Experiment with Radar Studio, TSW1400, Devpack, IWR1443 and measurement 2.7m RCS .5 target, measurement at 10meters.

Section 1 Purpose

This experiment utilizes the Sensing Estimator to extract parameters for use in Radar Studio. We then apply these radar parameters to Radar Studio, in order to process experiments, and illustrate what some of the key Radar Studio parameters are.

Note: References - The Radar Studio User Guide, Sensing Estimator User Guide, TSW1400 User Guide, and dfp Installation Instructions are all referenced. There is online training for using Radar Studio, with TSW1400 for mmWave, and a PPTX document.

Section 2 Hardware Setup

The TSW1400, Devpack, and Radar Sensor EVM are mounted together, using the short data cable, in a Panavise. Note: be careful not to crush components on the TSW1400 using the panavise.

Follow the TSW1400, Radar Studio user and Installation guide for hardware and software setup.

In my usage, I have a USB powered hub from the computer to the TSW1400, Devpack, and Radar Sensor IWR1443.

Figure 1 – Frontside TSW1400,Devpack, IWR1443 Radar Sensor EVM

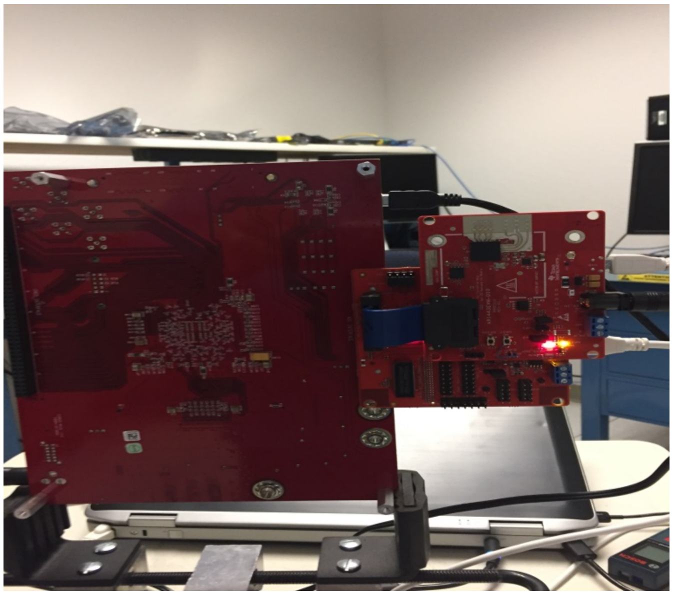
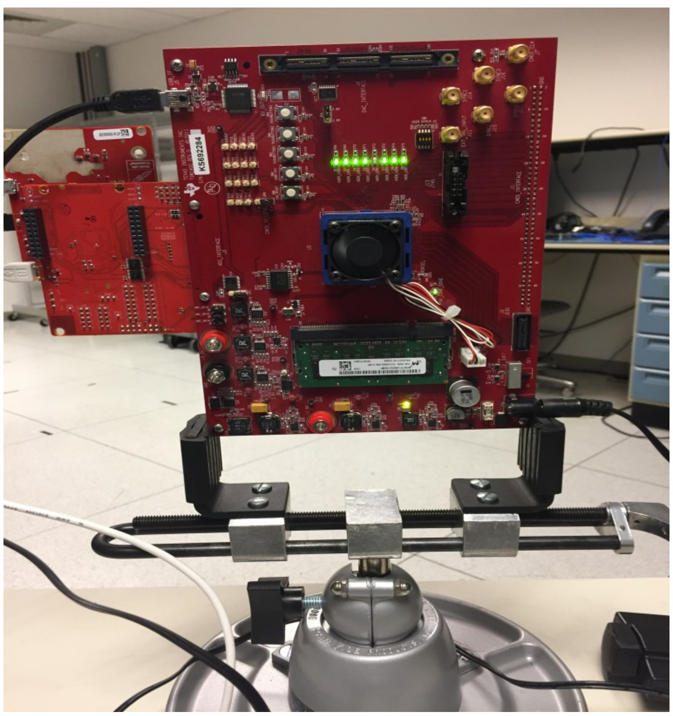


Figure 2 – Backside TSW1400,Devpack, IWR1443 Radar Sensor EVM



The RCS target is mounted on a tripod with Velcro. The RCS target is 2.7 meters from the radar sensor. See Figure 3.

Figure 3 – RCS Target

Section 3 Radar Key parameters – mmWave Sensing Estimator

The Radar Key parameters for this experiment are:

High Range Resolution, < 5cm

The Velocity max, and Velocity resolution are adjusted to get the desired number of FFT points, this is a range demonstration.   Velocity is not a key value.

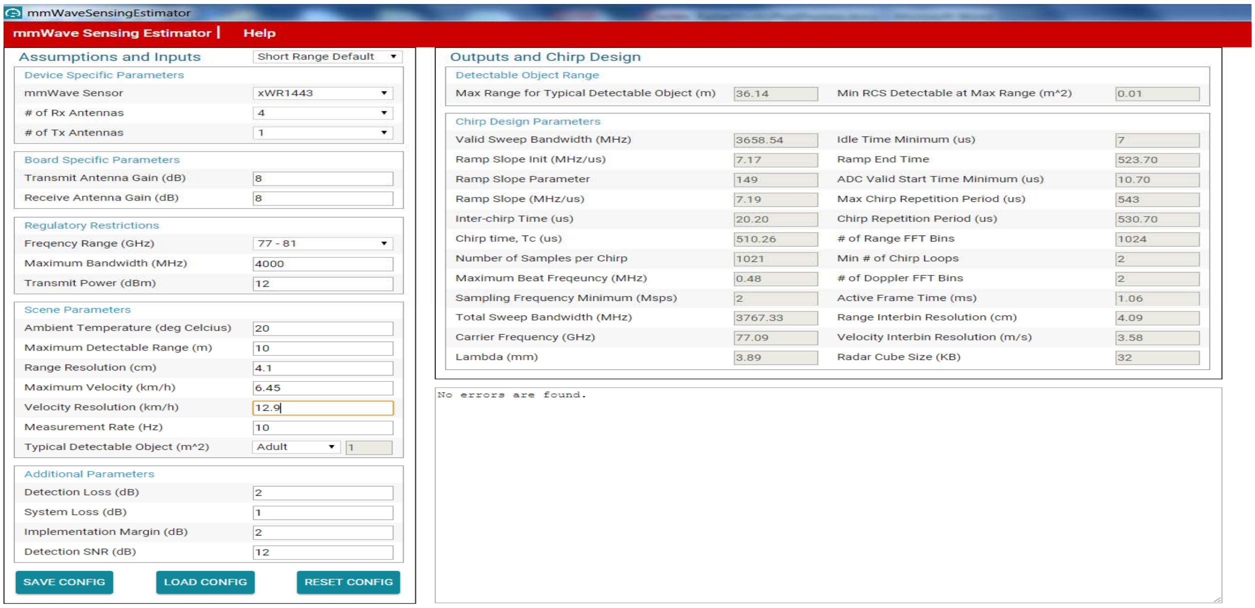
Range of 10 meters

Use of 1024 point FFT – highest native frequency bin resolution

Using the mmWave Sensing Estimator; the key parameters are shown in Figure 4, from mmWave Sensing Estimator Tool.

Load the provided configuration file into the Sensing Estimator -
test_range10m_rangeres4p1cm_1021samples.json

Figure 4 – mmWave Sensing Estimator



Note: if there are errors in the Sensing Estimator they would be displayed as red boxes, values, and have an error below the outputs and chirp design section.

Section 4 - Radar Studio operation

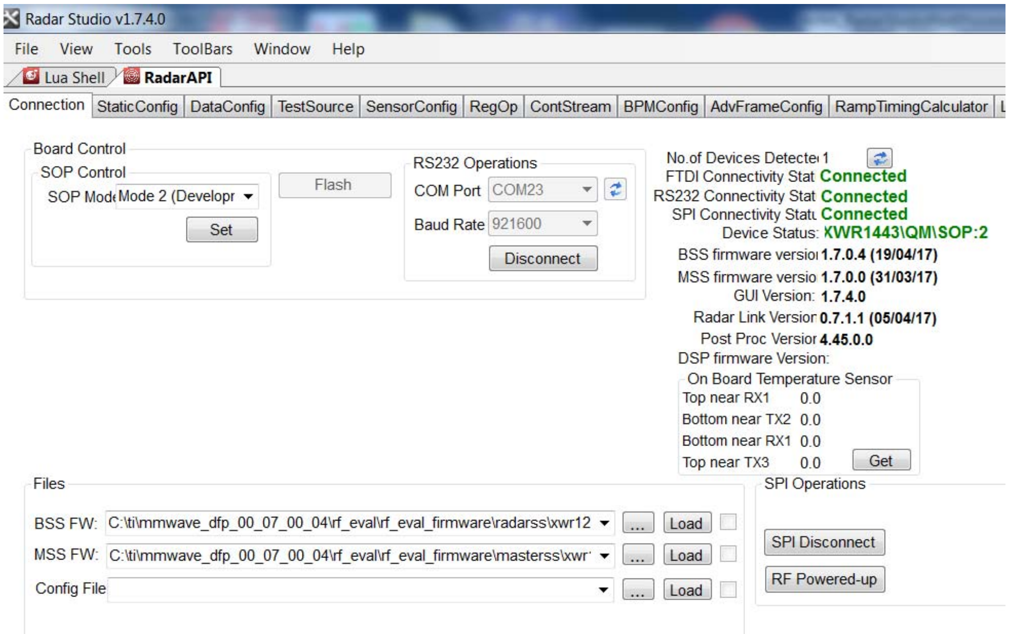
Radar Studio setup, is done by following the PPTX instructions, it is not clear in the graphics, there is a blue highlight for the different screens.

