10^{th} Order Digital Butter Worth Filter with 256 Point Signal Generator

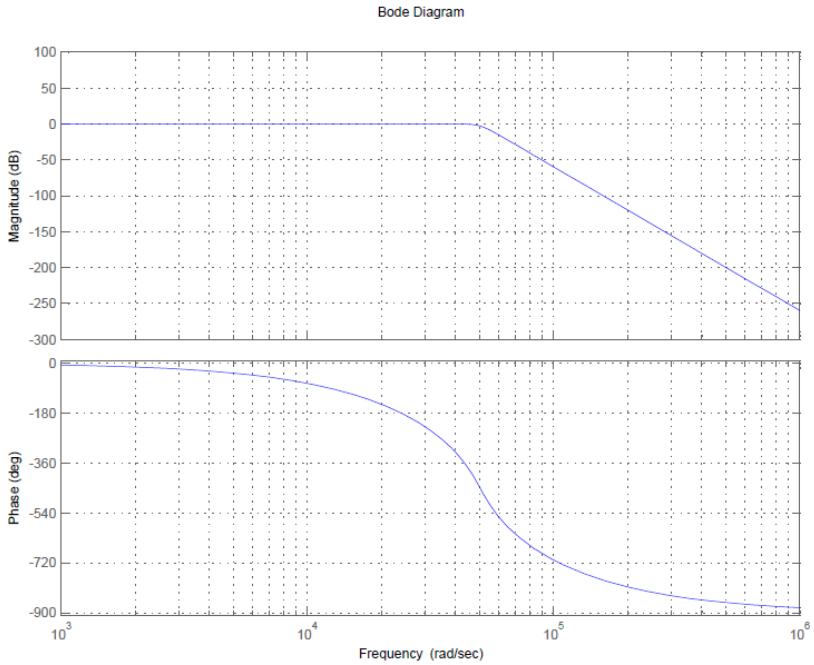
ECE641

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4/28/2011, Spring Semester 2011

Butterworth Filter:

- A Butterworth filter is one of many types of signal processing filters. The attribute that the Butterworth filter is best known for its maximally flat band pass.



Advantages and Disadvantages of the Butterworth Filter when compared to other filter (such as Chebychev I, II and elliptic).

Advantages

- Flat pass band and smooth stop band.
- No ripples in either the pass band or stop band

Disadvantages

- Slow roll off in the transition band with low filter orders when compared to other filter types.

Goal of this project

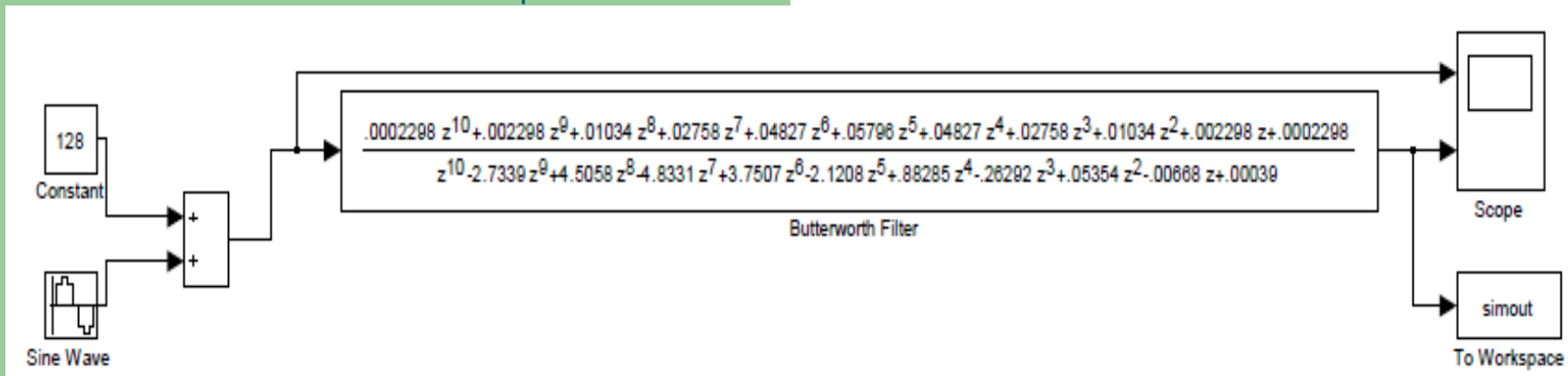
- In this project, I will introduce a 256 point sign wave at 4 kHz and 16 kHz to a Digital Butterworth filter with sampling frequency of 44.1 kHz and a cutoff frequency of 8 kHz.

