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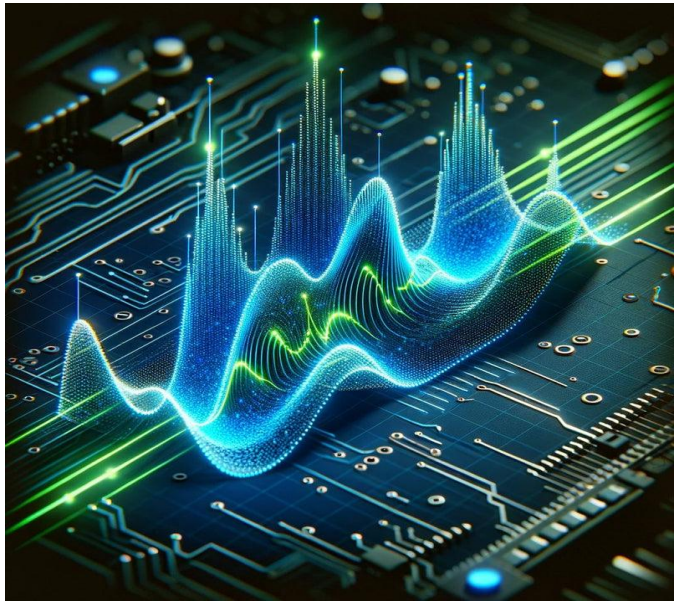
22EE603 – PRINCIPLES OF DIGITAL SIGNAL PROCESSING



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Assistant Professor/EEE

22EE603 – PRINCIPLES OF DIGITAL SIGNAL PROCESSING - CO's

CO1	Illustrate the basics of discrete time signals and systems. [U]
CO2	Interpret the concepts of Discrete and Fast Fourier transform [U]
CO3	Comprehend the architecture of advanced processors. [U]
CO4	Apply the concept of transformation techniques in Discrete Time systems. [AP]
CO5	Design different types of filters using various filter design techniques. [AP]

22EE603 – PRINCIPLES OF DIGITAL SIGNAL PROCESSING - Modules

1	Signals and Systems
2	Discrete Fourier Transform and Fast Fourier Transform
3	FIR Filters, IIR Filters and Digital Signal Processors

MODULE – II : Discrete Fourier Transform and Fast Fourier Transform

2.1	Discrete Fourier Transform (DFT)
2.2	Circular convolution of two sequence using DFT
2.3	DFT properties
2.4	Fast Fourier Transform (FFT)

2.4 Fast Fourier Transform

Introduction-FFT

- DFT with reduced number of calculations
- The radix –2 FFT is an efficient algorithm for computing N – point DFT of an N-point sequence.
- Divide and conquer approach is adopted
- In this approach, N-point DFT is decomposed into successively smaller DFTs.

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2.4 Fast Fourier Transform

Comparison-DFT and FFT

DFT	FFT
DFT Stands for Discrete Fourier transform	FFT Stands for fast Fourier transform
DFT is the discrete version of Fourier transform	FFT is DFT with reduced no of calculations
DFT transforms the time domain signals to frequency domain signal	Various fast DFT computations are called as FFT algorithms-DIT, DIF FFT
Applications of DFT includes Solving PDEs, Spectral analysis, correlation analysis	Applications of FFT includes Filtering algorithms, Polynomial multiplications

