LNCT GROUP OF COLLEGES

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Subject: Digital Signal Processing EC601

Unit:IV

Topic:FFT

Composite point FFT

Composit no → more than two factors.

Example :-

$6 = 2 \times 3 \qquad N = P_1 N_1$

$N = P_1 N_1 \qquad P_1 \rightarrow$ no. of subsequence

$N_1 \rightarrow$ no. of elements in subsequences.

for $N = 6 = 2 \cdot 3$.

Subsequences $x(0) \quad x(3)$ — ①

$x(1) \quad x(4)$ — ②

$x(2) \quad x(5)$ — ③

for $N = 6 = 2 \cdot 3$.

$x(0),\ x(2),\ x(4)$

$x(1),\ x(3),\ x(5)$

for $N = 6 = 2 \cdot 3$.

$x(0)$	$x(1)$
$x(2)$	$x(3)$
$x(4)$	$x(5)$
$x(2r)$	$x(2r+1)$

$r = 0, 1, \ldots, (N_1 - 1)$

for $N = 6 = 3 \cdot 2$

$x(0)$	$x(1)$	$x(2)$
$x(3)$	$x(4)$	$x(5)$
$x(3r)$	$x(3r+1)$	$x(3r+2)$

$r = 0, 1, \ldots (N_1 - 1)$

$$X(K) = \sum_{r=0}^{N_1-1} x(3r)\, W_N^{3rK} + \sum_{r=0}^{N_1-1} x(3r+1)\, W_N^{(3r+1)K} + \sum_{r=0}^{N_1-1} x(3r+2)\, W_N^{(3r+2)K}.$$

for $N = 9 = 3 \cdot 3$

$x(0)$	$x(1)$	$x(2)$
$x(3)$	$x(4)$	$x(5)$
$x(6)$	$x(7)$	$x(8)$
$x(3r)$	$x(3r+1)$	$x(3r+2)$

$r = 0, 1, \ldots, (N_1 - 1)$

for $N = 9$

$$X(K) = \sum_{r=0}^{N_1-1} x(3r)\, W_9^{3rK} + \sum_{r=0}^{N_1-1} x(3r+1)\, W_9^{(3r+1)K} + \sum_{r=0}^{N_1-1} x(3r+2)\, W_9^{(3r+2)K}$$

general composit FFT for $N = P_1 N_1$

$$X(K) = \sum_{r=0}^{N_1-1} x(P_1 r)\, W_N^{P_1 r K} + \sum_{r=0}^{N_1-1} (P_1 r+1)\, W_N^{(P_1 r+1)K} + \ldots + \sum_{r=0}^{N_1-1} x(rP_1 + P_1 - 1)\, W_N^{(rP_1 + \ldots}$$

— (A)

for $N=6=$

(1) $6 = 2\times 3$ $P_1 = 2$ $N_1 = 3$.

$$X(K) = \sum_{r=0}^{2} x(2r)\, W_6^{2rk} + \sum_{r=0}^{2} x(2r+1)\, W_6^{(2r+1)k}$$

$$x_1(K) = \qquad x_2(K)$$

(2) $N = 6 = 3\times 2$ $P_1 = 3$ $N_1 = 2$

$$X(K) = \sum_{r=0}^{1} x(3r)\, W_6^{3rk} + \sum_{r=0}^{1} x(3r+1)\, W_6^{(3r+1)k} + \sum_{r=0}^{1} x(3r+2)\, W_6^{k(3r+2)}$$

$K = 0, 1, 2, \ldots 5$

$$X(K) = \sum_{r=0}^{1} x$$

Three summation representation of 2 pt DFT of seq $x(3r)$, $x(3r+1)$ & $x(3r+2)$

$$X(K) = X_1(K) + W_6^K X_2(K) + W_6^{2K} X_3(K) \quad \text{—(1)}$$

$K = 0, 1, 2, \ldots 5$. $K = 0, 1$, $K = 0, 1$; $K = 0, 1$,

put $K=0$ in eq (1).

$$X(0) = X_1(0) + W_6^0 X_2(0) + W_6^0 X_3(0)$$

$$X(0) = X_1(0) + X_2(0) + X_3(0) \quad \text{—(a)}$$

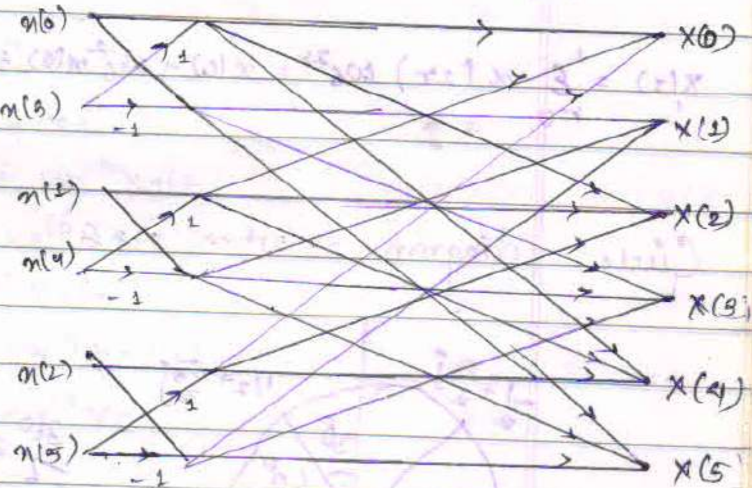
$$X(1) = X_1(0) + W_6^1 X_2(1) + W_6^2 X_3(1) \quad \text{—(b)}$$

$$X(2) = X_1(0) + W_6^2 X_2(0) + W_6^4 X_3(0) \quad \text{—(c)}$$

$$X(3) = X_1(1) + W_6^3 X_2(1) + W_6^6 X_3(1) \quad \text{—(d)}$$

$$X(4) = X_1(0) + W_6^4 X_2(0) + W_6^8 X_3(0) \quad \text{—(e)}$$

$$X(5) = X_1(1) + W_6^5 X_2(1) + W_6^0 X_3(1) \quad \text{—(f)}$$



$$X(K) = \sum_{r=0}^{2} x(2r)\, W_6^{2rk} + \sum_{r=0}^{2} x(2r+1)\, W_6^{(2r+1)k}.$$

$$= \sum_{r=0}^{2} x(2r)\, W_6^{2rk} + W_6^{k} \sum_{r=0}^{2} x(2r+1)\, W_6^{2rk}$$

3 pt DFT   3 pt DFT

$$X(K) = X_1(K) + W_6^K X_2(K)$$

put $K=0$ in equation (ii)

we have,

$$X_m(0) = X_{M-1,1}(0) + W_N^0 X_{M-1,2}(0) \quad \text{—(a)}$$

for $K=1$

$$X_m(1) = X_{M-1,1}(1) + W_N \cdot X_{M-1,2}(1) \quad \text{—(b)}$$

for $K=2$.