- Please note from the simulation that since the sign wave minimum and maximum values are between 0 and 255 that the DC average from of the signal is theoretically128.
- The digital filter was creating using normalized analog Butterworth filter, which was transformed from an analog filter into a digital filter by using bilinear transformation.
- The 256 points of the signal waveform created in from a mif file, which stores all 256 points into ram.

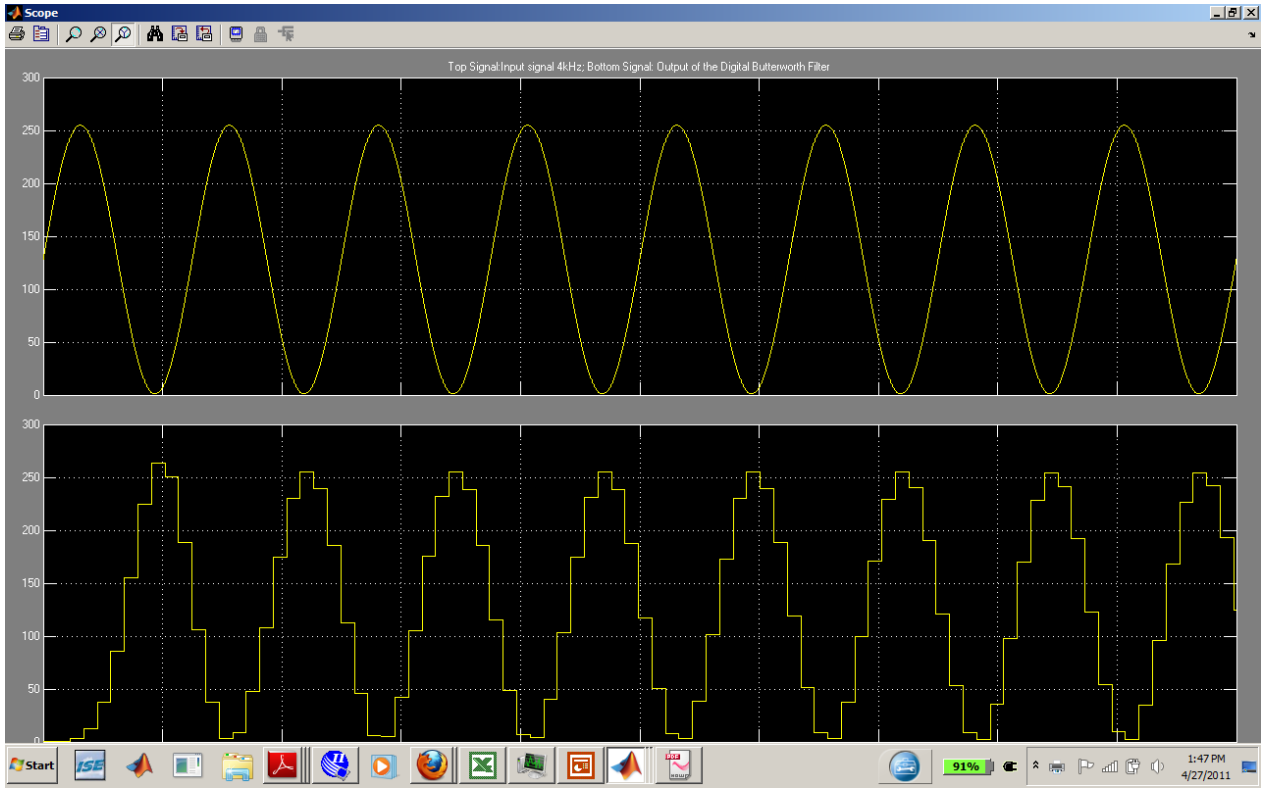
Digital Butterworth Filter Box Diagram

Below is a block diagram of a 10th order Digital Butterworth filter with a cutoff frequency (w_c) of 8 kHz and sampling frequency (w_s) of 44.1 kHz.

