## Discrete Fourier Transform

Images from "The Scientist and Engineer's Guide to Digital Signal Processing"

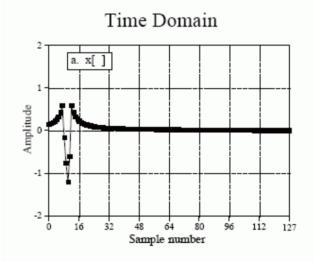
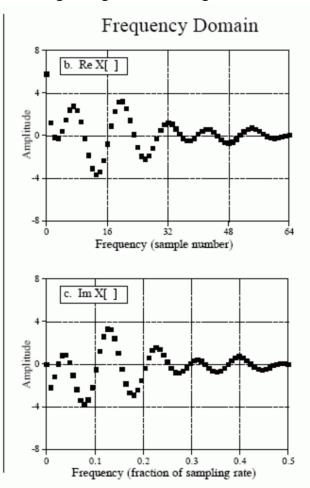


FIGURE 8-4 Example of the DFT. The DFT converts the time domain signal,  $x[\ ]$ , into the frequency domain signals,  $ReX[\ ]$  and  $ImX[\ ]$ . The horizontal axis of the frequency domain can be labeled in one of three ways: (1) as an array index that runs between 0 and N/2, (2) as a fraction of the sampling frequency, running between 0 and 0.5, (3) as a natural frequency, running between 0 and  $\pi$ . In the example shown here, (b) uses the first method, while (c) use the second method.



## **EQUATION 8-4**

The analysis equations for calculating the DFT. In these equations, x[i] is the time domain signal being analyzed, and  $Re\ X[k]$  &  $Im\ X[k]$  are the frequency domain signals being calculated. The index i runs from 0 to N-1, while the index k runs from 0 to N/2.

$$ReX[k] = \sum_{i=0}^{N-1} x[i] \cos(2\pi k i/N)$$

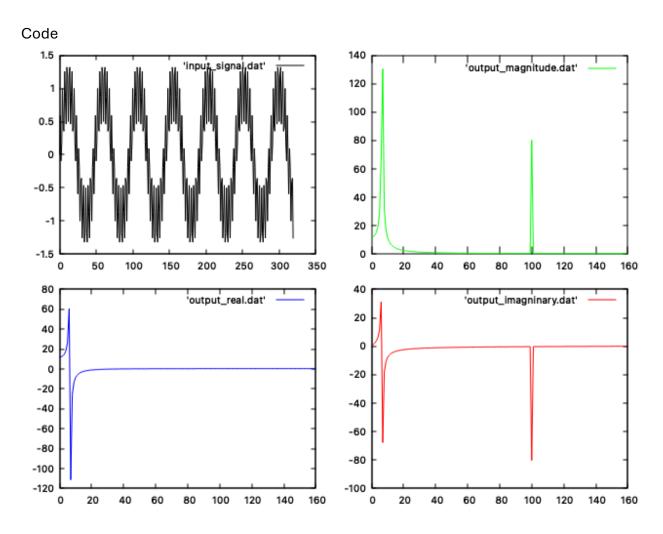
$$Im X[k] = -\sum_{i=0}^{N-1} x[i] \sin(2\pi k i/N)$$

## **EQUATION 8-1**

Equations for the DFT basis functions. In these equations,  $c_k[i]$  and  $s_k[i]$  are the cosine and sine waves, each N points in length, running from i = 0 to N-1. The parameter, k, determines the frequency of the wave. In an N point DFT, k takes on values between 0 and N/2.

$$c_k[i] = \cos(2\pi ki/N)$$

$$s_k[i] = \sin(2\pi ki/N)$$



Here's the DFT is taking the input signal from the time domain to the frequency domain. We see the real and imaginary components broken down below as well.