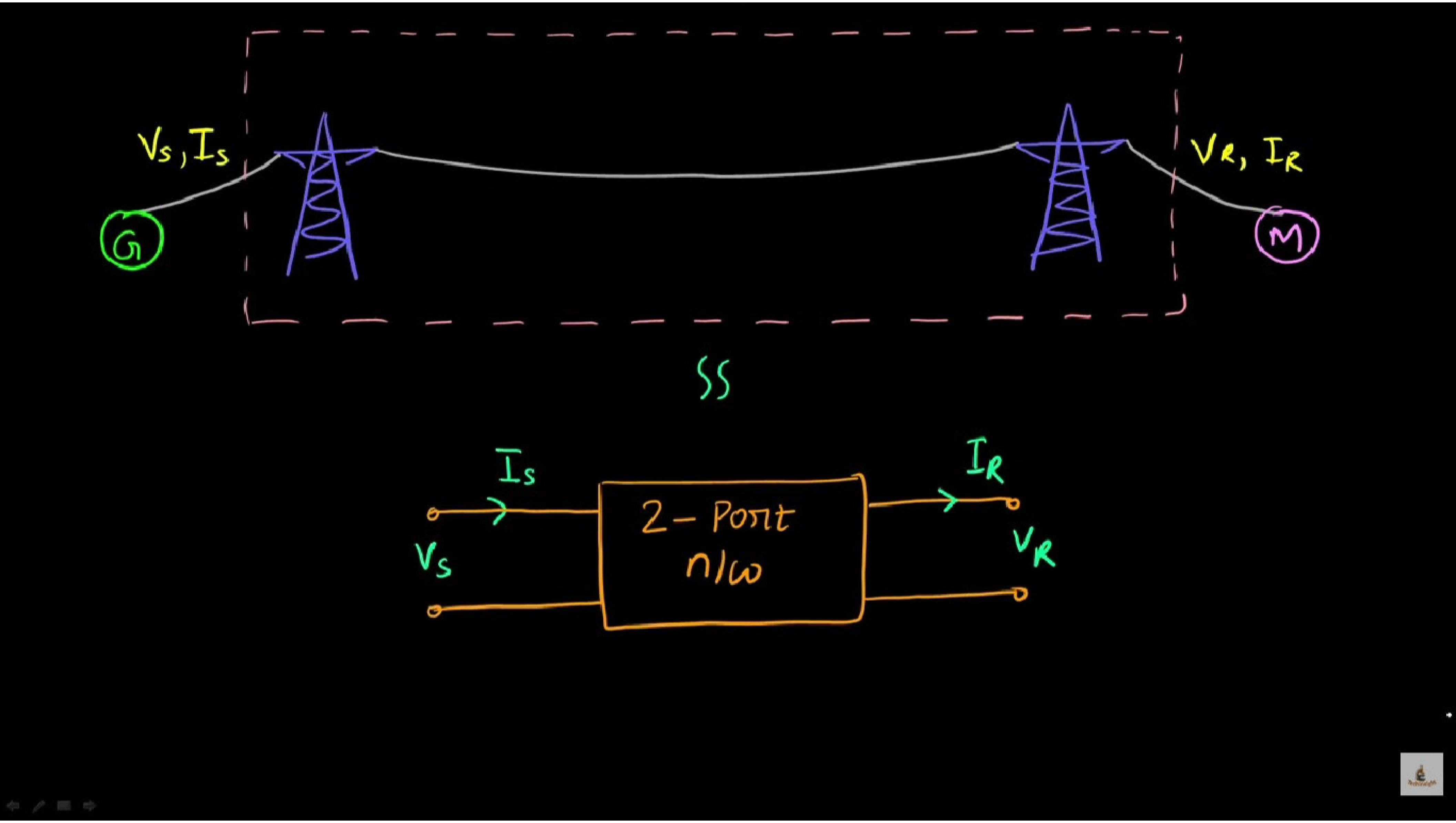
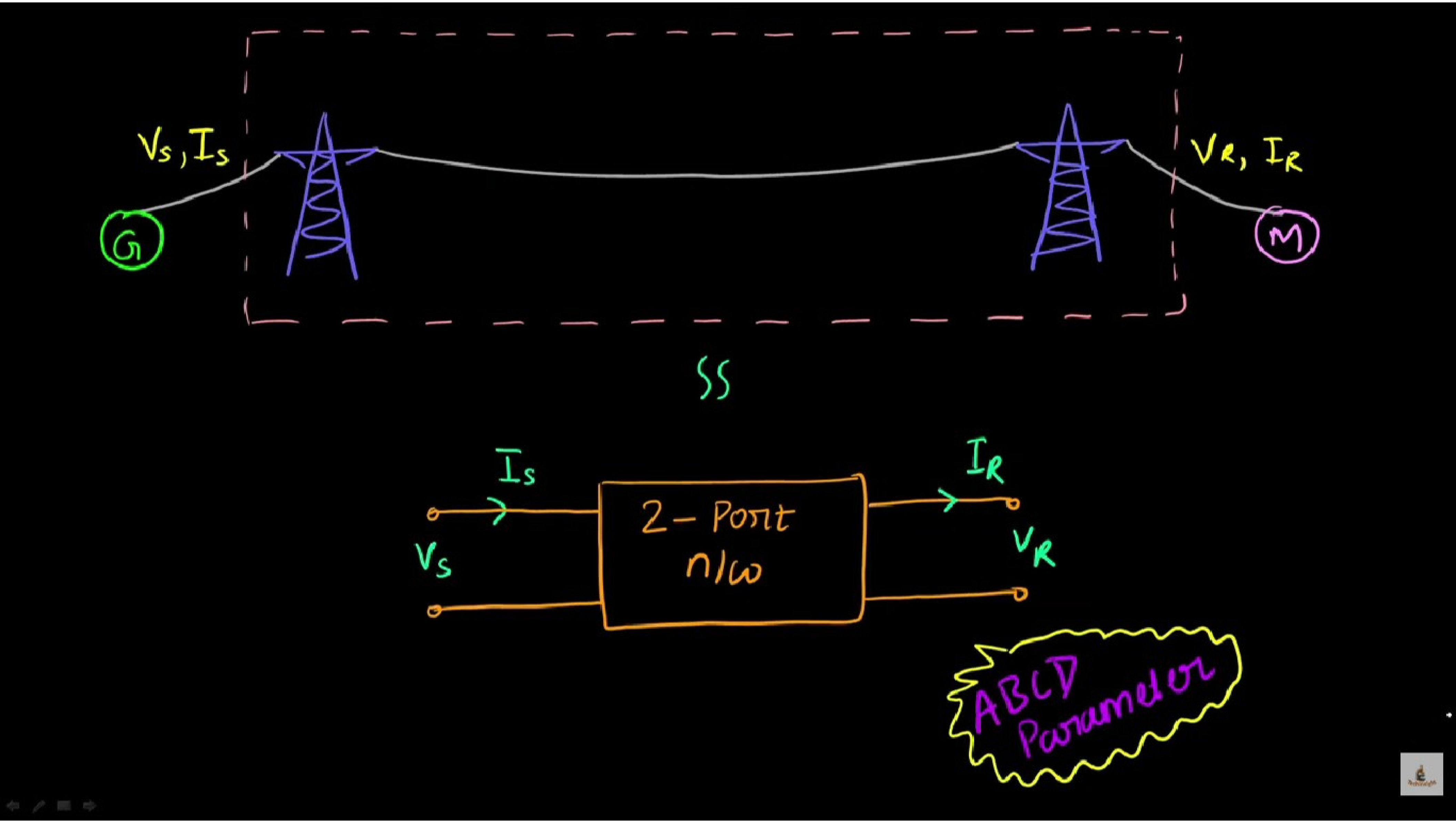
