



DTH2F3

Teknik Transmisi Radio

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1. PENDAHULUAN (KONSEP DASAR SALURAN TRANSMISI)

Content



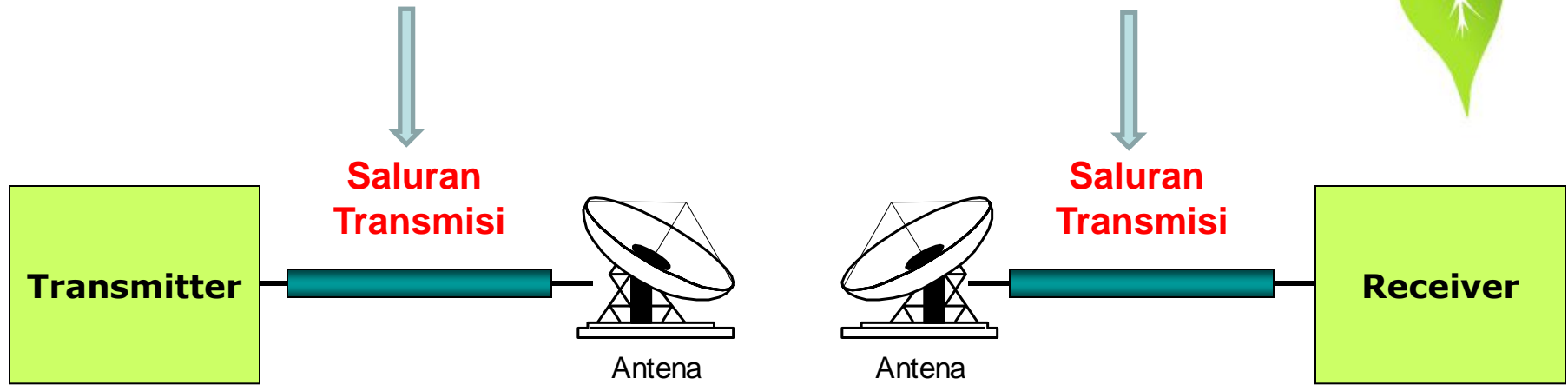
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5. Persamaan Umum Saluran Transmisi
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Fungsi dan Aplikasi Saluran Transmisi

BLOK SISTEM KOMUNIKASI RADIO



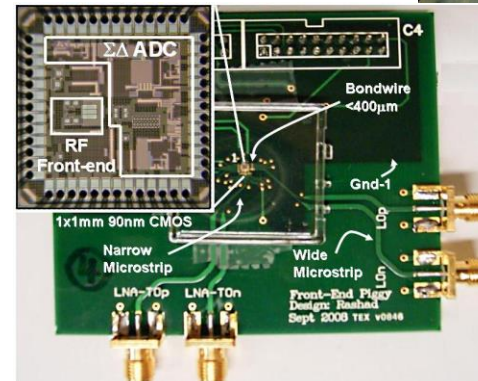
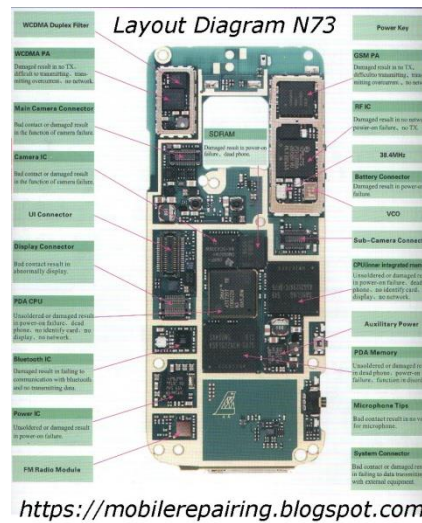
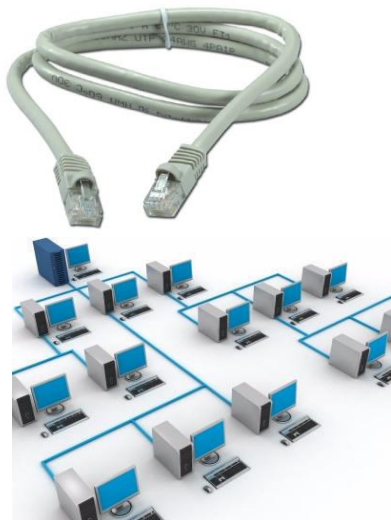
Transmitter berisi multiplexing, modulasi, upconverter, amplifier
Receiver berisi demultiplexing, demodulasi, down converter amplifier

Fungsi Saluran Transmisi



- Penghubung pesawat TV ke Antena dan sebaliknya
- Penghubung Sentral telepon dengan pelanggan
- Penghubung gardu listrik ke pelanggan pada jaringan PLN
- dll

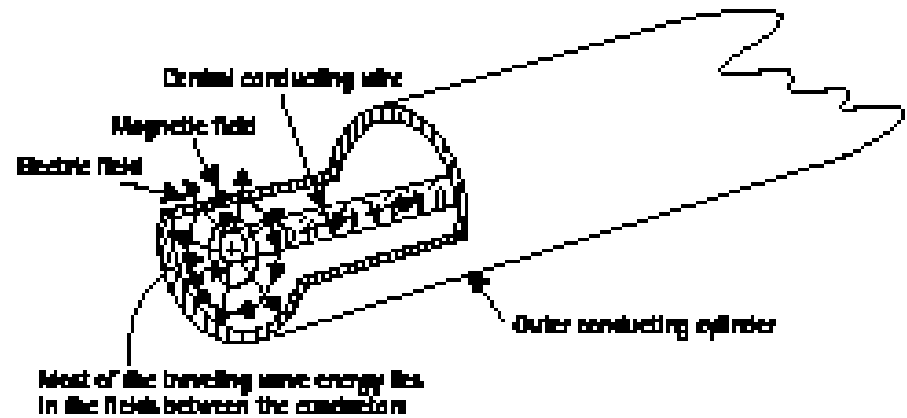
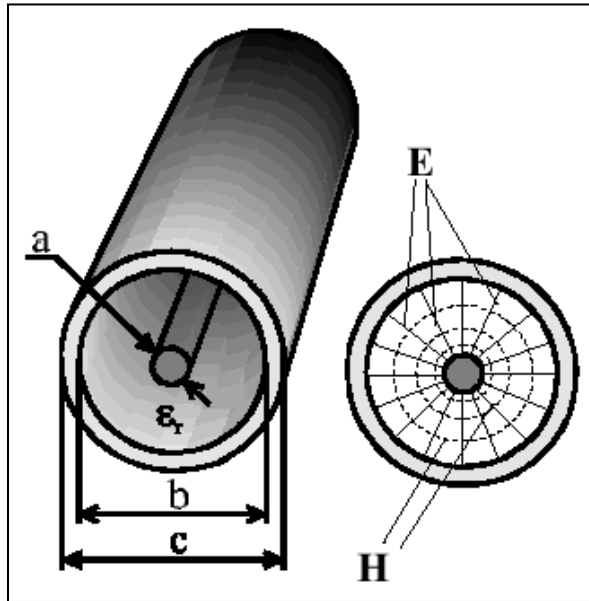
Aplikasi Saluran Transmisi



Contoh Saluran Transmisi



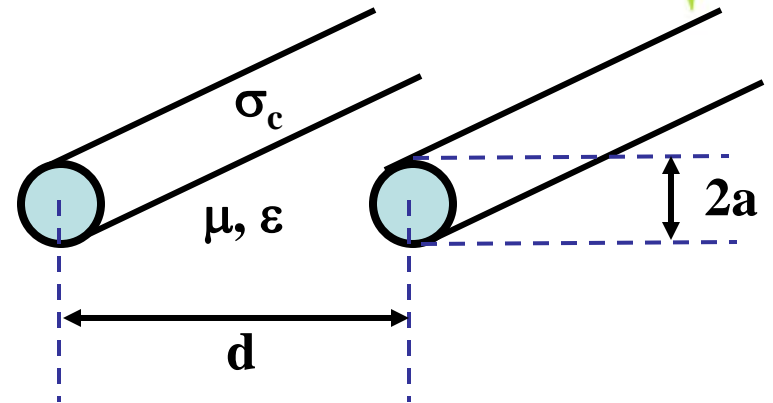
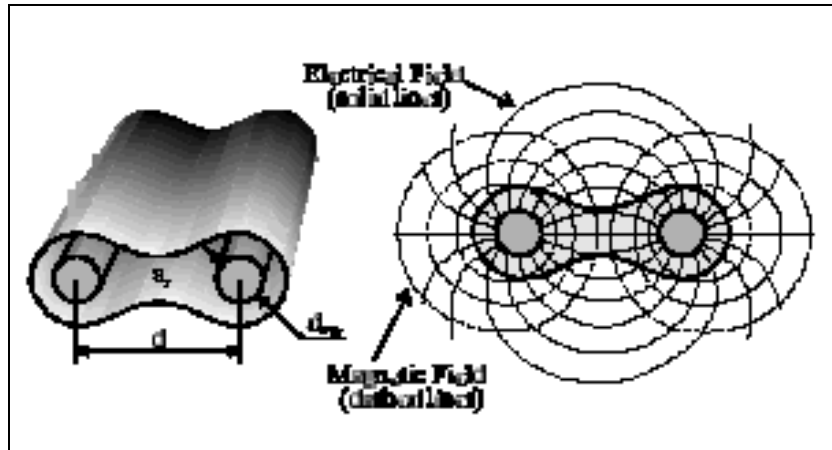
- Kabel Koaksial



