# 25: Cyclic Prefix

Tuesday, February 15, 2011
1:06 PM

Lecture 25

Announcement : Submit HW5 now.

HW6 is posted.
Due on Friday, Feb 25
(Last day of class)

Recall: DFT and FFT

Sequence (in discrete time) $x[n]$

z-transform : $X(z) = \sum_n x[n] z^{-n}$

DTFT : $X(e^{j\omega}) = \sum_n x[n] e^{-j\omega n}$
(Discrete time Fourier transform)

DFT : $x[n]$ is N-point $(n = 0, 1, 2, \ldots, N-1)$

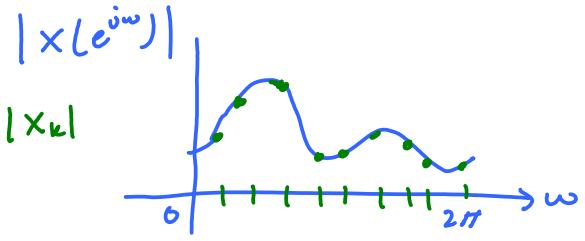
$$X(e^{j\omega}) = \sum_{n=0}^{N-1} x[n] e^{-j\omega n} \quad \text{(DTFT)} \quad 0 \le \omega < 2\pi$$

$$X_k = \sum_{n=0}^{N-1} x[n] e^{-jnk\frac{2\pi}{N}} = \sum_{n=0}^{N-1} x[n] e^{-jn\omega_k} \quad \text{(DFT)}$$

$$\omega_k = k\frac{2\pi}{N} \qquad 0 \le k < N$$

$$X_k = X(e^{j\omega})\Big|_{\omega = \omega_k = k\frac{2\pi}{N}}$$

$$\omega_k = 0, \frac{2\pi}{N}, 2\frac{2\pi}{N}, 3\frac{2\pi}{N}, \ldots, N-1\frac{2\pi}{N}$$




conclusion DFT is a sampled version of DTFT.

(FFT)

## Overview of our class

Multiple-Access Techniques in Mobile Communications.

main idea : orthogonality

Pre-midterm : 1G (AMPS) – Cellular Networks
+ Freq. Reuse
+ Erlang B formula

Post-midterm : 2G – GSM (FDMA + TDMA)
– IS-95 (FDMA+ CDMA) (CDMAOne) } Ch.4

Current : OFDM
– Cyclic prefix ( today )
+Quiz
– OFDMA } Ch.5

Ch. 6 : 3G UMTS / CDMA 2000
WCDMA

"fake 4G" HSPA +
WiMAX (wireless MAN)
LTE (long-term evolution)

4G LTE-Advanced
Mobile WiMAX Release 2
IMT-Advanced.

## Circular Convolution

Example : Convolution

$[1\ 2\ 3] * [4\ 5\ 6] = [4\ 13\ 28\ 27\ 18]$

1 2 3
6 5 4
6 5 4

$1 \times 4 = 4$
$5 \times 1 + 2 \times 4 = 5 + 8 = 13$

```
6  5  4          1×6 + 2×5 + 3×4 = 6 + 10 + 12 = 28
   6  5  4       6×2 + 5×3 = 12 + 15 = 27
      6  5  4    6×3 = 18
```

Example : Circular Convolution

$[1\ 2\ 3] \circledast [4\ 5\ 6]$

```
1 2 3 1 2 3 1 2 3 1 2 3 1 2 3
      6 5 4              2×6 + 3×5 + 1×4 = 12 + 15 + 4 = 31
        6 5 4            6×3 + 1×5 + 2×4 = 18 + 5 + 8 = 31
          6 5 4          1×6 + 2×5 + 3×4 = 6 + 10 + 12 = 28
```

Conclusion :

Circular convolution is an operation performed between two vectors of the same size (N)

To do it, proceed as in usual convolution

except 1) need to replicate one of the vectors

2) need to stop when you have N answers (elements).

Example :

$[1\ 2\ 3\ 0\ 0] \circledast [4\ 5\ 6\ 0\ 0]$

```
1  2  3  0  0  1  2  3  0  0  1  2  3  0  0
   0  0  6  5  4
      0  0  6  5  4
         0  0  6  5  4
            0  0  6  5  4
               0  0  6  5  4
```

1×4 = 4

5×1 + 4×2 = ..

6×3 = 18

exactly the same as $[1\ 2\ 3] * [4\ 5\ 6]$ above