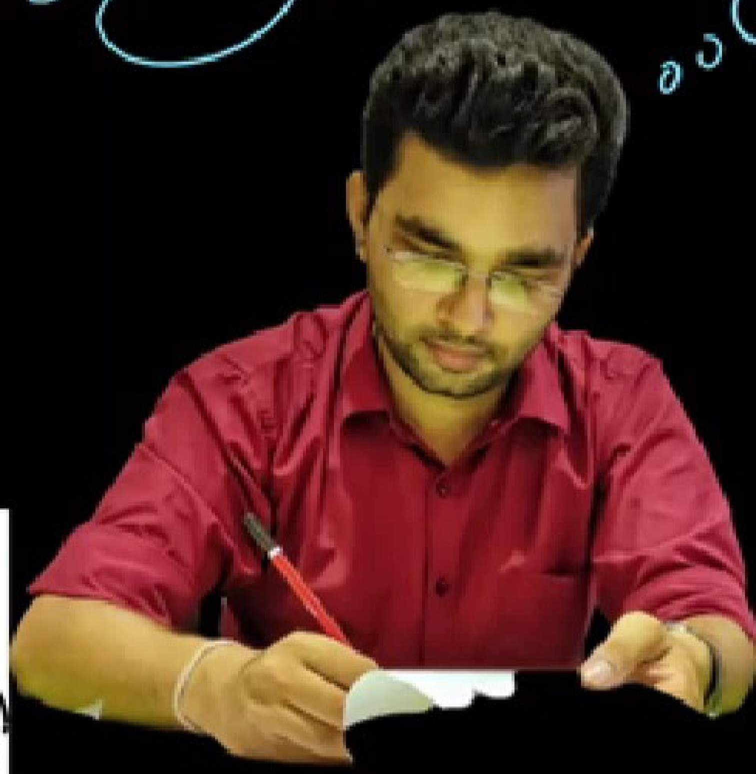
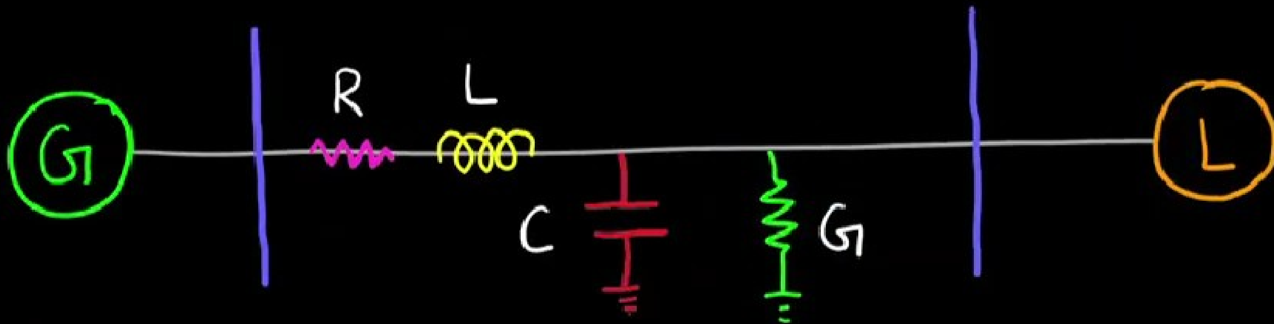
LOSSLESS TRANS. LINE



-Dr. Pranjal Saxena

(Assistant Professor)
B.Tech, M.Tech, PhD
techinsight08@gmail.com

TechInsight



PRACTICAL TL MODEL

* R → Losses in conductor → Lossy conductor

G → Losses in dielectric → Lossy insulator

* Ideal TL → Losses = 0 → R = 0, G = 0 → LOSSLESS TL

Lossless Transmission Line

" A TL that only exhibit pure reactive component (L, C) and zero loss component ($R = G = 0$)."

