Saluran Transmisi dan Bumbung Gelombang

TTG4D3 – Rekayasa Gelombang Mikro

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Outline

- Mode Saluran TE, TM dan TEM

Modes

Transmission Lines (Saluran Transmisi)

- 2 konduktor
- Support TEM Waves

Waveguide (Bumbung Gelombang)

- 1 konduktor
- Tidak Support TEM Waves

TEM Waves?
Gelombang elektromagnetik yang medan listrik dan medan magnet tegak lurus terhadap arah perambatan gelombang.

Propagasi Gelombang

- Gelombang TEM (Transverse Electromagnetic)

$$E_z = H_z = 0$$

- Gelombang TE (Transverse Electric)

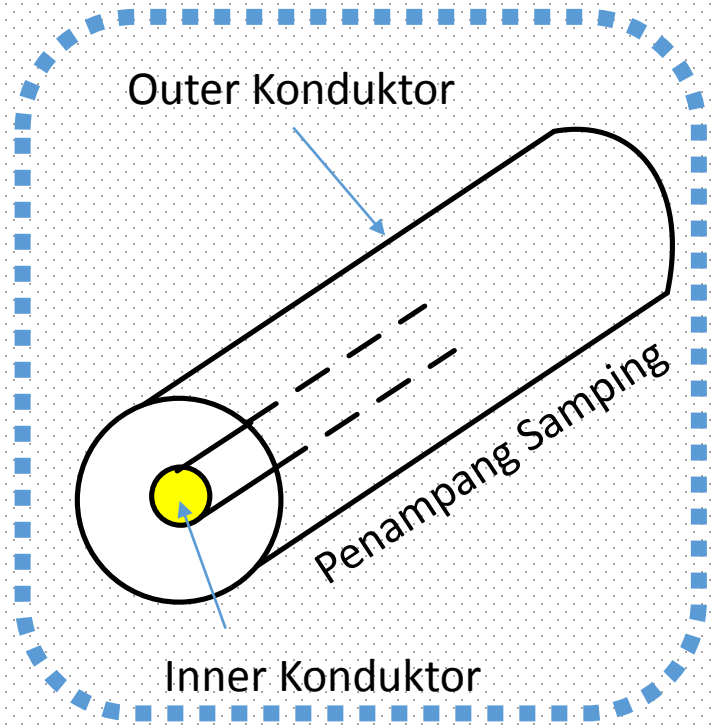
$$E_z = 0 \quad \text{dan} \quad H_z \neq 0$$