$$X_m(2) = X_{M-1,1}(2) + W_N^2 \cdot X_{M-1,2}(2) \quad \text{—(c)}$$

for $K=3$

$$X_m(3) = X_{M-1,1}(3) + W_N^3 \cdot X_{M-1,2}(K) \quad \text{—(d)}$$

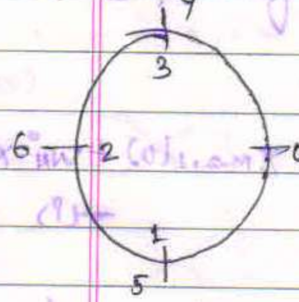
for $K=4$

$$X_m(4) = X_{M-1}(4) + W_N^4 \cdot X_{M-1,2}(4) \quad \text{—(e)}$$

$$= X_{M-1}(0) + W_N^4 \cdot X_{M-1,2}(0)$$

Since it is periodic by $N/2$

$\therefore$ $4=0$



$\therefore$ $\frac{N}{2}$ pt DFT

4 (0) = 4 pt DFT

periodicity = 4.

for $K=5$

$$X_m(5) = X_{M-1,1}(5) + W_N^5 \cdot X_{M-1,2}(5)$$

$$= X_{M-1,1}(1) + W_N^5 \cdot X_{M-1,2}(1) \quad \text{—(f)}$$

for $K=6$

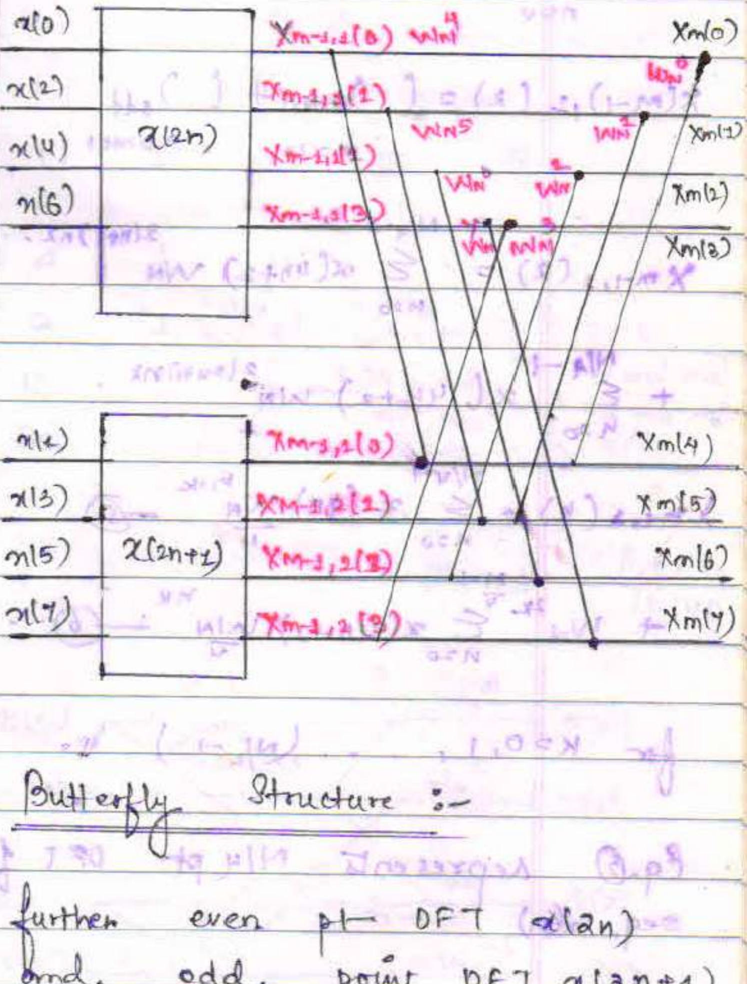
$$X_m(6) = X_{M-1,1}(6) + W_N^6 \cdot X_{M-1,2}(6)$$

$$= X_{M-1,1}(2) + W_N^6 \cdot X_{M-1,2}(2) \quad \text{—(g)}$$

for $K=7$.

$$X_m(7) = X_{M-1,1}(7) + W_N^7 \cdot X_{M-1,2}(7)$$

$$= X_{M-1,1}(3) + W_N^7 \cdot X_{M-1,2}(3) \quad \text{—(h)}$$



<u>Butterfly Structure</u> :-

further even pt DFT $x(2n)$ and odd point DFT $x(2n+1)$ are broken in even and odd point DFT's.

ie equation (iii) & (iv) are further divided into even & odd point DFT's.

In radix II smaller DFT will be the point 2 further N/2 DFT break into combination of 2, N/4 point DFT.

II nd decomposition of radix 2 DIT FFT starts from eq. (3) & (4).

from eq. (3)

$$X_{M-1,1}(K) = \sum_{n=0}^{N/2-1} x(2n) W_{N/2}^{nk}$$

$$= \sum_{n=0}^{N/2-1} x(2n) W_N^{2nk}$$

$$X_{(M-1),1}(k) = (\;)_{even,\; n=2n} + (\;)_{odd,\; n=2n+1}$$

$$X_{M-1,1}(k) = \sum_{n=0}^{N/4-1} x(4n+2) W_N^{2(n+1)nk}$$

$$+ \sum_{n=0}^{N/4-1} x(4n+2) W_N^{2(2n+1)nk}$$

$$X_{M-1,1}(k) = \sum_{n=0}^{N/4-1} x(4n) W_{N/4}^{nk} \quad -(5)$$

$$+ W_N^{2k} \sum_{n=0}^{N/4-1} x(4n+2) W_{N/4}^{nk} \quad -(6)$$

for $k = 0, 1, \ldots (N/2 - 1)$

Eq. (5) represents N/4 pt DFT of seq. x(4n)

Eq. (6) represents N/4 pt DFT of seq. (4n+2).

$$X_{M-1,1}(k) = X_{M-2,1}(k) + W_N^{2k} X_{M-2,2}(k) \quad -(7)$$

$$X_{M-2,1}(k) = \sum_{n=0}^{N/4-1} x(4n) W_{N/4}^{nk}$$

$$X_{M-2,2}(k) = \sum_{n=0}^{N/4-1} x(4n+2) W_{N/4}^{nk}$$

Similarly for eq. (4)

$$X_{M-1,2}(k) = \sum_{n=0}^{N/2-1} x(2n+1) W_{N/2}^{nk}$$

$$= (\;)_{even,\; n=2n} + (\;)_{odd,\; n=2n+1}$$

$$X_{M-1,2}(k) = X_{M-2,3}(k) + W_N^{2k} X_{M-2,4}(k) \quad -(8)$$

$$X_{M-2,3}(k) = \sum_{n=0}^{N/4-1} x(4n+1) W_{N/4}^{nk} \quad -(9)$$

$$X_{M-2,4}(k) = \sum_{n=0}^{N/4-1} x(4n+3) W_{N/4}^{nk} \quad -(10)$$

for N=8 eq. (5) and (8) represents N/2 point DFT which is comb of two N/4 pt DFT & eq. (6), (7), & (9) (10) rep. N/4 pt DFT of seq. x(4n), x(4n+2), x(4n+1), x(4n+3), for these eq. k = 0, 1, ... (N/4 - 1)

for N = 8 from eq. (5) & (8)

for k=0

$$X_{M-1,1}(0) = X_{M-2,1}(0) + W_N^0 X \quad -(P)$$

for k=1

$$X_{M-1,1}(1) = X_{M-2,1}(1) + W_N^1 X \quad -(j)$$

for k=2

$$X_{M-1,1}(2) = X_{M-2,1}(0) + W_N^2 X_{M-2,2}(0) \quad -(k)$$

for $K=3$.

