Effects of overflow and underflow in digital filtering

Lab 10, SDP

Objective

Students should observe the effects of internal format overflow and underflow events on the output of a digital filter.

Theoretical notions

Exercises

1. Consider the following system:

$$H(z) = \frac{1 - \frac{1}{2}z^{-1}}{\left(1 - \frac{1}{4}z^{-1}\right)\left(1 + \frac{1}{4}z^{-1}\right)}$$

   a. Draw the direct form II implementation and one of the series implementations
   b. Assume a fixed-point implementation with b bits for the fractionary part. Each product is quantized by rounding to this format. Find the variance of the rounding noise due to the internal multiplications, at the output of each implementation from a.

2. Consider the following system:

$$H(z) = \frac{1 - 0.8z^{-1} - 0.78z^{-3} + 0.1z^{-4}}{1 + 0.1z^{-1} - 0.08z^{-2} - 0.264z^{-3} - 0.0504z^{-4}}$$

   a. Generate an input signal $x[n] = 0.9u[n]$ and display it.
   b. Compute the output $y[n]$ of the system using the using Direct Form 2 implementation (use the function filter_df2() which we have created in a previous lab).
   c. Plot the output $y[n]$ as well the internal signal $w[n]$ (see the figure).

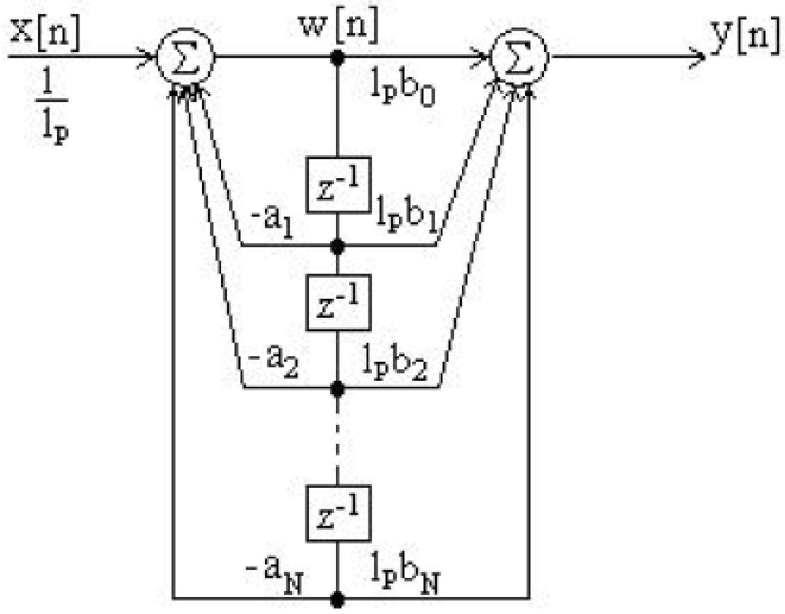

Figure 1: Scaling of a Direct Form 2 implementation

3. Display graphically the two summation characteristics $g1()$ and $g2()$ implemented in the provided `.m` files. What do they mean with regard to summation?
4. Apply the two summation functions $g1()$ and $g2()$ to the two sums in the filter implementation, to simulate the effect of a finite-length summator. Plot the output $y[n]$ as well the internal signal $w[n]$ (see the figure). Do they look good or not?
5. Compute the three scaling norms l_∞, l_1 and l_2 for overflow prevention, using the provided function `normescal()`. Apply the scalings to the system, as depicted in the figure. Plot again the signals $w[n]$ and $y[n]$. Is this better or worse than in the previous case?

Final questions

1. TBD