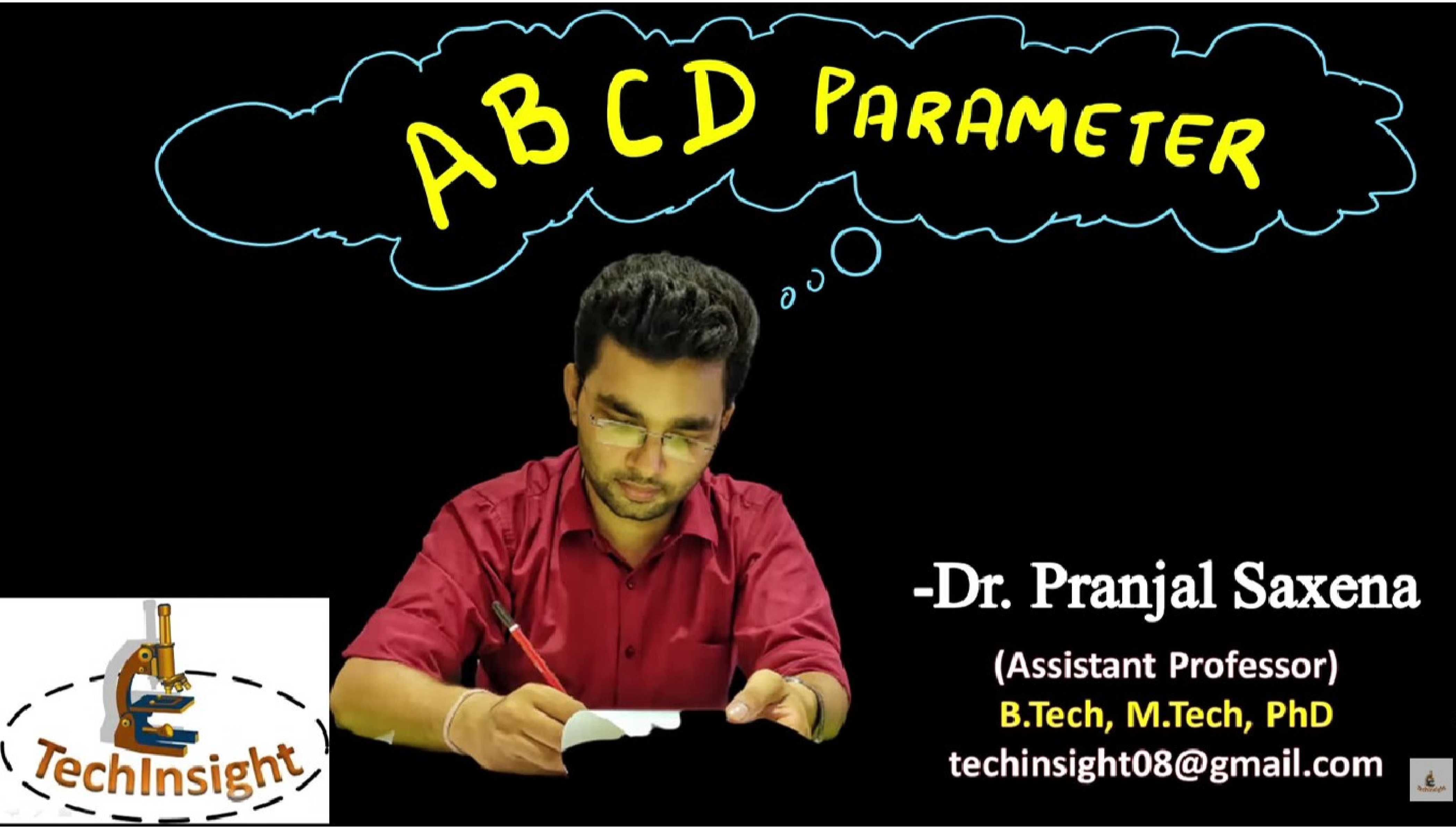


