REC

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$$X(k) = G(k) + W_N^k H(k); \quad k = 0 \text{ to } \frac{N}{2} - 1$$

$$= G(k) - W_N^k H(k); \quad k = \frac{N}{2} \text{ to } N-1$$

$$\boxed{N = 2^v}$$

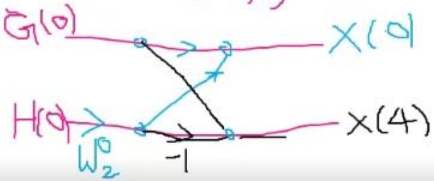
$$N = 5 \rightarrow 8$$

$$= \{1, 2, 3, 1, 1, 0, 0, 0\}$$

$$= 2^3$$

3 stages $= v$

Basic butterfly DIT



Activate Windows
Go to Settings to activate Windows.

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34 others

(*b*) A simplified butterfly, with only one complex multiplication.

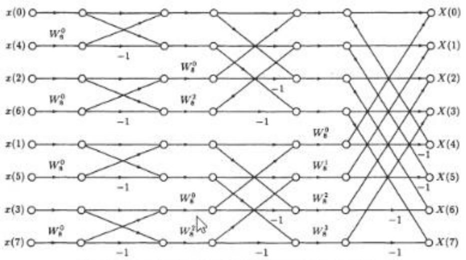
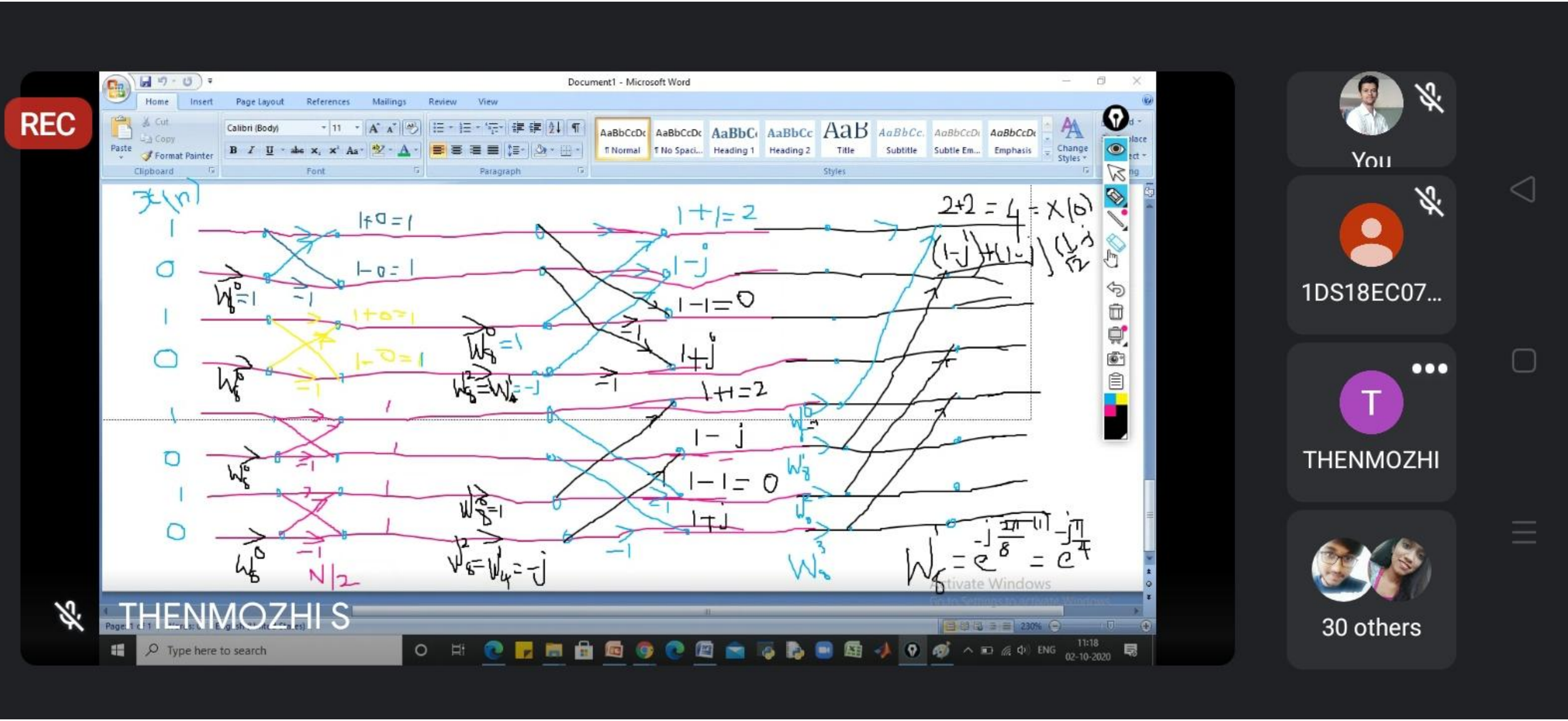


Fig. 7-6. A complete eight-point radix-2 decimation-in-time FFT.

