UEI407 : SIGNALS AND SYSTEMS

INTRODUCTION

Definition of Signal

A **signal** is a description of how one parameter varies with another parameter. For instance, voltage changing over time in an electronic circuit, or brightness varying with distance in an image.

Examples of **signals** include as temperature over time or space, sound (speech, music, etc) over time, images over space, etc. A **signal** carries information and contains energy.

Different types of **signals**: Analog **signal**: a function , continuous in amplitude, of a continuous independent variable (e.g., time).

- Analog signals

A signal could be an analog quantity that means it is defined with respect to the time. It is a continuous signal. These signals are defined over continuous independent variables. They are difficult to analyze, as they carry a huge number of values. They are very much accurate due to a large sample of values. In order to store these signals , you require an infinite memory because it can achieve infinite values on a real line. Analog signals are denoted by sine waves.

For example:

- Human voice

Human voice is an example of analog signals. When you speak, the voice that is produced travel through air in the form of pressure waves and thus belongs to a mathematical function, having independent variables of space and time and a value corresponding to air pressure.

What is the function of a Signal

In **signal** processing, a **signal** is a **function** that conveys information about a phenomenon. In electronics and telecommunications, it refers to any time varying voltage, current or electromagnetic wave that carries information.

A **signal** may also be defined as an observable change in a quality such as quantity.

DEFINITION OF SYSTEM

A **system** is any process that produces an output **signal** in response to an input **signal**.

A device or a set of rules defining the functional relation between the input and output is known as **a system**.

Continuous Time and Discrete Time Signals

If a signal is defined at all values of t where t is a continuous variable, the signal is known as a continuous time signal. Figure 1 is known as continuous time signal.

The signal shown in Figure 1 is continuous in time as well as in amplitude.

Figure 2 shows a signal, which is discrete time signal.

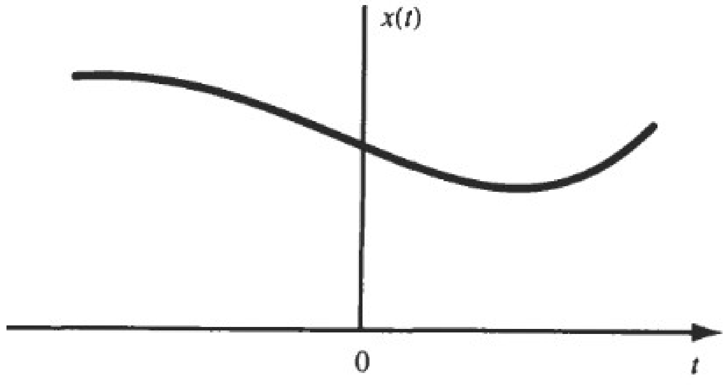

Figure 1

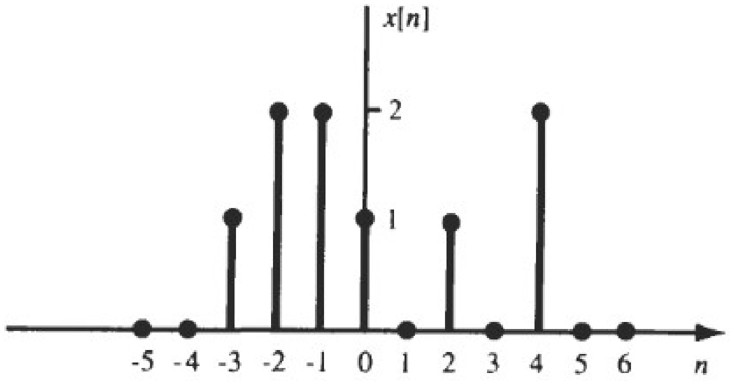

Figure 2

Classification of Continuous Time Signals

The continuous time signals are classified as follows:

(i) Analog signal

(ii) One sided signal

(iii) Real and complex signal

(iv) Even signal and Odd signal

Classification of Continuous Time Signals

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(i) Analog signal

(ii) One sided signal

(iii) Real and complex signal

(iv) Even signal and Odd signal

Continued….

(v) Periodic and Non–periodic signal

(vi) Piecewise continuous signal

(vii)Deterministic and Random Signal

(viii) Multichannel Signals

(ix) Multidimensional Signals

(x) Energy and Power signals.

Analog Signals

A continuous time signal $x(t)$ is said to be an analog signal if it takes any value in the interval (a,b) where a and b may be $-\infty$ to ∞ respectively.

