DTG2A3

Teknik Saluran Transmisi

2. MACAM-MACAM KONDISI SALURAN TRANSMISI

Where Are We?

1. PENDAHULUAN
   - Perkenalan dan sosialisasi SAP&syllabus
   - Review materi teori elektromagnetik
2. TEORI SALURAN TRANSMISI
   - Definisi Saluran transmisi
   - Konsep dan contoh Saluran transmisi
   - Model Saluran transmisi
   - Pengenalan parameter-parameter Saluran transmisi
   - Persamaan Umum Saluran Transmisi)
   - Konsep Bandwidth Saluran
3. KONDISI DAN TIPE SALTRAN
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   - Saluran distortionless
   - Saluran lossy
   - Saluran-saluran istimewa
4. KONSEP PANTULAN PADA SALURAN
   - SWR & VSWR
   - Koefisien pantul
   - Tegangan dan Arus
   - Praktikum Karakteristik Saluran Transmisi (Impedansi Input, VSWR, Koefisien Pantul, Pola Gelombang berdiri)
5. Kasus khusus Impedansi sumber dan Beban
   - Beban OC dan SC
   - Kasus Khusus lainnya
6. MACAM-MACAM SALTRAN
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   - MicrostripLine
   - StripLine
   - Waveguide
   - Coplanar Waveguide
7. MATCHING IMPEDANCE
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   - Tujuan matching impedance
   - Teknik Penyepadanan saluran transmisi dengan Trafo λ/4 Open Circuit /Short Circuit)
   - Teknik Penyepadanan saluran transmisi dengan stub tunggal (Paralel/Seri dan Open Circuit /Short Circuit)
   - Teknik Penyepadanan saluran transmisi dengan stub Ganda (Paralel/Seri dan Open Circuit /Short Circuit)
   - Praktikum Matching Impedansi menggunakan Stub
   - Perhitungan matching impedance menggunakan penyepadan rangkaian R, L, C
8. SMITCHCHART
   - Pengenalan Smith Chart
   - Tools pendukung
   - Cara menggunakan Smith Chart
   - Contoh penggunaan (λ/4 (transformator), Stub tunggal, stub ganda)
   - Praktikum matching Impedansi Saluran Menggunakan Smith Chart

Content

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2. Saluran tanpa rugi – rugi (Lossless / Lowloss)
3. Saluran Tanpa cacat (Distortionless)
4. Saluran Merugi (Lossy)
5. Saluran-saluran Istimewa

Pendahuluan

Loss dalam Saluran Transmisi

Conductor Loss

- In transmission line, the resistance of the conductors is never equal to zero (There are no perfect conductivity)
- Whenever current flows through conductors, some energy is dissipated in the form of heat.
- Conductor losses increase with an increase in frequency because of skin effect

Dielectric Loss

- the portion of the energy of an alternating electrical field in a dielectric medium that is converted into heat.

Radiation Loss

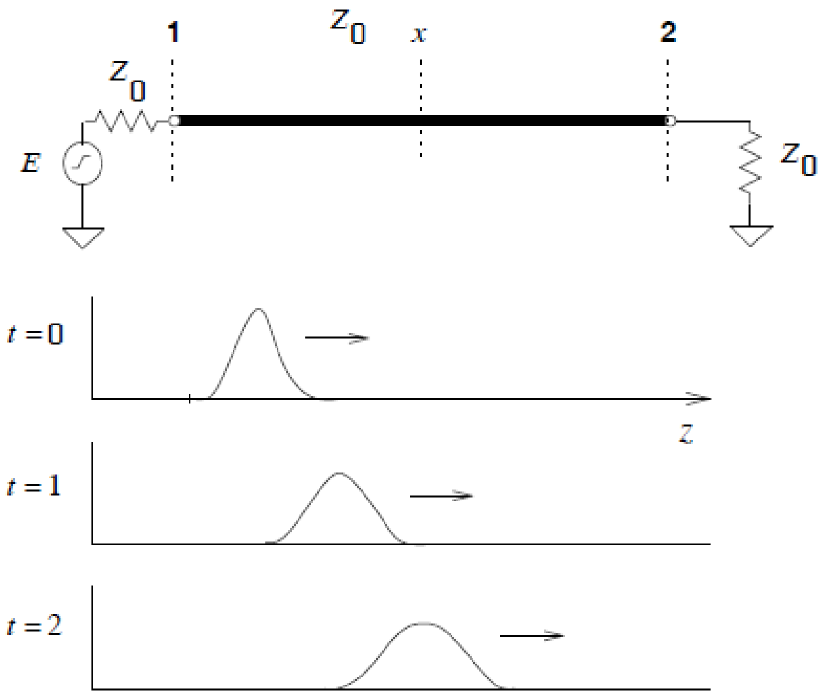
- Radiation losses occur because some magnetic lines of force about a conductor do not return to the conductor when the cycle alternates.
- These lines of force are projected into space as radiation, and this results in power losses

