Systems are classified into the following categories:

- Liner and Non-liner Systems
- Time Variant and Time Invariant Systems
- Liner Time variant and Liner Time invariant systems
- Static and Dynamic Systems
- Causal and Non-causal Systems
- Invertible and Non-Invertible Systems
- Stable and Unstable Systems

**Liner and Non-liner Systems**

A system is said to be linear when it satisfies superposition and homogenate principles. Consider two systems with inputs as \( x_1 t \), \( x_2 t \), and outputs as \( y_1 t \), \( y_2 t \) respectively. Then, according to the superposition and homogenate principles,

\[
T [a_1 x_1 t + a_2 x_2 t] = a_1 T[x_1 t] + a_2 T[x_2 t]
\]

\[
\therefore, \ T [a_1 x_1 t + a_2 x_2 t] = a_1 y_1 t + a_2 y_2 t
\]

From the above expression, is clear that response of overall system is equal to response of individual system.

**Example:**

\[ t = x^2 t \]

Solution:

\[ y_1 t = T[x_1 t] = x_1^2 t \]
\[ y_2 t = T[x_2 t] = x_2^2 t \]
\[ T [a_1 x_1 t + a_2 x_2 t] = (a_1 x_1 t + a_2 x_2 t)^2 \]

Which is not equal to \( a_1 y_1 t + a_2 y_2 t \). Hence the system is said to be non linear.

**Time Variant and Time Invariant Systems**

A system is said to be time variant if its input and output characteristics vary with time. Otherwise, the system is considered as time invariant.

The condition for time invariant system is:

\[ y n, t = y n - t \]

The condition for time variant system is:

\[ y n, t \neq y n - t \]

Where \( y n, t = T[xn - t] \) = input change

\[ y n - t \] = output change

**Example:**
\[ y_n = x - n \]
\[ y_n, t = T[xn - t] = x - n - t \]
\[ y_n - t = x - (n - t) = x - n + t \]

\[ \therefore y_n, t \neq y_n - t. \text{ Hence, the system is time variant.} \]

**Liner Time variant LTV and Liner Time Invariant LTI Systems**

If a system is both liner and time variant, then it is called liner time variant LTV system.

If a system is both liner and time Invariant then that system is called liner time invariant LTI system.

**Static and Dynamic Systems**

Static system is memory-less whereas dynamic system is a memory system.

**Example 1:** \( y_t = 2\cdot x_t \)

For present value \( t=0 \), the system output is \( y_0 = 2\cdot x_0 \). Here, the output is only dependent upon present input. Hence the system is memory less or static.

**Example 2:** \( y_t = 2\cdot x_t + 3\cdot x_t - 3 \)

For present value \( t=0 \), the system output is \( y_0 = 2\cdot x_0 + 3\cdot x - 3 \).

Here \( x-3 \) is past value for the present input for which the system requires memory to get this output. Hence, the system is a dynamic system.

**Causal and Non-Causal Systems**

A system is said to be causal if its output depends upon present and past inputs, and does not depend upon future input.

For non causal system, the output depends upon future inputs also.

**Example 1:** \( y_n = 2\cdot x_t + 3\cdot x_t - 3 \)

For present value \( t=1 \), the system output is \( y_1 = 2\cdot x_1 + 3\cdot x - 2 \).

Here, the system output only depends upon present and past inputs. Hence, the system is causal.

**Example 2:** \( y_n = 2\cdot x_t + 3\cdot x_t - 3 + 6x_t + 3 \)

For present value \( t=1 \), the system output is \( y_1 = 2\cdot x_1 + 3\cdot x - 2 + 6\cdot x_4 \) Here, the system output depends upon future input. Hence the system is non-causal system.

**Invertible and Non-Invertible systems**

A system is said to invertible if the input of the system appears at the output.

\[
\begin{align*}
YS &= XS \cdot H1(S) \cdot H2(S) \\
&= XS \cdot H1(S) \cdot \frac{1}{H1(S)} \
&= XS \cdot \frac{1}{H1(S)} \
&= YS = XS
\end{align*}
\]

\[ \therefore YS = XS \]

\[ Since H2S = 1/H1(S) \]


$$\rightarrow yt = xt$$

Hence, the system is invertible.

If $yt \neq xt$, then the system is said to be non-invertible.

**Stable and Unstable Systems**

The system is said to be stable only when the output is bounded for bounded input. For a bounded input, if the output is unbounded in the system then it is said to be unstable.

**Note:** For a bounded signal, amplitude is finite.

**Example 1:** $y t = x^2 t$

Let the input is $ut$ unitstepboundedinput then the output $yt = u2t = ut = bounded output$.

Hence, the system is stable.

**Example 2:** $y t = \int x(t) \, dt$

Let the input is $u t$ unitstepboundedinput then the output $yt = \int u(t) \, dt = ramp \ signal \ unboundedbecauseamplitudeof\ ramp \ isnot\ finiteit\ goes\ to\ finite\ when$ $\rightarrow infinite$.

Hence, the system is unstable.