Corso di Laurea in Ingegneria Informatica, Biomedica e delle Telecomunicazioni

Corso di Campi Elettromagnetici
a.a. 2019-2020

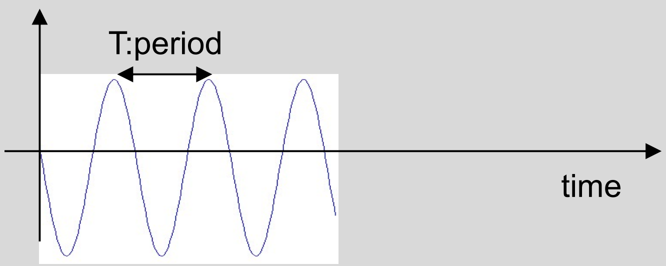
Maxwell equations
Time domain & Phasors

Phasors

Time domain

$f(t)$

Signals usually adopted in ICT applications



$$f(t) = A\cos\left(2\pi f_0 t + \alpha\right)$$

$$f_0 : frequency = \frac{1}{T}$$

$$\omega_0 : angular\ frequency = 2\pi f_0$$

Phasors

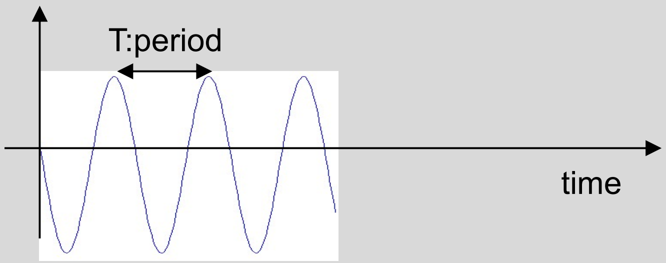
Time domain

$$f(t) = A\cos(\omega_0 t + \alpha)$$

Phasor domain

$$F = Ae^{j\alpha}$$

Signals usually adopted in ICT applications



$$f(t) = A\cos(2\pi f_0 t + \alpha)$$

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Phasors

Time domain

$$f(t) = A\cos(\omega_0 t + \alpha)$$

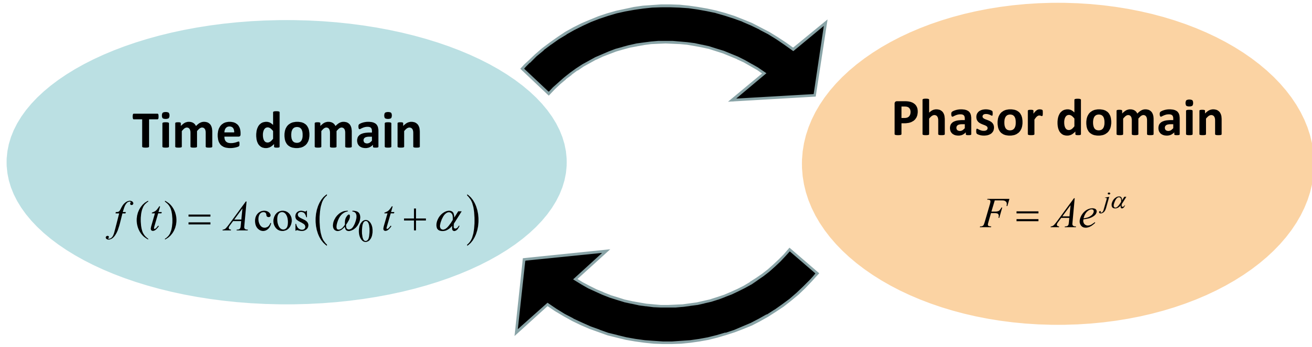
Phasor domain

$$F = Ae^{j\alpha}$$

1) How to jump back from the Phasor domain to the Time domain

2) Time domain derivative and Phasors

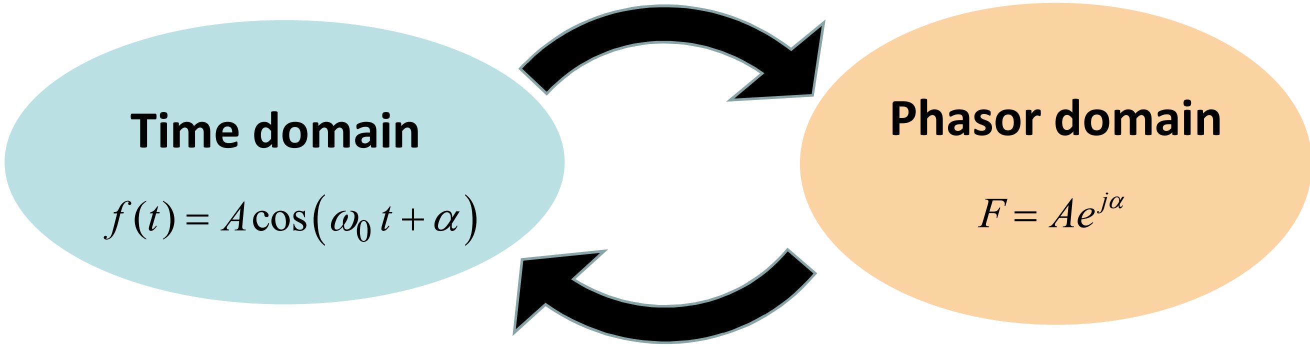
Phasors



1) How to jump back from the Phasor domain to the Time domain

$$f(t) = \mathrm{Re}\left\{Fe^{j\omega_0 t}\right\} = \mathrm{Re}\left\{Ae^{j\alpha}e^{j\omega_0 t}\right\} = A\cos(\omega_0 t + \alpha)$$

Phasors



$f(t) = A\cos(\omega_0 t + \alpha)$ → **T-to-P** → $F = Ae^{j\alpha}$

$F = Ae^{j\alpha}$ → **P-to-T** → $f(t) = \mathrm{Re}\left\{Fe^{j\omega_0 t}\right\} = A\cos(\omega_0 t + \alpha)$

Phasors

Time domain

$$f(t) = A\cos(\omega_0 t + \alpha)$$

Phasor domain

$$F = Ae^{j\alpha}$$

… memo …

$$f(t) \longrightarrow \boxed{\text{FT}} \longrightarrow F(\omega)$$

$$\frac{df}{dt} \longrightarrow \boxed{\text{FT}} \longrightarrow j\omega F(\omega)$$

2) Time domain derivative and Phasors

$$f(t) \longrightarrow \boxed{\text{T-to-P}} \longrightarrow F$$

$$\frac{df(t)}{dt} \longrightarrow \boxed{\text{T-to-P}} \longrightarrow j\omega_0 F$$

ω_0 now is fixed!

Phasors

- Phasors and functions of *n* variables

- Phasors and vector functions

- Phasors and vector functions of *n* variables

Phasors

- Phasors and functions of *n* variables

- Phasors and vector functions

- Phasors and vector functions of *n* variables

1) How to jump back from the Phasor domain to the Time domain

2) Time domain derivative and Phasors

Phasors

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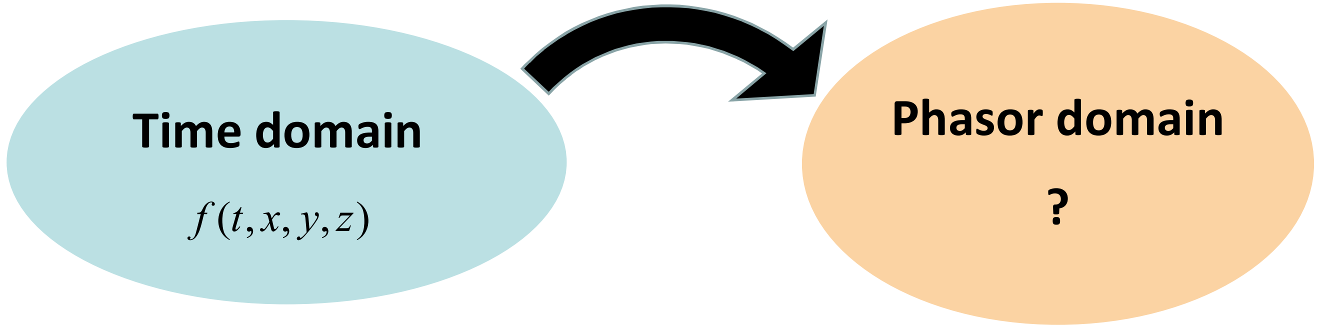
1) How to jump back from the Phasor domain to the Time domain