Leakage Loss

- Induction losses occur when the electromagnetic field about a conductor cuts through any nearby metallic object and a current is induced in that object.
- As a result, power is dissipated in the object and is lost.
- Leakage loss present in transmission line having dielectric with finite resistivity

Distorsi signal dalam saluran transmisi

- Any signal that carries significant **information must has some** non-zero **bandwidth. In other words, the signal energy (as well** as the information it carries) is **spread across many frequencies**
- If the different frequencies that comprise a signal travel at different velocities, that signal will arrive at the end of a transmission line **distorted. We call this phenomenon signal dispersion.**
- **dispersion** is the phenomenon in which the phase velocity of a wave depends on its frequency. or alternatively when the group velocity depends on the frequency



Dispersion of a pulse along a line.

Saluran lossless dan distortionless

Saluran Lossy tapi distortionless

Saluran Lossy dan terdistorsi

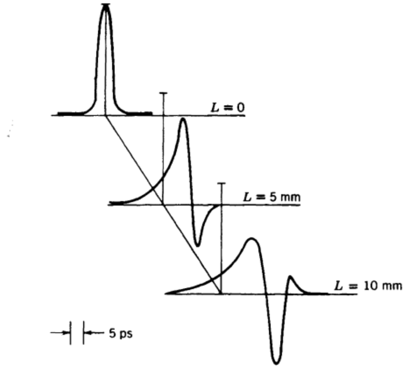


FIG. 8.16a Propagation of a 5-ps gaussian pulse along a microstrip line. Strip width = 0.32 mm, dielectric thickness = 0.4 mm, and ε_r = 6.9. Reproduced by permission from K. K. Li, G. Arjavalingam, A. Dienes, and J. R. Whinnery, *IEEE Trans.* **MTT-30**, 1270 (1982). © 1982 IEEE.

Saluran Tanpa Rugi-rugi (Lossless/Lowloss)

Saluran Lossless

- Pada saluran ini tidak terjadi redaman daya atau redaman amplituda (α = 0). Agar tercapai maka :
  - R' dan G' = 0 (punya konduktor dan dielektrik yang sempurna)
  - Saluran dioperasikan pada frekuensi tinggi (ω L'>>R dan ωC' >>G'
- Sehingga pada saluran lossless berlaku :

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

$$= \sqrt{(j\omega L)(j\omega C^{'})} = \sqrt{-\omega^2 L^{'} C^{'}}$$

$$= j\omega\sqrt{L^{'}C^{'}} = j\beta$$

$$\alpha = 0$$

$$\beta = \omega\sqrt{L^{'}C^{'}}$$

$$Z_0 = \sqrt{\frac{R^{'} + j\omega L^{'}}{G^{'} + j\omega C^{'}}} = \sqrt{\frac{L^{'}}{C^{'}}} = \mathrm{R}_0$$

$$\lambda = \frac{2\pi}{\beta} = \frac{1}{f\sqrt{L'C'}}$$

$$\mathrm{V}_\mathrm{p} = \frac{\omega}{\beta} = \frac{1}{\sqrt{L^{'}C^{'}}}$$

Catatan :

- Pada saluran lossless, kecepatan phasa tidak tergantung dari frequency **(frequency independence)**, maka pada saluran lossless juga berlaku **distortionless.**
- Pada kondisi tertentu, yaitu ketika **saluran transmisi sangat panjang** maka saluran lossless bisa bersifat **terdistorsi** karena perbedaan kecil kecepatan phasa akan menimbulkan delay yang besar jika saluran sangat panjang

Tegangan dan Arus pada Saluran Lossless

- Pada saluran transmisi lossless berlaku :

