




ANCORTEK

SDR SYSTEM DEVELOPMENT KIT

USER MANUAL

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USA



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TABLE OF CONTENTS

1	System Specification	3
1.1	Scope	3
1.2	Features	3
1.3	Parameters.....	3
2	Operation Instruction	8
2.1	Equipment List	8
2.2	System Description	9
2.3	Getting Started	10
2.4	Graphical User Interface	14

1 System Specification

1.1 Scope

Ancortek's SDR Development Kit offers the ability of integrating various software-defined transmitter-receiver systems for detection, tracking, imaging, and measuring of range (distance) and velocity (Doppler frequency) of targets.

1.2 Features

Support FMCW, FSK, and CW signal waveforms.

Expandable Bandwidth up to 800 MHz.

Recording of Complex (I & Q) Data.

USB 2.0 Interface to Host Computer.

Multifunctional Graphical User Interface (GUI).

1.3 Parameters

Parameters of 2.4 GHz, 5.8/6.2 GHz, and 9.8 GHz SDR-RF modules are illustrated in Table 1- 4.

Parameters of the FPGA-based SDR-PM processor module are listed in Table 5.

Customized higher power SDR-RF modules are available upon request.

Table 1 SDR-RF 240 Module Parameters

<i>Parameter</i>	<i>Min.</i>	<i>Typ.</i>	<i>Max.</i>	<i>units</i>
<i>Frequency Range</i>	<i>2.25</i>		<i>2.65</i>	<i>GHz</i>
<i>Expandable Frequency Range</i>	<i>2.05</i>		<i>2.65</i>	<i>GHz</i>
<i>Tune Voltage</i>	<i>0</i>		<i>5</i>	<i>V</i>
<i>Tuning Sensitivity @RF Port</i>		<i>0.1</i>		<i>GHz/V</i>
<i>Power Output</i>	<i>21</i>	<i>22</i>	<i>23</i>	<i>dBm</i>
<i>SSB Phase Noise @10KHz offset</i>		<i>-80</i>		<i>dBc</i>
<i>SSB Phase Noise @1MHz offset</i>		<i>-130</i>		<i>dBc</i>
<i>Conversion Gain Over Rx Channel</i>	<i>28</i>	<i>30</i>	<i>32</i>	<i>dB</i>
<i>Noise Figure over Rx channel</i>	<i>2.6</i>	<i>2.8</i>	<i>3.0</i>	<i>dB</i>
<i>Maximum input power</i>		<i>10</i>		<i>dBm</i>
<i>Input 1dB power compression</i>		<i>-15</i>		<i>dBm</i>
<i>Supply voltage</i>	<i>4.75</i>	<i>5</i>	<i>5.25</i>	<i>V</i>
<i>Supply current</i>	<i>650</i>	<i>670</i>	<i>700</i>	<i>mA</i>
<i>Operating temperature</i>	<i>-40</i>		<i>85</i>	<i>C°</i>
<i>Storage temperature</i>	<i>-65</i>		<i>150</i>	<i>C°</i>
<i>dimensions</i>	<i>L=79 W=56 H=13</i>			<i>mm</i>

Table 2 SDR-RF 580 Module Parameters

<i>Parameter</i>	<i>Min.</i>	<i>Typ.</i>	<i>Max.</i>	<i>units</i>
<i>Frequency Range</i>	<i>5.6</i>		<i>6.0</i>	<i>GHz</i>
<i>Expandable Frequency Range</i>	<i>5.2</i>		<i>6.0</i>	<i>GHz</i>
<i>Tune Voltage</i>	<i>0</i>		<i>5</i>	<i>V</i>
<i>Tuning Sensitivity @RF Port</i>		<i>0.13</i>		<i>GHz/V</i>
<i>Power Output</i>	<i>18</i>	<i>19</i>	<i>20</i>	<i>dBm</i>
<i>SSB Phase Noise @10KHz offset</i>		<i>-80</i>		<i>dBc</i>
<i>SSB Phase Noise @1MHz offset</i>		<i>-130</i>		<i>dBc</i>
<i>Conversion Gain Over Rx Channel</i>	<i>26</i>	<i>28</i>	<i>30</i>	<i>dB</i>
<i>Noise Figure over Rx channel</i>	<i>3.2</i>	<i>3.4</i>	<i>3.6</i>	<i>dB</i>
<i>Maximum input power</i>		<i>10</i>		<i>dBm</i>
<i>Input 1dB power compression</i>		<i>-11</i>		<i>dBm</i>
<i>Supply voltage</i>	<i>4.75</i>	<i>5</i>	<i>5.25</i>	<i>V</i>
<i>Supply current</i>	<i>650</i>	<i>670</i>	<i>700</i>	<i>mA</i>
<i>Operating temperature</i>	<i>-40</i>		<i>85</i>	<i>C°</i>
<i>Storage temperature</i>	<i>-65</i>		<i>150</i>	<i>C°</i>
<i>dimensions</i>	<i>L=79 W=56 H=13</i>			<i>mm</i>

