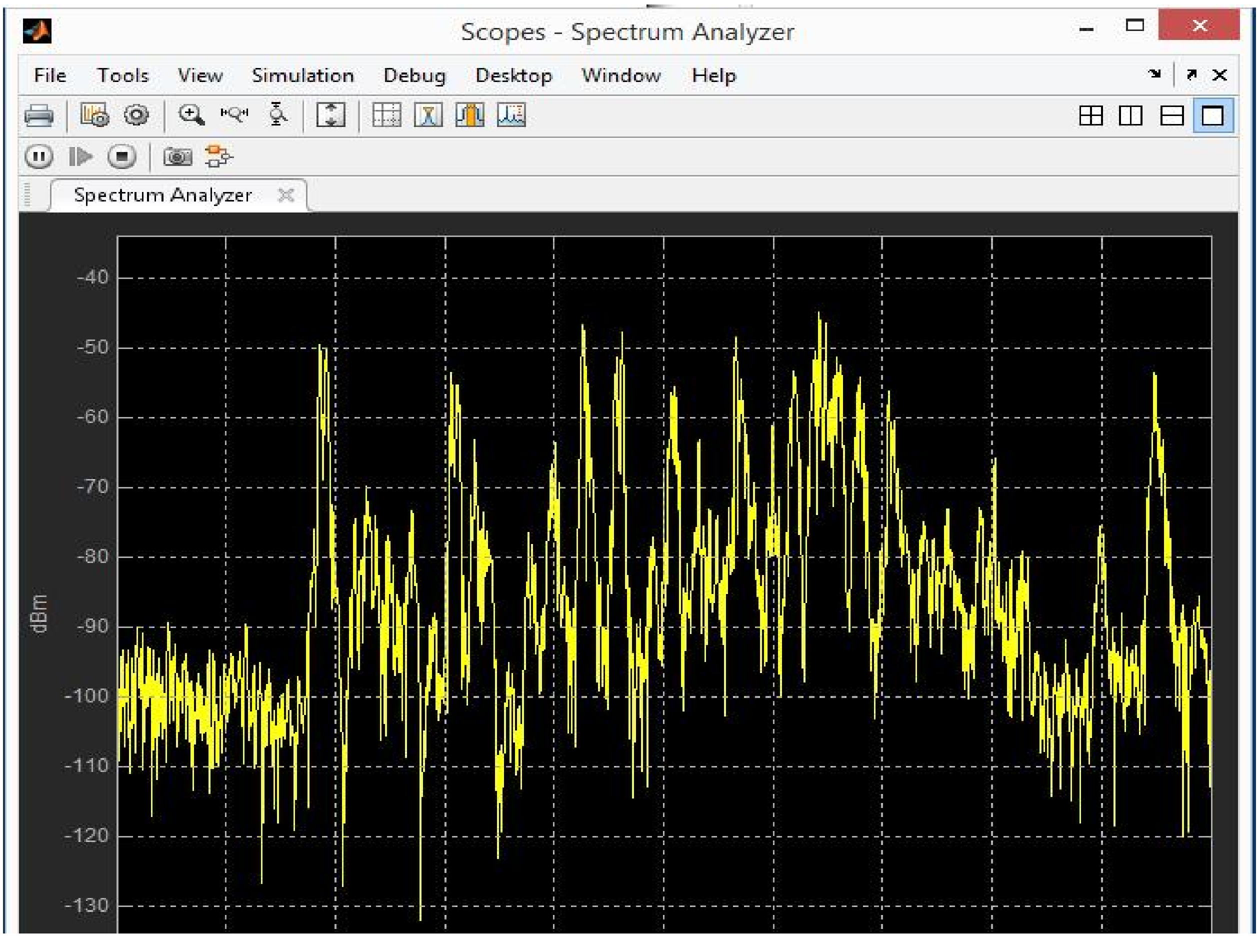
Transmitter Power Control(dB) [0 to 60dB]
0

DAC Scaling
2000

13.2. Demo Example of Receiving Over The Air GSM Signals with SDR Starter Kit in SIMULINK

GSM Signals over the air can be received using SDR Starter Kit in SIMULINK. It can be done using following steps

