DSP INTRODUCTION

What is DSP?

- Digital signal processing (DSP) is the study of signals in a digital representation and the processing methods of these signals.
- DSP and analogue signal processing are subfields of signal processing.
  - Signal processing is the processing, amplification and interpretation of signals and deals with the analysis and manipulation of signals.
- DSP has three major subfields: audio signal, digital image and speech processing.

Why DSP?

- Analogue processing
  - difficult to implement, necessary devices to perform the required operations even may not exist.
  - Inaccurate,
  - Noisy,
  - Small dynamic range,
  - Poor repeatability,
  - Inflexible to changes of algorithm
  - Slow,
  - High cost of storage of analogue waveforms

Signal Sampling

- In order to use an analogue signal on a computer it must be digitized with an analogue to digital converter (ADC) – Signal Sampling.
- Signal Sampling is usually carried out in two stages, discretisation and quantization.
  - Discretisation concerns the process of transferring continuous signals and equations into discrete forms e.g., Zero-Order-Hold (ZOH)
  - Quantisation is the process of approximating a continuous range of values (or a very large set of possible discrete values) by a relatively-small set of discrete symbols or integer values.

Frequency Domain

- Signals are converted from time or space domain to the frequency domain usually through the Fourier transform.
  - The Fourier transform converts the signal information to a magnitude and phase component of each frequency.
  - Often the Fourier transform is converted to the power spectrum, which is the magnitude of each frequency component squared.
- By studying signals in the frequency domain, engineers can get information of which frequencies are present in the input signal and which are missing.

Laplace, Fourier and z-transform

- An ordinary Laplace transform can be written as a special case of a two-sided transform, and since the two-sided transform can be written as the sum of two one-sided transforms.
- The theory of the Laplace-, Fourier-, and z-transforms are at bottom the same subject. However, a different point of view and different characteristic problems are associated with each of these major integral transforms.

DFT & FFT

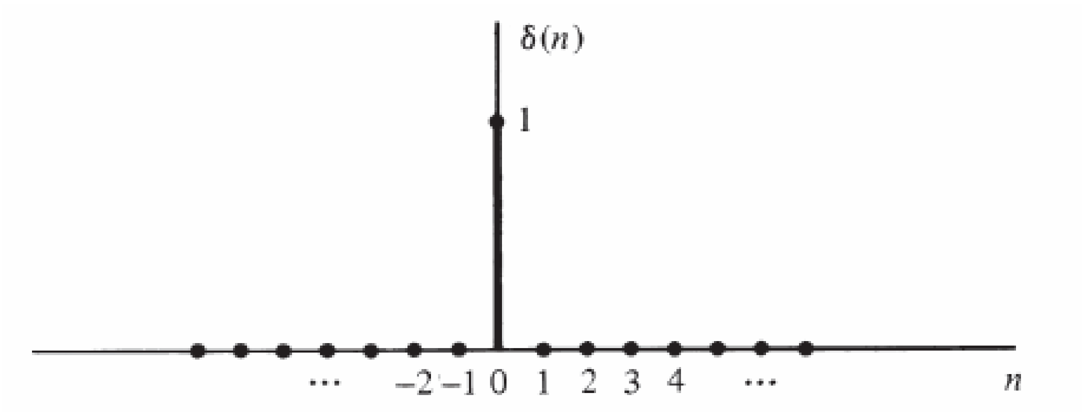
- It is impossible to apply the continuous Fourier transform to discrete and probably non-periodic signal, however, the Discrete Fourier transform (DFT) is available for the use with discrete data.
- A fast Fourier transform (FFT) is an efficient algorithm to compute the DFT and its inverse. FFTs are of great importance to a wide variety of applications, e.g., digital signal processing.

Discrete Time signals

2.1 Discrete-Time Signals

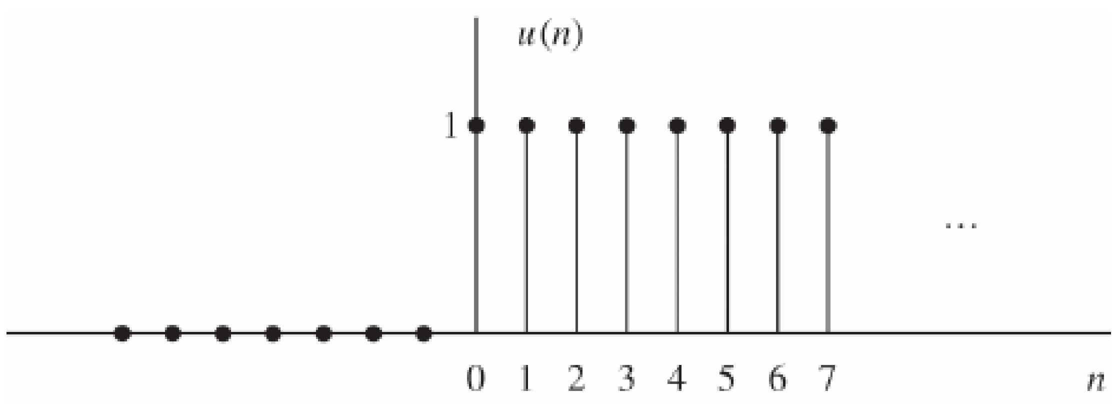
2.1.1 Some Elementary Discrete-Time Signals (1/2)

