SNS COLLEGE OF TECHNOLOGY

An Autonomous Institution

Coimbatore-35

Accredited by NBA – AICTE and Accredited by NAAC – UGC with 'A+' Grade
Approved by AICTE, New Delhi & Affiliated to Anna University, Chennai

DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

19ECT202 – SIGNALS AND SYSTEMS

II YEAR/ III SEMESTER

UNIT 1 – CLASSIFICATION OF SIGNALS AND SYSTEMS

TOPIC 5 – CLASSIFICATION OF SIGNALS

ENERGY AND POWER SIGNAL

- Energy Signal: The signal which has finite energy and zero average power. $0<E<\infty$

$$Energy\ E = \lim_{T\to\infty} \int_{-T}^{T} |x(t)|^2 dt \qquad Energy\ E = \lim_{N\to\infty} \sum_{n=-N}^{N} |x(n)|^2$$

- Power Signal: The signal which has finite average power and infinite energy. $0<P<\infty$

$$P = \lim_{T\to\infty} \frac{1}{2T} \int_{-T}^{T} |x(t)|^2 dt \qquad P = \lim_{N\to\infty} \frac{1}{2N+1} \sum_{n=-N}^{N} |x(n)|^2$$

POWER OF AN ENERGY SIGNAL IS ZERO OVER INFINITE TIME

Prove that the power of an energy signal is zero over infinite time

$$P = \lim_{T\to\infty} \frac{1}{2T} \int_{-T}^{T} x^2(t)\, dt$$

$$= \lim_{T\to\infty} \frac{1}{2T} \left[\lim_{T\to\infty} \int_{-T}^{T} x^2(t)\, dt \right]$$

$$= \lim_{T\to\infty} \frac{1}{2T} \underbrace{\int_{-\infty}^{\infty} x^2(t)\, dt}$$

$$= \lim_{T\to\infty} \frac{1}{2T} \cdot E$$

$$P = \frac{1}{\infty} \cdot E = 0$$

Power of an energy signal is zero over infinite time

ENERGY OF POWER SIGNAL IS INFINITE OVER INFINITE TIME

Prove that the energy of power signal is infinite over infinite time

$$E = \lim_{T \to \infty} \int_{-T/2}^{T/2} x^2(t)\, dt$$

Multiply and divide by T

$$= \lim_{T \to \infty} T \cdot \frac{1}{T} \int_{-T/2}^{T/2} x^2(t)\, dt$$

$$= \lim_{T \to \infty} T \underbrace{\left[\lim_{T \to \infty} \frac{1}{T} \int_{-T/2}^{T/2} x^2(t)\, dt \right]}_{P}$$

$$= \lim_{T \to \infty} T \cdot P$$

$$= \infty \cdot P$$

$$\boxed{E = \infty}$$

Energy of the power signal is infinite over infinite time.

ENERGY SIGNAL

$x(t) = \cos t$

$$E = \lim_{T\to\infty} \int_{-T}^{T} |x(t)|^2 \, dt$$

$$= \lim_{T\to\infty} \int_{-T}^{T} \cos^2 t \, dt$$

$$= \lim_{T\to\infty} \int_{-T}^{T} \frac{1+\cos 2t}{2} \, dt$$

$$= \frac{1}{2}\left[\lim_{T\to\infty} \int_{-T}^{T} 1 \, dt + \lim_{T\to\infty} \int_{-T}^{T} \cos 2t \, dt\right] \quad (\cos 2t \text{ term} \to 0)$$

$$= \frac{1}{2} \lim_{T\to\infty} [T+T] \Rightarrow \frac{1}{2} \lim_{T\to\infty} 2T$$

$$= \frac{1}{2} \cdot \infty \qquad \boxed{E = \infty} \text{ joules.}$$

POWER SIGNAL

$x(t) = \cos t$

$$P = \lim_{T \to \infty} \frac{1}{2T} \int_{-T}^{T} |x(t)|^2 \, dt$$

$$= \lim_{T \to \infty} \frac{1}{2T} \int_{-T}^{T} \cos^2 t \, dt$$

$$= \lim_{T \to \infty} \frac{1}{2T} \int_{-T}^{T} \frac{1+\cos 2t}{2} \, dt$$

$$= \frac{1}{2} \left[\lim_{T \to \infty} \frac{1}{2T} \int_{-T}^{T} dt + \lim_{T \to \infty} \frac{1}{2T} \int_{-T}^{T} \cancel{\cos 2t}^{\,0} \, dt \right]$$

