SIGNALS – QUICK NOTES

Continuous-Time, Discrete-Time and Digital Signals

1. Classification of Signals

- Based on their nature and characteristics, signals can be broadly classified as:
- Continuous-Time (CT) signals – also known as Analog signals.
- Discrete-Time (DT) signals.
- Digital signals.

2. Further Classification of CT and DT Signals

- Deterministic and Non-deterministic (Random) signals.
- Periodic and Non-periodic (Aperiodic) signals.
- Even and Odd signals.
- Energy and Power signals.

3. Continuous-Time (CT) Signal

- A signal which varies continuously with time t is called a continuous-time (CT) signal.
- A CT signal is defined for all values of t.
- It is represented by x(t), where t is the independent time variable.
- A CT signal is continuous in time; in the usual analog-signal context, its amplitude is also continuous.

Key idea: There is a signal value at every instant of time.

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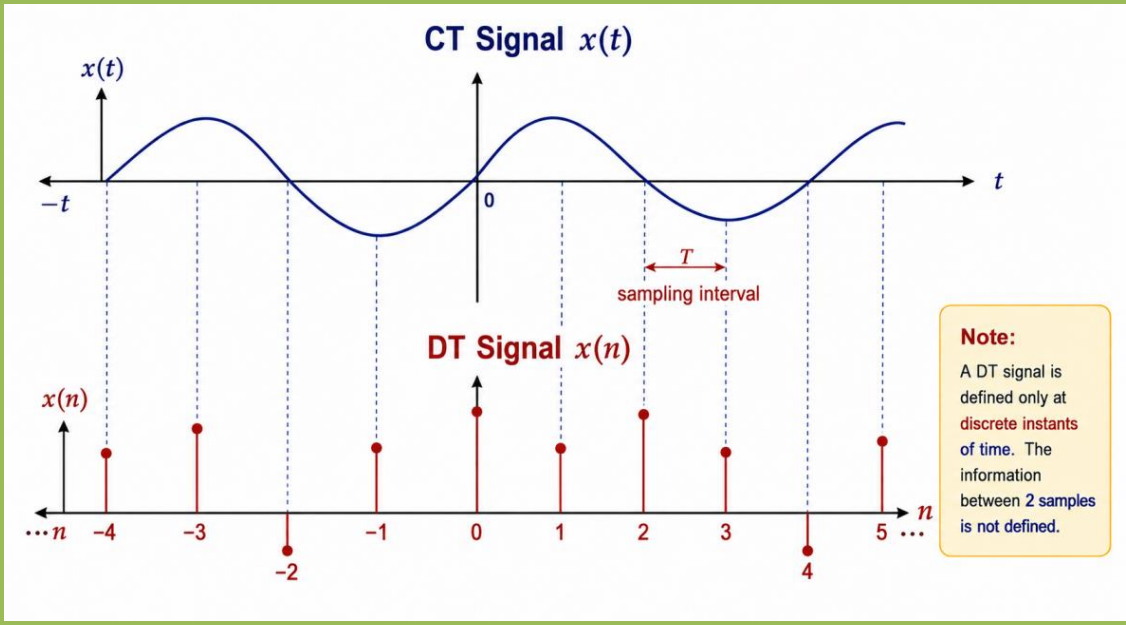

4. Discrete-Time (DT) Signal

- A DT signal can be obtained from a CT signal by sampling.
- A DT signal is defined only at specific, discrete time instants.
- The amplitude between two consecutive time instants is not defined.
- A DT signal is represented by x(n), where n is the independent discrete-time variable.
- For a DT signal, n is an integer: n = 0, ±1, ±2, ±3, ...

Sampling time T: When samples are taken at regular time intervals, the interval between consecutive samples is called the sampling time (or sampling interval) T.

5. Sampling: CT Signal → DT Signal

- Practically, a DT signal is obtained from a CT signal using the sampling process.
- Samples are taken at regular time intervals.
- Each sample represents an amplitude value of the CT signal at a particular sampling instant.

Important: A DT signal contains values only at discrete sampling instants; information between two samples is not defined.

