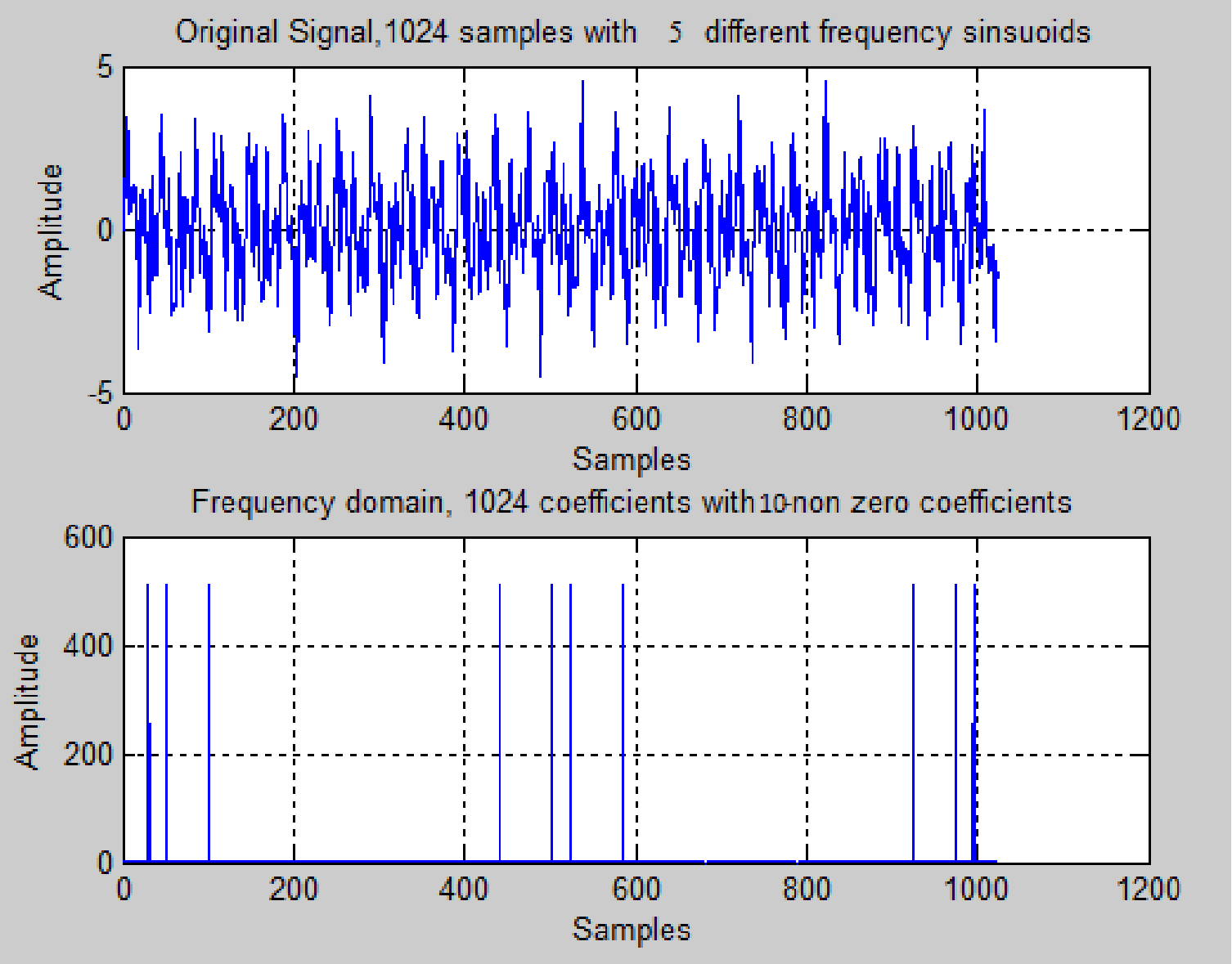
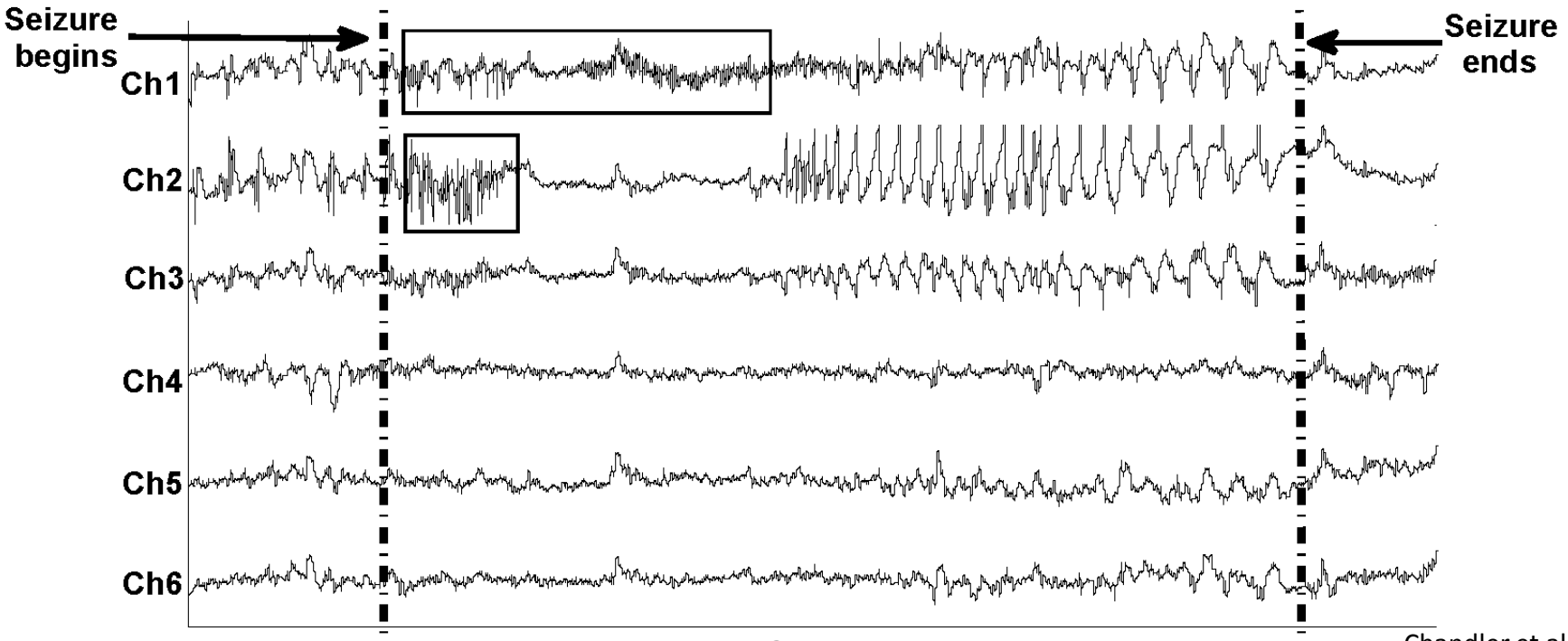
FFT Application Examples and Implementation