Table 3 SDR-RF 620 Module Parameters

<i>Parameter</i>	<i>Min.</i>	<i>Typ.</i>	<i>Max.</i>	<i>units</i>
<i>Frequency Range</i>	<i>6.0</i>		<i>6.4</i>	<i>GHz</i>
<i>Expandable Frequency Range</i>	<i>5.6</i>		<i>6.4</i>	<i>GHz</i>
<i>Tune Voltage</i>	<i>0</i>		<i>5</i>	<i>V</i>
<i>Tuning Sensitivity @RF Port</i>		<i>0.13</i>		<i>GHz/V</i>
<i>Power Output</i>	<i>18</i>	<i>19</i>	<i>20</i>	<i>dBm</i>
<i>SSB Phase Noise @10KHz offset</i>		<i>-80</i>		<i>dBc</i>
<i>SSB Phase Noise @1MHz offset</i>		<i>-130</i>		<i>dBc</i>
<i>Conversion Gain Over Rx Channel</i>	<i>26</i>	<i>28</i>	<i>30</i>	<i>dB</i>
<i>Noise Figure over Rx channel</i>	<i>3.2</i>	<i>3.4</i>	<i>3.6</i>	<i>dB</i>
<i>Maximum input power</i>		<i>10</i>		<i>dBm</i>
<i>Input 1dB power compression</i>		<i>-11</i>		<i>dBm</i>
<i>Supply voltage</i>	<i>4.75</i>	<i>5</i>	<i>5.25</i>	<i>V</i>
<i>Supply current</i>	<i>650</i>	<i>670</i>	<i>700</i>	<i>mA</i>
<i>Operating temperature</i>	<i>-40</i>		<i>85</i>	<i>C°</i>
<i>Storage temperature</i>	<i>-65</i>		<i>150</i>	<i>C°</i>
<i>dimensions</i>	<i>L=79 W=56 H=13</i>			<i>mm</i>

Table 4 SDR-RF 980 Module Parameters

<i>Parameter</i>	<i>Min.</i>	<i>Typ.</i>	<i>Max.</i>	<i>units</i>
<i>Frequency Range</i>	9.6		10.0	GHz
<i>Expandable Frequency Range</i>	9.2		10.2	GHz
<i>Tune Voltage</i>	0		5	V
<i>Tuning Sensitivity @RF Port</i>		0.2		GHz/V
<i>Power Output</i>	17	18	19	dBm
<i>SSB Phase Noise @10KHz offset</i>		-80		dBc
<i>SSB Phase Noise @1MHz offset</i>		-130		dBc
<i>Conversion Gain Over Rx Channel</i>	26	28	30	dB
<i>Noise Figure over Rx channel</i>	3.2	3.4	3.6	dB
<i>Maximum input power</i>		10		dBm
<i>Input 1dB power compression</i>		-13		dBm
<i>Supply voltage</i>	4.75	5	5.25	V
<i>Supply current</i>	650	670	700	mA
<i>Operating temperature</i>	-40		85	C°
<i>Storage temperature</i>	-65		150	C°
<i>dimensions</i>	L=79 W=56 H=13			mm

Table 5 SDR-PM 400 Module Parameters

<i>Parameter</i>	<i>Min.</i>	<i>Typ.</i>	<i>Max.</i>	<i>units</i>
<i>Supply voltage</i>	4.75	5	5.25	V
<i>Supply current</i>	180	200	220	mA
<i>Operating temperature</i>	-40 to +85			C°
<i>Storage temperature</i>	-65 to +150			C°
<i>dimensions</i>	L=79	W=76	H=13	mm

2 Operation Instruction

2.1 Equipment List

The Ancortek SDR Development Kit comes with SDR-RF module and SDR-PM processor module. The SDR-PM processor module is compatible with our 2.4 GHz, 5.8/6.2 GHz, and 9.8 GHz SDR-RF modules. For data collection, you will also need

1. AC/DC power adapter +5V.
2. USB 2.0 A to Mini-B cable.
3. SMA-M to SMA-M cables.
4. Transmitting and receiving antennas.
5. Ancortek Graphical User Interface: SDR-GUI or MATLAB-based SDR-GUI.
6. PC Windows Operating System.