Computing an N-point DFT using a radix-2 decimation-in-time FFT is much more efficient than calculating the DFT directly. For example, if $N = 2^\nu$, there are $\log_2 N = \nu$ *stages* of computation. Because each stage requires $N/2$ complex multiplies by the twiddle factors W_N^r and N complex additions, there are a total of $\frac{1}{2} N \log_2 N$ complex multiplications[1] and $N \log_2 N$ complex additions.

From the structure of the decimation-in-time FFT algorithm, note that once a butterfly operation has been performed on a pair of complex numbers, there is no need to save the input pair. Therefore, the output pair may be stored in the same registers as the input. Thus, only one array of size N is required, and it is said that the computations may be performed *in place*. To perform the computations in place, however, the input sequence $x(n)$ must be stored (or accessed) in nonsequential order as seen in Fig. 7-6. The *shuffling* of the input sequence that takes place is due to the successive decimations of $x(n)$. The ordering that results corresponds to a bit-reversed indexing of the original sequence. In other words, if the index n is written in binary form, the order in which in the input sequence must be accessed is found by reading the binary representation for n in reverse order as illustrated in the table below for $N = 8$: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x(n)
1+0=1
1-0=1
1+1=2
1-j
1-1=0
1+j
2+2=4=X(0)
N/2
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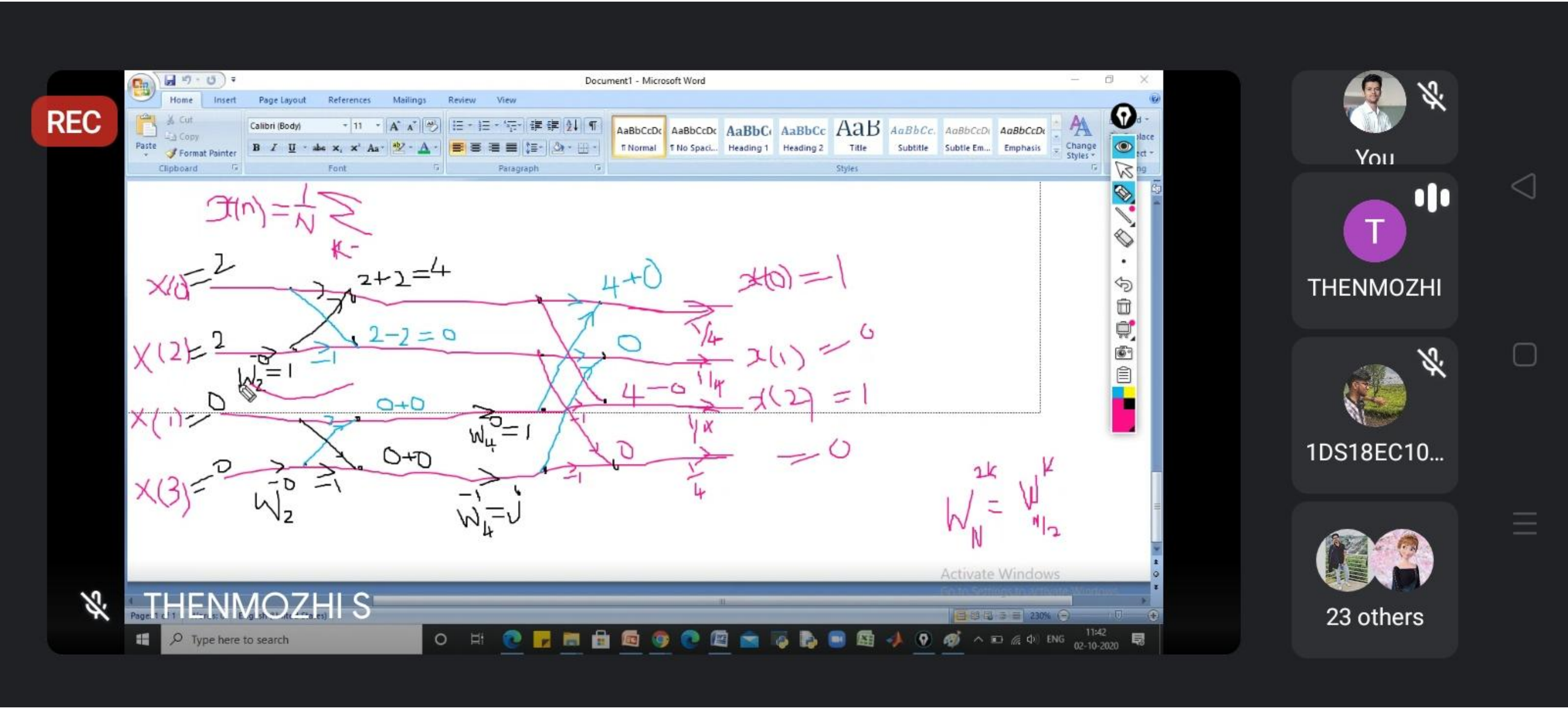
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x(n) = 1/N Σ
X(0) = 2
2+2=4
4+0
x(0) = 1
X(2) = 2
2-2=0
W2^0 = 1
x(1) = 0
4-0
x(2) = 1
0+0
X(1) = 0
W4^0 = 1
X(3) = 0
W2^0
W4^-1 = j
W_N^2k = W_N/2^k
Activate Windows
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