FFT Example 1: Signal Sparsity in time Frequency Domain



FFT Example 2: Seizure Detection Problem

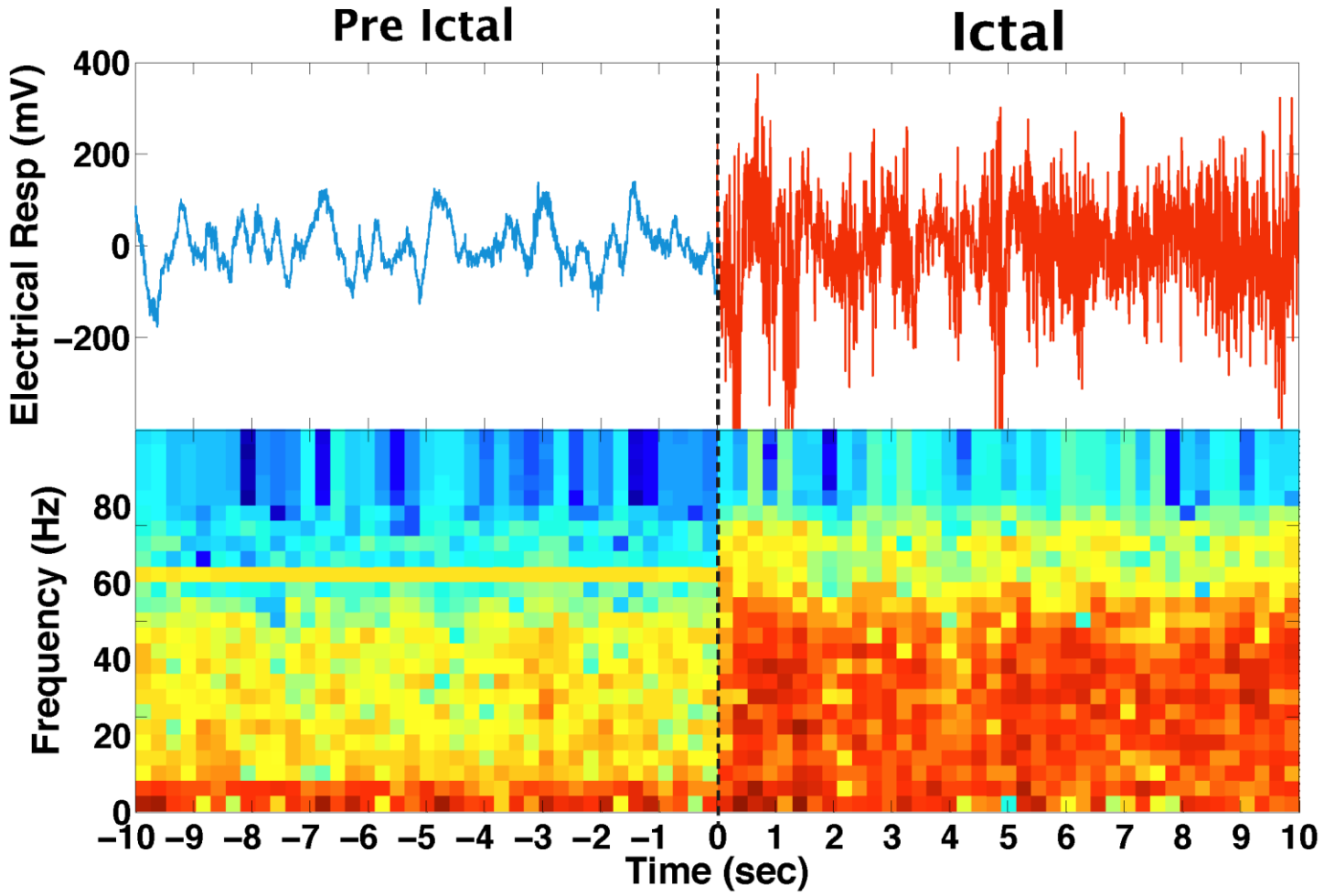
- Electrical signals can be detected by EEG signals before or just at the start of clinical symptoms
  - The ability to detect can be used to warn the patient or alert caregiver