Contoh saluran Transmisi



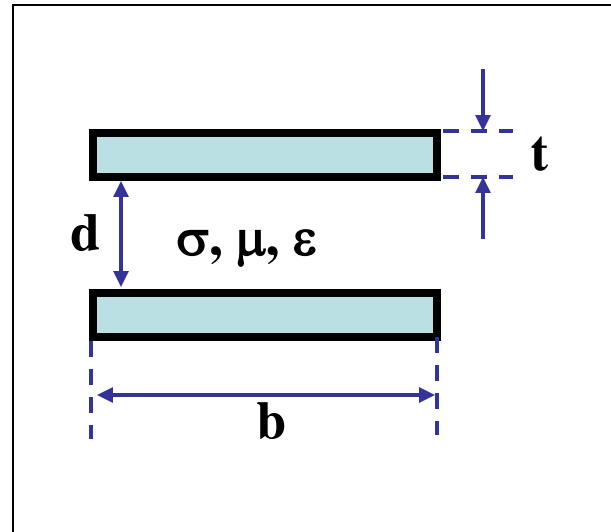
- 2 kawat sejajar



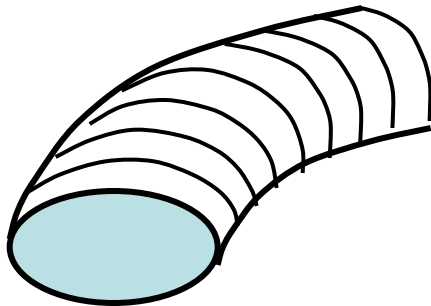
Contoh Saluran Transmisi



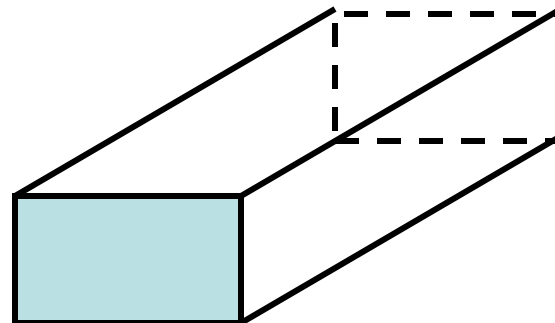
- Saluran Planar



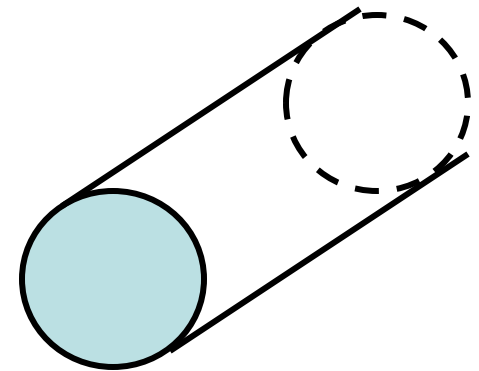
- Wave Guide



ellips



rectangular



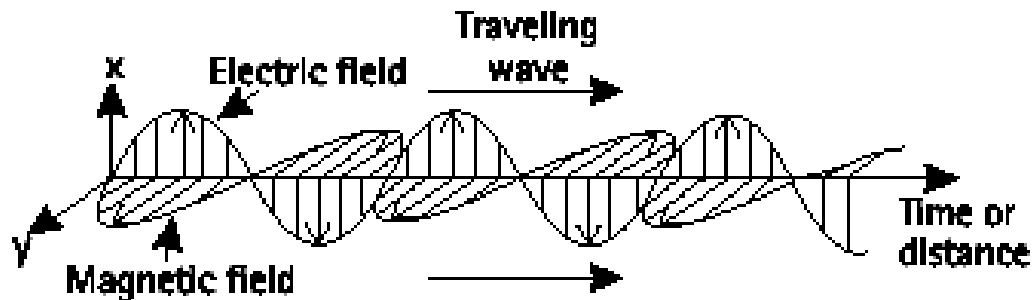
sirkular



Teori Saluran Transmisi

Teori Saluran Transmisi

- **Saluran transmisi** didefinisikan sebagai alat untuk menyalurkan energi elektromagnet dari suatu titik ke titik lain. Saluran transmisi dapat berupa kabel koaxial, kabel sejajar/twinlead, bumbung gelombang, optik, dan sebagainya.
- Macam-macam saluran transmisi umumnya ditentukan dari daerah frekuensi operasi, kapasitas daya yang disalurkan, maupun redaman saluran per meter. Disini karakteristik saluran transmisi diturunkan atas dasar analogi dengan gelombang datar dalam medium.



- **Saluran transmisi dikatakan uniform** jika distribusi penampang medan listrik dan medan magnetnya tampak sama pada tiap titik sepanjang saluran transmisi tersebut. Dalam hal ini, sebagaimana pada gelombang datar uniform, keadaan tersebut memerlukan karakteristik medium dielektrik yang uniform sepanjang saluran transmisi.
- Contoh saluran transmisi adalah : kabel PLN, kabel penghubung antara sentral yang bisa berbentuk serat optik, kabel koax, strip line, twisted pair.

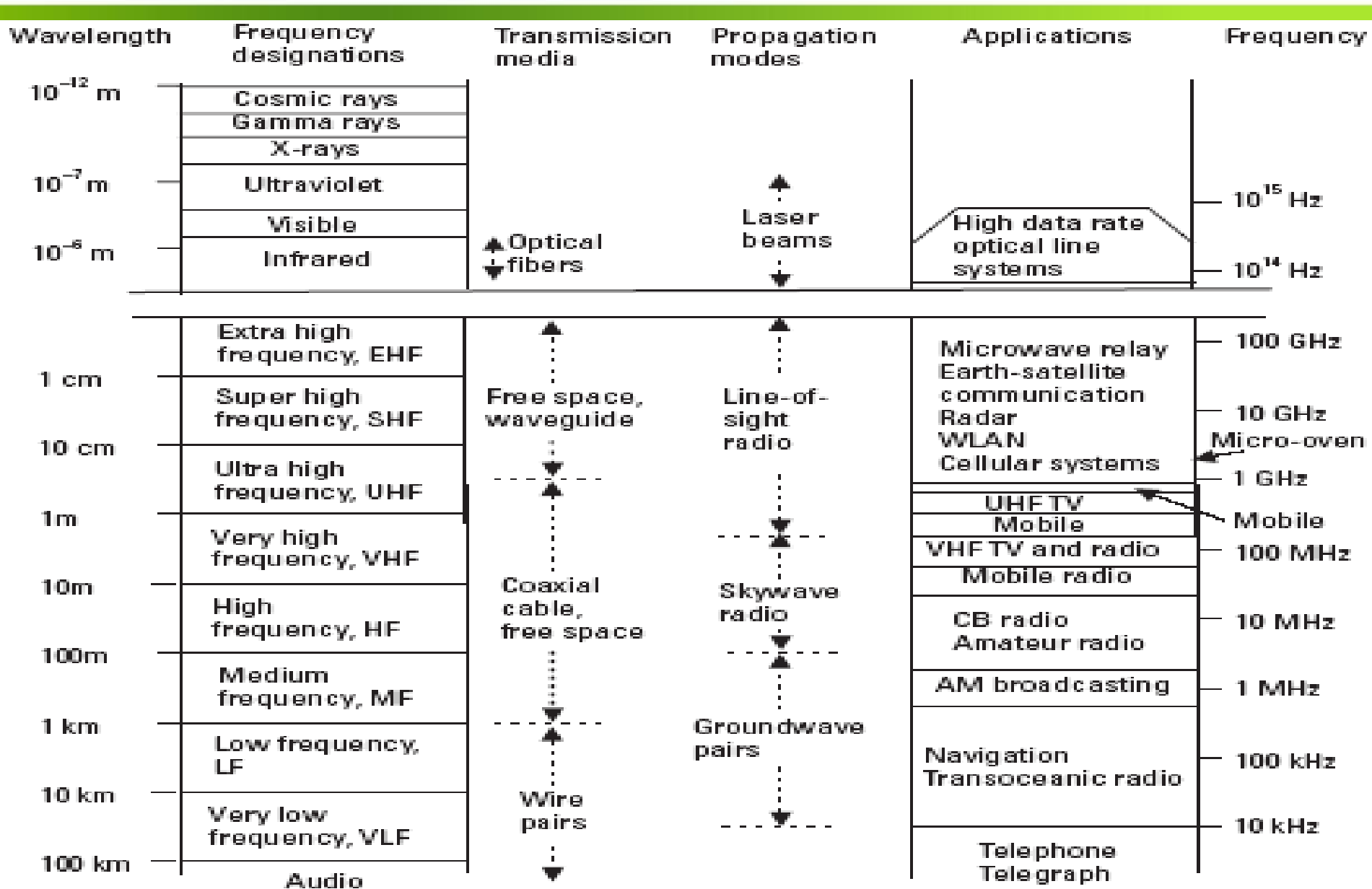


Figure 4.10 Allocation and applications of electromagnetic spectrum.

Teori Saluran Transmisi

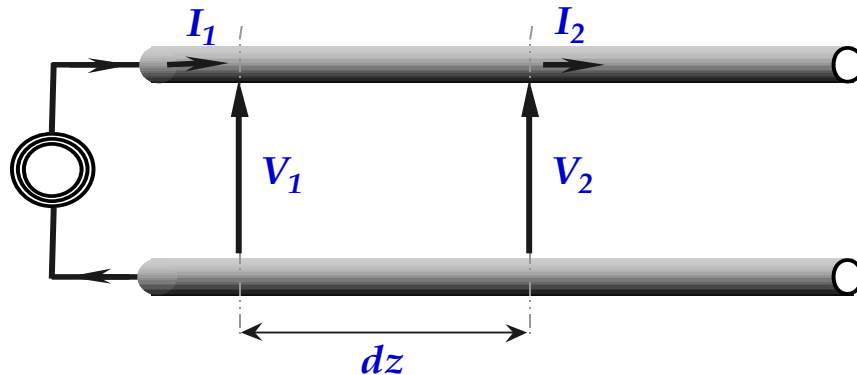


Key point about transmission line operation

Voltage and current on a transmission line is a function of both time and *position*.

$$V = f(z, t)$$

$$I = f(z, t)$$



The major deviation from circuit theory with transmission line, distributed networks is this positional dependence of voltage and current!

- Must think in terms of position and time to understand transmission line behavior
- This positional dependence is added when the assumption of the size of the circuit being small compared to the signaling wavelength