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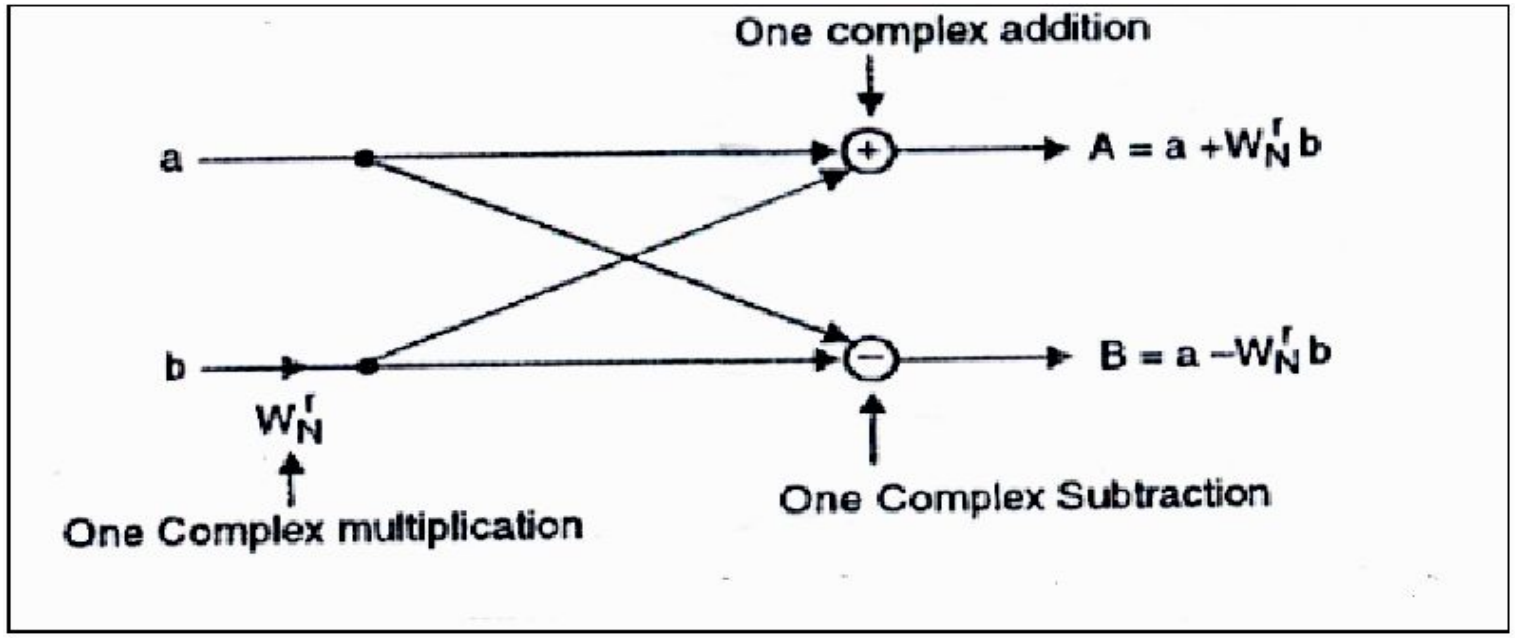
2.4 Fast Fourier Transform

Flowgraph



Advantages

- FFT- Fast fourier Transform, this used to convert the time domain signals into frequency domain signals
- The radix –2 FFT is an efficient algorithm for computing N – point DFT of an N-point sequence.
- FFT is faster(has lower complexity) when calculated using computers.