Vs, Is
G
VR, IR
M
SS
Is
IR
2-Port
n/w
Vs
VR



Vs, Is
VR, IR
G
M
Is
IR
2-Port
n/w
Vs
VR
ABCD
Parameter


ABCD PARAMETER
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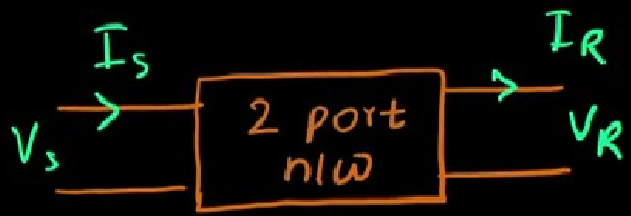
Quality of n/w



1. Passive → contain no EMF source
2. Linear → Having elements (R, L, C) that have consistent characteristic, doesn't change with V or I
3. Bilateral → Impedance is independent of direction of current flowing.

#ABCD Parameter

* Also known as generalized circuit constants or ABCD constants

$$\begin{bmatrix} V_s \\ I_s \end{bmatrix} = \begin{bmatrix} A & B \\ C & D \end{bmatrix} \begin{bmatrix} V_R \\ I_R \end{bmatrix}$$

$$V_s = AV_R + BI_R$$

$$I_s = CV_R + DI_R.$$

NOTE:- ABCD are complex numbers.

ABCD parameter when receiving end is open ckt

$\underline{\text{open ckt}} \rightarrow I_R = 0$

$$V_s = AV_R + B\cancelto{0}{I_R}$$

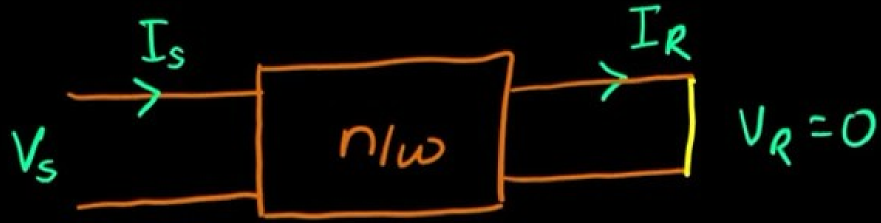
$$I_s = CV_R + D\cancelto{0}{I_R}$$

$$A = \left.\frac{V_s}{V_R}\right|_{I_R=0} \rightarrow \text{Open ckt Reverse voltage Ratio}$$

$$C = \left.\frac{I_s}{V_R}\right|_{I_R=0} \rightarrow \text{open ckt conductance or Transfer admittance}$$

ABCD parameter when receiving end is short ckt.