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

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

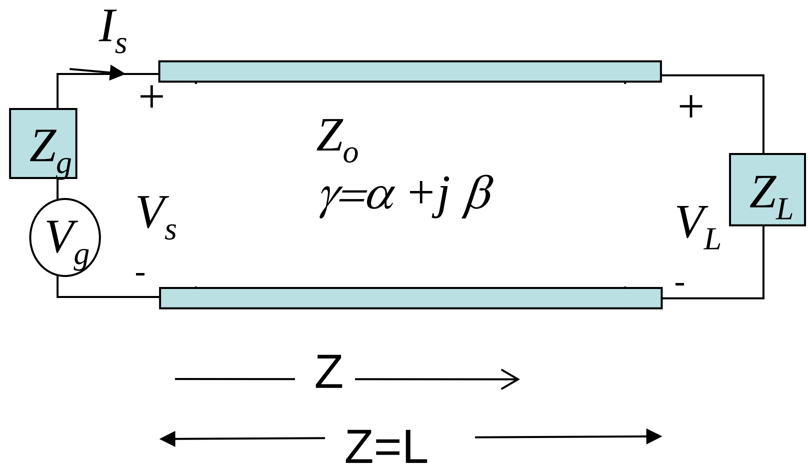
$$\mathrm{V(z)} = \mathrm{V_0}^{+} \mathrm{e}^{-j\beta_z} + \mathrm{V_0}^{-} \mathrm{e}^{+j\beta_z}$$

$$\mathrm{I(z)} = \mathrm{I_0}^{+} \mathrm{e}^{-j\beta_z} + \mathrm{I_0} \mathrm{e}^{+j\beta_z} = \frac{\mathrm{V_0}^{+}}{\mathrm{Z_0}} \mathrm{e}^{-j\beta_z} - \frac{\mathrm{V_0}^{-}}{\mathrm{Z_0}} \mathrm{e}^{+j\beta_z}$$

Revisi !!!

Tegangan dan Arus pada Saluran Lossless

Persamaan Tegangan Dan Arus Jika Parameter Sumber diketahui !

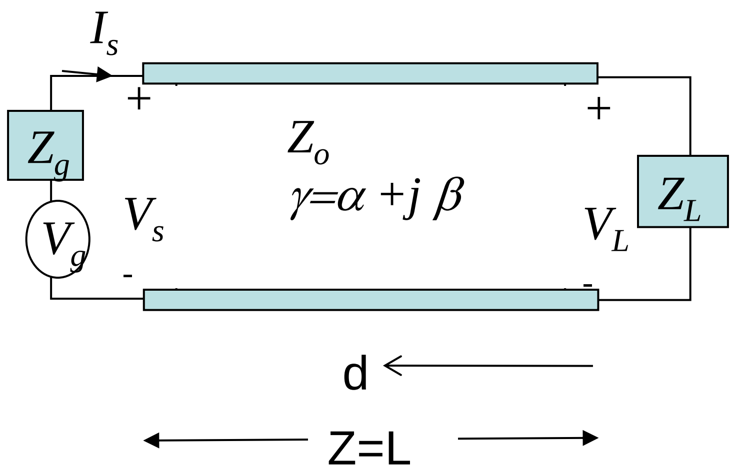


$$
\begin{aligned}
V_z &= V_s \cosh \gamma z - I_s Z_0 \sinh \gamma z \\
&= V_s \cosh j\beta z - I_s Z_0 \sinh j\beta z \\
&= V_s \cos \beta z - I_s Z_0 \, j \sin \beta z
\end{aligned}
$$

$$
\begin{aligned}
I_z &= I_s \cosh \gamma z - \frac{V_s}{Z_0} \sinh \gamma z \\
&= I_s \cosh j\beta z - \frac{V_s}{Z_0} \sinh j\beta z \\
&= I_s \cos \beta z - \frac{V_s}{Z_0} \, j \sin \beta z
\end{aligned}
$$

Tegangan dan Arus pada Saluran Lossless

Persamaan Tegangan Dan Arus Jika Parameter Beban diketahui !



$$
\begin{aligned}
V_d &= V_L \cosh \gamma d + I_L Z_0 \sinh \gamma d \\
&= V_L \cosh j\beta d + I_L Z_0 \sinh j\beta d \\
&= V_L \cos \beta d + I_L Z_0 j \sin \beta d
\end{aligned}
$$

$$
\begin{aligned}
I_d &= I_L \cosh \gamma d + \frac{V_L}{Z_0} \sinh \gamma d \\
&= I_L \cosh j\beta d + \frac{V_L}{Z_0} \sinh j\beta d \\
&= I_L \cos \beta d + \frac{V_L}{Z_0} j \sin \beta d
\end{aligned}
$$