The normal setup is:

- Launch program
- Load configuration file
- Connection
- Static Configuration
- Data Configuration
- Ramp Timing Calculator
- Sensor Configuration
- Run Experiment and Post Processing

4.1 Launch Program

Figure 5 – Radar Studio - Connection



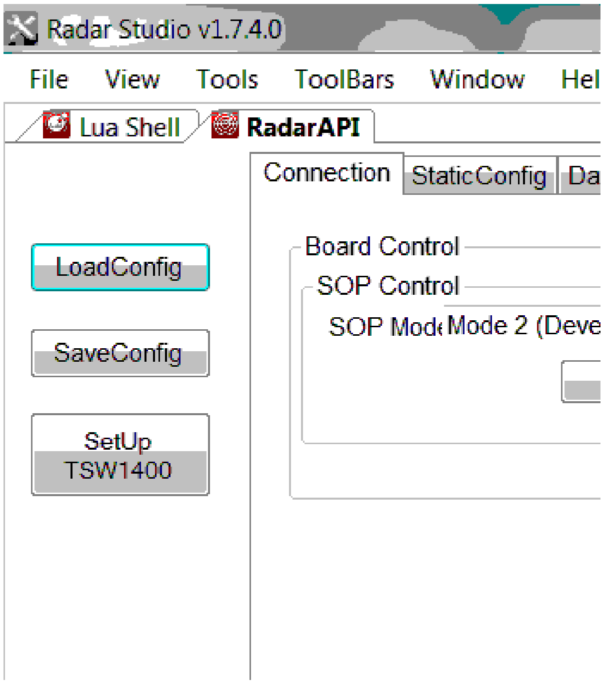
Follow through the initialization steps, Board Control Set, Connect RS232 Com Port (Control port).

Load the BSS FW, MSS FW, SPI Connect.

RF Power Up.

Load Configuration File, on the left of the display, use Load Config, navigate to setup file.

Figure 6 – Radar Studio – Connection – Load Configuration

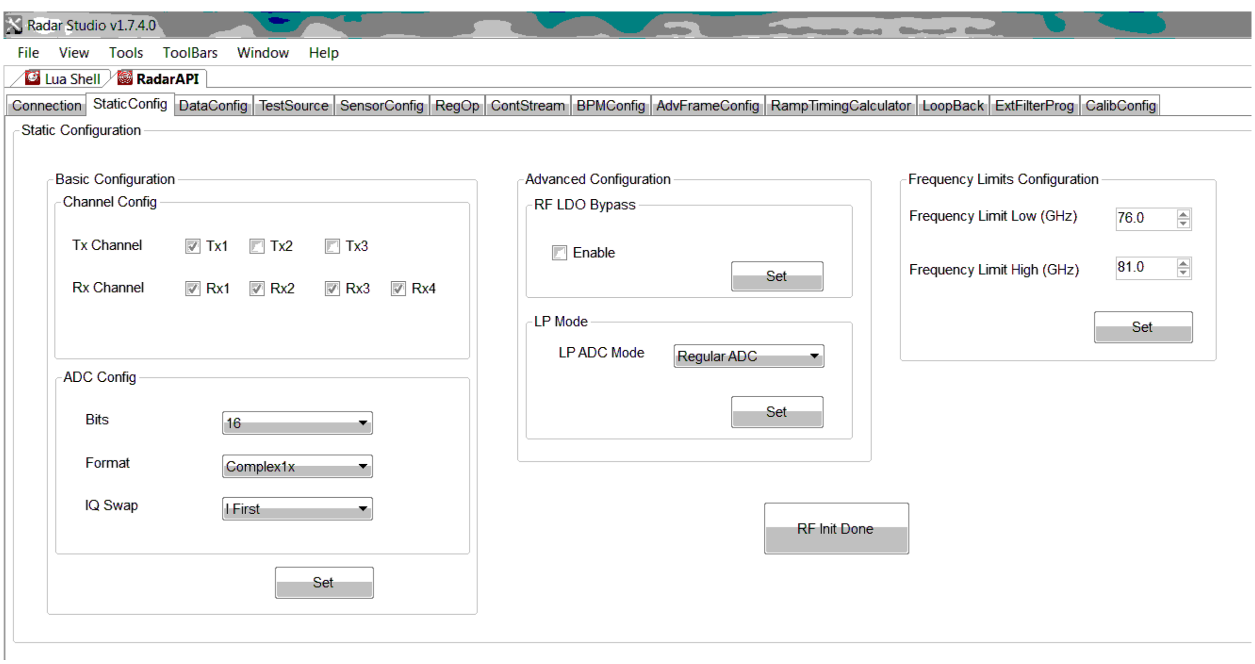


4.2 Static Config – select the Static Config tab

The Tx Channel, Rx Channel have to match the Sensing Estimator.

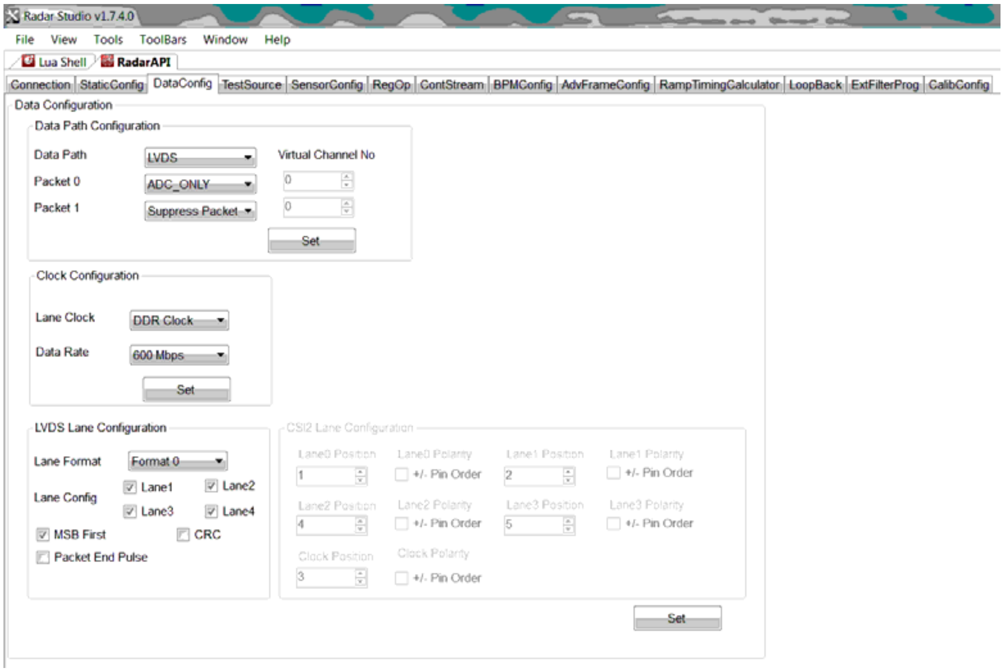
Set the Basic Configuration, LP Mode, and Select RF Init

Figure 7 – Radar Studio – Static Configuration



4.3 Data Config (LVDS output) – select the Data Config tab

Figure 8 – Radar Studio – Data Configuration



Normally the number of LVDS lanes matches the number of receivers active. We can lower the DDR clock rate, but then we need to calculate the chirp/frame time. Set the Data Path Configuration, Set the Clock Configuration, Set the LVDS Lane Configuration.

4.4 Profile, Chirp, and Frame Configuration

Note: The goal is to populate the Sensor Config tab. Some of the values calculated in Radar Studio are different from the Sensing Estimator, ADC Start time, Idle Time, Excess Ramp time. Currently you need to select the larger values.

Chirp, Profile, Frame configuration, is done in steps. Comparing the Sensing Estimator and the various tabs for Radar Studio.

Ramp Timing Calculator – open the Ramp Timing Calculator tab

You need to enter the ADC mode, DFE output mode, Synthesizer Slope, number of samples in Chirp, DFE output rate, HPF settings in the Ramp Timing inputs.

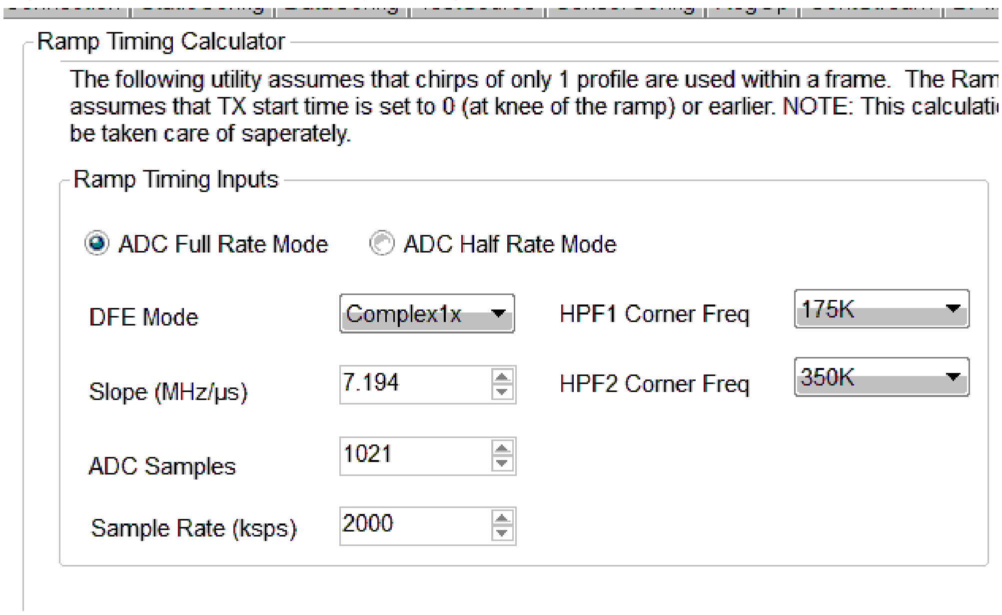
Normally the DFE Mode is Complex 1x.

