



SNS COLLEGE OF TECHNOLOGY

**Coimbatore-35
An Autonomous Institution**

Accredited by NBA – AICTE and Accredited by NAAC – UGC with 'A+' Grade
Approved by AICTE, New Delhi & Affiliated to Anna University, Chennai



DEPARTMENT OF BIOMEDICAL ENGINEERING

19BMB302 - BIOMEDICAL SIGNAL PROCESSING

III YEAR/ V SEMESTER

Unit 1 : TRANSFORMS



TRANSFORMS

- Introduction and Sampling theorem
- ECG signal conversion system
- Discrete Fourier Transform (DFT)
- Decimation in time FFT
- Decimation in time FFT Problems
- Decimation in frequency FFT
- Decimation in frequency FFT Problems
- Multi rate Signal Processing
- Wavelet Transform



Find the DFT of a sequence $x(n)=\{1,2,3,4,4,3,2,1\}$ using DIF algorithm.

$$N=8$$

$$W_8^0 = e^{\left(\frac{-j2\pi}{8}\right)^0} = 1$$

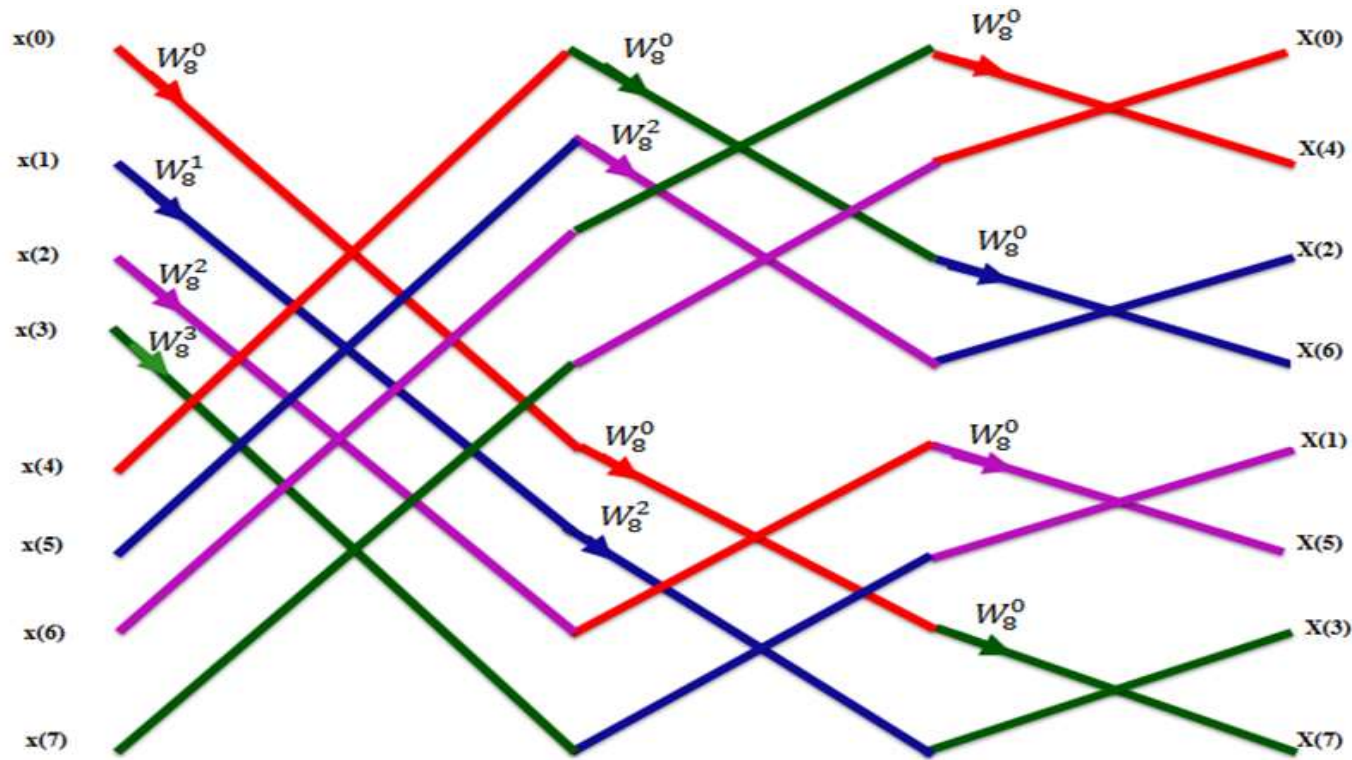
$$W_8^1 = e^{\left(\frac{-j2\pi}{8}\right)^1} = 0.707 - j 0.707$$