Impedansi Input Saluran Lossless

Pada saluran transmisi lossless berlaku :

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

$\alpha = 0$, maka :

$$Z_{in} = Z_0 \left[\frac{Z_L + Z_0 \tanh j\beta l}{Z_0 + Z_L \tanh j\beta l} \right] = Z_0 \left[\frac{Z_L + jZ_0 \tan \beta l}{Z_0 + jZ_L \tan \beta l} \right]$$

$$\tanh j\beta l = j \tan \beta l$$

$$\sinh j\beta l = j \sin \beta l$$

$$\cosh j\beta l = \cos \beta l$$

Saluran Lossless

Contoh Kasus

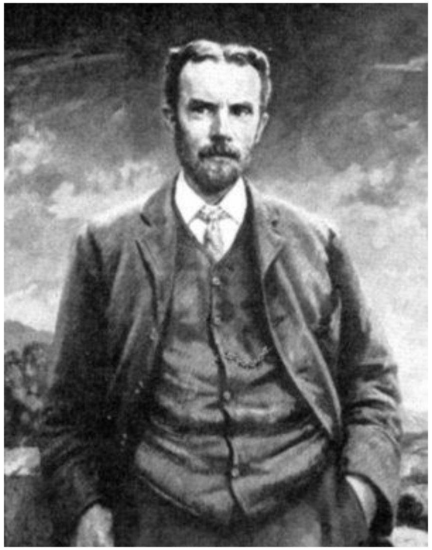
- Suatu saluran sepanjang 5 km menghubungkan sentral ke pelanggan. Diasumsikan saluran bersifat lossless dan mempunyai impedansi karakteristik = 50 ohm dan konstanta fasa = 5 rad/km. Tegangan yang dikirimkan oleh sentral (tegangan sumber) = $10 < 0^0$ volt. Dipelanggan terdapat pesawat telepon yang mempunyai impedansi 50 ohm. Carilah :
  - Impedansi input di sisi sentral
  - Tegangan dan arus di pesawat telepon pelanggan

Saluran Tanpa Cacat (Distortionless)

Saluran Tanpa Cacat (Distortionless)

- Dua jenis distorsi pada saluran :
  - ***Distorsi Redaman***. Distorsi ini terjadi apabila nilai redaman merupakan fungsi dari frekuensi
  - ***Distorsi fasa/distorsi kecepatan fasa***. Distorsi ini terjadi jika nilai kecepatan fasa bergantung pada nilai frekuensi
- Supaya saluran terbebas dari distorsi maka :
  - Konstanta redaman bukan fungsi frekuensi
  - Kecepatan fasa bukan fungsi frekuensi
- Untuk memenuhi syarat distortionless : **Oliver Heaviside (1850–1925)** menemukan solusinya pada abad 19!

$$\frac{R'}{L'} = \frac{G'}{C'} \rightarrow \textbf{Why???}$$



Saluran Tanpa Cacat (Distortionless)

Konstanta – konstanta pada saluran distortionless :

$$\gamma = \sqrt{(R' + j\omega L')(G' + j\omega C')} = \sqrt{L'\left(\frac{R'}{L'} + j\omega\right)C'\left(\frac{G'}{C'} + j\omega\right)}$$

$$\gamma = \sqrt{L'C'}\sqrt{\left(\frac{R'}{L'} + j\omega\right)\left(\frac{G'}{C'} + j\omega\right)}$$

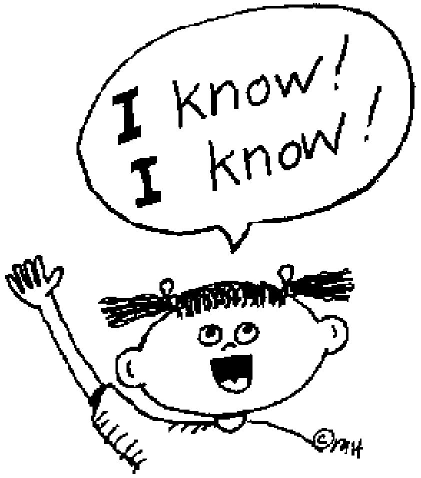
$$\gamma = \sqrt{L'C'}\left(\frac{R'}{L'} + j\omega\right) \text{ atau } \gamma = \sqrt{L'C'}\left(\frac{G'}{C'} + j\omega\right)$$