Normally the ADC Mode is full rate, if the DFE output rate is < 5000ksps it can be Half rate .

Synthesizer slope, ADC samples, come from the Estimator.

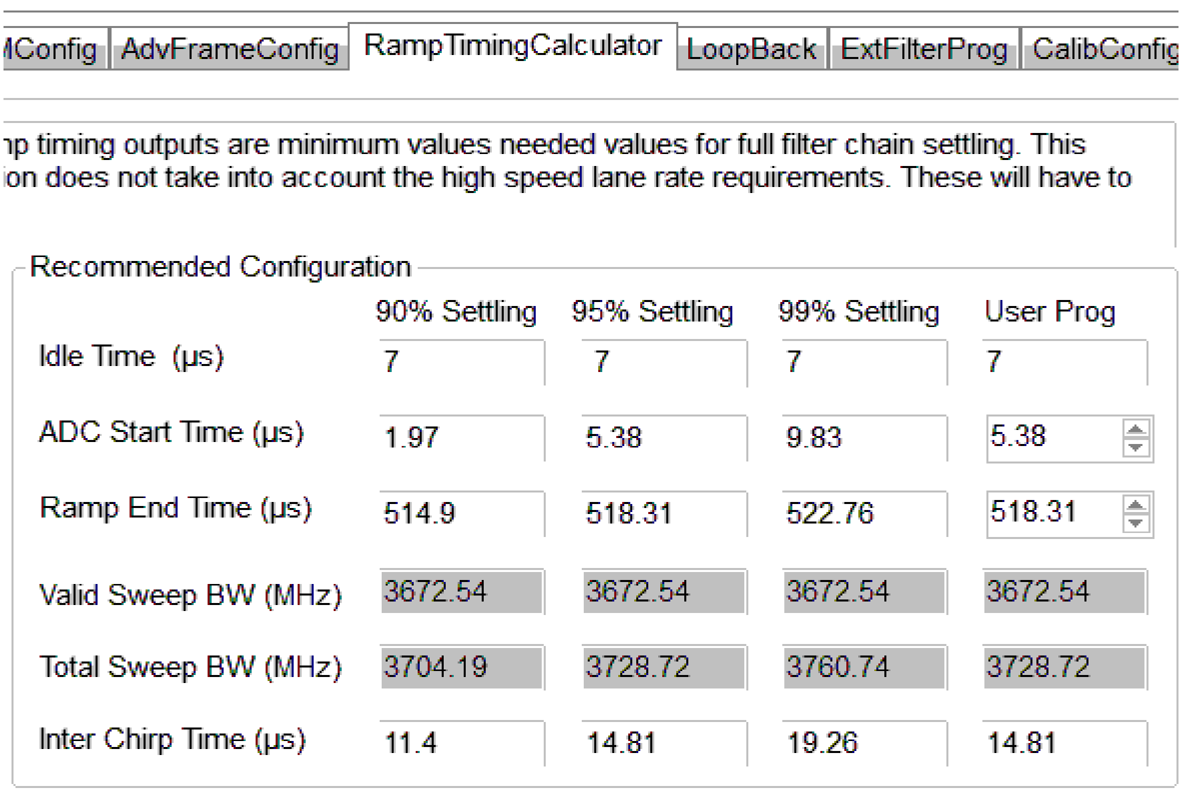
The HPF1, HPF2 analog High Pass filters, normally use the default values.

Figure 9 – Radar Studio – Ramp Timing Calculator



You then need to record the recommended configuration for the 99% column.

Figure 10 – Radar Studio – Ramp Timing Calculator – Recommended Configuration

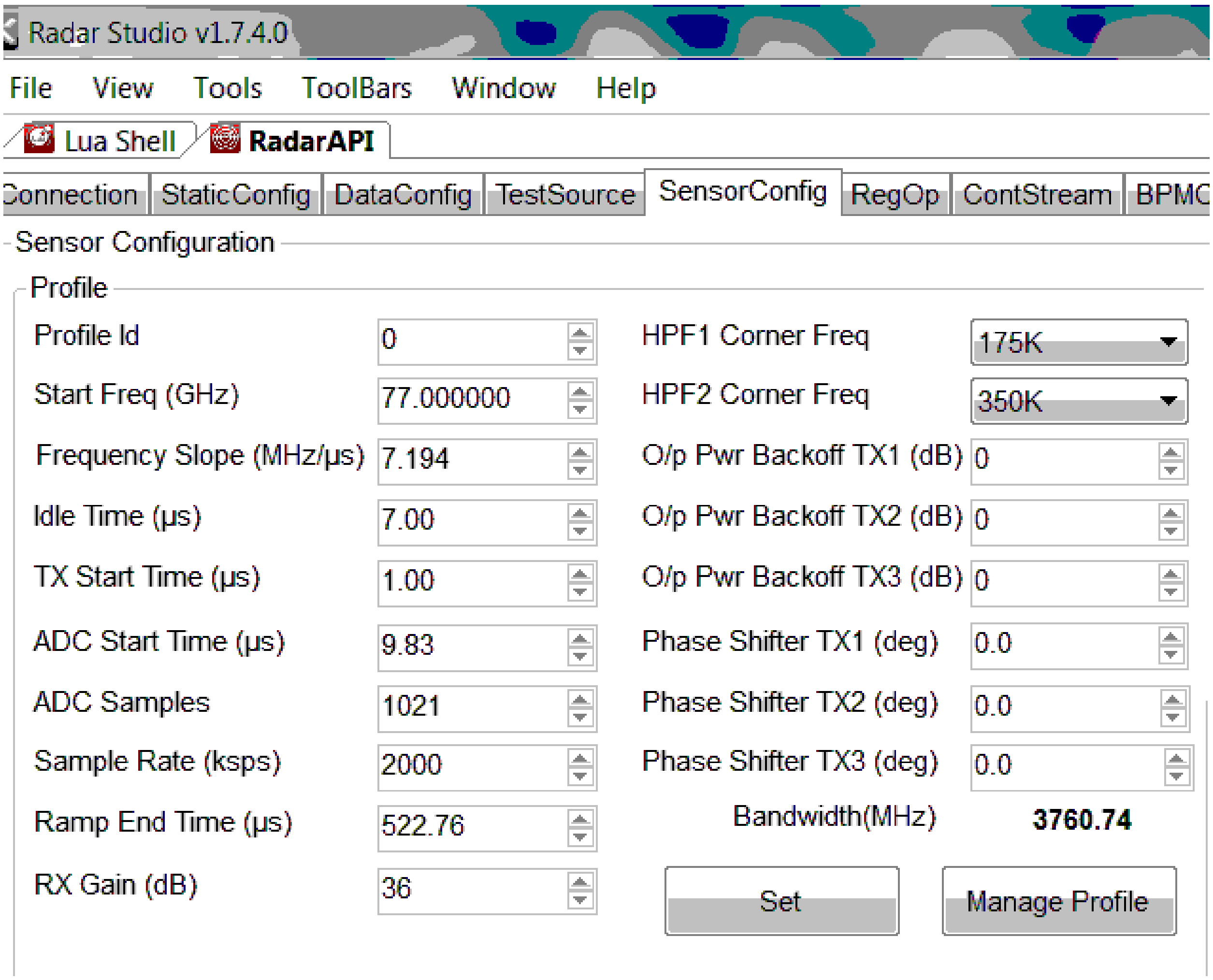


You need to copy the chirp settings to the SensorConfig tab of Radar Studio.

- Idle Time
- ADC Start Time
- Ramp End Time
- Note: Tx start time is not calculated, we use 1us as a default.

Chirp Configuration

Figure 11 – Radar Studio – Chirp Configuration - Profile

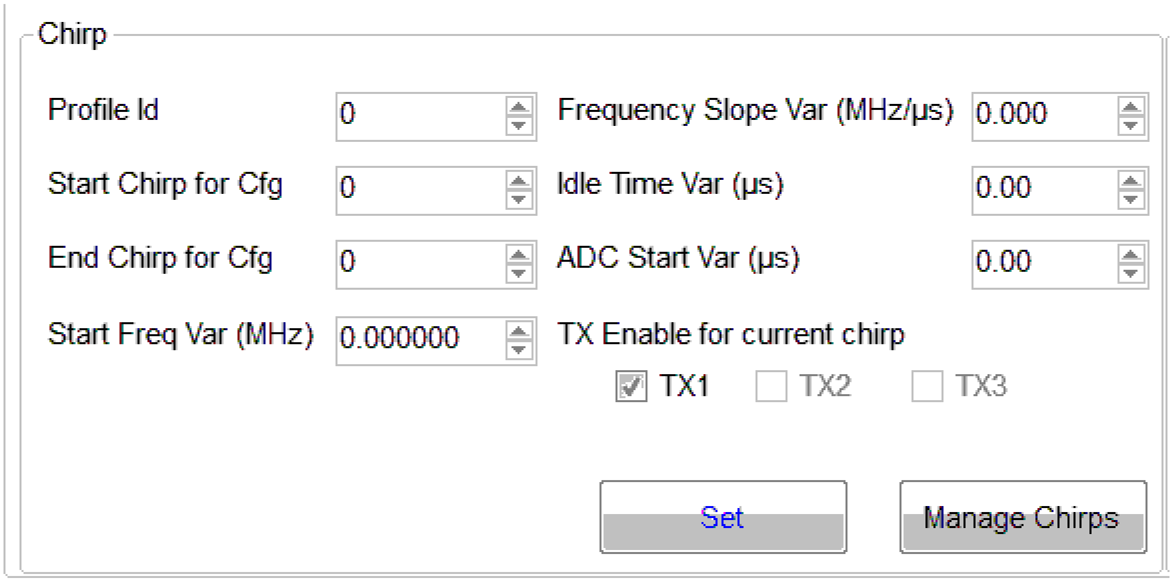


If the initial case has > 1 Tx, you need to set different chirps, note: when the file is saved multiple chirps are not restored after save. Make sure you save a picture of the additional profile or chirp configurations, as you will have to enter them manually.