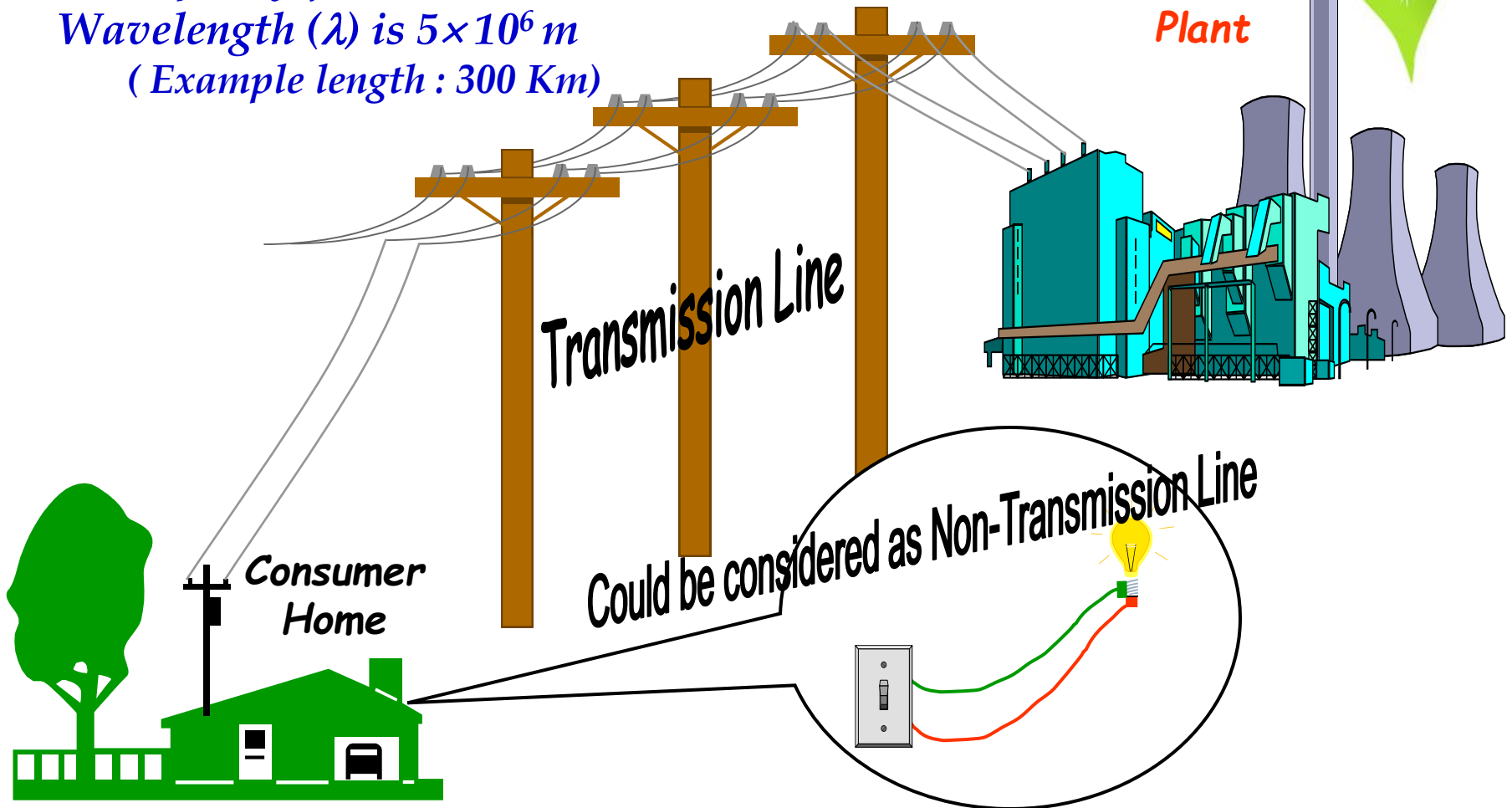
Teori Saluran Transmisi

Electrical Power Transmission Line

Power Frequency (f) is @ 60 Hz

Wavelength (λ) is 5×10^6 m

(Example length : 300 Km)



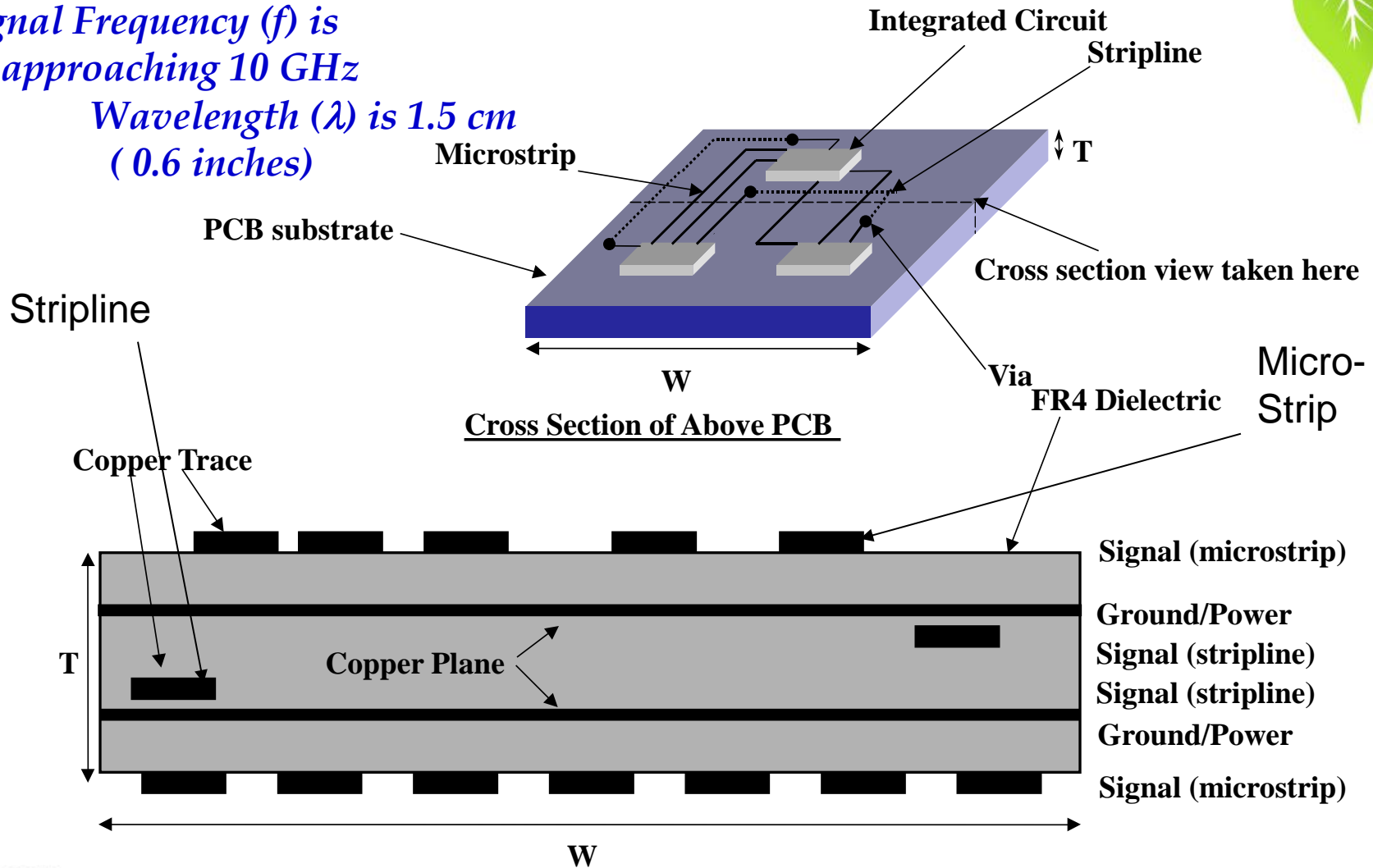
Teori Saluran Transmisi



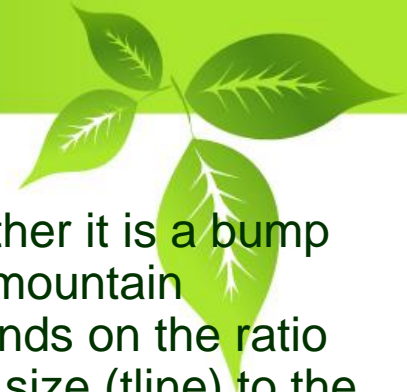
PC Transmission Line

Signal Frequency (f) is approaching 10 GHz

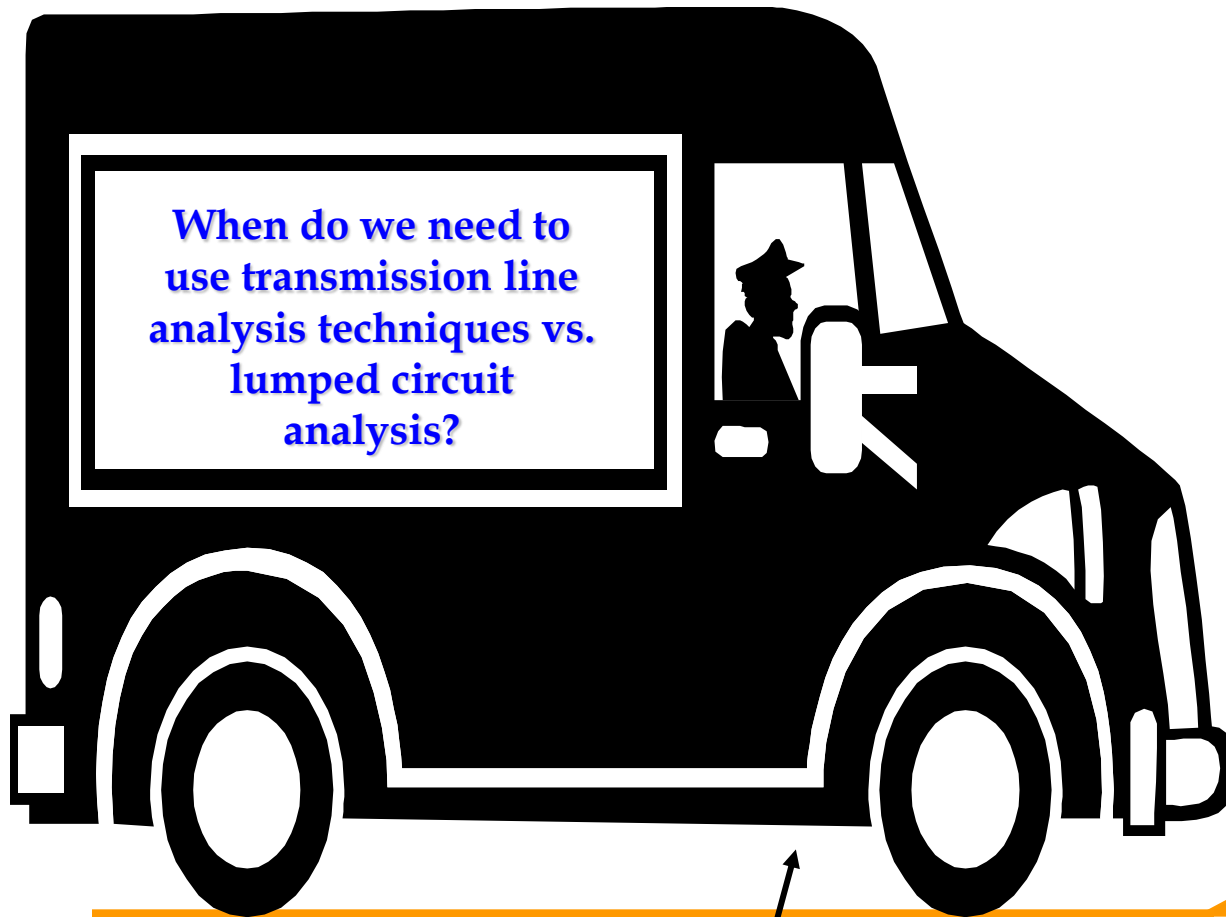
Wavelength (λ) is 1.5 cm (0.6 inches)



Teori Saluran Transmisi



When does a line become a T-Line? (analogy)



Wavelength/edge rate

Tline

- Whether it is a bump or a mountain depends on the ratio of its size (tline) to the size of the vehicle (signal wavelength)
- Similarly, whether or not a line is to be considered as a transmission line depends on the ratio of length of the line (delay) to the wavelength of the applied frequency