$$\text{Maka} : \alpha = \frac{R'}{L'}\sqrt{L'C'} \text{ atau } \alpha = \frac{G'}{C'}\sqrt{L'C'} \text{ dan } \beta = \omega\sqrt{L'C'}$$

$$V_p = \frac{\omega}{\beta} = \frac{1}{\sqrt{L'C'}}$$

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

Frequency Independent

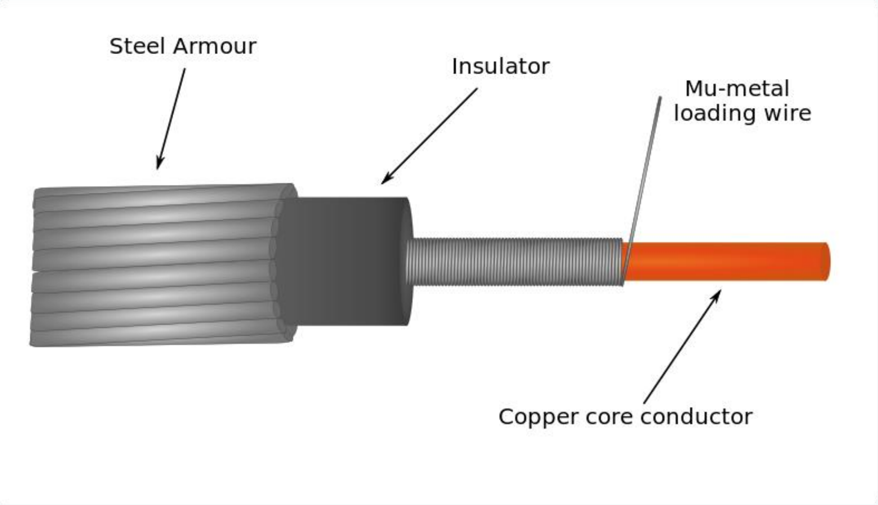


Saluran Tanpa Cacat (Distortionless)

Dalam kenyataannya saluran transmisi tidak ada yang ideal memenuhi syarat distortionless line, dan kebanyakan kondisi adalah :

$$\frac{G'}{C'} \leq \frac{R'}{L'}$$

Bagaimana cara agar kondisi distortionless Line/Heaviside terpenuhi???



Mu metal submarine telegraph cable construction. This was a type of cable used for long undersea telegraph cables, invented by The Telegraph Construction and Maintenance Company Ltd., London, in 1923. The copper conductor was wrapped with fine wire made of Mu metal, a high permeability nickel-iron alloy. It had been found that the seawater surrounding ordinary cables distorted the signal carried by them, resulting in very low transmission rates. The Mu metal wrapping added inductance to the cable, correcting the distortion and enabling higher data rates.

Saluran Merugi (Lossy)

Saluran Lossy

???

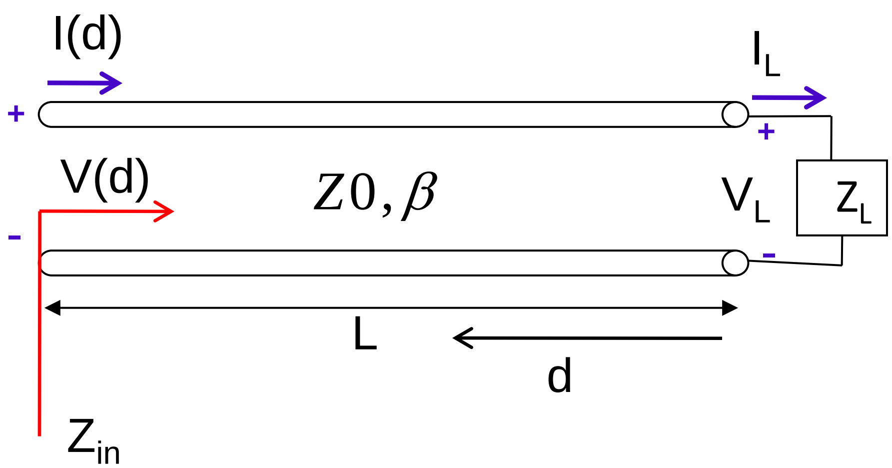
Latihan soal

1. Suatu saluran transmisi beroperasi pada frekuensi 125 Mhz memiliki impedansi karakteristik 40 Ω, konstanta redaman 0,02 Np/m, dan konstanta phasa 0,75 rad/m.
   a. Apakah saluran diatas lossless?
   b. Apakah saluran diatas distortionless?
   c. Hitunglah konstanta primer saluran diatas!
2. A lossless line has a characteristic resistance of 50 Ω . The line length is 1.185 λ . The load impedance is 110 + j80 Ω . Find the input impedance.

