Lastname: ___________________

5Digit SS:___________________

LABORATORY
FFT Filter

LAB FFT: INTRODUCTION TO FAST FOURIER TRANSFORM
(10 points)

In this lab you will be introduced to the design for a Fast Fourier Transform (FFT). FFT are one of the most important DSP objects and are used not only to compute an approximation of the Fourier Transform, but also to enable a fast convolution, a very time consuming filtering operation when done in the time domain.
In the **pre-lab** you will compute with "pencil-and-paper" the results you later expect in your design implementation. In the **design part** you will design an 8 point radix-2 FFT using the principle of decimation in frequency.

Lab Objectives

After completing this lab you should be able to

- Develop a radix-2 FFT and compute test data
- Understand the difference between DFT and FFT
- Design and simulate a FFT using the principle of decimation in frequency using Simulink

Pre-lab (3 points)

The following figure shows the 8 point radix-2 FFT using the principle of decimation in frequency:

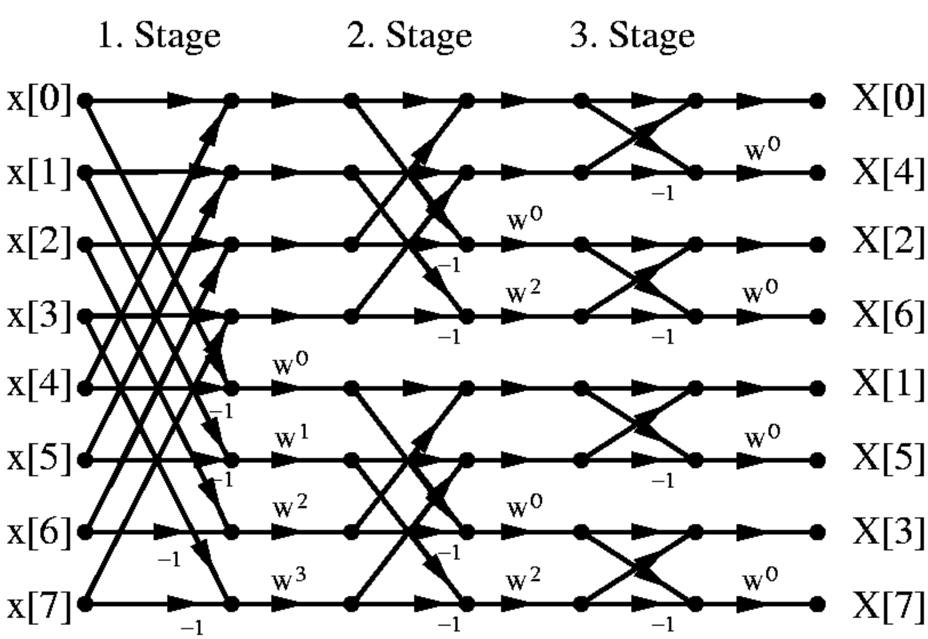


Fig. 1

Lastname: ____________________

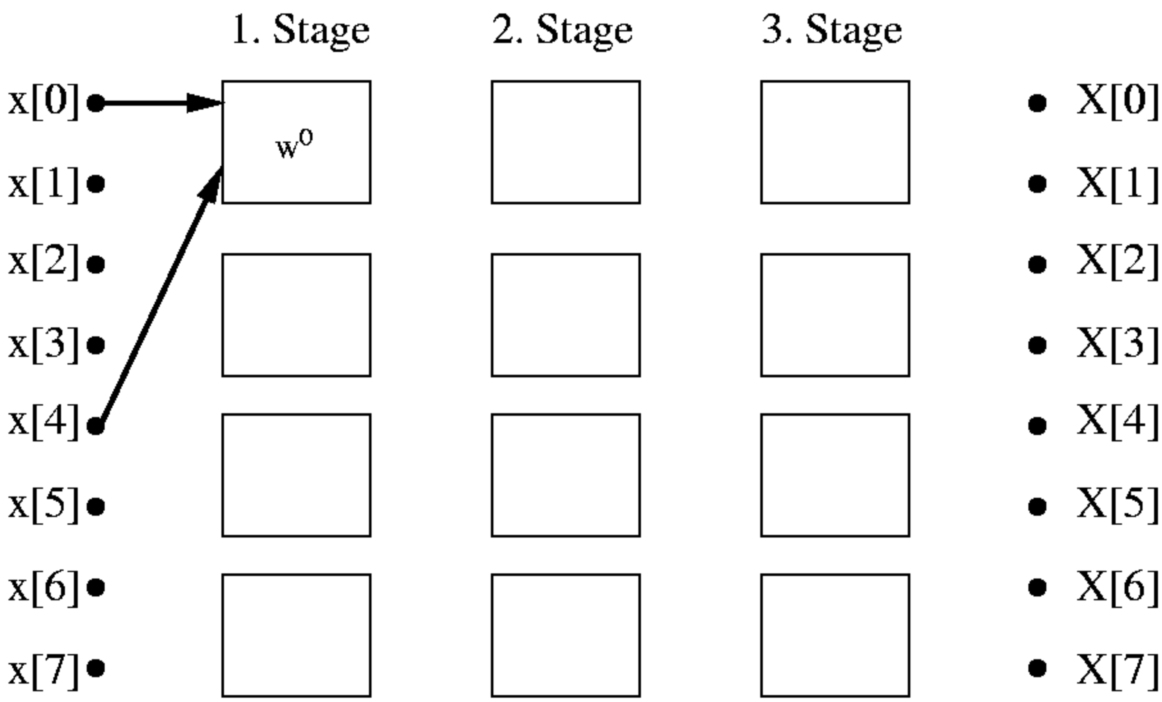
5Digit SS:___________________

LABORATORY
FFT Filter

1. Determine from the signal flow graph in Fig.1 the number of butterfly types required in each stage.

	1. stage	**2. stage**	**3. stage**
Butterfly with w^0			
Butterfly with w^1			
Butterfly with w^2			
Butterfly with w^3			

