Digital Signal Processing

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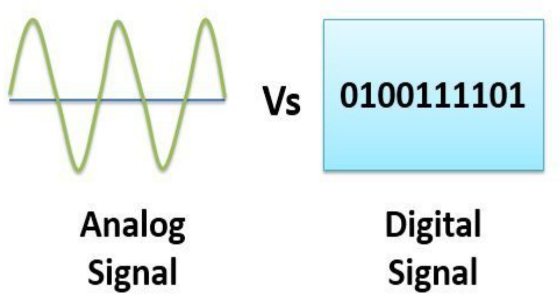
Lecture 7 - Topics

- Fourier Transform
- Formula
- Representation
- Measurement tools
- Conditions for existence

Properties:

- Linearity
- Time shifting
- Multiplication
- Duality



Fourier Transform

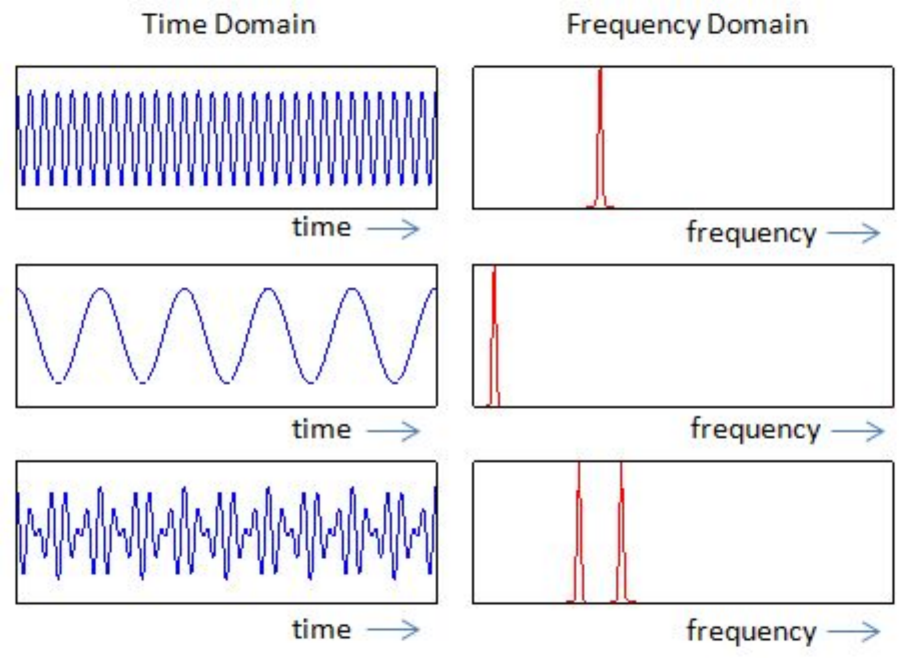
- Named after French mathematician **Joseph Fourier**, the Fourier transform is a mathematical procedure that allows us to determine the frequency content of a function.
- **The Fourier transform is a mathematical function that decomposes a waveform, which is a function of time, into the frequencies that make it up.**
- The result produced by the Fourier transform is a complex valued function of frequency.

Fourier Transform

- Basically, converts time domain representation of a signal to frequency domain representation.
- Formula is :

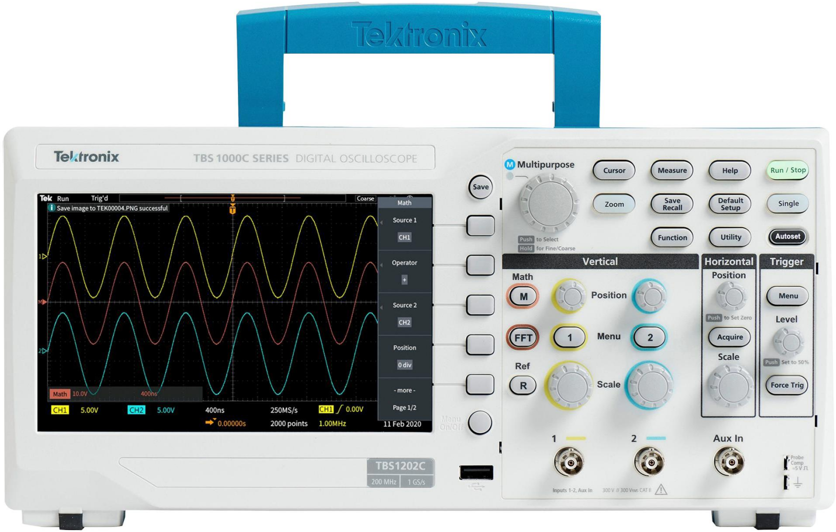
$$x[k] = \sum_{n=0}^{N-1} x[n] e^{\frac{-j2\pi kn}{N}}$$

Representation



Measurement Tools

Oscilloscope - for Time Domain measurement



Spectrum Analyser - for Frequency measurement

Fourier Transform - Conditions

Conditions required for any x(t) to be fulfilled if it wants to get fourier transformed :

1. x(t) needs to be fully integrable (it should be lesser than infinity)

2. the function must have finite number of minima and maxima (highest and lowest value of peaks are inifinite)

3. the function must have finite number of disconitunities

DFT - Properties

- Linearity :

It states that the DFT of a combination of signals is equal to the sum of DFT of individual signals.

$$x_1(n) \rightarrow X_1(\omega) \qquad \text{and} \qquad x_2(n) \rightarrow X_2(\omega)$$

Then $$ax_1(n) + bx_2(n) \rightarrow aX_1(\omega) + bX_2(\omega)$$

where **a** and **b** are constants.

DFT - Properties

- Time Shift :

The Fourier transform of g(t–a) where a is a real number that shifts the original function has the same amount of shift in the magnitude of the spectrum.

if x(n) --> X(K)

then x(n-a) --> X(K-a)

DFT - Properties

- Duality :
- The Duality Property tells us that if x(t) has a Fourier Transform X(ω), then if we form a new function of time that has the functional form of the transform, X(t), it will have a Fourier Transform x(ω) that has the functional form of the original time function (but is a function of frequency). Mathematically, we can write:

$$x(t) \leftrightarrow X(\omega)$$
$$X(t) \leftrightarrow 2\pi\, x(-\omega)$$

DFT - Properties

- Multiplication:
- If there are two signal x1n and x2n and their respective DFTs are X1k and X2K, then multiplication of signals in time sequence corresponds to circular convolution of their DFTs.

If, $x_1(n) \longleftrightarrow X_1(K) \quad \& \quad x_2(n) \longleftrightarrow X_2(K)$

Then, $x_1(n) \times x_2(n) \longleftrightarrow X_1(K) \copyright X_2(K)$

Thank you