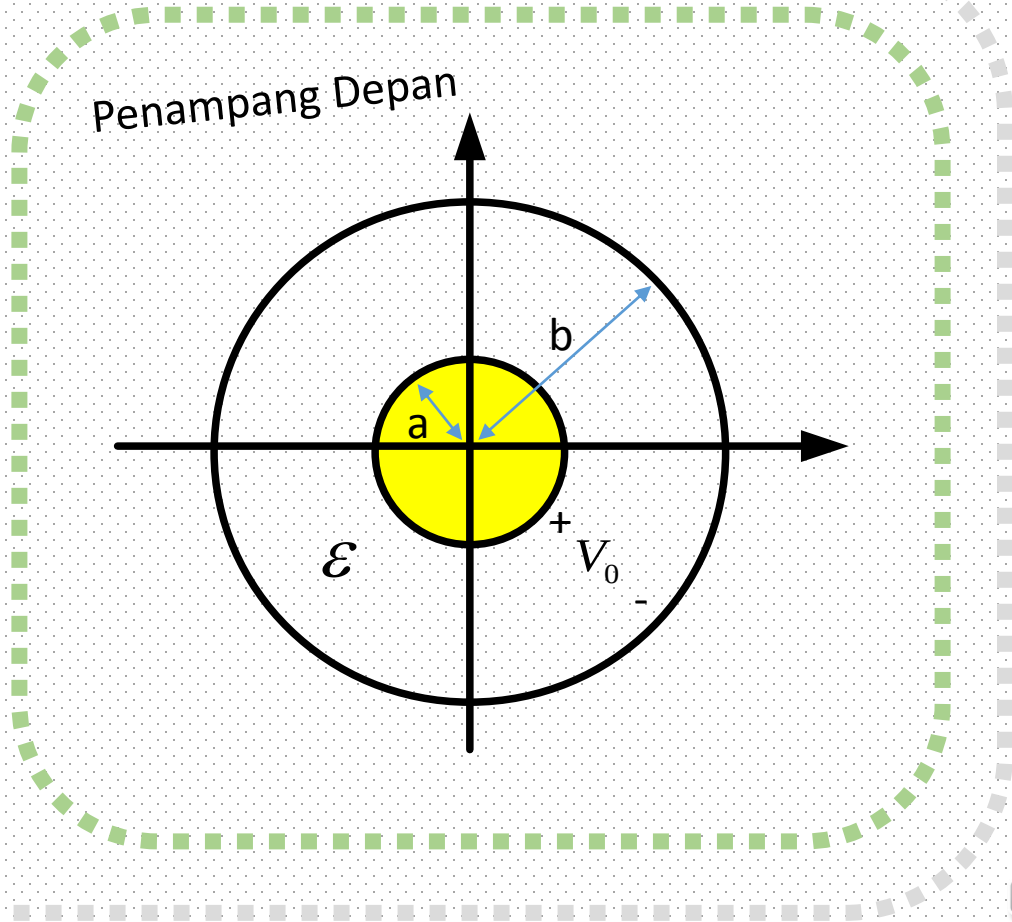
- Gelombang TM (Transverse Magnetic)

$$E_z \neq 0 \quad \text{dan} \quad H_z = 0$$

Saluran Transmisi : Kabel Koaksial (1)

- Kabel Koaksial → Mode TEM

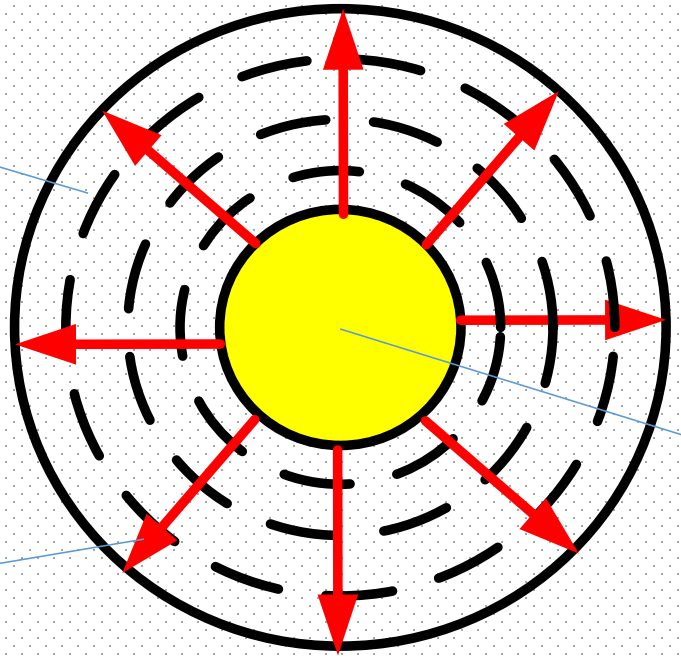




Saluran Transmisi : Kabel Koaksial (2)