$\rightarrow V_R = 0$



$$V_s = A\cancel{V_R}^{\,0} + BI_R$$

$$I_s = C\cancel{V_R}^{\,0} + DI_R$$

$$B = \left.\frac{V_s}{I_R}\right|_{V_R=0}$$

Short ckt Resistance

$$D = \left.\frac{I_s}{I_R}\right|_{V_R=0}$$

Short ckt reverse current transfer Ratio

Meaning of ABCD

* $V_S = AV_R + BI_R$
  $I_S = CV_R + DI_R$

$$A = \left.\frac{V_S}{V_R}\right|_{I_R=0} \qquad B = \left.\frac{V_S}{I_R}\right|_{V_R=0}$$

$$C = \left.\frac{I_S}{V_R}\right|_{I_R=0} \qquad D = \left.\frac{I_S}{I_R}\right|_{V_R=0}$$

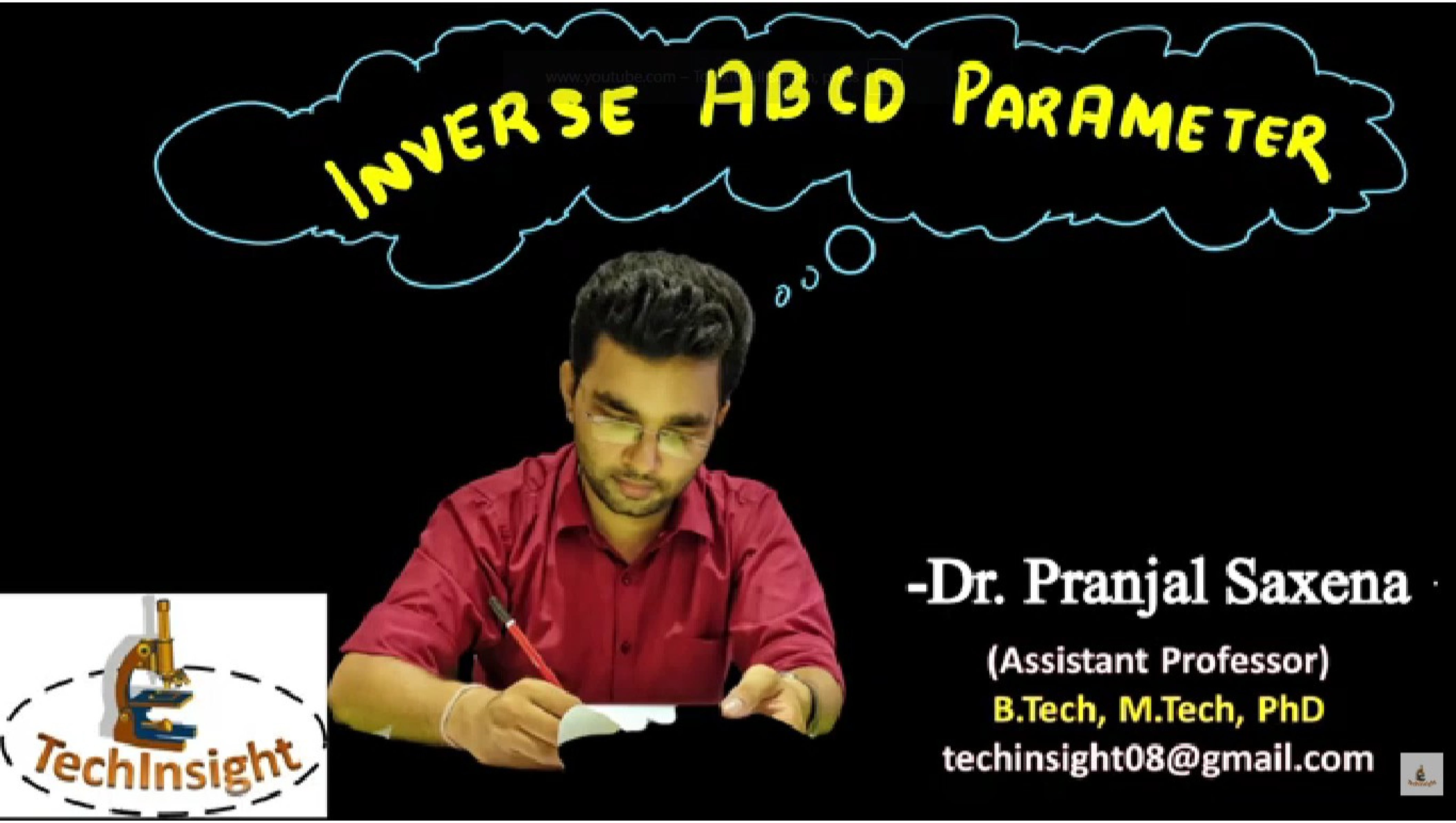
* A → voltage ratio
  D → current ratio

  → Dimension less

C → Admittance (mho)

B → Impedance (ohm)

A	V_s/V_R	Voltage Ratio or Reverse voltage gain	No unit
B	V_s/I_R	Short Circuit Resistance or Reverse transfer impedance	ohm
C	I_s/V_R	Open circuit Conductance or Reverse transfer admittance	mho
D	I_s/I_R	Current Ratio or Reverse current gain	No unit


INVERSE ABCD PARAMETER
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Inverse ABCD parameter