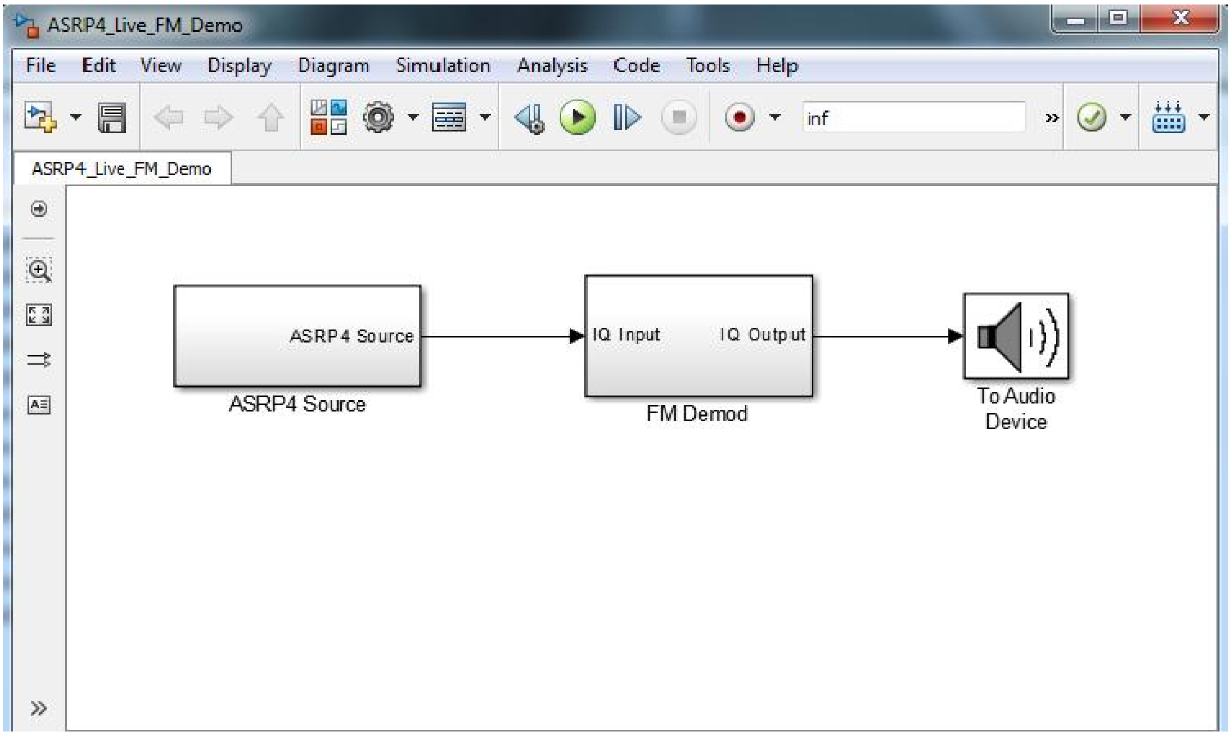
- Connect SDR Starter kit to your PC
- Open ASRP4 Rev4.0 MATLAB Drivers and Demos folder
- Open ReceiverSpectrumDemo.m file, set the parameters and run the file
- Next the Simulink file named ASRP4_Spectrum_Analyzer_Demo will be simulated and the Spectrum Analyzer window opens and the GSM signals received over the air can be viewed as shown below



13.3. Demo Example of Receiving Over The Air FM Signals with SDR Starter Kit in SIMULINK

Live FM Signals can be received using SDR Starter Kit in SIMULINK. It can be done using following steps

- Connect SDR Starter kit to your PC
- Open “ASRP4 Rev4.0 MATLAB Drivers and Demos” folder
- Open “ReceiverFMDemo.m” file and set the required FM station frequency in RfcenterFrequency and run the file
- Next the Simulink file named “ASRP4_Live_FM_Demo” will be simulated and the particular FM station which has been tuned will be demodulated in realtime and the audio is played through the speakers.



14. SDR Starter Kit Working with LabView

NI LabView is a very powerful Graphical programming IDE and provides lot of Signal Processing Libraries like Modulation Toolkit, Spectral Measurement Toolkit and Advance Signal Processing Toolkit making it ideal choice of developing wireless applications. Most interestingly SDR Starter Kit comes with LabView drivers. Users can directly use ASRP4 LabView drivers to readily get started working with RF signals. Below is the simple way of working in LabView environment.

14.1. Minimum System Requirements

Minimum system requirements to work with SDR Starter Kit with LABVIEW is any Windows OS and preinstalled LABVIEW2013 and above with 2GB RAM and Intel Core i3/i5/i7 (3Gen/4Gen).