One Side Signals

If a continuous time signal x(t) has zero value for $t<0$, the signal is said to be one side(positive sided) signal. On the other hand, if the signal x(t) has zero value for $t>0$, it s also known as one side (negative sided) signal.

A continuous time signal x(t) is said to be perpetual if it is represented by same equal value for all time.

The signal $x_1(t) = A \sin\omega_0 t\, u(t)$ is one sided whereas $x_2(t) = A \sin\omega_0 t$ is perpetual shown in Figure 3(a) and Figure 3(b) respectively.

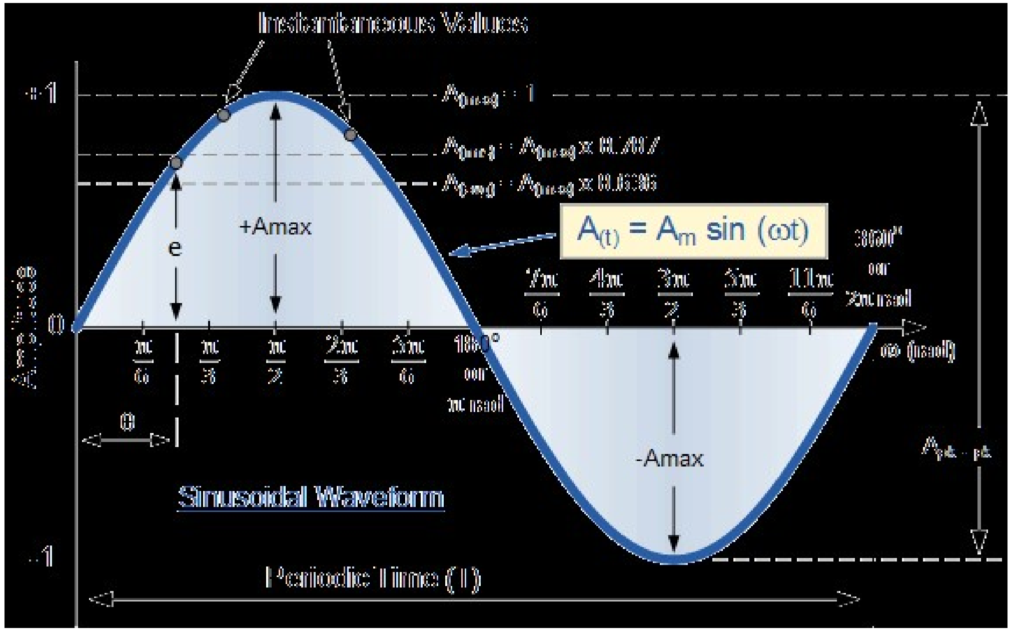


Figure 3(a) : Single sided sinusoidal function

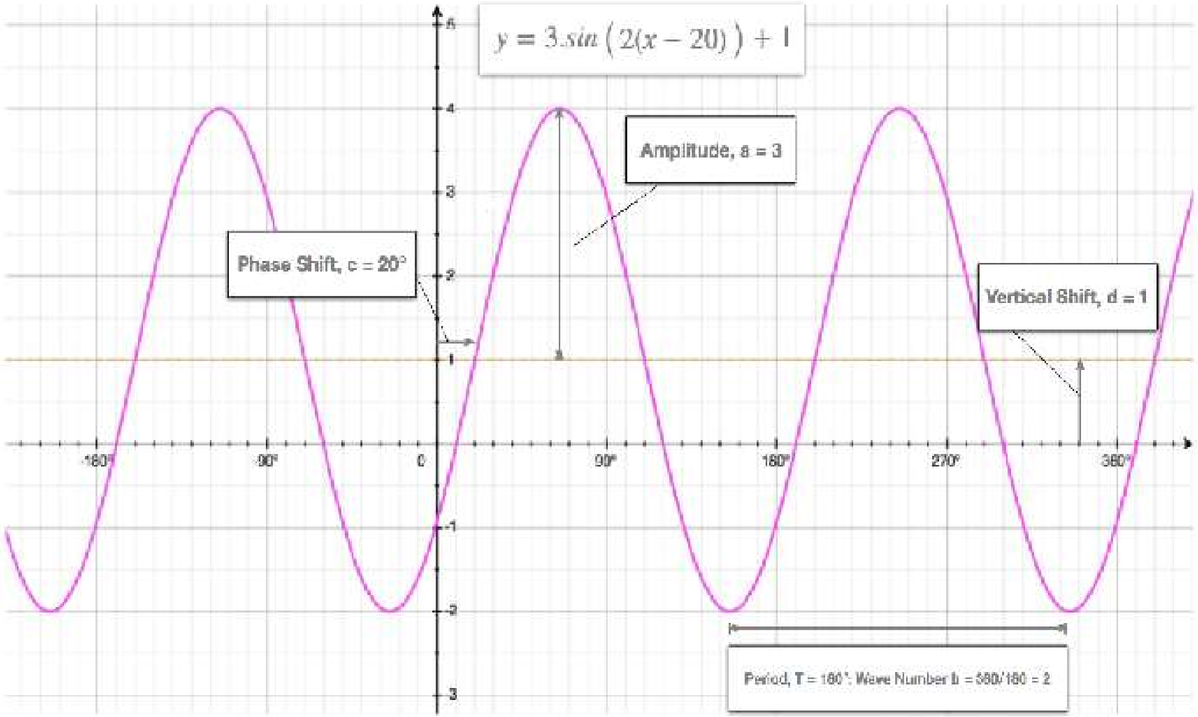


Figure 3(b) : Double sided sinusoidal function

Real and Complex Signals