Chandler et al
BioCass 2011

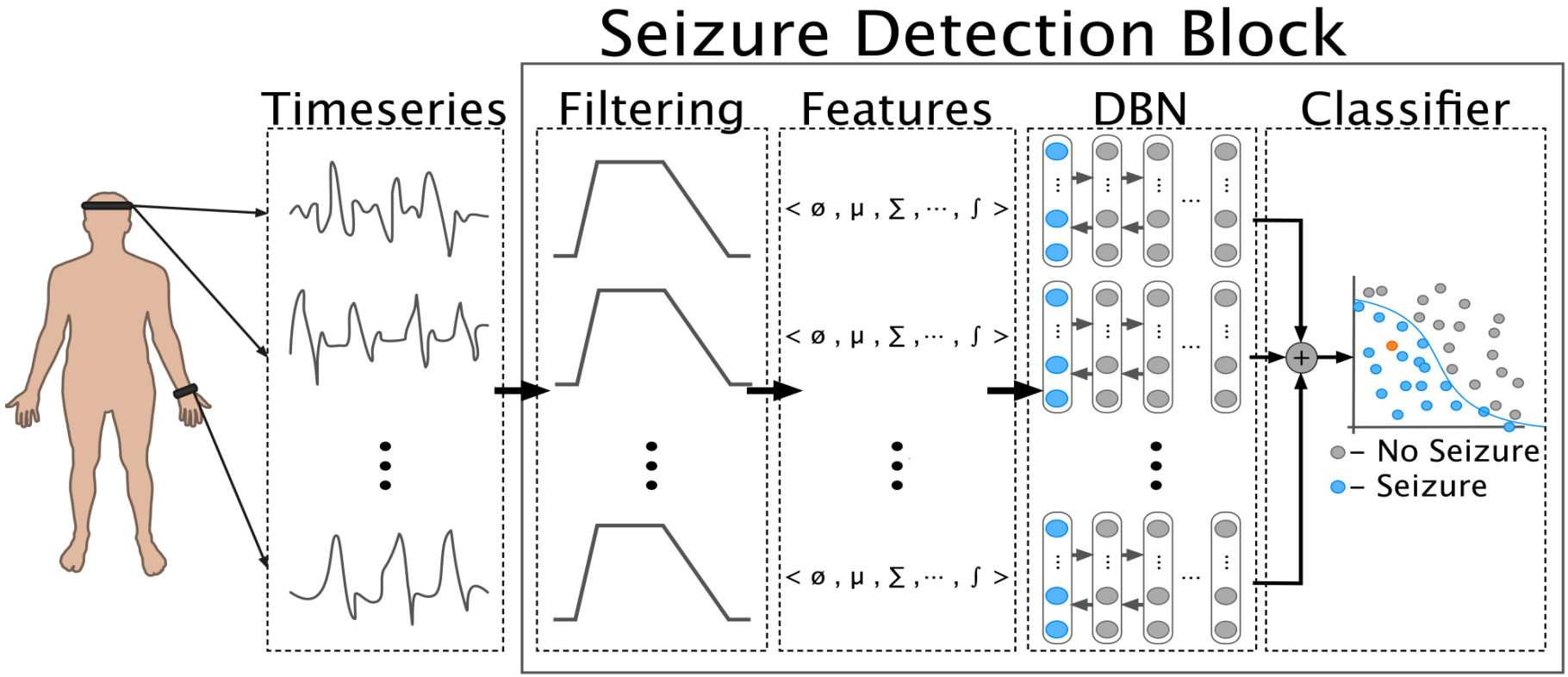
FFT Example 2: For Seizure, Frequency and Time domain analysis

- "We [doctors] detect seizures by looking at the evolution of frequency and amplitude in EEG" Dr. Jennifer Hopp, Epilepsy Center, UMMC.

