NEPAL COLLEGE OF INFORMATION TECHNOLOGY Balkumari, Lalitpur

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Shift: Day

Semester: Fifth (IV) - (BE COMP)

Subject: Digital Signal Analysis and Processing

Instructor: Er. Yogesh Deb

2024-Spring

Q.N) Find the 8-point DIF-FFT of
$x(n) = \sin \frac{\pi}{3} n$

Soln:

Here,

$x(n) = \sin \frac{\pi}{3} n$ for $0 \le n < 7$

$x(0) = \sin 0 = 0$

$x(1) = \sin\left(\frac{\pi}{3}\right) = \frac{\sqrt{3}}{2}$

$x(2) = \sin\left(\frac{2\pi}{3}\right) = \frac{\sqrt{3}}{2}$

$x(3) = \sin(\pi) = 0$

$x(4) = \sin\left(\frac{4\pi}{3}\right) = -\frac{\sqrt{3}}{2}$

$x(5) = \sin\left(\frac{5\pi}{3}\right) = -\frac{\sqrt{3}}{2}$

$x(6) = \sin\left(\frac{6\pi}{3}\right) = 0$

$x(7) = \sin\left(\frac{7\pi}{3}\right) = \frac{\sqrt{3}}{2}$

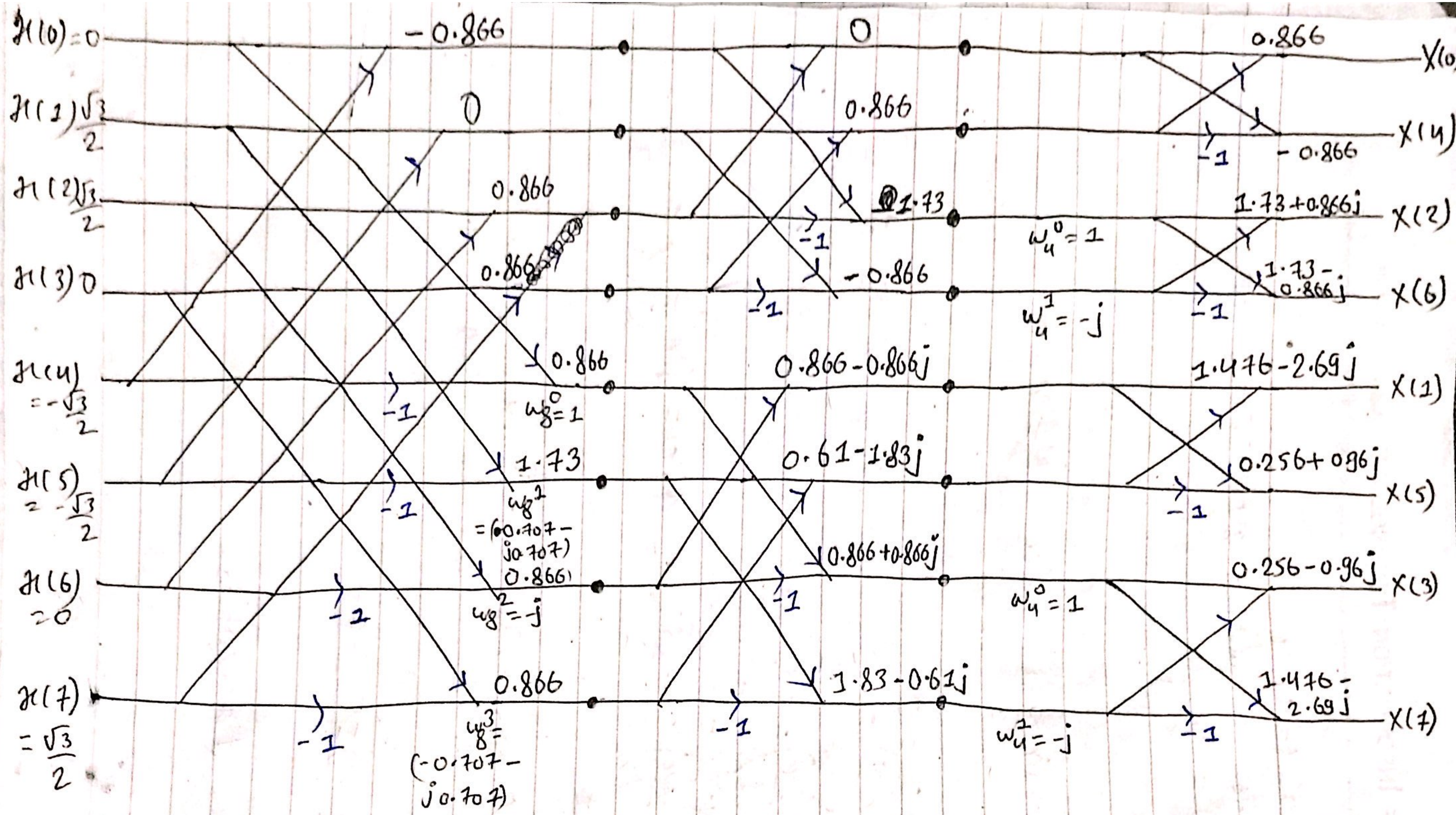
For 8-point

$x(n) = \left\{0, \frac{\sqrt{3}}{2}, \frac{\sqrt{3}}{2}, 0, -\frac{\sqrt{3}}{2}, -\frac{\sqrt{3}}{2}, 0, \frac{\sqrt{3}}{2}\right\}$

Using DIF-FFT

Butterfly diagram is:

Scanned with CamScanner


x(0) = 0
x(1) √3/2
x(2) √3/2
x(3) 0
x(4) = -√3/2
x(5) = -√3/2
x(6) = 0
x(7) = √3/2
-0.866
0
0.866
0.866
0.866
1.73
0.866
0.866
-1
-1
-1
-1
w8^0 = 1
w8^1 = (0.707 - j0.707)
w8^2 = -j
w8^3 = (-0.707 - j0.707)
0
0.866
1.73
-0.866
0.866-0.866j
0.61-1.83j
0.866+0.866j
1.83-0.61j
-1
-1
-1
-1
w4^0 = 1
w4^1 = -j
w4^0 = 1
w4^1 = -j
0.866
-0.866
1.73+0.866j
1.73-0.866j
1.476-2.69j
0.256+0.96j
0.256-0.96j
1.476-2.69j
-1
-1
-1
-1
X(0)
