Classification of System

مسائل محلولة

Linear and No Linear [L&NL]

Static and Dynamic [S&D]

Time Variant and Time nonVariant

Causal and non Causal

Stable and unstable [BIBO]

د. عمر الامين

Linear and non linear example

ex 1]

Time scaling

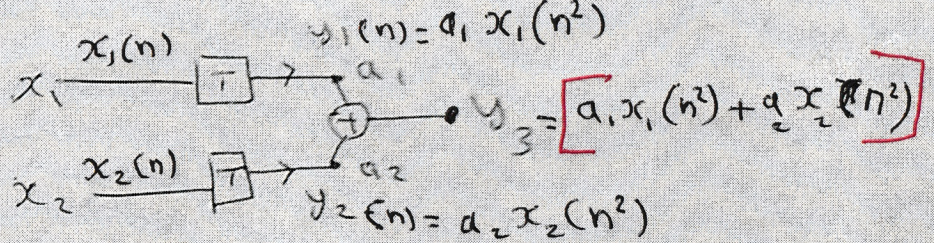
$$y(n) = x(n^2)$$

$x_1(n^2)$, $x_2(n^2)$

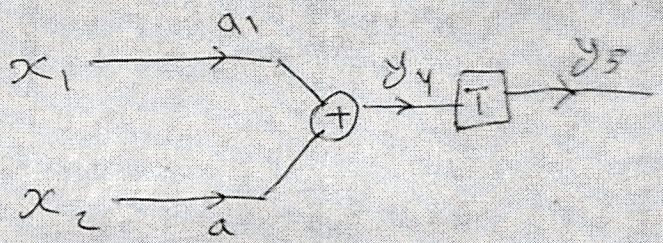
$y_1(n) = x_1(n^2)$ $\quad$ $y_2 = x_2(n^2)$

$y_3(n) = y_1(n) + y_2(n)$

$$y_3(n) = a_1 x_1(n^2) + a_2 x_2(n^2)$$



$y_4(n) = a_1 x_1(n) + a_2 x_2(n)$



$$y_5(n) = a_1 x_1(n^2) + a_2 x_2(n^2)$$

$\therefore$ $y_3(n) = y_5(n)$

Linear system

الاستنتاج الاول

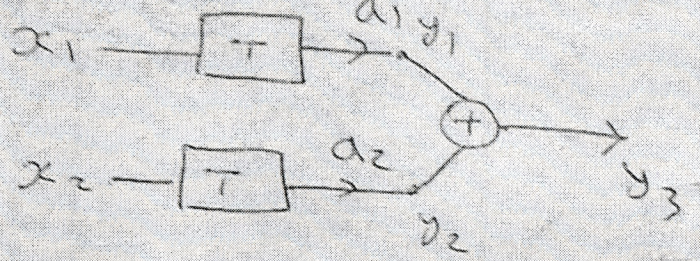
System linearty is independent of Time scaling

ex 2 $y(n) = \underbrace{n}_{\text{coeff.}} x(n)$ (dependent on n)