Model Saluran Transmisi

Model Saluran Transmisi



- The electrical characteristics of a transmission line become increasingly critical as the frequency of transmission increases
- Instead of examining the EM field distribution within these transmission lines (Very Complex), we will simplify the discussion by using a simple model consisting of distributed elements (inductors, capacitors, resistor). This model called **distributed element model** or **transmission line model**
- essentially, transmission line model needs to be used in circuits where the wavelengths of the signals have become comparable to the physical dimensions of the components. An often quoted engineering rule of thumb is that parts larger than **one tenth** of a wavelength will usually need to be analysed as distributed elements

Model Saluran Transmisi



Low Frequency Vs High Frequency

- At low frequencies, the circuit elements are lumped since voltage and current waves affect the entire circuit at the same time.
- At microwave frequencies, such treatment of circuit elements is not possible since voltage and current waves do not affect the entire circuit at the same time.
- The circuit must be broken down into unit sections within which the circuit elements are considered to be lumped.
- This is because the dimensions of the circuit are comparable to the wavelength of the waves according to the formula:

$$\lambda = c/f$$

where,

c = velocity of light

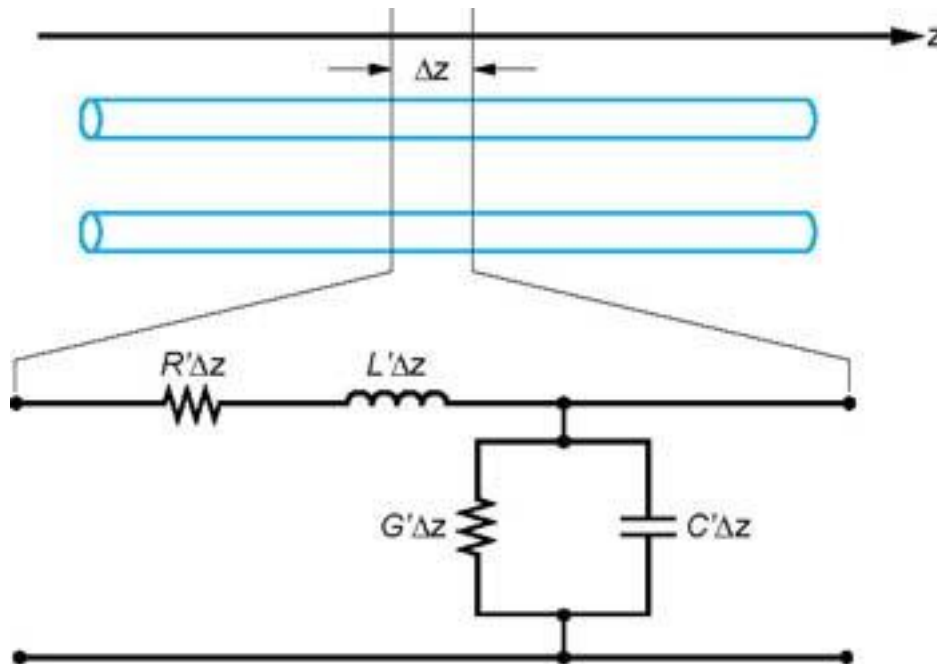
f = frequency of voltage/current

- The transmission line is divided into small units where the circuit elements can be lumped.

Model Saluran Transmisi



- The differential segment of the transmission line



R' = resistance per unit length
 L' = inductance per unit length
 C' = capacitor per unit length
 G' = conductance per unit length



Parameter-parameter dalam Saluran Transmisi

Parameter-parameter dalam Saluran Transmisi



- Konstanta primer saluran :
 - R' , L' , G' , C'
- Konstanta sekunder saluran :
 - Konstanta propagasi (γ)
 - Impedansi karakteristik (Z_0)
 - Kecepatan fasa (V_{ph})
 - Kecepatan group (V_g)

Parameter-parameter dalam Saluran Transmisi



Konstanta primer (Resistance (R'))

- The transmission line has electrical resistance along its length. This resistance is usually expressed in ohms per unit length and is shown as existing continuously from one end of the line to the other.



Figure 3-4.—Distributed resistance.

Parameter-parameter dalam Saluran Transmisi



Konstanta primer (Inductance (L'))

- When current flows through a wire, magnetic lines of force are set up around the wire
- As the current increases and decreases in amplitude, the field around the wire expands and collapses accordingly
- The energy produced by the magnetic lines of force collapsing back into the wire tends to keep the current flowing in the same direction
- This represents a certain amount of inductance, which is expressed in microhenrys per unit length

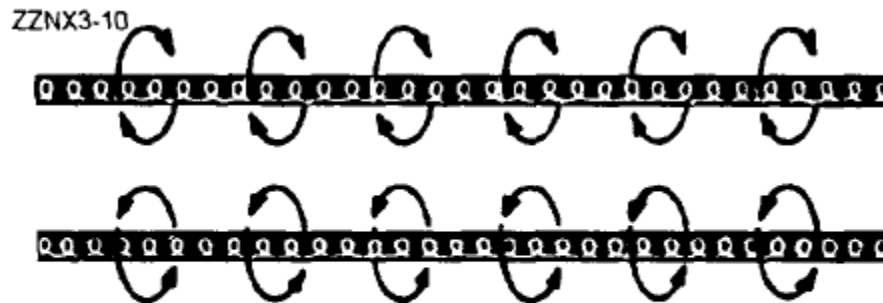


Figure 3-2.—Distributed inductance.

Parameter-parameter dalam Saluran Transmisi



Konstanta primer (Capacitance (C'))

- Capacitance also exists between the transmission line wires.
- two parallel wires act as plates of a capacitor and that the air between them acts as a dielectric.
- The capacitance between the wires is usually expressed in picofarads per unit length



Figure 3-3.—Distributed capacitance.

Parameter-parameter dalam Saluran Transmisi



Konstanta primer (Conductance (G'))

- Since any dielectric, even air, is not a perfect insulator, a small current known as LEAKAGE CURRENT flows between the two wires.
- In effect, the insulator acts as a resistor, permitting current to pass between the two wires.
- This property is called CONDUCTANCE (G) and is usually given in
- micromhos per unit length.

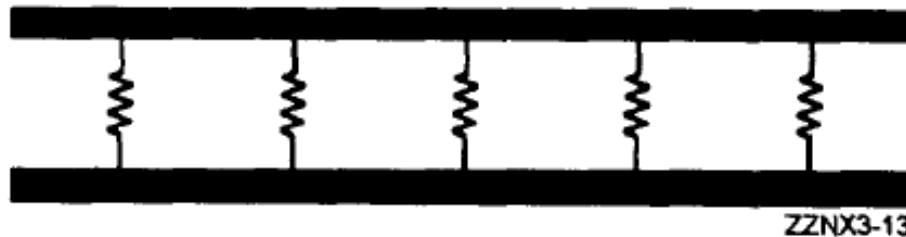


Figure 3-5.—Leakage in a transmission line.

TUGAS 2



1. Carilah formula konstanta primer beberapa jenis saluran transmisi!
2. Apa saja yang mempengaruhi besarnya nilai konstanta primer dari suatu jenis saluran transmisi?

Parameter-parameter dalam Saluran Transmisi



Konstanta Sekunder Saluran Transmisi

$\gamma = \sqrt{(R' + j\omega L')(G' + j\omega C')} = \sqrt{Z'Y'} =$ Konstanta propagasi saluran

$\gamma = \alpha + j\beta$, $\alpha =$ konstanta redaman (Np/km); $\beta =$ konstanta fasa (rad/km)

$Z_0 = \sqrt{\left(\frac{R' + j\omega L}{G' + j\omega C'}\right)} = \sqrt{\frac{Z'}{Y'}} =$ Impedansi karakteristik saluran

$$Z_0 = R_0 + jX_0$$

R' = Resistansi per satuan panjang (Ohm/m)

L' = Induktansi per satuan panjang (H/m)

G' = Konduktansi per satuan panjang (mho/m) atau (s/m)

C' = Kapasitansi per satuan panjang (farad/m)

$$1 \text{ Np} = 8,686 \text{ dB}$$

Parameter-parameter dalam Saluran Transmisi



Konstanta Sekunder....Konstanta Propagasi

Propagation Constant

$$\gamma = \sqrt{(R' + j\omega L')(G' + j\omega C')} = \alpha + j\beta$$

Konstanta redaman

Menyebabkan penurunan amplitudo gelombang karena desipasi daya sepanjang transmisi. Nilai α terkait dengan resistansi saluran

Konstanta fasa

Menyebabkan perubahan fasa dan bentuk gelombang terkait dengan perubahan induktansi dan kapasitansi sepanjang saluran

Parameter-parameter dalam Saluran Transmisi



Konstanta Sekunder.....Impedansi Karakteristik

$$Z_0 = \sqrt{\frac{R' + j\omega L'}{G' + j\omega C'}}$$

- ❑ Impedansi Karakteristik saluran didefinisikan dari suatu saluran transmisi yang panjangnya tak hingga
- ❑ Jika saluran tersebut dicatu dengan tegangan AC maka akan muncul arus yang mengalir di sepanjang saluran (pengaruh nilai C' dan G')
- ❑ Perbandingan tegangan dan arus pada input saluran transmisi dengan panjang tak hingga disebut **Impedansi Karakteristik**

Parameter-parameter dalam Saluran Transmisi



Konstanta Sekunder.....Wavelength (λ)

- **Wavelength (Panjang gelombang)** didefinisikan sebagai jarak dimana gelombang merambat sepanjang saluran agar pergeseran gelombang mencapai 2π radian (satu gelombang penuh)

$$\lambda = \frac{2\pi}{\beta} \text{ (meter)}$$

- Jika suatu saluran menggunakan suatu dielektrik tertentu maka panjang gelombang bisa dituliskan :

$$\lambda = \frac{\lambda_0}{\sqrt{\epsilon_r}} \text{ (meter)}$$

λ_0 = Panjang gelombang di udara

ϵ = Konstanta dielektrik

Parameter-parameter dalam Saluran Transmisi



Konstanta Sekunder.....Kecepatan Phasa (V_p)

- **Kecepatan Phasa (phase velocity / wave velocity/ velocity of propagation)** didefinisikan sebagai kecepatan dimana gelombang merambat sepanjang saluran pada frekuensi tertentu.

$$V_p = \lambda \times f \text{ (meter / second)}$$

$$V_p = \frac{2\pi}{\beta} \times f \longrightarrow V_p = \frac{\omega}{\beta}$$

- Jika saluran menggunakan bahan dielektrik maka

$$V_p = \frac{C}{\sqrt{\epsilon_r}}$$

C = Cepat rambat gelombang di udara

Parameter-parameter dalam Saluran Transmisi



Konstanta Sekunder.....Kecepatan Group (V_g)

- ❑ **Kecepatan Group (group velocity)** didefinisikan sebagai kecepatan dari sekumpulan gelombang dimana masing – masing gelombang mempunyai fasa yang sama

