

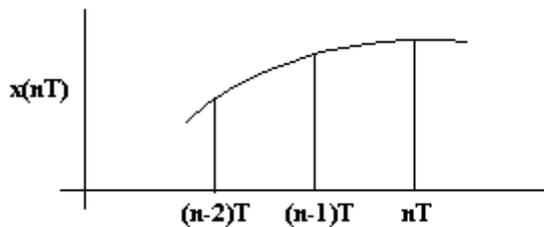
EE 311**Hour Exam 3 Review Questions****March 28, 2018**

1. An analog filter has a cutoff frequency of ω_c . To make a digital filter using the BLT, this cutoff frequency is *prewarped* to a new frequency called ω_{prewarp} . What happens to ω_c and ω_{prewarp} as the sample frequency f_s gets very large? Do they get close together or further apart. Justify your answer.

2. The BLT was derived from trapezoidal integration. Simpson's rule provides a method of approximating an integral by determining the area under a parabola instead of a trapezoid. Thus if the figure below represents a sampled parabola, the area between $(n-2)T$ and nT is given by

$$\text{Area} = \frac{2T}{3}[x(n-2)T + 4x(n-1)T + x(nT)]$$

Use this equation to derive an expression for the "parabolic transform" in z.



3. Write Pade's equations for the numerator and denominator coefficients of a filter which has $N = 3$ and $M = 2$ if the ideal filter is given by:

$$h(n) = \{0.25, 0.5, 1.0, 0.5, 0.25, 0.125, 0.0625, 0.03125, \dots\}$$

It is not necessary to solve the equations.

4. Circle those filters which have the characteristics shown. Note that in some cases more than one answer should be circled to be correct.

- A) Flat pass band (low pass filter).
Butterworth Chebyshev Elliptic
- B) Monotonic stop band (low pass filter).
Butterworth Chebyshev Elliptic
- C) Fastest transition band for a given order.
Butterworth Chebyshev Elliptic
- D) All pole analog filters.
Butterworth Chebyshev Elliptic
- E) Minimizes the RMS error over all bands.
Butterworth Chebyshev Elliptic

5. What are frequency transformations and what are they used for?

6. A lowpass Butterworth filter is to meet the following frequency specifications:

Passband 0Hz to 150Hz with a ripple less than .05

Stopband 200Hz to infinity with a ripple less than .01.

Find the minimum order Butterworth filter to satisfy these specifications.

7. FIR filters

- A) have linear phase
- B) are lower in order than elliptic filters which meet the same specifications
- C) may have multiple zeros at the origin
- D) may have poles at the $Z = -1$ point
- E) are always stable
- F) All of the above
- G) None of the above

8. IIR filters

- A) have multiple feedback terms
- B) may not have poles at the origin
- C) may be unstable
- D) usually have linear phase
- E) have all positive impulse response terms
- F) All of the above
- G) None of the above

9. Lowpass Elliptic filters:

- A) are flat in the passband
- B) have poles at the origin
- C) are generally lower order than Butterworth filters that meet similar specifications.
- D) are monotonic in the stopband
- E) have feedback terms in the difference equation
- F) All of the above

10. The BLT

- A) Produces a stable digital filter from a stable analog filter.
- B) Maps and infinite frequency space in the S-plane to a finite frequency space in the z-plane.
- C) Cannot be used for analog filters that are not band limited.
- D) Can be derived from trapezoidal integration.
- E) All of the above.
- F) None of the above.

11. An IIR filter has been designed using the bilinear transform. If the final design that was implemented has a cutoff frequency of 200 Hz and the sample frequency was 600 Hz, what was the cutoff frequency of the analog filter **BEFORE** it was prewarped. Show your calculations.

12. In using Pade's method of direct design or Prony's method of direct design we begin by writing a transfer function for an IIR filter along with a set of difference equations as shown below:

$$H(z) = \frac{\sum_{k=0}^M b_k z^{M-k}}{z^N + \sum_{k=1}^N a_k z^{N-k}}$$

$$h(k) = b_k - a_1 h(k-1) - a_2 h(k-2) - \dots - a_N h(k-N) \quad \text{for } 0 \leq k \leq M$$

and

$$h(k) = -a_1 h(k-1) - a_2 h(k-2) - \dots - a_N h(k-N) \quad \text{for } k > M$$

Explain how the two methods are the same and how they are different.

13. Find the pole and zero locations for a simple resonator which has a center frequency of 400Hz, a bandwidth of 20Hz, and a sample frequency of 3000Hz. Show all work. Put your results in rectangular format.