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

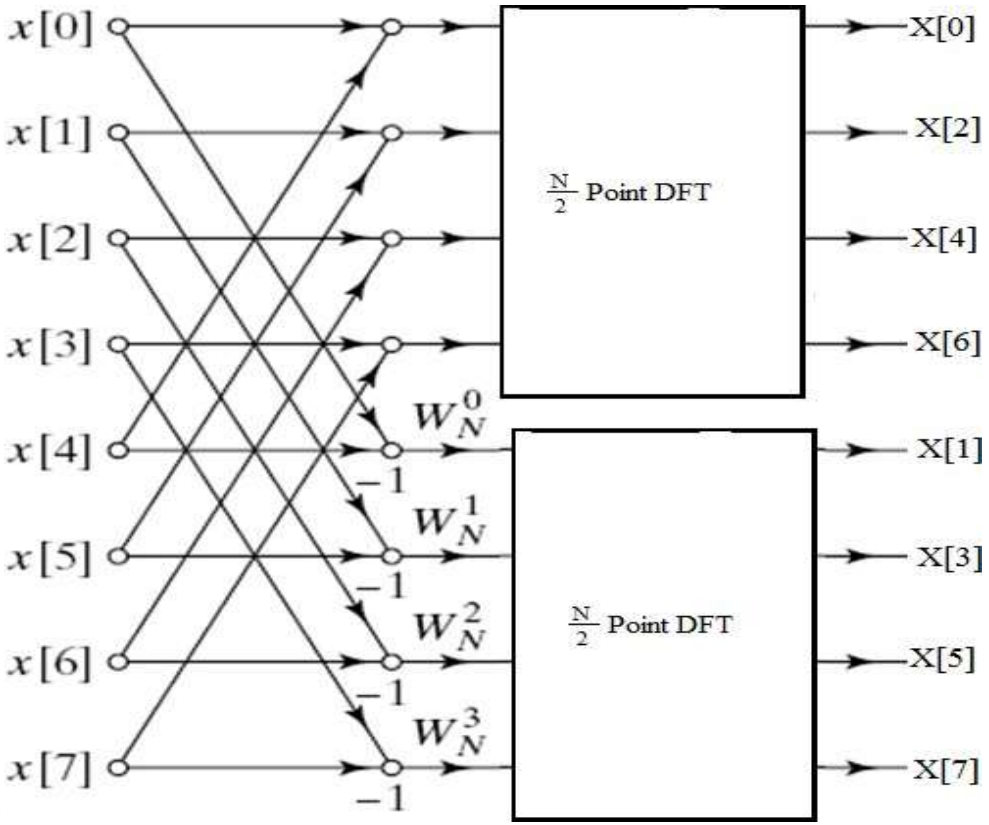
III YEAR/ V SEMESTER

Unit 1 : TRANSFORMS

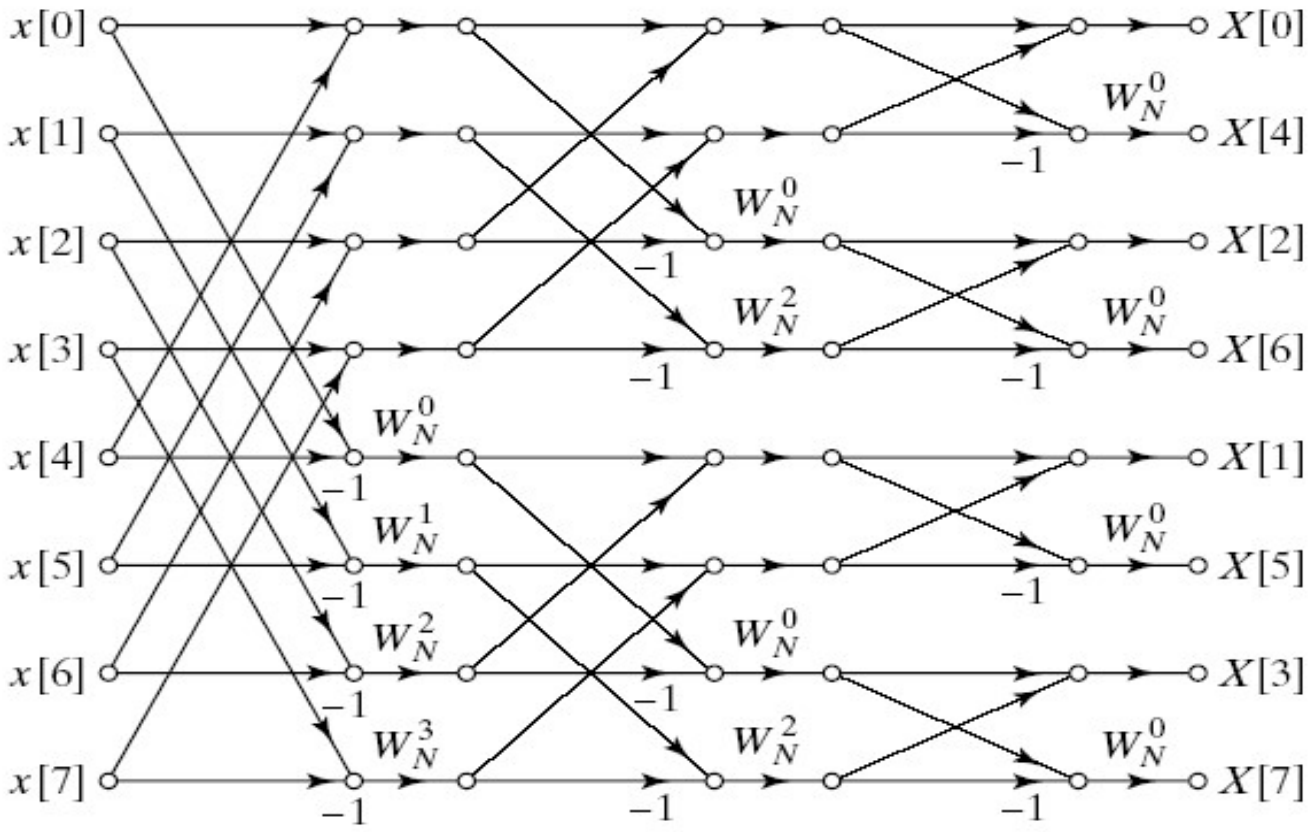
TRANSFORMS

- 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

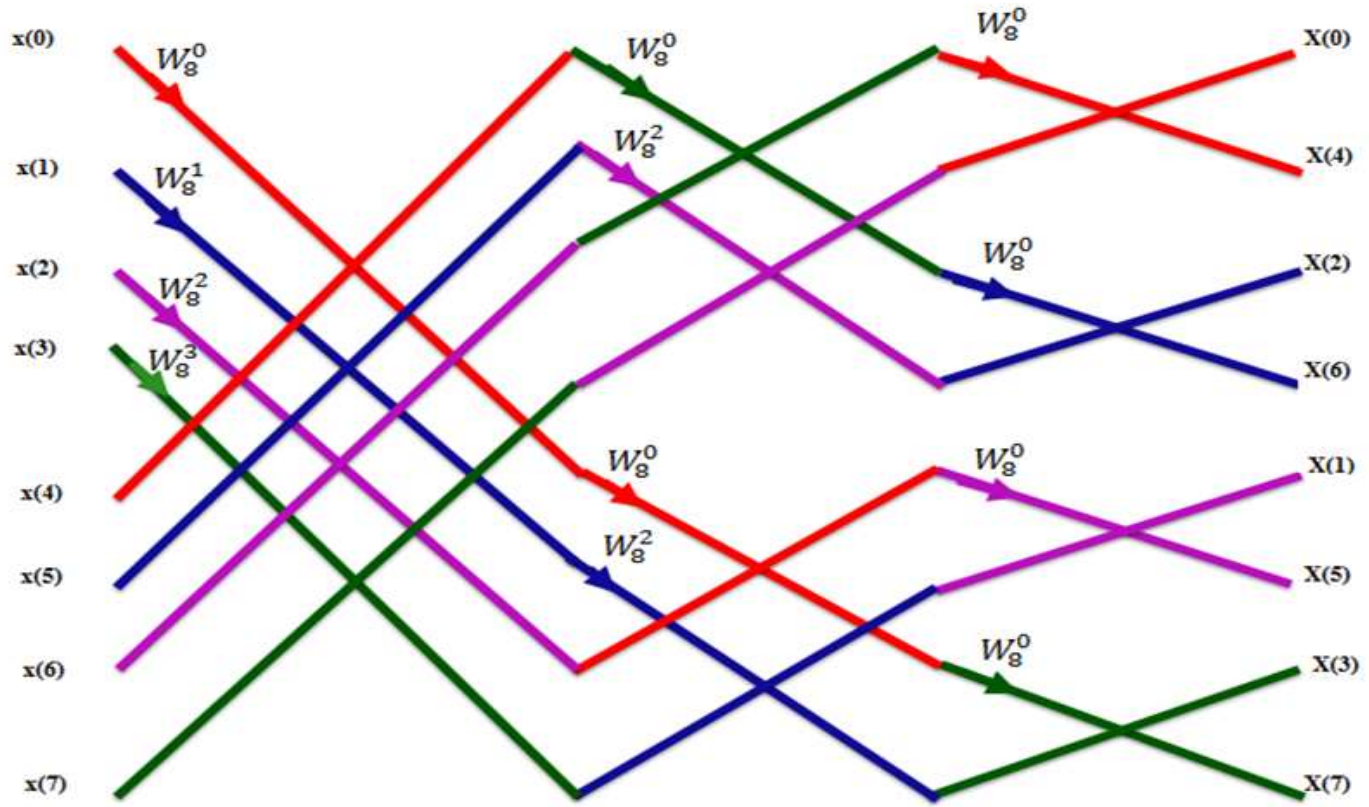
Decimation-In-Frequency FFT Algorithm



DIF



DIF


x(0)
x(1)
x(2)
x(3)
x(4)
x(5)
x(6)
x(7)
W_8^0
W_8^1
W_8^2
W_8^3
W_8^0
W_8^2
W_8^0
W_8^0
W_8^2
W_8^0
X(0)
X(4)
X(2)
X(6)
X(1)
X(5)
X(3)
X(7)

Steps in DIF FFT

4.7 Summary of Steps for Radix - 2 DIF-FFT Algorithm

1. The number of input samples $N = 2^M$, where, M is number of stages.
2. The input sequence is in natural order.