Note: Rx Gain is 24-48db, 30 is the default, 36 is a value here, most of the time we use 48.

After you have entered profile 0, depress Set.

Figure 12 – Radar Studio – Chirp Configuration - Chirp



In the chirp tab, we have the individual Tx set, since we have 1 Tx from the Sensing Estimator, we have one Chirp (simplified). We reference the RF profile entered above.

Depress Set when complete.

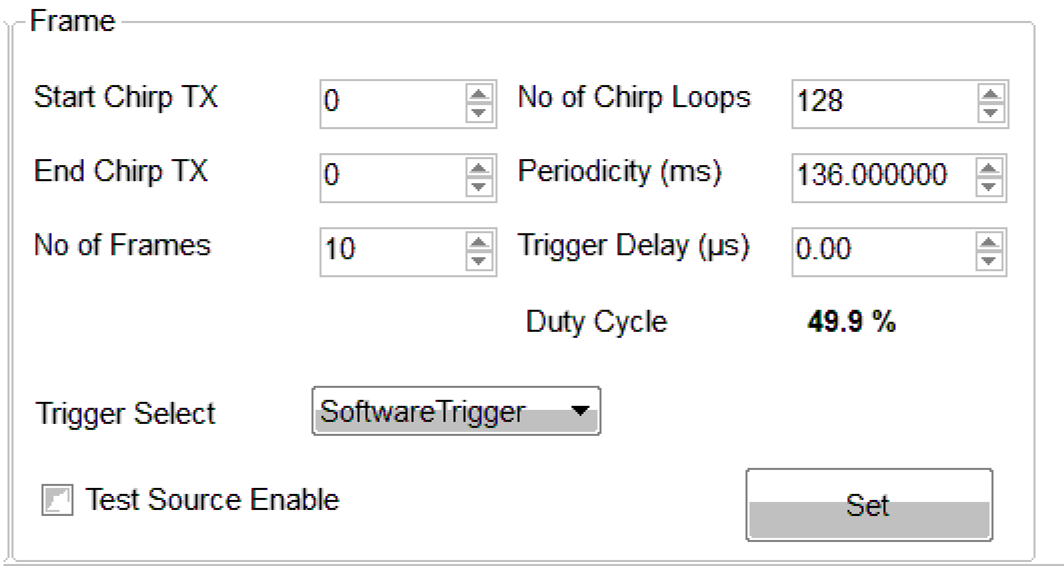
Frame Configuration

The frame configuration is the number of chirp sets * number of Frames from the Sensing Estimator.

The Sensing Estimator has 2 frames, typically we record 10.

Chirp period * 2 * number of chirp loops (128, min is 2) = Periodicity for Frame ms (note 2 is to maintain 50% dutycycle)

Figure 13 – Radar Studio – Chirp Configuration - Frame



4.5 Running the experiment and Post Processing

We then run radar Studio, setting the profile, chirp, frame configuration, we then Setup TSW1400 (left margin), arm TSW1400, and Trigger TSW1400.

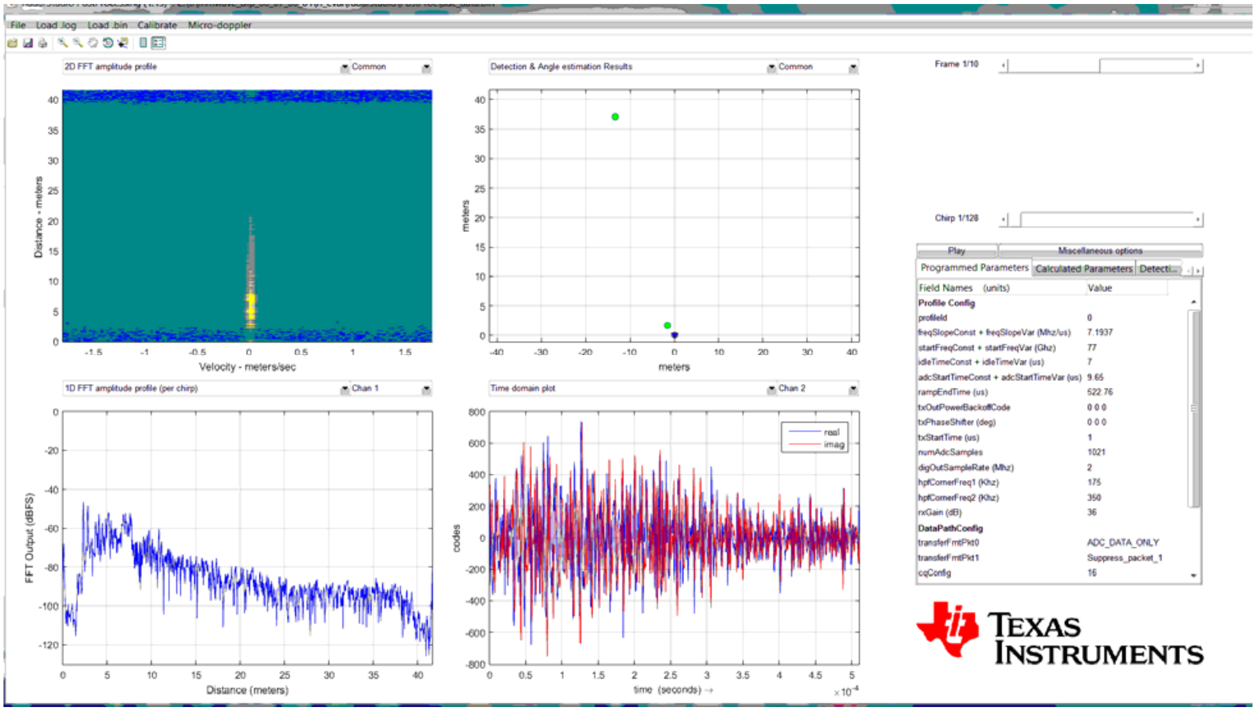
Wait for capture complete. Then push Post Process..

5.0 Matlab Post Processing Radar Studio

In the Sensor Configuration tab, there is a location for the file, that will be written by TSW1400, and then read for Post Processing.

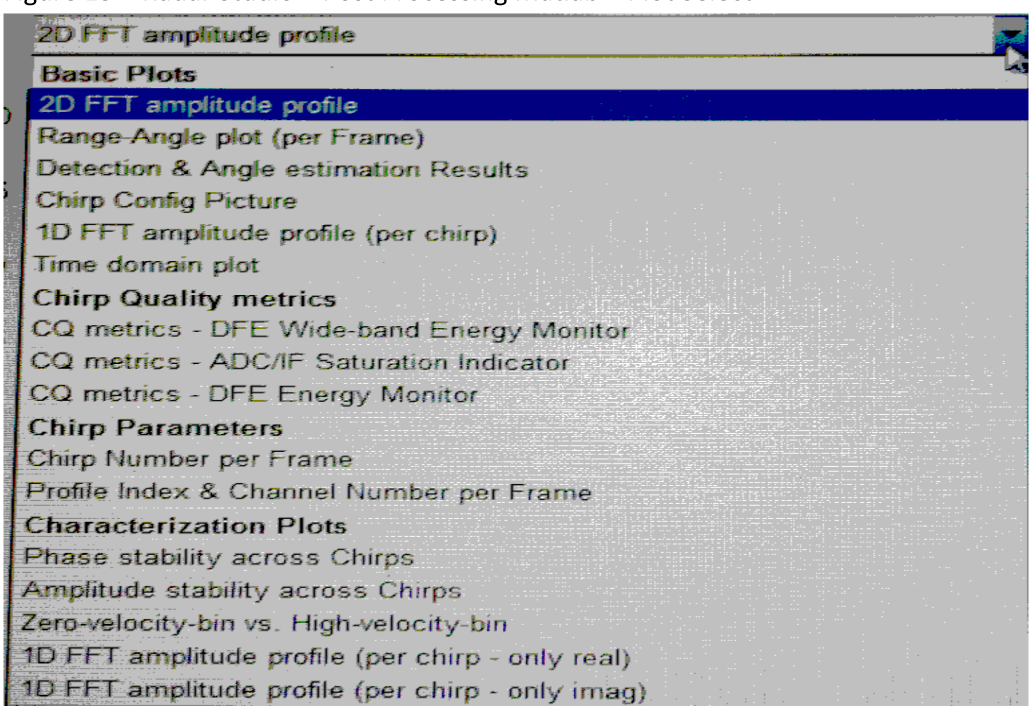
The Compiled Matlab GUI is run after post processing, look at the lower right status box on Radar Studio if there are error conditions during the experiment run, we don’t expect post-processing to be successful.

