6. Sampling Rate Conversion

6.1 Down- and Up-Sampled Signals in the Time-Domain

Given a continuous-time sinusoidal signal with amplitude 2 and frequency 2 Hz. Sample this signal with a sampling frequency of 16 Hz in the time range from 0 to 2 seconds and plot these two signals into a single subplot.

Down-sample the sampled signal with a down-sampling factor M=2 and an up-sampled sequence with an up-sampling factor L=3 and plot these two signals into a single subplot.

6.2 Down- and Up-Sampled Signals in the Frequency-Domain

Create and plot the output spectra of a down- and an up-sampled signal.

To this end, choose a triangular spectrum generated by the commands

```
freq = [0 0.42 0.48 1];
mag = [0 1 0 0];
x = fir2(101,freq,mag);
```

Choose the down-sampling factors M=2 and M=3, and the upsampling factor L=5, respectively.

6.3 Design of a Decimator

Write a script to design the decimator with specifications as considered in chapter 4.6.

Specify the decimator with a ***fdesign.decimator*** object and design three versions of the decimator with the design methods **equiripple**, **ifir**, and **multistage**, respectively.

Compare the number of stages, the costs and the magnitude responses, respectively.

6.4 Nyquist Filter Design

Design a lowpass fourth-band Nyquist FIR filter using the window-based design approach.

Use a peak passband ripple of 0.05, and a minimum stopband attenuation of 60 dB.

Design the filter a second time using the ***firnyquist*** function with minimum order option.

Compare the filter order of both designs. Verify the linear phase for both designs.

Plot the gain responses and verify that the coefficients of the impulse response of the Nyquist filter are equal to zero for $n = \pm 4, \pm 8, \ldots$.

Verify the frequency condition of a Nyquist filter. To this end, create the three uniformly shifted magnitude responses using ***iirshiftc*** of the second fourth-band Nyquist filter. Add up all four magnitude responses, and plot all magnitude responses into a single plot.

6.5 Fractional Sampling Rate Converter Design

Write a script to design the fractional sampling rate converter considered in chapter 4.9.

Simulate your fractional sampling rate converter and plot the output sequence.

Verify the coefficients of the Lagrange polynomials using the given M-File ***lagrange_poly*** and the coefficients of the FIR transfer functions in the Farrow structure.