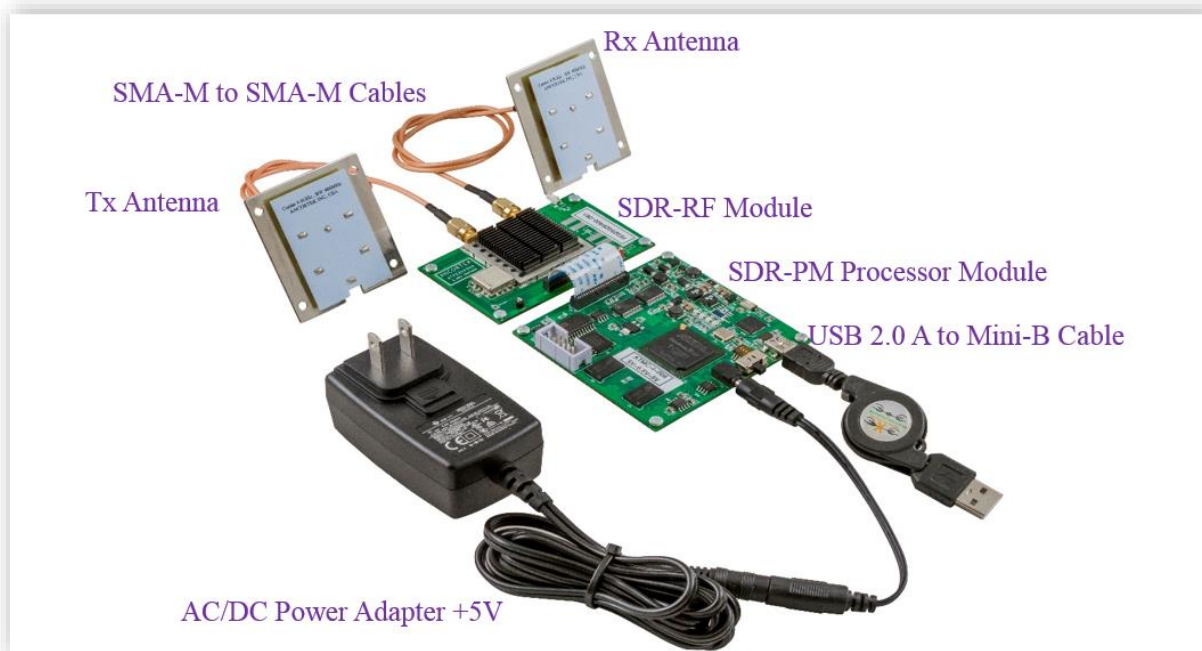


Figure 1 - Equipment List.

2.2 System Description

Figure 2 is a high level block diagram of the SDR Development Kit. A graphical user interface (SDR-GUI) is used to control the configuration of the SDR via a USB 2.0 cable. Digital samples of control voltage are generated by the FPGA firmware. After D/A converter, an analog control voltage is directly sent to the voltage controlled oscillator (VCO). The output of the mixer in the receive chain is digitized and streamed to host computer for further processing.