In case we know, V_s, I_s and we want to find V_R, I_R

By using inverse ABCD parameter

$$\begin{bmatrix} V_s \\ I_s \end{bmatrix} = A \begin{bmatrix} V_R \\ I_R \end{bmatrix}$$

$$\frac{1}{A}\begin{bmatrix} V_s \\ I_s \end{bmatrix} = \begin{bmatrix} V_R \\ I_R \end{bmatrix} \Rightarrow \begin{bmatrix} V_R \\ I_R \end{bmatrix} = A^{-1}\begin{bmatrix} V_s \\ I_s \end{bmatrix}$$

$$\begin{bmatrix} V_R \\ I_R \end{bmatrix} = \underbrace{\begin{bmatrix} A' & B' \\ C' & D' \end{bmatrix}}_{\text{Inverse ABCD matrix}} \begin{bmatrix} V_s \\ I_s \end{bmatrix} \Rightarrow \begin{aligned} V_R &= A' V_s + B' I_s \\ I_R &= C' V_s + D' I_s \end{aligned}$$

$$A' = \left.\frac{V_R}{V_S}\right|_{I_S=0} \longrightarrow \text{Forward voltage gain}$$

$$B' = \left.\frac{V_R}{I_S}\right|_{V_S=0} \longrightarrow \text{Forward transfer impedance}$$

$$C' = \left.\frac{I_R}{V_S}\right|_{I_S=0} \longrightarrow \text{Forward transfer admittance}$$

$$D' = \left.\frac{I_R}{I_S}\right|_{V_S=0} \longrightarrow \text{Forward current gain}$$

Dependent and Independent Variable

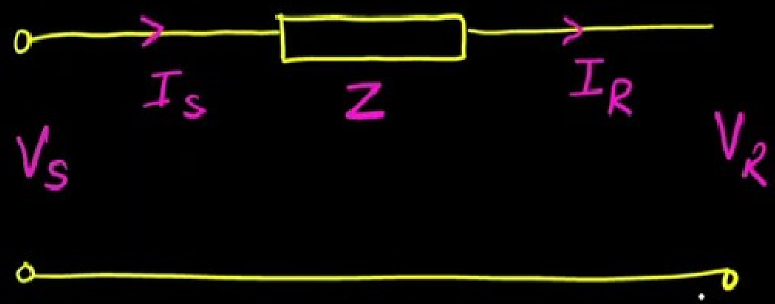
1. ABCD Parameter

$$\underbrace{\begin{bmatrix} V_S \\ I_S \end{bmatrix}}_{\text{dependent}} = \begin{bmatrix} A & B \\ C & D \end{bmatrix} \underbrace{\begin{bmatrix} V_R \\ I_R \end{bmatrix}}_{\text{independent}}$$

2. Inverse ABCD Parameter

$$\underbrace{\begin{bmatrix} V_R \\ I_R \end{bmatrix}}_{\text{dependent}} = \begin{bmatrix} A' & B' \\ C' & D' \end{bmatrix} \underbrace{\begin{bmatrix} V_S \\ I_S \end{bmatrix}}_{\text{independent}}$$

ABCD Parameters Short TL



$$\begin{bmatrix} V_s \\ I_s \end{bmatrix} = \begin{bmatrix} 1 & Z \\ 0 & 1 \end{bmatrix} \begin{bmatrix} V_R \\ I_R \end{bmatrix}$$

* $A = 1$ $B = Z$

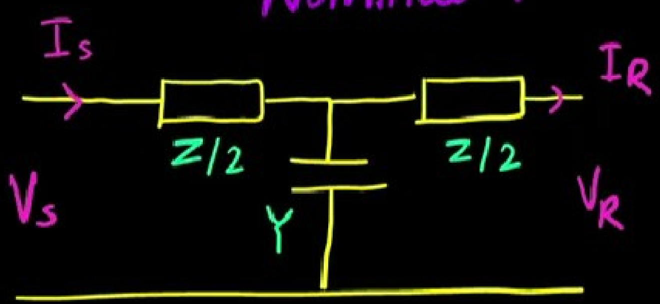
  $C = 0$ $D = 1$

* $A = D = 1$ [n/w is symmetrical]

* $AD - BC = 1$ [n/w is reciprocal]

