Digital Signal Processing

Lecture (10): Classification of Discrete-Time Signals

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Classification of Discrete-Time Signals

The discrete-time signals can be classified according to a number of different characteristics as follows:

- Energy signals and power signals
- Periodic signals and aperiodic signals
- Symmetric (even) and antisymmetric (odd) signals

Energy signals and power signals

The energy E of a signal $x[n]$ is defined as

$$E = \sum_{n=-\infty}^{\infty} |x[n]|^2$$

We have used the magnitude-squared values of x[n], so that our definition applies to complex-valued signals as well as real-valued signals. The energy of a signal can be finite or infinite. If E is finite (i.e., $0 < E < \infty$), then x[n] is called an energy signal. Many signals that possess infinite energy, have a finite average power. The average power of discrete-time signal x[n] is defined as

$$P = \lim_{N \to \infty} \frac{1}{2N+1} \sum_{n=-N}^{N} |x[n]|^2$$

Energy signals and power signals

Example: Determine the power and energy of the unit step sequence.

$$E = \sum_{n=-\infty}^{\infty} |u[n]|^2 = \infty$$

$$P = \lim_{N\to\infty} \frac{1}{2N+1} \sum_{n=-N}^{N} |u[n]|^2 = \lim_{N\to\infty} \frac{N+1}{2N+1} = \lim_{N\to\infty} \frac{1+\frac{1}{N}}{2+\frac{1}{N}} = \frac{1}{2}$$