Parameter-parameter dalam Saluran Transmisi



Contoh Soal

1. Suatu saluran telepon open wire memiliki $R' = 10\Omega/\text{km}$, $L' = 0,0037$ henry/km, $C' = 0,0083 \times 10^{-6}$, dan $G' = 0,4 \times 10^{-6}$ mho/km, pada frekuensi 1 KHz tentukan :
 - a) Konstanta propagasi
 - b) Konstanta redaman
 - c) Konstanta phasa
 - d) Impedansi karakteristik
 - e) Panjang gelombang
 - f) Kecepatan phasa

Parameter-parameter dalam Saluran Transmisi



Solusi

a) Konstanta propagasi

$$\gamma = \sqrt{(R' + j\omega L')(G' + j\omega C')} = \alpha + j\beta$$

$$\gamma = \sqrt{(10 + j2\pi 1000(0,0037))(0,4 \cdot 10^{-6} + j2\pi 1000(0,0083 \cdot 10^{-6}))} = \alpha + j\beta$$

$$\gamma = \sqrt{(10 + j23,25)(0,4 \cdot 10^{-6} + j52,15 \cdot 10^{-6})} = \alpha + j\beta$$

$$\gamma = \sqrt{(25,31 \angle 66,73^\circ)(52,15 \cdot 10^{-6} \angle 89,56^\circ)} = \alpha + j\beta$$

$$\gamma = \sqrt{1319,92 \cdot 10^{-6} \angle 156,29^\circ} = \alpha + j\beta$$

$$\gamma = 0,03633 \angle 78,145^\circ = 0,00746 + j0,0356(\text{perKm}) = \alpha + j\beta$$

b) Konstanta redaman

$$\alpha = 0,00746(\text{neper} / \text{Km}) = 0,0000648(\text{dB} / \text{m})$$

c) Konstanta phasa

$$\beta = 0,0356(\text{radian} / \text{Km})$$

$$1\text{neper} = 8,686\text{dB}$$

Parameter-parameter dalam Saluran Transmisi



Solusi

a) Impedansi Karakteristik

$$Z_0 = \sqrt{\frac{(R' + j\omega L')}{(G' + j\omega C')}} = \sqrt{\frac{25,31 \angle 66,73^\circ}{52,15 \cdot 10^{-6} \angle 89,56^\circ}} = 696,66 \angle -11,415^\circ = 682,88 - j137,88(\text{ohm})$$

b) Panjang Gelombang

$$\lambda = \frac{2\pi}{\beta} = \frac{2\pi}{0,0356} = 176,49(\text{km})$$

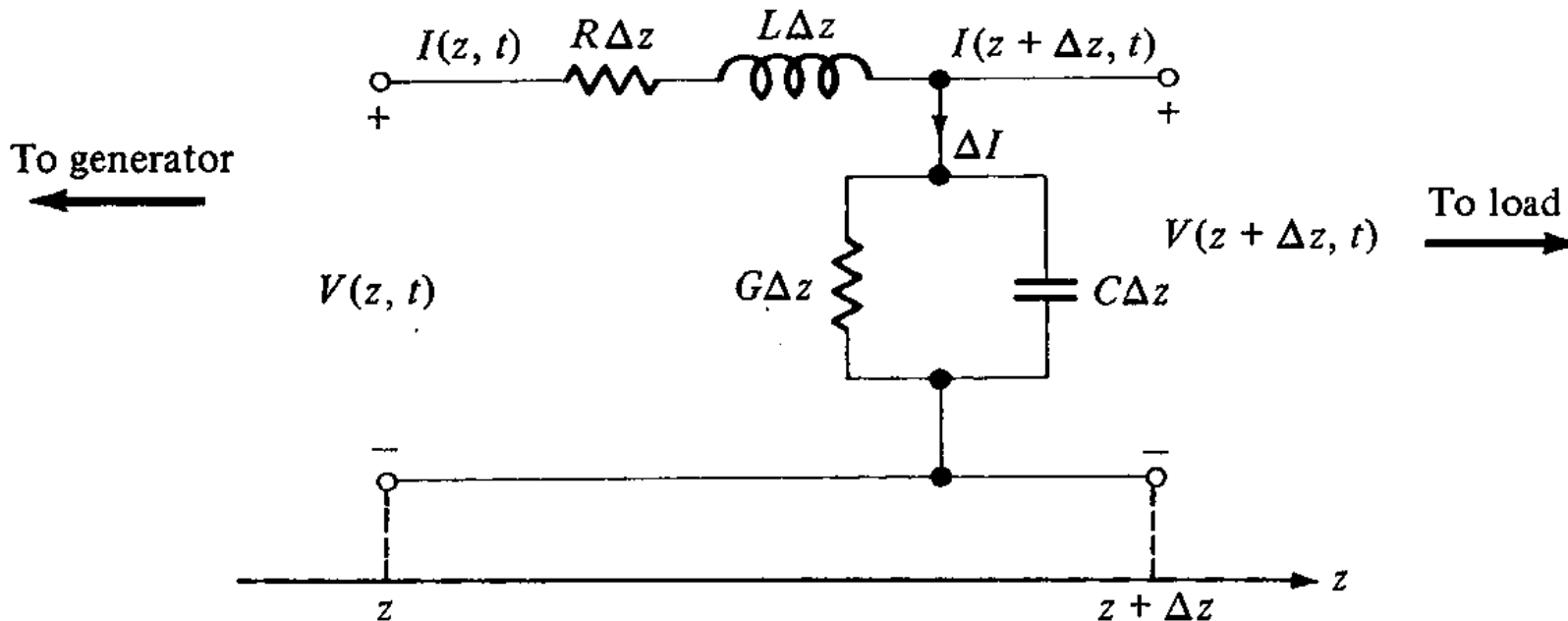
c) Kecepatan Phasa

$$V_p = \lambda \times f = 176,49 \cdot 10^3 \times 1000 = 176,49 \cdot 10^6 (\text{m/s})$$



Persamaan Umum Saluran Transmisi

Persamaan Umum Saluran Transmisi



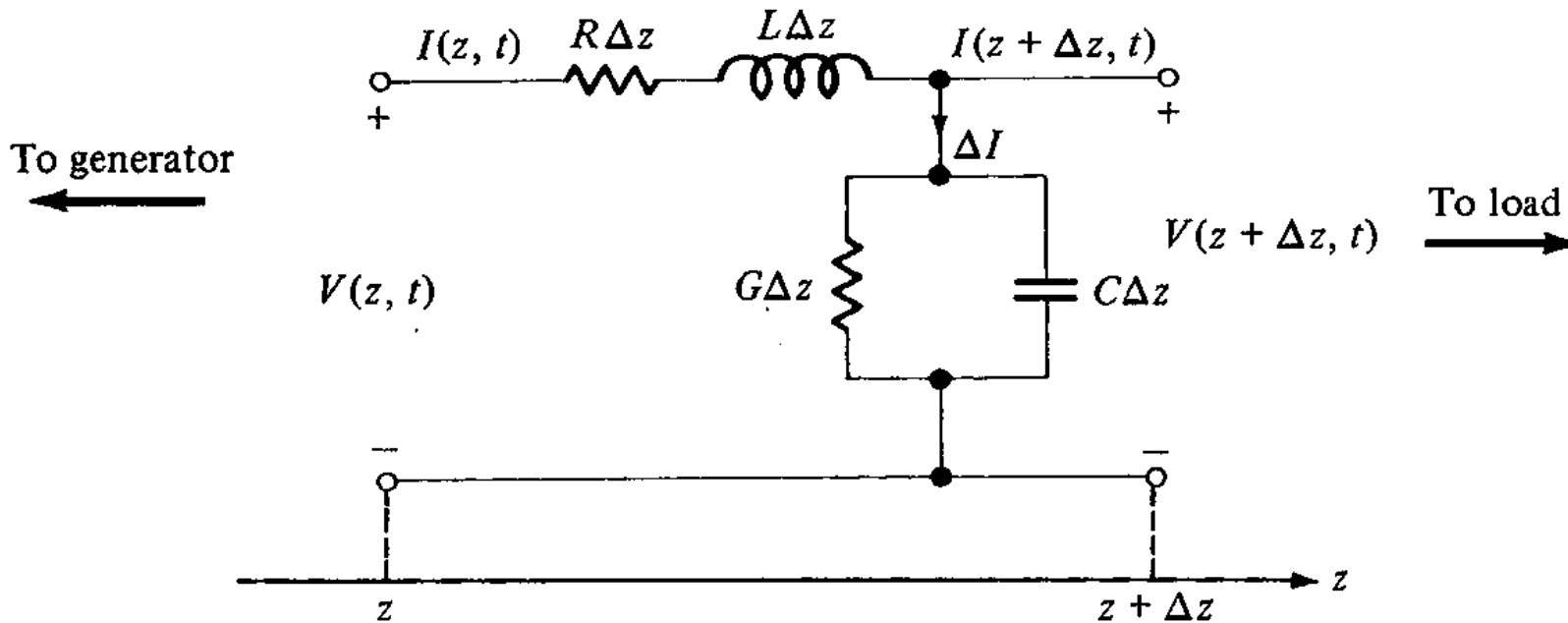
$$V(z, t) = (R' \Delta z + J\omega L' \Delta z) I(z, t) + V(z + \Delta z, t)$$

$$\frac{-V(z + \Delta z, t) - V(z, t)}{\Delta z} = (R' + J\omega L') I(z, t)$$

➔ Taking the limit as Δz tends to 0 leads to

$$\frac{\partial V(z, t)}{\partial z} = -(R' + J\omega L') I(z, t)$$

Persamaan Umum Saluran Transmisi



$$I(z, t) = \Delta I + I(z + \Delta z, t)$$

$$I(z, t) - I(z + \Delta z, t) = \frac{V(z + \Delta z, t)}{1/G' \Delta z} + \frac{V(z + \Delta z, t)}{1/J\omega C' \Delta z}$$

$$I(z, t) - I(z + \Delta z, t) = (G' \Delta z + J\omega C' \Delta z) V(z + \Delta z, t)$$

$$\frac{I(z, t) - I(z + \Delta z, t)}{\Delta z} = (G' + J\omega C') V(z + \Delta z, t)$$