Medan Magnet

$\hat{a}_\phi$



Medan Listrik

$\hat{a}_\rho$

$\hat{a}_\rho \perp \hat{a}_\phi \perp \hat{a}_z$

Mode TEM

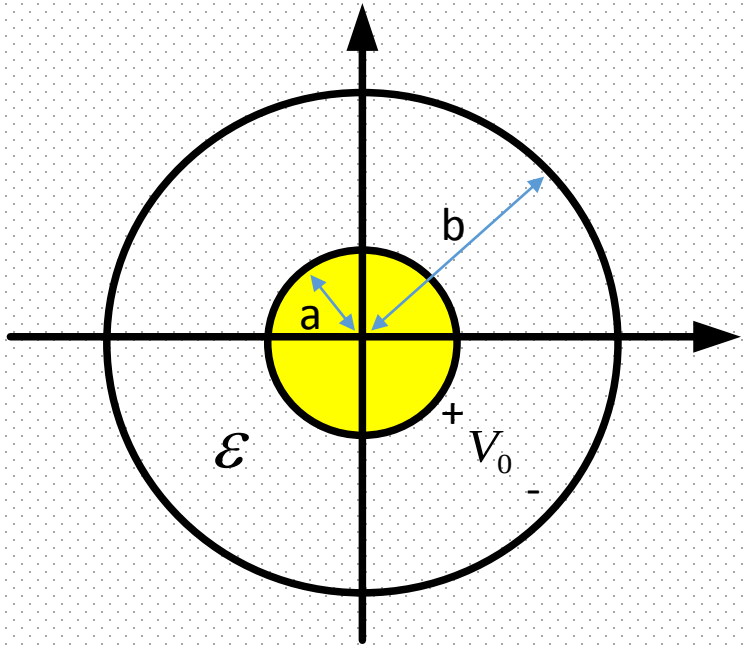
Arah Rambat

$\hat{a}_z$

Saluran Transmisi : Kabel Koaksial (2)

Impedansi Karakteristik

$$Z_0 = \sqrt{\frac{L}{C}} = \frac{1}{2\pi}\sqrt{\frac{\mu_0}{\varepsilon}}\ln\left[\frac{b}{a}\right]$$



Kapasitansi per satuan panjang

$$C = \frac{2\pi\varepsilon}{\ln[b/a]}; \frac{farad}{m}$$

Konstanta Fasa

$$\beta = \omega\sqrt{LC} = \omega\sqrt{\mu_0\varepsilon}$$

Induktansi per satuan panjang

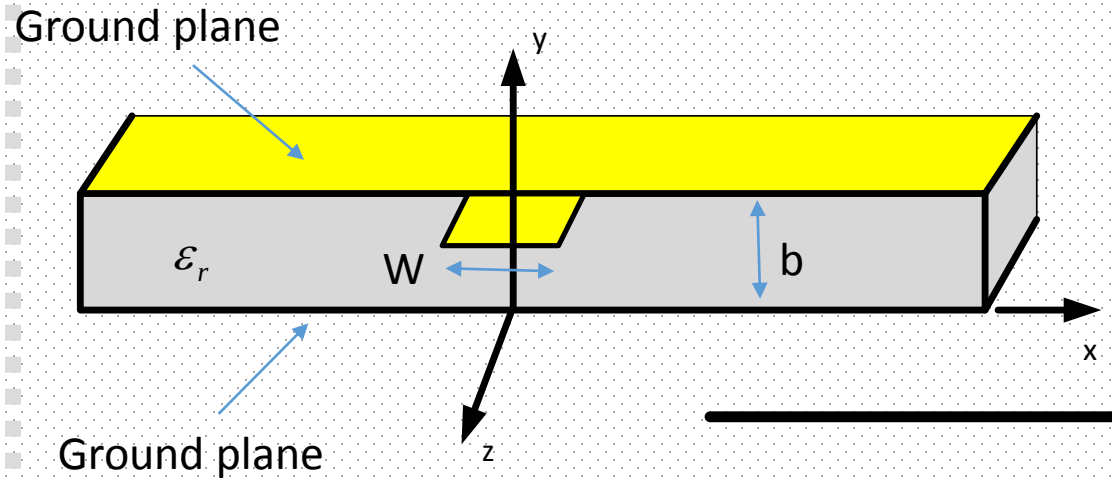
$$L = \frac{\mu_0}{2\pi}\ln\left[\frac{b}{a}\right]; \frac{henry}{m}$$