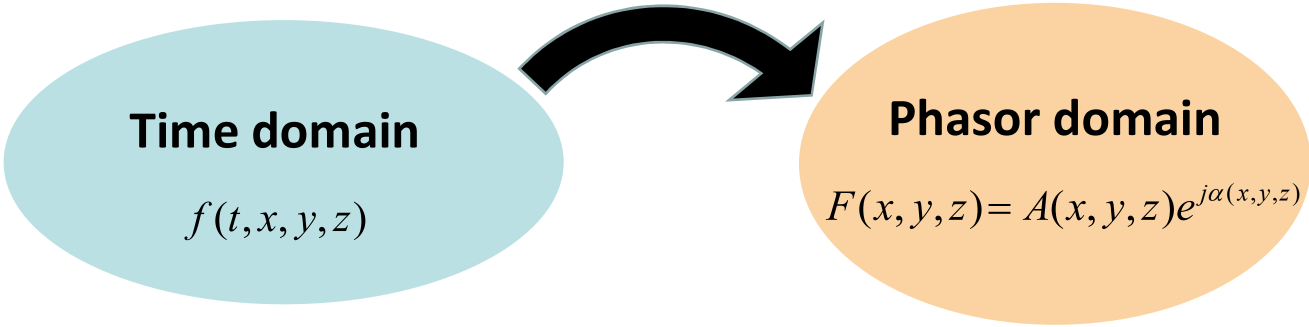
2) Time domain derivative and Phasors

Phasors and functions of *n* variables



$$f(t,x,y,z) = A(x,y,z)\cos\left(\omega_0 t + \alpha(x,y,z)\right)$$

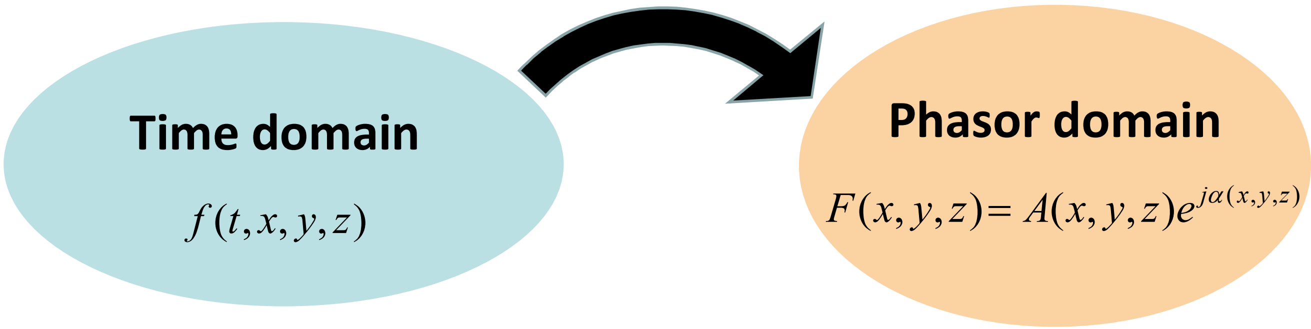
Phasors and functions of *n* variables



$$f(t,x,y,z) = A(x,y,z)\cos\left(\omega_0 t + \alpha(x,y,z)\right)$$

$$F(x,y,z) = A(x,y,z)e^{j\alpha(x,y,z)}$$

Phasors and functions of *n* variables



$$f(t,x,y,z) = A(x,y,z)\cos\left(\omega_0 t + \alpha(x,y,z)\right)$$

$$F(x,y,z)= A(x,y,z)e^{j\alpha(x,y,z)}$$

1) How to jump back from the Phasor domain to the Time domain

Phasors and functions of *n* variables

Time domain

$f(t,x,y,z)$

Phasor domain

$F(x,y,z)=A(x,y,z)e^{j\alpha(x,y,z)}$

$$f(t,x,y,z)=A(x,y,z)\cos\left(\omega_0 t+\alpha(x,y,z)\right)$$

$$F(x,y,z)=A(x,y,z)e^{j\alpha(x,y,z)}$$

1) How to jump back from the Phasor domain to the Time domain

$$f(t,x,y,z)=\mathrm{Re}\left\{F(x,y,z)e^{j\omega_0 t}\right\}$$

Phasors and functions of *n* variables

Time domain

$f(t,x,y,z)$

Phasor domain

$F(x,y,z) = A(x,y,z)e^{j\alpha(x,y,z)}$

$$f(t,x,y,z) = A(x,y,z)\cos\left(\omega_0 t + \alpha(x,y,z)\right)$$

2) Time domain derivative and Phasors

$f(t,x,y,z)$ → **T-to-P** → $F(x,y,z)$

$\dfrac{\partial f}{\partial t}$ → **T-to-P** → **?**

Phasors and functions of *n* variables

Time domain

$f(t,x,y,z)$

Phasor domain

$F(x,y,z)= A(x,y,z)e^{j\alpha(x,y,z)}$

$$f(t,x,y,z) = A\left(x,y,z\right)\cos\left(\omega_0 t + \alpha\left(x,y,z\right)\right)$$

2) Time domain derivative and Phasors

$f(t,x,y,z)$ → **T-to-P** → $F(x,y,z)$

$\dfrac{\partial f}{\partial t}$ → **T-to-P** → $j\omega_0 F(x,y,z)$

Phasors and functions of *n* variables

Time domain

$f(t,x,y,z)$

→

Phasor domain

$F(x,y,z) = A(x,y,z)e^{j\alpha(x,y,z)}$

$$f(t,x,y,z) = A(x,y,z)\cos\left(\omega_0 t + \alpha(x,y,z)\right)$$

2) Time domain derivative and Phasors

$f(t,x,y,z)$ → **T-to-P** → $F(x,y,z)$

$\frac{\partial f}{\partial t}$ → **T-to-P** → $j\omega_0 F(x,y,z)$

$\frac{\partial f}{\partial x}$ → **T-to-P** → **?**

Phasors and functions of *n* variables

Time domain → **Phasor domain**

$f(t,x,y,z)$ → $F(x,y,z) = A(x,y,z)e^{j\alpha(x,y,z)}$

$$f(t,x,y,z) = A(x,y,z)\cos\left(\omega_0 t + \alpha(x,y,z)\right)$$

2) Time domain derivative and Phasors

$f(t,x,y,z)$ → **T-to-P** → $F(x,y,z)$

$\frac{\partial f}{\partial t}$ → **T-to-P** → $j\omega_0 F(x,y,z)$

$\frac{\partial f}{\partial x}$ → **T-to-P** → $\frac{\partial F(x,y,z)}{\partial x}$

Phasors

- Phasors and functions of *n* variables

- Phasors and vector functions

- Phasors and vector functions of *n* variables

1) How to jump back from the Phasor domain to the Time domain

2) Time domain derivative and Phasors

Phasors and vector functions

Time domain

$$\vec{\mathbf{f}}(t) = f_x(t)\hat{i}_x + f_y(t)\hat{i}_y + f_z(t)\hat{i}_z$$

Phasor domain

?

$$f_x(t) = A_x \cos\left(\omega_0 t + \alpha_x\right)$$

$$f_y(t) = A_y \cos\left(\omega_0 t + \alpha_y\right)$$

$$f_z(t) = A_z \cos\left(\omega_0 t + \alpha_z\right)$$

Phasors and vector functions

Time domain

$$\vec{\mathbf{f}}(t) = f_x(t)\hat{i}_x + f_y(t)\hat{i}_y + f_z(t)\hat{i}_z$$

Phasor domain

?

$$f_x(t) = A_x \cos\left(\omega_0 t + \alpha_x\right)$$ → **T-to-P** →

$$f_y(t) = A_y \cos\left(\omega_0 t + \alpha_y\right)$$ → **T-to-P** →

$$f_z(t) = A_z \cos\left(\omega_0 t + \alpha_z\right)$$ → **T-to-P** →

Phasors and vector functions

Time domain

$$\vec{\mathbf{f}}(t) = f_x(t)\hat{i}_x + f_y(t)\hat{i}_y + f_z(t)\hat{i}_z$$

Phasor domain

?