Saluran-saluran Istimewa

Saluran Istimewa

Suatu saluran transmisi Lossless dengan panjang L dengan impedansi beban Z_L



$$Z_{in} = Z_0 \left[\frac{Z_L + jZ_0 \tan \beta l}{Z_0 + jZ_L \tan \beta l} \right]$$

1. $L = n \lambda / 2$

$$Z_{in} = Z_0 \left[\frac{Z_L + jZ_0 \tan \beta l}{Z_0 + jZ_L \tan \beta l} \right]$$

$$= Z_0 \left[\frac{Z_L + jZ_0 \tan \frac{2\pi}{\lambda} \cdot \frac{\lambda}{2}}{Z_0 + jZ_L \tan \frac{2\pi}{\lambda} \cdot \frac{\lambda}{2}} \right] = Z_0 \left[\frac{Z_L + jZ_0 \tan \pi}{Z_0 + jZ_L \tan \pi} \right]$$

$$= Z_L$$

1. $L = n \lambda / 4$

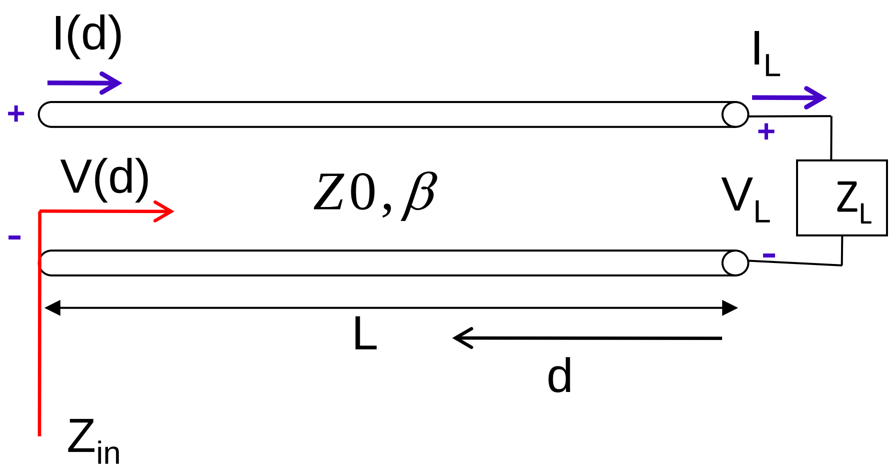
$$Z_{in} = Z_0 \left[\frac{Z_L + jZ_0 \tan \beta l}{Z_0 + jZ_L \tan \beta l} \right]$$

$$= Z_0 \left[\frac{Z_L + jZ_0 \tan \frac{2\pi}{\lambda} \cdot \frac{\lambda}{4}}{Z_0 + jZ_L \tan \frac{2\pi}{\lambda} \cdot \frac{\lambda}{4}} \right] = Z_0 \left[\frac{Z_L + jZ_0 \tan \frac{\pi}{2}}{Z_0 + jZ_L \tan \frac{\pi}{2}} \right]$$

$$= \frac{Z_0{}^2}{Z_L}$$

Saluran Istimewa

Suatu saluran transmisi Lossless dengan panjang L dengan impedansi beban Z_L



$$Z_{in} = Z_0 \left[\frac{Z_L + jZ_0 \tan \beta L}{Z_0 + jZ_L \tan \beta L} \right]$$

$$V_d = V_L \cos \beta d + I_L Z_0 j \sin \beta d$$

$$I_d = I_L \cos \beta d + \frac{V_L}{Z_0} j \sin \beta d$$

3. $L << \lambda$

$$Z_{in} = Z_0 \left[\frac{Z_L + jZ_0 \tan \beta L}{Z_0 + jZ_L \tan \beta L} \right]$$
$$= Z_0 \left[\frac{Z_L + jZ_0 \tan \frac{2\pi L}{\lambda}}{Z_0 + jZ_L \tan \frac{2\pi L}{\lambda}} \right] = Z_0 \left[\frac{Z_L + jZ_0 \tan 0}{Z_0 + jZ_L \tan 0} \right]$$
$$= Z_L$$