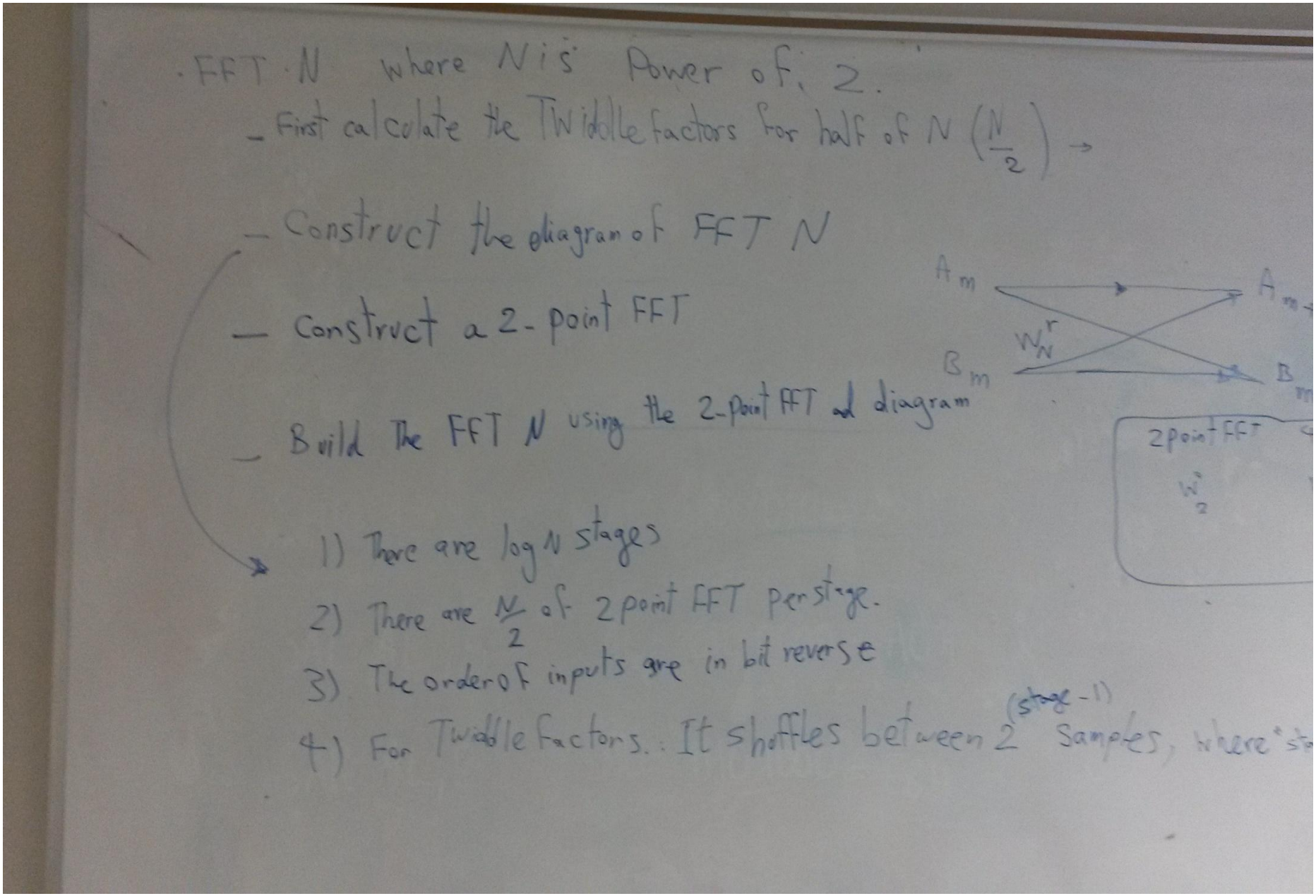


A wearable solution for Multi-physiological signal processing

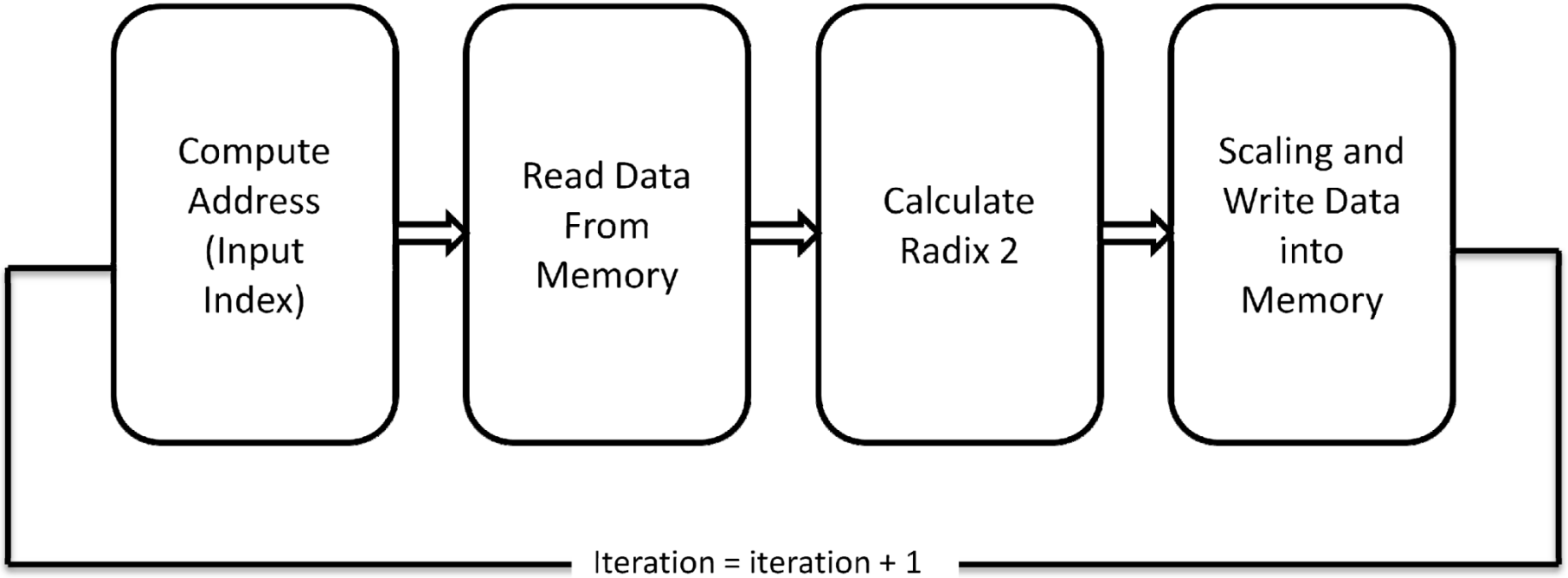