X(4)
X(2)
X(6)
X(1)
X(5)
X(3)
X(7)

From above figure,

$X(0) = 0.866$, $X(1) = 1.476 - 2.69j$

$X(2) = 1.73 + 0.866j$, $X(3) = 0.256 - 0.96j$

$X(4) = -0.866$, $X(5) = 0.256 + 0.96j$, $X(6) = 1.73 - 0.866j$

$X(7) = 1.476 - 2.69j$

Hence,
the 8-point DIF-FFT of $x(n)$ is:

$$X(K) = \{0.866,\ 1.476-2.69j,\ 1.73+0.866j,\ 0.256-0.96j,\ -0.866,\ 0.256+0.96j,\ 1.73-0.866j,\ 1.476-2.69j\}$$

\#.

2023 - Fall

Q N) Define Fast Fourier Transform (FFT)? Determine 8-point DFT of the sequence using Decimation in Frequency FFT (DIFFFT).

$x(n) = \cos\left(\frac{n\pi}{4}\right)$

⇒

↳ A Fast Fourier Transform (FFT) is an algorithm that computes the Discrete Fourier Transform (DFT) or its inverse (IDFT) of a sequence.

↳ It helps to calculate DFT of a given sequence in more faster way with the use of less memory.

Here,

Given sequence is:

$$x(n) = \cos\left(\frac{n\pi}{4}\right)$$

For $n=0$;

$$x(0) = \cos(0) = 1$$

$$x(1) = \cos\left(\frac{\pi}{4}\right) = \frac{1}{\sqrt{2}}$$

$$x(2) = \cos\left(\frac{2\pi}{4}\right) = 0$$

$$x(3) = \cos\left(\frac{3\pi}{4}\right) = -\frac{1}{\sqrt{2}}$$

$$x(4) = \cos\left(\frac{4\pi}{4}\right) = -1$$

$$x(5) = \cos\left(\frac{5\pi}{4}\right) = \frac{-1}{\sqrt{2}}$$

$$x(6) = \cos\left(\frac{6\pi}{4}\right) = 0$$

$$x(7) = \cos\left(\frac{7\pi}{4}\right) = \frac{1}{\sqrt{2}}$$

For 8-point

$$x(n) = \left\{1, \frac{1}{\sqrt{2}}, 0, -\frac{1}{\sqrt{2}}, -1, -\frac{1}{\sqrt{2}}, 0, \frac{1}{\sqrt{2}}\right\}$$