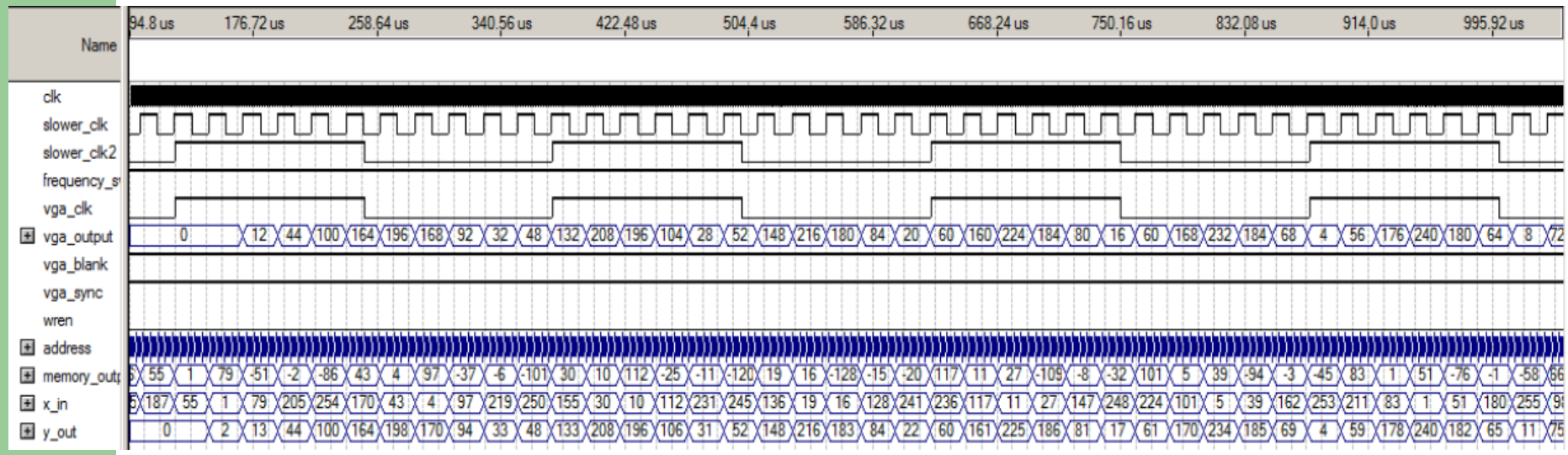
*Please note that the coefficients from the block diagram represent the filter specification mentioned above



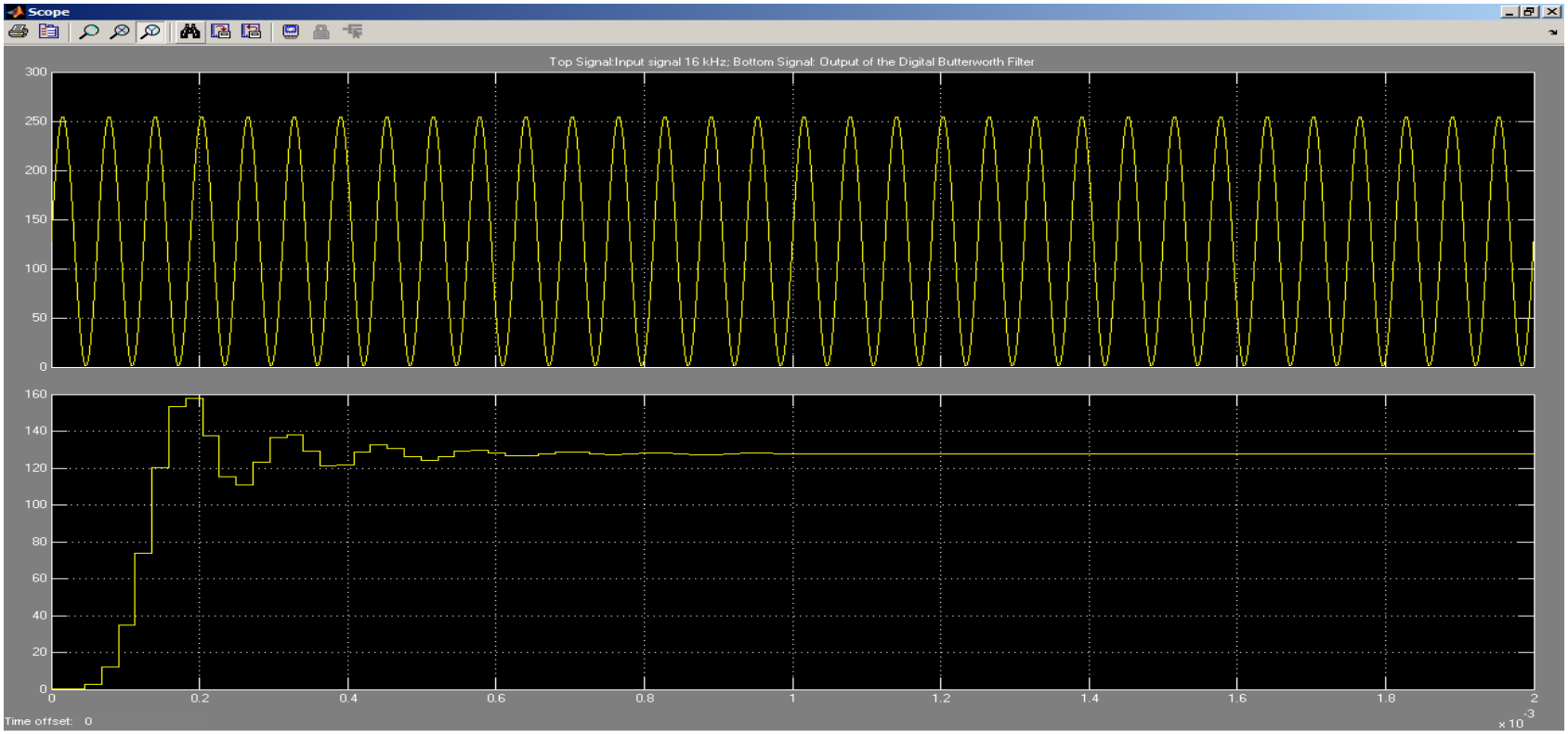
Ideal simulation results with the input signal set at 4kHz using Matlab/Simulink.