ABCD Parameter of Medium TL

Nominal T

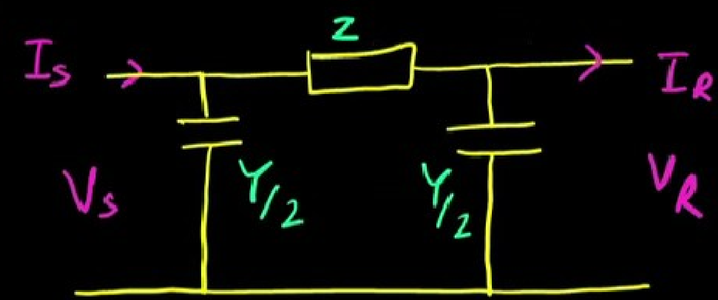


$$A = D = \left[1 + \frac{YZ}{2}\right]$$

$$B = Z\left[1 + \frac{YZ}{2}\right]$$

$$C = Y$$

Nominal π



$$A = D = \left[1 + \frac{YZ}{2}\right]$$

$$B = Z$$

$$C = Y\left[1 + \frac{YZ}{4}\right]$$

ABCD parameter of Long TL

$A = D = \cosh \gamma l$

$B = Z_c \sinh \gamma l$

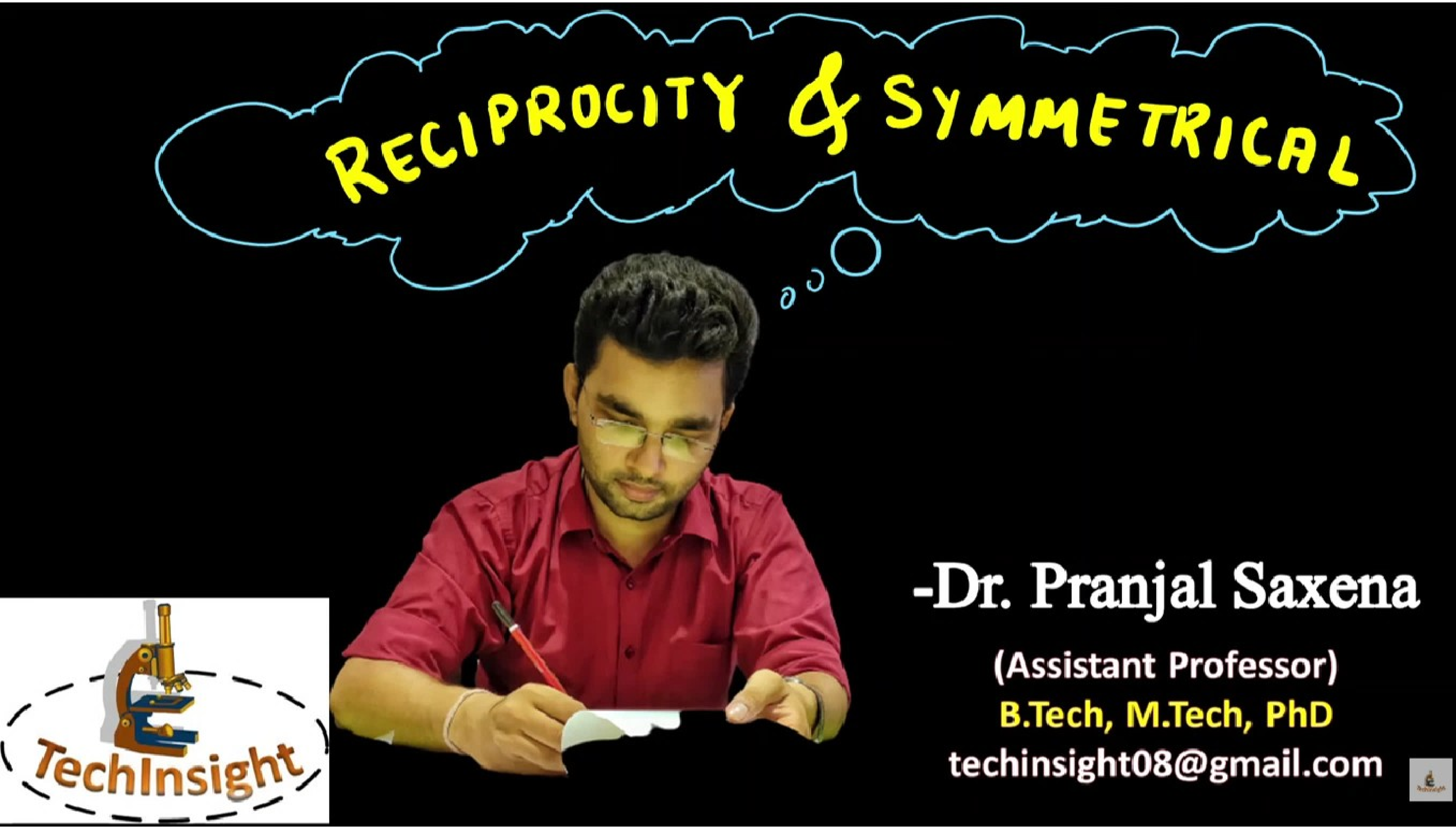
$C = \frac{1}{Z_c} \sinh \gamma l$

$\gamma \rightarrow$ propogation constant $= \sqrt{ZY}$

$Z_c \rightarrow$ surge or characteristic impedance $= \sqrt{\frac{Z}{Y}}$

$Z \rightarrow$ series impedance

$Y \rightarrow$ shunt admittance


RECIPROCITY & SYMMETRICAL
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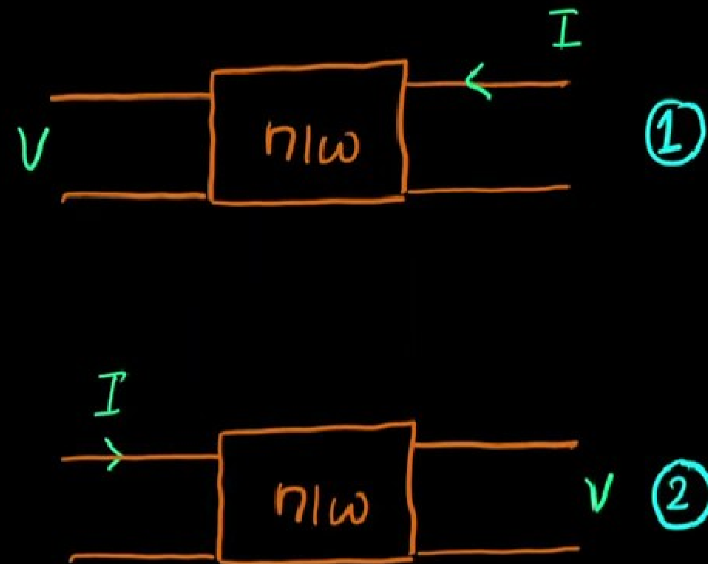
Reciprocity