$y_1(n) = a_1 n x_1(n)$

$y_2(n) = a_2 n x_2(n)$

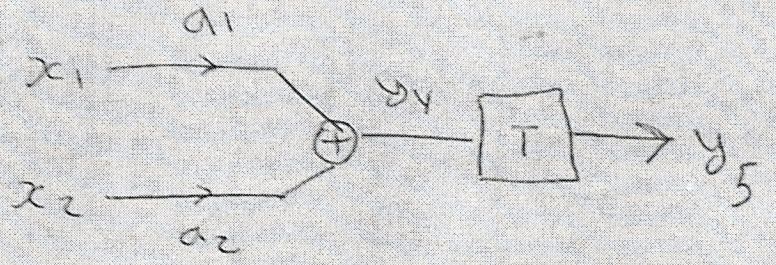
$y_3(n) = a_1 n x_1(n) + a_2 n x_2(n)$



$y_4(n) = a_1 x_1(n) + a_2 x_2(n)$

$y_5(n) = n[a_1 x_1(n) + a_2 x_2(n)]$

$= a_1 n x_1(n) + a_2 n x_2(n)$



$\therefore y_3(n) = y_5(n)$

Linear system

الاستنتاج الثاني

The system linearity is independent of the coeff used T.V or I.T.V

T.V Time variant

I.T.V independent Time varia

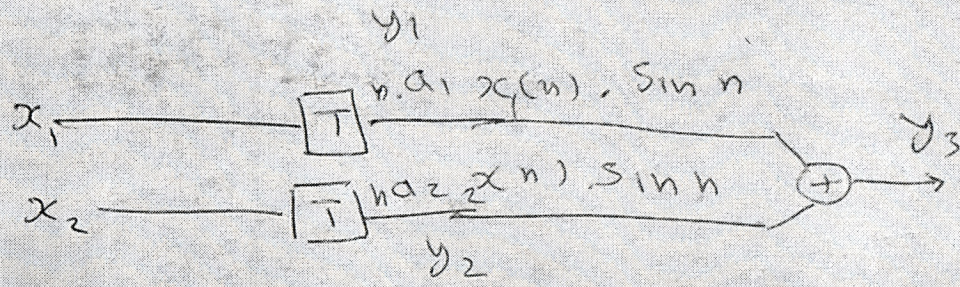
(3)

ex3 Time dependent

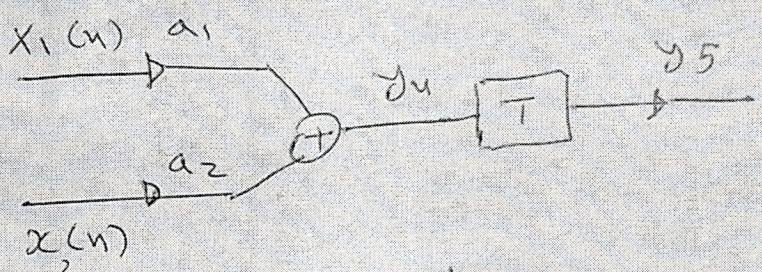
$y(n) = \underbrace{\sin n}_{\text{coeff}} \cdot x(n)$

$y_1(n) = a_1 \sin n \, x_1(n)$

$y_2(n) = a_2 \sin n \, x_2(n)$



$y_3(n) = a_1 \sin n \, x_1(n) + a_2 \sin n \, x_2(n)$



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

$y_5 = \sin n \cdot [a_1 x_1(n) + a_2 x_2(n)]$

$y_5 = a_1 \sin n \, x_1(n) + a_2 \sin(n) \, x_2(n)$

$y_3 = y_5$

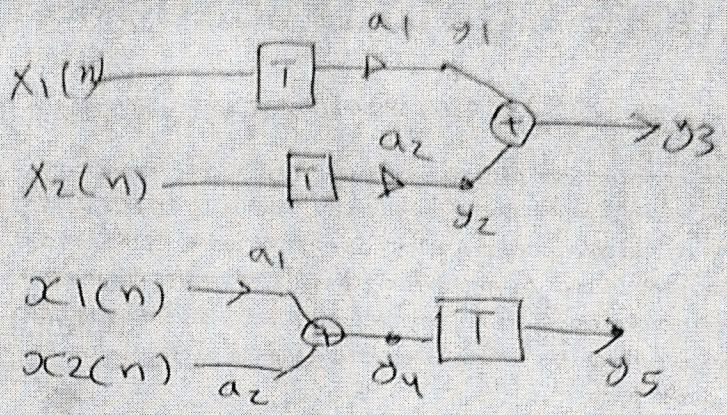
∴ Linear system

الاستنتاج النهائي

The system linearty is independent of the coff. used

ex/ Find The Linear and Non linear classification of The following system

$y(n) = e^3 x(n)$



$y_1(n) = a_1 e^3 x_1(n)$

$y_2(n) = a_2 e^3 x_2(n)$

$y_3(n) = a_1 e^3 x_1(n) + a_2 e^3 x_2(n)$

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

$y_5(n) = e^3 [a_1 x_1(n) + a_2 x_2(n)] = a_1 e^3 x_1(n) + a_2 e^3 x_2(n)$

$\therefore y_3 = y_5$ $\therefore$ the system is Linear

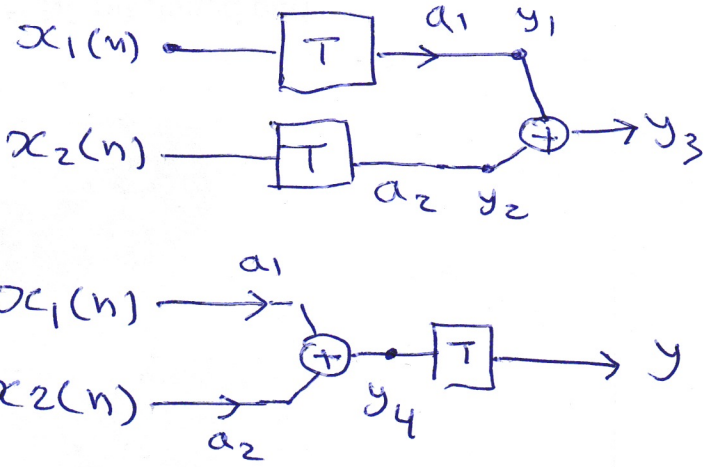
The system linearity is independent of The Coeffe used