Using DIF-FFT

Butterfly diagram is given as:

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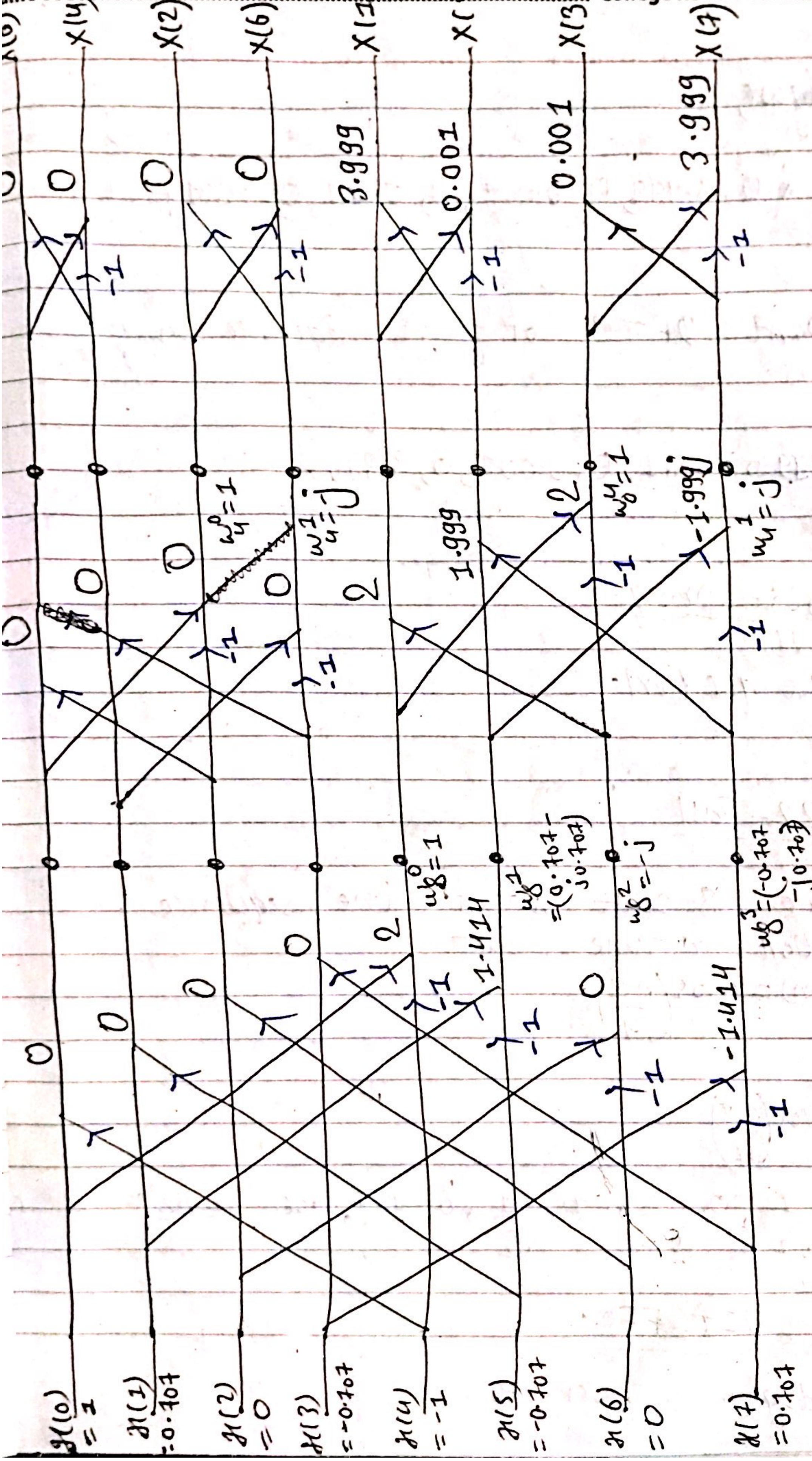