$$W_8^2 = e^{\left(\frac{-j2\pi}{8}\right)^2} = -j$$

$$W_8^3 = e^{\left(\frac{-j2\pi}{8}\right)^3} = -0.707 - j 0.707$$



DIF





Input	Stage 1 O/P	Stage 2 O/P	Output
1	$1+4=5$	$5+5=10$	$10+10=20$
2	$2+3=5$	$5+5=10$	$10-10=0$
3	$3+2=5$	$(5-5)(1)=0$	0
4	$4+1=5$	$(5-5)(-j)=0$	0
4	$(1-4)(1)=-3$	$-3+(-j) = -3-j$	$(-3-j)+(-2.828-j1.414)$ $=-5.828 - j2.414$
3	$(2-3) (0.707-j0.707)$ $=-0.707+j0.707$	$(-0.707+j0.707)+$ $(-2.121-j2.121)$ $=-2.828-j1.414$	$[(-3-j)-(-2.828-j1.414)] (1)$ $=-0.172 + j0.414$
2	$(3-2)(-j) = -j$	$(-3-(-j)) (1) = -3 + j$	$(-3 + j)+(2.828-j1.414)$ $=-0.172 - j0.414$
1	$(4-1) (-0.707-j0.707)$ $=-2.121-j2.121$	$[(-0.707+j0.707)-$ $(-2.121-j2.121)] (-j)$ $=2.828-j1.414$	$[(-3 + j)-(-2.828-j1.414)] (1)$ $=-5.828 + j2.414$



- $X(k) = \{20, -5.828 - j2.414, 0, -0.172 - j0.414, 0, -0.172 + j0.414, 0, -5.828 + j2.414\}$



Find the DFT of a sequence $x(n)=\{1,1,1,1,1,1,1,1\}$ using DIF algorithm.

$$N=8$$

$$W_8^0 = e^{\left(\frac{-j2\pi}{8}\right)^0} = 1$$

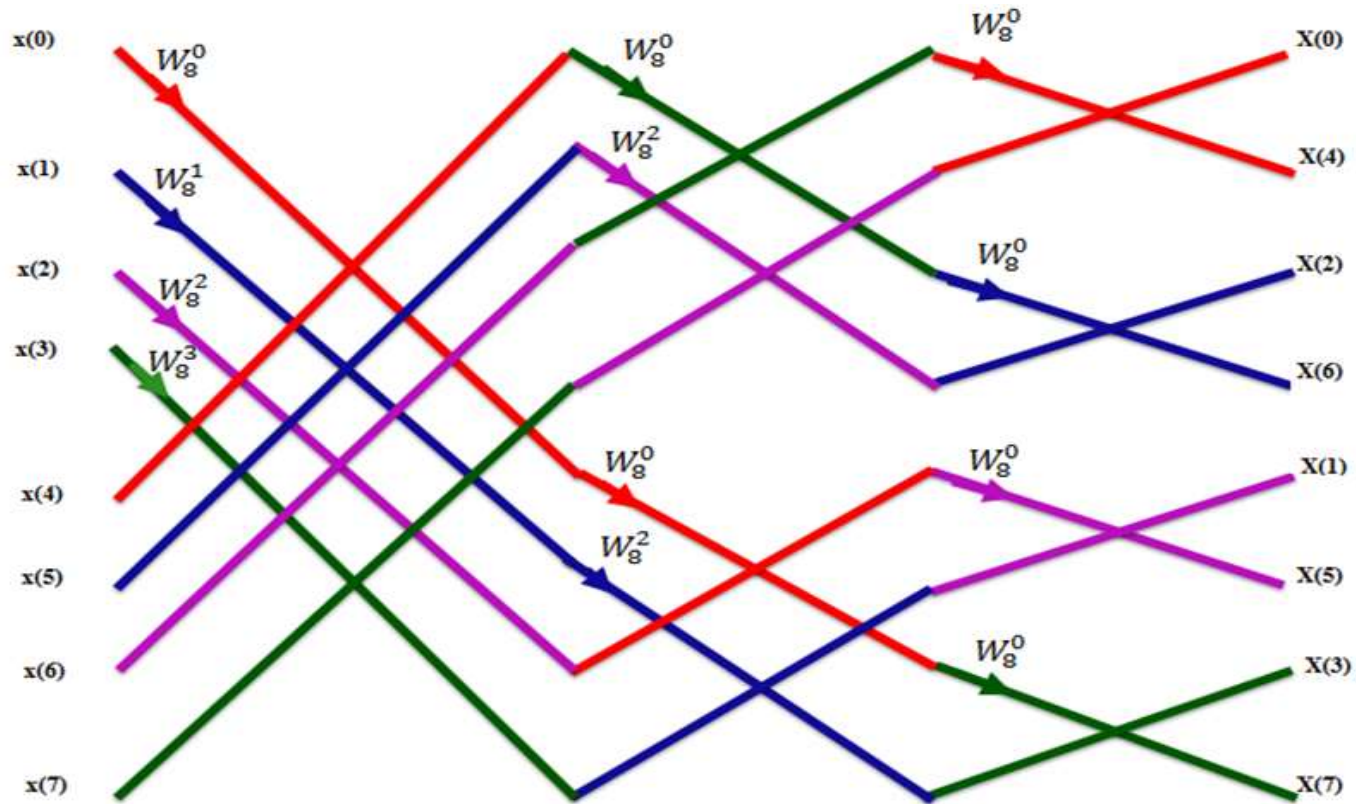
$$W_8^1 = e^{\left(\frac{-j2\pi}{8}\right)^1} = 0.707 - j 0.707$$