"The two port n/w is said to be Reciprocal if the ratio of response to excitation remain same, even when the position of response and excitation are interchanged."

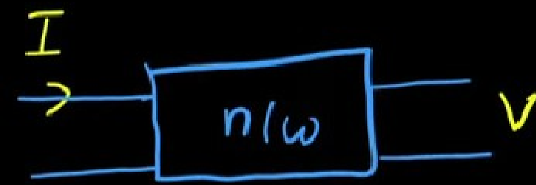


↳ case 1 $\frac{I}{V} = \frac{I}{V}$ of case 2

* A n/w consist of active components (generator, transistor) will not be reciprocal.

Reciprocity in ABCD parameters

"A n/w is said to be reciprocal if voltage appear at port-2 due to current at port-1 is same as voltage appear at port-1 when same current is applied at port-2"



* Generally, a n/w consist entirely linear-passive component is usually reciprocal

linear-passive component → R, L, C

Conditions of Reciprocity

* $\begin{vmatrix} A & B \\ C & D \end{vmatrix} = 1$

* $AD - BC = 1$

* N/w that are reciprocal and

  Lossless; A and D ⟶ Purely Real

  C and B ⟶ Purely imaginary

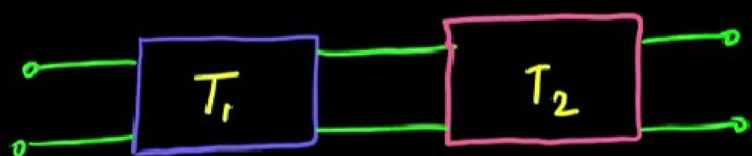
Symmetrical

"A n/w is symmetrical if i/p impedance is equal to its o/p impedance"

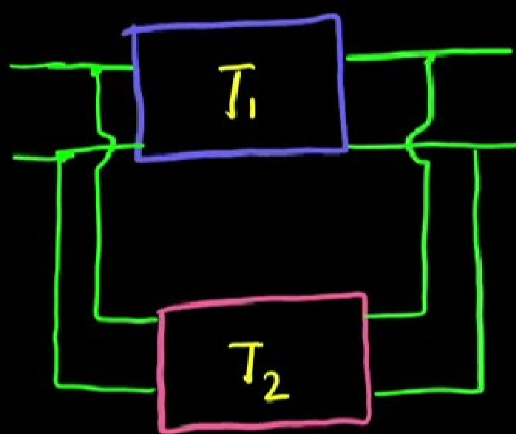
$$\frac{V_s}{I_s} = \boxed{Z_{i/p} = Z_{o/p}} = \frac{V_R}{I_R}$$

* $\dfrac{V_s}{I_s} = \dfrac{V_R}{I_R} \Rightarrow \dfrac{V_s}{V_R} = \dfrac{I_s}{I_R} \Rightarrow \boxed{A = D}$

CASCADING



" Series connection"



" Shunt connection"

Series Connections

* "when o/p of one network is connected to the i/p of other n/w"

Tandem Connection

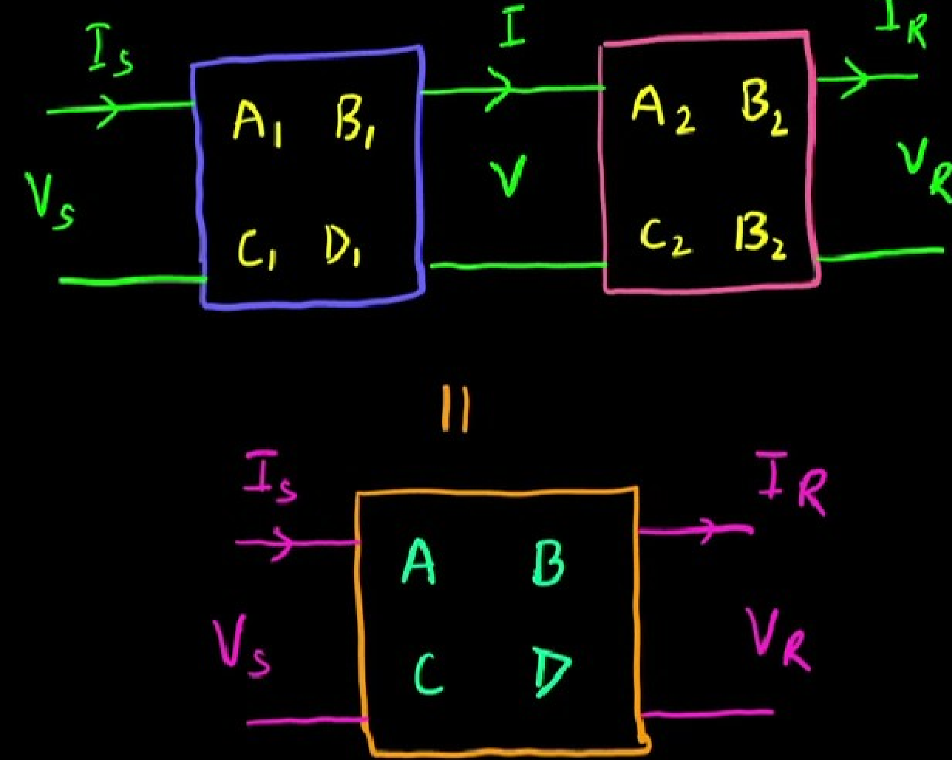
* $$\begin{bmatrix} A & B \\ C & D \end{bmatrix} = \begin{bmatrix} A_1 & B_1 \\ C_1 & D_1 \end{bmatrix} \begin{bmatrix} A_2 & B_2 \\ C_2 & D_2 \end{bmatrix}$$