$f_x(t) = A_x \cos\left(\omega_0 t + \alpha_x\right)$ → **T-to-P** → $F_x = A_x e^{j\alpha_x}$

$f_y(t) = A_y \cos\left(\omega_0 t + \alpha_y\right)$ → **T-to-P** → $F_y = A_y e^{j\alpha_y}$

$f_z(t) = A_z \cos\left(\omega_0 t + \alpha_z\right)$ → **T-to-P** → $F_z = A_z e^{j\alpha_z}$

Phasors and vector functions

Time domain

$$\vec{\mathbf{f}}(t) = f_x(t)\hat{i}_x + f_y(t)\hat{i}_y + f_z(t)\hat{i}_z$$

Phasor domain

$$\vec{\mathbf{F}} = F_x\hat{i}_x + F_y\hat{i}_y + F_z\hat{i}_z$$

$f_x(t) = A_x \cos(\omega_0 t + \alpha_x)$ → **T-to-P** → $F_x = A_x e^{j\alpha_x}$

$f_y(t) = A_y \cos(\omega_0 t + \alpha_y)$ → **T-to-P** → $F_y = A_y e^{j\alpha_y}$

$f_z(t) = A_z \cos(\omega_0 t + \alpha_z)$ → **T-to-P** → $F_z = A_z e^{j\alpha_z}$

Phasors and vector functions

Time domain

$$\vec{\mathbf{f}}(t) = f_x(t)\hat{i}_x + f_y(t)\hat{i}_y + f_z(t)\hat{i}_z$$

Phasor domain

$$\vec{\mathbf{F}} = F_x\hat{i}_x + F_y\hat{i}_y + F_z\hat{i}_z$$

$\vec{\mathbf{f}}(t)$ → **T-to-P** → $\vec{\mathbf{F}}$

$$\vec{\mathbf{f}}(t) = f_x(t)\hat{i}_x + f_y(t)\hat{i}_y + f_z(t)\hat{i}_z = A_x\cos\left(\omega_0 t + \alpha_x\right)\hat{i}_x + A_y\cos\left(\omega_0 t + \alpha_y\right)\hat{i}_y + A_z\cos\left(\omega_0 t + \alpha_z\right)\hat{i}_z$$

$$\vec{\mathbf{F}} = F_x\hat{i}_x + F_y\hat{i}_y + F_z\hat{i}_z = A_x e^{j\alpha_x}\hat{i}_x + A_y e^{j\alpha_y}\hat{i}_y + A_z e^{j\alpha_z}\hat{i}_z$$

Phasors and vector functions

Time domain

$$\vec{\mathbf{f}}(t) = f_x(t)\hat{i}_x + f_y(t)\hat{i}_y + f_z(t)\hat{i}_z$$

Phasor domain

$$\vec{\mathbf{F}} = F_x\hat{i}_x + F_y\hat{i}_y + F_z\hat{i}_z$$

1) How to jump back from the Phasor domain to the Time domain

Phasors and vector functions

Time domain

$$\vec{\mathbf{f}}(t) = f_x(t)\hat{i}_x + f_y(t)\hat{i}_y + f_z(t)\hat{i}_z$$

Phasor domain

$$\vec{\mathbf{F}} = F_x\hat{i}_x + F_y\hat{i}_y + F_z\hat{i}_z$$

1) How to jump back from the Phasor domain to the Time domain

$F_x = A_x e^{j\alpha_x}$ → **P-to-T** →

$F_y = A_y e^{j\alpha_y}$ → **P-to-T** →

$F_z = A_z e^{j\alpha_z}$ → **P-to-T** →

Phasors and vector functions

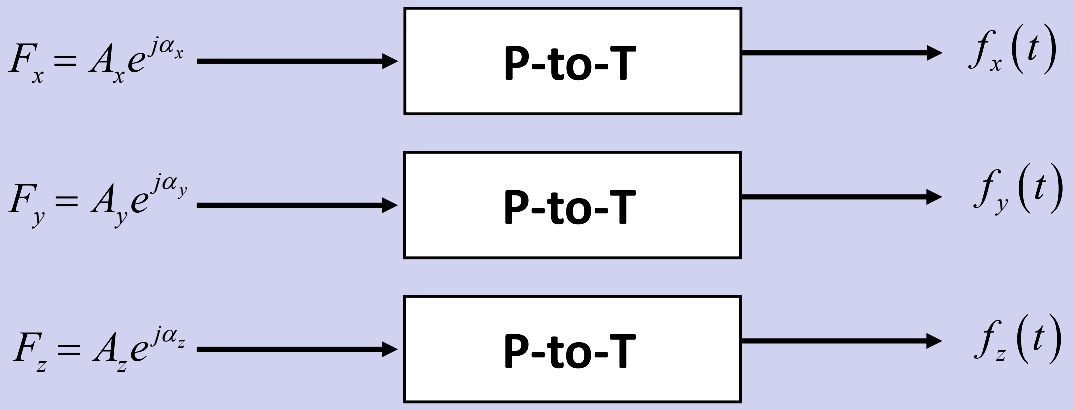
Time domain

$$\vec{\mathbf{f}}(t) = f_x(t)\hat{i}_x + f_y(t)\hat{i}_y + f_z(t)\hat{i}_z$$

Phasor domain

$$\vec{\mathbf{F}} = F_x\hat{i}_x + F_y\hat{i}_y + F_z\hat{i}_z$$

1) How to jump back from the Phasor domain to the Time domain



Phasors and vector functions

Time domain

$$\vec{\mathbf{f}}(t) = f_x(t)\hat{i}_x + f_y(t)\hat{i}_y + f_z(t)\hat{i}_z$$

Phasor domain

$$\vec{\mathbf{F}} = F_x\hat{i}_x + F_y\hat{i}_y + F_z\hat{i}_z$$

1) How to jump back from the Phasor domain to the Time domain

$F_x = A_x e^{j\alpha_x}$ → **P-to-T** → $f_x(t) = \mathrm{Re}\{F_x e^{j\omega_0 t}\} = A_x \cos(\omega_0 t + \alpha_x)$

$F_y = A_y e^{j\alpha_y}$ → **P-to-T** → $f_y(t) = \mathrm{Re}\{F_y e^{j\omega_0 t}\} = A_y \cos(\omega_0 t + \alpha_y)$

$F_z = A_z e^{j\alpha_z}$ → **P-to-T** → $f_z(t) = \mathrm{Re}\{F_z e^{j\omega_0 t}\} = A_z \cos(\omega_0 t + \alpha_z)$

Phasors and vector functions

Time domain

$$\vec{\mathbf{f}}(t) = f_x(t)\hat{i}_x + f_y(t)\hat{i}_y + f_z(t)\hat{i}_z$$

Phasor domain

$$\vec{\mathbf{F}} = F_x\,\hat{i}_x + F_y\hat{i}_y + F_z\hat{i}_z$$

2) Time domain derivative and Phasors

Phasors and vector functions

Time domain

$$\vec{\mathbf{f}}(t) = f_x(t)\hat{i}_x + f_y(t)\hat{i}_y + f_z(t)\hat{i}_z$$

Phasor domain

$$\vec{\mathbf{F}} = F_x\hat{i}_x + F_y\hat{i}_y + F_z\hat{i}_z$$

2) Time domain derivative and Phasors

$\vec{\mathbf{f}}(t)$ → **T-to-P** → $\vec{\mathbf{F}}$

$\dfrac{d\vec{\mathbf{f}}(t)}{dt}$ → **T-to-P** → **?**

Phasors and vector functions

Time domain

$$\vec{\mathbf{f}}(t) = f_x(t)\hat{i}_x + f_y(t)\hat{i}_y + f_z(t)\hat{i}_z$$

Phasor domain

$$\vec{\mathbf{F}} = F_x\hat{i}_x + F_y\hat{i}_y + F_z\hat{i}_z$$

2) Time domain derivative and Phasors

$\vec{\mathbf{f}}(t)$ → **T-to-P** → $\vec{\mathbf{F}}$

$\dfrac{d\vec{\mathbf{f}}(t)}{dt}$ → **T-to-P** → **?**

$$\frac{d\vec{\mathbf{f}}(t)}{dt} = \frac{df_x(t)}{dt}\hat{i}_x + \frac{df_y(t)}{dt}\hat{i}_y + \frac{df_z(t)}{dt}\hat{i}_z$$

Phasors and vector functions

Time domain

$$\vec{\mathbf{f}}(t) = f_x(t)\hat{i}_x + f_y(t)\hat{i}_y + f_z(t)\hat{i}_z$$

Phasor domain

$$\vec{\mathbf{F}} = F_x\hat{i}_x + F_y\hat{i}_y + F_z\hat{i}_z$$

2) Time domain derivative and Phasors

$\vec{\mathbf{f}}(t)$ → **T-to-P** → $\vec{\mathbf{F}}$

$\dfrac{d\vec{\mathbf{f}}(t)}{dt}$ → **T-to-P** → ?

$$\frac{d\vec{\mathbf{f}}(t)}{dt} = \frac{df_x(t)}{dt}\hat{i}_x + \frac{df_y(t)}{dt}\hat{i}_y + \frac{df_z(t)}{dt}\hat{i}_z$$

$\dfrac{df_x(t)}{dt}$ → **T-to-P** → ?