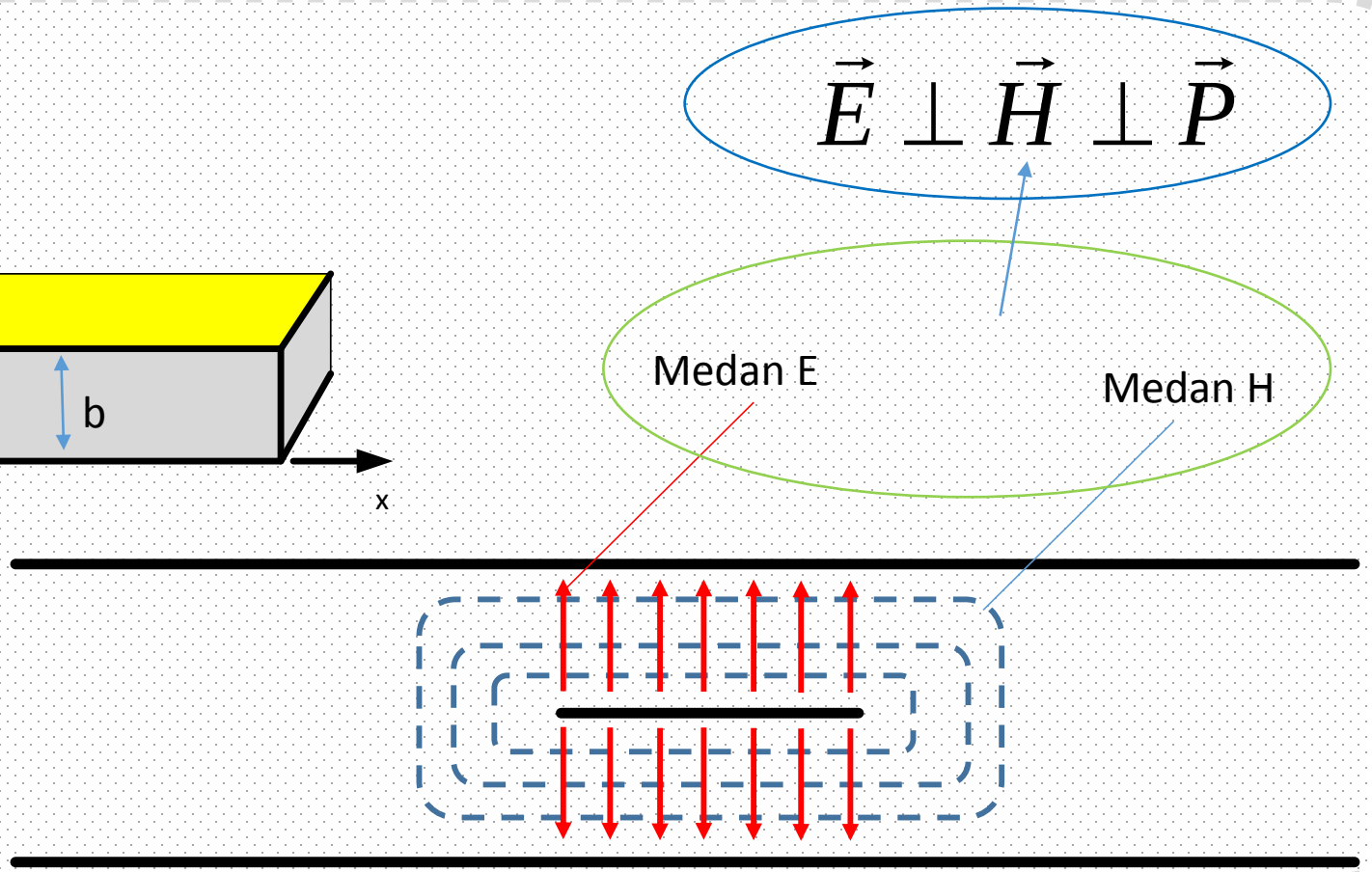
Kecepatan Propagasi

$$v_p = \frac{\omega}{\beta} = \frac{1}{\sqrt{\mu_0\varepsilon_0}}\frac{1}{\sqrt{\varepsilon_r}} = c\frac{1}{\sqrt{\varepsilon_r}}$$