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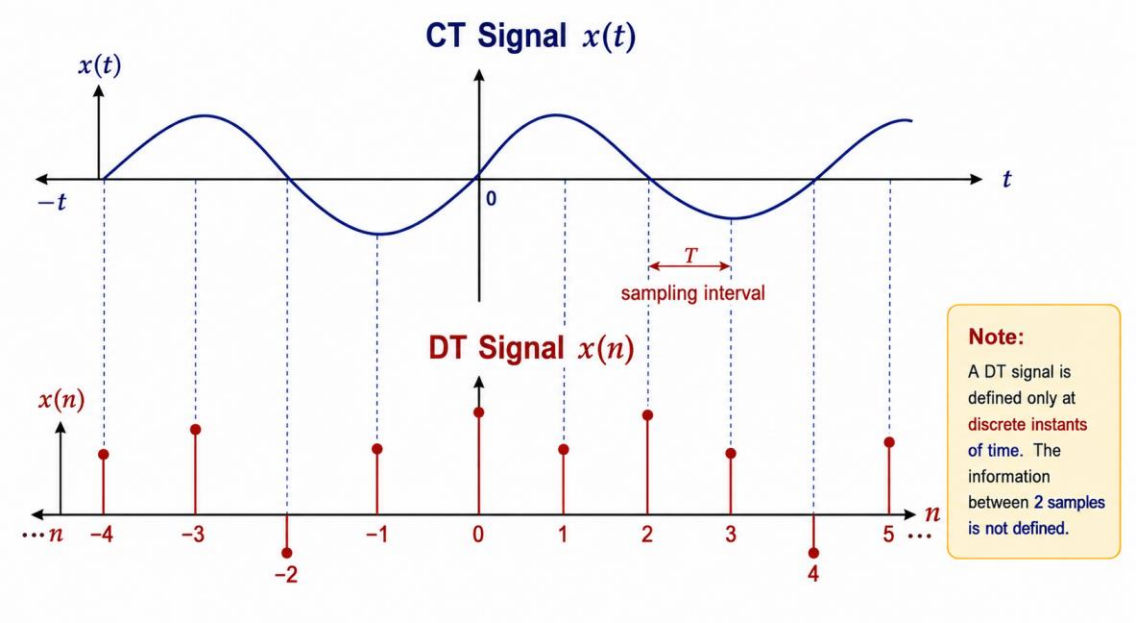
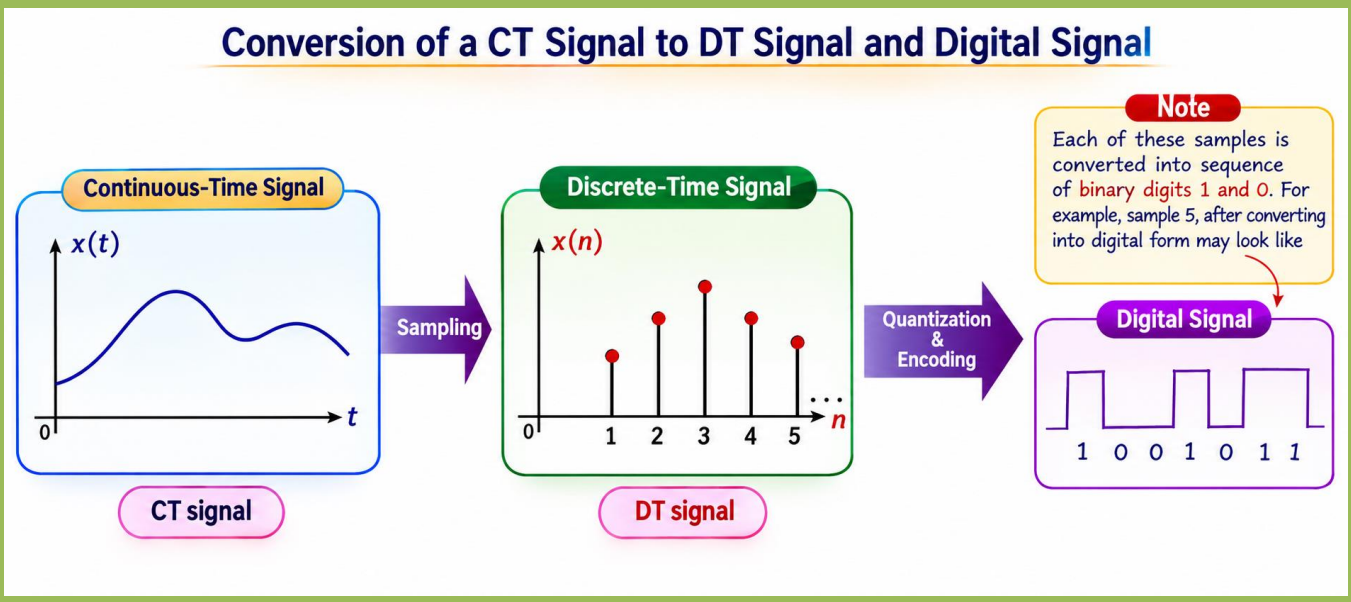


6. Digital Signal

- A digital signal is obtained from a DT signal by applying further processing such as quantization and Analog-to-Digital Conversion (ADC).
- Digital signals are represented using discrete amplitude levels and binary digits such as 1 and 0.
- Each sampled value can be quantized to a permitted level and then encoded into a binary sequence.



7. Transducers and Naturally Occurring CT Signals

- CT signals arise naturally when a physical phenomenon such as speech, heartbeat or an earthquake is converted into an electrical signal using an appropriate transducer.
- A transducer is a device that converts one form of energy into another form.
- Examples include a microphone and a speaker.

Example: A microphone converts a speech signal into an electrical signal; a speaker converts an electrical signal back into a sound/speech signal.

8. Generation Point of View

Type	Examples
Naturally generated signals	Speech, heartbeat, etc.
Synthetically generated signals	Discrete and digital signals generated/processed in computing systems.

9. Important Notes to Remember

- All naturally occurring signals are analog in nature.
- Analog signals are also commonly referred to as continuous signals.
- Signals in a computing environment are digital.
- A digital signal is composed of binary digits 1 and 0.
- Examples of continuous signals include sine wave, cosine wave and triangular wave.
- In telephone communication, voice signals may be converted into intermediate discrete and digital signals for processing.

10. Quick Revision

Signal	Defined at	Representation
CT / Analog	Every instant of time	x(t)
DT	Discrete time instants	x(n)
Digital	Discrete instants and discrete levels	Binary digits such as 0 and 1