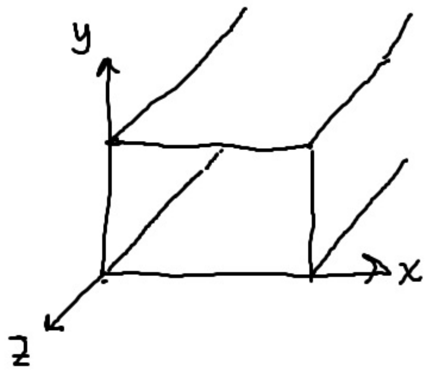
# Dikdörtgen Dalga Kılavuzu




$$\left.\begin{aligned}\bar{\nabla}^2 \bar{E} + k^2 \bar{E} = 0 \\ \bar{\nabla}^2 \bar{H} + k^2 \bar{H} = 0\end{aligned}\right\}$$ Fazör domain'inde dalga denklemleri

$$\bar{\nabla}^2 = \bar{\nabla}\cdot\bar{\nabla} = \left(\hat{a}_x \frac{\partial}{\partial x} + \hat{a}_y \frac{\partial}{\partial y} + \hat{a}_z \frac{\partial}{\partial z}\right)\cdot \left(\hat{a}_x \frac{\partial}{\partial x} + \hat{a}_y \frac{\partial}{\partial y} + \hat{a}_z \frac{\partial}{\partial z}\right)$$

$$= \underbrace{\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2}}_{\substack{\text{transvers düzlem} \\ \bar{\nabla}_t^2}} + \underbrace{\frac{\partial^2}{\partial z^2}}_{\text{yayılım yönü}}$$

$$\bar{\nabla}^2 = \bar{\nabla}_t^2 + \bar{\nabla}_z^2$$

$$= \bar{\nabla}_t^2 + \frac{\partial}{\partial z^2}$$

$$\bar{\nabla}^2 \bar{E} = \bar{\nabla}_t^2 \bar{E} + \frac{\partial^2 \bar{E}}{\partial z^2}$$

$$\bar{E} \rightsquigarrow e^{-\gamma z} e^{j\omega t} = e^{-(\alpha + j\beta)z} e^{j\omega t} = \underbrace{e^{-\alpha z}}_{\text{sönümleme}} \underbrace{e^{j(\omega t - \beta z)}}_{\text{yayılım}}$$

$$\frac{\gamma \bar{E}}{\partial z^2} = \gamma^2 \bar{E}$$

$$k = \omega\sqrt{\mu\epsilon}$$

Dalga denklemleri $\rightarrow$ $\bar{\nabla}_t^2 \bar{E} + (\gamma^2 + k^2)\bar{E} = 0$

$\hookrightarrow$ $\bar{\nabla}_t^2 \bar{H} + \underbrace{(\gamma^2 + k^2)}_{h^2} \bar{H} = 0$

$$h^2 = \gamma^2 + k^2 \rightarrow \gamma^2 = h^2 - k^2 \rightarrow \gamma = \sqrt{h^2 - k^2}$$

$$= \sqrt{h^2 - \omega^2 \mu\epsilon}$$

$\omega_c = 2\pi f_c$

$\downarrow$

$\omega_c$ : cut-off frequency (kesme frekansı) $\leftarrow$

? $\leftarrow$ $h^2 - \omega^2\mu\epsilon > 0$ ise $\gamma$ reel

$h^2 - \omega_c^2\mu\epsilon = 0$ ise $\gamma = 0$

$h^2 - \omega^2\mu\epsilon < 0$ ise $\gamma$ imajiner

$$e^{-\gamma z} e^{j\omega t} = e^{-(\alpha+j\beta)z} e^{j\omega t} = \underbrace{e^{-\alpha z}}_{\text{sönümlenme}} \underbrace{e^{j(\omega t-\beta z)}}_{\text{yayılım}}$$

**Durum 1:** $\omega_c < \omega$ ise $h^2-\omega^2\mu\epsilon<0$ ise $\gamma$ imajiner

$$e^{-\gamma z} e^{j\omega t} = e^{-(\cancel{\alpha}+j\beta)z} e^{j\omega t} = \cancel{\underbrace{e^{-\alpha z}}_{\text{sönümlenme}}} \underbrace{e^{j(\omega t-\beta z)}}_{\text{yayılım}}$$

**Durum 2:** $\omega_c > \omega$ ise $h^2-\omega^2\mu\epsilon>0$ ise $\gamma$ reel

$$e^{-\gamma z} e^{j\omega t} = e^{-(\alpha+\cancel{j\beta})z} e^{j\omega t} = \underbrace{e^{-\alpha z}}_{\text{sönümlenme}} \underbrace{e^{j(\omega t-\cancel{\beta z})}}_{\cancel{\text{yayılım}}}$$

## Homojen vektör Helmholtz denklemleri :

$$\bar{\nabla}^2 \bar{E} + k^2 \bar{E} = 0 \quad \circledast$$

$$\bar{\nabla}^2 \bar{H} + k^2 \bar{H} = 0 \quad \circledast\circledast$$

$k = w\sqrt{\mu\epsilon}$ : wavenumber $(1/m)$

$$\bar{\nabla}^2 \bar{E} = (\bar{\nabla}_t^2 + \bar{\nabla}_\rho^2)\bar{E} = (\bar{\nabla}_{xy}^2 + \bar{\nabla}_z^2)\bar{E} = \left(\bar{\nabla}_{xy}^2 + \frac{\partial^2}{\partial z^2}\right)\bar{E}$$

$$= \bar{\nabla}_{xy}^2 \bar{E} + \frac{\partial^2}{\partial z^2}\bar{E} = \bar{\nabla}_{xy}^2 \bar{E} + \gamma^2 \bar{E}$$

$\bar{E}$ ; $e^{-\gamma z} e^{jwt}$ terimi içeriyor

$$e^{-(\alpha + j\beta)z} e^{jwt} = e^{-\alpha z} e^{j(wt - \beta z)}$$

$\circledast$ denklemi $\quad \bar{\nabla}_{xy}^2 \bar{E} + k^2 \bar{E} + \gamma^2 \bar{E} = \overbrace{\bar{\nabla}_{xy}^2 \bar{E} + (k^2 + \gamma^2)\bar{E}} = 0$

Benzer şekilde

$\circledast\circledast$ denklemi $\quad \bar{\nabla}_{xy}^2 \bar{H} + k^2 \bar{H} + \gamma^2 \bar{H} = \underbrace{\bar{\nabla}_{xy}^2 \bar{H} + (k^2 + \gamma^2)\bar{H} = 0}$

Bu denklemlerin çözümleri dalga kılavuzunun ara kesitine ve sınır koşullarına bağlı

$E_x, E_y, E_z$ ; $H_x, H_y, H_z$ ← 6 adet skaler fonksiyon var ;

ancak bunlar birbirlerinden tamamen bağımsız değil

$$\bar{\nabla} \times \bar{E} = -jw\bar{B} = -jw\mu\bar{H}$$

$$\bar{\nabla} \times \bar{H} = jw\bar{D} + \cancel{\bar{J}}_{\,0} = jw\epsilon\bar{E}$$

(kaynaksız ortam)