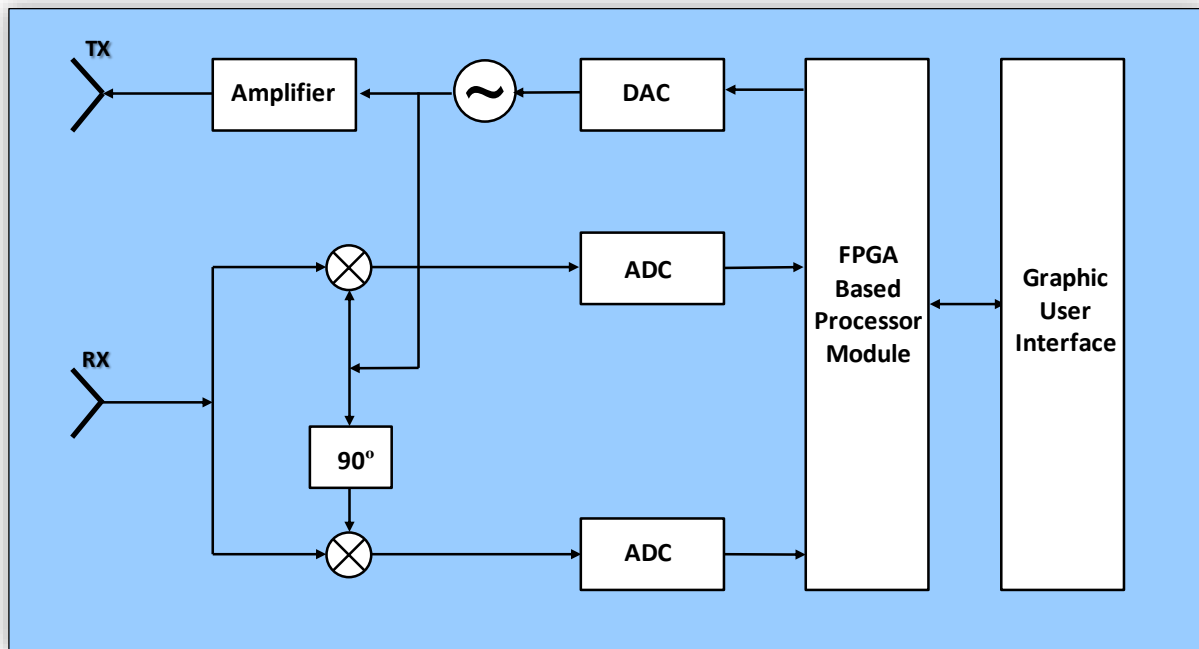


Figure 2 - System Block Diagram.

2.3 Getting Started

1. Run setup.exe to install the Ancortek SDR-GUI.
2. Plug in the Ancortek transceiver and go to the Device Manager, right click "Unknown Device".

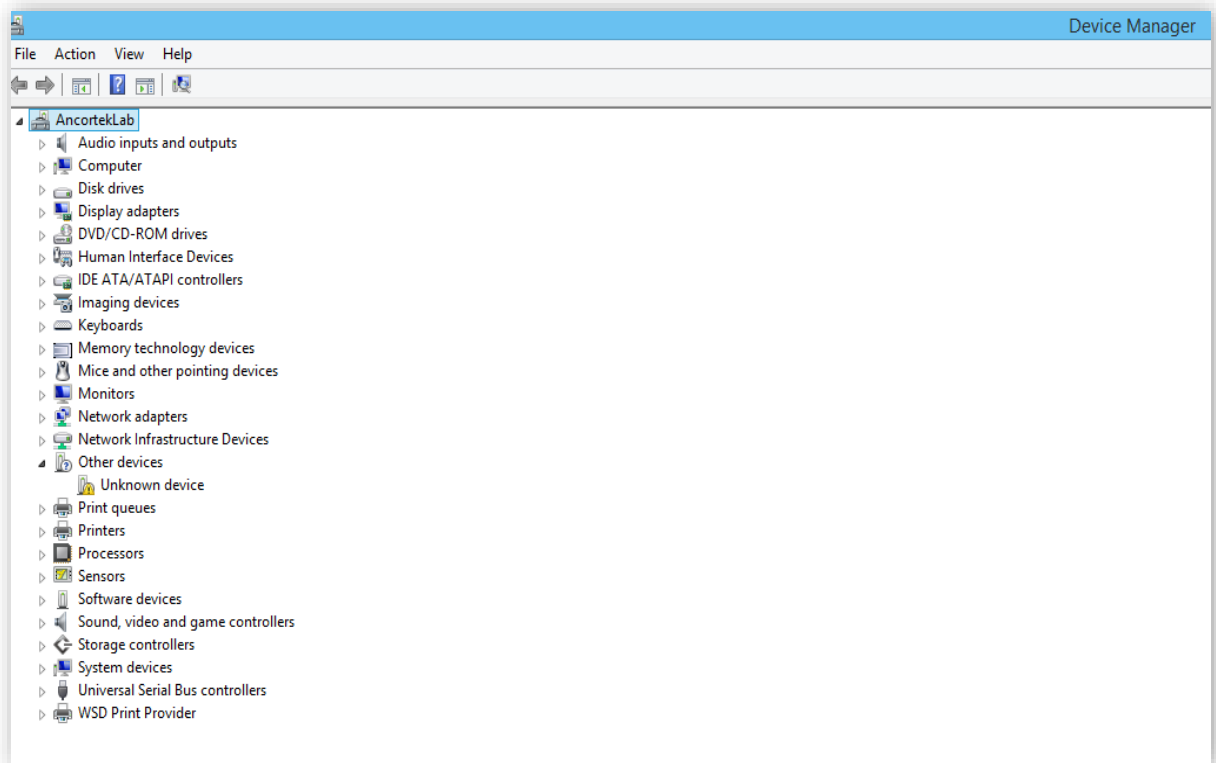


Figure 3 - Device Manager Window.