$x_{M-1,1}(3) = x_{M-2,1}(1) + W_N^3 x_{M-2,2}(1)$ —(d)

In eq (8)

for $K=0$

$X_{M-1,2}(0) = X_{M-2,3}(0) + W_N^0 X_{M-2,4}(0)$ —(m)

for $K=1$

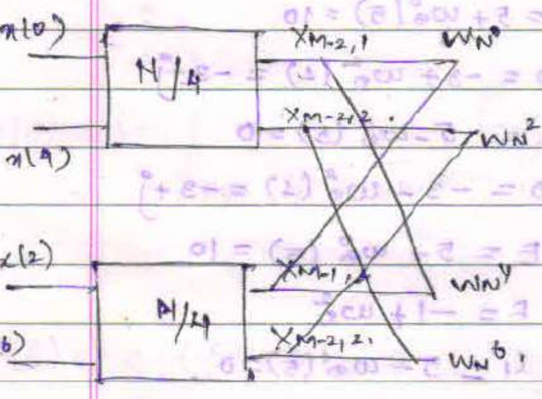
$X_{M-1,2}(1) = X_{M-2,3}(1) + W_N^2 X_{M-2,4}(1)$ —(n)

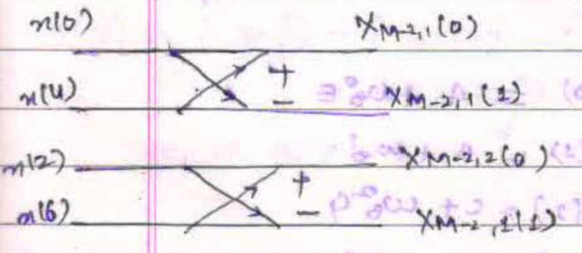
for $K=2$

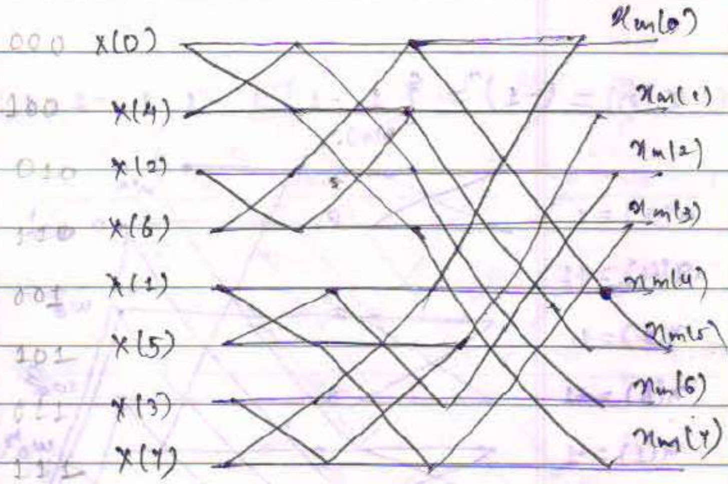
$X_{M-1,2}(2) = X_{M-2,3}(0) + W_N^4 X_{M-2,4}(0)$ —(o)

for $K=3$.

$X_{M-1,2}(3) = X_{M-2,3}(1) + W_N^6 X_{M-2,4}(1)$ —(p)

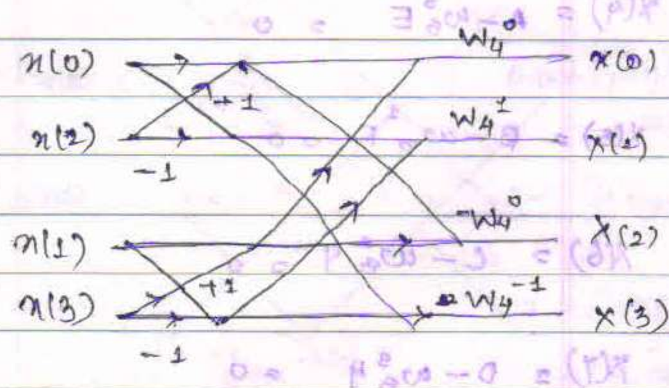






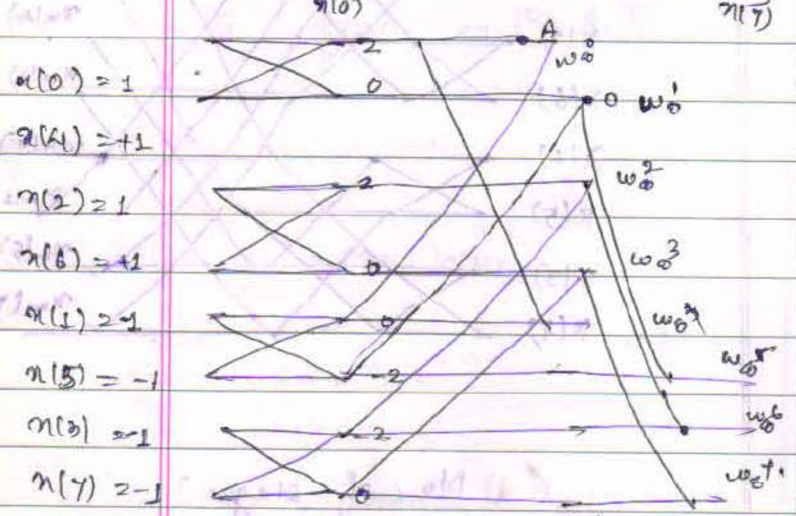
No. of stages

N	I	II	III	IV
2^2 4	1	W_4^0 W_4^2		
2^3 8	1	W_8^0 W_8^2	W_8^0 W_8^1 W_8^2 W_8^3	
2^4 16	1	W_{16}^0, W_{16}^4	W_{16}^0, W_{16}^2, W_{16}^6, W_{16}^8, W_{16}^4	W_{16}^0 W_{16}^1 W_{16}^2 W_{16}^7 W_{16}^3 W_{16}^4 W_{16}^5 W_{16}^6
~~32.~~				
2^5 32	1	W_{32}^0 W_{32}^8	W_{32}^0, W_{32}^4, W_{32}^8, W_{32}^{12}, W_{32}^{16}	0, 2, 4, 6, 8, 10, 12, 14



Qo. Determine 8 point DFT of seq. $x(n) = (-1)^n$ using Radix 2 decimation in time FFT algorithm.