- Use FFT and filtering



FFT N-point implementation from FFT-2

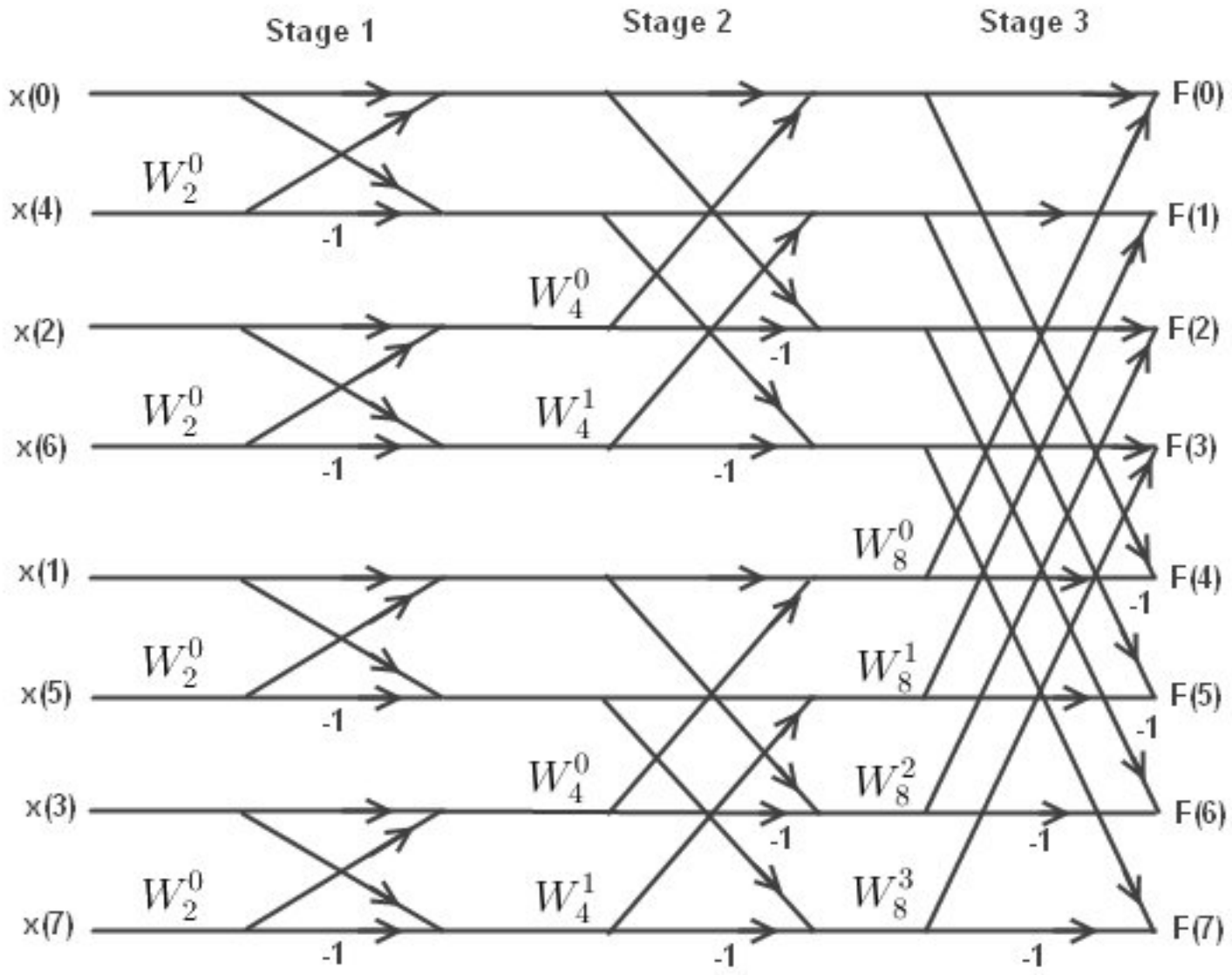


FFT-N Calculation from FFT-2 (Radix-2)