Figure 14 – Radar Studio – Post Processing Matlab



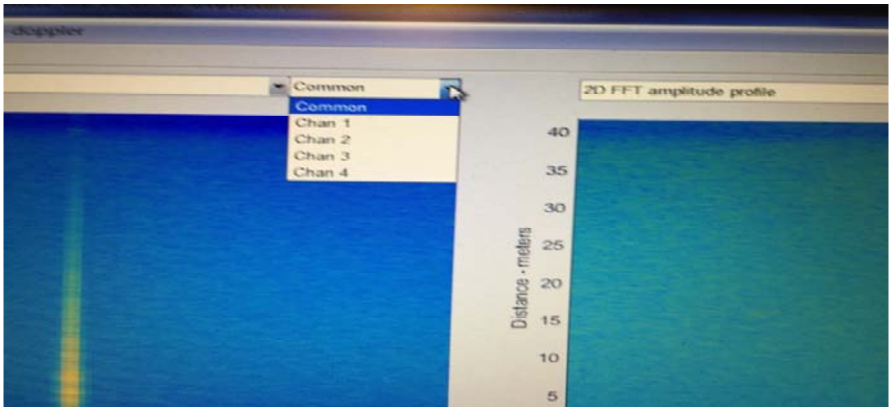
At the top of each selected graph, there are different graph types that can be selected. These are setup by default, then you can change them.

Figure 15 – Radar Studio – Post Processing Matlab – Plot Select



Under each graph section on the right side, we can have a collection of common or individual receiver channels.

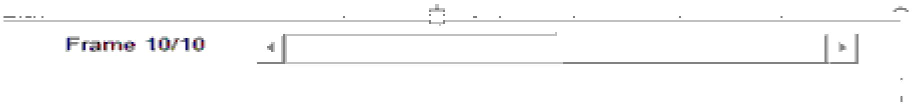
Figure 16 – Radar Studio – Post Processing Matlab – Plot Select



On the right side of the graph, there are several data selectors, sets of parameters, and a miscellaneous option menu.

Frame Selector

Figure 17 – Radar Studio – Post Processing Matlab – Frame Select

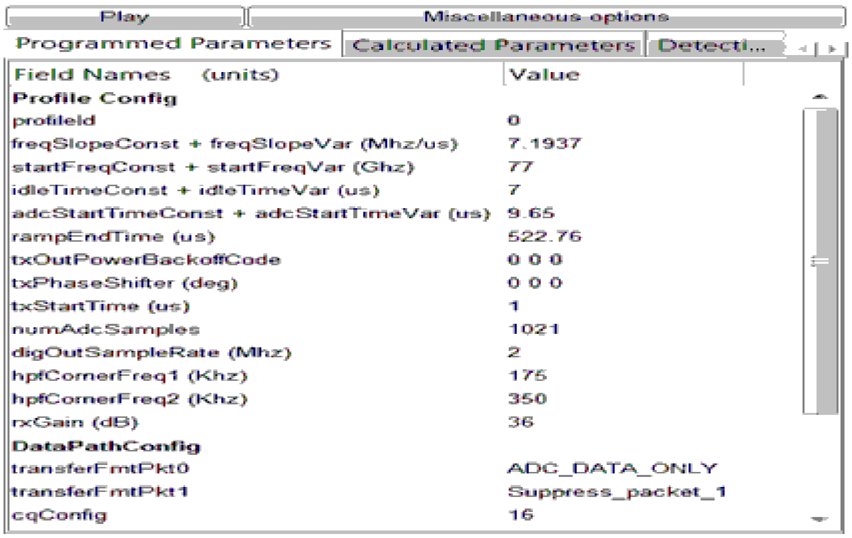


Chirp Selector

Figure 18 – Radar Studio – Post Processing Matlab – Chirp Select

The Frame, Chirp selectors can be used to select specific captured data for display.

Figure 19 – Radar Studio – Post Processing Matlab – Play, Miscellaneous, Programmed Parameters, Calculated Parameters, Detection

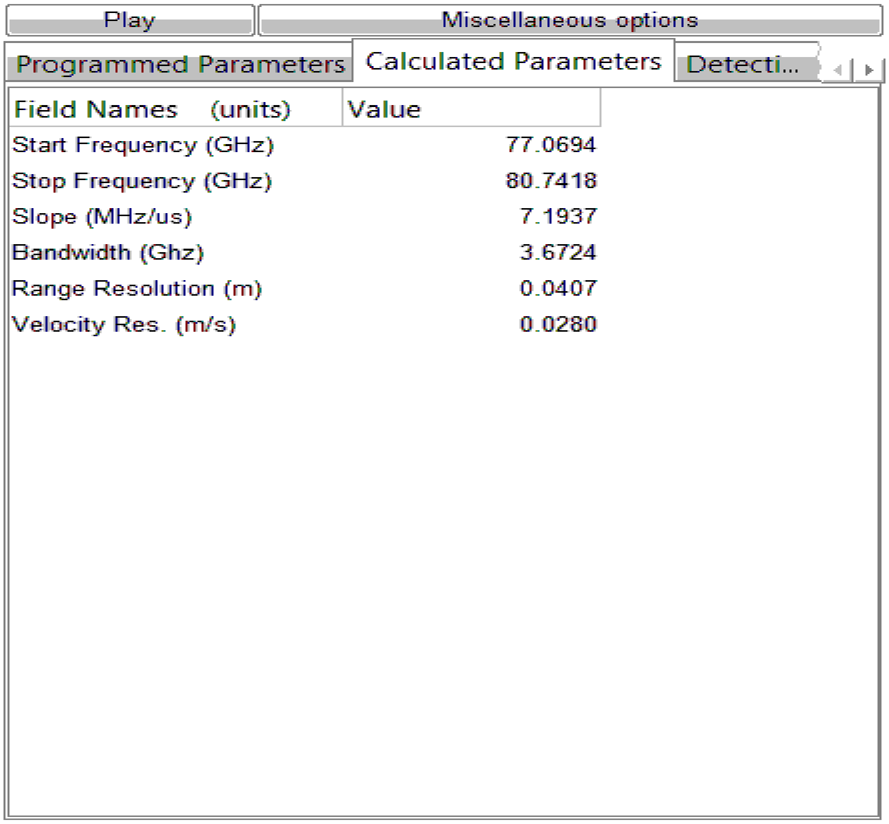


The play button allows a specific selected chip to be played across multiple frames.

The Programmed Parameters – are passed from the Radar Studio setup to the Matlab script. They are shown in the above figure.

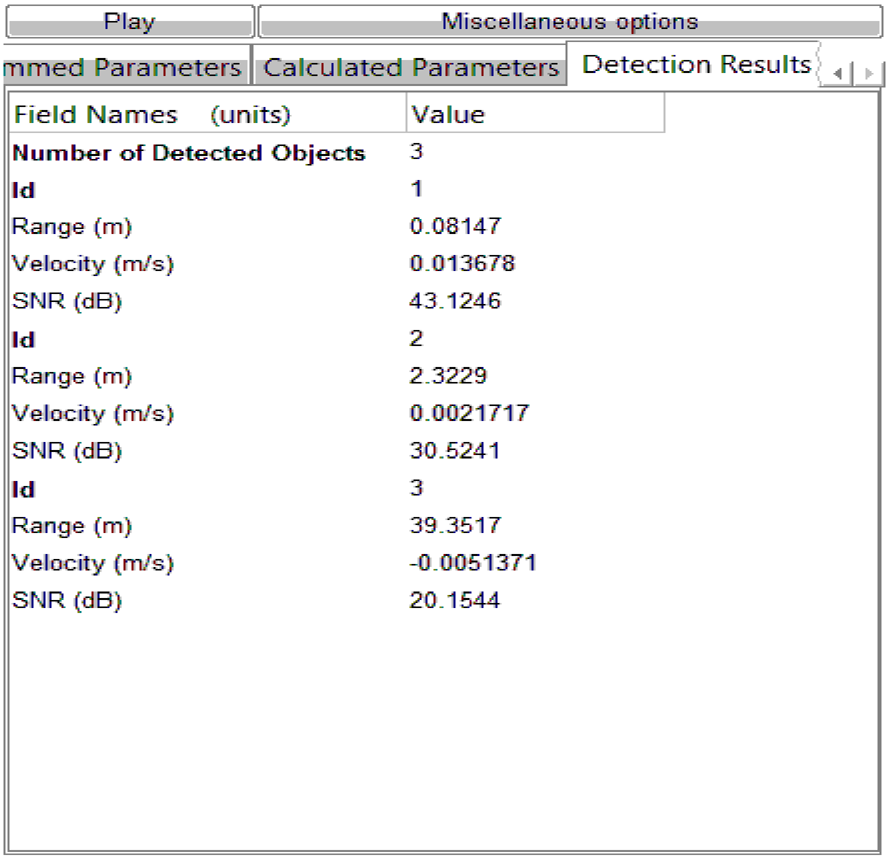
Calculated Parameters – these are computed from the Chirp, Profile parameters for Matlab.

Figure 20 – Radar Studio – Post Processing Matlab – Calculated Parameters



We pass the ADC Buffer data from the radar sensor, through Radar Studio, to the recorded file. The recorded file is post processed, so that we can detect specific objects.