$x(n) = (-1)^n = \{1, -1, 1, -1, 1, -1, 1, -1\}$



$X(0) = A + W_8^0 E = 4 + W_8^0 - 4$

$X(1) = B + W_8^1 F = 0 + W_8^1 + 0$

$X(2) = C + W_8^2 G = 0$

$X(3) = D + W_8^3 H = 4 - W_8^0(-4) = 8$

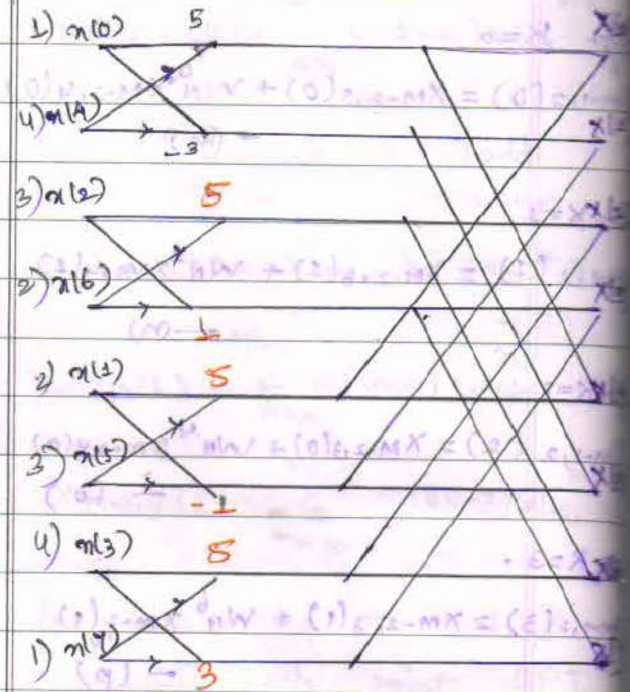
$X(4) = A - W_8^0 E = 0$

$X(5) = B - W_8^1 F = 0$

$X(6) = C - W_8^2 G = 0$

$X(7) = D - W_8^3 H = 0$

Qo. Determine 8-pt DFT of sequence $x(n) = \{1, 2, 3, 4, 4, 3, 2, 1\}$ using Radix-2 DITFFT



$A = 5 + W_8^0(5) = 10$

$B = -3 + W_8^2(1) = -3 - j$

$C = 5 - W_8^0(5) = 0$

$D = -3 - W_8^2(1) = -3 + j$

$E = 5 + W_8^0(5) = 10$

$F = -1 + W_8^2$

$G = 5 - W_8^0(5) = 0$

$H = -1 - W_8^2 = -1 + 3j$

$X(0) = A + W_8^0 E$

$X(1) = B + W_8^1$

$X(2) = C + W_8^2 G$

$X(3) = D + W_8^3 H$

$X(4) = A - W_8^0 E$

$X(5) = B - W_8^1 F$

$X(6) = C - W_8^2 G$

$X(7) = D - W_8^3 H.$

$X(0) = 5 + W_8^0(5) + W_8^0[5 + W_8^0(5)]$

$= 10 + 10$

$= 20$

$X(1) = [-3 + W_8^2(1)] + W_8^1[-1 + W_8^2(3)]$

$= -3 - j + W_8^1[-1 - 3j]$

$= -3 - j + (0.707 - 0.707j)(-1 - 3j)$

$= -5.828 - j \cdot 2.414$

$X(2) = 0 + (-j)0 = 0$

$X(3) = (-3 + j) + (-0.707 - j0.707)(-1 + 3j)$

$= -0.172 - 0.414j$

$X(4) = 10 - 10$

$= 0$

$X(5) = (-3 - j) - (0.707 - 0.707j)(-1 - 3j)$

$= -0.172 + 0.414j$

$X(6) = 0 - (-j) \cdot 0 = 0$

$X(7) = (-3 + j) - (-0.707 - 0.707j)(-1 + 3j)$

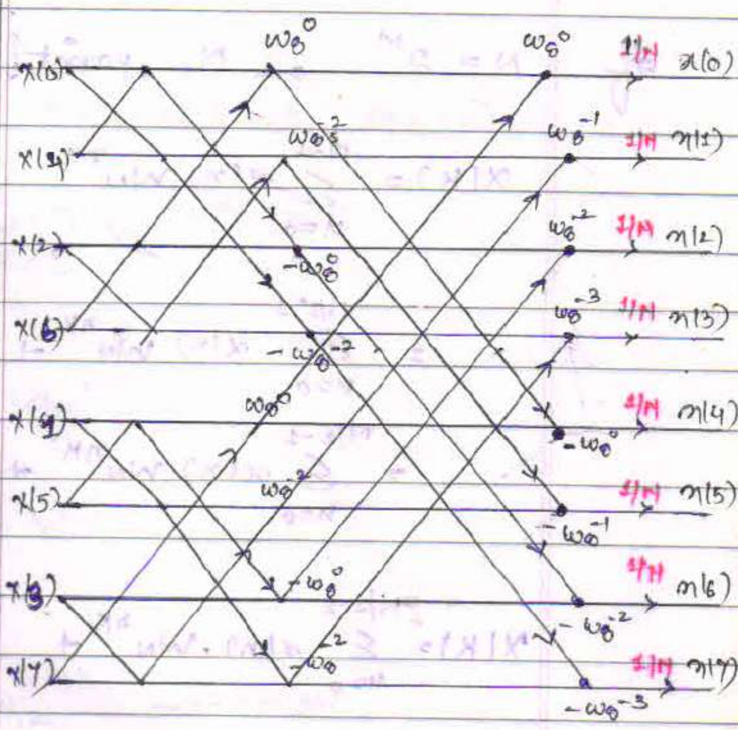
$= 5.828 + 2.414j$

$X(K) = \{20, -5.828 - 2.414j, 0.0172 - 0.414j, 0, 0.172 + 0.414j, 0, 5.828 + 2.414j\}$.

→ ans

FOR IDFT :-

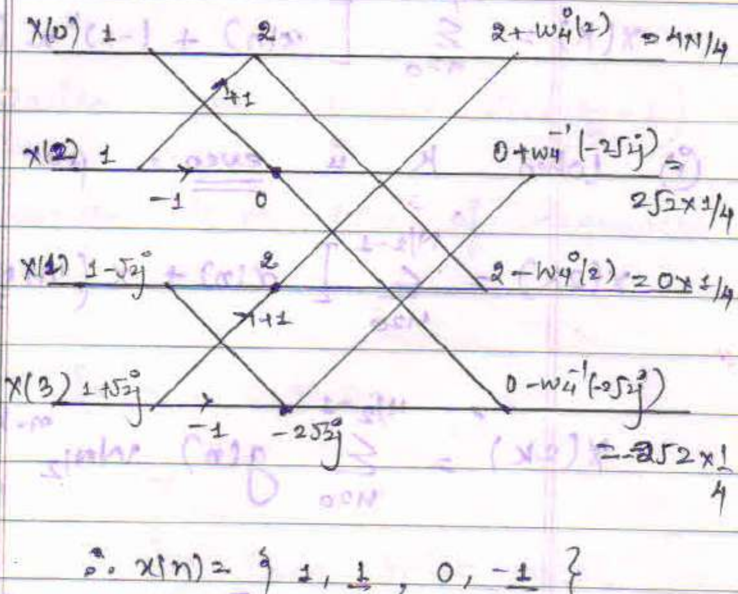
$$x(n) = \frac{1}{N}\sum_{k=0}^{N-1} X(k) \cdot W_N^{-nk}$$



Qo. Determine 4 pt IDFT of

$X(K) = \{1, 1 - \sqrt{2}j, 1, 1 + \sqrt{2}j\}$

using Radix - 2.



