

Tutorial Questions: Windowing and Zero Padding

1. A single complex sinusoid with frequency f_0 exists for all time and has a spectrum $\delta(f - f_0)$. Show that this is the case.
2. Determine the spectrum for the above single complex sinusoid but now multiplied by a rectangular window with width T_c and centered at $t = 0$ i.e. from $-T_c/2$ to $+T_c/2$.
3. A sinc function results in the above case. Sketch the magnitude spectrum of the determined sinc function and determine the locations of the nulls under two scenarios:
 - (a) When $f_0 T_c = n$ where n is an integer;
 - (b) When $f_0 T_c$ is not equal to an integer.
4. Sketch the magnitude of a sinc function and label the main lobe, nulls and side lobes.
5. Explain clearly, in your own words, the following terms, in the context of the DFT and windowing giving equations where possible:
 - (a) Coherent gain;
 - (b) Side lobe fall off rate in:
 - i. Decibels per decade;
 - ii. Decibels per octave.
 - (c) Spectral leakage;
 - (d) Scalloping loss;
 - (e) Absolute dynamic range;
 - (f) Far-field dynamic range;
 - (g) Resolution.
6. If a signal has a magnitude A and a measurement of the signal yields a value B instead, write down, in simple text form (i.e. no special formatting; use $_$ for subscript and $^$ for superscript), the formulas for:
 - (a) The measurement error;
 - (b) The fractional error;
 - (c) The percentage error;
 - (d) The dB error.
7. When carrying out an FFT of a cosine wave whose frequency is 0.1Hz and whose amplitude is unity, explain why the peak amplitude measurement obtained in the range 0.09Hz to 0.11Hz should ideally have a value of 0.5?
8. Explain the concept of linear interpolation in your own words, without using any mathematical formulae.
9. Explain the reasons for performing zero padding? Describe the process in the time domain and the effect on the resulting frequency domain.