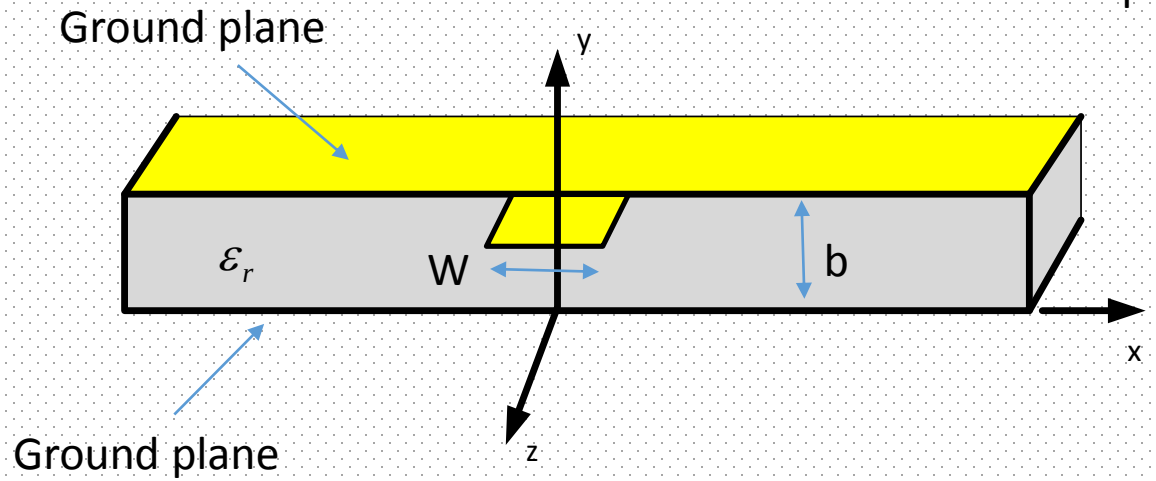
Saluran Transmisi : Stripline (1)

- Stripline (TEM)





Saluran Transmisi : Stripline (2)



Impedansi

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

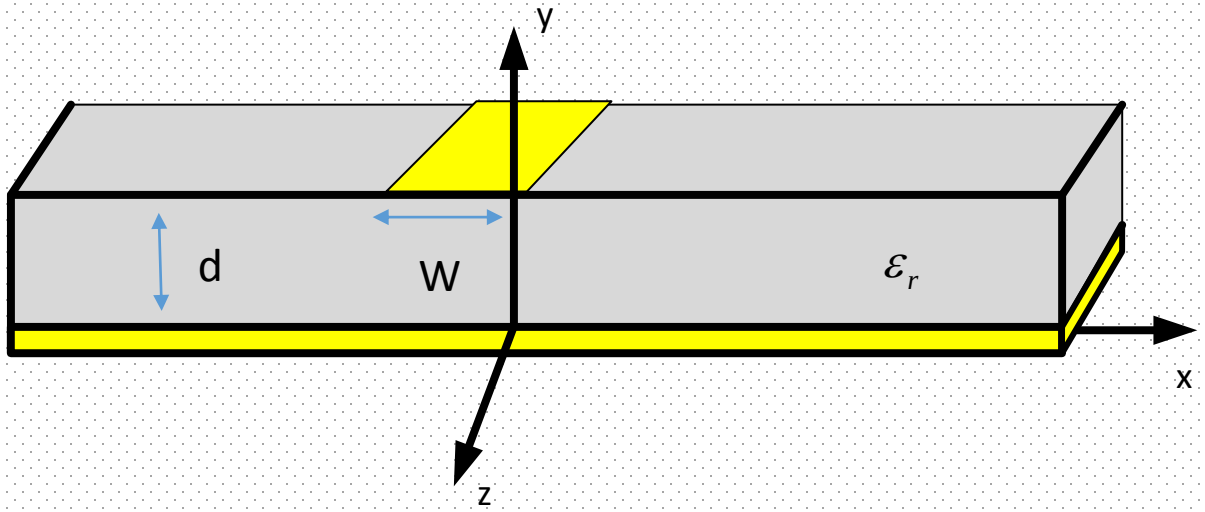
$$Z_0 = \frac{30\pi}{\sqrt{\varepsilon_e}} \frac{b/W_e}{1+0{,}441b/W_e}$$