3. Click "Update Driver".

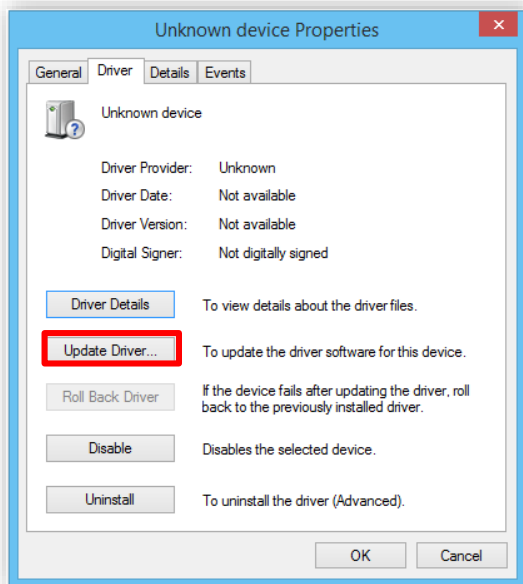


Figure 4 - Update Driver.

4. Click "Browse my computer for driver software".

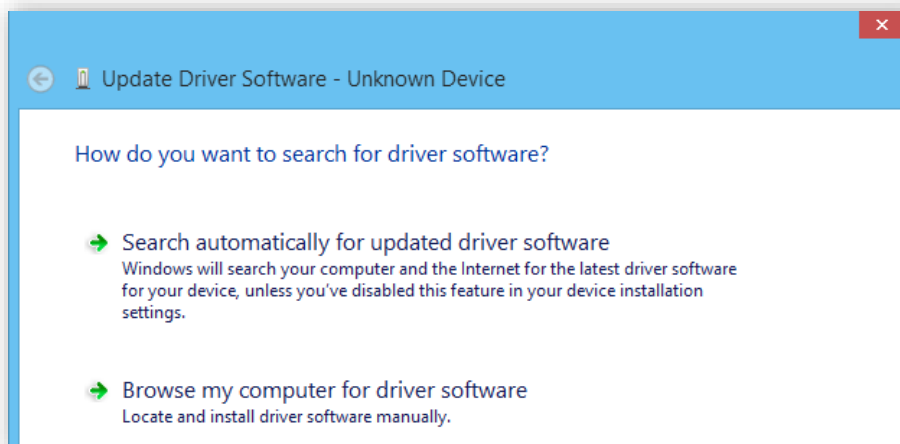


Figure 5 - Browse Computer for Driver Software.

5. Select the driver in the installation directory "Ancortek SDR/driver" according to Figure 6 below.

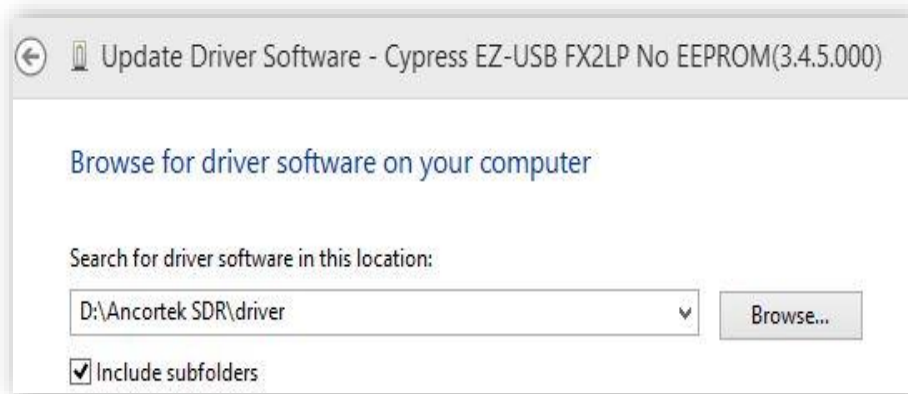


Figure 6 - Update Driver Software.

6. Driver software installed successfully.

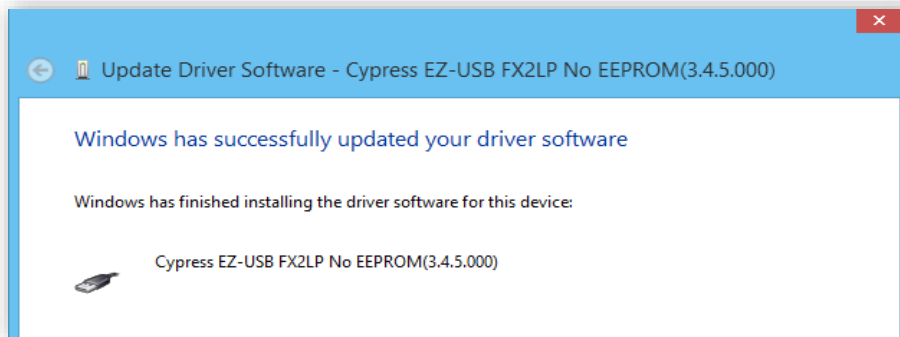


Figure 7 - Driver Software Installed Successfully.