$\dfrac{df_y(t)}{dt}$ → **T-to-P** → ?

$\dfrac{df_z(t)}{dt}$ → **T-to-P** → ?

Phasors and vector functions

Time domain

$$\vec{\mathbf{f}}(t) = f_x(t)\hat{i}_x + f_y(t)\hat{i}_y + f_z(t)\hat{i}_z$$

Phasor domain

$$\vec{\mathbf{F}} = F_x\hat{i}_x + F_y\hat{i}_y + F_z\hat{i}_z$$

2) Time domain derivative and Phasors

$\vec{\mathbf{f}}(t)$ → **T-to-P** → $\vec{\mathbf{F}}$

$\dfrac{d\vec{\mathbf{f}}(t)}{dt}$ → **T-to-P** → **?**

$$\frac{d\vec{\mathbf{f}}(t)}{dt} = \frac{df_x(t)}{dt}\hat{i}_x + \frac{df_y(t)}{dt}\hat{i}_y + \frac{df_z(t)}{dt}\hat{i}_z$$

$\dfrac{df_x(t)}{dt}$ → **T-to-P** → $j\omega_0 F_x$

$\dfrac{df_y(t)}{dt}$ → **T-to-P** → $j\omega_0 F_y$

$\dfrac{df_z(t)}{dt}$ → **T-to-P** → $j\omega_0 F_z$

Phasors and vector functions

Time domain

$$\vec{\mathbf{f}}(t) = f_x(t)\hat{i}_x + f_y(t)\hat{i}_y + f_z(t)\hat{i}_z$$

Phasor domain

$$\vec{\mathbf{F}} = F_x\hat{i}_x + F_y\hat{i}_y + F_z\hat{i}_z$$

2) Time domain derivative and Phasors

$\vec{\mathbf{f}}(t)$ → **T-to-P** → $\vec{\mathbf{F}}$

$\frac{d\vec{\mathbf{f}}(t)}{dt}$ → **T-to-P** → $j\omega_0 F_x\hat{i}_x + j\omega_0 F_y\hat{i}_y + j\omega_0 F_z\hat{i}_z$

$$\frac{d\vec{\mathbf{f}}(t)}{dt} = \frac{df_x(t)}{dt}\hat{i}_x + \frac{df_y(t)}{dt}\hat{i}_y + \frac{df_z(t)}{dt}\hat{i}_z$$

$\frac{df_x(t)}{dt}$ → **T-to-P** → $j\omega_0 F_x$

$\frac{df_y(t)}{dt}$ → **T-to-P** → $j\omega_0 F_y$

$\frac{df_z(t)}{dt}$ → **T-to-P** → $j\omega_0 F_z$

Phasors and vector functions

Time domain

$$\vec{\mathbf{f}}(t) = f_x(t)\hat{i}_x + f_y(t)\hat{i}_y + f_z(t)\hat{i}_z$$

Phasor domain

$$\vec{\mathbf{F}} = F_x\hat{i}_x + F_y\hat{i}_y + F_z\hat{i}_z$$

2) Time domain derivative and Phasors

$\vec{\mathbf{f}}(t)$ → **T-to-P** → $\vec{\mathbf{F}}$

$\dfrac{d\vec{\mathbf{f}}(t)}{dt}$ → **T-to-P** → $j\omega_0\vec{\mathbf{F}} = j\omega_0 F_x\hat{i}_x + j\omega_0 F_y\hat{i}_y + j\omega_0 F_z\hat{i}_z$

$$\frac{d\vec{\mathbf{f}}(t)}{dt} = \frac{df_x(t)}{dt}\hat{i}_x + \frac{df_y(t)}{dt}\hat{i}_y + \frac{df_z(t)}{dt}\hat{i}_z$$

$\dfrac{df_x(t)}{dt}$ → **T-to-P** → $j\omega_0 F_x$

$\dfrac{df_y(t)}{dt}$ → **T-to-P** → $j\omega_0 F_y$

$\dfrac{df_z(t)}{dt}$ → **T-to-P** → $j\omega_0 F_z$

Phasors and vector functions

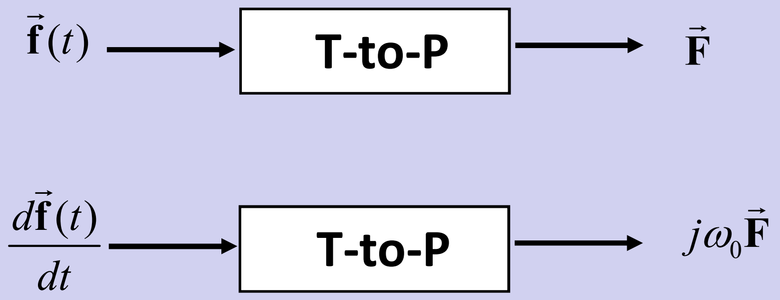
Time domain

$$\vec{\mathbf{f}}(t) = f_x(t)\hat{i}_x + f_y(t)\hat{i}_y + f_z(t)\hat{i}_z$$

Phasor domain

$$\vec{\mathbf{F}} = F_x\hat{i}_x + F_y\hat{i}_y + F_z\hat{i}_z$$

2) Time domain derivative and Phasors



Phasors

- Phasors and functions of n variables

- Phasors and vector functions

- Phasors and vector functions of *n* variables

1) How to jump back from the Phasor domain to the Time domain

2) Time domain derivative and Phasors

Phasors and vector functions of *n* variables

Time domain

$$\vec{\mathbf{f}}(t,x,y,z)=f_x(t,x,y,z)\hat{i}_x+f_y(t,x,y,z)\hat{i}_y+f_z(t,x,y,z)\,\hat{i}_z$$

Phasor domain

$$\vec{\mathbf{F}}(x,y,z)=F_x(x,y,z)\hat{i}_x+F_y(x,y,z)\hat{i}_y+F_z(x,y,z)\hat{i}_z$$

$$f_x(t,x,y,z)=A_x(x,y,z)\cos\left(\omega_0 t+\alpha_x(x,y,z)\right) \quad \longrightarrow \quad \text{T-to-P} \quad \longrightarrow \quad F_x(x,y,z)=A_x(x,y,z)e^{j\alpha_x(x,y,z)}$$

$$f_y(t,x,y,z)=A_y(x,y,z)\cos\left(\omega_0 t+\alpha_y(x,y,z)\right) \quad \longrightarrow \quad \text{T-to-P} \quad \longrightarrow \quad F_y(x,y,z)=A_y(x,y,z)e^{j\alpha_y(x,y,z)}$$

$$f_z(t,x,y,z)=A_z(x,y,z)\cos\left(\omega_0 t+\alpha_z(x,y,z)\right) \quad \longrightarrow \quad \text{T-to-P} \quad \longrightarrow \quad F_z(x,y,z)=A_z(x,y,z)e^{j\alpha_z(x,y,z)}$$

Phasors and vector functions of *n* variables

Time domain

$$\vec{\mathbf{f}}(t,x,y,z) = f_x(t,x,y,z)\hat{i}_x + f_y(t,x,y,z)\hat{i}_y + f_z(t,x,y,z)\,\hat{i}_z$$

Phasor domain

$$\vec{\mathbf{F}}(x,y,z) = F_x(x,y,z)\hat{i}_x + F_y(x,y,z)\hat{i}_y + F_z(x,y,z)\hat{i}_z$$