$$W_8^2 = e^{\left(\frac{-j2\pi}{8}\right)^2} = -j$$

$$W_8^3 = e^{\left(\frac{-j2\pi}{8}\right)^3} = -0.707 - j 0.707$$



DIF





Input	Stage 1 O/P	Stage 2 O/P	Output
1	$1+1=2$	$2+2=4$	$4+4=8$
1	$1+1=2$	$2+2=4$	$4-4=0$
1	$1+1=2$	$(2-2)(1)=0$	0
1	$1+1=2$	$(2-2)(-j)=0$	0
1	$(1-1)(1)=0$	0	0
1	$(1-1)(0.707-j0.707)=0$	0	0
1	$(1-1)(-j) = 0$	0	0
1	$(1-1)(-0.707-j0.707) = 0$	0	0



Find the IDFT of a sequence $X(k) = \{20, -5.828 - j2.414, 0, -0.172 - j0.414, 0, -0.172 + j0.414, 0, -5.828 + j2.414\}$ using DIT algorithm.

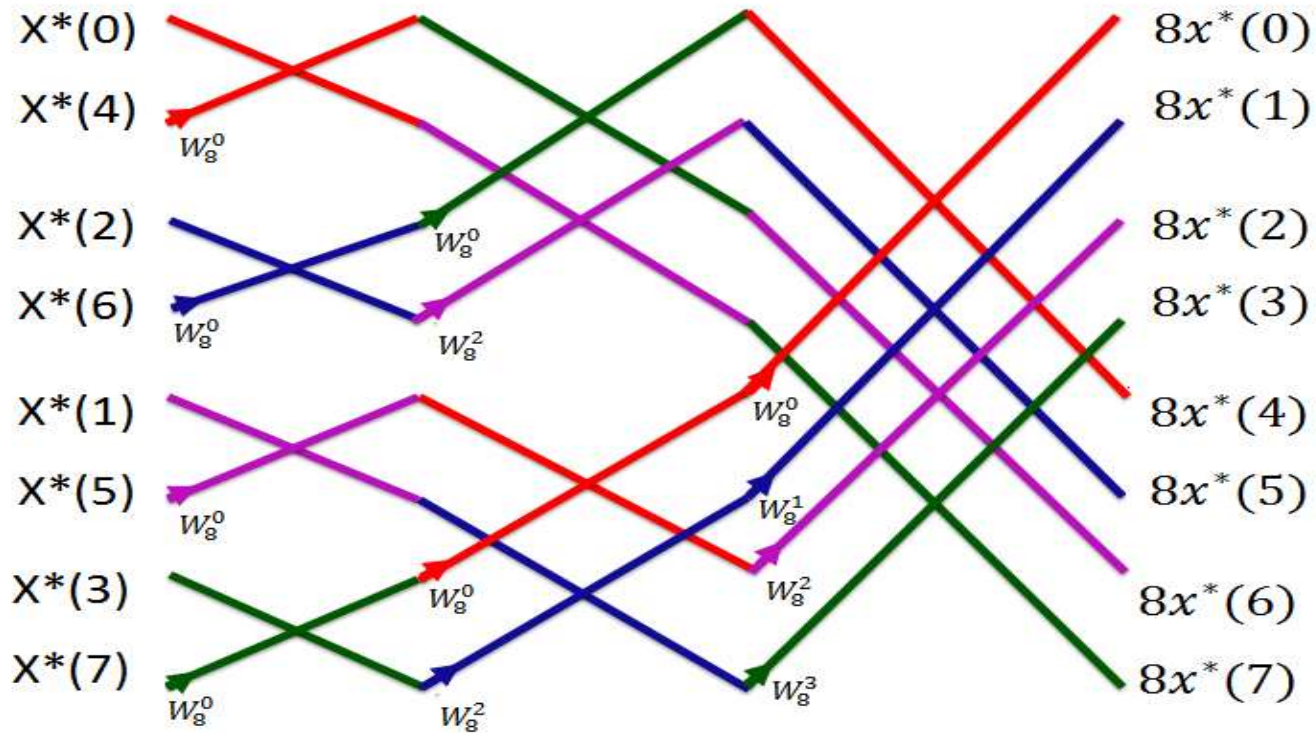
$$N=8$$

$$W_8^0 = e^{\left(\frac{-j2\pi}{8}\right)^0} = 1$$

$$W_8^1 = e^{\left(\frac{-j2\pi}{8}\right)^1} = 0.707 - j0.707$$

$$W_8^2 = e^{\left(\frac{-j2\pi}{8}\right)^2} = -j$$

$$W_8^3 = e^{\left(\frac{-j2\pi}{8}\right)^3} = -0.707 - j0.707$$





Input	Stage 1 O/P	Stage 2 O/P	Output
20	$20+0=20$	$20+0=20$	$20+(-12)=8$
0	$20-0=20$	$20+0=20$	$20+(0.707-j0.707)$ $(-2.828-j2.828) =16$