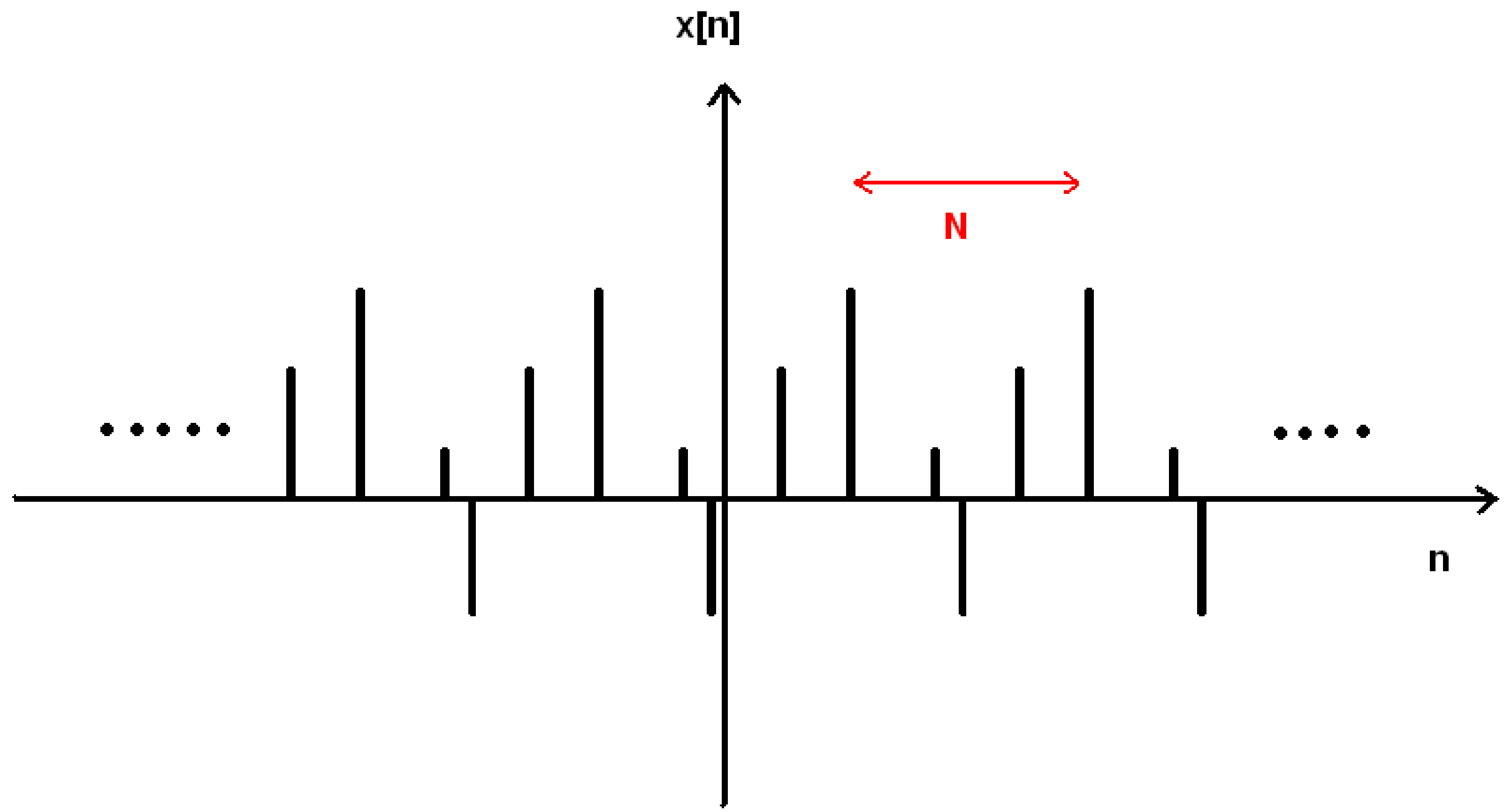
Periodic signals and aperiodic signals

A signal $x[n]$ is periodic with period N (N > 0) if and only if

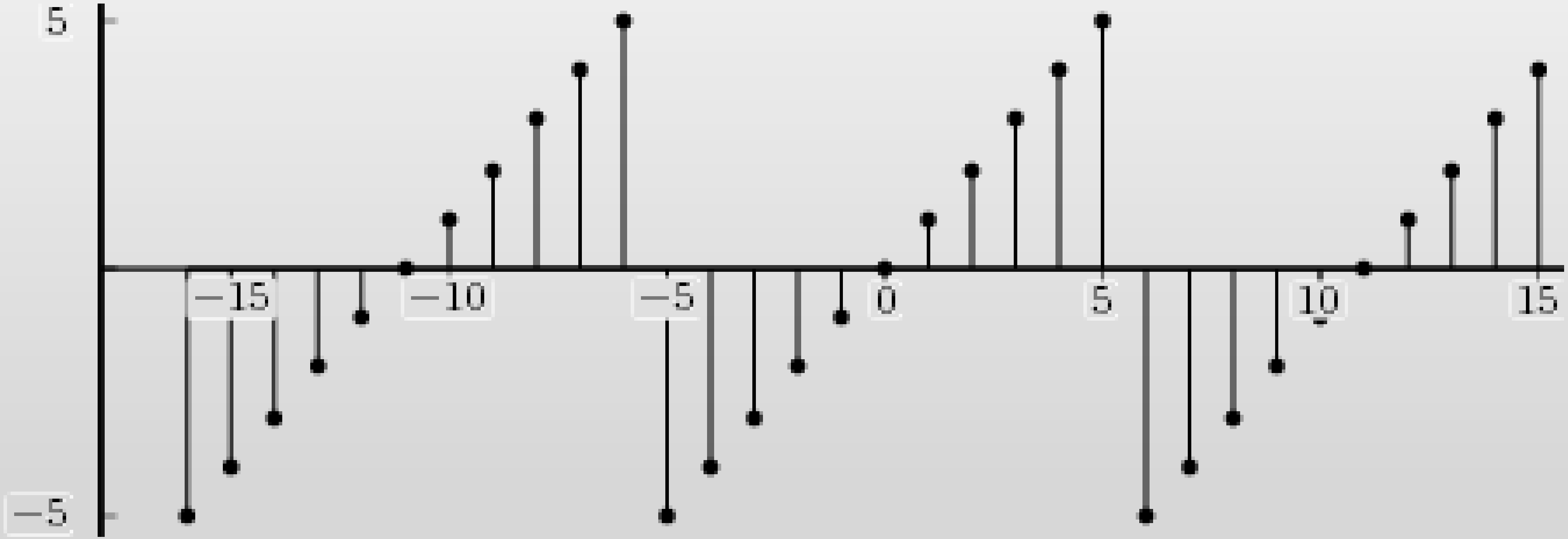
$$x[n+N] = x[n] \quad for\ all\ n$$

The smallest value of N for which the above equation holds is called the fundamental period. If there is no value of N that satisfies the above equation, the signal is called non-periodic or aperiodic.