Inorder to run any precompiled Labview executables, LABVIEW2013 runtime engine is required. This runtime engine is available free of cost from National Instruments website. LABVIEW executable software will only work after the Installation of this runtime engine. For example SDR-LAB software executables provided with SDR STARTER KIT requires LABVIEW Runtime engine to work. Please make sure to Install LABVIEW2013 (32bit) Runtime engine for running any LABVIEW EXE’s.

For LABVIEW based custom application development, LABVIEW2013 and above versions are recommended. Labview2013 Software is available for one month free Evaluation from National Instruments. Students can install this free one month trial software for testing the demo applications.

14.1.1. Demo Example of receiving signal with SDR Starter Kit in LabView

Live RF Signals can be received with SDR Starter kit in LabView. It can be done in three steps

1. Connect to SDR Starter Kit
2. Configure the Board with API Software
3. Start streaming signals to PC

The above steps are shown below in LabView IDE

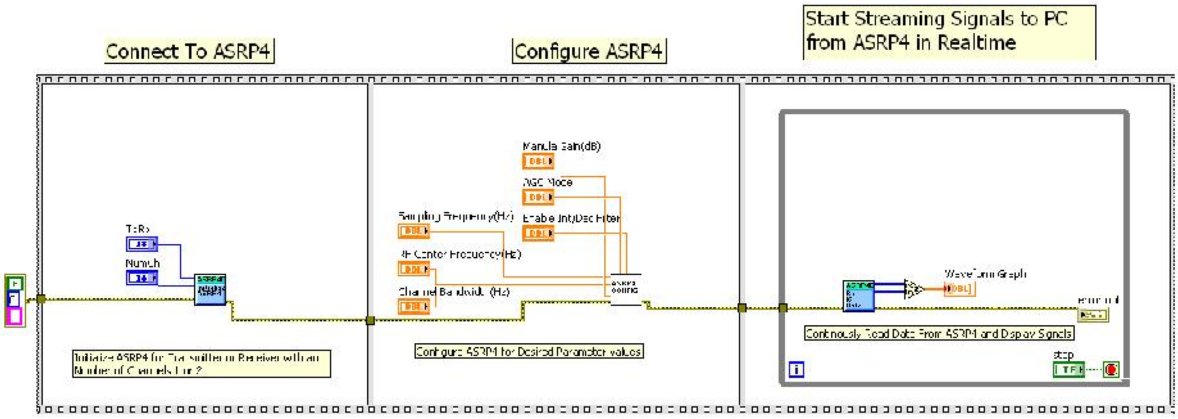
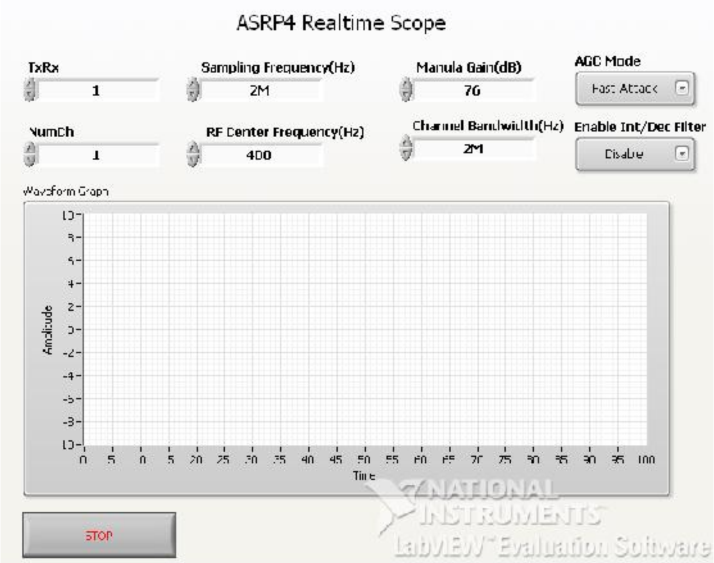

Connect To ASRP4
Configure ASRP4
Start Streaming Signals to PC from ASRP4 in Realtime
TxRx
NumCh
Initialize ASRP4 for Transmitter or Receiver with an Number of Channels 1 or 2
Manula Gain(dB)
AGC Mode
Sampling Frequency(Hz)
Enable Int/Dec Filter
RF Center Frequency(Hz)
Channel Bandwidth (Hz)
Configure ASRP4 for Desired Parameter values
Waveform Graph
error out
Continously Read Data From ASRP4 and Display Signals
stop
DBL
TF

Figure 12: Program Window - ASRP4 Configuration and Streaming IQData in Realtime into LabView

