

**EE16B, Spring 2018
UC Berkeley EECS**

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Lecture 13A

Signals

Discrete Fourier Transform (DFT)

Audio DSP: powered by the DFT

The screenshot displays a software interface for audio processing. At the top, a system tray shows network speed (1.3 KiB/s up, 475 B/s down), battery level (11%), and system time (Sat Apr 14, 09:52). The main window is titled "OpenGL Spectrum analyzer".

Key components of the interface include:

- Top Left:** A digital display showing "00:04" and "1. Dire Straits".
- Top Center:** An "X MULTIMEDIA SYSTEM - EQUALIZER" with frequency sliders for PREAMP, 60, 170, 310, 600, 1K, 3K, 6K, 12K, 14K, and 16K.
- Top Right:** A "Blur scope" window showing a horizontal red line.
- Bottom Left:** A "Spectrum analyzer" window showing a green bar chart.
- Bottom Right:** A "PLAYLIST EDITOR" window showing "1. Dire Straits - Calling Elvis 6:26".

In the center of the interface is a large 3D bar chart with a grid of colored squares (green, cyan, blue, purple, red) on the x and y axes, representing a 2D frequency spectrum.



JPEG images: powered by DCTs

JPEG quality: 98



JPEG quality: 5 (higher spatial frequencies discarded)



8x8 DCT blocks

DCT vs DFT

DCT-II [\[edit \]](#)

$$X_k = \sum_{n=0}^{N-1} x_n \cos \left[\frac{\pi}{N} \left(n + \frac{1}{2} \right) k \right] \quad k = 0, \dots, N - 1.$$

The DCT-II is probably the most commonly used form, and is often simply referred to as "the DCT".[\[1\]\[2\]](#)

This transform is exactly equivalent (up to an overall scale factor of 2) to a DFT of $4N$ real inputs of even symmetry where the even-indexed elements are zero. That is, it is half of the DFT of the $4N$ inputs y_n , where $y_{2n} = 0$, $y_{2n+1} = x_n$ for $0 \leq n < N$, $y_{2N} = 0$, and $y_{4N-n} = y_n$ for $0 < n < 2N$. DCT II transformation is also possible using $2N$ signal followed by a multiplication by half shift. This is demonstrated by [Makhoul](#).