RF Measurement Fundamentals Exercises

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Fourier Transform and FFTs

Exercise 2-1 Lowpass Sampling

Goal

Examine the aliasing effect on lowpass signals when not sampling fast enough.

Implementation

1. Open the `Sampling.vi` file located in the `<Exercises>/RF Measurement Fundamentals` folder.
2. Start the Sampling VI.
   - ❑ Set **Carrier Frequency** = 1 Hz (~ 0 Hz).
   - ❑ Set **Signal Pass Band Bandwidth** = 5 MHz.
   - ❑ Set **Sampling Rate** = 20 MHz.
   - ❑ Set **Real/Complex Spectra** switch to **Real Spectra**.
3. What is the lowest and highest frequency content of the signal?
   _____
4. Using the above highest frequency, what is the minimum sampling rate we can use to satisfy Nyquist?
   _____
5. If you sample at any frequency less than Nyquist what will happen?
   _____
6. Set **Sampling Rate** to 4 MHz to see what happens.
   - ❑ What is the foldover frequency if the sample rate = 4 MHz?
     _____

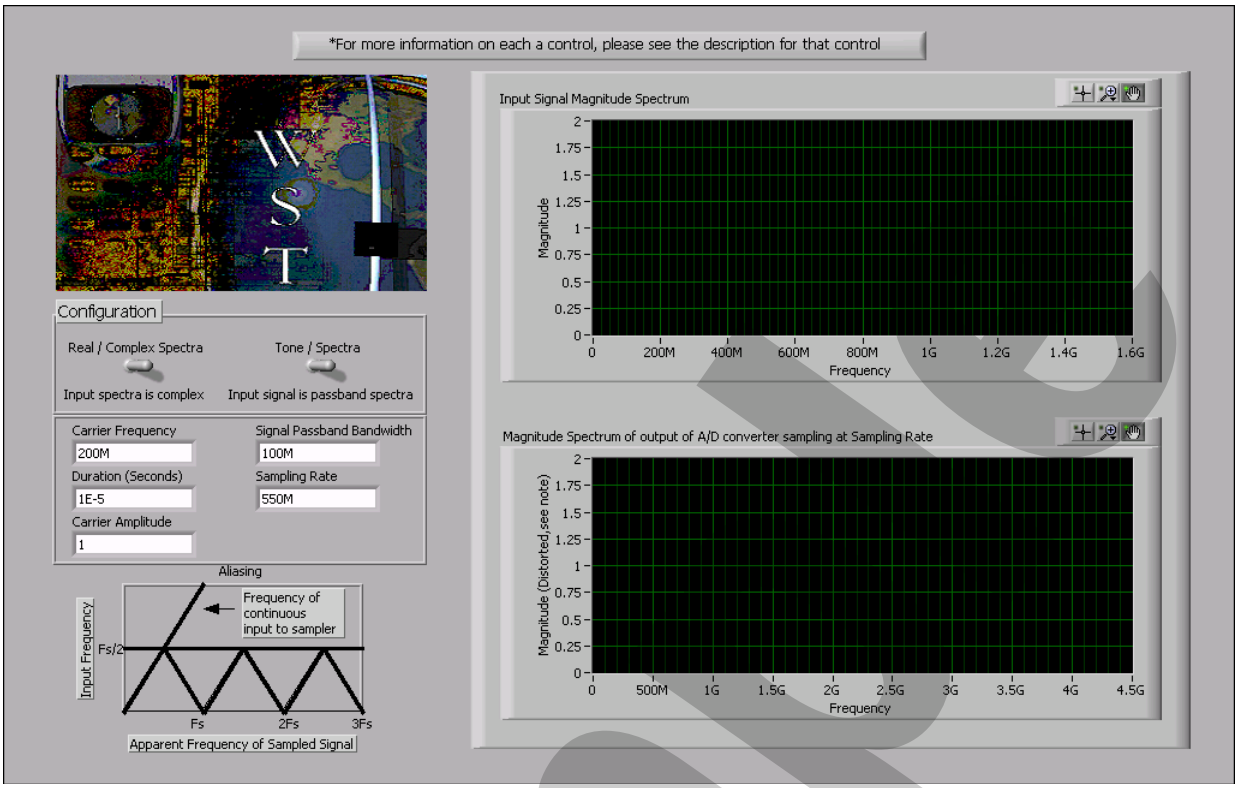

Figure 2-1. Sampling VI Front Panel

End of Exercise 2-1

Exercise 2-2 BandPass Sampling

Goal

Examine under sampling and how it can sometimes be used to sample below f_{max}.

Implementation

1. Open the `Sampling.vi` file located in the `<Exercises>/RF Measurement Fundamentals` folder.
2. Run the Sampling VI.
   - ❑ Set **Carrier Frequency** = 20 MHz.
   - ❑ Set **Signal Pass Band Bandwidth** = 5 MHz.
3. What is the lowest and highest frequency content of the Signal?

   _____
4. Using the above highest frequency, what is the minimum sampling rate we can use to satisfy Nyquist?

   _____
5. Utilizing the under-sampling equation from the following table, determine the valid integer values of *m*.

   Let $m = 1, 2, 3, 4, 5$

   For $m = 1$, $fs_{min} = 22.5$ MHz and $fs_{max} = 35$ MHz

   Set the sample rate to 22.5 and 35 MHz and observe the output spectrum. Which one would you choose?

   _____

   Applying the restriction that $fs \geq 2B$, do any of the *m* values become invalid?

   _____

   If so, which ones and why?

   _____

Requirement	Sample Rate Expression	Conditions
Acceptable ranges of *fs* for bandpass sampling	$\frac{2fc - B}{m} \geq fs \geq \frac{2fc + B}{m + 1}$	m = any positive integer so that $fs \geq 2B$
Sample rate in the middle of the acceptable sample rate	$fs_{cntr} = \frac{fc - \frac{B}{2}}{m} + \frac{fc + \frac{B}{2}}{m + 1}$	m = any positive integer so that $fs_{cntr} \geq 2B$
Sample rate at an intermediate point in the acceptable sample rate bands	$fs_i = \frac{4fc}{m_{odd}}$	m_{odd} = any positive odd integer so that $fs_i \geq 2B$
Optimum sample rate to avoid spectral inversion	$fs_o = \frac{2fc - B}{m_{even}}$	m_{even} = any positive odd integer so that $fs_o \geq 2B$
Absolute minimum *fs* to avoid aliasing	$fs_{MN} = \frac{2fc + B}{R_{INT}}$	where $R_{INT} \leq \frac{fc + \frac{B}{2}}{B} \leq R_{INT} + 1$

End of Exercise 2-2