

Tutorial 2: Sampling

Exercise 1

Given an analog signal

$$x(t) = 5\cos(2\pi \cdot 2,500t) + 2\cos(2\pi \cdot 3,200t), \text{ for } t \geq 0$$

Sampled at a rate of 8,000 Hz,

- sketch the spectrum of the sampled signal up to 20 kHz;
- sketch the recovered analog signal spectrum if an ideal low-pass filter with a cutoff frequency of 4 kHz is used to filter the sampled signal in order to recover the original signal.

Exercise 2

Given an analog signal

$$x(t) = 3\cos(2\pi \cdot 1,500t) + 2\cos(2\pi \cdot 4,200t), \text{ for } t \geq 0$$

Sampled at a rate of 8,000 Hz,

- sketch the spectrum of the sampled signal up to 20 kHz;
- sketch the recovered analog signal spectrum if an ideal low-pass filter with a cutoff frequency of 4 kHz is used to filter the sampled signal in order to recover the original signal;
- determine the frequency/frequencies of aliasing noise.

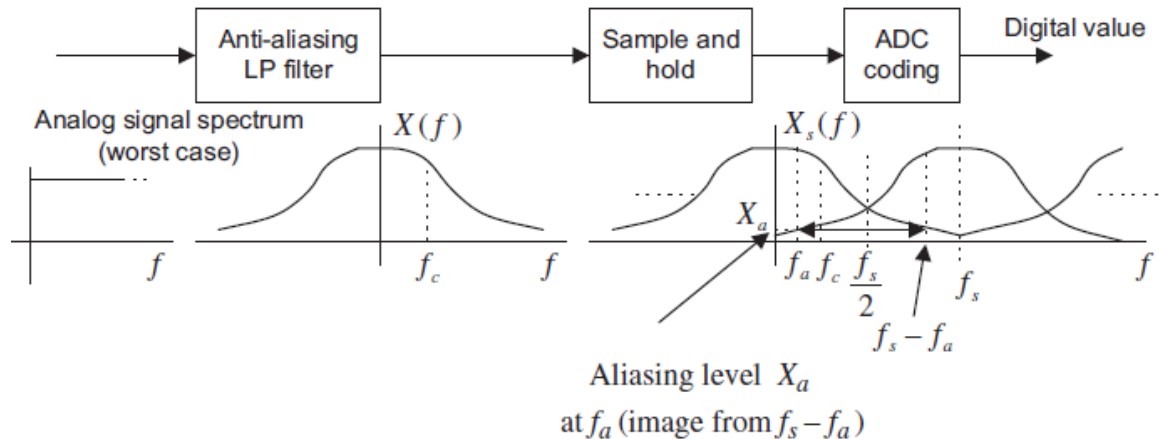
Exercise 3

Given a DSP system in which a sampling rate of 8,000 Hz is used and the anti-aliasing filter is a second-order Butterworth low-pass filter with a cutoff frequency of 3.4 kHz, determine

- the percentage of aliasing level at the cutoff frequency;
- the percentage of aliasing level at a frequency of 1,000 Hz.

Exercise 4

Given the DSP system, where a sampling rate of 40,000 Hz is used, the anti-aliasing filter is the Butterworth low-pass filter with a cutoff frequency 8 kHz, and the percentage of aliasing level at the cutoff frequency is required to be less than 1%, determine the order of the anti-aliasing low-pass filter.



Exercise 5

Assuming that a 4-bit ADC channel accepts analog input ranging from 0 to 5 volts, determine the following:

- number of quantization levels;
- step size of the quantizer or resolution;
- quantization level when the analog voltage is 3.2 volts;
- binary code produced by the ADC;
- quantization error.

Exercise 6

Assuming that a 5-bit ADC channel accepts analog input ranging from 0 to 4 volts, determine the following:

- number of quantization levels;
- step size of the quantizer or resolution;
- quantization level when the analog voltage is 1.2 volts;
- binary code produced by the ADC;
- quantization error.