7. Open the SDR-GUI.

8. MATLAB-based SDR-GUI is available for academic research groups upon request.

2.4 Graphical User Interface

2.4.1 Ancortek SDR-GUI

After running setup.exe and updating the driver software, Ancortek SDR-GUI, as shown in Figure 8, will appear. The GUI gives users access to selecting of waveforms, operating parameters, filtering types, and recording. It is capable of showing graphical representation of signals in time and frequency domain.

1. Control Panel

The Control Panel includes selecting of waveforms, operating parameters, filtering types, and recording.

- **Active Device**

- 1) The upper-left pop-up menu: List of detected Ancortek devices.
- 2) The upper-right pop-up menu: Center frequency. Please choose the right center frequency before activating the device.
- 3) Activate: Start the data stream and plotting. This button is also used to stop the data stream or plotting.
- 4) Refresh: Find Ancortek devices and list them in the upper-left pop-up menu.

- **Operating Parameters: Operating Mode**

- 1) FMCW Sawtooth: Range and Doppler estimation.
- 2) FSK: Range and Doppler estimation of moving targets.
- 3) CW: Doppler estimation.

- **Operating Parameters: Signal Parameters**

- 1) Bandwidth: Sweep bandwidth for FMCW Sawtooth.
- 2) Samples per Sweep: Number of time samples per sweep.
- 3) Sweep Time: Length of one sweep or pulse. Changing the Sweep Time and Samples per Sweep will change the sampling rate.

- **Operating Parameters: Display Mode**

- 1) Range & Time Scope: Range obtained from FFT of the beat signal (FMCW Sawtooth).
- 2) Velocity Scope: Velocity obtained from the FFT of complex signal (FSK & CW).
- 3) Range-Velocity Map: Range-Doppler map (FMCW Sawtooth).
- 4) Range Waterfall: Waterfall of Range & Time Scope (FMCW Sawtooth) and waterfall of detected range (FSK).
- 5) Velocity Waterfall: Waterfall of Velocity (FMCW Sawtooth & FSK & CW).

- **Stream Filtering**

- 1) DC Subtraction: Remove the mean value of the waveform.
- 2) Amplitude Correction: Normalize the amplitude of signal.
- 3) Hamming Window: Using Hamming Window before taking FFTs.
- 4) Direct Clutter Cancellation: Background subtraction for FMCW-Sawtooth.
Please make sure that there is no target at the scene at the very beginning to collect clutter data when Direct Clutter Cancellation is enabled.
- 5) Outdoor Range Weighting: Correct range-based signal attenuation via radar equation.
- 6) Range Windowing: Select range to display.
- 7) Velocity Windowing: Select velocity to display.

- **Display Parameters: Dynamic Range**

- 1) Dynamic Range Auto: Computes the color limits automatically using minimum and maximum data values.
- 2) Dynamic Range: Sets the color limits to specified minimum and maximum values when Auto is unchecked.

Note: Data values less than minimum or greater than maximum map to minimum and maximum, respectively. Values between minimum and maximum linearly map to the current colormap.

- **Display Parameters: Update Rate**

Update Rate: Set update rate of graphical plots. Data processing time will affect the actual update rate.

- **Display Parameters: Doppler Parameters**

Sweep Count: Number of pulses collected for signal processing. Decrease this value will ease processing burden, thus may increase update rate of graphical plots.

- **Display Parameters: Waterfall Parameters**

- 1) History Size: Number of rows in data for waterfall display.
- 2) Display Method: Resampling algorithm used for matrix data.
- 3) Color Scheme: Change the colormap.

Note: In FSK mode, we suggest using Standard or B&W color scheme for Range Waterfall.

- **Export**

- 1) Screen Capture: Save the Top or Bottom View of graphical results into a file.
- 2) Duration: Raw data length to record.
- 3) Record Data Stream: Start recording. The raw data will be saved into .dat file for post-processing. Below is Matlab sample codes for reading the .dat file. Data is the raw data in $(I + jQ)$ format.

```
filename = '2015-03-25-10-08-12.dat'; % File name
fileID = fopen(filename, 'r');
dataArray = textscan(fileID, '%f');
fclose(fileID);
radarData = dataArray{1};
clearvars fileID dataArray ans;

fc = radarData(1); % Center frequency
Tsweep = radarData(2); % Sweep time in ms
NTS = radarData(3); % Number of time samples per sweep
Bw = radarData(4); % FMCW Bandwidth. For FSK, it is frequency step;
For CW, it is 0.
Data = radarData(5:end); % raw data in I+j*Q format
```

- 4) Record Status: When recording and saving are done, success information will appear.

2. Graphic Panel

The Graphic Panel will show the graphical representation of signals in time and frequency domain.