* 

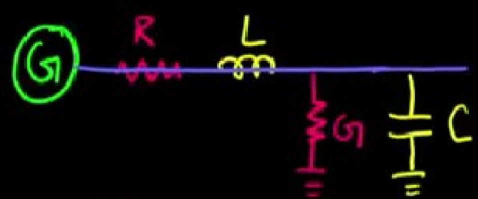
Practical TL or Lossy TL

Lossless TL

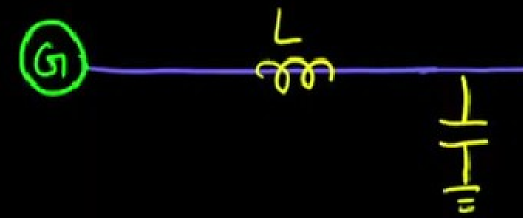
* Ideal Lossless line $\longrightarrow$ $R = 0$, $G = 0$

  Practical lossless line $\longrightarrow$ $R \ll \omega L$, $G \ll \omega C$

Features of Lossless TL

1. 

Practical TL or
Lossy TL



Lossless TL

Z (series impedance) $= R + j\omega L$

Y (shunt admittance) $= G + j\omega C$

$Z = j\omega L \quad [R << j\omega L]$

$Y = j\omega C \quad [G << j\omega C]$

2. In lossless line,

$$P_{deliver} = P_{Received}$$

→ No powerloss b/w source and Load end

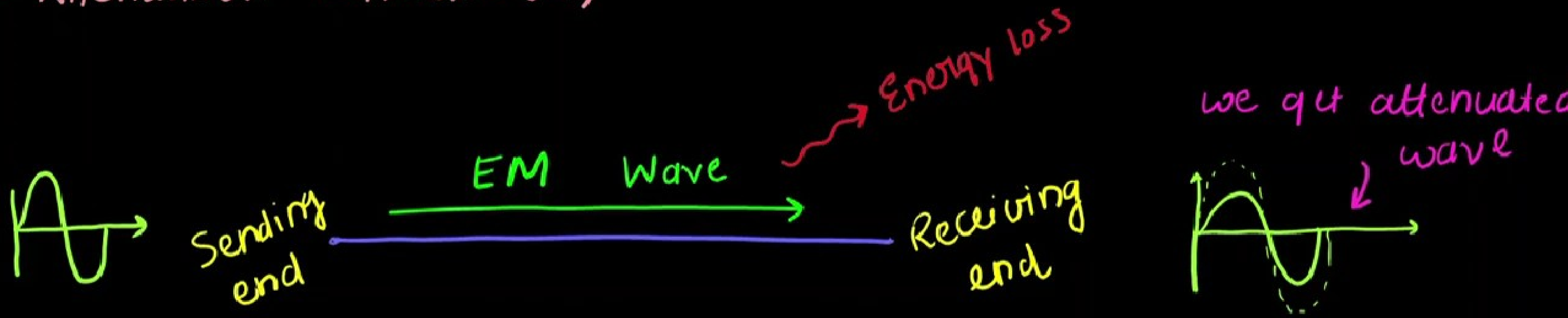
3. In lossless TL

- Line conductors ⟶ Perfect Conductor
- Dielectric ⟶ Perfect Insulator

4.

TL Nature	Line Parameters	Surge Impedance	Z_0 Nature
Lossy	R, L, C, G	$\sqrt{\frac{R+j\omega L}{G+j\omega C}}$	complex
Lossless	L, C	$\sqrt{L/C}$	Real

5. Attenuation Constant (α)



attenuation constant (α) : measure attenuation of EM wave passing through a $\boxed{\text{medium}}$