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

→ Radix-2 Decimation In FREQUENCY Algorithm :-

If $N = 2^M$, N point DFT of seq. $x(n)$ is -

$$X(K) = \sum_{n=0}^{N-1} x(n)\, W_N^{nK}, \quad K = 0, 1, \ldots, (N-1) \quad \text{— (1)}$$

$$= \sum_{n=0}^{N/2-1} x(n)\, W_N^{nK} + \sum_{n=0}^{N/2-1} x(n)\, W_N^{nK}, \quad K=0,1,\ldots(N-1)$$

$$= \sum_{n=0}^{N/2-1} x(n)\, W_N^{nK} + \sum_{n=0}^{N/2-1} x\left(n+\frac{N}{2}\right) W_N^{\left(n+\frac{N}{2}\right)K}, \quad K=0,1,\ldots(N-1)$$

$$X(K) = \sum_{n=0}^{N/2-1} x(n) \cdot W_N^{nK} + \sum_{n=0}^{N/2-1} x\left(n+\frac{N}{2}\right) W_N^{nK} \cdot W_N^{N/2 K}$$

Since,

$W_N^N = 1$, $W_N^{N/2} = -1$ (half symmetry)

$$\therefore X(K) = \sum_{n=0}^{N/2-1} x(n)\, W_N^{nK} + \sum_{n=0}^{N/2-1} x\left(n+\frac{N}{2}\right) W_N^{nK} (-1)^K.$$

$$X(K) = \sum_{n=0}^{N/2-1} \left[x(n) + (-1)^K x\left(n+\frac{N}{2}\right)\right] W_N^{nK} \quad \text{— (II)}$$

(i) When K is <u>even</u>, put $K = 2K$ in eq. (II)

$$X(2K) = \sum_{n=0}^{N/2-1} \left[x(n) + x\left(n+\frac{N}{2}\right)\right] W_N^{n \cdot 2K}.$$

$$X(2K) = \sum_{n=0}^{N/2-1} g(n)\, W_{N/2}^{n \cdot K} \quad \text{— (III)}$$

where $g(n) = \left[x(n) + x\left(n+\frac{N}{2}\right)\right]$ — (IV)

Equation (iii) represent N/2 point DFT of the sequence $g(n)$, for this equation K varies from $0, 1, 2, \ldots \left(\frac{N}{2}-1\right)$.

(ii) when K is ODD, put $K = (2K+1)$ in eq. (ii)

$$X(2K+1) = \sum_{n=0}^{N/2-1} \left[x(n) - x\left(n+\frac{N}{2}\right)\right] W_N^{(2K+1)n}.$$

$$X(2K+1) = \sum_{n=0}^{N/2-1} h(n)\, W_N^{2Kn} \cdot W_N^{n}.$$

$$X(2K+1) = \sum_{n=0}^{N/2-1} \left[h(n) \cdot W_N^{n}\right] \cdot W_N^{2nK}$$

$$X(2K+1) = \sum_{n=0}^{N/2-1} h(n)\, W_N^{n} \cdot W_{N/2}^{nK}. \quad \text{—— (v)}$$

where $h(n) = x(n) - x\left(n+\frac{N}{2}\right)$ —— (vi)

Equation (v) represents $\frac{N}{2}$ point DFT of the sequence $h(n)\, W_N^{n}$.

for this equation K varies from $0, 1, 2, \ldots \left(\frac{N}{2}-1\right)$

for $N=8$ eq. (iii) & (v) represents 4 pt DFT of sequences $g(n)$ and $h(n) W_N^{n}$.

for these equations K varies from 0 to 3.

$$\left.\begin{aligned}
g(0) &= x(0) + x(4) \quad \text{—— (a)}\\
g(1) &= x(1) + x(5) \quad \text{—— (b)}\\
g(2) &= x(2) + x(6) \quad \text{—— (c)}\\
g(3) &= x(3) + x(7) \quad \text{—— (d)}
\end{aligned}\right\} \text{Even point DFT.}$$

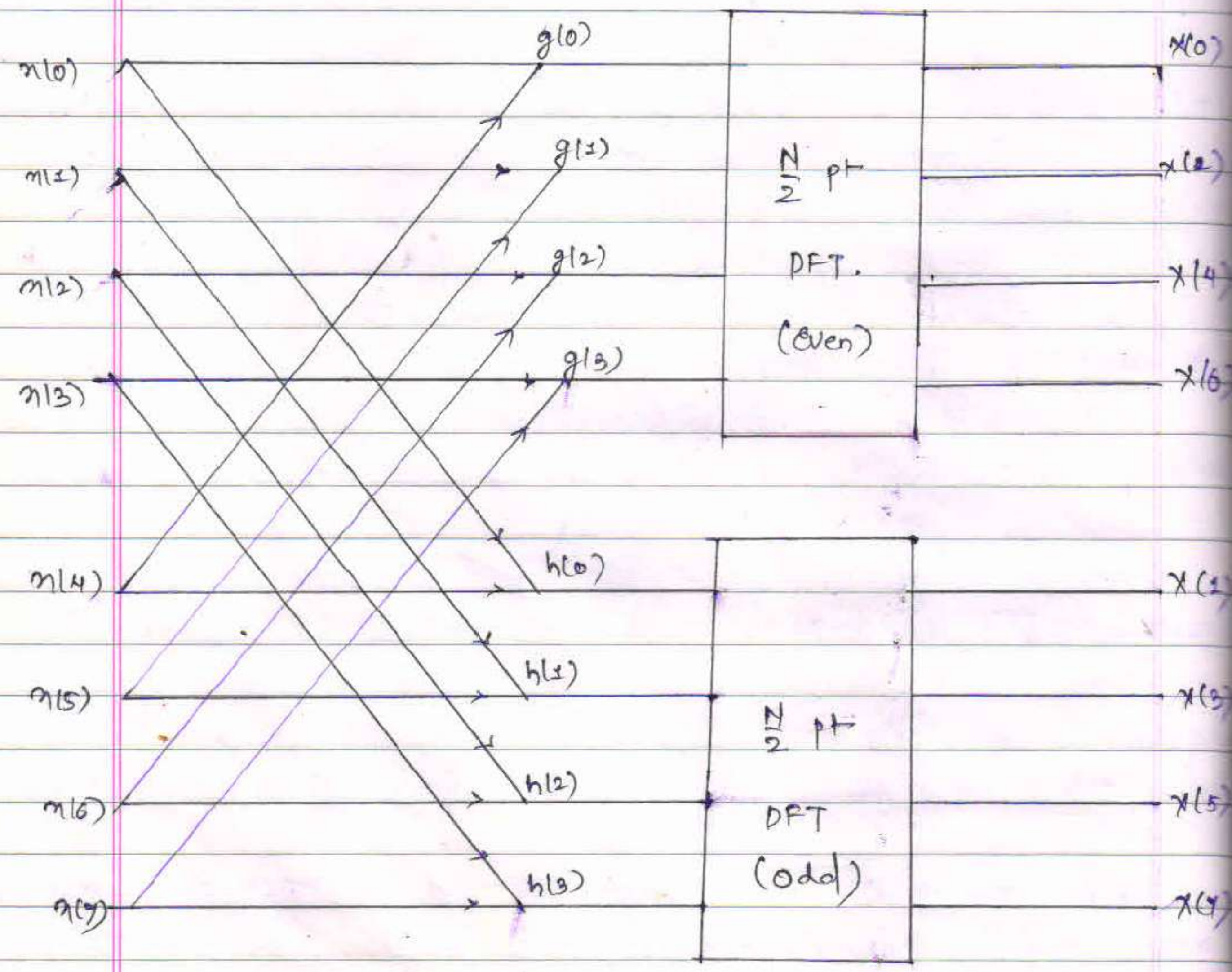
Also, $h(0) = x(0) - x(4)$ —— (e)