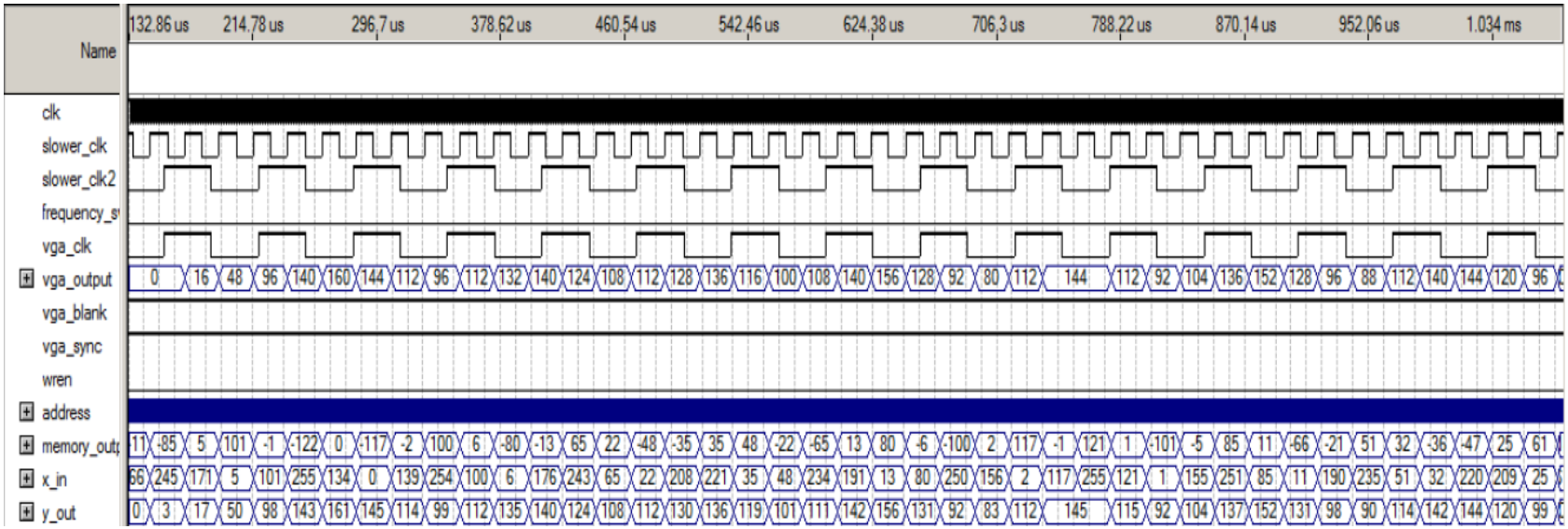
Altera-Quartus simulation with the input signal set at 4 kHz.



Ideal simulation results with the input signal set at 16 kHz using Matlab/Simulink.



Altera-Quartus simulation with the input signal set at 16 kHz.



Demo and Q/A

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References

- **Course Text**
- (1) Meyer-Baese, U. Digital Signal Processing with Field Programmable Gate Arrays: 3rd Ed, Springer Press 2007.
- (2) Taan S. ElAli, Discrete Systems and Digital Signal Processing with Matlab: CRC Press 2005
- (3) D. Pellerin and D. Taylor, VHDL Made Easy! : Prientice Hall PTR 1997.