Lossy
$\alpha \neq 0$

Lossless
$\alpha = 0$

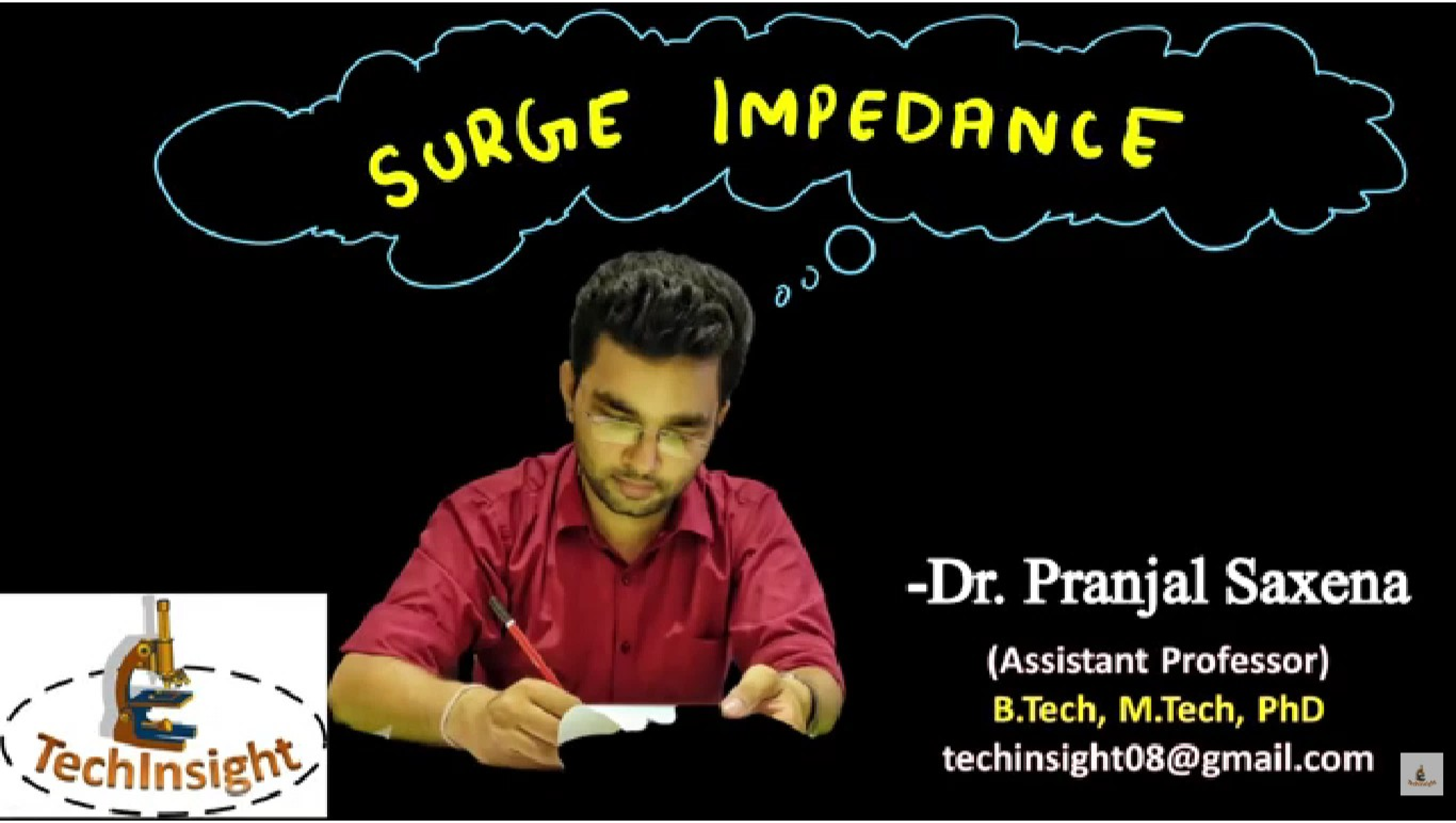
* wave attenuation

R, G of TL

6. We know that Lossless line is pysically Impossible

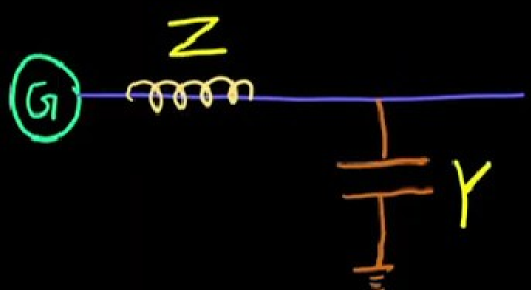
Practical Importance ?

use loss line TL equations to approximate the behavior of low-Loss TL.