$h(1) = x(1) - x(5)$ —— (f)

$h(2) = x(2) - x(6)$ —— (g)

$h(3) = x(3) - x(7)$ —— (h)

$\times W_N^n$ = Odd point DFT



In radix - 2 smaller DFT will be the point 2, so 2^{nd} decomposition starts from (II) or (V).

from eq. (5).

$$X(2k) = \sum_{n=0}^{N/2-1} g(n) W_{N/2}^{nk} \quad , \quad k = 0, 1, 2, \dots \left(\frac{N}{2} - 1\right)$$

$$X(2K) = \sum_{n=0}^{N/4-1} g(n) W_N^{2nk} + \sum_{n=N/4}^{N/2-1} g(n) W_N^{2nk}$$

$$= \sum_{n=0}^{N/4-1} g(n) W_N^{2nk} + \sum_{n=0}^{N/4-1} g\left(n+\frac{N}{4}\right) W_N^{2\left(n+\frac{N}{4}\right)k}$$

$$= \sum_{n=0}^{N/4-1} \left\{ g(n) W_N^{2nk} + g\left(n+\frac{N}{4}\right) W_N^{2nk} \cdot W_N^{2N/4\,k} \right\}$$

$$= \sum_{n=0}^{N/4-1} \left\{ g(n) W_N^{2nk} + g\left(n+\frac{N}{4}\right) W_N^{2nk} \cdot W_N^{N/2\,k} \right\}$$

$$\therefore X(2K) = \sum_{n=0}^{N/4-1} \left[g(n) + g\left(n+\frac{N}{4}\right)(-1)^k \right] W_N^{2nk} \quad \text{— (7)}$$

for k is even $k = 2K$ in eq. (7)

$$X(4K) = \sum_{n=0}^{N/4-1} \left[g(n) + g\left(n+\frac{N}{4}\right) \right] W_N^{4nk}$$

$$X(4K) = \sum_{n=0}^{N/4-1} \left[g(n) + g\left(n+\frac{N}{4}\right) \right] W_{N/4}^{nk}$$

$$X(4K) = \sum_{n=0}^{N/4-1} \left[A(n) \cdot W_{N/4}^{nk} \right] \quad \text{— (VIII)}$$

where $A(n) = g(n) + g\left(n+\frac{N}{4}\right)$ — (IX)

for K is odd put $K = (2K+1)$ in equation (VII)

$$X(4K+2) = \sum_{n=0}^{N/4-1} \left[g(n) - g\left(n+\frac{N}{4}\right) \right] W_N^{2n(2K+1)}$$

$$= \sum_{n=0}^{N/4-1} \left[g(n) - g\left(n+\frac{N}{4}\right) \right] W_N^{4nk} \cdot W_N^{2n}$$

$$X(4k+2) = \sum_{n=0}^{N/4} B(n)\, W_N^{2n}\, W_{N/4}^{nk} \quad \text{—— (x)}$$

where $B(n) = g(n) - g\left(n+\frac{N}{4}\right)$ —— (xi)

for $N=8$ eq. (viii) and (x) represents 2 pt DFT the sequence $A(n)$ and $B(n) \cdot W_N^{2n}$.

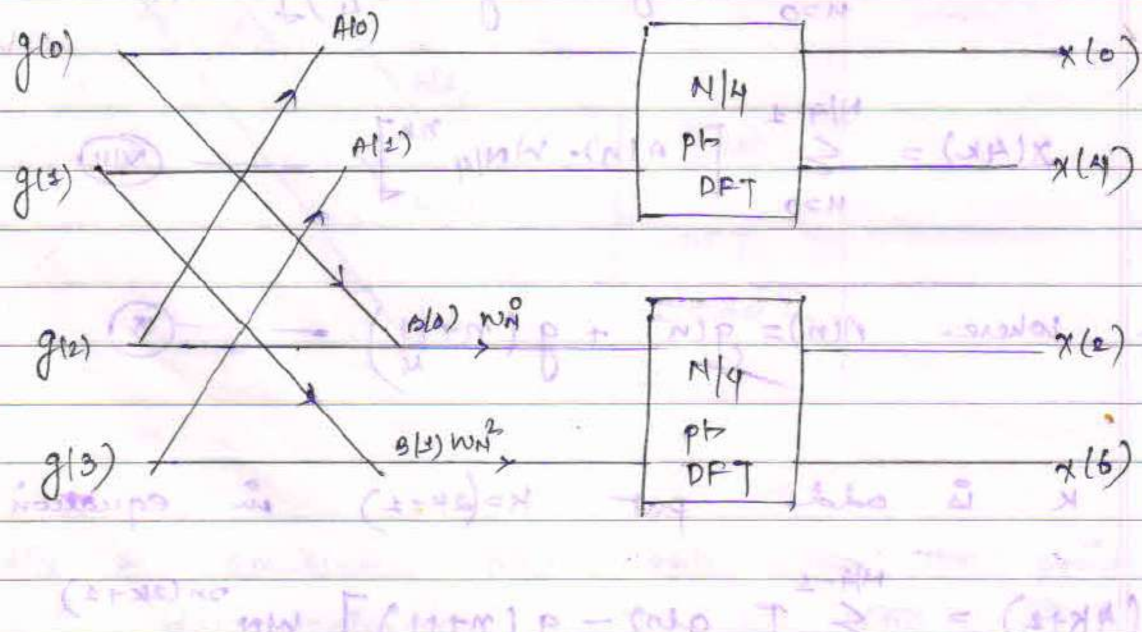
for these equations K varies as 0 and 1.