$\vec{\mathbf{f}}(t,x,y,z)$ → **T-to-P** → $\vec{\mathbf{F}}(x,y,z)$

$$\begin{aligned}\vec{\mathbf{f}}(t,x,y,z) &= f_x(t,x,y,z)\hat{i}_x + f_y(t,x,y,z)\hat{i}_y + f_z(t,x,y,z)\hat{i}_z = \\ &= A_x(x,y,z)\cos\left(\omega_0 t + \alpha_x(x,y,z)\right)\hat{i}_x + \\ &\quad A_y(x,y,z)\cos\left(\omega_0 t + \alpha_y(x,y,z)\right)\hat{i}_y + \\ &\quad A_z(x,y,z)\cos\left(\omega_0 t + \alpha_z(x,y,z)\right)\hat{i}_z\end{aligned}$$

$$\begin{aligned}\vec{\mathbf{F}}(x,y,z) &= F_x(x,y,z)\hat{i}_x + F_y(x,y,z)\hat{i}_y + F_z(x,y,z)\hat{i}_z = \\ &= A_x(x,y,z)e^{j\alpha_x(x,y,z)}\hat{i}_x + A_y(x,y,z)e^{j\alpha_y(x,y,z)}\hat{i}_y + A_z(x,y,z)e^{j\alpha_z(x,y,z)}\hat{i}_z\end{aligned}$$

Phasors and vector functions of *n* variables

Time domain

$$\vec{\mathbf{f}}(t,x,y,z) = f_x(t,x,y,z)\hat{i}_x + f_y(t,x,y,z)\hat{i}_y + f_z(t,x,y,z)\,\hat{i}_z$$

Phasor domain

$$\vec{\mathbf{F}}(x,y,z) = F_x(x,y,z)\hat{i}_x + F_y(x,y,z)\hat{i}_y + F_z(x,y,z)\hat{i}_z$$

1) How to jump back from the Phasor domain to the Time domain

$$F_x(x,y,z) = A_x(x,y,z)e^{j\alpha_x(x,y,z)} \rightarrow \textbf{P-to-T} \rightarrow f_x(t,x,y,z) = \text{Re}\left\{F_x(x,y,z)e^{j\omega_0 t}\right\}$$

$$F_y(x,y,z) = A_y(x,y,z)e^{j\alpha_y(x,y,z)} \rightarrow \textbf{P-to-T} \rightarrow f_y(t,x,y,z) = \text{Re}\left\{F_y(x,y,z)e^{j\omega_0 t}\right\}$$

$$F_z(x,y,z) = A_z(x,y,z)e^{j\alpha_z(x,y,z)} \rightarrow \textbf{P-to-T} \rightarrow f_z(t,x,y,z) = \text{Re}\left\{F_z(x,y,z)e^{j\omega_0 t}\right\}$$

Phasors and vector functions of *n* variables

Time domain

$$\vec{\mathbf{f}}(t,x,y,z) = f_x(t,x,y,z)\hat{i}_x + f_y(t,x,y,z)\hat{i}_y + f_z(t,x,y,z)\,\hat{i}_z$$

Phasor domain

$$\vec{\mathbf{F}}(x,y,z) = F_x(x,y,z)\hat{i}_x + F_y(x,y,z)\hat{i}_y + F_z(x,y,z)\hat{i}_z$$

2) Time domain derivative and Phasors

$\vec{\mathbf{f}}(t,x,y,z)$ → **T-to-P** → $\vec{\mathbf{F}}(x,y,z)$

$\dfrac{\partial \vec{\mathbf{f}}}{\partial t}$ → **T-to-P** → $j\omega_0\vec{\mathbf{F}}(x,y,z) = j\omega_0 F_x(x,y,z)\hat{i}_x + j\omega_0 F_y(x,y,z)\hat{i}_y + j\omega_0 F_z(x,y,z)\hat{i}_z$

$$\frac{\partial \vec{\mathbf{f}}(t,\vec{\mathbf{r}})}{\partial t} = \frac{\partial f_x}{\partial t}\hat{i}_x + \frac{\partial f_y}{\partial t}\hat{i}_y + \frac{\partial f_z}{\partial t}\hat{i}_z$$

$\dfrac{\partial f_x(t)}{\partial t}$ → **T-to-P** → $j\omega_0 F_x(x,y,z)$

$\dfrac{\partial f_y(t)}{\partial t}$ → **T-to-P** → $j\omega_0 F_y(x,y,z)$

$\dfrac{\partial f_z(t)}{\partial t}$ → **T-to-P** → $j\omega_0 F_z(x,y,z)$

Phasors and vector functions of *n* variables

Time domain

$$\vec{\mathbf{f}}(t,x,y,z) = f_x(t,x,y,z)\hat{i}_x + f_y(t,x,y,z)\hat{i}_y + f_z(t,x,y,z)\,\hat{i}_z$$

Phasor domain

$$\vec{\mathbf{F}}(x,y,z) = F_x(x,y,z)\hat{i}_x + F_y(x,y,z)\hat{i}_y + F_z(x,y,z)\hat{i}_z$$

2) Time domain derivative and Phasors

$\vec{\mathbf{f}}(t,x,y,z)$ → **T-to-P** → $\vec{\mathbf{F}}(x,y,z)$

$\nabla\cdot\vec{\mathbf{f}}$ → **T-to-P** → $\nabla\cdot\vec{\mathbf{F}}(x,y,z)$

$$\nabla\cdot\vec{\mathbf{f}}(t,\vec{\mathbf{r}}) = \frac{\partial f_x}{\partial x} + \frac{\partial f_y}{\partial y} + \frac{\partial f_z}{\partial z}$$

$\frac{\partial f_x}{\partial x}$ → **T-to-P** → $\frac{\partial F_x(x,y,z)}{\partial x}$

$\frac{\partial f_y}{\partial y}$ → **T-to-P** → $\frac{\partial F_y(x,y,z)}{\partial y}$

$\frac{\partial f_z}{\partial z}$ → **T-to-P** → $\frac{\partial F_z(x,y,z)}{\partial z}$

Phasors and vector functions of *n* variables

Time domain

$$\vec{\mathbf{f}}(t,x,y,z)=f_x(t,x,y,z)\hat{i}_x+f_y(t,x,y,z)\hat{i}_y+f_z(t,x,y,z)\,\hat{i}_z$$

Phasor domain

$$\vec{\mathbf{F}}(x,y,z)=F_x(x,y,z)\hat{i}_x+F_y(x,y,z)\hat{i}_y+F_z(x,y,z)\hat{i}_z$$

2) Time domain derivative and Phasors

$\vec{\mathbf{f}}(t,x,y,z)$ → **T-to-P** → $\vec{\mathbf{F}}(x,y,z)$

$\nabla\times\vec{\mathbf{f}}$ → **T-to-P** → $\nabla\times\vec{\mathbf{F}}(x,y,z)$

$$\nabla\times\vec{\mathbf{f}}(t,\vec{\mathbf{r}})=\left(\frac{\partial f_z}{\partial y}-\frac{\partial f_y}{\partial z}\right)\hat{i}_x+\left(\frac{\partial f_x}{\partial z}-\frac{\partial f_z}{\partial x}\right)\hat{i}_y+\left(\frac{\partial f_y}{\partial x}-\frac{\partial f_x}{\partial y}\right)\hat{i}_z$$

Phasors and vector functions of *n* variables

Time domain

$$\vec{\mathbf{f}}(t,x,y,z) = f_x(t,x,y,z)\hat{i}_x + f_y(t,x,y,z)\hat{i}_y + f_z(t,x,y,z)\,\hat{i}_z$$

Phasor domain

$$\vec{\mathbf{F}}(x,y,z) = F_x(x,y,z)\hat{i}_x + F_y(x,y,z)\hat{i}_y + F_z(x,y,z)\hat{i}_z$$

2) Time domain derivative and Phasors

$\vec{\mathbf{f}}(t,x,y,z)$ → **T-to-P** → $\vec{\mathbf{F}}(x,y,z)$

$\frac{\partial \vec{\mathbf{f}}}{\partial t}$ → **T-to-P** → $j\omega_0 \vec{\mathbf{F}}(x,y,z)$

$\nabla \cdot \vec{\mathbf{f}}$ → **T-to-P** → $\nabla \cdot \vec{\mathbf{F}}(x,y,z)$