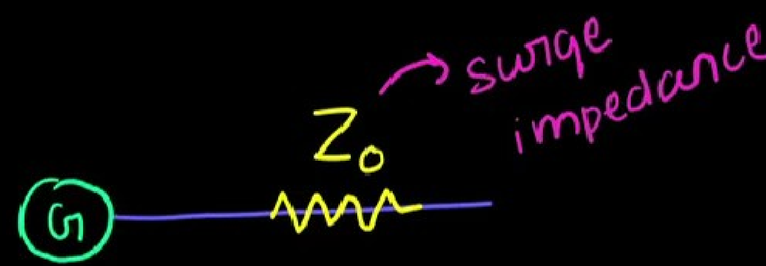

SURGE IMPEDANCE
-Dr. Pranjal Saxena
(Assistant Professor)
B.Tech, M.Tech, PhD
techinsight08@gmail.com
TechInsight

Surge Impedance

"In a lossless line, the impedance offer by line Inductance and Capacitance is known as surge impedance"



$\approx$

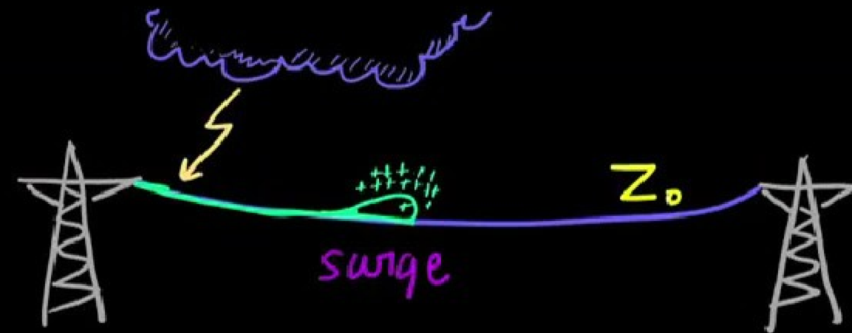


$Z_0 \rightarrow$ purely resistive in nature

* surge impedance also known as;
  - ↳ Characteristic impedance
  - ↳ Natural impedance

Meaning

1. Surge impedance →



"Impedance that will offer by TL to the surge flowing through it"

2. Natural Impedance

"surge impedance has nothing to do with load, Z_0 is natural impedanie affered the TL."