* $A = A_1A_2 + B_1C_2$

  $B = A_1B_2 + B_1D_2$

  $C = A_2C_1 + C_2D_1$

  $D = B_2C_1 + D_1D_2$



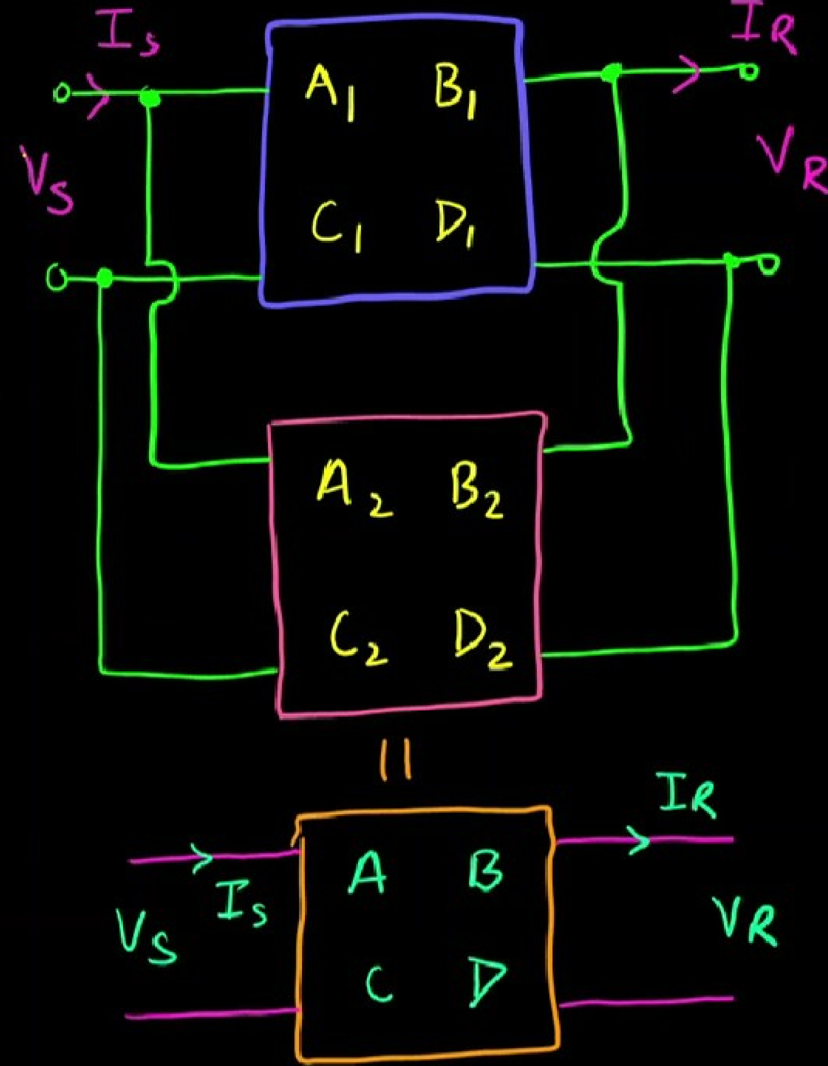
Shunt Connection

$$A = \frac{A_1 B_2 + A_2 B_1}{B_1 + B_2}$$

$$B = \frac{B_1 B_2}{B_1 + B_2}$$

$$D = \frac{D_1 B_2 + D_2 B_1}{B_1 + B_2}$$

$$C = C_1 + C_2 + \frac{(A_1 - A_2)(D_2 - D_1)}{B_1 + B_2}$$



Important Point

* If two reciprocal n/w are connected in parallel, then the cascaded n/w is also reciprocal.

* In series connection, cascaded n/w is not reciprocal.