A continuous time signal x(t) is said to be real, if its value is a real number. On the other hand, it is said to be complex if its value is a complex number. A complex signal x(t) is represented by

$$x(t) = x_1(t) + jx_2(t) \qquad (1)$$

where

$$j = \sqrt{-1}$$

In equation (1), $x_1(t)$ and $x_2(t)$ are continuous real signals.

Even Signal and Odd Signals

A signal x(t) is said to be even if

$$x(t) = x(-t) \tag{2}$$

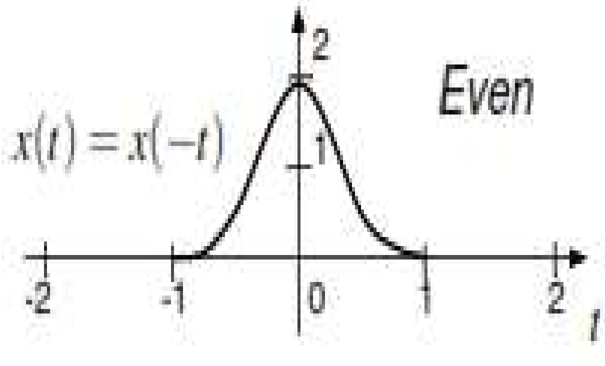
is satisfied.

On the other hand, a signal x(t) is said to be odd if

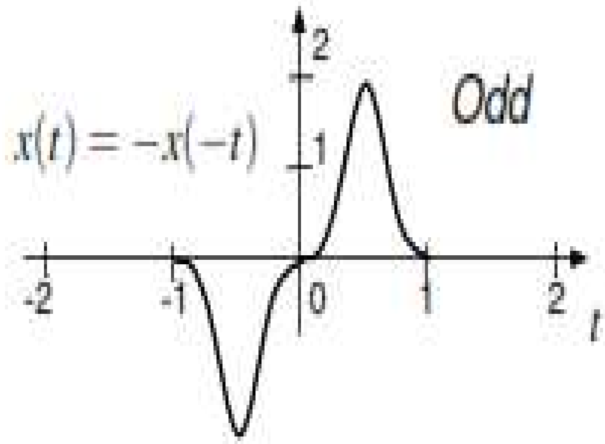
$$x(t) = -x(-t) \tag{3}$$

is satisfied.

Figure 4(a),(c),(e) and Figure 4(b), (d), (f) show even and odd signals respectively.



(a)



(b)

