WHAT TO READ FOR THE EXAM OF DIGITAL LINEAR FILTERING I?

PART I:

Learning Outcomes:

(a) What is a digital filter and how to analyze its performance using a difference equation, its transfer function and frequency response as well as its magnitude, phase, group delay, and phase delay responses?
(b) There are numerous structures implementing the very same transfer function. – **Among these structures, concentrate only on direct-form structures, transposed-form structures, and cascade-form structures consisting of second-order and first-order blocks.**
(c) Advantages and drawbacks when comparing infinite-impulse response (IIR) and finite-impulse response (FIR) filters with each other.
(d) Overall filter synthesis procedure in nutshell and various approximation criteria for the filter responses.

A Very Likely Question:

Explain shortly (using formulas and/or words), but still clearly enough, the meanings of the following terms: - **Comment: In this question, also Parts III, IV, and V are involved and their learning outcomes will be given later on. Based on these learning outcomes, additional terms will be included.**
- Direct-form structure
- Cascade-form structure
- Transposed-form structure
- Difference equation
- Minimax error criterion for the weighted error function
- Least-squared error criterion
- Maximally-flat error criterion
- Some of the filter responses such as phase delay and group delay responses; the complete list can be seen above in the learning outcomes.
- The benefits of the use the phase delay in analysing the filter performance when filtering approximately periodic signals.
- Filter design process very briefly
- The benefits of the use the phase delay in analysing the filter performance when filtering approximately periodic signals.

- Some more - Also some crucial terms from Parts III, IV, and V. Concentrate on the learning outcomes and the explanations to be given later on.
Comment: Note that the terms mentioned above are only candidates for the first question. They will vary in each exam.

What to read in Part I?

Pages definitely not needed: 1, 19-27, 36-37, 40-44, 46, 69-70, 80

PART II:

No Questions Directly from This Part

PART III:

Learning Outcomes:

(a) The characteristics of the four types of linear-phase FIR filters, their use in practical applications, and their synthesis using the windowing technique and the Remez algorithm.

Questions Concentrate on the Above-Mentioned Learning Outcomes as Follows:

(a) **The characteristics of the four types of linear-phase FIR filters:** Definitions of these four filter types by means of the impulse response; Time- and frequency-domain characteristics as well as how to exploit the coefficient symmetry in the implementation. Furthermore, given a transfer function or an impulse response, there is need to determine the filter type as well as its frequency-domain characteristics by means of the zero-phase frequency response and the phase term, that is, there is a need to express the frequency response in the simplest possible form.

(b) **The use of the four types of linear-phase FIR filters in practical applications**: No additional comments needed; see the lecture notes.

(c) **The windowing technique and the Remez algorithm**: Basic principles described clearly enough as well as the benefits and drawbacks in the design of linear-phase FIR filters.

What to read in Part III?

Pages to read: 0, 2-8, 11-60, 83-95, 100-125, 154-158, 192-221.

PART IV:

Learning Outcomes:

(a) The characteristics of classical analog filters and their digital IIR equivalents, that classical recursive digital filters; The synthesis of low-pass IIR filters by transforming analog filters to their digital equivalents using the bilinear transformation, and the synthesis of high-pass, band-pass, and band-stop filters by applying appropriate z-plane transformations to low-pass IIR filters.

Questions Concentrate on the Above-Mentioned Learning Outcomes as Follows:

(a) **The characteristics of classical analog filters and their digital IIR equivalents, that is, classical recursive filters**: **There is a need to remember only the simple formulas for synthesizing Butterworth filters!**

(b) **The bilinear transformation**: How to use the bilinear transformation for designing recursive digital filters with the aid of analog filters? Why is the bilinear transformation still a good technique for generating recursive digital filters? Design of a digital Butterworth filter for meeting the given criteria.

(c) **The synthesis of high-pass, band-pass, and band-stop IIR filters by applying appropriate z-plane transformations to low-pass IIR filters**: **NO QUESTIONS** because we had not enough time to go through this part of the lecture notes. However, please read also this part for the probable later use. It contains material that does not exist in any textbook.

What to read in Part IV?

Pages to read: 0-55 with the emphasis on the above mentioned goals.

PART V:

Learning Outcomes:

(a) Attractive properties of the two's complement arithmetic; The commonly used model for estimating the output noise due to the multiplication roundoff errors; Scaling of the cascaded-form IIR filters by using three commonly used scaling norms and the resulting trade-offs between the probabilities of overflows and the output noises; Finite word-length effects on the variations in the filter coefficients and their impact on various kinds of oscillations in IIR filters.

A Very Likely Question:

For two’s complement arithmetic, scale a simple IIR filter according to one of the three commonly used scaling norms and estimate the variance of the output noise due to the multiplication round-off errors.

Comment: **No question on** finite word-length effects on the variations in the filter coefficients and their impact on various kinds of oscillations in IIR filters. However, please read also this part for the probable later use.

What to read in Part V?

Pages to read: 0-40, 45-64, and Appendix B at the end of Part V with the emphasis on the above mentioned goals.

Final Comment I: If there are still crucial matters concerning the exam, please do not hesitate to contact the lecturer by an e-mail. The e-mail address is ts@cs.tut.fi

Final Comment II: Good luck for the exam!