Problem Set #15

EEEC20034 - Introduction to Digital Signal Processing

NYCU

Problem 1

Consider the butterfly in Fig. 1. This butterfly was extracted from a signal flow graph implementing an FFT algorithm. Choose the most accurate statement from the following list:

1. The butterfly was extracted from a decimation-in-time FFT algorithm.
2. The butterfly was extracted from a decimation-in-frequency FFT algorithm.
3. It is not possible to say from the figure which kind of FFT algorithm the butterfly came from.

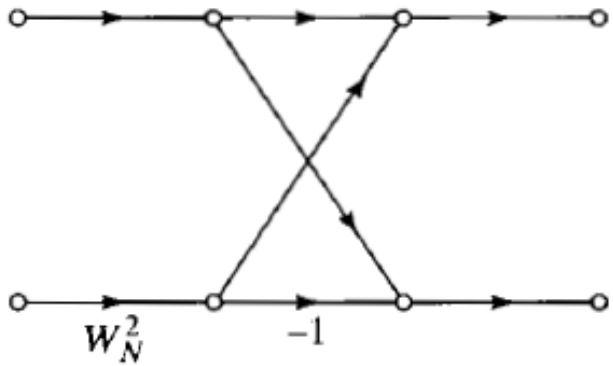

Figure 1

Problem 2

The butterfly in Fig. 2 was taken from a decimation-in-frequency FFT with $N = 16$, where the input sequence was arranged in normal order. Note that a 16-point FFT will have four stages, indexed $m = 1, ..., 4$. Which of the four stages have butterflies of this form? Justify your answer.

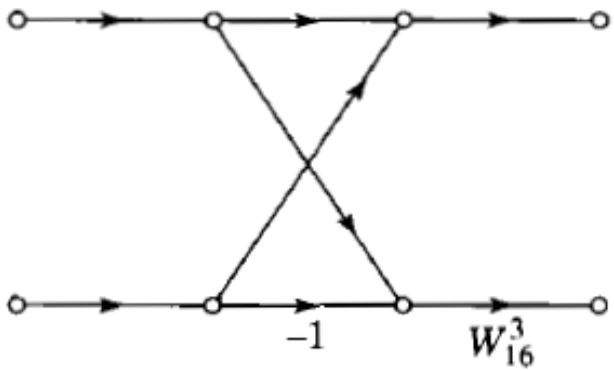

Figure 2

Problem 3 I

Consider a class of DFT-based algorithms for implementing a causal FIR filter with impulse response $h[n]$ that is zero outside the interval $0 \leq n \leq 63$. The input signal (for the FIR filter) $x[n]$ is segmented into an infinite number of possibly overlapping 128-point blocks $x_i[n]$, for i and integer and $-\infty \leq i \leq \infty$, such that

$$x_i[n] = \begin{cases} x[n], & iL \leq n \leq iL + 127 \\ 0, & otherwise, \end{cases}$$

where L is a positive integer.
Specify a method for computing

$$y_i[n] = x_i[n] * h[n]$$

for any i. Your answer should be in the form of a block diagram utilizing only the types of modules shown in Fig. 3 and Fig. 4. A module may be used more than once or not at all.

Problem 3 II

The four modules in Fig. 4 either use radix-2 FFTs to compute $X[k]$, the N-point DFT of $x[n]$, or use radix-2 inverse FFTs to compute $x[n]$ from $X[k]$.
Your specification must include the lengths of FFTs and IFFTs used.
For each "shift by n_0" module, you should also specify a value for n_0, the amount by which the input sequences is to be shifted.

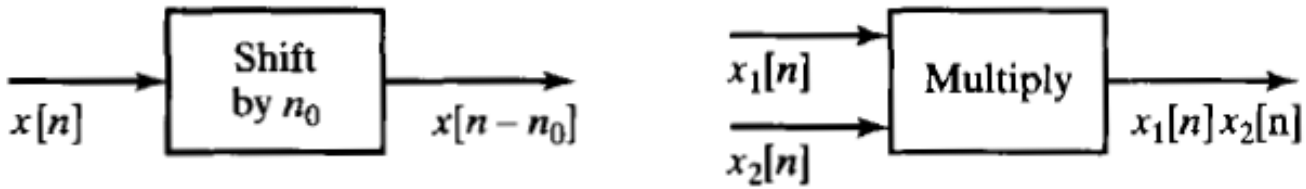

Figure 3

Problem 3 III

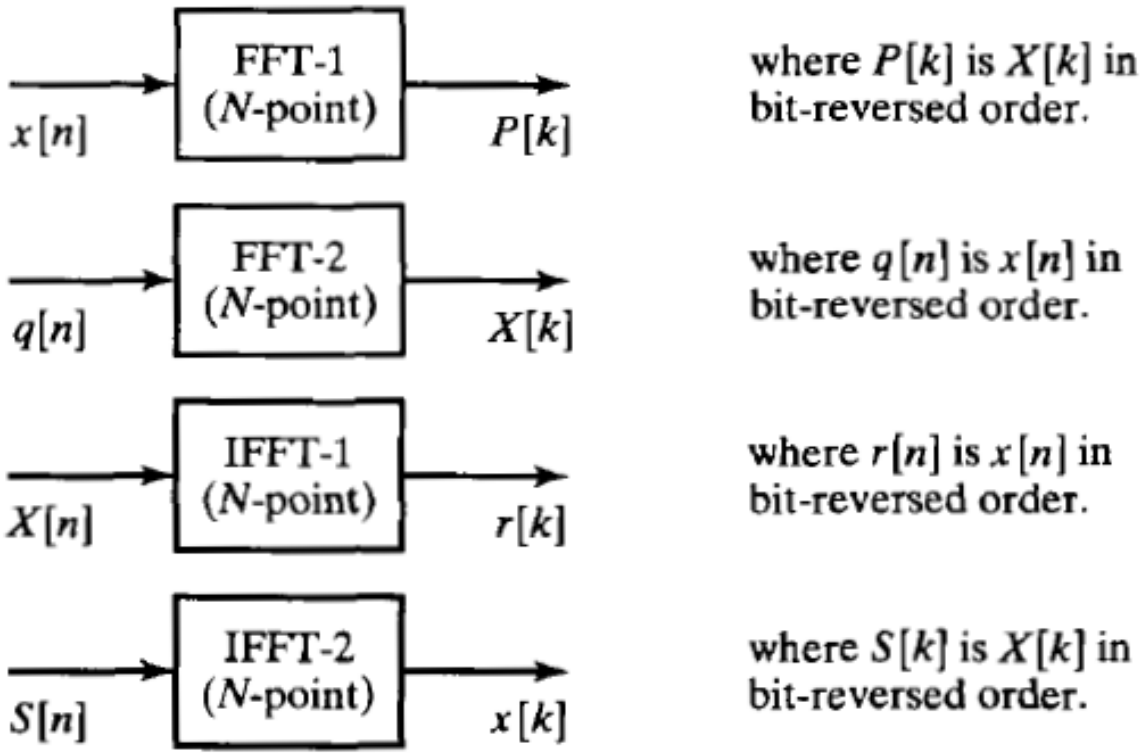

Figure 4