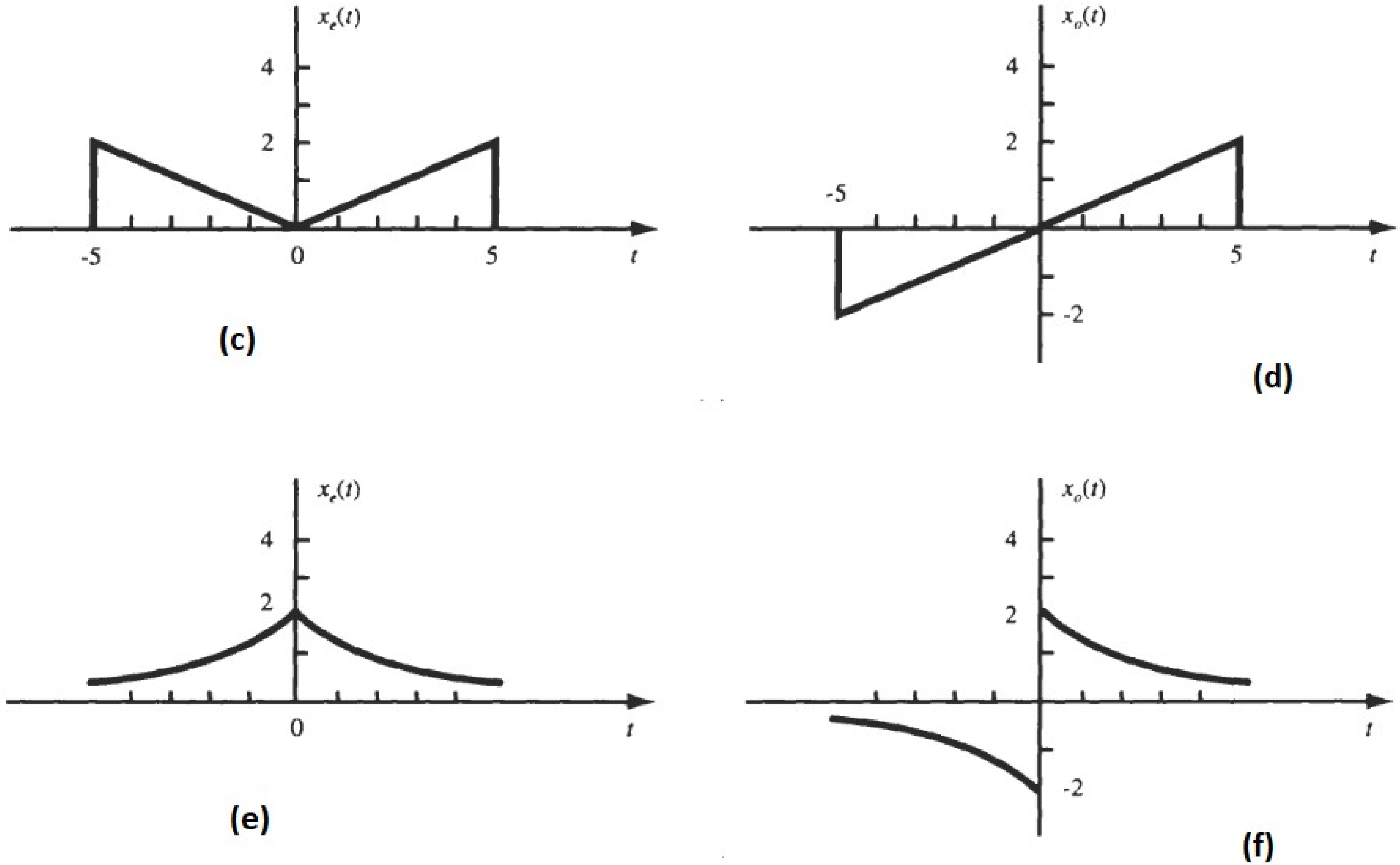


Figure 4 : Even and Odd Signals

Find the even and odd components of $x(t) = e^{jt}$.

Let $x_e(t)$ and $x_o(t)$ be the even and odd components of e^{jt}, respectively.

$$e^{jt} = x_e(t) + x_o(t)$$

From Eqs. (*1.5*) and (*1.6*) and using Euler's formula, we obtain

$$x_e(t) = \tfrac{1}{2}(e^{jt} + e^{-jt}) = \cos t$$

$$x_o(t) = \tfrac{1}{2}(e^{jt} - e^{-jt}) = j \sin t$$

Show that the product of two even signals or of two odd signals is an even signal and that the product of an even and an odd signal is an odd signal.

Let $x(t) = x_1(t)x_2(t)$. If $x_1(t)$ and $x_2(t)$ are both even, then

$$x(-t) = x_1(-t)x_2(-t) = x_1(t)x_2(t) = x(t)$$

and $x(t)$ is even. If $x_1(t)$ and $x_2(t)$ are both odd, then

$$x(-t) = x_1(-t)x_2(-t) = -x_1(t)[-x_2(t)] = x_1(t)x_2(t) = x(t)$$

and $x(t)$ is even. If $x_1(t)$ is even and $x_2(t)$ is odd, then

$$x(-t) = x_1(-t)x_2(-t) = x_1(t)[-x_2(t)] = -x_1(t)x_2(t) = -x(t)$$

and $x(t)$ is odd. Note that in the above proof, variable t represents either a continuous or a discrete variable.