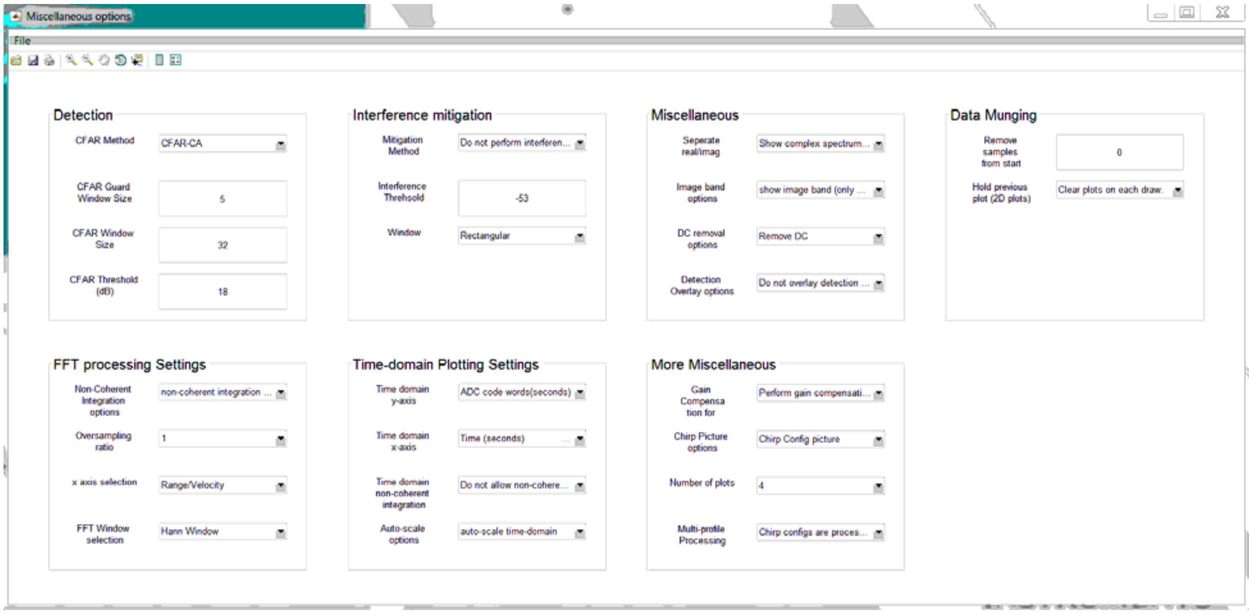
Figure 21 – Radar Studio – Post Processing Matlab – Detection



The miscellaneous options, brings up another set of processing and graph selections. It is described in the following sections

Miscellaneous options

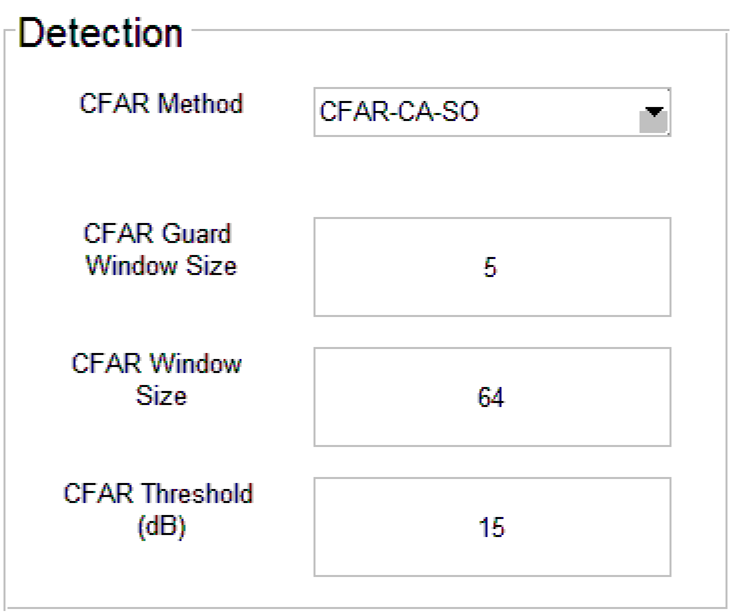
Figure 22 – Radar Studio – Post Processing Matlab – Miscellaneous options



Note: normally this can be left open, to reprocess the desired mode of the captured data.

a) Detection

Figure 23 – Radar Studio – Post Processing Matlab – Miscellaneous options - Detection



CFAR Method – the 3 modes are covered in Section 2.1 of Part 2 of the Hardware Accelerator User Guide. For the xWR1642, the equivalent DSP code is being described. Also covered in http://www.radartutorial.eu/01.basics/False%20Alarm%20Rate.en.html

CFAR-CA – default

CFAR_CAGO – looks for greater of the left or right samples, picks the larger for comparison with current

CFAR_CASO – looks for smaller of the left or right samples, picks the smaller for comparsion with current This is the 2nd choice.

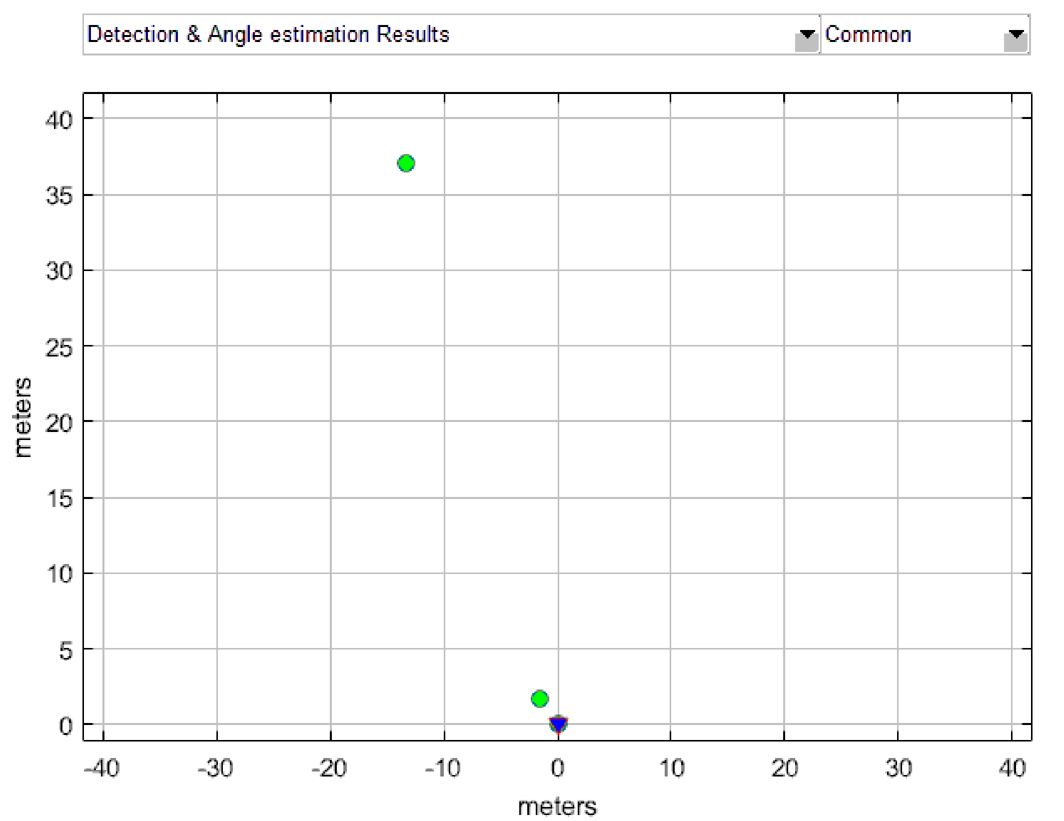
CFAR Guard Window – these are the samples around the peak-being-measured to exclude from the average

CFAR Window Size – the number of cells to include in the cell average.

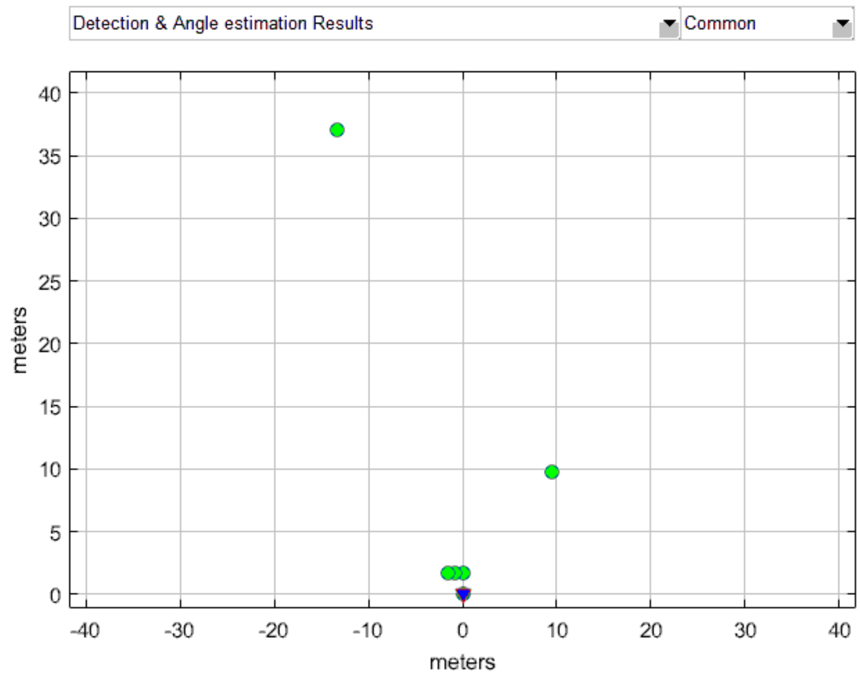
CFAR Threshold – how strong in db a peak must be above the average

Note: some references have additional CFAR capabilities, these could be built into the x1642 version, due to DSP coding, they are not in the HardWare Accelerator in the x1443 devices.

