Experiment 4

IIR Filters

1. Purpose

   The purpose of this experiment is to study design of Infinite Impulse Response (IIR) filters. Two methods, namely Impulse Invariance and Bilinear Transformation Methods, are employed in the design of discrete-time filters with Butterworth and Chebyshev approximations

2. Laboratory Work

   Throughout the laboratory work, assume the following filter specifications are to be met

$$0.7 \leq \left|H\left(e^{jw}\right)\right| \leq 1, \quad 0 \leq w \leq 0.2\pi$$
$$\left|H\left(e^{jw}\right)\right| \leq 0.25, \qquad 0.4\pi \leq w \leq \pi$$

   Also assume that the discrete-time filters are obtained from continuous-time filters via some transformations

   a. Compare the Impulse method and the Bilinear Transformation for transforming a continuous-time filer into a discrete one

   b. Design a discrete-time filter with a Butterworth approximation. Use the Impulse Invariance method to obtain the discrete-time filter. Plot the magnitude and phase response of the filter.

   c. Repeat part (b) using the Bilinear Transformation

   d. Design a discrete-time filter with a Chebyshev approximation. Use the Impulse Invariance method to obtain the discrete-time filter. Plot the magnitude and phase response of the filter.

   e. Repeat part (d) using Bilinear Transformation.

   f. Apply the following signal to the input of your filter (for each one):

$$x[n] = \cos(2\pi\, n\, 0.02) + \sin(2\pi\, n\, 0.06) + \cos(2\pi\, n\, 0.3), \quad n = 0, \ldots, 255$$

      and compute the output $y[n]$. Plot input and output magnitude spectra to see the effect of filtering. Plot the time-domain waveforms on which the effect of lowpass filtering should also be evident.

   g. Compare Burtterworth and Chebyshev approximations in terms of complexity, magnitude and phase response.