$\nabla \times \vec{\mathbf{f}}$ → **T-to-P** → $\nabla \times \vec{\mathbf{F}}(x,y,z)$

Phasors and vector functions of *n* variables

Time domain

$$\vec{\mathbf{f}}(x,y,z,t) = f_x(x,y,z,t)\hat{i}_x + f_y(x,y,z,t)\hat{i}_y + f_z(x,y,z,t)\,\hat{i}_z$$

Phasor domain

$$\vec{\mathbf{F}}(x,y,z) = F_x(x,y,z)\hat{i}_x + F_y(x,y,z)\hat{i}_y + F_z(x,y,z)\hat{i}_z$$

2) Time domain derivative and Phasors

$$\vec{\mathbf{f}}(x,y,z,t) \longrightarrow \boxed{\text{T-to-P}} \longrightarrow \vec{\mathbf{F}}(x,y,z)$$

$$\frac{\partial \vec{\mathbf{f}}}{\partial t} \longrightarrow \boxed{\text{T-to-P}} \longrightarrow j\omega_0 \vec{\mathbf{F}}(x,y,z)$$

$$\nabla \cdot \vec{\mathbf{f}} \longrightarrow \boxed{\text{T-to-P}} \longrightarrow \nabla \cdot \vec{\mathbf{F}}(x,y,z)$$

$$\nabla \times \vec{\mathbf{f}} \longrightarrow \boxed{\text{T-to-P}} \longrightarrow \nabla \times \vec{\mathbf{F}}(x,y,z)$$

Maxwell equations
Time domain & Phasor domain

Time domain

$$
\begin{cases}
\nabla \times \vec{\mathbf{e}}(\vec{\mathbf{r}},t) = -\dfrac{\partial \vec{\mathbf{b}}(\vec{\mathbf{r}},t)}{\partial t} \\
\nabla \times \vec{\mathbf{h}}(\vec{\mathbf{r}},t) = \dfrac{\partial \vec{\mathbf{d}}(\vec{\mathbf{r}},t)}{\partial t} + \vec{\mathbf{j}}(\vec{\mathbf{r}},t) \\
\nabla \cdot \vec{\mathbf{d}}(\vec{\mathbf{r}},t) = \rho(\vec{\mathbf{r}},t) \\
\nabla \cdot \vec{\mathbf{b}}(\vec{\mathbf{r}},t) = 0
\end{cases}
$$

Maxwell equations
Time domain & Phasor domain

Time domain

$$\begin{cases} \nabla \times \vec{\mathbf{e}}(\vec{\mathbf{r}},t) = -\dfrac{\partial \vec{\mathbf{b}}(\vec{\mathbf{r}},t)}{\partial t} \\ \nabla \times \vec{\mathbf{h}}(\vec{\mathbf{r}},t) = \dfrac{\partial \vec{\mathbf{d}}(\vec{\mathbf{r}},t)}{\partial t} + \vec{\mathbf{j}}(\vec{\mathbf{r}},t) \\ \nabla \cdot \vec{\mathbf{d}}(\vec{\mathbf{r}},t) = \rho(\vec{\mathbf{r}},t) \\ \nabla \cdot \vec{\mathbf{b}}(\vec{\mathbf{r}},t) = 0 \end{cases}$$

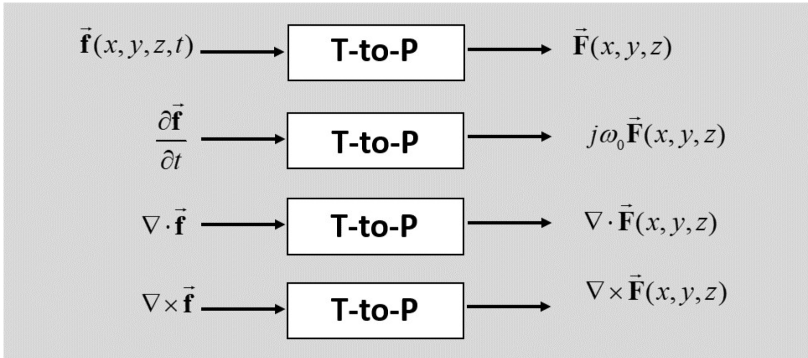
Phasor domain

Maxwell equations
Time domain & Phasor domain

Time domain

$$
\begin{cases}
\nabla \times \vec{\mathbf{e}}(\vec{\mathbf{r}},t) = -\dfrac{\partial \vec{\mathbf{b}}(\vec{\mathbf{r}},t)}{\partial t} \\
\nabla \times \vec{\mathbf{h}}(\vec{\mathbf{r}},t) = \dfrac{\partial \vec{\mathbf{d}}(\vec{\mathbf{r}},t)}{\partial t} + \vec{\mathbf{j}}(\vec{\mathbf{r}},t) \\
\nabla \cdot \vec{\mathbf{d}}(\vec{\mathbf{r}},t) = \rho(\vec{\mathbf{r}},t) \\
\nabla \cdot \vec{\mathbf{b}}(\vec{\mathbf{r}},t) = 0
\end{cases}
$$

Phasor domain



Maxwell equations
Time domain & Phasor domain

Time domain

$$
\begin{cases}
\nabla \times \vec{\mathbf{e}}(\vec{\mathbf{r}},t) = -\dfrac{\partial \vec{\mathbf{b}}(\vec{\mathbf{r}},t)}{\partial t} \\
\nabla \times \vec{\mathbf{h}}(\vec{\mathbf{r}},t) = \dfrac{\partial \vec{\mathbf{d}}(\vec{\mathbf{r}},t)}{\partial t} + \vec{\mathbf{j}}(\vec{\mathbf{r}},t) \\
\nabla \cdot \vec{\mathbf{d}}(\vec{\mathbf{r}},t) = \rho(\vec{\mathbf{r}},t) \\
\nabla \cdot \vec{\mathbf{b}}(\vec{\mathbf{r}},t) = 0
\end{cases}
$$

Phasor domain

$$\begin{cases} \\ \end{cases}$$

$\vec{\mathbf{f}}(x,y,z,t)$ → T-to-P → $\vec{\mathbf{F}}(x,y,z)$

$\dfrac{\partial \vec{\mathbf{f}}}{\partial t}$ → T-to-P → $j\omega_0 \vec{\mathbf{F}}(x,y,z)$

$\nabla \cdot \vec{\mathbf{f}}$ → T-to-P → $\nabla \cdot \vec{\mathbf{F}}(x,y,z)$

$\nabla \times \vec{\mathbf{f}}$ → T-to-P → $\nabla \times \vec{\mathbf{F}}(x,y,z)$

$\vec{\mathbf{e}}(\vec{\mathbf{r}},t)$ → T-to-P → $\vec{\mathbf{E}}(\vec{\mathbf{r}})$

Maxwell equations
Time domain & Phasor domain

Time domain

$$\begin{cases} \nabla \times \vec{\mathbf{e}}(\vec{\mathbf{r}},t) = -\dfrac{\partial \vec{\mathbf{b}}(\vec{\mathbf{r}},t)}{\partial t} \\ \nabla \times \vec{\mathbf{h}}(\vec{\mathbf{r}},t) = \dfrac{\partial \vec{\mathbf{d}}(\vec{\mathbf{r}},t)}{\partial t} + \vec{\mathbf{j}}(\vec{\mathbf{r}},t) \\ \nabla \cdot \vec{\mathbf{d}}(\vec{\mathbf{r}},t) = \rho(\vec{\mathbf{r}},t) \\ \nabla \cdot \vec{\mathbf{b}}(\vec{\mathbf{r}},t) = 0 \end{cases}$$

Phasor domain

$\vec{\mathbf{f}}(x,y,z,t)$ → T-to-P → $\vec{\mathbf{F}}(x,y,z)$

$\dfrac{\partial \vec{\mathbf{f}}}{\partial t}$ → T-to-P → $j\omega_0 \vec{\mathbf{F}}(x,y,z)$

$\nabla \cdot \vec{\mathbf{f}}$ → T-to-P → $\nabla \cdot \vec{\mathbf{F}}(x,y,z)$

$\nabla \times \vec{\mathbf{f}}$ → T-to-P → $\nabla \times \vec{\mathbf{F}}(x,y,z)$