3. Characteristic impedance ⟶ as it is decided by the geometry of 2 conductors.

Features of surge Impedance

* Z_0 (Over Head TL) ⟶ 400 to 600 Ω

  Z_0 (underground Cable) ⟶ 40 to 60 Ω

  ↳ As cable has 20 to 60 time more capacitance than OHTL

* Surge impedance $= \sqrt{\frac{L}{C}}$ ⟶ independent of Length

  ⟶ depends on spacing b/w conductors

* value of surge impedance will be same at all pts of line

Calculation of characteristic Impedance

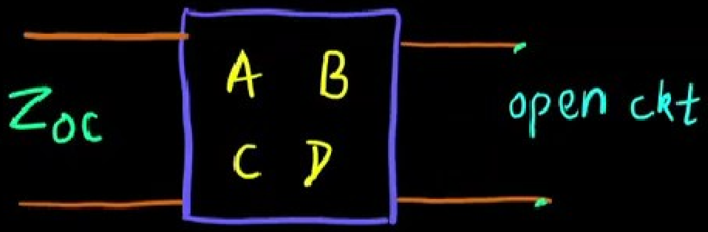
① 2-conductor TL

$$Z_0 = \frac{276}{\sqrt{\epsilon_r}} \log \frac{d}{r}$$

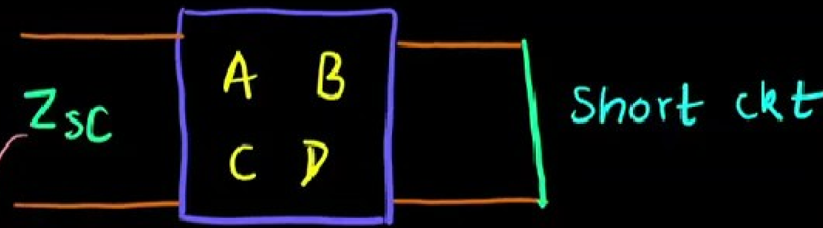
② coaxial cable

$$Z_0 = \frac{138}{\sqrt{\epsilon_r}} \cdot \log \frac{d_1}{d_2}$$

*



open ckt impedance → $1/C$



short ckt impedance → B

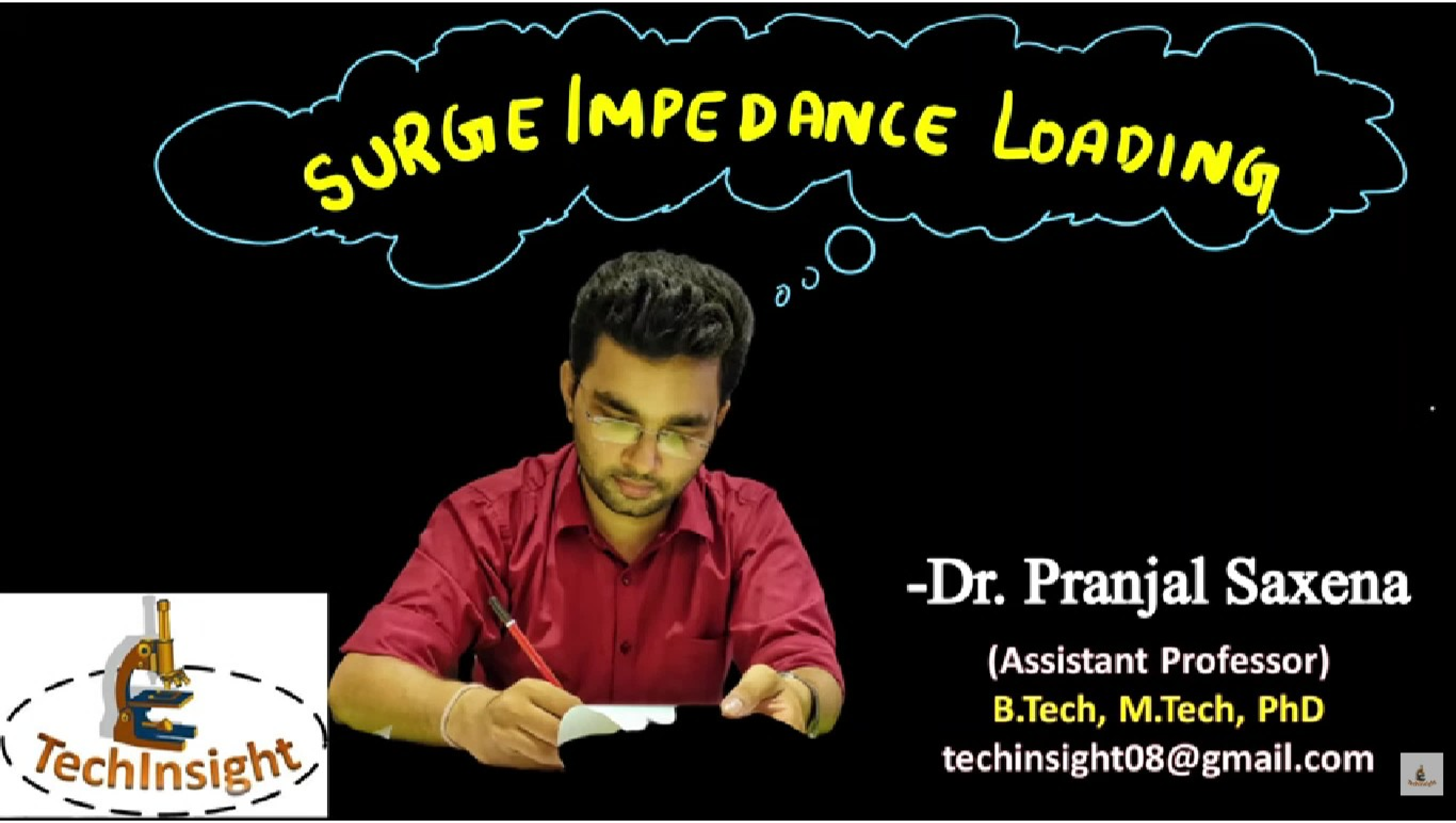
→ $Z_{oc} \cdot Z_{sc} = \frac{B}{C} = \frac{Z}{Y}$