0	0	$20-0=20$	$20+(-j)(j4)=24$
0	0	$20-0=20$	$20+(-0.707-j0.707)$ $(-8.484+j8.484)=32$
$-5.828 + j2.414$	$(-5.828 + j2.414)+$ $(-0.172 - j0.414)$ $=-6.000+j2$	$(-6.000+j2)+$ $(-6.000-j2)$ $=-12$	$20-(-12)=32$
$-0.172 - j0.414$	$(-5.828 + j2.414)-$ $(-0.172 - j0.414)$ $=-5.656+j2.828$	$(-5.656+j2.828) +$ $(-j)(5.656+j2.828)$ $=-2.828-j2.828$	$20-(0.707-j0.707)(-2.828-$ $j2.828) =24$
$-0.172 + j0.414$	$(-0.172 + j0.414)+$ $(-5.828 - j2.414)$ $=-6.000-j2$	$(-6.000+j2)-$ $(-6.000-j2)$ $=j4$	$20-(-j)(j4)=16$
$-5.828 - j2.414$	$(-0.172 + j0.414)-$ $(-5.828 - j2.414)$ $=5.656+j2.828$	$(-5.656+j2.828) -$ $(-j)(5.656+j2.828)$ $=-8.484+j8.484$	$20+(-0.707-j0.707)(-$ $8.484+j8.484)=8$



$$8 x^*(n) = \{8, 16, 24, 32, 32, 24, 16, 8\}$$

$$8 x(n) = \{8, 16, 24, 32, 32, 24, 16, 8\}$$

$$x(n) = \{1, 2, 3, 4, 4, 3, 2, 1\}$$



Find the IDFT of a sequence
 $X(k) = \{4, 1 - j2.414, 0, 1 - j0.414, 0, 1 + j0.414, 0, 1 + j2.414\}$ using DIF algorithm.