$\vec{\mathbf{e}}(\vec{\mathbf{r}},t)$ → T-to-P → $\vec{\mathbf{E}}(\vec{\mathbf{r}})$

$\nabla \times \vec{\mathbf{e}}(\vec{\mathbf{r}},t)$ → T-to-P → $\nabla \times \vec{\mathbf{E}}(\vec{\mathbf{r}})$

Maxwell equations
Time domain & Phasor domain

Time domain

$$\begin{cases} \nabla \times \vec{\mathbf{e}}(\vec{\mathbf{r}},t) = -\dfrac{\partial \vec{\mathbf{b}}(\vec{\mathbf{r}},t)}{\partial t} \\ \nabla \times \vec{\mathbf{h}}(\vec{\mathbf{r}},t) = \dfrac{\partial \vec{\mathbf{d}}(\vec{\mathbf{r}},t)}{\partial t} + \vec{\mathbf{j}}(\vec{\mathbf{r}},t) \\ \nabla \cdot \vec{\mathbf{d}}(\vec{\mathbf{r}},t) = \rho(\vec{\mathbf{r}},t) \\ \nabla \cdot \vec{\mathbf{b}}(\vec{\mathbf{r}},t) = 0 \end{cases}$$

Phasor domain

$$\begin{cases} \nabla \times \vec{\mathbf{E}}(\vec{\mathbf{r}}) \end{cases}$$

$\vec{\mathbf{f}}(x,y,z,t)$ → T-to-P → $\vec{\mathbf{F}}(x,y,z)$

$\dfrac{\partial \vec{\mathbf{f}}}{\partial t}$ → T-to-P → $j\omega_0 \vec{\mathbf{F}}(x,y,z)$

$\nabla \cdot \vec{\mathbf{f}}$ → T-to-P → $\nabla \cdot \vec{\mathbf{F}}(x,y,z)$

$\nabla \times \vec{\mathbf{f}}$ → T-to-P → $\nabla \times \vec{\mathbf{F}}(x,y,z)$

$\vec{\mathbf{e}}(\vec{\mathbf{r}},t)$ → T-to-P → $\vec{\mathbf{E}}(\vec{\mathbf{r}})$

$\nabla \times \vec{\mathbf{e}}(\vec{\mathbf{r}},t)$ → T-to-P → $\nabla \times \vec{\mathbf{E}}(\vec{\mathbf{r}})$

Maxwell equations
Time domain & Phasor domain

Time domain

$$\begin{cases} \nabla \times \vec{\mathbf{e}}(\vec{\mathbf{r}},t) = -\dfrac{\partial \vec{\mathbf{b}}(\vec{\mathbf{r}},t)}{\partial t} \\ \nabla \times \vec{\mathbf{h}}(\vec{\mathbf{r}},t) = \dfrac{\partial \vec{\mathbf{d}}(\vec{\mathbf{r}},t)}{\partial t} + \vec{\mathbf{j}}(\vec{\mathbf{r}},t) \\ \nabla \cdot \vec{\mathbf{d}}(\vec{\mathbf{r}},t) = \rho(\vec{\mathbf{r}},t) \\ \nabla \cdot \vec{\mathbf{b}}(\vec{\mathbf{r}},t) = 0 \end{cases}$$

Phasor domain

$$\begin{cases} \nabla \times \vec{\mathbf{E}}(\vec{\mathbf{r}}) \end{cases}$$

$\vec{\mathbf{f}}(x,y,z,t)$ → **T-to-P** → $\vec{\mathbf{F}}(x,y,z)$

$\dfrac{\partial \vec{\mathbf{f}}}{\partial t}$ → **T-to-P** → $j\omega_0 \vec{\mathbf{F}}(x,y,z)$

$\nabla \cdot \vec{\mathbf{f}}$ → **T-to-P** → $\nabla \cdot \vec{\mathbf{F}}(x,y,z)$

$\nabla \times \vec{\mathbf{f}}$ → **T-to-P** → $\nabla \times \vec{\mathbf{F}}(x,y,z)$

$\vec{\mathbf{b}}(\vec{\mathbf{r}},t)$ → **T-to-P** → $\vec{\mathbf{B}}(\vec{\mathbf{r}})$

Maxwell equations
Time domain & Phasor domain

Time domain

$$\begin{cases} \nabla \times \vec{\mathbf{e}}(\vec{\mathbf{r}},t) = -\dfrac{\partial \vec{\mathbf{b}}(\vec{\mathbf{r}},t)}{\partial t} \\ \nabla \times \vec{\mathbf{h}}(\vec{\mathbf{r}},t) = \dfrac{\partial \vec{\mathbf{d}}(\vec{\mathbf{r}},t)}{\partial t} + \vec{\mathbf{j}}(\vec{\mathbf{r}},t) \\ \nabla \cdot \vec{\mathbf{d}}(\vec{\mathbf{r}},t) = \rho(\vec{\mathbf{r}},t) \\ \nabla \cdot \vec{\mathbf{b}}(\vec{\mathbf{r}},t) = 0 \end{cases}$$

Phasor domain

$$\begin{cases} \nabla \times \vec{\mathbf{E}}(\vec{\mathbf{r}}) \end{cases}$$

$\vec{\mathbf{f}}(x,y,z,t)$ → T-to-P → $\vec{\mathbf{F}}(x,y,z)$

$\dfrac{\partial \vec{\mathbf{f}}}{\partial t}$ → T-to-P → $j\omega_0 \vec{\mathbf{F}}(x,y,z)$

$\nabla \cdot \vec{\mathbf{f}}$ → T-to-P → $\nabla \cdot \vec{\mathbf{F}}(x,y,z)$

$\nabla \times \vec{\mathbf{f}}$ → T-to-P → $\nabla \times \vec{\mathbf{F}}(x,y,z)$

$\vec{\mathbf{b}}(\vec{\mathbf{r}},t)$ → T-to-P → $\vec{\mathbf{B}}(\vec{\mathbf{r}})$

$\dfrac{\partial \vec{\mathbf{b}}(\vec{\mathbf{r}},t)}{\partial t}$ → T-to-P → $j\omega_0 \vec{\mathbf{B}}(\vec{\mathbf{r}})$

Maxwell equations
Time domain & Phasor domain

Time domain

$$\begin{cases} \nabla \times \vec{\mathbf{e}}(\vec{\mathbf{r}},t) = -\dfrac{\partial \vec{\mathbf{b}}(\vec{\mathbf{r}},t)}{\partial t} \\ \nabla \times \vec{\mathbf{h}}(\vec{\mathbf{r}},t) = \dfrac{\partial \vec{\mathbf{d}}(\vec{\mathbf{r}},t)}{\partial t} + \vec{\mathbf{j}}(\vec{\mathbf{r}},t) \\ \nabla \cdot \vec{\mathbf{d}}(\vec{\mathbf{r}},t) = \rho(\vec{\mathbf{r}},t) \\ \nabla \cdot \vec{\mathbf{b}}(\vec{\mathbf{r}},t) = 0 \end{cases}$$

Phasor domain

$$\begin{cases} \nabla \times \vec{\mathbf{E}}(\vec{\mathbf{r}}) = -j\omega_0 \vec{\mathbf{B}}(\vec{\mathbf{r}}) \\ \\ \\ \\ \end{cases}$$

$\vec{\mathbf{f}}(x,y,z,t)$ → T-to-P → $\vec{\mathbf{F}}(x,y,z)$

$\dfrac{\partial \vec{\mathbf{f}}}{\partial t}$ → T-to-P → $j\omega_0 \vec{\mathbf{F}}(x,y,z)$

$\nabla \cdot \vec{\mathbf{f}}$ → T-to-P → $\nabla \cdot \vec{\mathbf{F}}(x,y,z)$

$\nabla \times \vec{\mathbf{f}}$ → T-to-P → $\nabla \times \vec{\mathbf{F}}(x,y,z)$

$\vec{\mathbf{b}}(\vec{\mathbf{r}},t)$ → T-to-P → $\vec{\mathbf{B}}(\vec{\mathbf{r}})$

$\dfrac{\partial \vec{\mathbf{b}}(\vec{\mathbf{r}},t)}{\partial t}$ → T-to-P → $j\omega_0 \vec{\mathbf{B}}(\vec{\mathbf{r}})$