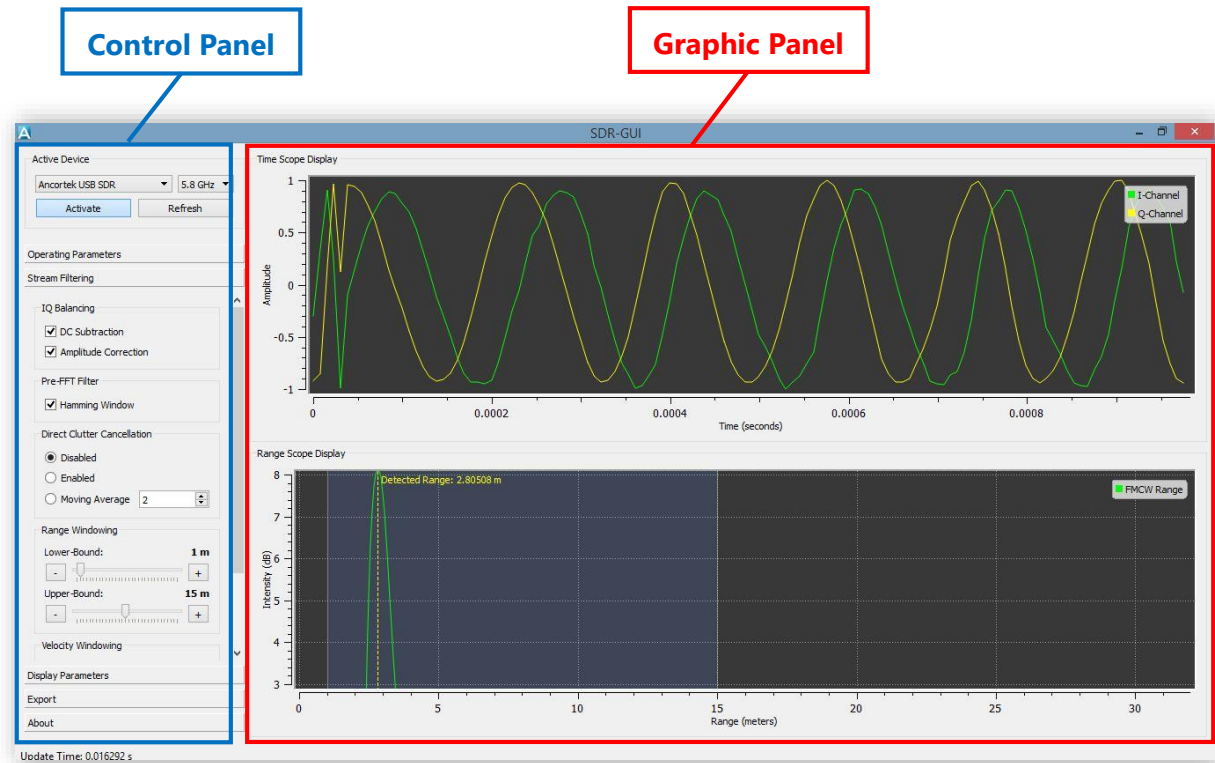


Figure 8 - Ancortek SDR-GUI.

2.4.2 MATLAB-based SDR-GUI

MATLAB-based SDR-GUI is available upon request. It is shown in Figure 9.

1. Control Panel

The Control Panel includes selecting of waveforms, operating parameters, filtering types, and recording.

- **Start/Stop**

Start: Start the data stream and plotting. Please remember to choose the right center frequency from the pop-up menu on the right.

Stop: Stop the data stream or plotting.

- **Waveforms**

- 1) FMCW_Sawtooth: Range and Doppler estimation.
- 2) FMCW_Triangle: Range and Doppler estimation without range-Doppler coupling effect.
- 3) FSK: Range and Doppler estimation of moving targets.
- 4) CW: Doppler estimation.

- **Parameters**

- 1) Bandwidth: Sweep bandwidth for FMCW.
- 2) Sweep Time: Length of one sweep or pulse.
- 3) Sampling Number: Number of time samples per sweep. Changing the Sweep Time and Sampling Number will change the sampling rate.
- 4) Frequency: Frequency of transmitted signal.

- **Filtering**

- 1) Direct Clutter Cancellation: Background subtraction for FMCW-Sawtooth and FMCW-Triangle. Please make sure that there is no target at the scene at the very beginning to collect clutter data when Direct Clutter Cancellation is enabled. Just after a few milliseconds, the target could enter the scene.
- 2) Range Notch Filter: Filter out the clutter nearby when the target of interest is far from the transceiver for FMCW-Sawtooth and FMCW-Triangle. Please change notch width according to the distance of target of interest.
- 3) Doppler Notch Filter: Filter out unwanted Doppler for range-Doppler map of FMCW-Sawtooth. Please change notch width according to the velocity of target of interest.