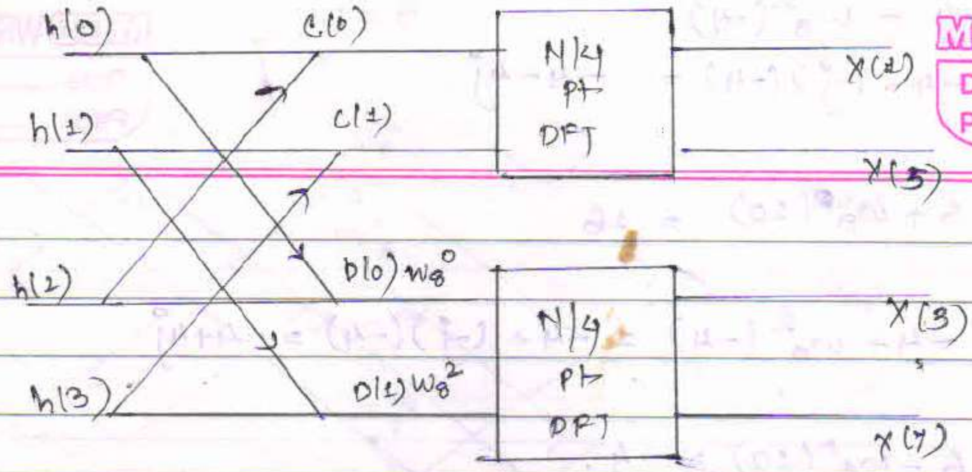
$$A(0) = g(0) + g\left(\frac{N}{4}\right) = g(0) + g(2) \quad \text{—— (i)}$$

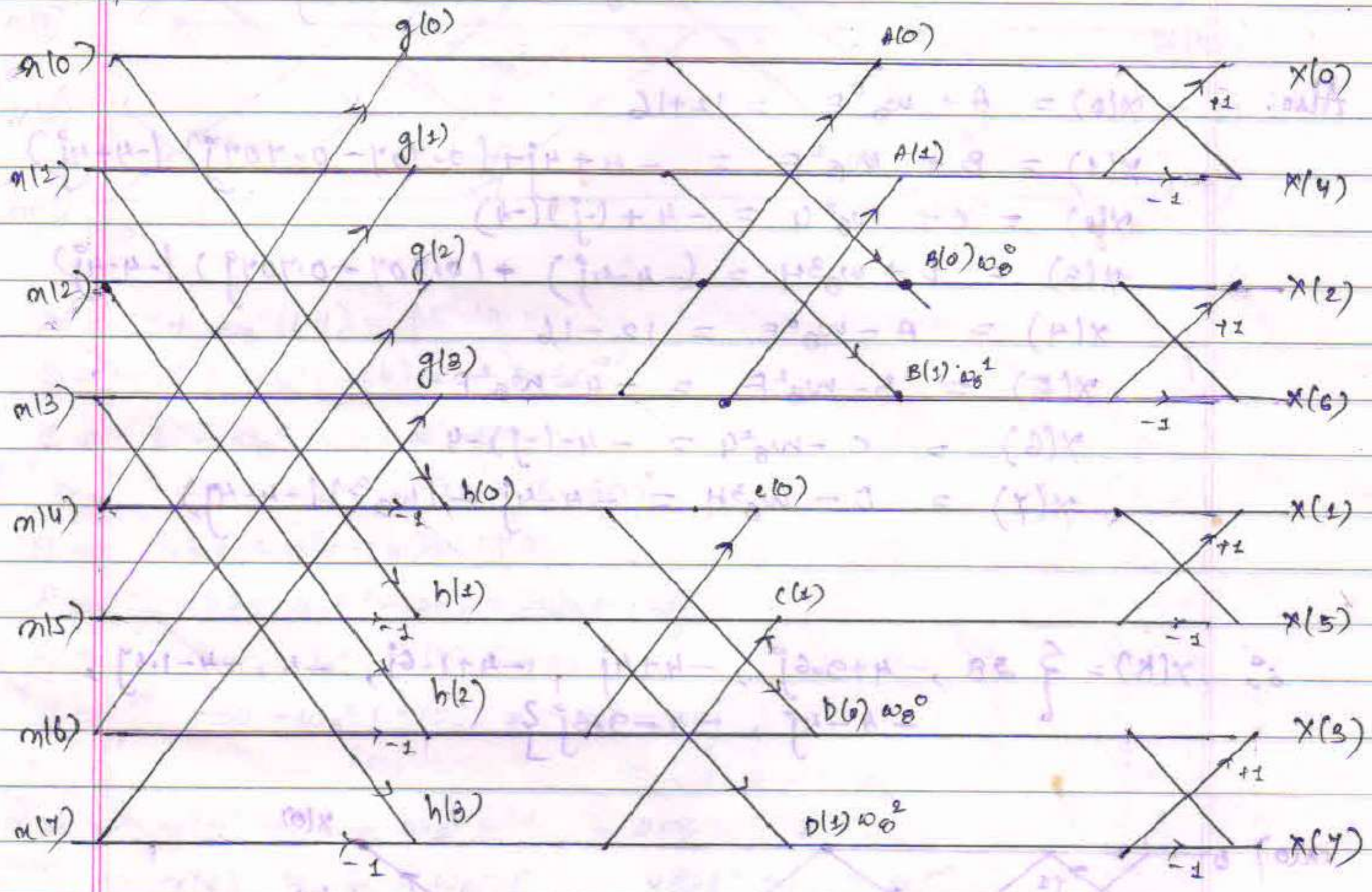
$$A(1) = g(1) + g(3) \quad \text{—— (j)}$$

