

RF Measurement Fundamentals Exercises

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Appendix A

Additional Information and Resources

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?

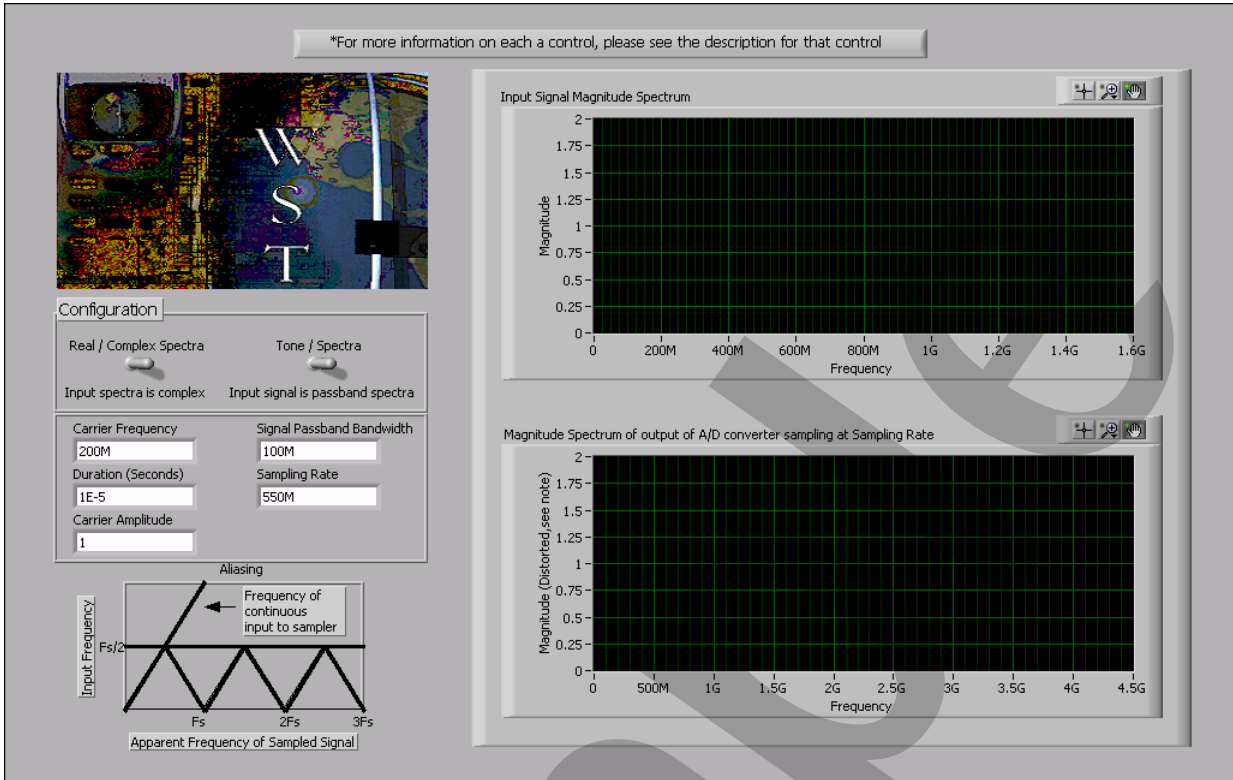


Figure 2-1. Sampling VI Front Panel

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 $m = 1$, $f_{s_{\min}} = 22.5$ MHz and $f_{s_{\max}} = 35$ 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 $f_s \geq 2B$, do any of the m values become invalid?

If so, which ones and why?

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

End of Exercise 2-2