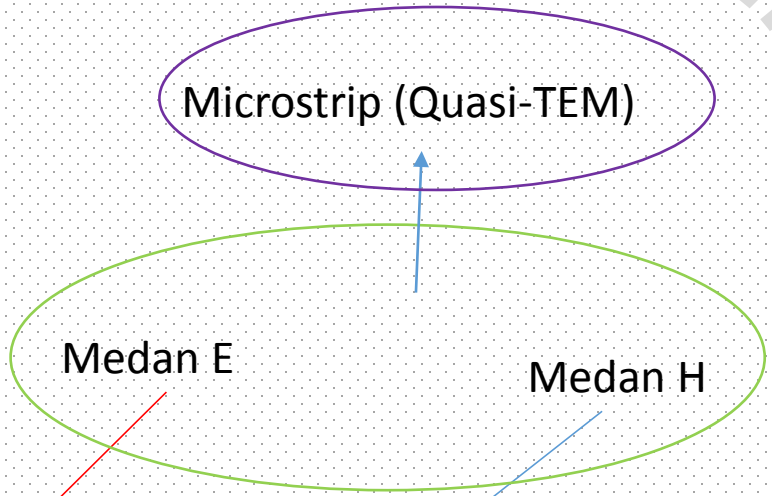
$$\frac{W_e}{b} = \frac{W}{b} - \begin{cases} 0 & untuk\, W/b > 0{,}35 \\ (0{,}35 - W/b)^2 & untuk\, W/b < 0{,}35 \end{cases}$$

Konstanta Fasa

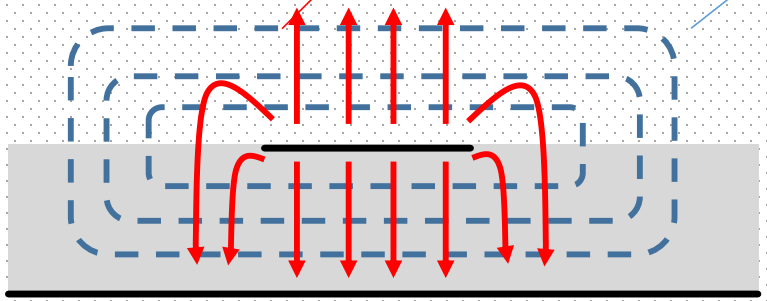
$$\beta = \omega\sqrt{LC} = \omega\sqrt{\varepsilon\mu} = \frac{\omega}{c}\sqrt{\varepsilon_r}$$

Saluran Transmisi : Microstrip (1)