3. The number of stages in the flow graph is given by $M = \log_2 N$.
4. Each stage consists of $\frac{N}{2}$ butterflies.
5. Inputs/outputs for each butterfly are separated by 2^{M-m} samples, where m represents the stage index i e., for first stage $m = 1$ and for second stage $m = 2$ so on.
6. The number of complex multiplications is given by $\frac{N}{2} \log_2 N$.
7. The number of complex additions is given by $N \log_2 N$.
8. The twiddle factor exponents are a function of the stage index m and is given by

$$k = \frac{Nt}{2^{M-m+1}}, \quad t = 0, 1, 2, \ldots, 2^{M-m} - 1 \qquad (4.38)$$

9. The number of sets or sections of butterflies in each stage is given by the formula 2^{m-1}.
10. The exponent repeat factor (ERF), which is the number of times the exponent sequence associated with m repeated is given by 2^{m-1}.

Table 4.2 Comparison of number of complex multiplications for the direct evaluation of the DFT versus the FFT algorithm

Number of Stages M	Number of Points N	Number of Complex Multiplications Using		Speed Improvement Factor $\frac{N^2}{(N/2)\log_2 N}$
		Direct evaluation N^2	FFT algorithm $(N/2)\log_2 N$	
2	4	16	4	4
3	8	64	12	5.333
4	16	256	32	8
5	32	1,024	80	12.8
6	64	4,096	192	21.33
7	128	16,384	448	36.57
8	256	65,536	1024	64
9	512	2,62,144	2,304	113.77
10	1,024	10,48,576	5,120	204.8

Thank You!