The received signal can be viewed in realtime scope as shown below



ASRP4 Realtime Scope

TxRx: 1

Sampling Frequency(Hz): 2M

Manula Gain(dB): 76

AGC Mode: Fast Attack

NumCh: 1

RF Center Frequency(Hz): 400

Channel Bandwidth(Hz): 2M

Enable Int/Dec Filter: Disable

Figure 13: Front Panel Window - ASRP4 Configuration and Streaming IQData in Realtime into LabView

14 lkhs

14.1.2. Demo Example of signal generation with SDR Starter Kit in LabView

RF Signals can be generated with SDR Starter kit in LabView. It can be done in three steps

1. Initialize ASRP4
2. Configure ASRP4
3. Generate signal and transmit continuously

The above steps are shown below in LabView IDE

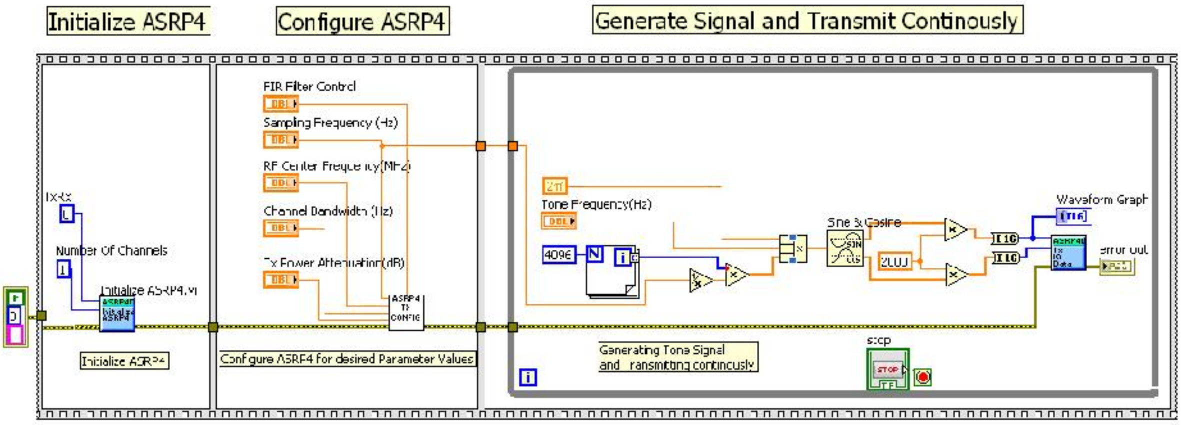
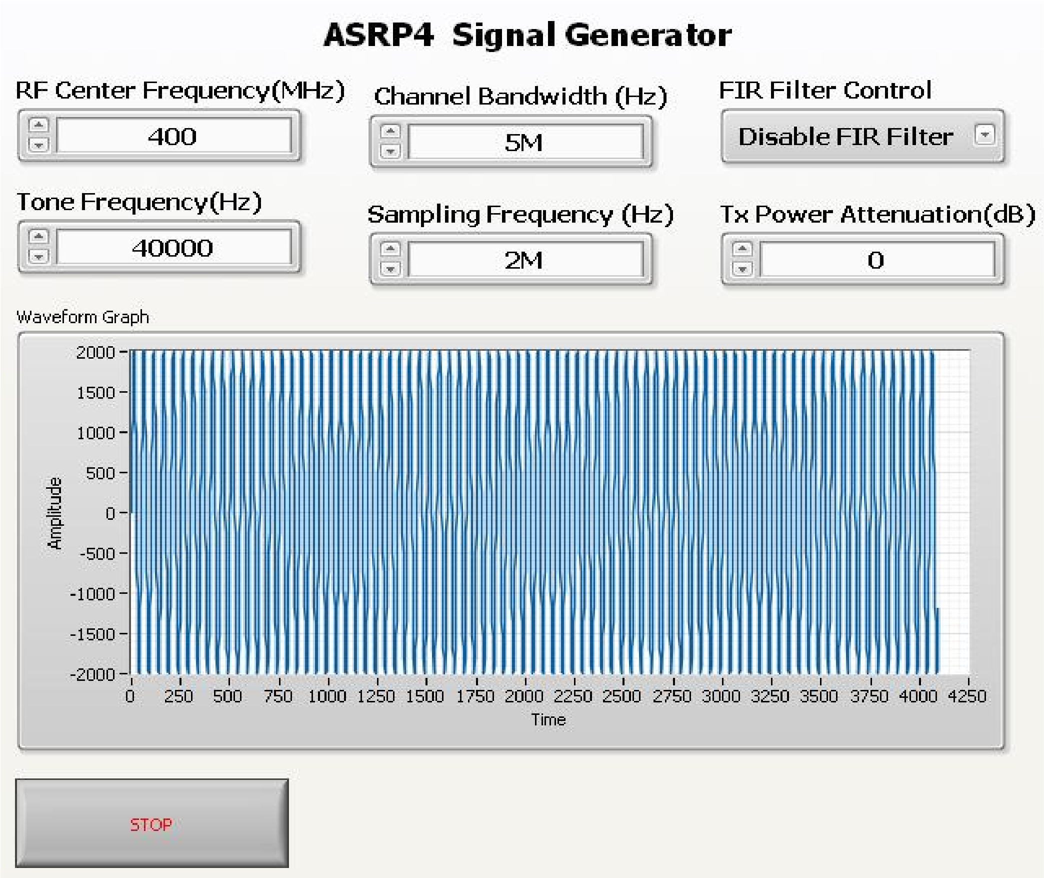