$$= \frac{1}{2} \lim_{T \to \infty} \frac{1}{\cancel{2T}} [\cancel{2T}]$$

$$P = \frac{1}{2} \text{ Watts}$$

DT ENERGY AND POWER SIGNAL

$$x(n) = e^{j\left(n\pi/2 + n\pi/8\right)}$$

$$E = \sum_{n=-\infty}^{\infty} |x(n)|^2$$

$$= \sum_{n=-\infty}^{\infty} 1$$

$$\sum_{n=-N}^{N} 1 = N_2 - N_1 + 1$$

$$= \lim_{N\to\infty} \sum_{n=-N}^{N} (1)$$

$$= \lim_{N\to\infty} (N+N+1)$$

$$= \lim_{N\to\infty} (2N+1)$$

$$E = \infty \text{ joules.}$$

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

$$= \lim_{N\to\infty} \frac{1}{2N+1} \sum_{n=-N}^{N} 1$$

$$= \lim_{N\to\infty} \frac{1}{2N+1} N-(-N)+1$$

$$= \lim_{N\to\infty} \frac{1}{\cancel{2N+1}} \cancel{(2N+1)}$$

$$P = 1 \text{ Watts}$$

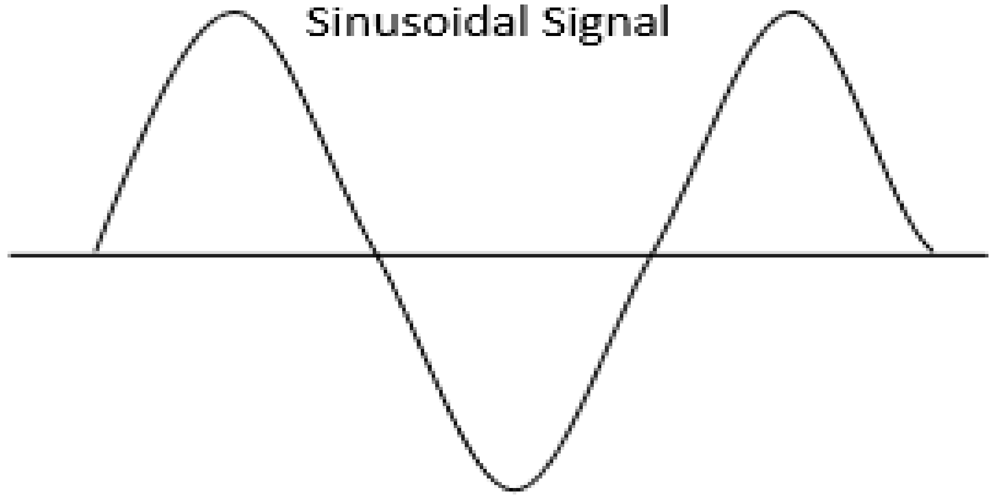
COMPARISON - ENERGY AND POWER SIGNAL

S.No.	Energy Signal	Power Signal
1	Total Energy is finite and non-zero **i.e., 0<E<∞**	Normalized Power is finite and non-zero **i.e., 0<P<∞**
2	Non-Periodic signals are energy signals	Periodic signals are power signals
3	Power of an energy signal is zero over infinite time	Energy of the power signal is infinite over infinite time
4	$Energy\ E = \lim_{T \to \infty} \int_{-T}^{T} \lvert x(t) \rvert^2 dt$	$P = \lim_{T \to \infty} \frac{1}{2T} \int_{-T}^{T} \lvert x(t) \rvert^2 dt$

DETERMINISTIC AND RANDOM SIGNAL

- **Deterministic signal:** A signal which can be completely represented by any mathematical equation

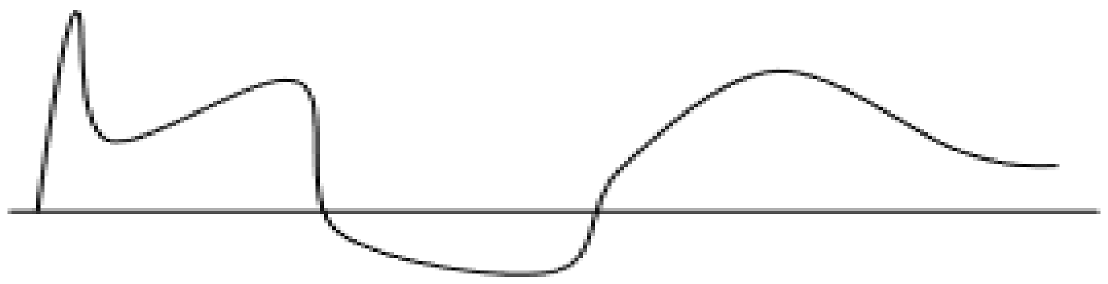
Eg: Sinusoidal Signal



Deterministic signal

- **Random signal:** A signal which cannot be completely represented by any mathematical equation

Eg: Noise Signal



Random signal

ASSESSMENT

1. If the inversion of time axis does not change the amplitude is called -------------signal.
2. Odd signal is also called as --------------------
3. A signal that is defined for every instants of time is known as -------------------
4. Even and Odd signals can be represented in --------------- and ------------ time.
5. All the periodic signals are ---------------
6. Compare energy and power signal.
7. A signal which can be completely represented by any mathematical equation is called ---------------
8. The power of the energy is ----------- over ----------time.

THANK YOU