From above figure,

$$X(K) = \{0, 3.999, 0, 0.001, 0, 0.001, 0, 3.999\}$$

Hence,
the 8-point DFT of given sequence using DIF-FFT is:-

$$X(K) = \{0, 3.999, 0, 0.001, 0, 0.001, 0, 3.999\}$$

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2023-Spring

⇓

No question

2022-Fall

Q.N) Determine 8-point DFT of the sequence using Decimation in Time FFT.

$$x(n) = \cos\left(\frac{n\pi}{4}\right)$$

Soln:

$$x(n) = \cos\left(\frac{n\pi}{4}\right)$$

$$x(n) = \left\{1, \frac{1}{\sqrt{2}}, 0, \frac{-1}{\sqrt{2}}, -1, \frac{-1}{\sqrt{2}}, 0, \frac{1}{\sqrt{2}}\right\} \text{ for } 0 \le n \le 7$$

now,

Using DIT-FFT:

Butterfly diagram is given as:-

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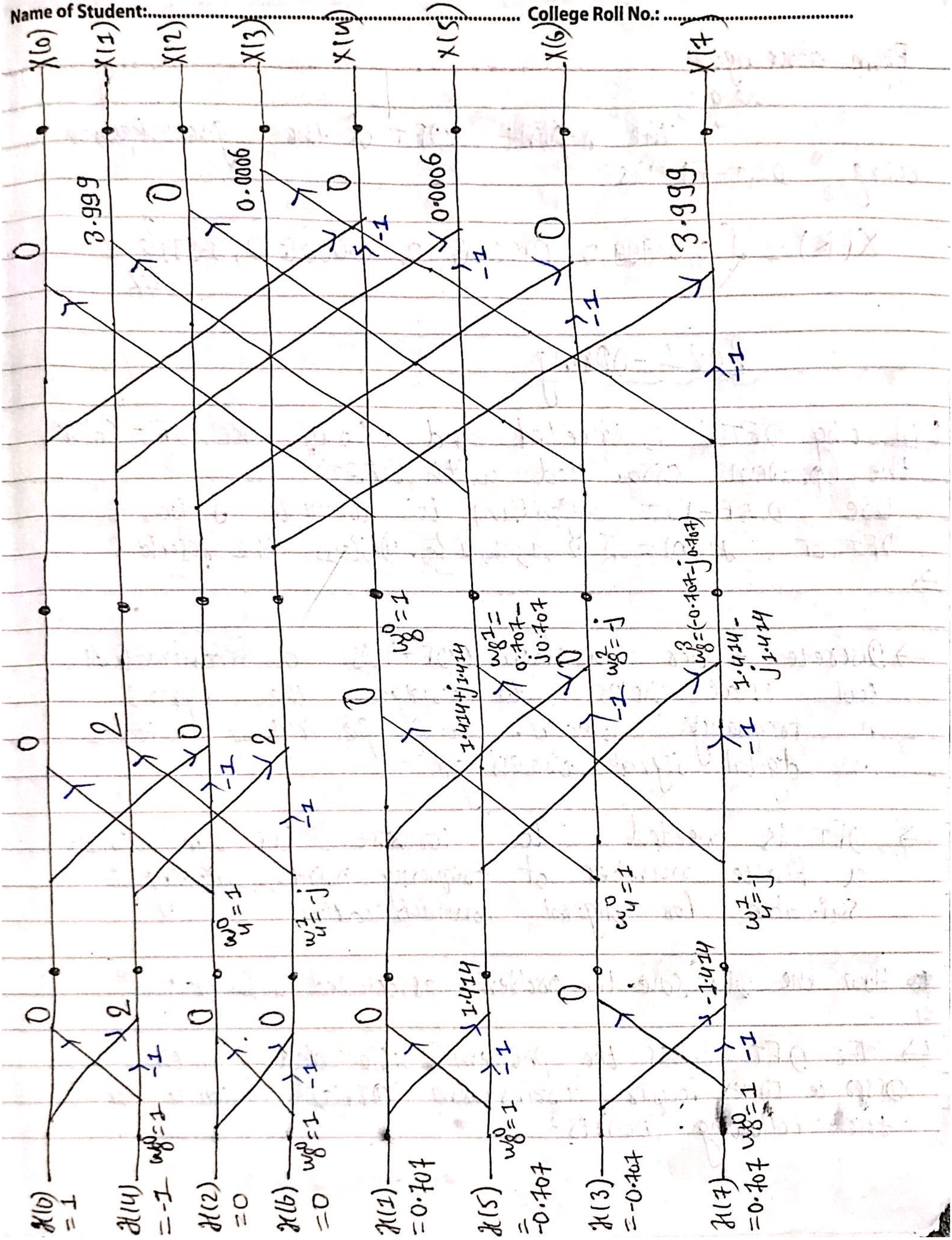