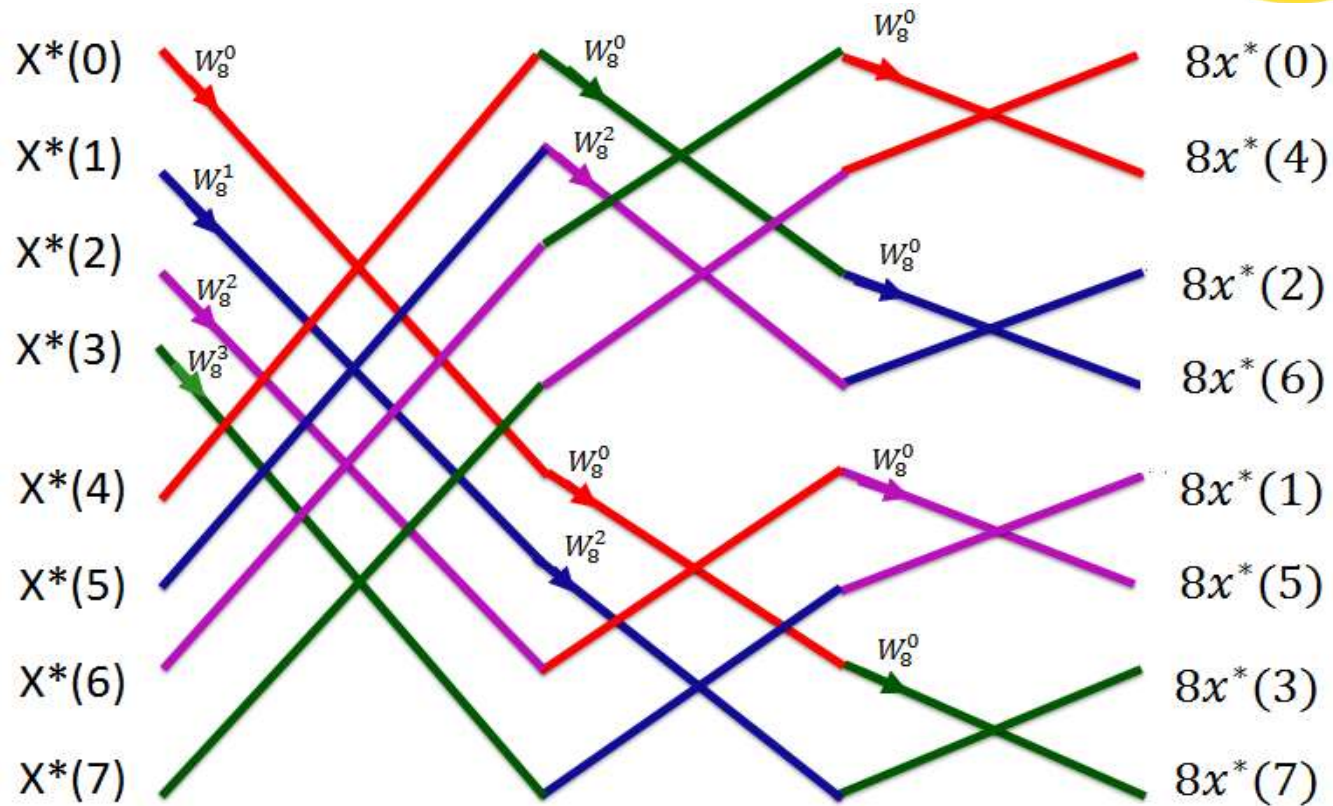
$$N=8$$

$$W_8^0 = e^{\left(\frac{-j2\pi}{8}\right)^0} = 1$$

$$W_8^1 = e^{\left(\frac{-j2\pi}{8}\right)^1} = 0.707 - j 0.707$$

$$W_8^2 = e^{\left(\frac{-j2\pi}{8}\right)^2} = -j$$

$$W_8^3 = e^{\left(\frac{-j2\pi}{8}\right)^3} = -0.707 - j 0.707$$





Input	Stage 1 O/P	Stage 2 O/P	Output
4	$4+0=4$	$4+0=4$	$4+4=8$
$1+ j2.414$	$(1+ j2.414)+(1-j0.414)$ $=2+j2$	$(2+j2)+(2-j2)=4$	$4-4=0$
0	0	$4-0=4$	$4+4=8$
$1+j0.414$	$(1+j0.414)+1- j2.414$ $=2-j2$	$[(2+j2)-(2-j2)](-j)=4$	$4-4=0$
0	$(4-0)(1)=4$	$4+0=4$	$4+4=8$
$1-j0.414$	$[(1+ j2.414)-(1-j0.414)]$ $(0.707-j0.707)=2+j2$	$(2+j2)+(2-j2) =4$	$4-4=0$
0	0	$4-0=4$	$4+4=8$
$1- j2.414$	$(1+j0.414)+1- j2.414$ $=2-j2$	$[(2+j2)-(2-j2)](-j)=4$	$4-4=0$

$$8 x^*(n) = \{8, 8, 8, 8, 0, 0, 0, 0\}$$

$$8 x(n) = \{8, 8, 8, 8, 0, 0, 0, 0\}$$



Thank You!