SIGNALS & SYSTEMS

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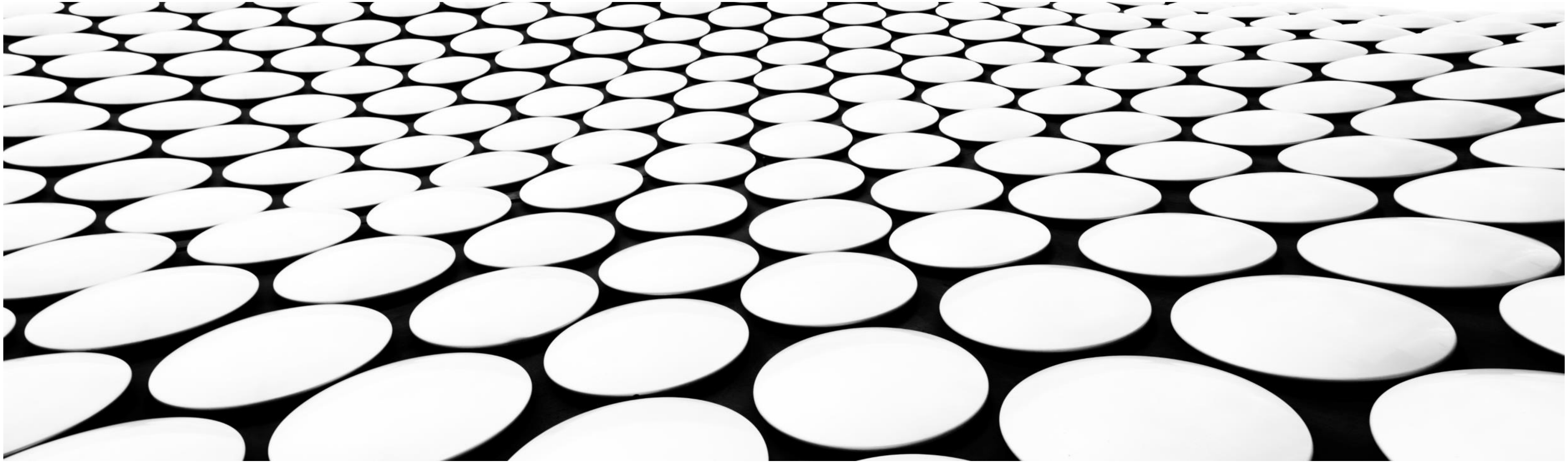

Determine whether the following systems are linear or non-linear

(i) $y(t) = t.x(t)$ (ii) $y(t) = x^2(t)$ (iii) $y(t) = ax(t) + b$

Solution:

(i) Given that $y(t) = t.x(t)$

Let $y_1(t) = tx_1(t)$ and $y_2(t) = tx_2(t)$

Now, the linear combination of the two outputs will be

$$y_3(t) = a_1\, y_1(t) + a_2 y_2(t) = a_1\, tx_1(t) + a_2 tx_2(t)$$

Also the response to the linear combination of input will be

$$y_4(t) = f[a_1 x_1(t) + a_2 x_2(t)] = t[a_1 x_1(t) + a_2 x_2(t)]$$

$$y_4(t) = a_1 t\, x_1(t) + a_2 t\, x_2(t)$$

Since the output $y_3(t) = y_4(t)$, the system is **linear system.**

(ii) Given that $y(t) = x^2(t)$

Let $y_1(t) = x_1^2(t)$ and $y_2(t) = x_2^2(t)$

Now, the linear combination of the two outputs will be

$$y_3(t) = a_1\, y_1(t) + a_2 y_2(t) = a_1\, x_1^2(t) + a_2\, x_2^2(t)$$

Also the response to the linear combination of input will be

$$y_4(t) = f[a_1 x_1(t) + a_2 x_2(t)] = [a_1 x_1(t) + a_2 x_2(t)]^2$$

$$y_4(t) = a_1\, x_1^2(t) + a_2\, x_2^2(t) + 2a_1\, a_2\, x_1(t)\, x_2(t)$$

Since the output $y_3(t) \neq y_4(t)$, the system is **not a linear system.**

(iii) Given that $y(t) = ax(t) + b$

Let $y_1(t) = ax_1(t)+b$ and $y_2(t) = ax_2(t)+b$

Now, the linear combination of the two outputs will be

$$y_3(t) = a_1\, y_1(t) + a_2 y_2(t) = a_1(ax1(t)+b) + a_2\,(ax_2(t)+b)$$

Also the response to the linear combination of input will be

$$y_4(t) = f[a_1x_1(t) + a_2x_2(t)] = a[a_1x_1(t) + a_2x_2(t)] + b$$

Since the output $y_3(t) \neq y_4(t)$, the system is **not a linear system.**

Invertible and Non-invertible System: A system is said to be **invertible** if its input $x(t)$ can always be uniquely determined from its output $y(t)$. From this definition, it follows that an invertible system will always produce distinct outputs from any two distinct inputs. If a system is invertible, this is most easily demonstrated by finding the inverse system. If a system is not invertible, often the easiest way to prove this is to show that two distinct inputs result in identical outputs.

Stability : The bounded-input bounded-output (BIBO) stability is most commonly defined in system analysis. A system having the input $x(t)$ and output $y(t)$ is **BIBO stable** if, a bounded input produces a bounded output.