الاستنتاج الثاني

L & NL

ex 5

$$y(n) = \underbrace{2n}_{\text{Time dependent}} + \overbrace{x(n)}^{\text{I/P}}$$



$$y_1(n) = [2n + x_1(n)] \cdot a_1$$

$$y_2(n) = [2n + x_2(n)] \cdot a_2$$

$$y_3(n) = 2n a_1 + a_1 x_1(n) + 2n a_2 + a_2 x_2(n)$$

$$y_4 = \underbrace{[a_1 x_1(n) + a_2 x_2(n)]}_{\text{I/P}}$$

$$y_5 = 2n + [a_1 x_1(n) + a_2 x_2(n)]$$

$$y_5 = 2n + a_1 x_1(n) + a_2 x_2(n)$$

$y_3 \neq y_5$ non-Linear System

if any added / subtracted Term other Than i/p and o/p is available in The system relationship Then The system will be nonlinear

نتيجة

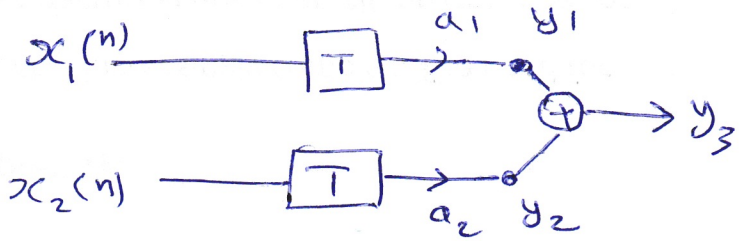
اذا كان في اي حد مضاف او مطروح غير الداخل والخارج في العلاقة يبقى النظام غير خطي

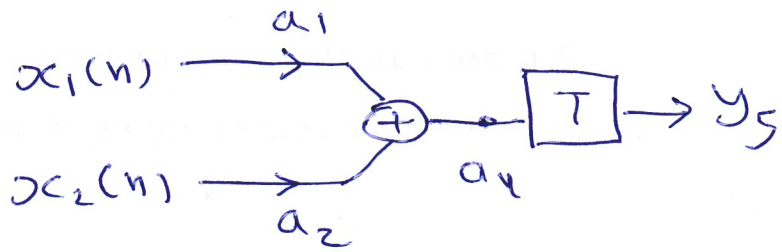
L & NL

ex 6

$y(n) = 2 + x(n)$ ← I/P

Time independent





$y_1(n) = [2 + x_1(n)] \cdot a_1$

$y_2(n) = [2 + x_2(n)] \cdot a_2$

$$y_3(n) = 2a_1 + a_1 x_1(n) + 2a_2 + a_2 x_2(n)$$

$$y_4 = [x_1(n) \cdot a_1 + x_2(n) \cdot a_2] \leftarrow \text{I/P}$$

$$y_5 = 2 + [x_1(n) \cdot a_1 + x_2(n) \cdot a_2]$$

$$y_5 = 2 + x_1(n)\, a_1 + x_2(n)\, a_2$$

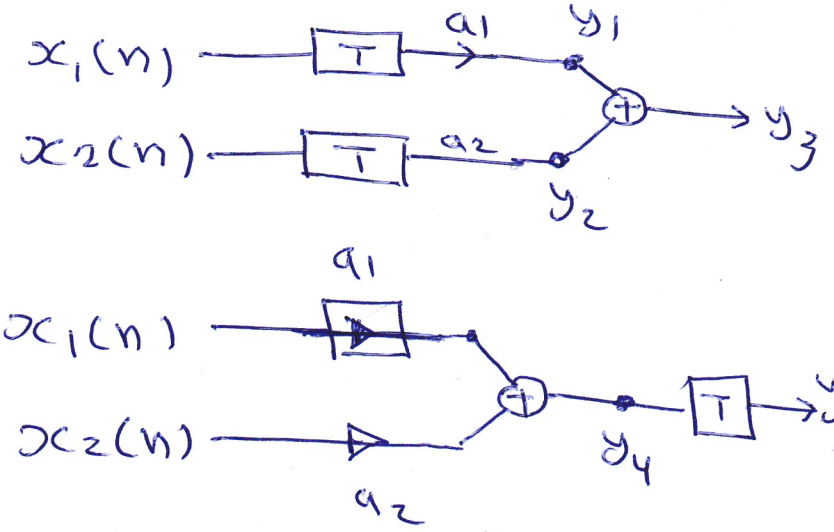
$\therefore y_3 \neq y_4$

if any added/subtracted Term other Than i/p and o/p is available in The system relation ship Then The system will be nonlinear