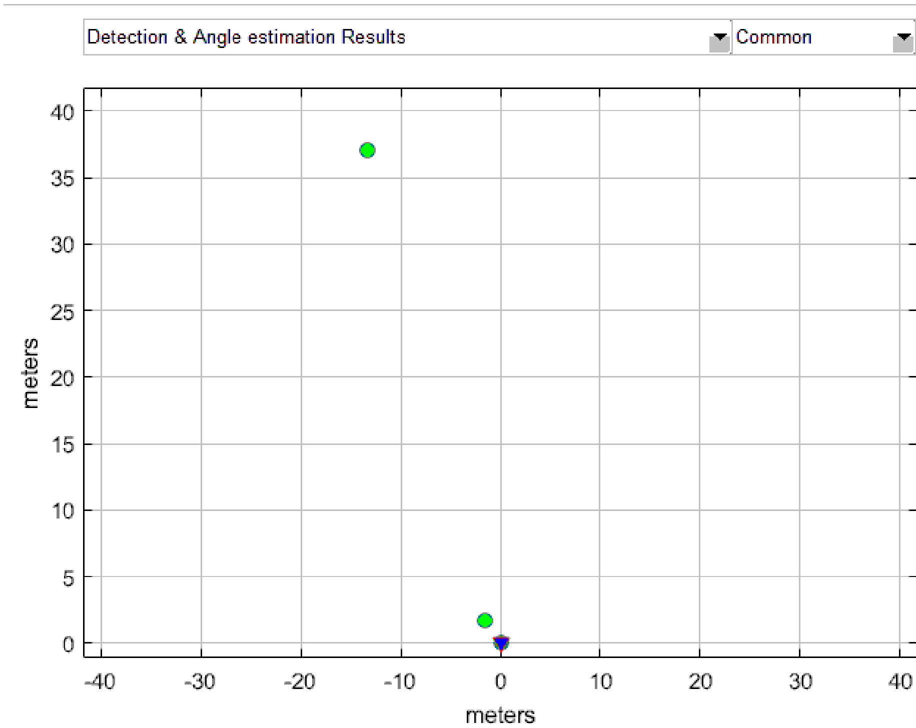
Reference default



Example change to CFAR_CASO, lower the detect SNR to 12

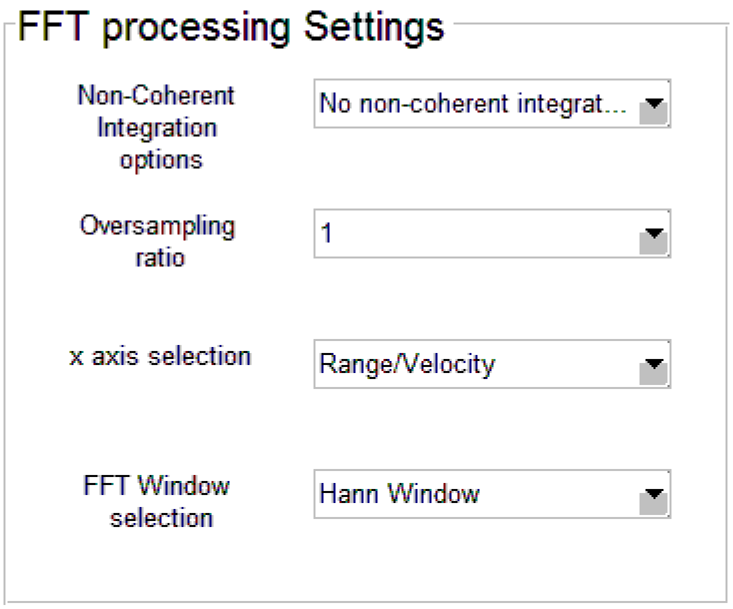


Changing the window size to 64 samples, changing the SNR back to 15



b) FFT Processing Settings

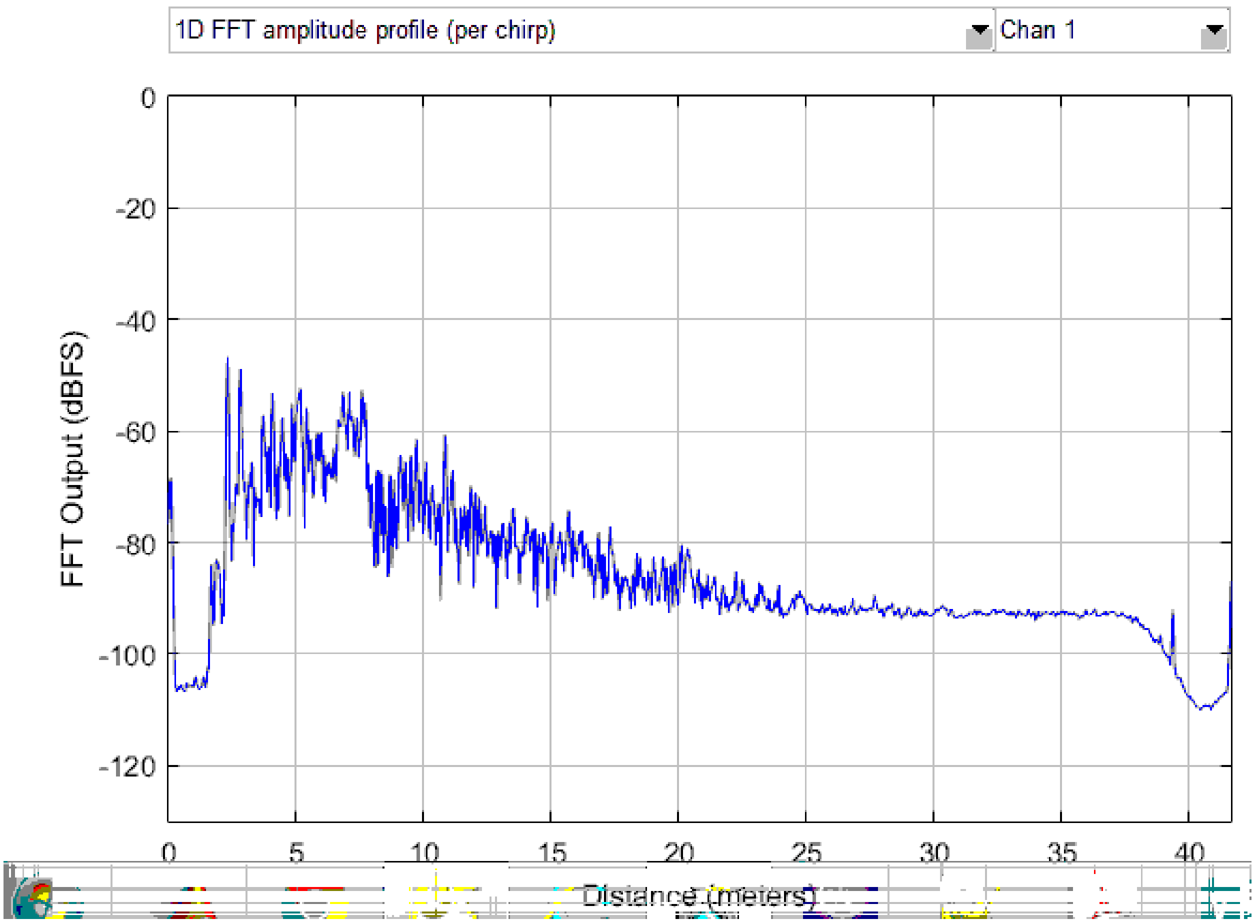
Figure 23 – Radar Studio – Post Processing Matlab – Miscellaneous options – FFT Processing



FFT processing Settings which affects the Lower left graph.

Integration across chirps, and receivers - Compare changes in the lower left graph for the option changes below. Selecting Non Coherent Integration across chirps, provides an averaging for each Receiver channel

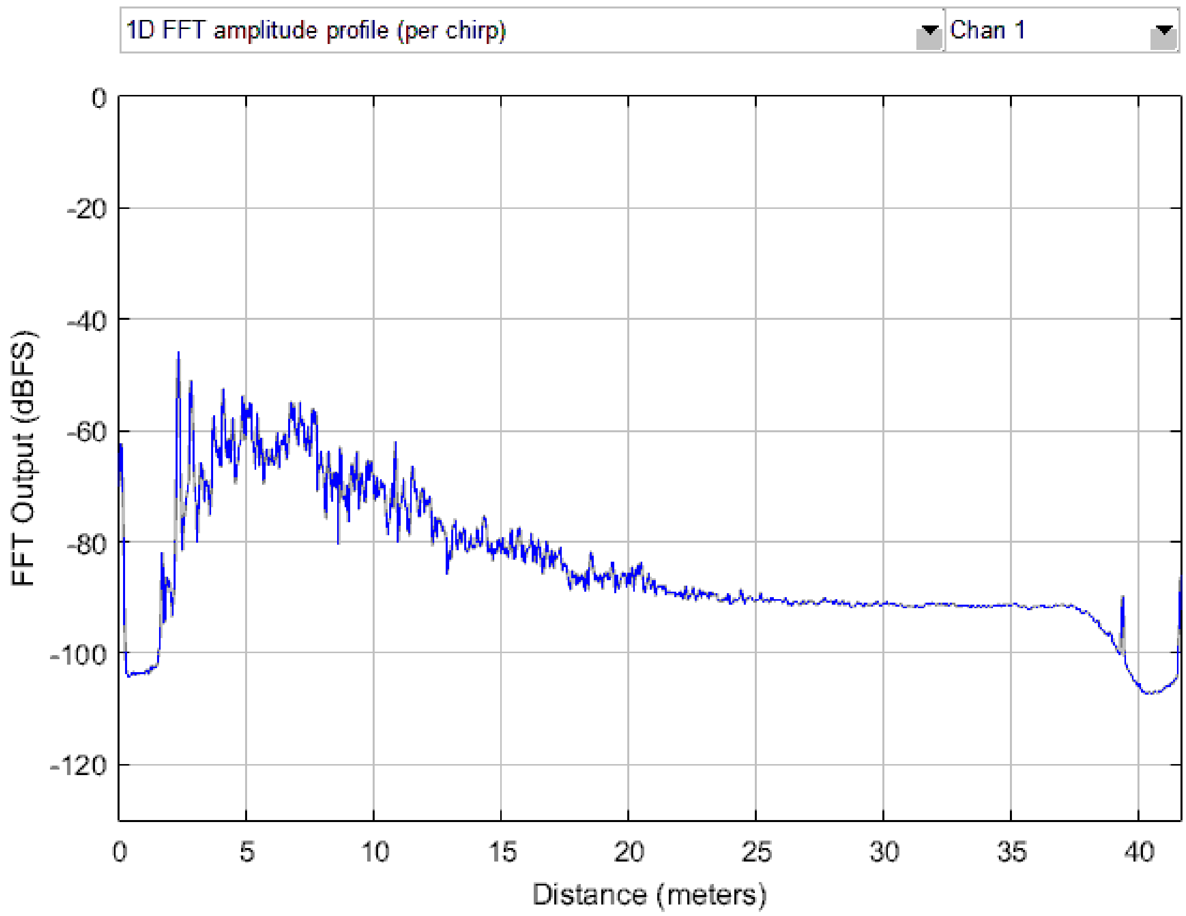
Figure 24 – Radar Studio – Post Processing Matlab – Miscellaneous options – FFT affects



