## DFT Analysis (5B)

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## Frequency View of a X[i] Vector

$\frac{N}{2}-1\left\{\begin{array}{l|}\hline X[0] \\ \hline X[1] \\ \hline X[2] \\ \hline \\ \hline \frac{N}{2}-1 \\ \hline \\ \hline X[N / 2+1] \\ \hline X[N / 2] \\ \hline X[N / 2+1] \\ \hline \\ \hline X[N-2] \\ \hline X[N-1] \\ \hline\end{array}\right.$

| $0 \cdot f_{0}$ | $0 \cdot f_{s} / N$ |
| ---: | ---: |
| $+1 \cdot f_{o}$ | $1 \cdot f_{s} / N$ |
| $+2 \cdot f_{o}$ | $2 \cdot f_{s} / N$ |
|  |  |
|  |  |
|  |  |
| $+(N / 2-1) \cdot f_{o}$ | $(N / 2-1) \cdot f_{s} / N$ |
| $+(N / 2) \cdot f_{o}$ | $(N / 2) \cdot f_{s} / N$ |
| $-(N / 2-1) \cdot f_{o}$ | $-(N / 2-1) \cdot f_{s} / N$ |
|  |  |
|  |  |
|  |  |
|  |  |
| $-2 \cdot f_{0}$ | $-2 \cdot f_{s} / N$ |
| $-1 \cdot f_{0}$ | $-1 \cdot f_{s} / N$ |


| 0/N |
| :---: |
| 1/N |
| $2 / N$ |
|  |
|  |
|  |
|  |
| $(N / 2-1) / N$ |
| (1/2)/N |
| $-(N / 2-1) / N$ |
|  |
|  |
|  |
| , |
| $-2 / \mathrm{N}$ |
| $-1 / \mathrm{N}$ |


| 0 cycle |
| ---: |
| 1 cycle |
| 2 cycles |
|  |
|  |
| $(N / 2-1)$ cycles |
| $(N / 2)$ cycles |
| $-(N / 2-1)$ cycles |
|  |
|  |
| -2 cycles |
| -1 cycle |

## Resolutions of Frequency and Time Domains

Freq Domain
Time Domain


## Using Sampling Frequency and Time

Freq Domain


## Relations between Sampling Frequency and Time

Freq Domain
Time Domain


## Frequency and Time Interval (1)

Freq Domain


## Frequency and Time Interval (2)



## Frequency and Time Interval (3)



Frequency and Time Interval (4)
$\Delta f_{5}=\frac{f_{55}}{8}=\frac{1}{8 \tau} \quad$ The finer frequency resolution


$$
f_{h 5}=\frac{f_{s 5}}{2}=\frac{1}{2 \tau}
$$

Use zero padding

## References

[1] http://en.wikipedia.org/
[2] J.H. McClellan, et al., Signal Processing First, Pearson Prentice Hall, 2003
[3] A "graphical interpretation" of the DFT and FFT, by Steve Mann