Unit sample sequence



$$\delta(n) = \begin{cases} 0, & n < 0 \\ 1, & n = 0 \\ 0, & n > 0 \end{cases}$$

Unit step signal

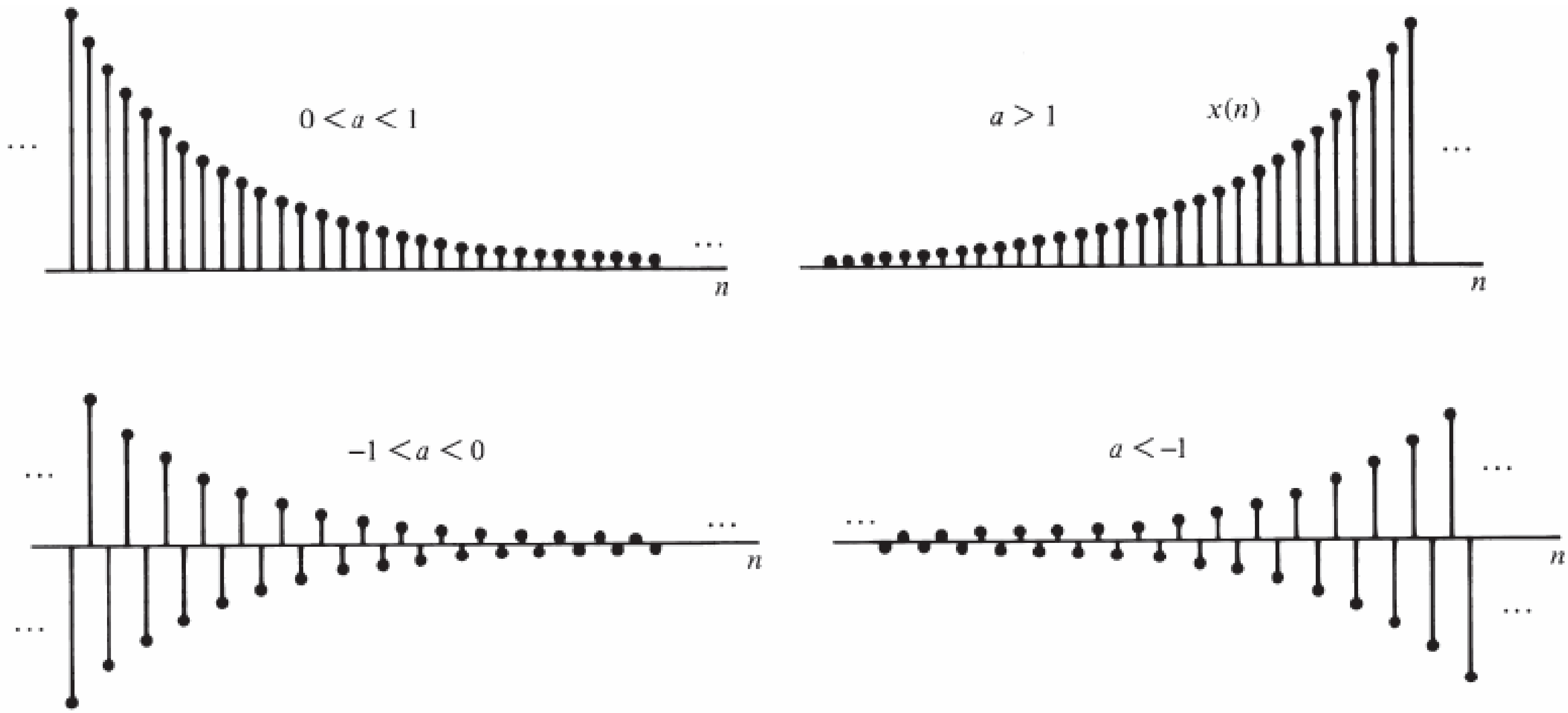


$$u(n) = \begin{cases} 0, & n < 0 \\ 1, & n \geq 0 \end{cases}$$

2.1 Discrete-Time Signals

2.1.1 Some Elementary Discrete-Time Signals (2/2)

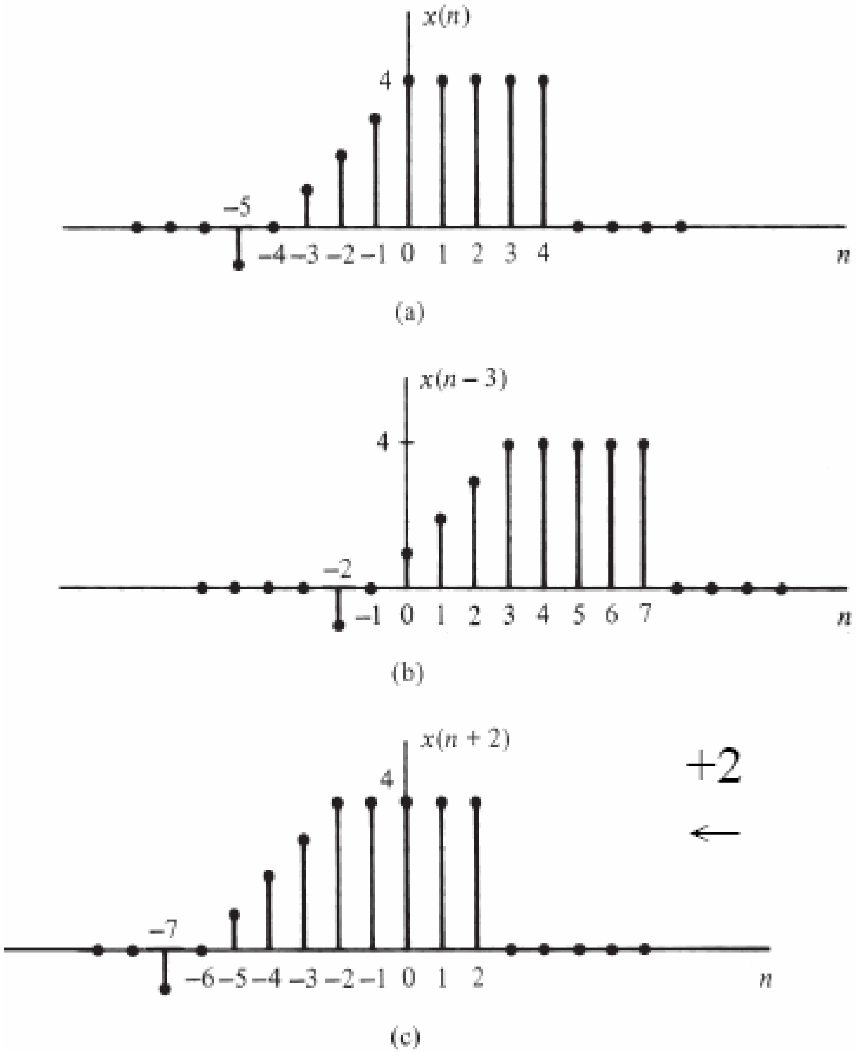
<u>Exponential Signal</u> — $x(n) = a^n,\ -\infty < n < \infty$