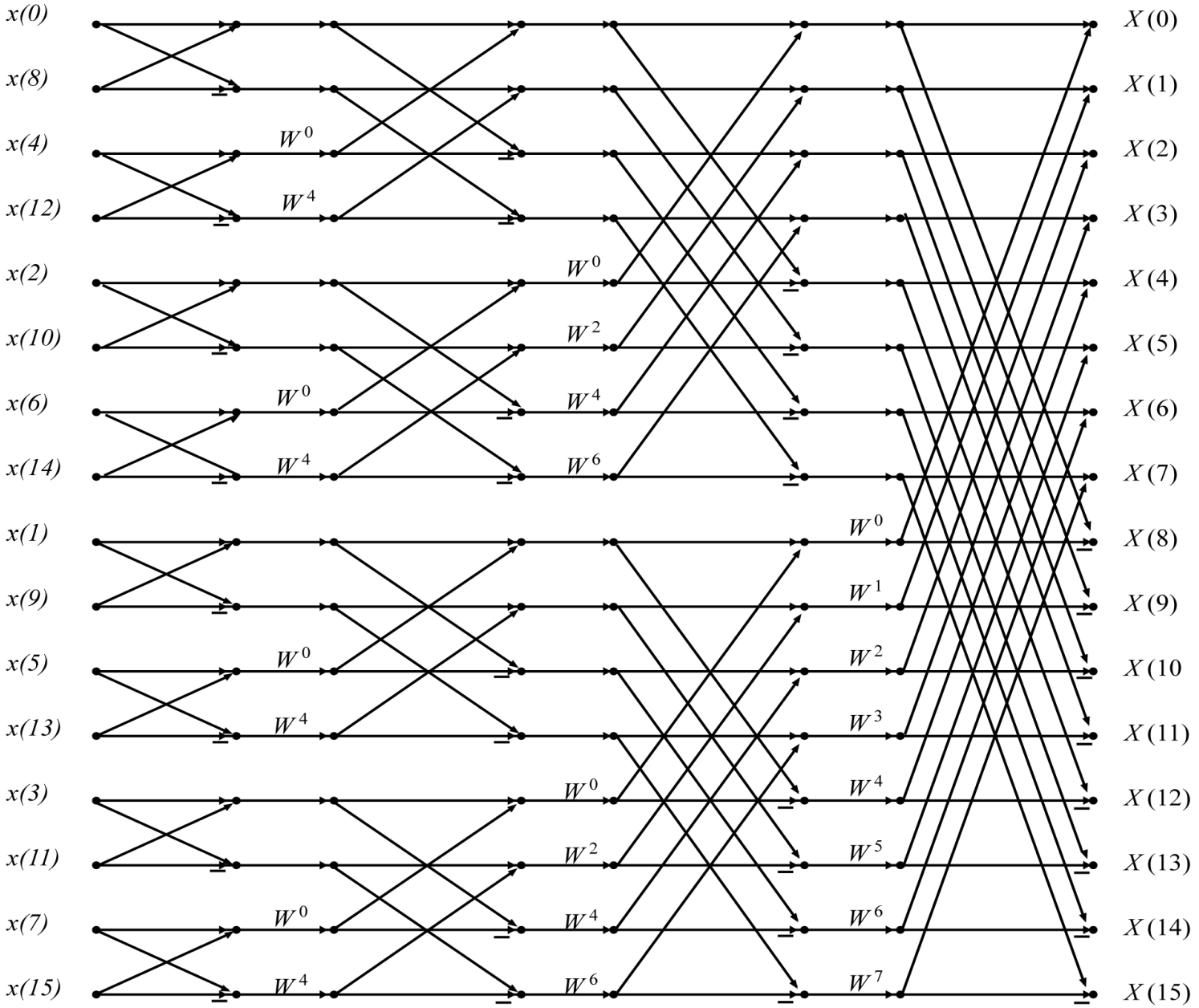


FFT 8-Point

An 8 Input Butterfly. Note, you double a 4 input butterfly, extend output lines, then connect the upper and lower butterflies together with diagonal lines.