Taking the limit as Δz tends to 0 leads to

$$\frac{\partial I(z, t)}{\partial z} = -(G' + J\omega C') V(z, t)$$

Persamaan Umum Saluran Transmisi



$$\frac{\partial V(z,t)}{\partial z} = -(R' + j\omega L')I(z,t)$$

$$\frac{\partial I(z,t)}{\partial z} = -(G' + j\omega C')V(z,t)$$

Disebut Telegrapher's Equations

$$\frac{d^2 V(t,z)}{dz^2} - \gamma^2 V(t,z) = 0$$

$$\frac{d^2 I(t,z)}{dz^2} - \gamma^2 I(t,z) = 0$$

Disebut Persamaan Differential saluran transmisi

Solusi Tegangan dan arus :

$$V(z) = V_0^+ e^{-\gamma z} + V_0^- e^{+\gamma z}$$

$$I(z) = I_0^+ e^{-\gamma z} + I_0^- e^{+\gamma z}$$

Ingat :

$$e^{\gamma z} = \cosh \gamma z + \sinh \gamma z$$

$$e^{-\gamma z} = \cosh \gamma z - \sinh \gamma z$$

Atau dalam bentuk fungsi hiperbolic:

$$V(z) = (V_0^+ + V_0^-) \cosh \gamma z + (V_0^- - V_0^+) \sinh \gamma z$$

$$I(z) = (I_0^+ + I_0^-) \cosh \gamma z + (I_0^- - I_0^+) \sinh \gamma z$$

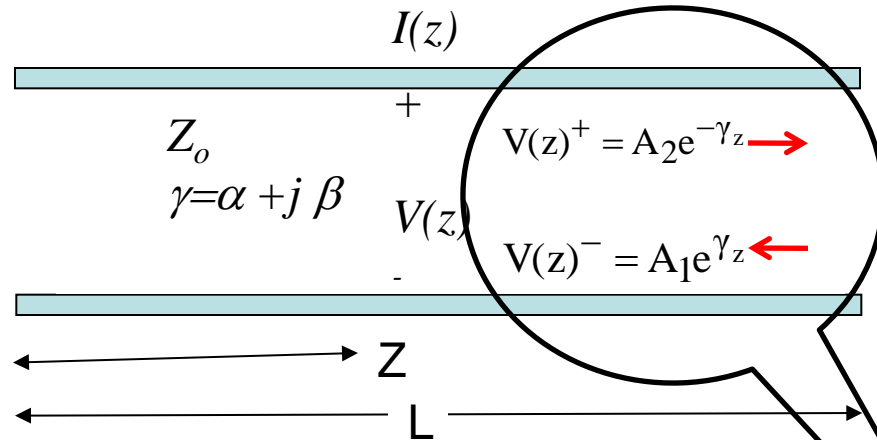
Dalam Fungsi Real Time:

$$V(z, t) = \text{Re} \{ V(z) e^{j\omega t} \}$$

$$v(z, t) = V_0^+ e^{-\alpha z} \cos(\omega t - \beta z) + V_0^- e^{\alpha z} \cos(\omega t + \beta z)$$

$$i(z, t) = I_0^+ e^{-\alpha z} \cos(\omega t - \beta z) + I_0^- e^{\alpha z} \cos(\omega t + \beta z)$$

Persamaan Umum Saluran Transmisi



$$V(z) = A_1 e^{\gamma z} + A_2 e^{-\gamma z}$$
$$I(z) = \frac{1}{Z_0} (-A_1 e^{\gamma z} + A_2 e^{-\gamma z})$$

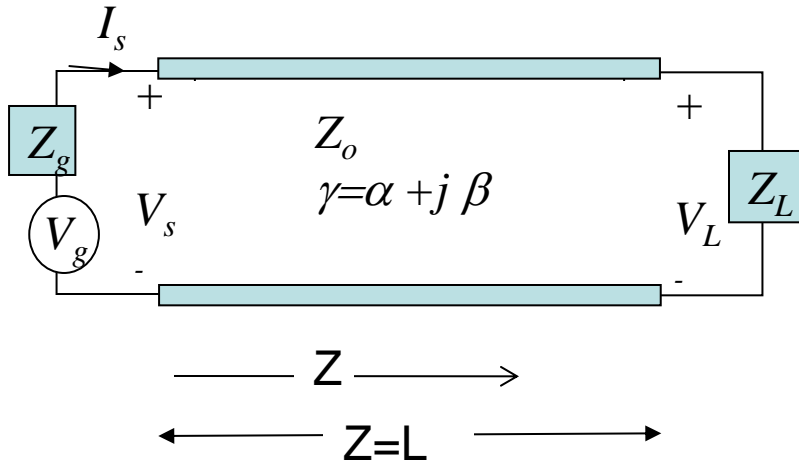
$V(z)$ = Tegangan sejauh z dari sumber
 $I(z)$ = Arus sejauh z dari sumber

Persamaan Umum saluran transmisi

Menggambarkan ada **dua gelombang yang merambat** dalam saluran transmisi :

- V^+ dan atau I^+ yang merambat pada arah (Z positif)
- V^- dan atau I^- yang merambat pada arah (Z negatif)

Persamaan Tegangan dan Arus jika Parameter sumber diketahui



Jika $z = 0$ maka didapat:

$$\begin{aligned} V_z = V_s = A_1 + A_2 \\ I_z = I_s = \frac{-A_1 + A_2}{Z_0} \end{aligned} \quad \left| \quad \rightarrow \quad \begin{aligned} A_1 &= \frac{V_s - I_s \cdot Z_0}{2} \\ A_2 &= \frac{V_s + I_s \cdot Z_0}{2} \end{aligned}$$

Substitusikan A_1 dan A_2 ke pers 1, didapat:

$$V_z = \left[\frac{V_s - I_s \cdot Z_0}{2} \right] e^{\gamma z} + \left[\frac{V_s + I_s \cdot Z_0}{2} \right] e^{-\gamma z}$$

$$V_z = V_s \left[\frac{e^{\gamma z} + e^{-\gamma z}}{2} \right] - I_s \cdot Z_0 \left[\frac{e^{\gamma z} - e^{-\gamma z}}{2} \right]$$

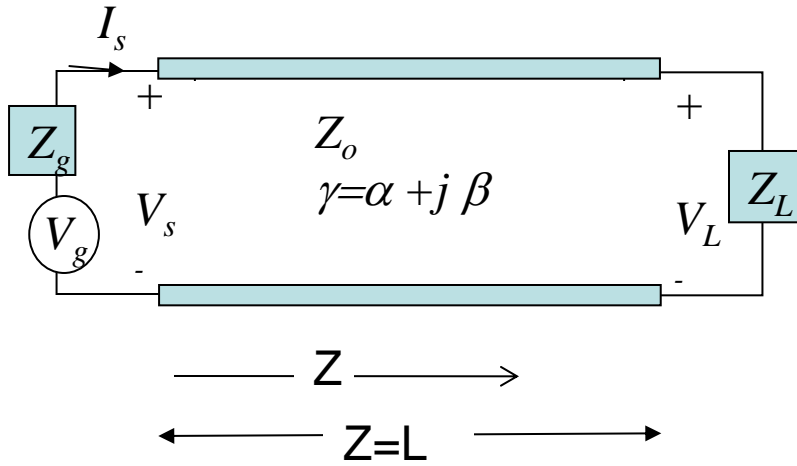
Persamaan umum saluran :

$$V_z = A_1 e^{\gamma z} + A_2 e^{-\gamma z} \quad \text{--- Pers 1}$$

$$I_z = \frac{1}{Z_0} (-A_1 e^{\gamma z} + A_2 e^{-\gamma z}) \quad \text{--- Pers 2}$$

$$V_z = V_s \cosh \gamma z - I_s Z_0 \sinh \gamma z$$

Persamaan Tegangan dan Arus jika Parameter sumber diketahui



Substitusikan A_1 dan A_2 ke pers 2, didapat:

$$I_z = \left[\frac{I_s \cdot Z_0 - V_s}{2Z_0} \right] e^{\gamma z} + \left[\frac{V_s + I_s \cdot Z_0}{2Z_0} \right] e^{-\gamma z}$$

$$I_z = I_s \left[\frac{e^{\gamma z} + e^{-\gamma z}}{2} \right] - \frac{V_s}{Z_0} \left[\frac{e^{\gamma z} - e^{-\gamma z}}{2} \right]$$

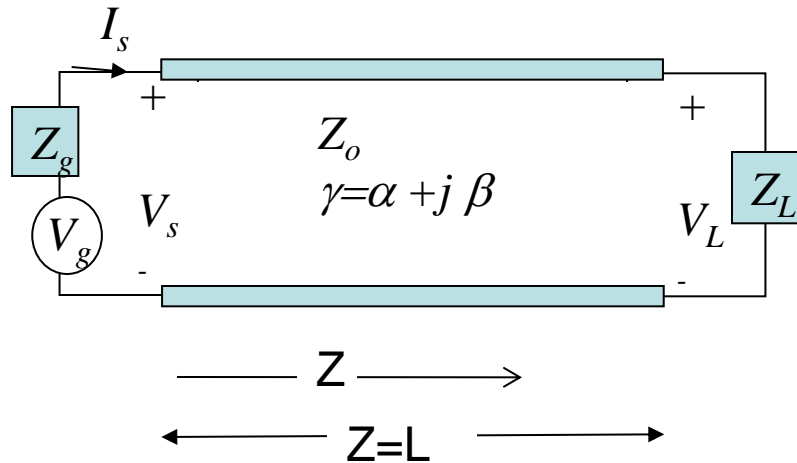
Persamaan umum saluran :

$$V_z = A_1 e^{\gamma z} + A_2 e^{-\gamma z} \quad \text{---> Pers 1}$$

$$I_z = \frac{1}{Z_0} (-A_1 e^{\gamma z} + A_2 e^{-\gamma z}) \quad \text{---> Pers 2}$$

$$I_z = I_s \cosh \gamma z - \frac{V_s}{Z_0} \sinh \gamma z$$

Persamaan Tegangan dan Arus jika Parameter sumber diketahui

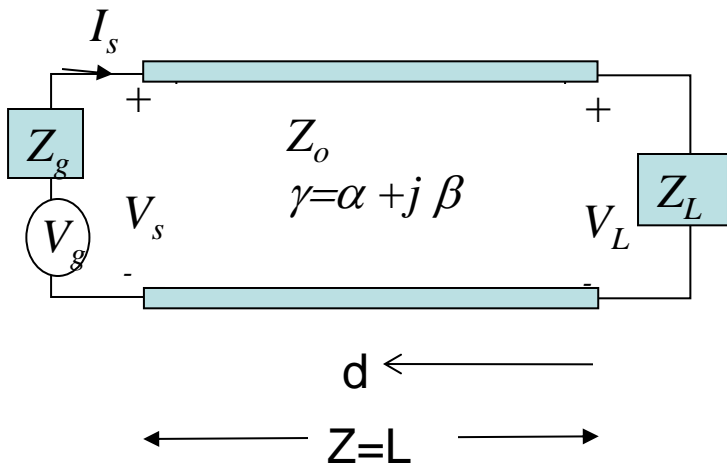


$$V_z = V_s \cosh \gamma z - I_s Z_0 \sinh \gamma z$$

$$I_z = I_s \cosh \gamma z - \frac{V_s}{Z_0} \sinh \gamma z$$

**Persamaan Tegangan
Dan Arus Jika
Parameter
Sumber diketahui !**

Persamaan Tegangan dan Arus jika Parameter Beban diketahui



Persamaan umum saluran :

$$V_z = A_1 e^{\gamma z} + A_2 e^{-\gamma z} \quad \text{--- Pers 1}$$

$$I_z = \frac{1}{Z_o} (-A_1 e^{\gamma z} + A_2 e^{-\gamma z}) \quad \text{--- Pers 2}$$