2.4 Fast Fourier Transform

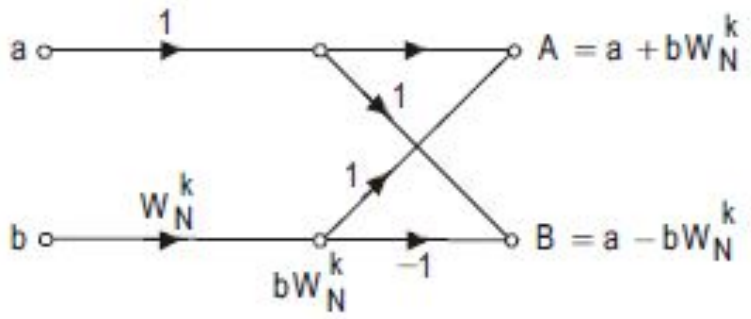
Classification

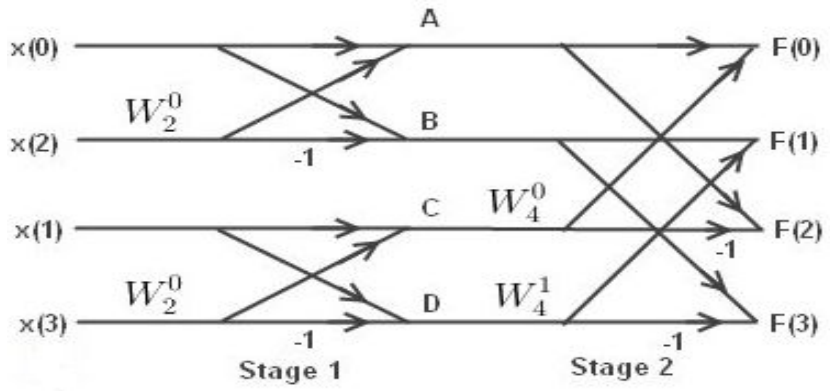
1. • Decimation in Time algorithm
2. • Decimation in Frequency algorithm

2.4 Fast Fourier Transform

Decimation in Time algorithm

- In DIT FFT, the time domain sequence is decimated
- The input should be in bit-reversal order and the output will be in normal order.
- The complex multiplication takes place before the add-subtract operation





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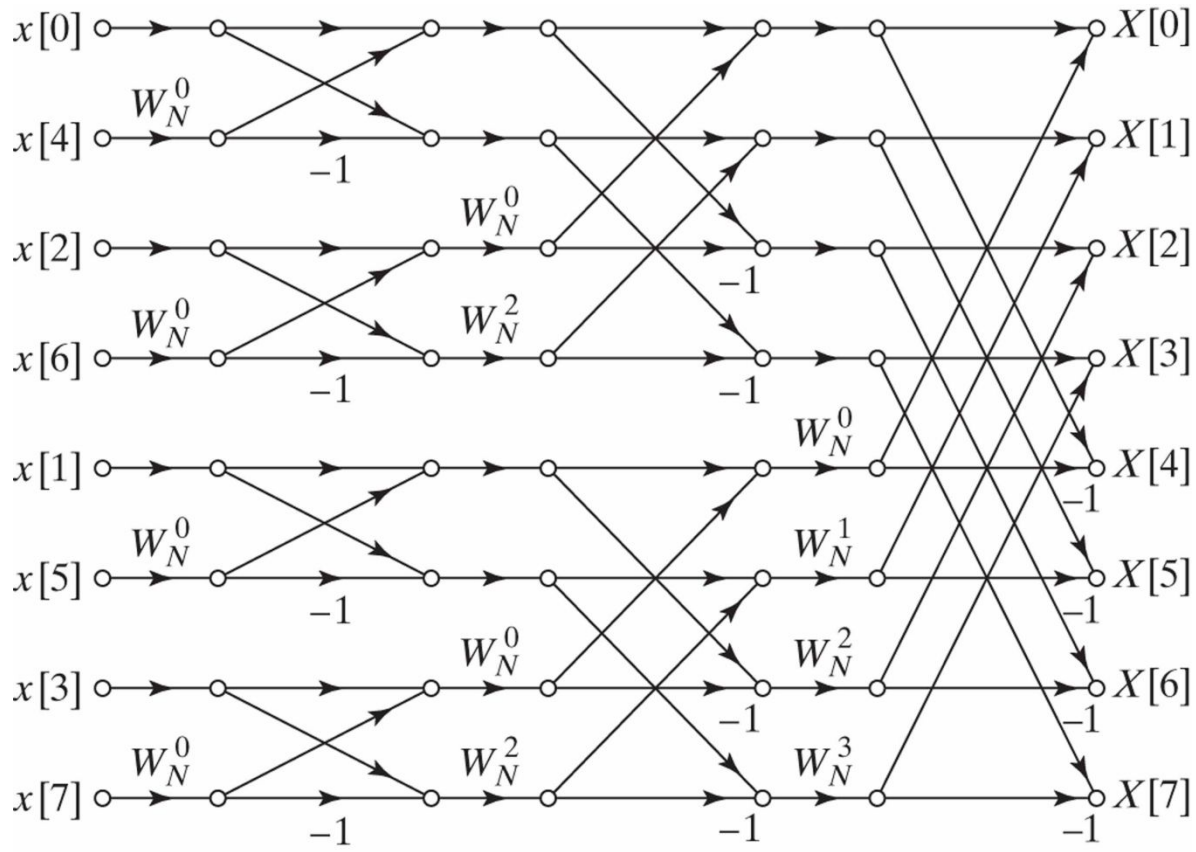
2.4 Fast Fourier Transform