FFT 16-Point

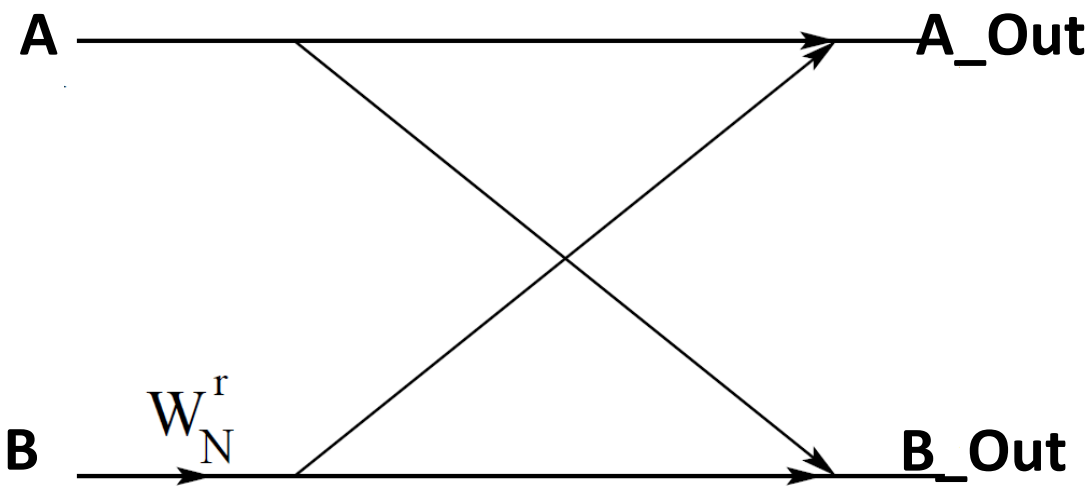

x(0)
x(8)
x(4)
x(12)
x(2)
x(10)
x(6)
x(14)
x(1)
x(9)
x(5)
x(13)
x(3)
x(11)
x(7)
x(15)
W 0
W 4
W 0
W 2
W 4
W 6
W 0
W 4
W 0
W 2
W 4
W 6
W 0
W 1
W 2
W 3
W 4
W 5
W 6
W 7
X (0)
X (1)
X (2)
X (3)
X (4)
X (5)
X (6)
X (7)
X (8)
X (9)
X (10
X (11)
X (12)
X (13)
X (14)
X (15)

Twiddle factor Computation in Matlab

- Twiddle factor calculation in Matlab:

- Ex: N=8,
  - W0=exp(-2*pi*0*i/N)=1
  - w1=exp(-2*pi*1*i/N)
  - ….
  - W7=exp(-2*pi*7*i/N)

Radix-2 Butterfly Implementation



A_Out = A + W * B

B_Out = A – W * B

Where A = Ar + iAi, B= Br + iBi, W=Wr + iWi

So, Aout = (Ar + WrBr – WiBi) + (Br + WrBi + WiBr);

Bout = (Ar - WrBr + WiBi) + (Br – WrBi – WiBi);