2. Redraw the radix-2 signal flow graph from Fig.1 such that the butterfly operations do not overlap and input/output are in natural rather then bit-reverse order by completing the following figure:



3. Each butterfly k∈[0,3] perform an complex value operation of the type

$$D = A+B; \qquad \text{and} \quad E = (A-B)W^k$$

Complete the following table for the given input values (1 extra point)

	A	**B**	**D**	**E**
Butterfly with w^0	**2**	**10**		
Butterfly with w^1	**4**	**12**		
Butterfly with w^2	**6**	**14**		
Butterfly with w^3	**8**	**16**		

Hint: Use a pocket calculator or MatLab for $\mathbf{w^1}$ or $\mathbf{w^3}$

4. Using MatLab compute for x=2:2:16 the FFT X=fft(x) and complete the following table:

	X[0]	**X[1]**	**X[2]**	**X[3]**	**X[4]**	**X[5]**	**X[6]**	**X[7]**
Real								
Imag								

Simulink Design-lab

Follow the directions below to implement the 8-point radix-2 FFT circuit.

A. Getting Started

If you are in B114 or the digital logic lab:

1. On the desktop double click on **Engineering folder**.

2. Double click on **MatLab** icon  to start **MatLab**.

3. From the to top icon list in the **MatLab** window click on the **Simulink** icon  to start **Simulink.**

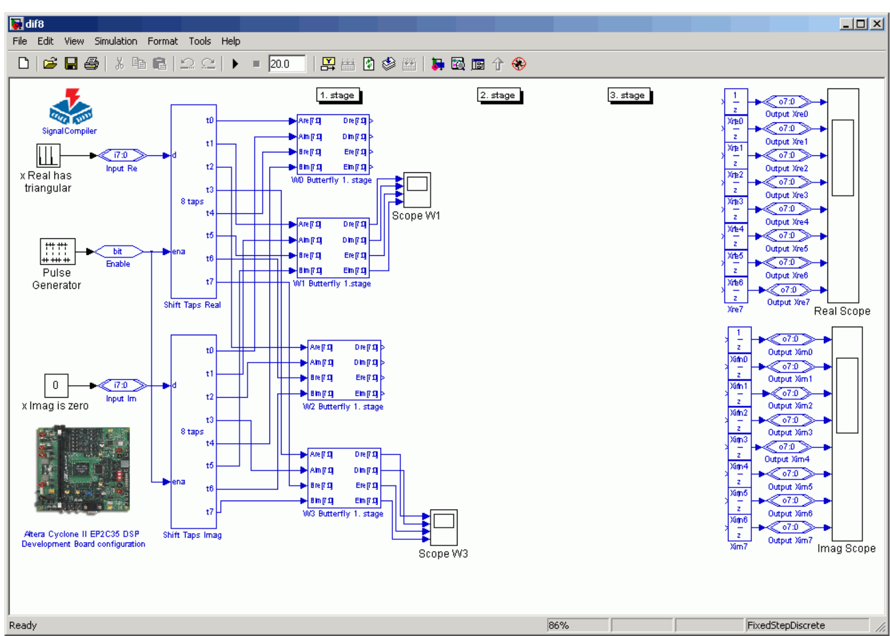
4. You should not save anything on the local hard disk. You will have to use a Zip, a floppy disc, or your "mapped" home directory to save the files. Create a New Folder named **DSPwFPGAs** on your mapped network drive.

B. Design the W1 and W3 Butterflies

1. Download the file `dif8.mdl` from the class webpage and put the file in the **DSPwFPGAs** folder.

2. Click on the "Current Directory" selection icon and select as current directory the **DSPwFPGAs** folder.

3. The files in the **DSPwFPGAs** folder are now visible in the upper left **MatLab** window. Double click on the `dif8.mdl` file and you should see after a moment the design:



4. Modify the butterfly blocks for $\mathbf{w}^0$ and $\mathbf{w}^2$, as they are not yet completed in the `dif8.mdl`.

5. Modify the butterfly blocks for $\mathbf{w}^1$ or $\mathbf{w}^3$ such that you match the values computed in the pre-lab D=16 E=-6+j6 for $\mathbf{w}^1$ and D=24 E=6+j6 for $\mathbf{w}^3$. Verify the correct result via a Simulink simulation using the provided scopes for W1 and W3. (Print out the simulation waveform for W1 and W3) Hint: you may use the 3*/5+ complex multiplier you had designed in lab 3 to design the butterfly.

C. Completion of the 8-point radix-2 FFT

1. Complete your design using the signal flow graph you developed in the pre-lab.

2. Copy the 8 additional SubSystems first and then wire them as determined in the pre-lab.

3. Verify the design via Simulink simulation for the correct real and imaginary part using the provided scopes and the data you computed in the pre-lab. (Print the simulation waveform for the real and imaginary parts)

4. Compile the design using **Signal Compiler** and determine

LEs = ________________

Embedded 9-bit Multiplier = ________________

MHz = ________________

from the report files.

F. Deliverables:

1. Solve the problems of the pre-lab. (3 points).

2. Print the MDF file and the Simulink simulation (7 points).

Make sure your name and SS is on all pages you turn in!