Decimation in Time algorithm



- **Watch this video:**

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2.4 Fast Fourier Transform

Solved Problem-DIT FFT

Find the response of an LTI system with *h(n) = {1, 2} and x(n) = {1, 2, 1} using DIT-FFT algorithm*

Let us find the 4-point FFT for $x(n)$ and $h(n)$

We know $y(n) = x(n) * h(n)$

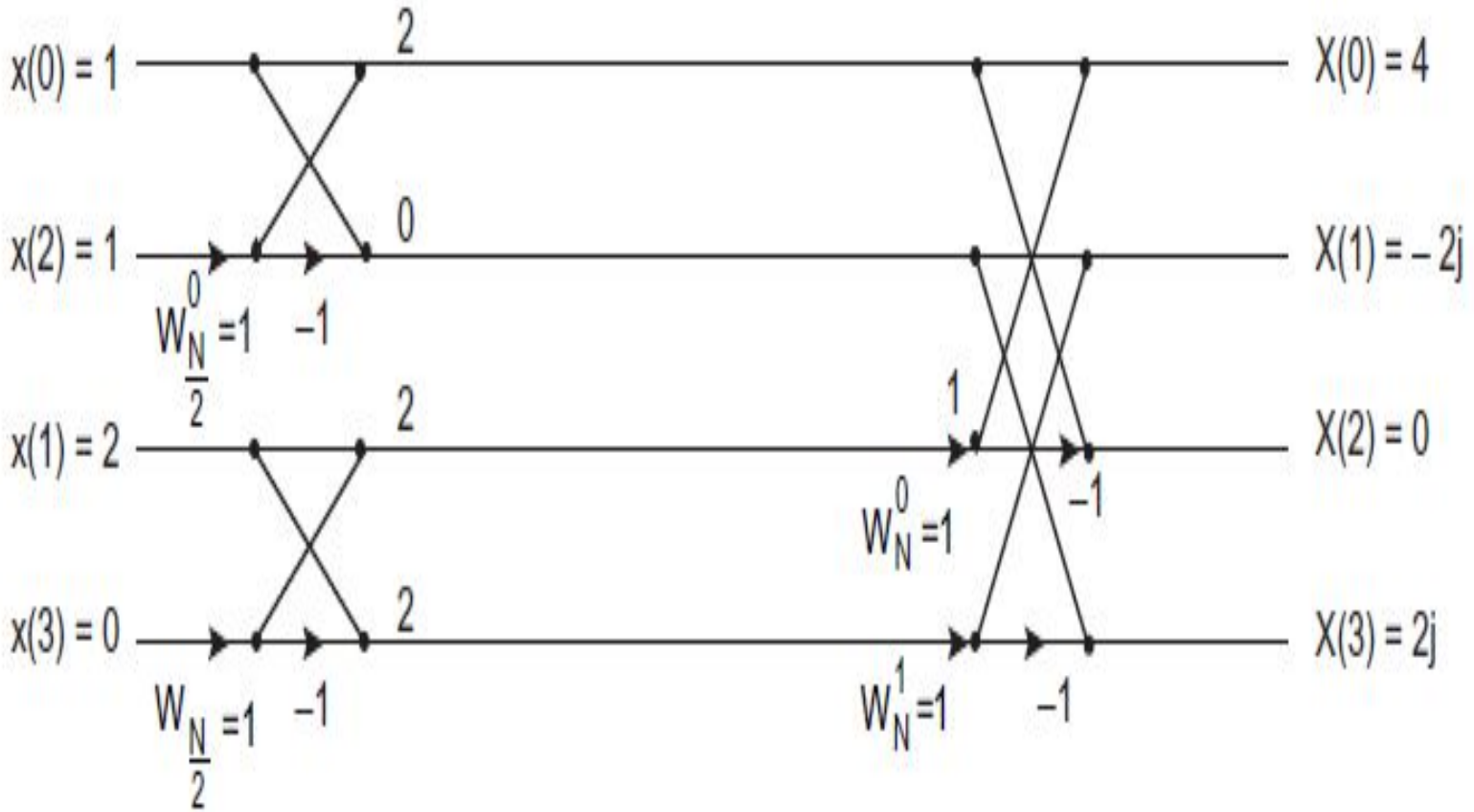
or $Y(k) = X(k) \cdot H(k)$

(i) Hence first find the 4-point FFT of $x(n)$, $h(n)$

(ii) To obtain $Y(k)$ find their product

(iii) To obtain $y(n)$ find inverse FFT of $Y(k)$

2.4 Fast Fourier Transform