Jika $z = L$ maka didapat:

$$\begin{cases} V_L = A_1 e^{\gamma L} + A_2 e^{-\gamma L} \\ I_L = \frac{1}{Z_o} [-A_1 e^{\gamma L} + A_2 e^{-\gamma L}] \end{cases} \rightarrow \begin{cases} A_1 = \left[\frac{V_L - I_L \cdot Z_o}{2} \right] e^{-\gamma L} \\ A_2 = \left[\frac{V_L + I_L \cdot Z_o}{2} \right] e^{\gamma L} \end{cases}$$

Substitusikan A_1 dan A_2 ke pers 1, didapat:

$$V_z = \left[\frac{V_L - I_L \cdot Z_o}{2} \right] e^{\gamma z - \gamma L} + \left[\frac{V_L + I_L \cdot Z_o}{2} \right] e^{-\gamma z + \gamma L}$$

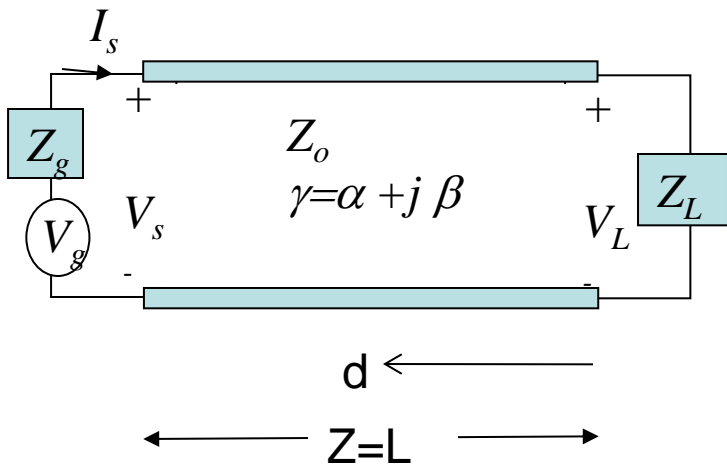
$$V_d = \left[\frac{V_L - I_L \cdot Z_o}{2} \right] e^{-\gamma(L-d)} + \left[\frac{V_L + I_L \cdot Z_o}{2} \right] e^{\gamma(L-d)}$$

$$V_d = \left[\frac{V_L - I_L \cdot Z_o}{2} \right] e^{-\gamma d} + \left[\frac{V_L + I_L \cdot Z_o}{2} \right] e^{\gamma d}$$

$$V_d = V_L \left[\frac{e^{\gamma d} + e^{-\gamma d}}{2} \right] e^{-\gamma} + I_L Z_o \left[\frac{e^{\gamma d} - e^{-\gamma d}}{2} \right]$$

$$V_d = V_L \cosh \gamma d + I_L Z_o \sinh \gamma d$$

Persamaan Tegangan dan Arus jika Parameter Beban diketahui



Persamaan umum saluran :

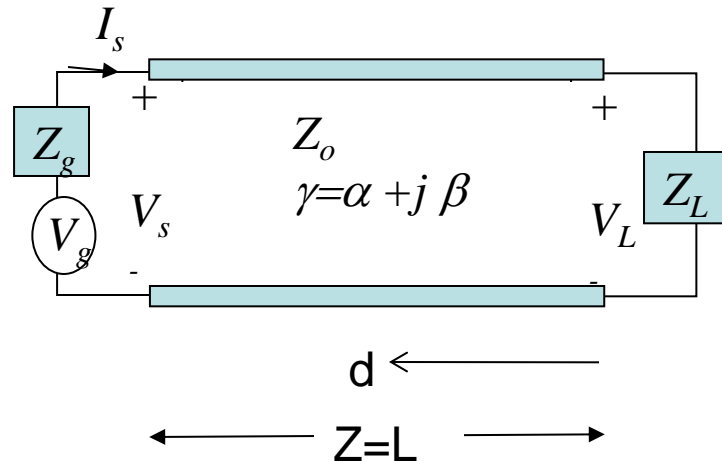
$$V_z = A_1 e^{\gamma z} + A_2 e^{-\gamma z} \quad \text{---} \rightarrow \quad \text{Pers 1}$$

$$I_z = \frac{1}{Z_0} (-A_1 e^{\gamma z} + A_2 e^{-\gamma z}) \quad \text{---} \rightarrow \quad \text{Pers 2}$$

Dengan cara yang sama masukkan A_1 dan A_2 ke pers 2, maka didapat :

$$I_d = I_L \cosh \gamma d + \frac{V_L}{Z_0} \sinh \gamma d$$

Persamaan Tegangan dan Arus jika Parameter Beban diketahui



$$V_d = V_L \cosh \gamma d + I_L Z_0 \sinh \gamma d$$

$$I_d = I_L \cosh \gamma d + \frac{V_L}{Z_0} \sinh \gamma d$$

**Persamaan Tegangan
Dan Arus Jika
Parameter
Beban diketahui !**

Impedansi Karakteristik



- Pada slide sebelumnya sudah didefinisikan mengenai impedansi karakteristik
- Alternatif pengertian impedansi karakteristik yang dilihat dari persamaan umum saluran transmisi, adalah ratio antara tegangan dan arus yang merambat ke satu arah ($V(z)^+/I(z)^+$) atau ($-V(z)^-/I(z)^-$) pada setiap titik di saluran transmisi

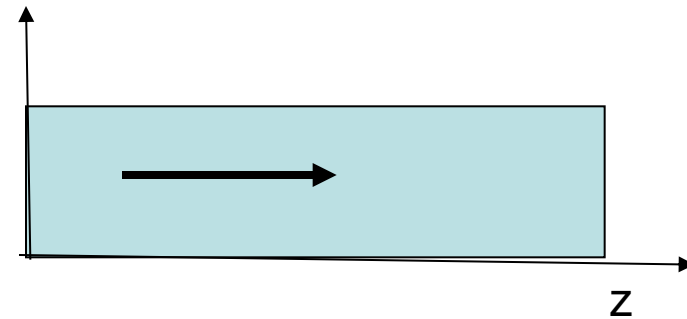
$$\frac{dV(z)}{dz} = -(R + j\omega L)I(z)$$

$$V(z) = V(z)^+ = V^+ e^{-\gamma z}$$

$$I(z) = I(z)^+ = I^+ e^{-\gamma z}$$

$$(-\gamma V^+ e^{-\gamma z}) = -(R + j\omega L)I^+ e^{-\gamma z}$$

$$Z_o = \frac{V^+}{I^+} = \frac{R + j\omega L}{\gamma} = \sqrt{\frac{R + j\omega L}{G + j\omega C}} = R_o + jX_o = -\frac{V^-}{I^-}$$



Impedansi Karakteristik

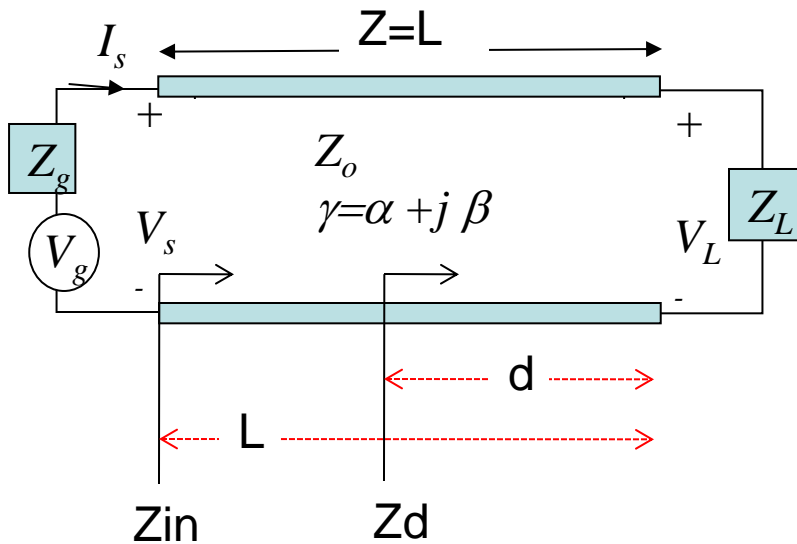
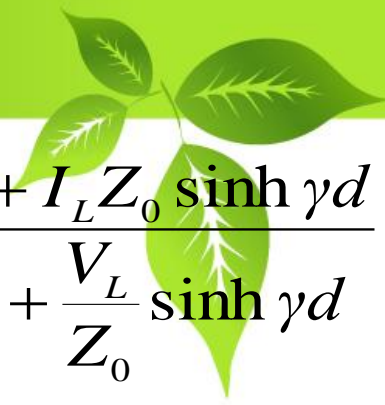


- Dapat disimpulkan bahwa impedansi karakteristik bukan merupakan fungsi dari jarak, dan besarnya hanya tergantung dari nilai R' , L' , C' , dan G' saja.
- Untuk mempermudah desain dan aplikasi biasanya nilai impedansi karakteristik (Z_0) dari berbagai jenis saluran sudah dibuat formula-formula yang bisa langsung digunakan

TUGAS 3

1. Carilah formula-formula Impedansi karakteristik (Z_0) beberapa jenis saluran transmisi!
2. Apa saja yang mempengaruhi besarnya nilai impedansi karakteristik dari suatu jenis saluran transmisi?

Persamaan Impedansi Saluran Transmisi



$$Z_d = \frac{V_d}{I_d} = \frac{V_L \cosh \gamma d + I_L Z_0 \sinh \gamma d}{I_L \cosh \gamma d + \frac{V_L}{Z_0} \sinh \gamma d}$$

Kalikan dengan $\frac{1}{I_L \cosh \gamma d}$

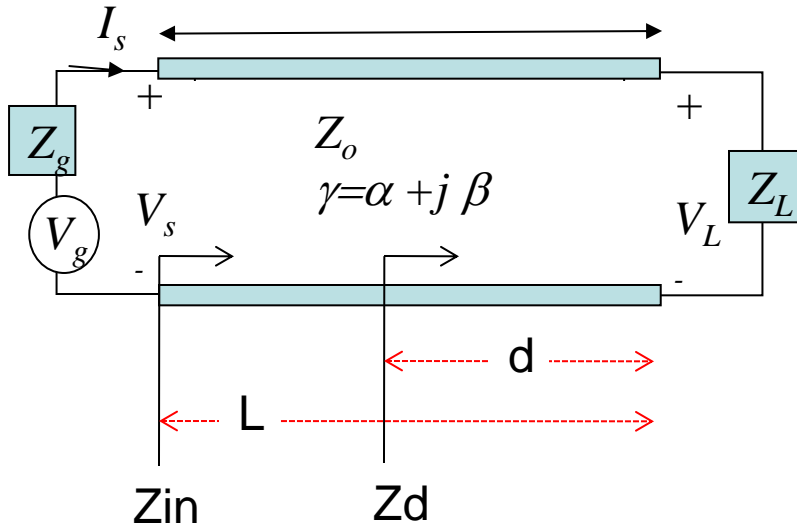
Didapat :

$$Z_d = Z_0 \left[\frac{Z_L + Z_0 \tanh \gamma d}{Z_0 + Z_L \tanh \gamma d} \right]$$

Merupakan **impedansi saluran sejauh d dari beban !**

Bedakan dengan impedansi karakteristik saluran !!!