Figure 14: Program Window - ASRP4 Configuration and Streaming IQData in Realtime from LabView


ASRP4 Signal Generator

RF Center Frequency(MHz): 400

Channel Bandwidth (Hz): 5M

FIR Filter Control: Disable FIR Filter

Tone Frequency(Hz): 40000

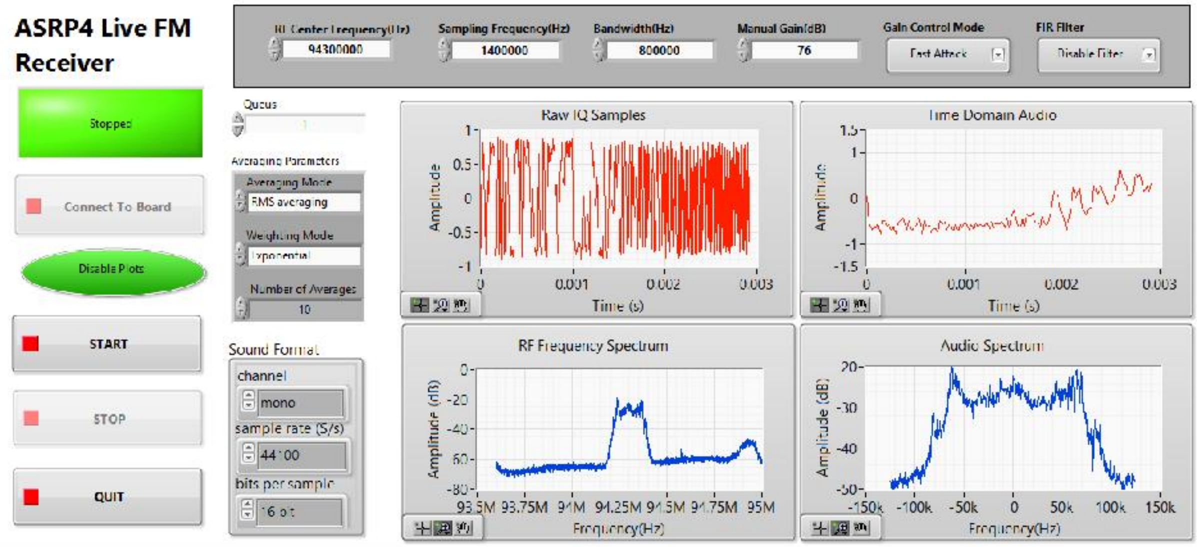
Sampling Frequency (Hz): 2M

Tx Power Attenuation(dB): 0

Figure 15: Front Panel Window - ASRP4 Configuration and Streaming IQData in Realtime from LabView

14.2. Live FM Receiver Demo in LabView with SDR Starter Kit

A Live FM Receiver Demo Software developed in LabView with SDR Starter Kit is provided with full source code. Users can use it as reference for developing application. Below is the Screen capture of the same.



ASRP4 Live FM Receiver

RF Center Frequency(Hz)	Sampling Frequency(Hz)	Bandwidth(Hz)	Manual Gain(dB)	Gain Control Mode	FIR Filter
94300000	1400000	800000	76	Fast Attack	Disable Filter

Queue: 1

Averaging Parameters
Averaging Mode: RMS averaging
Weighting Mode: Exponential
Number of Averages: 10

Sound Format
channel: mono
sample rate (S/s): 44100
bits per sample: 16 bit

Figure 16: Front Panel Window - ASRP4 Configuration and Streaming IQData in Realtime into LabView

APPENDIX A. LICENSING