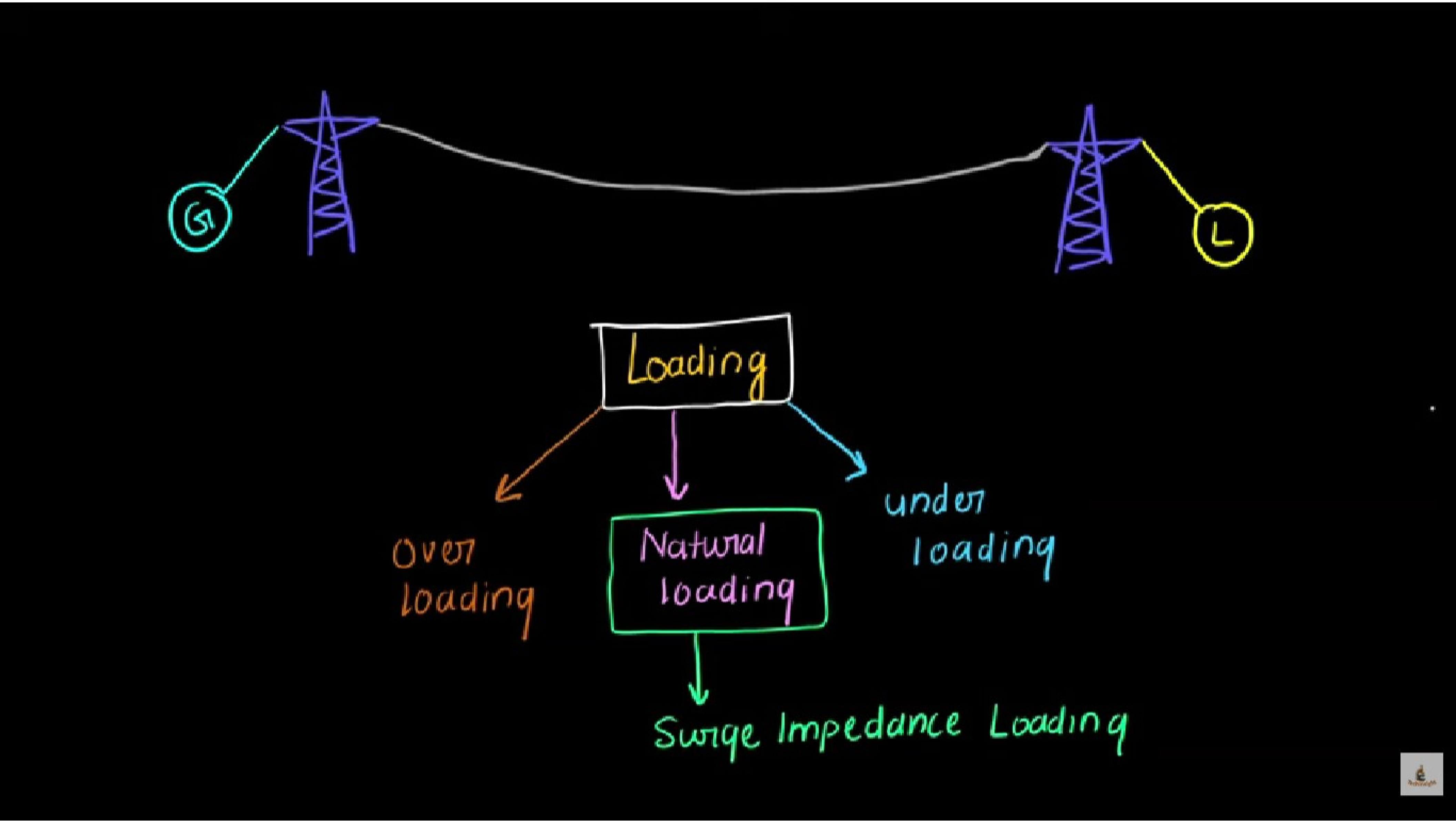
Z → series impedance

Y → shunt admittance

→ $Z_0 = \sqrt{Z_{oc} \cdot Z_{sc}} = \sqrt{\frac{B}{C}} = \sqrt{\frac{Z}{Y}}$

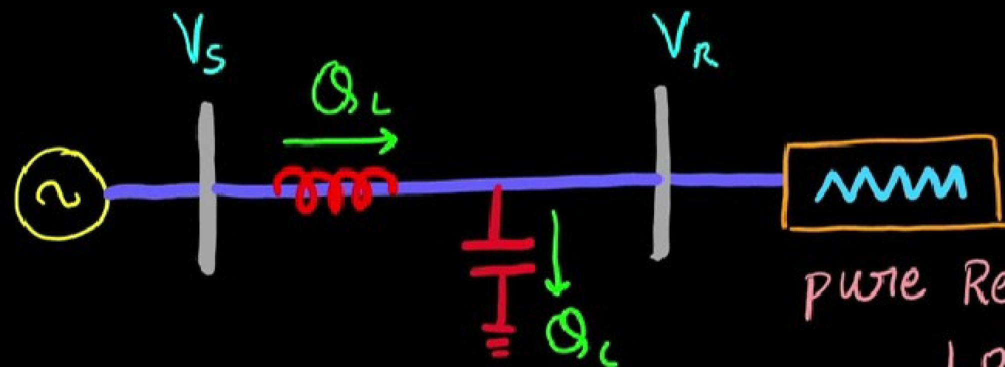
A	V_S/V_R	Voltage Ratio or Reverse voltage gain	No unit
B	V_S/I_R	Short Circuit Resistance or Reverse transfer impedance	ohm
C	I_S/V_R	Open circuit Conductance or Reverse transfer admittance	mho
D	I_S/I_R	Current Ratio or Reverse current gain	No unit


SURGE IMPEDANCE LOADING
-Dr. Pranjal Saxena
(Assistant Professor)
B.Tech, M.Tech, PhD
techinsight08@gmail.com
TechInsight


G
L
Loading
Over loading
Natural loading
under loading
Surge Impedance Loading

Surge Impedance Loading

" SIL is the power delivered by the TL to a purely resistive load equal to its surge impedance."



pure Resistive Load $= Z_0$

* In surge impedance loading

↳ $Q_L = Q_C \longrightarrow V_S = V_R$

* Called natural loading

$$\therefore \boxed{SIL = \frac{V_R^2}{Z_0}}$$

W or MW

Calculating Surge Impedance

* $Q_L = Q_C \longrightarrow$ Surge loading conditions

$$Q_C = Q_L$$

$$\frac{V_\phi^2}{X_C} = I_\phi^2 X_L$$

$$\frac{V}{I} = \sqrt{X_L X_C} = \sqrt{\frac{j\omega L l}{j\omega C l}} = \sqrt{\frac{L}{C}}$$