ex7

(7)
L & NL

$$x(n) = \underbrace{x(n-2)}_{i/p\,1} + \underbrace{x(n+3)}_{i/p\,2}$$



$$y_1(n) = a_1\left[x_1(n-2) + x_1(n+3)\right]$$

$$y_2(n) = a_2\left[x_2(n-2) + x_2(n+3)\right]$$

$$y_3 = a_1 x_1(n-2) + a_1 x_1(n+3) + a_2 x_2(n-2) + a_2 x_2(n+3)$$

$$y_4(n) = \left[a_1 x_1(n) + a_2 x_2(n)\right]$$

$$y_5 = \underbrace{\left[a_1 x_1(n-2) + a_2 x_2(n-2)\right]}_{i/p\,1} + \underbrace{\left[a_1 x_1(n+3) + a_2 x_2(n+3)\right]}_{i/p\,2}$$

$$y_5 = a_1 x_1(n-2) + a_1 x_1(n+3) + a_2 x_2(n-2) + a_2 x_2(n+3)$$

$y_3 = y_5$ ∴ Linear system

The system output is sum of shifted Input

if The o/p is summation of Time shifted terms of i/p. Then The system will be linear

ex

① $y(n) = x(n-1) + x(n+1) + x(n+2)$

② $y(n) = x(n-3) + x(n) + x(n+5)$

③ $y(n) = x(n) + x(n-10)$

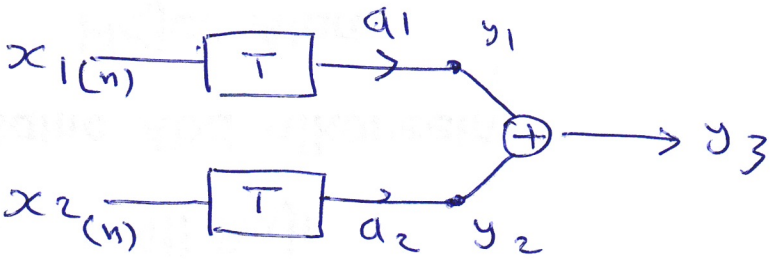
L & NL

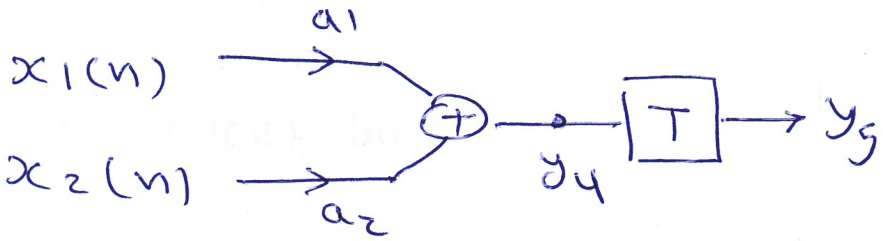
ex 8| ⟵ SNL

$$y(n) = \int_{-\infty}^{n} x(n)\, dn$$

integral and differential operators are linear

الاستنتاج الخاص





$$y_1(n) = a_1 \int_{-\infty}^{n} x_1(n)\, dn$$

$$y_2(n) = a_2 \int_{-\infty}^{n} x_2(n)\, dn$$

$$y_3(n) = a_1 \int_{-\infty}^{n} x_1(n)\, dn + a_2 \int_{-\infty}^{n} x_2(n)\, dn$$

$$y_3(n) = \int_{-\infty}^{n} a_1 x_1(n)\, dn + \int_{-\infty}^{n} a_2 x_2(n)\, dn$$

$$y_3(n) = \int_{-\infty}^{n} [a_1 x_1(n) + a_2 x_2(n)]\, dn$$

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

R(I/P)

$$y_5(n) = \int_{-\infty}^{n} [a_1 x_1(n) + a_2 x_2(n)]\, dn$$

$\therefore y_3 = y_5$ $\therefore$ linear system

HW1

10

LSNL

① $y(n) = [\log(n) + 3n^2] \cdot x(n)$

② $y(n) = n.u(n) \cdot x(n)$

③ $y(n) = 2n^3 + x(n^3)$

④ $y(n) = x(n-1) + x(n+1)$

⑤ $y(n) = \frac{d}{dn} x(n)$