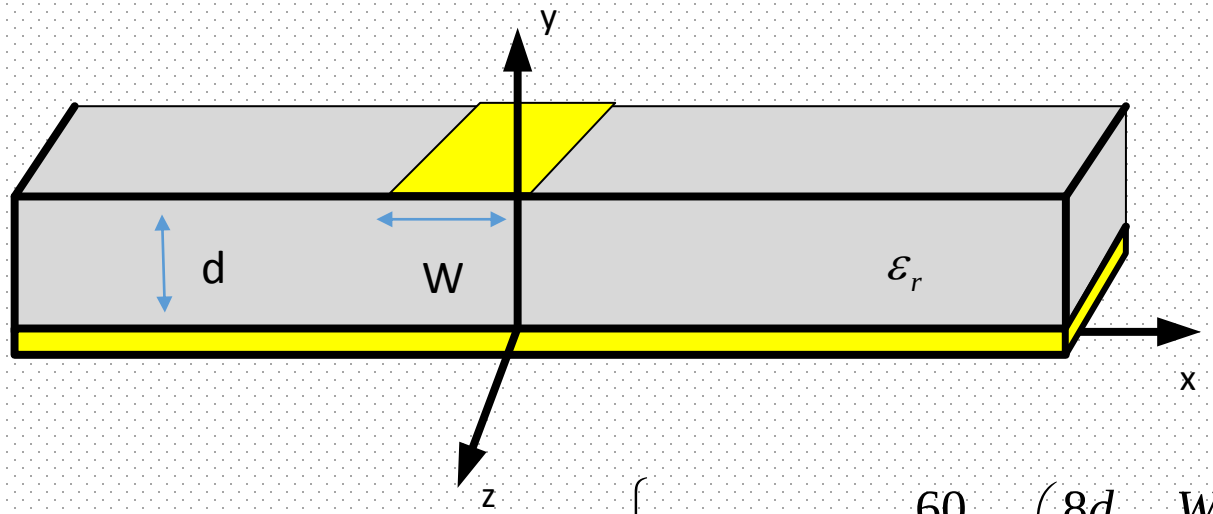




$$d << \lambda$$



Saluran Transmisi : Microstrip (2)



Konstanta Fasa

$$\beta = \frac{\omega}{c}\sqrt{\varepsilon_e}$$

$$\varepsilon_e = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\frac{1}{\sqrt{1 + 12\,d/W}}$$

Impedansi

$$Z_0 = \begin{cases} \dfrac{60}{\sqrt{\varepsilon_e}} \ln\left(\dfrac{8d}{W} + \dfrac{W}{4d}\right) & untuk\ W/d \le 1 \\ \dfrac{120\pi}{\sqrt{\varepsilon_e}\left[W/d + 1{,}393 + 0{,}667\ln(W/d + 1{,}444)\right]} & untuk\ W/d > 1 \end{cases}$$

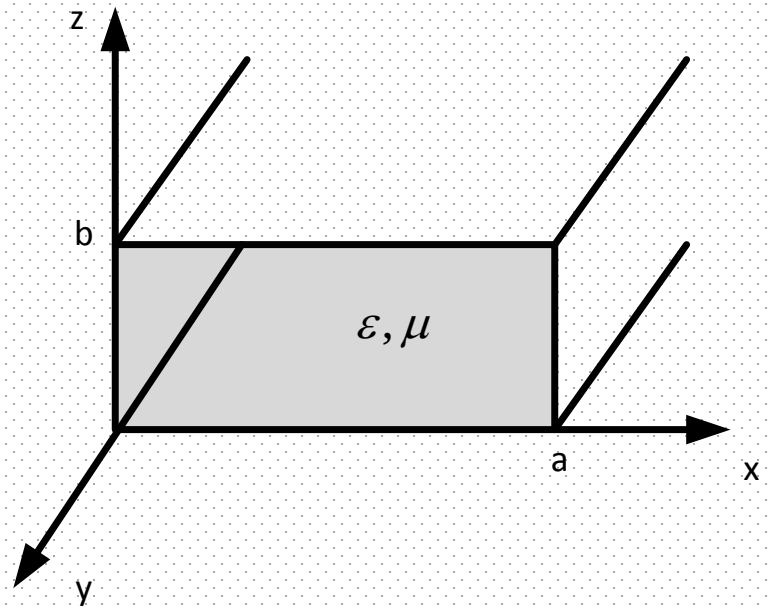
Saluran Transmisi : Bumbung Gelombang Rectangular (1)

Tidak terjadi perambatan gelombang TEM, karena hanya memakai 1 konduktor.

Gelombang TE
(Transverse Electric)

$$E_z = 0$$

$$H_z \neq 0$$



Gelombang TM
(Transverse Magnetic)

$$E_z \neq 0$$

$$H_z = 0$$

Saluran Transmisi : Bumbung Gelombang Rectangular (2)

- TE & TM Mode → BW terbatas
- TE & TM Mode → dispersive → kec. Fasa tergantung frekuensi

- Keuntungan?
  - Power tinggi
  - low loss

Referensi

- Microwave Engineering 3rd Edition, David M. Pozar

Terima Kasih