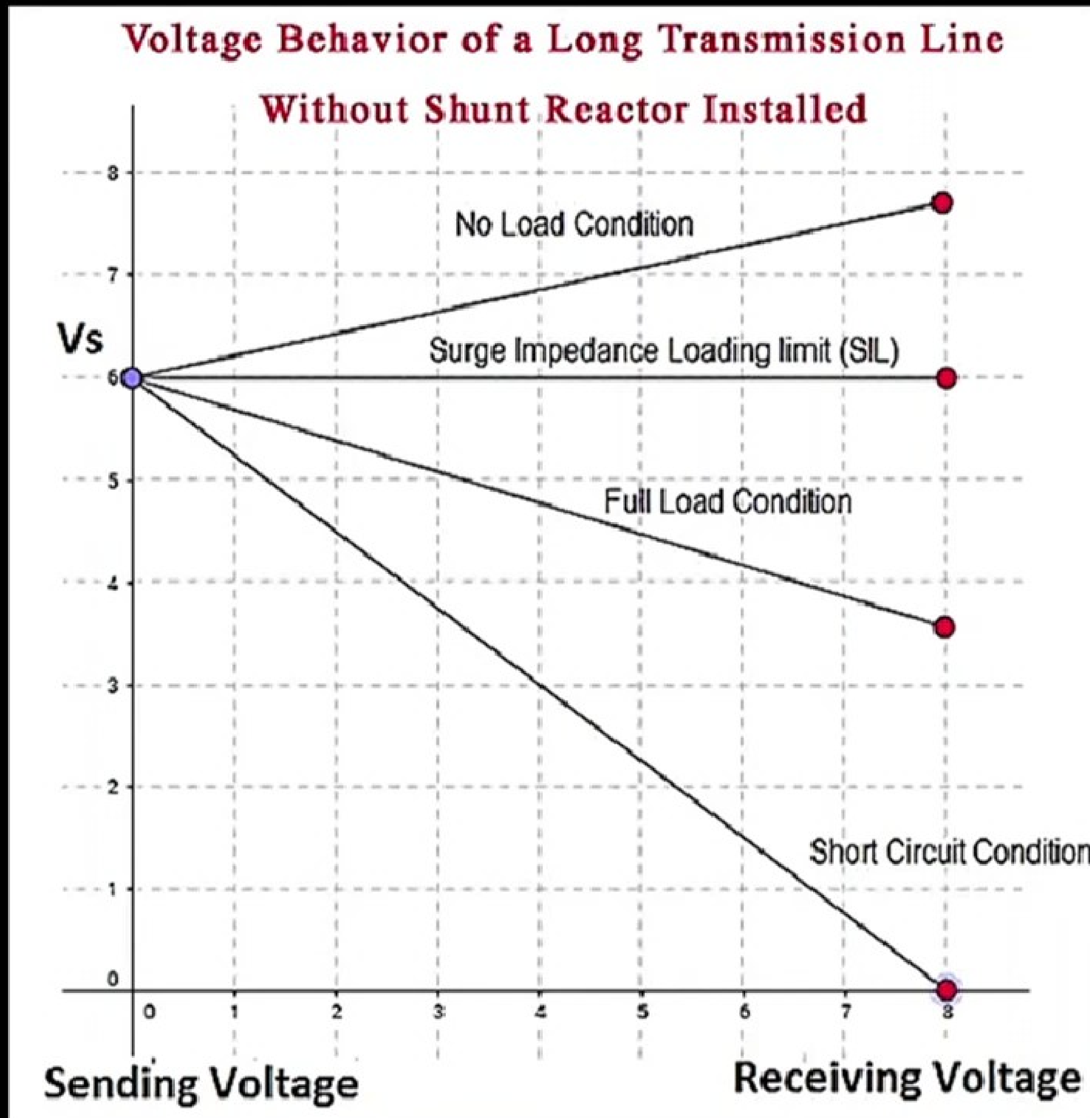
$$\therefore \boxed{Z_0 = \sqrt{\frac{L}{C}}}$$

Importance of SIL

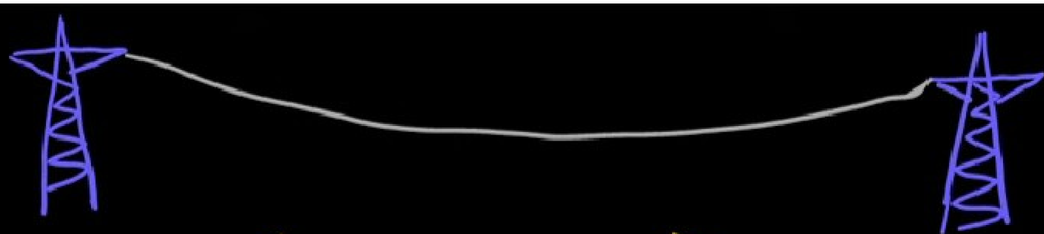
* Help in determining the max^m loading of TL

Loading Conditions	Voltage	Profile
Loading > SIL	$V_R < V_s$	Sag
Loading = SIL	$V_R = V_s$	Flat
Loading < SIL	$V_R > V_s$	Swell

(Ferranti Effect)


Voltage Behavior of a Long Transmission Line
Without Shunt Reactor Installed
No Load Condition
Surge Impedance Loading limit (SIL)
Full Load Condition
Short Circuit Condition
Vs
Sending Voltage
Receiving Voltage
0
1
2
3
4
5
6
7
8

*



High Capacitance

$\downarrow$

$Z_0 \downarrow$

$\downarrow$

SIL $\uparrow$

$\downarrow$

More power can be transfer without overload.

Low capacitance

$\downarrow$

$Z_0 \uparrow$

$\downarrow$

SIL $\downarrow$

$\downarrow$

Less power can be transfer without overload.

$\boxed{\text{NOTE}}$ → High value of Z_0 is undesirable.