$$B(0) = g(0) - g(2) \quad \text{—— (k)}$$

$$B(1) = g(0) - g(3) \quad \text{—— (l)}$$







Q. $x(n) = \{0, 1, 2, 3, 4, 5, 6, 7\}$; $N = 8$

$A = 4 + 8w_8^0 = 12$

$B = -4 + w_8^2(-4)$

$= -4 + (-j)(-4) = -4 + 4j$

$E = 8 - w_8^0(8) = -4$

$D = -4 - w_8^2(-4)$
$= -4 - (-j)(-4) = -4 - 4j$

$E = 6 + w_8^0(10) = 16$

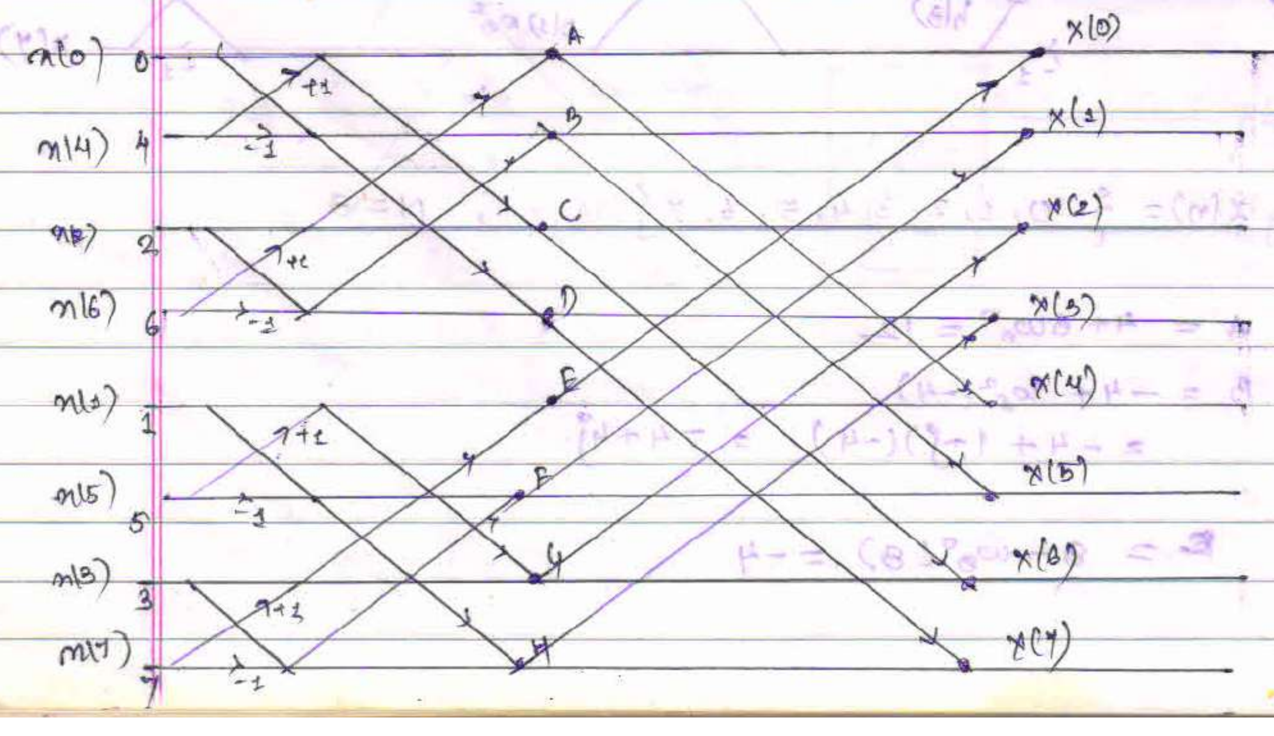
$F = -4 + w_8^2(-4) = -4 + (-j)(-4) = -4 + 4j$

$G = 6 - w_8^0(10) = -4.$

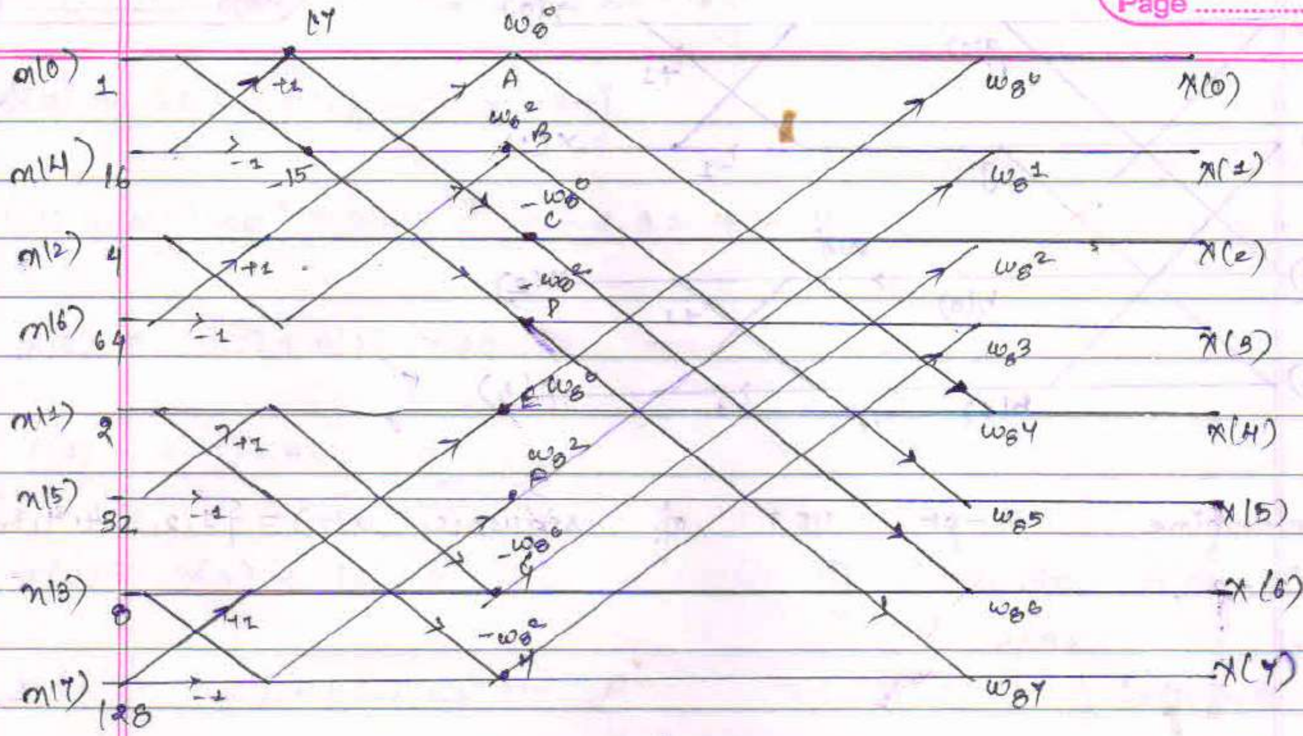
$H = -4 - w_8^2(-4) = -4-(-j)(-4) = -4-4j$

Also.
$x(0) = A + w_8^0 E = 12+16$
$x(1) = B + w_8^1 F = -4+4j+(0.707-0.707j)(-4+4j)$
$x(2) = C + w_8^2 G = -4 + (-j)(-4)$
$x(3) = D + w_8^3 H = (-4-4j) + (0.707-0.707j)(-4-4j)$
$x(4) = A - w_8^0 E = 12-16$
$x(5) = B - w_8^1 F = -4 - w_8^1 F$
$x(6) = C - w_8^2 G = -4-(-j)-4$
$x(7) = D - w_8^3 H = -4-4j-(w_8^3)(-4-4j)$

$\therefore$ $x(K) = \{28, -4+9.6j, -4+4j, -4+1.6j, -4, -4-1.6j, -4-4j, -4-9.6j\}$



Q. $x(n) = 2^n$; $N = 8$



$A = 17 + W_8^0(64) = 85$

$B = -15 + W_8^2(-60) = -15 + 60j$

$C = 17 - W_8^0(68) = -51$

$D = -15 - W_8^2(-60) = -15 - 60j$

$E = 34 + W_8^0(136) = 170$

$F = -30 + W_8^2(-120) = -30 + 120j$

$G = 34 - W_8^0(136) = -102$

$H = -30 - W_8^2(-120) = -30 - 120j$

Now,

$X(0) = A + W_8^0 E = 255$

$X(1) = B + W_8^1 \cdot F = 48.63 + j(116.05)$

$X(2) = C + W_8^2 G = -51 + 102j$

$X(3) = D + W_8^3 H = -78.63 + 46.05j$

$X(4) = A + (-W_8^0) E = -85$

$X(5) = B - W_8^1 F = -78.63 - 46.05j$

$X(6) = C - W_8^2 G = -51 - 102j$

$X(7) = D - W_8^3 H = 48.63 - 166.05j$

$\therefore X(k) = \{255,\ 48.63 + 116.05j,\ -51 + 102j,\ -78.63 + 46.05j,\ -85,\ -78.63 - 46.05j,\ -51 - 102j,\ 48.63 - 166.05j\}$

$\longrightarrow$ ans.