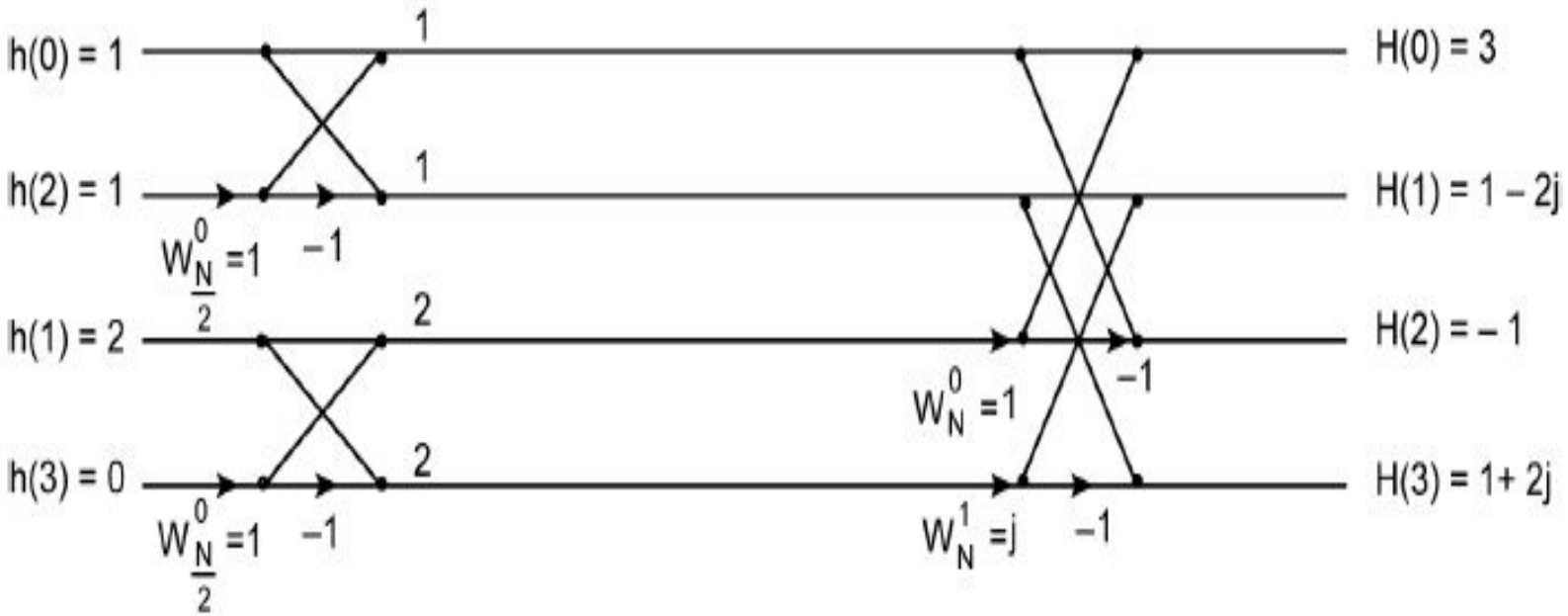
2.4 Fast Fourier Transform

Let us now find the 4-point FFT of $h(n) = \{1, 2\}$

Now $h(n) = \{1, 2, 0, 0\}$

Writing in bit-reversal order

$$h_r(n) = \{1, 0, 2, 0\}$$



2.4 Fast Fourier Transform

$$Y(k) = X(k)\ H(k)$$

$$= \{4, -2j, 0, 2j\}\ \{3, 1-2j, -1, 1+2j\}$$

$$Y(k) = \{12, -4-2j, 0, -4+2j\}$$

2.4 Fast Fourier Transform

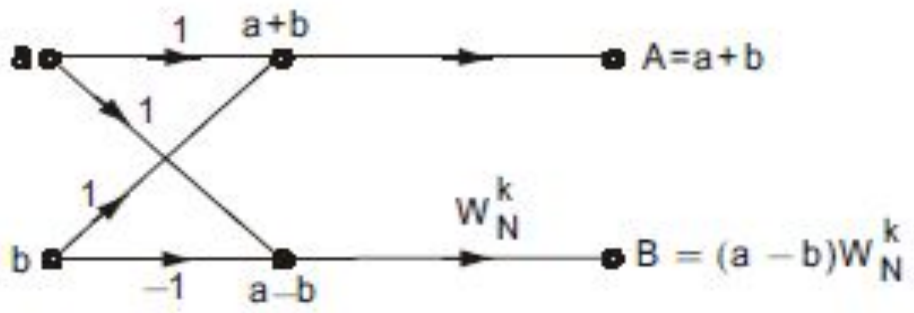
Problems:

1. Compute an 8-point DFT of the following sequences using DIT algorithm x(n)={1,-1,1,-1,0,0,0,0}
2. Compute an 8-point DFT of the following sequences using DIT algorithm x(n)={1,1,1,1,1,1,1,1}
3. Compute an 8-point DFT of the following sequences using DIT algorithm x(n)={0.5,0,0.5,0,0.5,0,0.5,0}
4. Compute an 8-point DFT of the following sequences using DIT algorithm x(n)={1,2,3,2,1,2,3,2}
5. Compute an 8-point DFT of the following sequences using DIT algorithm x(n)={0,0,1,1,1,1,0,0}

2.4 Fast Fourier Transform

Decimation in Frequency Algorithm

- In DIF FFT, the frequency domain sequence is decimated.
- The input is normal order, while output is bit reversed.
- The complex multiplication takes place after the add-subtract operation.