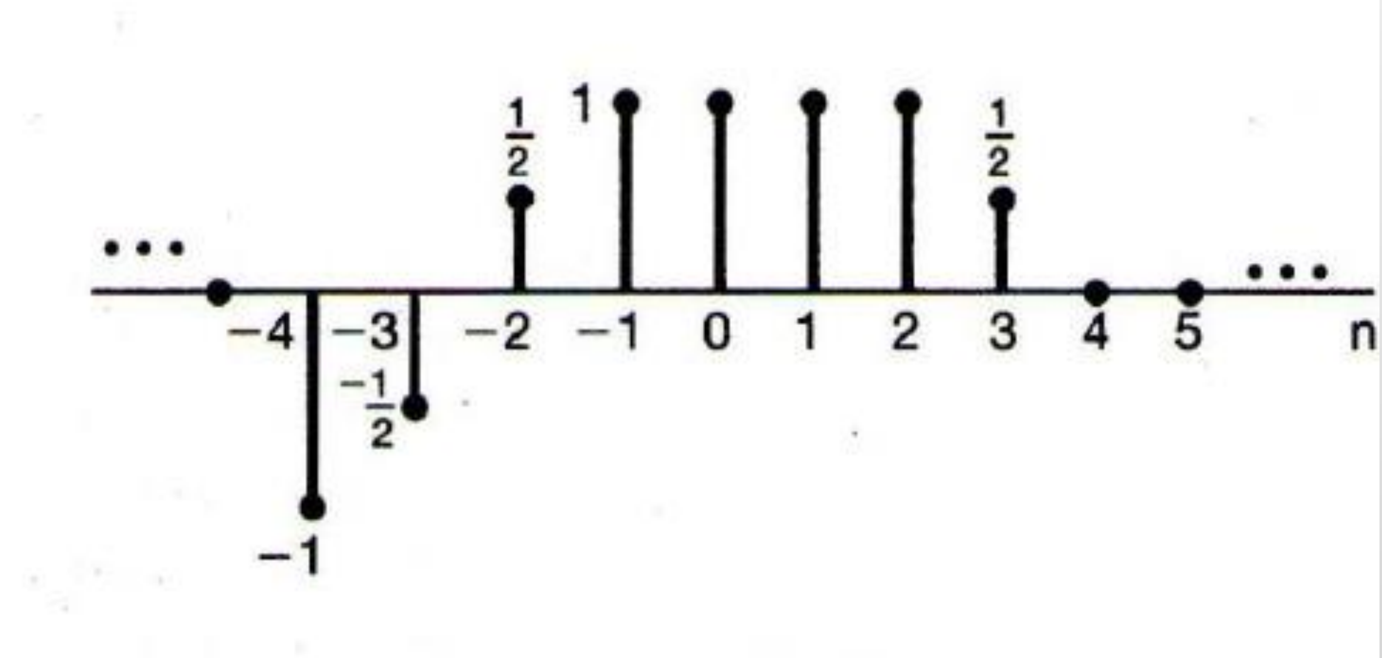
Periodic signal



Periodic signal



Aperiodic signal



Symmetric (even) and antisymmetric (odd) signals

A real-valued signal $x[n]$ is called symmetric (even) if

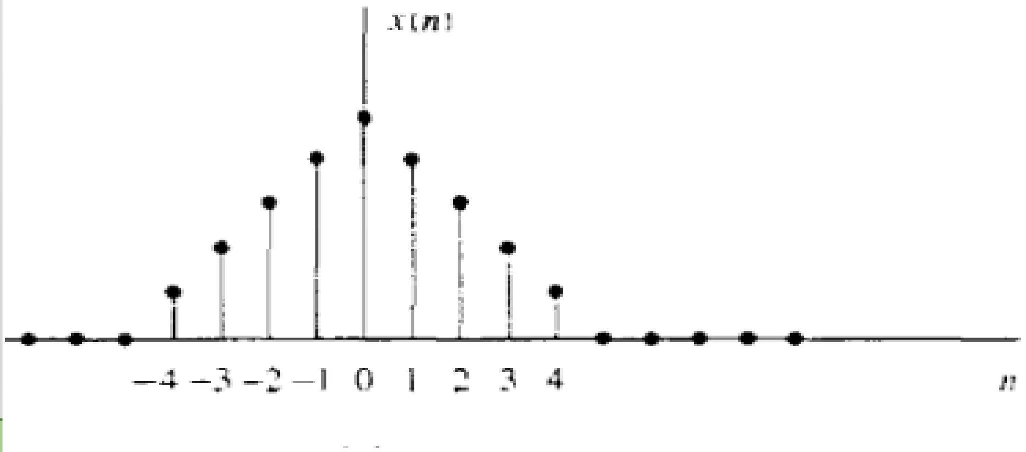
$$x[-n] = x[n]$$

On the other hand, a signal $x[n]$ is called antisymmetric (odd) if

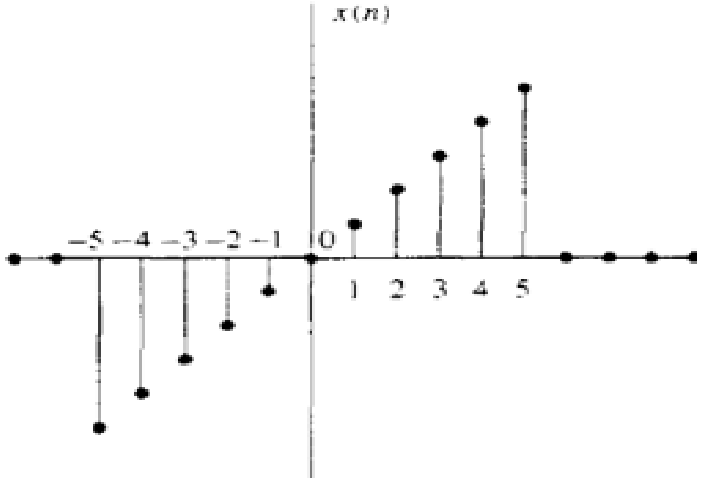
$$x[-n] = -x[n]$$

We note that if $x[n]$ is odd, then $x[0] = 0$.

Examples of signals with even and odd symmetry are shown in the following figure.



Even signal



odd signal