EE 210 LECTURE 3

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1 Introduction

Let us go through the basic idea of a signal and a system.

1. **Signal** : Signal is any physical quantity that is measurable and conveys some information. In this course, a signal is represented by a mathematical function of an independent variable.

2. **Systems** : System is physical entity that either generates a signal or processes a signal to produce modified verision of the input signal. In this course, a system is represented by mathematical operator which operates on some signal to give the desired output.

2 Classification of Signals & Digital processing

2.1 Classification of Signals

1. Analog Signals : The signals whose values are continuous over the range of dependent variable, are called analog signals.

2. Digital Signals : The signals whose values are discrete over the range of dependent variable, are called digital signals.

2.2 Digital processing

If X(t) is a signal, and it takes continuous values, it is a analog signal and if it takes discrete values, it is a digital signal.

For example, speech outputs of microphone are analog signals, whereas stock market prices in a day can be related to Digital signals.At origin, all signals are considered **analog**

The Significance of Digital Processing:

1. Low cost
2. Noise robustness

Firstly, an analog circuit is converted into **electrical form** form **non electrical form** through a sensor using a microphone.

An **analog and a continuous time signal** can be converted to **analog and a discrete time signal** by sampling process and passing signal through hold circuit.
[1]

[1] Here 't' refers to time in all contexts

Then this modified signal is further converted into **digital and discrete signal** by a quantizer & encoder. quantizer and encoder are collectively called as **ADE(analog to digital conversion)**

The components and processes involved in conversion of Analog continuous time signal to Digital and discrete time signal are :

1. Sensor (Microphone)
2. Sampling
3. Hold Circuit
4. Quantizer
5. Encoder

3 Periodic and Aperiodic signals

3.1 Definition

1. **Periodic signals** : The ***minimum positive value of t_o***, for which X(t) = X(t+t_o), for some t_o is called the fundamental period of X(t). If such fundamental period exists, then X(t) is called a periodic signal.

2. **Aperiodic signals** : If for a signal X(t), X(t) $\neq$ X(t+t_o), for any t_o, or simply a fundamental period does not exist, then it is called an Aperiodic signal.

3.2 Periodicity in analog and digital signals

For analog signals, the condition *X(t) = X(t+t_o) for some t_o* , where t_o takes any real value should be satisfied for the signal to be periodic.

Wheareas for digital signals, the condition *X(t) = X(t+t_o) for some t_o*, where t_o takes any integer value should be satisfied for the signal to be periodic.

4 Even and Odd signals

If X(t) is assumed to be a signal,

1. **Even Signal** : If X(t) = X(-t), for all t > 0, then the signal is an even signal.
2. **Odd Signal** : If X(t) $\neq$ X(-t), for all t > 0, then the signal is an odd signal.

When the domain of the signal is changed (Time to Frequency & Frequency to Time), we can still exploit the features of odd and even functions after the domain change, if the signal is odd or even in the previous domain.

A given signal can have :

1. Odd components
2. Even components
3. Both odd and even components

4.1 Expressing odd and even components of a signal

$X(t) = X_{odd}(t) + X_{even}(t)$
$X(-t) = X_{odd}(-t) + X_{even}(-t)$

So, we know $X(t) + X(-t) = X_{odd}(t) + X_{even}(t) + X_{odd}(-t) + X_{even}(-t)$
$X(t) + X(-t) = X_{odd}(t) + X_{even}(t) + X_{odd}(t) - X_{even}(t)$
$X(t) + X(-t) = 2X_{even}(t)$

so, even component of $X(t) = X_{even}(t) = \dfrac{X(t) + X(-t)}{2}$

similarly, $X(t) - X(-t) = X_{odd}(t) + X_{even}(t) - X_{odd}(-t) - X_{even}(-t)$
$X(t) - X(-t) = 2X_{odd}(t)$

so, odd component of $X(t) = X_{odd}(t) = \dfrac{X(t) - X(-t)}{2}$

Here, '-t' is just a perception that we are referring to time that is earlier than the chosen reference time and should not be confused with negative time.