EXPERIMENT NO: 2

To Analyze Systems and their Properties

Objective:

To demonstrate the properties of different systems.

Theory:

Systems are used to process signals, may characterized by its inputs, its output (or responses) and rule of operation (or laws), adequate to describe its behavior.

The study of system consists of three major areas 1) Mathematical modeling, 2) Analysis and 3) Design.

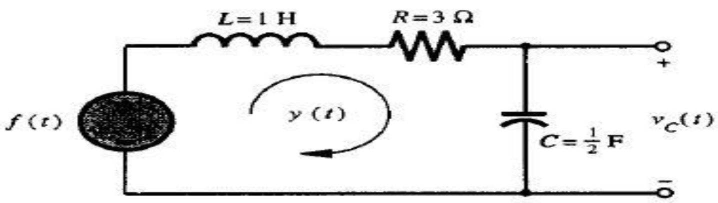

Fig. 1: A simple electrical system.

Now let us study several properties of a given system:

Linear and Non-linear System Property:

A linear system is any system that obeys the superposition principle means if it satisfies the additivity and homogeneity property which is further described below. A nonlinear system is any system that does not have at least one of these properties.
Now if x(t) = H[f(t)] is the response of the system to an input f(t), (Here 'A′ is a constant).
To show that a system 'H' obeys the scaling or homogeneity property:

H [A.f(t)] = A.x(t)………………………………….(1)

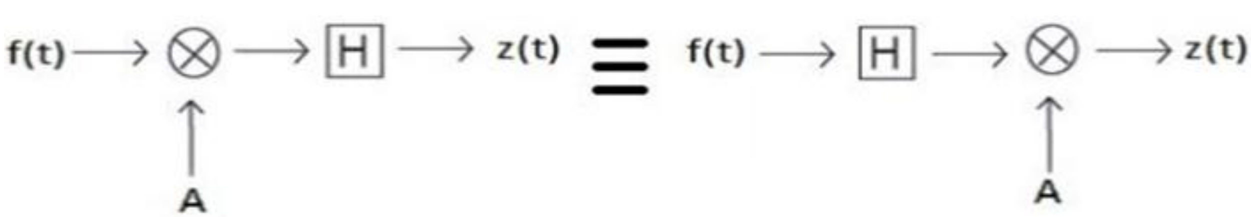

Fig. 2: Linearity property

If f(t) and g(t) are two distinct signals and x(t) = H[f(t)] *and* y(t) = H[g(t)]

To demonstrate that a system H obeys the additivity property is to show that

H [f(t)+g(t)] = x(t)+y(t)………………………….(2)

Time-variant and Time invariant System Property:

A system is said to be time invariant if the response of the system to an input is not a function of time. On the other hand a system is time variant if the response to an input alters with time i.e. the system has varying response to the same input at different instants of time.

