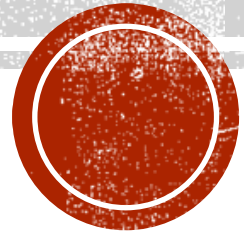
IMPLEMENTATION OF 16-POINT DFT USING OBC DA



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Matrix Form DFT (16-Point DFT)

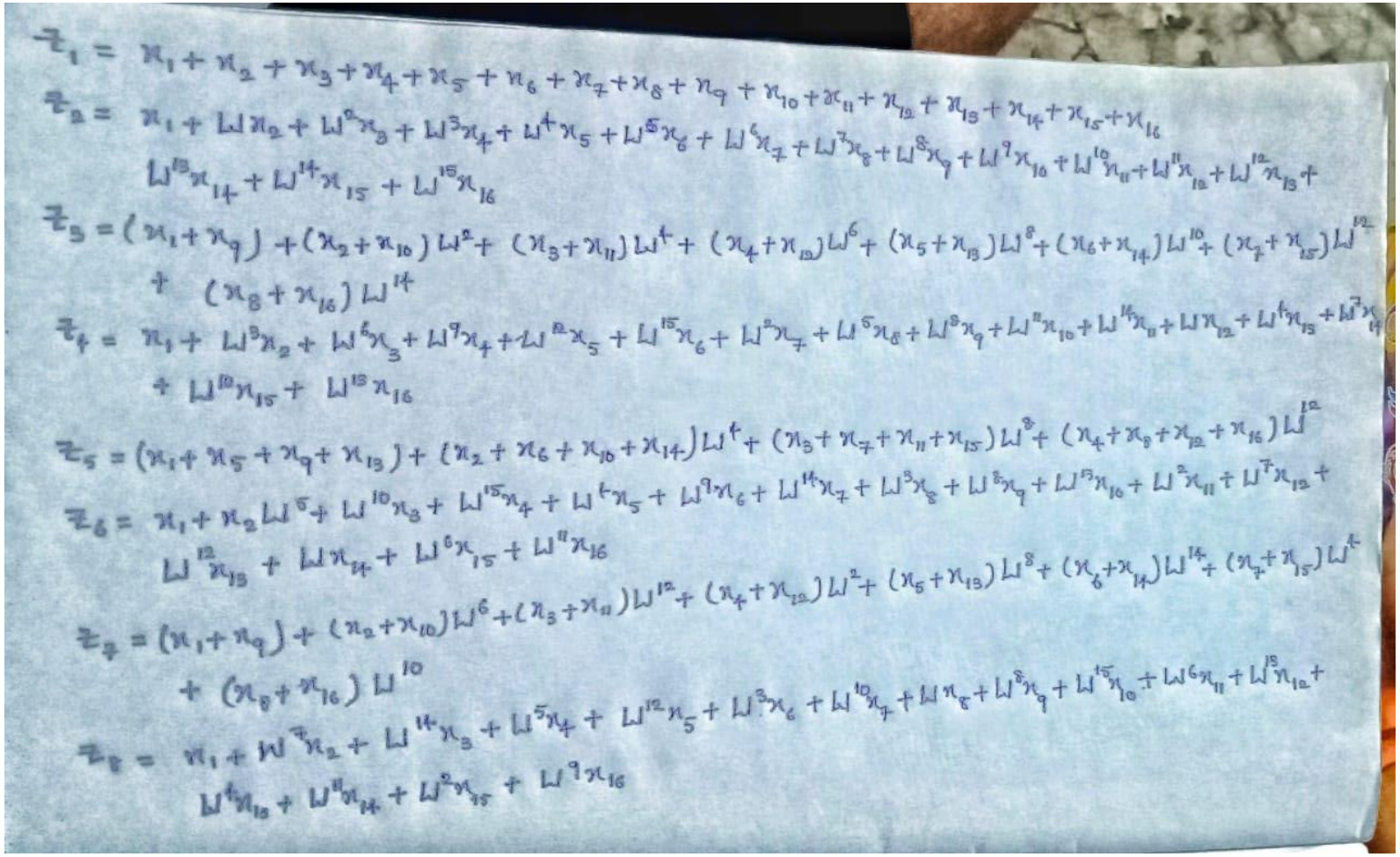
$$Z = C \quad X$$

$$\begin{bmatrix} z_1 \\ z_2 \\ z_3 \\ z_4 \\ z_5 \\ z_6 \\ z_7 \\ z_8 \\ z_9 \\ z_{10} \\ z_{11} \\ z_{12} \\ z_{13} \\ z_{14} \\ z_{15} \\ z_{16} \end{bmatrix} = \begin{bmatrix} 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & w & w^2 & w^3 & w^4 & w^5 & w^6 & w^7 & w^8 & w^9 & w^{10} & w^{11} & w^{12} & w^{13} & w^{14} & w^{15} \\ 1 & w^2 & w^4 & w^6 & w^8 & w^{10} & w^{12} & w^{14} & 1 & w^2 & w^4 & w^6 & w^8 & w^{10} & w^{12} & w^{14} \\ 1 & w^3 & w^6 & w^9 & w^{12} & w^{15} & w^2 & w^5 & w^8 & w^{11} & w^{14} & w & w^4 & w^7 & w^{10} & w^{13} \\ 1 & w^4 & w^8 & w^{12} & 1 & w^4 & w^8 & w^{12} & 1 & w^4 & w^8 & w^{12} & 1 & w^4 & w^8 & w^{12} \\ 1 & w^5 & w^{10} & w^{15} & w^4 & w^9 & w^{14} & w^3 & w^8 & w^{13} & w^2 & w^7 & w^{12} & w & w^6 & w^{11} \\ 1 & w^6 & w^{12} & w^2 & w^8 & w^{14} & w^4 & w^{10} & 1 & w^6 & w^{12} & w^2 & w^8 & w^{14} & w^4 & w^{10} \\ 1 & w^7 & w^{14} & w^5 & w^{12} & w^3 & w^{10} & w & w^8 & w^{15} & w^6 & w^{13} & w^4 & w^{11} & w^2 & w^9 \\ 1 & w^8 & 1 & w^8 & 1 & w^8 & 1 & w^8 & 1 & w^8 & 1 & w^8 & 1 & w^8 & 1 & w^8 \\ 1 & w^9 & w^2 & w^{11} & w^4 & w^{13} & w^6 & w^{15} & w^8 & w & w^{10} & w^3 & w^{12} & w^5 & w^{14} & w^7 \\ 1 & w^{10} & w^4 & w^{14} & w^8 & w^2 & w^{12} & w^6 & 1 & w^{10} & w^4 & w^{14} & w^8 & w^2 & w^{12} & w^6 \\ 1 & w^{11} & w^6 & w & w^{12} & w^7 & w^2 & w^{13} & w^8 & w^3 & w^{14} & w^9 & w^4 & w^{15} & w^{10} & w^5 \\ 1 & w^{12} & w^8 & w^4 & 1 & w^{12} & w^8 & w^4 & 1 & w^{12} & w^8 & w^4 & 1 & w^{12} & w^8 & w^4 \\ 1 & w^{13} & w^{10} & w^7 & w^4 & w & w^{14} & w^{11} & w^8 & w^5 & w^2 & w^{15} & w^{12} & w^9 & w^6 & w^3 \\ 1 & w^{14} & w^{12} & w^{10} & w^8 & w^6 & w^4 & w^2 & 1 & w^{14} & w^{12} & w^{10} & w^8 & w^6 & w^4 & w^2 \\ 1 & w^{15} & w^{14} & w^{13} & w^{12} & w^{11} & w^{10} & w^9 & w^8 & w^7 & w^6 & w^5 & w^4 & w^3 & w^2 & w \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \\ x_5 \\ x_6 \\ x_7 \\ x_8 \\ x_9 \\ x_{10} \\ x_{11} \\ x_{12} \\ x_{13} \\ x_{14} \\ x_{15} \\ x_{16} \end{bmatrix}$$

$$W = e^{-2\pi i/N} \quad (N=16)$$

This is Matrix form of 16 point DFT which we have to implement

By solving, we will get these following equations



$$Z_9 = x_1 + \omega^8 x_2 + x_3 + \omega^8 x_4 + x_5 + \omega^8 x_6 + x_7 + \omega^8 x_8 + x_9 + \omega^8 x_{10} + x_{11} + \omega^8 x_{12} + x_{13} + \omega^8 x_{14} + x_{15} + \omega^8 x_{16}$$

$$Z_9 = x_1 + x_3 + x_5 + x_7 + x_9 + x_{11} + x_{13} + x_{15} + (x_2 + x_4 + x_6 + x_8 + x_{10} + x_{12} + x_{14} + x_{16})\omega^8$$

$$Z_{10} = x_1 + \omega^9 x_2 + \omega^2 x_3 + \omega^{11} x_4 + \omega^4 x_5 + \omega^{13} x_6 + \omega^6 x_7 + \omega^{15} x_8 + \omega^6 x_9 + \omega^{15} x_{10} + \omega^{10} x_{11} + \omega^3 x_{12} + \omega^{12} x_{13} + \omega^5 x_{14} + \omega^{14} x_{15} + \omega^7 x_{16}$$

$$Z_{11} = x_1 + \omega^{10} x_2 + \omega^4 x_3 + \omega^{14} x_4 + \omega^8 x_5 + \omega^2 x_6 + \omega^{12} x_7 + \omega^6 x_8 + \omega^{16} x_9 + \omega^{10} x_{10} + \omega^4 x_{11} + \omega^{14} x_{12} + \omega^8 x_{13} + \omega^2 x_{14} + \omega^{12} x_{15} + \omega^6 x_{16}$$