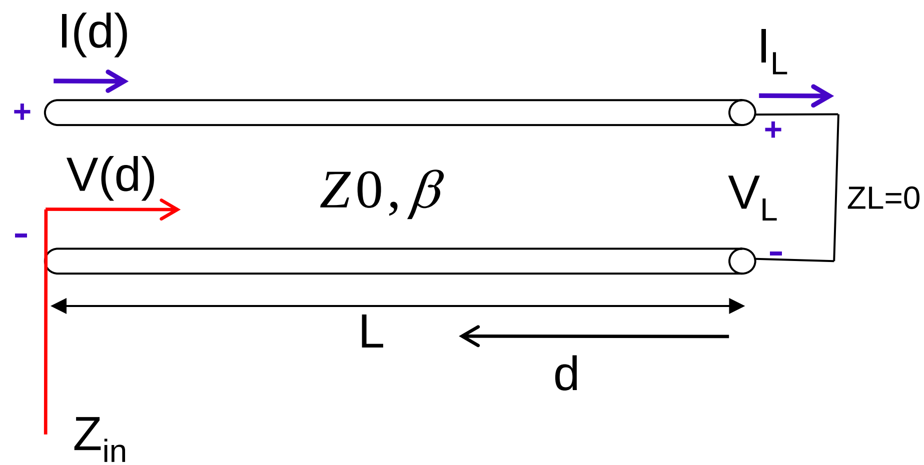
Nilai tegangan dan arusnya:

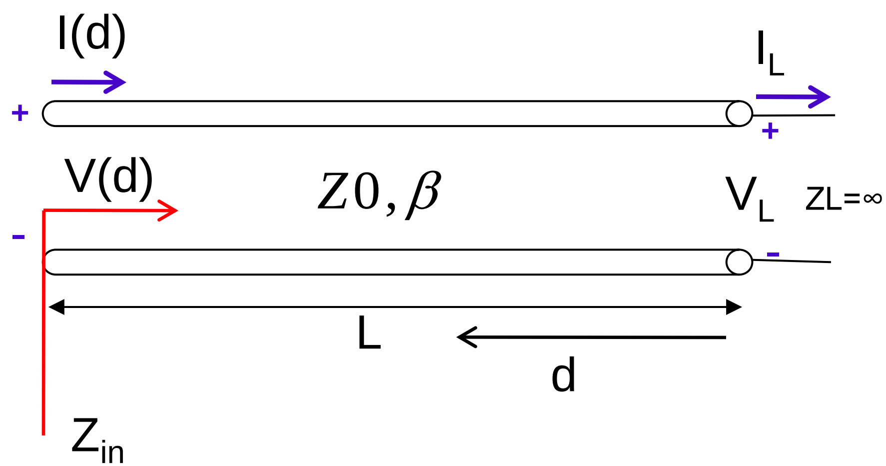
$$V_d = V_L \cos \beta d + I_L Z_0 j \sin \beta d$$
$$= V_L \cos \frac{2\pi}{\lambda} d + I_L Z_0 j \sin \frac{2\pi}{\lambda} d$$
$$sehingga \quad V(d=0) \approx V(d=l)$$

$$I_d = I_L \cos \beta d + \frac{V_L}{Z_0} j \sin \beta d$$
$$= I_L \cos \frac{2\pi}{\lambda} d + \frac{V_L}{Z_0} j \sin \frac{2\pi}{\lambda} d$$
$$sehingga \quad I(d=0) \approx I(d=L)$$

Saluran Istimewa

Suatu saluran transmisi Lossless dengan panjang L dengan impedansi beban Z_L





4. $Z_L = 0$

$$Z_{in} = Z_0\left[\frac{Z_L + jZ_0 \tan \beta l}{Z_0 + jZ_L \tan \beta l}\right]$$

$$= Z_0\left[\frac{0 + jZ_0 \tan \beta l}{Z_0 + j0 \tan \beta l}\right] = Z_0\left[\frac{jZ_0 \tan \beta l}{Z_0}\right]$$

$$= jZ_0 \tan \beta l$$

5. $Z_L = \infty$

$$Z_{in} = Z_0\left[\frac{Z_L + jZ_0 \tan \beta l}{Z_0 + jZ_L \tan \beta l}\right]$$