- **RawData**

- 1) Record: Record up to 8 seconds worth of raw data. Micro-Doppler analysis of the recorded raw data will appear in the Graphic Panel.
- 2) Save: Save the recorded raw data into .mat file for post-processing. Below is Matlab sample codes for reading the .mat file. Data is the raw data in (I+jQ) format.

```
raw = load('fmcw.mat');  
Data = raw.DATA;  
SweepTime = raw.SWEEPTIME;  
NTS = raw.sampnumberpersweep;  
BandWidth = raw.BANDWIDTH;  
samp_rate = 1/SweepTime*NTS*1000;
```

3) Replay: Reshow the micro-Doppler analysis of the selected raw data.

2. Graphic Panel

The Graphic Panel includes selecting of graphical representation of signals in time and frequency domain.

- **FMCW_Sawtooth graphical results**

- 1) Stream: I & Q data.
- 2) Waterfall: Waterfall of range profile.
- 3) Range Profile: Range obtained from FFT of the beat signal.
- 4) Range Doppler: Range-Doppler map.

- **FMCW_Triangle graphical results**

- 1) Stream: I & Q data.
- 2) Range History: History of detected range.
- 3) Velocity History: History of detected velocity.

- **FSK graphical results**

- 1) Stream: I & Q data.
- 2) Velocity History: History of detected velocity.
- 3) Range History: History of detected range.

- **CW graphical results**

- 1) Stream: I & Q data.
- 2) Waterfall: Waterfall of velocity profile.
- 3) Velocity Profile: Velocity obtained from the FFT of the $(I + jQ)$
- 4) Velocity History: History of detected velocity.

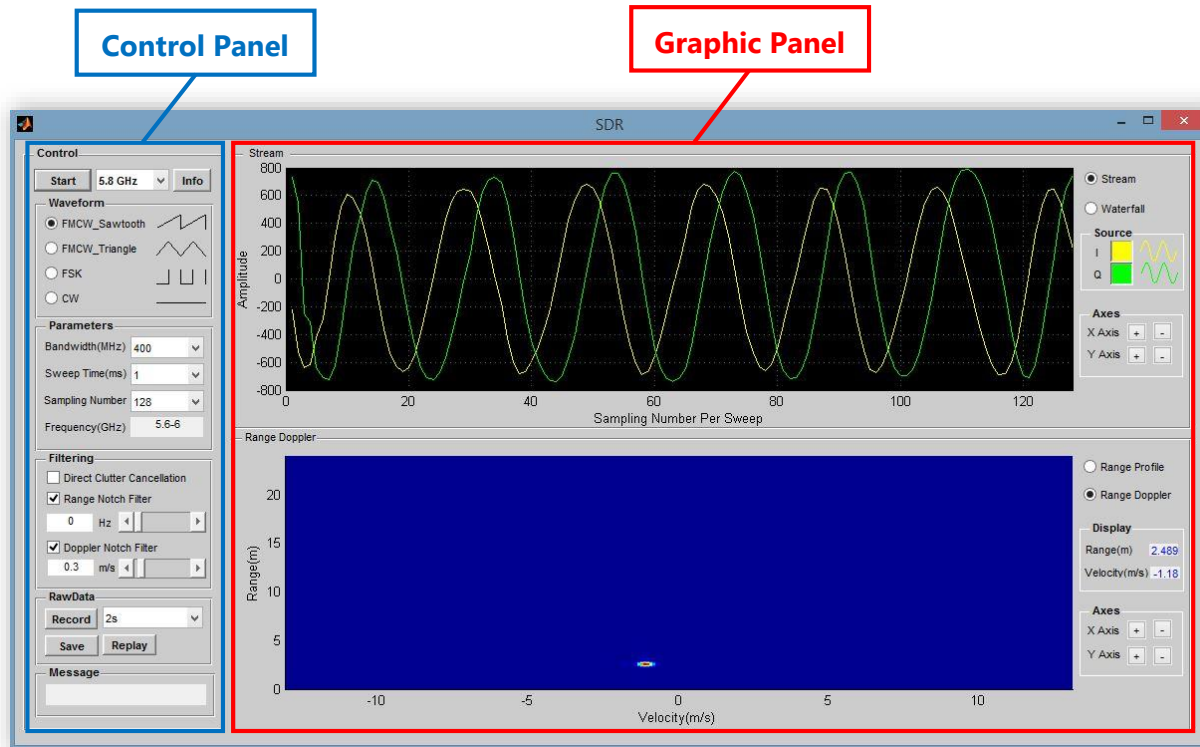


Figure 9 - MATLAB version of the SDR-GUI.