Midterm Exam, Spring 2017

Digital Signal Processing, ECE-539

University of New Mexico

Instructor: Balu Santhanam

Date Assigned: 03/22/2017, 11:00 AM, Wednesday

Due Back : 03/23/2017, 11:00 AM, Thursday

Instructions

1. Write clearly and legibly. Chicken scratch is hazardous to both the student and the professor.
2. Provide steps to obtain partial credit
3. It is assumed that you are aware of the UNM academic honesty policy. Needless to say copying will be dealt with seriously.

Problem # 1.0

0.2in Consider a M channel PR filterbank with analysis filters $H_k(z),\ \ 0 \leq k \leq M-1$ and synthesis filters $F_k(z),\ 0 \leq k \leq M-1$. For this M-channel system:

1. Show that interchanging the analysis filters for the synthesis filters will result in a alias free system with $A(z) = 0$ and the same transmit component $T(z)$.

2. Suppose the analysis and synthesis filters are replaced with the filters $H_k(z^2)$ and $F_k(z^2)$, is the resulting system still a PR system ?

3. Supposed we replace the synthesis filters $F_k(z)$ with $F_k(zW_M^l)$, where $0 \leq l \leq M-1$ is independent of the index k. If $\hat{x}_1[n]$ is the new output, how is this output related to the output of the original PR system $x[n]$?

Problem # 2.0

Suppose the transmit end filters of a two channel TMUX are given by:

$$F_o(z) = 1 - kz^{-1} - kz^{-2} + z^{-3},\ F_1(z) = -1 + kz^{-1} - kz^{-2} + z^{-3}$$

For this system:

1. determine the type-II polyphase matrix $\mathbf{R}(z)$ associated with these transmit filters.
2. determine the type-I polyphase matrix associated with the receiver end that results in a PR-TMUX system. What are the corresponding receiver end filters.
3. Does a lossless FIR transmit end system produce a lossless FIR receiver end system? Justify your answer properly.
4. Is this solution for the receiver end filters unique? Justify your answer properly.

Problem # 3.0

A discrete-time LTI system has a impulse response given by:

$$h[n] = \begin{cases} (-1)^n & 0 \leq n \leq N-1 \\ 0 & \text{otherwise} \end{cases}$$

For this system:

1. Is this LTI system causal and BIBO stable? Justify your answer.
2. Determine the type-I polyphase components of the underlying system function $H(z)$ with respect to $M = 2$.
3. Determine the type-I polyphase components of the system function $H(z)$ with respect to $M = 3$.
4. Suppose $\tilde{h}[n] = (-1)^n h[n]$, how are the polyphase components of the new system function related to the polyphase components of the old one.

Problem # 4.0

Determine if the following statements are true or not. In each case provide provide proper justification for your answer. This means that if you believe a statement to be true prove it and if you think it is false provide an appropriate counter example.

1. If the transmit and receiver end filters of a two channel PR-TMUX are interchanged then the resulting system is still a PR-TMUX.

2. A lossless, FIR, analysis section in a PR filterbank will result in a lossless FIR synthesis section also.

3. The Nyquist sampling frequency for a bandpass analog waveform is twice the largest frequency of the signal.

4. The Haar filterbank discussed in class is a QMF filterbank, a paraunitary QMF filterbank, and also the direct inversion PR filterbank.

5. The choice of $X_m = \sigma_x$ in a uniform quantizer will result in minimum distortion and the maximum output SNR.