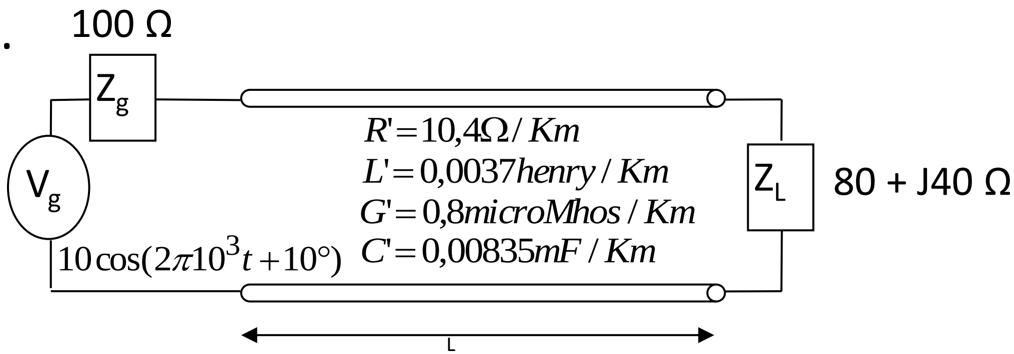
$$= Z_0\left[\frac{\infty + jZ_0 \tan \beta l}{Z_0 + j\infty \tan \beta l}\right]$$

$$= \frac{Z_0}{j \tan \beta l}$$

$$Z_0 = \sqrt{Z_{in(oc)} \times Z_{in(Sc)}}$$

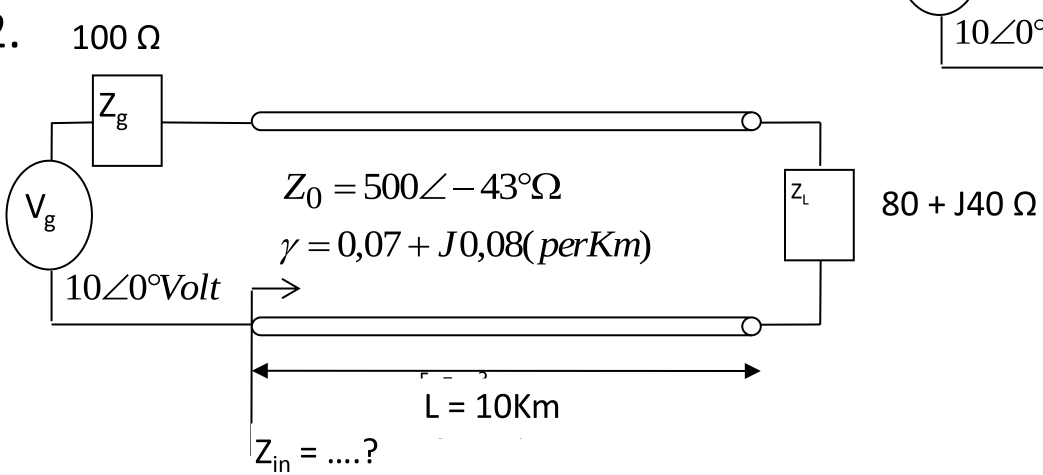
Tugas 4

1.

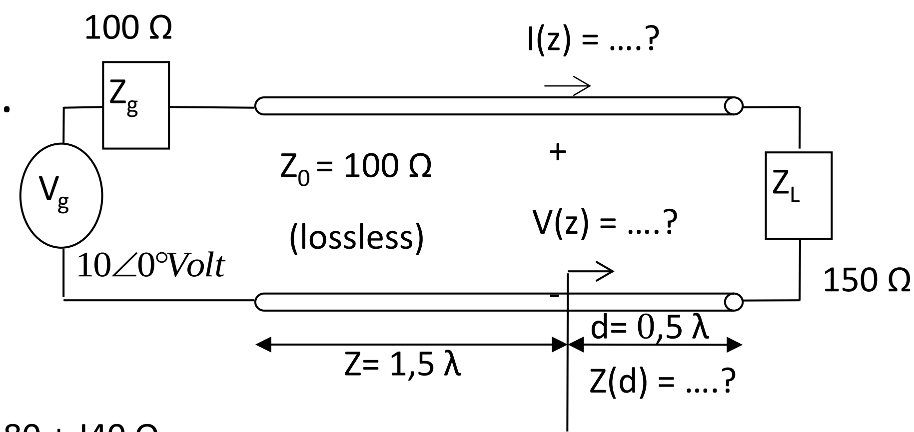


Find! Z_0, γ, V_p, λ, α, β

2.



3.



Questions???


Thank You