From above figure,
we get;
The 8-point DFT of the given sequence using DIT-FFT is:-

$X(K) = \{0, 3.999, 0, 0.0006, 0, 0.0006, 0, 3.999\}$ #.

2021 - Spring

Q.N) why DFT is needed and how the DFT solve the problem associated with DTFT?
Use DIF-FFT algorithm to compute 8-point DFT of $x(n) = \{2, 1, 1, 1\}$. Discuss the result.

⇒

↳ Discrete Fourier Transform (DFT) is a mathematical tool that helps to analyze the signals in frequency domain. It is particularly used in digital signal processing.

↳ DFT is needed to convert the signal into a finite number of frequency points, making it suitable for digital communication.

How the DFT solve the problem associated with DTFT?
⇒
↳ The DFT solves the problem associated with Discrete Time Fourier Transform (DTFT) because of the following points:-

i) Infinite length:
DTFT analyze the signals over an infinite duration which is impossible in practice. But, DFT analyzes a finite segment of the given signal making it computationally easier.

ii) Computational Complexity:
DTFT involves integrals over a continuous frequency range which is impractical for real-time processing. But, DFT uses a finite set of points which is much faster when combined with FFT algorithms such as DIT-FFT or DIF-FFT.

iii) Storage and display:
DTFT produces an infinite number of frequency components which are impossible to store or display. But, DFT reduces the frequency domain to a manageable size which is easier to store or display.

Numerical Parts

$x(n) = \{2, 1, 1, 1\}$

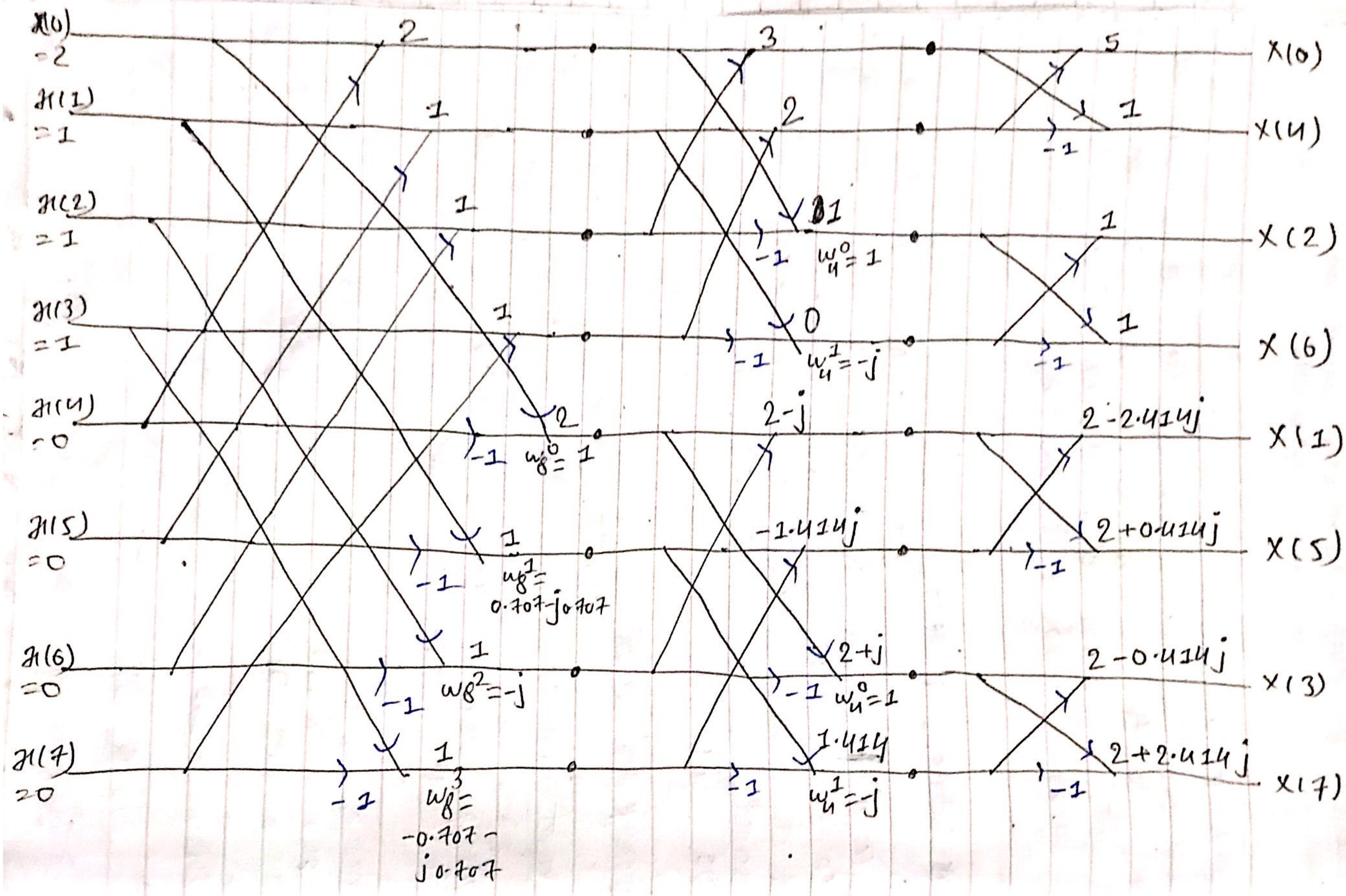
For 8-point DFT, we have to perform zero padding.