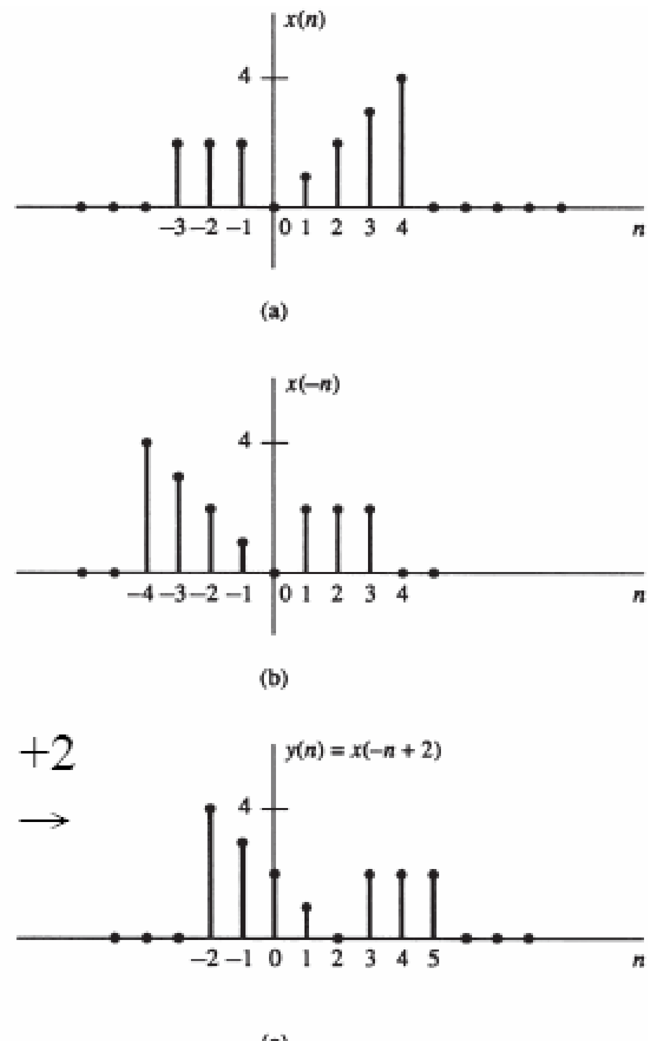


2.1 Discrete-Time Signals

2.1.3 Simple Manipulations of Discrete-Time Signals (1/2)

Transformation of the independent variable (time)





2.1 Discrete-Time Signals

2.1.3 Simple Manipulations of Discrete-Time Signals (2/2)

Addition, multiplication, and scaling of sequences

$$y(n) = Ax(n)$$

$$y(n) = x_1(n) + x_2(n)$$

$$y(n) = x_1(n)\ x_2(n)$$