

## Time Harmonic Fields

### Planar Sinusoidal Wave

$$\mathbf{E} = \hat{E} \cos(\omega t - \mathbf{k} \cdot \mathbf{r} + \phi) \mathbf{e}_E \quad \text{instantaneous value}$$

$$\mathbf{E} = E_0 e^{-j\mathbf{k} \cdot \mathbf{r}} \mathbf{e}_E \quad \text{complex value}$$

$$E_0 = \hat{E} e^{j\phi} \quad \text{top value scale}$$

$$E_0 = \frac{\hat{E}}{\sqrt{2}} e^{j\phi} \quad \text{effective value scale}$$

### Propagation Rate

$$v = \frac{1}{\sqrt{\mu_0 \mu_r \epsilon_0 \epsilon_r}} \quad v = \frac{\omega}{k} \quad k = |\mathbf{k}|$$

### Wave Impedance Non-Conductive Space

$$\eta = \sqrt{\frac{\mu_r \mu_0}{\epsilon_r \epsilon_0}}$$

### Rule of Right-Hand Systems

$$\mathbf{e}_k = \mathbf{e}_E \times \mathbf{e}_H \quad E = \eta H \quad \mathbf{e}_k = \mathbf{e}_E \times \mathbf{e}_B \quad E = vB$$

### Planar Wave in Space with Conductivity

$$\mathbf{E} = E_0 e^{\gamma z} \mathbf{e}_x$$

### Complex Propagation Constant

$$\gamma = \sqrt{j\omega\mu_r\mu_0(\sigma + j\omega\epsilon_r\epsilon_0)} \quad \gamma = \alpha + j\beta$$

### Wave Impedance, Space With Given Conductivity

$$\eta = \sqrt{\frac{j\omega\mu_r\mu_0}{\sigma + j\omega\epsilon_r\epsilon_0}}$$

### Penetration Depth

$$\delta = \sqrt{\frac{2}{\omega\mu_r\mu_0\sigma}}$$