PE Course: Digital Filter Design

MM5: Implementation of Discrete-Time Filters

1 Reading

Page 340-370 and 391-402 of Alan V. Oppenheim, Ronald W. Schafer, and John R. Buck: "*Discrete-Time Signal Processing (Second Edition)*", Prentice Hall, 1999.

2 Content

- Block diagram and signal flow graph
- Structures of IIR and FIR systems
- Round-off noise in digital filters

3 Exercise

1. Consider a discrete-time system described as

$$H(z) = \frac{1 - 0.25z^{-2}}{1 + 0.2z^{-1} - 4.8z^{-2}}$$

   (a) What is this filter's order?
   (b) Write the difference equation expression of this system;
   (c) Sketch out the direct form I implementation of this system;
   (d) Sketch out the direct form II (Canonical) implementation of this system;
   (e) Sketch out the signal flow graph expression of direct form II;
   (f) Sketch out the cascade realization with first order direct-form II module;
   (g) Sketch out the parallel realization with second order direct-form II module.

2. Consider a discrete-time system described as

$$y[n] = x[n] + x[n-2],$$

   Where $x[n]$ represents the input signal and $y[n]$ represents the output signal.
   (a) What kind of filter (IIR or FIR) is this system and how about this filter's order?
   (b) Write the system function ($H(z)$) of this system;
   (c) Is this filter linear phase? and explain the reason;
   (d) Sketch out the direct form realization of this system;
   (e) Sketch out the special structure for the linear-phase FIR system (optional).

3. Go to the course webpage and download the sound file **noisy_speech.wav**, which is a noised speech signal. Try to design a proper filter such that you can hear this speech and tell us what it is.