$$Z_{11} = x_1 + x_9 + (x_2 + x_{10})\omega^{10} + (x_3 + x_{11})\omega^4 + (x_4 + x_{12})\omega^{14} + (x_5 + x_{13})\omega^8 + (x_6 + x_{14})\omega^2 + (x_7 + x_{15})\omega^{12} + (x_8 + x_{16})\omega^6$$

$$z_{12} = 1x_1 + w^1x_2 + w^6x_3 + wx_4 + w^{12}x_5 + w^7x_6 + w^2x_7 + w^{13}x_8 + w^6x_9 + w^5x_{10} + w^{14}x_{11} + w^1x_{12} + w^7x_{13} + w^{15}x_{14} + w^{10}x_{15} + w^5x_{16}$$

$$z_{13} = x_1 + w^{12}x_2 + w^8x_3 + w^7x_4 + x_5 + w^{12}x_6 + w^6x_7 + w^7x_8 + x_9 + w^{12}x_{10} + w^6x_{11} + w^7x_{12} + x_{13} + w^{12}x_{14} + w^8x_{15} + w^7x_{16}.$$

$$z_{13} = x_1 + x_5 + x_9 + x_{13} + (x_2 + x_6 + x_{14} + x_{10})w^{12} + w^5(x_3 + x_7 + x_{11} + x_{15}) + (x_4 + x_8 + x_{12} + x_{16})w^4$$

$$z_{14} = x_1 + w^{13}x_2 + w^{10}x_3 + w^7x_4 + w^4x_5 + w^1x_6 + w^{14}x_7 + w^1x_8 + w^8x_9 + w^5x_{10} + w^2x_{11} + w^{15}x_{12} + w^{12}x_{13} + w^9x_{14} + w^6x_{15} + w^3x_{16}$$

$$z_{15} = x_1 + w^{14}x_2 + w^{12}x_3 + w^{10}x_4 + w^8x_5 + w^6x_6 + w^4x_7 + w^2x_8 + x_9 + w^{14}x_{10} + w^{12}x_{11} + w^{10}x_{12} + w^8x_{13} + w^6x_{14} + w^4x_{15} + w^2x_{16}$$

$$z_{15} = x_1 + x_9 + (x_2 + x_{10})w^{14} + w^{12}(x_3 + x_{11}) + w^{10}(x_4 + x_{12}) + w^8(x_5 + x_{13}) + (x_6 + x_{14})w^6 + (x_7 + x_{15})w^4 + (x_8 + x_{16})w^2$$

$$Z_{16} = x_1 + \omega^{15} x_2 + \omega^{14} x_3 + \omega^{13} x_4 + \omega^{12} x_5 +$$
$$\omega^{11} x_6 + \omega^{10} x_7 + \omega^{9} x_8 + \omega^{8} x_9 + \omega^{7} x_{10} +$$
$$\omega^{6} x_{11} + \omega^{5} x_{12} + \omega^{4} x_{13} + \omega^{3} x_{14} + \omega^{2} x_{15}$$
$$+ \omega x_{16}$$

The above equations, I had implemented in Verilog using OBC DA architecture and then, these inputs are given

```
x0=32'd2;
x1=32'd2;
x2=32'd3;
x3=32'd4;
x4=32'd5;
x5=32'd6;
x6=32'd7;
x7=32'd8;
x8=32'd9;
x9=32'd10;
x10=32'd11;
x11=32'd12;
x12=32'd13;
x13=32'd14;
x14=32'd3;
x15=32'd2;
```

outputs we got are faithful, all are in 2's complemented representation

```
re0=00000000000000000000000001101111
re1=11111111111111111111111110111
re2=11111111111111111111111110111
re3=11111111111111111111111110111
re4=00000000000000000000000000011
re5=11111111111111111111111110111
re6=11111111111111111111111110111
re7=11111111111111111111111110111
re8=11111111111111111111111111011
re9=11111111111111111111111110111
re10=11111111111111111111111110111
re11=11111111111111111111111110111
re12=00000000000000000000000000011
re13=11111111111111111111111110111
re14=11111111111111111111111110111
re15=11111111111111111111111110111
im0=00000000000000000000000000000000
im1=11111111111111111111111111000
im2=00000000000000000000000000100
im3=00000000000000000000000001000
im4=00000000000000000000000000110
im5=11111111111111111111111111000
im6=11111111111111111111111111100
im7=00000000000000000000000001000
im8=00000000000000000000000000000
im9=11111111111111111111111111000
im10=00000000000000000000000000100
im11=00000000000000000000000001000
im12=11111111111111111111111111010
im13=11111111111111111111111111000
im14=11111111111111111111111111100
im15=00000000000000000000000001000
```

THANK YOU