Digital Signal Processing and Digital Filters

Imperial College London

Practice Sheet 11

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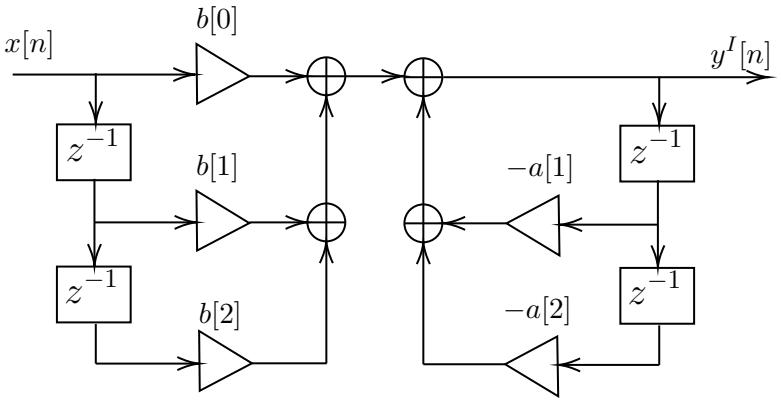
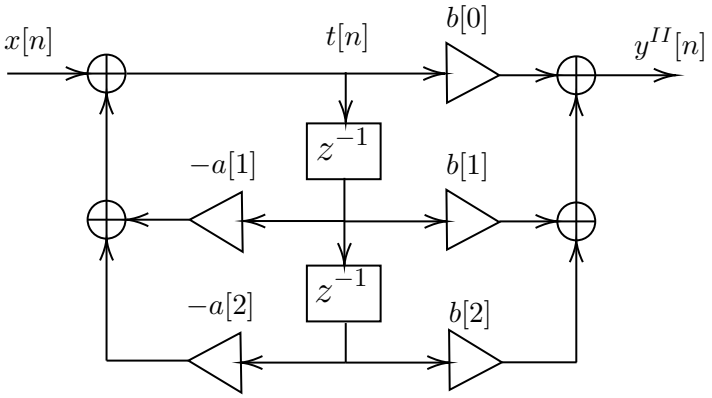
The purpose of the practice sheet is to enhance the understanding of the course materials. The practice sheet does not constitute towards the final grade. Students are welcome to discuss the problems amongst themselves. The questions will be discussed in the Q&A sessions with the instructor.

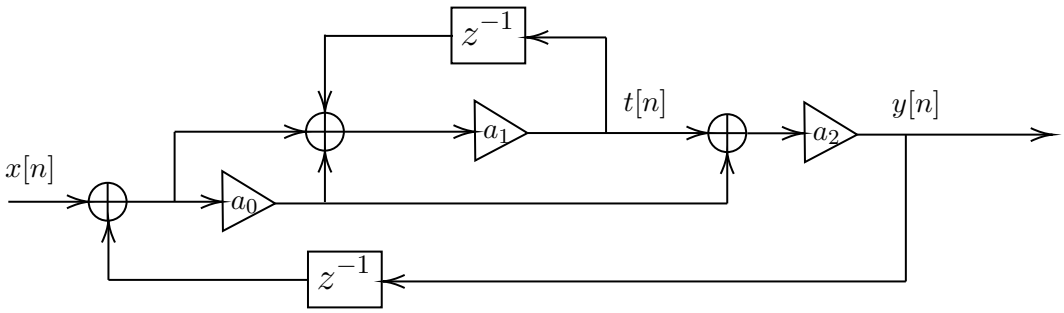
1) The Direct Form I and Direct Form II of digital filters are depicted in the diagrams below.





Let the input initial conditions be $x[0] = -1$ and $x[1] = 2$. Find y_0, y_1, t_0, t_1 such that, if $y^I[i] = y^{II}[i] = y_i$ and $t[i] = t_i, i = 0, 1$, then the two forms are equivalent, i.e., $y^I[n] = y^{II}[n], \forall n \in \mathbb{Z}$.

2) Let $y[n]$ be the output of a linear system as depicted below



(a) Convert the block diagram into an equivalent transposed form,

(b) Derive the transfer function of the original block diagram and compute the values of $b[i], i = 0, 1, 2$ and $a[i], i = 0, 1$ from its Direct Form I/II representation as shown in the diagram of Question 1.

3) Let a linear system be described by

$$G(z) = \frac{\left(z^2+1\right)\left(z - e^{j\frac{\pi}{4}}\right)\left(2z - \sqrt{2} + i\sqrt{2}\right)}{\left(z^2 - z\left(7/10 + 3/10j\right) + 3/5 + 12/25j\right)\left(z^2 - z\left(7/10 - 3/10j\right) + 3/5 - 12/25j\right)}$$

(a) Calculate the zeros and poles of the system.

(b) Write the system as the product of two biquads such that ensure a low peak gain.