

1. Basics

Consider a simple sampling rate conversion system with a conversion rate of $\frac{4}{3}$. The system consists of two upsampling blocks, each by 2, and one downsampling block of 3.

1. What are anti-imaging and anti-aliasing filters and where do we need them in our system?
2. Sketch the block diagram.
3. Sketch the input, intermediate and output spectra in the frequency domain.
4. How is the amplitude affected by the up- and downsampling and where does it come from?
5. Sketch the frequency response of the anti-aliasing and anti-imaging filters needed for this upsampling system.

2. Synchronous Conversion

Our system will now be upsampled directly by a factor of 4, and again downsampled by a factor of 3, but with linear interpolation and decimation methods. The input signal is given as $x(n) = \sin(\frac{n\pi}{6})$, $n = 0, \dots, 48$.

1. What are the impulse responses of the two interpolation filters? Sketch their magnitude responses.
2. Plot the signals (input, intermediate and output signal) in time domain.
3. What is the delay resulting from the causal interpolation/decimation filters?
4. Show the error introduced by this interpolation/decimation method, in the frequency domain.

3. Polyphase Representation

Now we extend our system using a polyphase decomposition of the interpolation/decimation filters.

1. Sketch the idea of polyphase decomposition using a block diagram. What is the benefit of such decomposition?
2. Calculate the polyphase filters for up- and downsampling (using interpolation and decimation).
3. Use Matlab to plot all resulting signals in the time and frequency domain.

4. Asynchronous Conversion

1. What is the basic concept of asynchronous sampling rate conversion?
2. Sketch the block diagram and discuss the individual operations.
3. What is the necessary oversampling factor L for a 20-bit resolution?
4. How can we simplify the oversampling operations?
5. How can we make use of polyphase filtering?
6. Why are halfband filters an efficient choice for the upsampling operation?
7. Which parameters determine the interpolation algorithms in the last stage of the conversion?