You can still select each receiver channel above and to the right of the graph.

Selecting the Non Coherent Integration across chirps AND antennas, gives an average view of the receivers combined.

Figure 25 – Radar Studio – Post Processing Matlab – Miscellaneous options – FFT affects



Oversampling ratio applies a zero insertion technique for having more points for FFT processing. Normally it is set to 1.

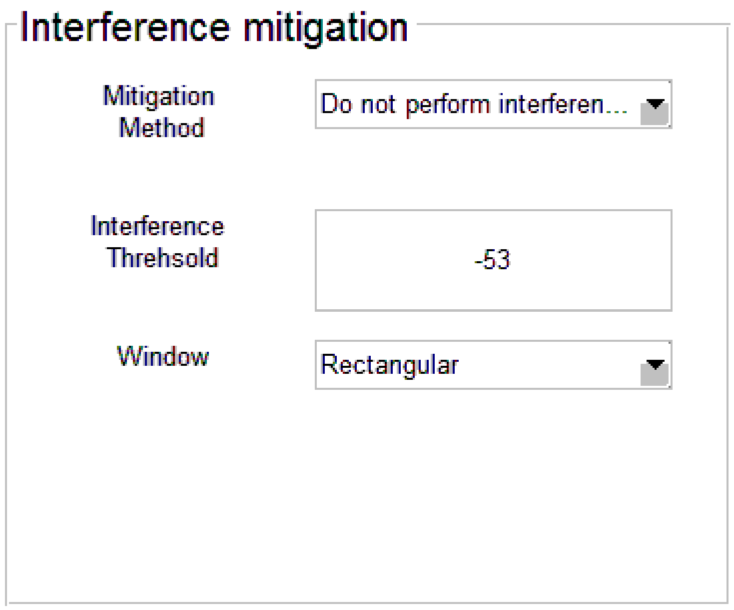
X axis for FFT plat can be Distance, or Frequency using the selected value.

FFT Window selection provides the prewindowing for the ADC Buffer samples prior to the FFT.   Hahn is normally selected.

Note: the FFT window selection also affects the heat map.

c) Interference Mitigation

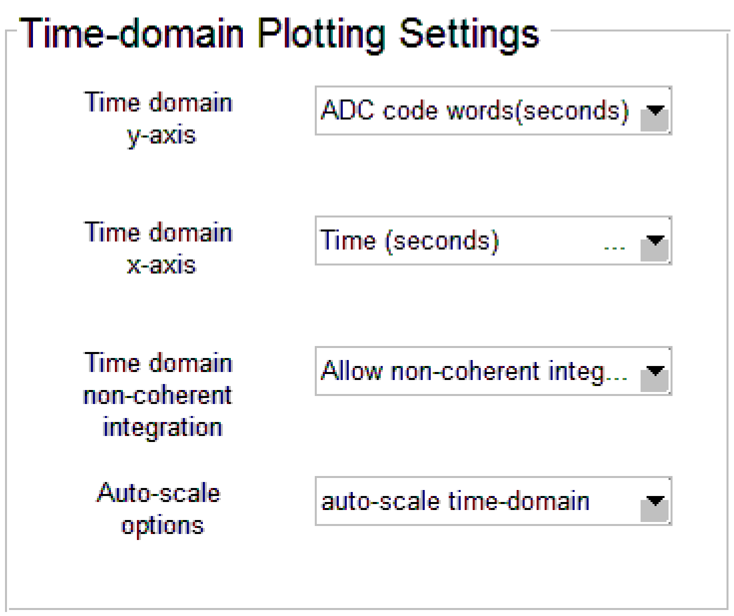
Figure 26 – Radar Studio – Post Processing Matlab – Miscellaneous options – Interference Mitigation



allows for detection if Interference (I think using the CQ data), this is not yet enabled – TBD, it may also require Complex 2x processing

d) Time Domain Plotting Settings

Figure 27 – Radar Studio – Post Processing Matlab – Miscellaneous options – Time Domain Plotting



Time Domain Y axis, can be IQ signed integers or x/fullscale normalized.

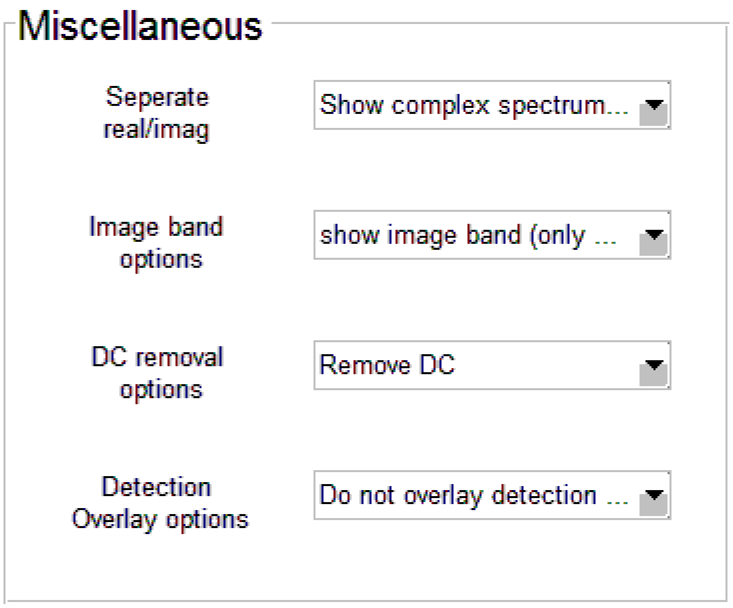
Time Domain X axis, can be Time, Ramp Frequency, or Sample number

Time incoherent integration – normal, or allows chirps to be averaged

Auto Scale – scale for sample size or not

e) Miscellaneous

Figure 28 – Radar Studio – Post Processing Matlab – Miscellaneous options – Miscellaneous



Separate real / imag – I leave this off

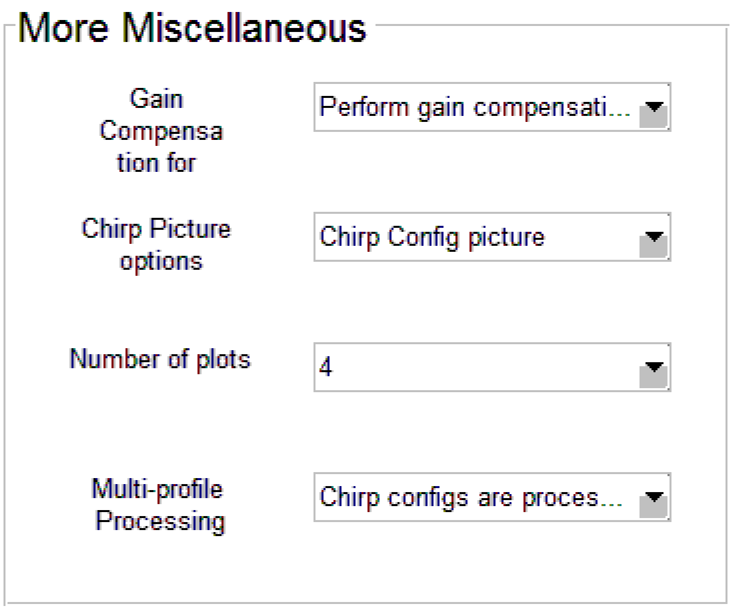
Imag band options – if this is Complex 2x mode, can ignore the negative frequency section, not used for Complex 1x

DC removal options – normally DC is removed

Detection overlay options – overlays detection results on heat map plot

f) More Miscellaneous

Figure 29 – Radar Studio – Post Processing Matlab – Miscellaneous options – More Miscellaneous



Gain Compensation – the default is Perform Gain compensation.   There is no gain compensation or energy compensation (I think this tries to reverse HPF1, HPF2).

Chirp Picture options – I don't see a difference with this selected.

There is a frame select, and chirp within a frame select slider on the main graph.

Number of plots 1,2,4,9 – using the selector above the plot you can select different plot values, common or specific Receiver plots.

Multi profile processing – the graph can selective plot different chirp-profile data, if there are multiple profiles.

Section 5 – 10m measurement example IWR1642