FFT inputs bit reversal and memory addressing

- Bit reversal inputs example to FFT 8-point diagram

0 = 000 reversed -> 000 = 0

1 = 001 reversed -> 100 = 4

2 = 010 reversed -> 010 = 2

3 = 011 reversed -> 110 = 6

4 = 100 reversed -> 001 = 1

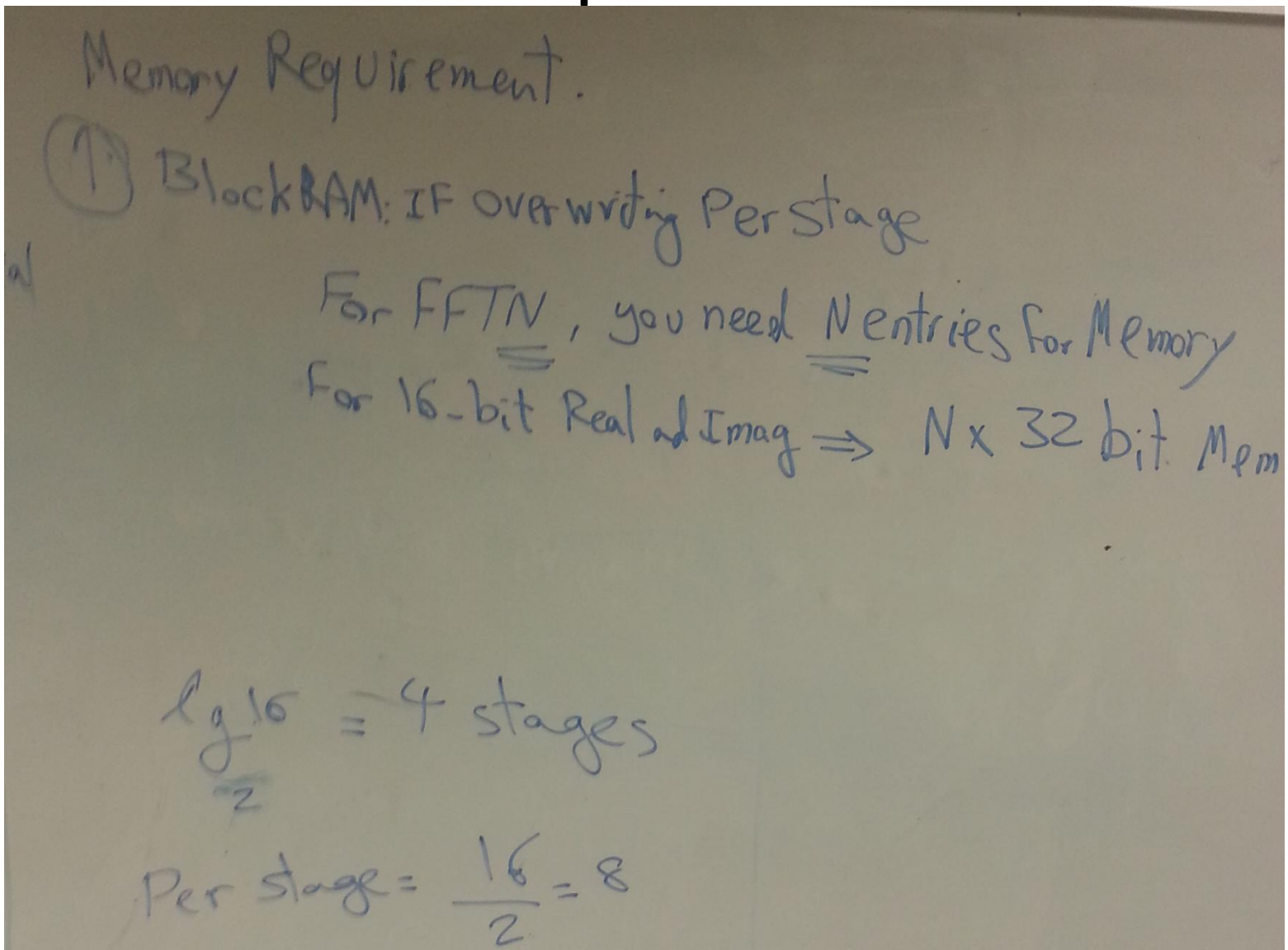
5 = 101 reversed -> 101 = 5

6 = 110 reversed -> 011 = 3

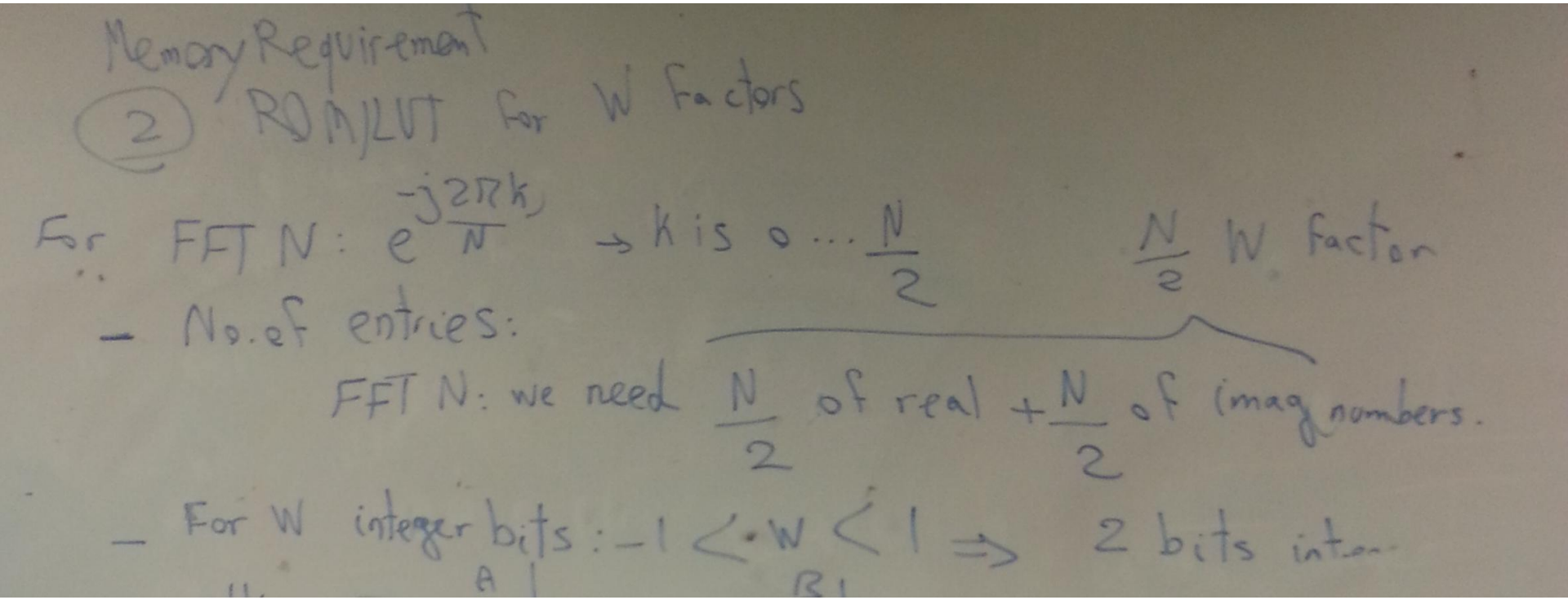
- Refer to for FFT-8 example (very useful) in slides:

http://www.csee.umbc.edu/~tinoosh/cmpe691/slides/osattari_ms.pdf

FFT Memory storage requirements for serial implementation



FFT Twiddle factor Memory



More details for FFT

- For more details refer to these documents:
- http://www.csee.umbc.edu/~tinoosh/cmpe691/slides/osattari_ms.pdf
- http://www.csee.umbc.edu/~tinoosh/cmpe691/slides/Handout.fft1.diagrams.pdf
- And FFT example from the book in the slides