Persamaan Impedansi Saluran Transmisi



$$Z_d = Z_0 \left[\frac{Z_L + Z_0 \tanh \gamma d}{Z_0 + Z_L \tanh \gamma d} \right]$$

Jika $d = L$ maka :

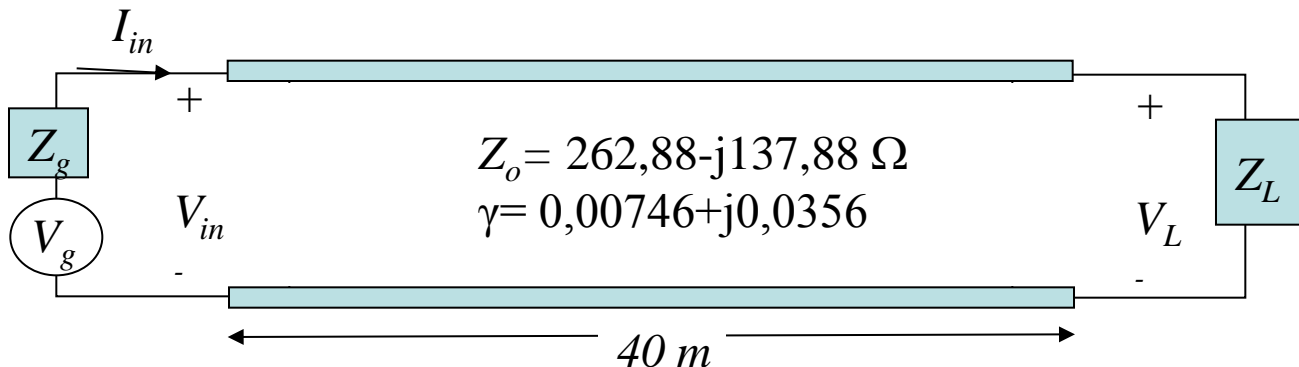
$$Z_{d=L} = Z_{in} = Z_0 \left[\frac{Z_L + Z_0 \tanh \gamma L}{Z_0 + Z_L \tanh \gamma L} \right]$$

Adalah Impedansi Input Saluran Transmisi !

Latihan



- A 40-m long TL has $V_g = 15 \cos(\omega t)$, $Z_o = 262,88 - j137,88 \Omega$, and $\gamma = 0,00746 + j0,0356$ (per m). If $Z_g = Z_L = Z_o$, find:
 - a) the input impedance Z_{in} ,
 - b) the sending-end current I_{in}
 - c) the sending-end voltage V_{in} ,
 - d) the receiving-end voltage V_L .
 - e) the receiving-end current I_L
 - f) Impedance at point 20 m from load



Parameter-parameter dalam Saluran Transmisi



Solusi

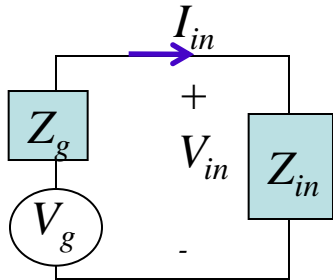
a) Input Impedance (Z_{in})

Karena saluran match dengan beban, maka $Z_0 = Z_L = 262,88 - j137,88 \Omega$

Maka:

$$Z_{in} = Z_0 \left[\frac{Z_L + Z_0 \tanh \gamma L}{Z_0 + Z_L \tanh \gamma L} \right] = Z_0 = 262,88 - j137,88 \Omega$$

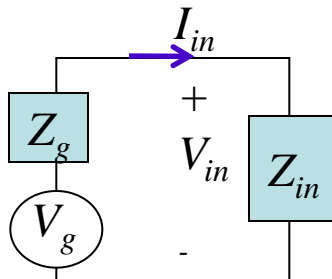
b) Sending-end Current (I_{in})



$$I_{in} = \frac{V_g}{Z_g + Z_{in}} = \frac{15 \angle 0^\circ}{(262,88 - j137,88) + (262,88 - j137,88)} = \frac{15 \angle 0^\circ}{525,76 - j275,76}$$

$$I_{in} = \frac{15 \angle 0^\circ}{593,69 \angle -27,68^\circ} = 0,0253 \angle 27,68^\circ = 0,0253 \cos(\omega t + 27,68^\circ) \text{ (ampere)}$$

c) Sending-end voltage (V_{in})



$$V_{in} = \frac{Z_{in}}{Z_{in} + Z_g} \times V_g = \frac{262,88 - j137,88}{(262,88 - j137,88) + (262,88 - j137,88)} \times 15 \angle 0^\circ$$

$$V_{in} = \frac{15 \angle 0^\circ}{2} = 7,5 \angle 0^\circ \text{ (volt)} = 7,5 \cos(\omega t) \text{ (volt)}$$

Parameter-parameter dalam Saluran Transmisi



Solusi

d) Receiving-end Voltage (V_L)

$$V_z = V_{in} \cosh \gamma z - I_{in} Z_0 \sinh \gamma z$$

$$V_L = V_{in} \cosh \gamma L - I_{in} Z_0 \sinh \gamma L$$

$$V_L = 7,5 \angle 0^\circ \cosh \{(0,00746 + j0,0356)40\} \\ - (0,0253 \angle 27,68^\circ)(262,88 - j137,88) \sinh \{(0,00746 + j0,0356)40\}$$

$$V_L = 6,096 \angle -82,32^\circ = 6,096 \cos(\omega t - 82,32^\circ) (\text{volt})$$

e) Receiving-end Current (I_L)

$$I_z = I_{in} \cosh \gamma z - \frac{V_{in}}{Z_0} \sinh \gamma z$$

$$I_L = I_{in} \cosh \gamma L - \frac{V_{in}}{Z_0} \sinh \gamma L = 0,0253 \angle 27,68^\circ \cosh \{(0,00746 + j0,0356)40\} \\ - \frac{7,5 \angle 0^\circ}{262,88 - j137,88} \sinh \{(0,00746 + j0,0356)40\} = 0,02055 \angle -54,64^\circ$$

$$= 0,02055 \cos(\omega t - 54,64^\circ)$$

$$\cosh jx = \cos x$$

$$\sinh jx = j \sin x$$

Review Kembali!!!

$$\cosh(x + y) = \cosh x \cosh y + \sinh x \sinh y$$

$$\sinh(x + y) = \sinh x \cosh y + \cosh x \sinh y$$

Parameter-parameter dalam Saluran Transmisi



Solusi

f) $\underline{Z}_{d=20m}$

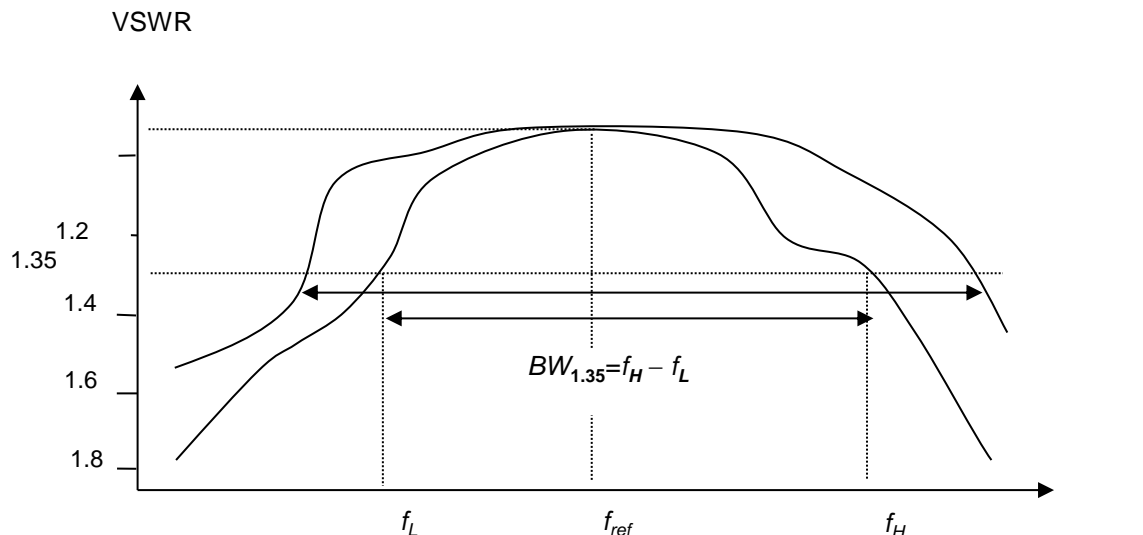
$$Z_d = Z_0 \left[\frac{Z_L + Z_0 \tanh \gamma d}{Z_0 + Z_L \tanh \gamma d} \right] = Z_0 = 262,88 - j137,88\Omega$$



Konsep Bandwidth dalam Saluran Transmisi

Bandwidth dalam Saluran Transmisi

- Matching impedansi yang dilakukan pada frekuensi tunggal/referensi bisa saja berhasil mencapai VSWR minimum yang mendekati 1 di saluran utamanya, terutama jika salurannya lossless. Jika saluran lossy, maka matching dengan VSWR minimum mendekati 1 dapat dicapai pada pangkal saluran (titik input), sedangkan di ujung saluran (titik beban) VSWR akan cenderung membesar.
- Setelah matching dilakukan pada frekuensi referensi, saluran tersebut bagi komponen sinyal dengan frekuensi yang semakin jauh dari referensi akan semakin tidak matched.
- Dapat dibuat plot kurva respons VSWR saluran terhadap frekuensi.



Bandwidth dalam Saluran Transmisi



- Jika band-width filter didefinisikan pada respons 3 dB dari referensi, maka *band-width saluran transmisi didefinisikan untuk nilai VSWR maksimum yang diijinkan sebagai referensi*. Tetapi nilai VSWR maksimum referensi tersebut tidak disepakati berharga tertentu, bisa saja 1,15; 1,20; 1,35; atau 1,50 asalkan cukup baik untuk aplikasi yang bersangkutan (pantulan tidak membahayakan peralatan, khususnya pesawat pemancar).
- Matching berganda (transformator- $\lambda/4$ ganda, stub ganda) bertujuan memperlebar bandwidth pada VSWR yang sama dibandingkan dengan matching tunggal.

Questions???