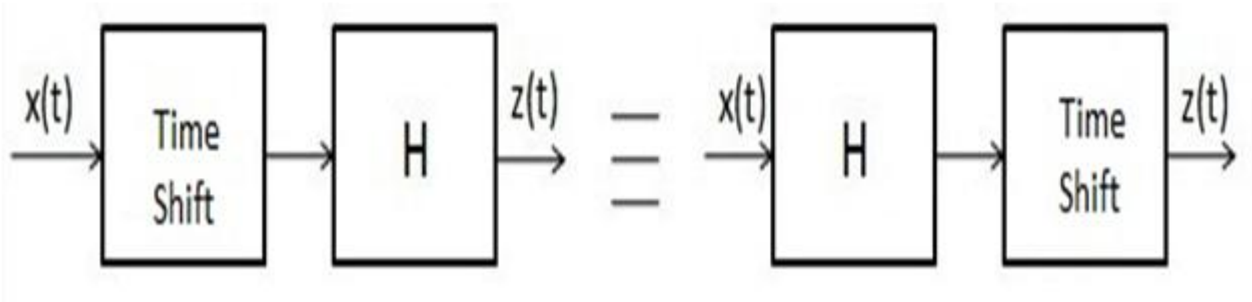

Fig. 3: Time invariance property

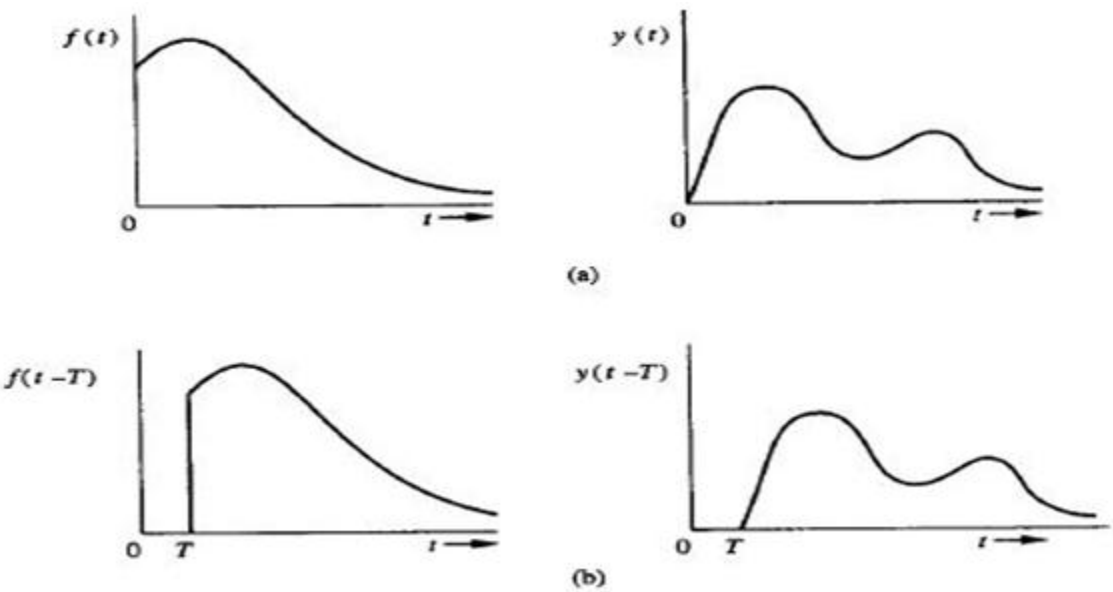

Fig.4: Example of time invariant system

Where f(t) is input to an LTI system and corresponding system response is y(t).

Causality and Non-causality System Property:

A causal system is a system in which the output depends only on current or past inputs, but not on future inputs. Similarly, an anti-causal system is a system in which the output depends only on current or future inputs, but not past inputs. Finally, a non-causal system is a system in which the output depends on both past and future inputs.

<u>Memory (Dynamic) and Memory less (Static) System Property</u>:

Consider a time-domain system with input x and output y, where for all $t \in Time$,

$$y(t) = x^2(t).$$

Here the output signal at each time depends only on the input at that time. Such systems are said to be memory less (static) because you do not have to remember previous values (or future values, for that matter) of the input in order to determine the current value of the output otherwise the system is said to have memory.

$$y(t) = \int_{-\infty}^{t} x(\tau)d\tau$$

For memory (dynamic) system the output at time t depends on the input for all $-\infty < \tau \leq t$.

<u>Stable and Unstable System Property</u>:

If a system is BIBO stable, then the output will be bounded for every input to the system that is bounded,

For a continuous time linear time-invariant (LTI) system, the condition for BIBO stability is that the impulse response be absolutely integrable

$$\int_{-\infty}^{\infty} |h(t)|\ \mathrm{d}t = \|h\|_1 < \infty$$

For a discrete time LTI system, the condition for BIBO stability is that the impulse response be absolutely summable.

Waveforms to be observed:

Check the following properties of systems for the input – output relations given below:

1. Memory less (Static)
2. Causal
3. Linear
4. Time Invariant
5. Stable

a. $y(t) = u(x(t))$ where $x(t) = 3t/4$
b. $y(t) = x(t-5) - x(3-t)$
c. $y(t) = \frac{x(t)}{x(t-1)}$
d. $y(t) = x\left(\frac{t}{2}\right)$
e. $y(t) = x(t)\cos(wt)$

Assume $x(t) = ramp(t+1) - 2ramp(t) + ramp(t-1)$ for parts (b) to (e).

Check the following properties of systems for input – output relations given below:

1. Memory less (Static)
2. Causal
3. Linear
4. Time Invariant
5. Stable

a. $y(t) = \int_{-\infty}^{t} x(\tau)\, d\tau$

b. $y(t) = x^n(t)$

c. $y(t) = e^{x(t)}$ where $x(t)$ is real

d. $y(t) = \frac{d}{dt}(x(t))$

e. $y(t) = \frac{d}{dt}(x(t-1))$

f. $y(t) = x(t)\frac{d}{dt}(x(t))$

g. $y(t) = x(t)\frac{d}{dt}(x(t-1))$

Assume $x(t) = u\left(t + \frac{1}{2}\right) - u(t - \frac{1}{2})$ for parts (a) to (g).

MATLAB Program:

The student must write the code from .mfile and associated functions used in this section.

Results:

Using an example, the student must clearly mention input arguments used and corresponding output obtained (in the form of numerical values / graphs) in this section.

Comments on the results:

The student must describe in short the inferences drawn from the experiment and observations from the results obtained in his/ her own words.