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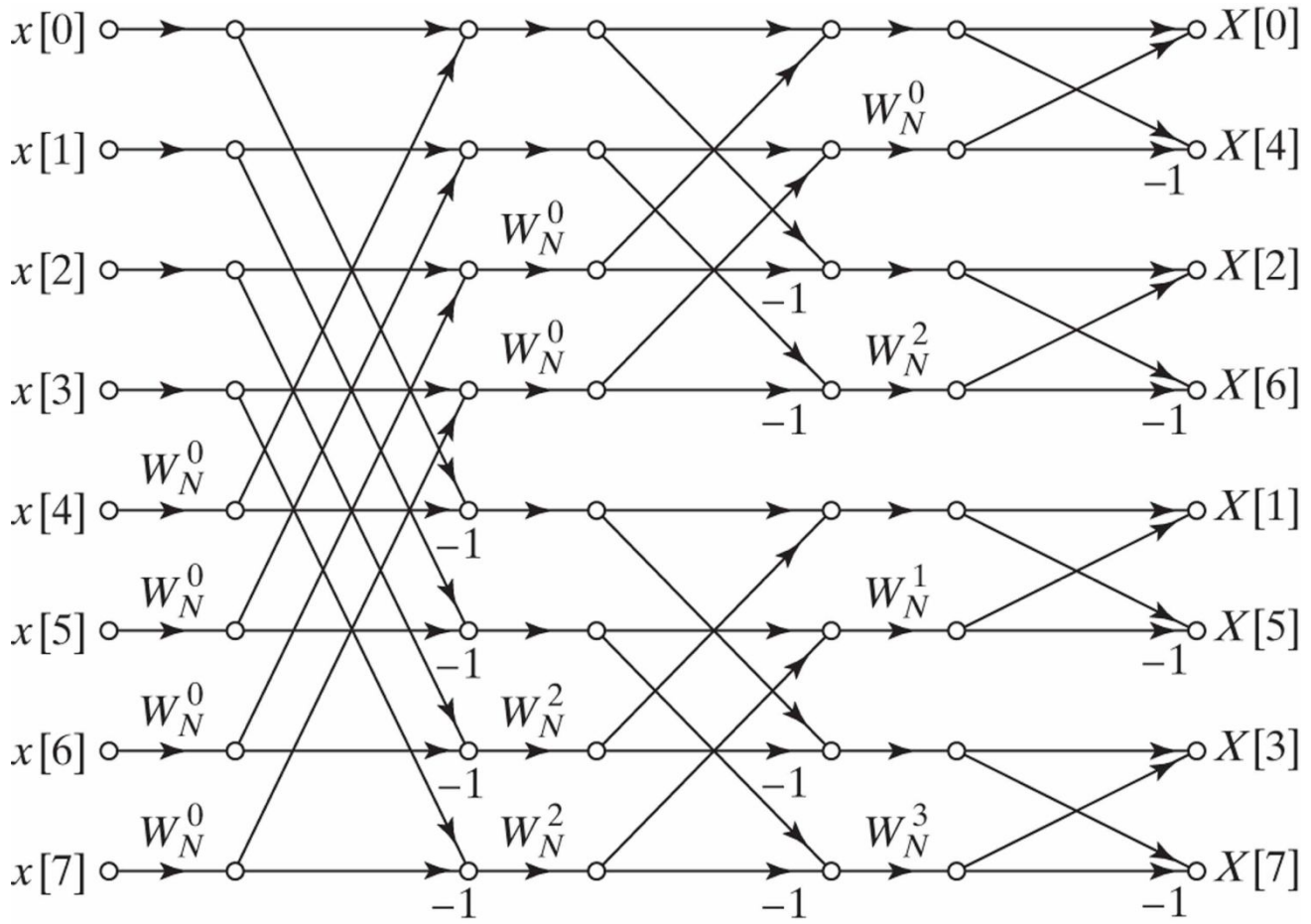
2.4 Fast Fourier Transform

Decimation in Frequency Algorithm



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2.4 Fast Fourier Transform

Comparison-DIT FFT, DIF FFT

Sr No	DIT FFT	DIF FFT
1	DITFFT algorithms are based upon decomposition of the input sequence into smaller and smaller sub sequences.	DIFFFT algorithms are based upon decomposition of the output sequence into smaller and smaller sub sequences.
2	In this input sequence x(n) is splitted into even and odd numbered samples	In this output sequence X(k) is considered to be splitted into even and odd numbered samples
3	Splitting operation is done on time domain sequence.	Splitting operation is done on frequency domain sequence.
4	In DIT FFT input sequence is in bit reversed order while the output sequence is in natural order.	In DIFFFT, input sequence is in natural order. And DFT should be read in bit reversed order.

FFT Computation using Matlab-DIT FFT, DIF FFT

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2.4 Fast Fourier Transform

Problems:

1. Compute an 8-point DFT of the following sequences using DIF algorithm
   x(n)={1,-1,1,-1,0,0,0,0}
2. Compute an 8-point DFT of the following sequences using DIF algorithm
   x(n)={1,1,1,1,1,1,1,1}
3. Compute an 8-point DFT of the following sequences using DIF algorithm
   x(n)={0.5,0,0.5,0,0.5,0,0.5,0}
4. Compute an 8-point DFT of the following sequences using DIF algorithm
   x(n)={1,2,3,2,1,2,3,2}
5. Compute an 8-point DFT of the following sequences using DIF algorithm
   x(n)={0,0,1,1,1,1,0,0}