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

Now,

Using DIF-FFT

Butterfly diagram is given as:



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From above diagram,
we get;
The required 8-point DFT of $x(n)$ is:

$$X(K) = \{5, 1, 1, 1, 2-2.414j, 2+0.414j, 2-0.414j, 2+2.414j\}$$

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2021 - Fall
Q.No 3a)

Q.N) Find the 8-point DIT - FFT of
$x(n) = \sin \frac{3\pi n}{4}$, for $0 \le n \le 7$.

Soln:

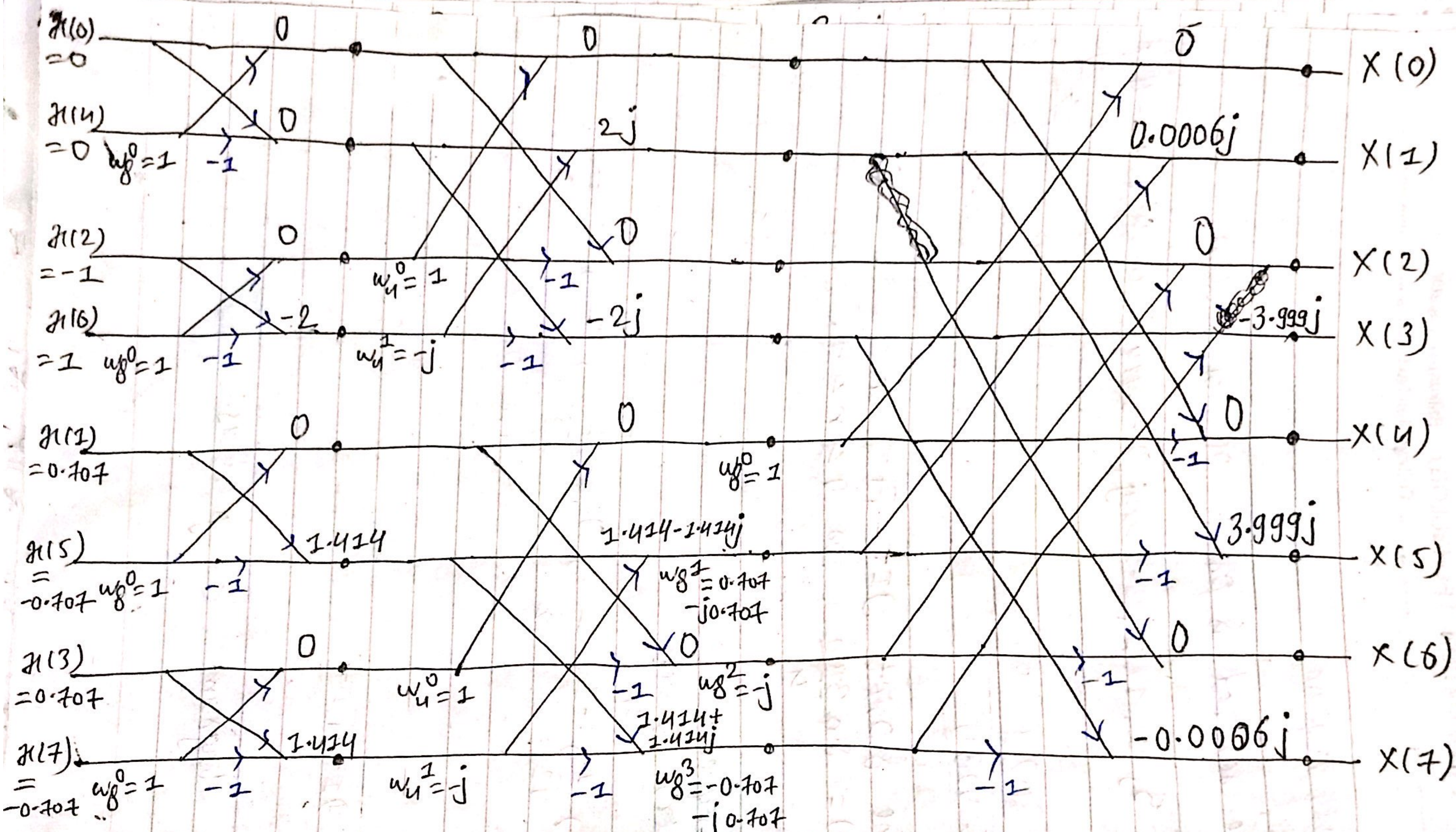
Given sequence is:
$x(n) = \sin \frac{3\pi n}{4}$

$$x(n) = \left\{0, \frac{1}{\sqrt{2}}, -1, \frac{1}{\sqrt{2}}, 0, -\frac{1}{\sqrt{2}}, 1, -\frac{1}{\sqrt{2}}\right\}$$
for $0 \le n \le 7$.

Now,

Using DIT-FFT

Butterfly diagram is given as:



x(0) = 0
x(4) = 0
x(2) = −1
x(6) = 1
x(1) = 0.707
x(5) = −0.707
x(3) = 0.707
x(7) = −0.707
W8^0 = 1
W4^0 = 1
W4^1 = −j
W8^1 = 0.707 − j0.707
W8^2 = −j
W8^3 = −0.707 − j0.707
−1
0
−2
1.414
2j
−2j
1.414 − 1.414j
1.414 + 1.414j
0.0006j
−3.999j
3.999j
−0.0006j
X(0)
X(1)
X(2)
X(3)
X(4)
X(5)
X(6)
X(7)

Hence,
the 8-Point DFT of given sequence is:-

$$X(K) = \{0, 0.0006j, 0, -3.999j, 0, 3.999j, 0, -0.0006j\}$$

\#.

Year :2020 / Semester : Fall

3b) How efficient is FFT? Determine 8-point DFT of the sequence $x(n) = \{1, \dot{0}, 2, 0, 3, 0, 1, 1\}$ using Decimation in Frequency Radix-2 Butterfly Structure (DIF-FFT).

⇒

↳ Fast Fourier Transform (FFT) is more efficient for computing the Discrete Fourier Transform (DFT) or it's inverse (IDFT) of a given sequence.

↳ FFT helps to calculate DFT of a given sequence in more faster way ~~and~~ with the efficient use of memory.

↳ Two types of ~~a~~ FFT-algorithm exist in order to find DFT of a sequence. They are:-

i) Decimation in Time FFT (DIT-FFT)
ii) Decimation in Frequency FFT (DIF-FFT)

Numerical Parts:

Here,

Given sequence is:

$x(n) = \{1, 0, 2, 0, 3, 0, 1, 1\}$

Using ~~x~~ DIF-FFT

The Radix-2 butterfly structure is given as:

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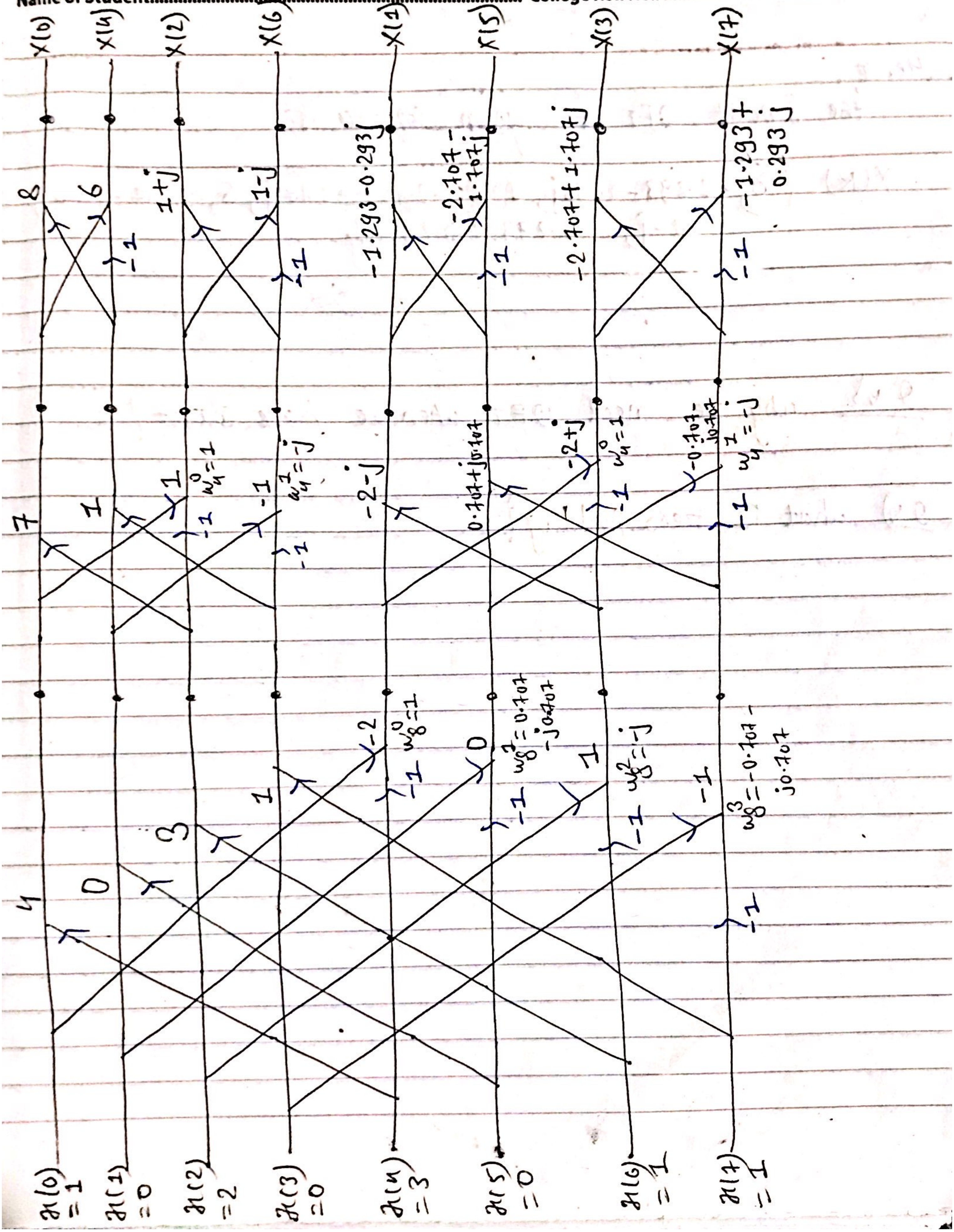

Hence,
the 8-point DFT of given sequence is:

$$X(K) = \{8, -1.293 - 0.293j, 1+j, -2.707 + 1.707j, 6, -2.707 - 1.707j, 1-j, -1.293 + 0.293j\}$$

\#.

Q.N) why we need DFT when we have DTFT?

Q.N) what is zero padding?