Maxwell equations
Time domain & Phasor domain

Time domain

$$\begin{cases} \nabla \times \vec{\mathbf{e}}(\vec{\mathbf{r}},t) = -\dfrac{\partial \vec{\mathbf{b}}(\vec{\mathbf{r}},t)}{\partial t} \\ \nabla \times \vec{\mathbf{h}}(\vec{\mathbf{r}},t) = \dfrac{\partial \vec{\mathbf{d}}(\vec{\mathbf{r}},t)}{\partial t} + \vec{\mathbf{j}}(\vec{\mathbf{r}},t) \\ \nabla \cdot \vec{\mathbf{d}}(\vec{\mathbf{r}},t) = \rho(\vec{\mathbf{r}},t) \\ \nabla \cdot \vec{\mathbf{b}}(\vec{\mathbf{r}},t) = 0 \end{cases}$$

Phasor domain

$$\nabla \times \vec{\mathbf{E}}(\vec{\mathbf{r}}) = -j\omega_0 \vec{\mathbf{B}}(\vec{\mathbf{r}})$$

$\vec{\mathbf{f}}(x,y,z,t)$ → T-to-P → $\vec{\mathbf{F}}(x,y,z)$

$\dfrac{\partial \vec{\mathbf{f}}}{\partial t}$ → T-to-P → $j\omega_0 \vec{\mathbf{F}}(x,y,z)$

$\nabla \cdot \vec{\mathbf{f}}$ → T-to-P → $\nabla \cdot \vec{\mathbf{F}}(x,y,z)$

$\nabla \times \vec{\mathbf{f}}$ → T-to-P → $\nabla \times \vec{\mathbf{F}}(x,y,z)$

$\vec{\mathbf{h}}(\vec{\mathbf{r}},t)$ → T-to-P → $\vec{\mathbf{H}}(\vec{\mathbf{r}})$

Maxwell equations
Time domain & Phasor domain

Time domain

$$\begin{cases} \nabla \times \vec{\mathbf{e}}(\vec{\mathbf{r}},t) = -\dfrac{\partial \vec{\mathbf{b}}(\vec{\mathbf{r}},t)}{\partial t} \\ \nabla \times \vec{\mathbf{h}}(\vec{\mathbf{r}},t) = \dfrac{\partial \vec{\mathbf{d}}(\vec{\mathbf{r}},t)}{\partial t} + \vec{\mathbf{j}}(\vec{\mathbf{r}},t) \\ \nabla \cdot \vec{\mathbf{d}}(\vec{\mathbf{r}},t) = \rho(\vec{\mathbf{r}},t) \\ \nabla \cdot \vec{\mathbf{b}}(\vec{\mathbf{r}},t) = 0 \end{cases}$$

Phasor domain

$$\begin{cases} \nabla \times \vec{\mathbf{E}}(\vec{\mathbf{r}}) = -j\omega_0 \vec{\mathbf{B}}(\vec{\mathbf{r}}) \\ \\ \\ \end{cases}$$

$\vec{\mathbf{f}}(x,y,z,t)$ → T-to-P → $\vec{\mathbf{F}}(x,y,z)$

$\dfrac{\partial \vec{\mathbf{f}}}{\partial t}$ → T-to-P → $j\omega_0 \vec{\mathbf{F}}(x,y,z)$

$\nabla \cdot \vec{\mathbf{f}}$ → T-to-P → $\nabla \cdot \vec{\mathbf{F}}(x,y,z)$

$\nabla \times \vec{\mathbf{f}}$ → T-to-P → $\nabla \times \vec{\mathbf{F}}(x,y,z)$

$\vec{\mathbf{h}}(\vec{\mathbf{r}},t)$ → T-to-P → $\vec{\mathbf{H}}(\vec{\mathbf{r}})$

$\nabla \times \vec{\mathbf{h}}(\vec{\mathbf{r}},t)$ → T-to-P → $\nabla \times \vec{\mathbf{H}}(\vec{\mathbf{r}})$

Maxwell equations
Time domain & Phasor domain

Time domain

$$\begin{cases} \nabla \times \vec{\mathbf{e}}(\vec{\mathbf{r}},t) = -\dfrac{\partial \vec{\mathbf{b}}(\vec{\mathbf{r}},t)}{\partial t} \\ \nabla \times \vec{\mathbf{h}}(\vec{\mathbf{r}},t) = \dfrac{\partial \vec{\mathbf{d}}(\vec{\mathbf{r}},t)}{\partial t} + \vec{\mathbf{j}}(\vec{\mathbf{r}},t) \\ \nabla \cdot \vec{\mathbf{d}}(\vec{\mathbf{r}},t) = \rho(\vec{\mathbf{r}},t) \\ \nabla \cdot \vec{\mathbf{b}}(\vec{\mathbf{r}},t) = 0 \end{cases}$$

Phasor domain

$$\begin{cases} \nabla \times \vec{\mathbf{E}}(\vec{\mathbf{r}}) = -j\omega_0 \vec{\mathbf{B}}(\vec{\mathbf{r}}) \\ \nabla \times \vec{\mathbf{H}}(\vec{\mathbf{r}}) \end{cases}$$

$\vec{\mathbf{f}}(x,y,z,t) \longrightarrow$ T-to-P $\longrightarrow \vec{\mathbf{F}}(x,y,z)$

$\dfrac{\partial \vec{\mathbf{f}}}{\partial t} \longrightarrow$ T-to-P $\longrightarrow j\omega_0 \vec{\mathbf{F}}(x,y,z)$

$\nabla \cdot \vec{\mathbf{f}} \longrightarrow$ T-to-P $\longrightarrow \nabla \cdot \vec{\mathbf{F}}(x,y,z)$

$\nabla \times \vec{\mathbf{f}} \longrightarrow$ T-to-P $\longrightarrow \nabla \times \vec{\mathbf{F}}(x,y,z)$

$\vec{\mathbf{h}}(\vec{\mathbf{r}},t) \longrightarrow$ T-to-P $\longrightarrow \vec{\mathbf{H}}(\vec{\mathbf{r}})$

$\nabla \times \vec{\mathbf{h}}(\vec{\mathbf{r}},t) \longrightarrow$ T-to-P $\longrightarrow \nabla \times \vec{\mathbf{H}}(\vec{\mathbf{r}})$

Maxwell equations
Time domain & Phasor domain

Time domain

$$\begin{cases} \nabla \times \vec{\mathbf{e}}(\vec{\mathbf{r}},t) = -\dfrac{\partial \vec{\mathbf{b}}(\vec{\mathbf{r}},t)}{\partial t} \\ \nabla \times \vec{\mathbf{h}}(\vec{\mathbf{r}},t) = \dfrac{\partial \vec{\mathbf{d}}(\vec{\mathbf{r}},t)}{\partial t} + \vec{\mathbf{j}}(\vec{\mathbf{r}},t) \\ \nabla \cdot \vec{\mathbf{d}}(\vec{\mathbf{r}},t) = \rho(\vec{\mathbf{r}},t) \\ \nabla \cdot \vec{\mathbf{b}}(\vec{\mathbf{r}},t) = 0 \end{cases}$$

Phasor domain

$$\begin{cases} \nabla \times \vec{\mathbf{E}}(\vec{\mathbf{r}}) = -j\omega_0 \vec{\mathbf{B}}(\vec{\mathbf{r}}) \\ \nabla \times \vec{\mathbf{H}}(\vec{\mathbf{r}}) \end{cases}$$

$\vec{\mathbf{f}}(x,y,z,t)$ →	T-to-P	→ $\vec{\mathbf{F}}(x,y,z)$
$\dfrac{\partial \vec{\mathbf{f}}}{\partial t}$ →	T-to-P	→ $j\omega_0 \vec{\mathbf{F}}(x,y,z)$
$\nabla \cdot \vec{\mathbf{f}}$ →	T-to-P	→ $\nabla \cdot \vec{\mathbf{F}}(x,y,z)$
$\nabla \times \vec{\mathbf{f}}$ →	T-to-P	→ $\nabla \times \vec{\mathbf{F}}(x,y,z)$

$\vec{\mathbf{d}}(\vec{\mathbf{r}},t)$ → T-to-P → $\vec{\mathbf{D}}(\vec{\mathbf{r}})$

Maxwell equations
Time domain & Phasor domain

Time domain

$$\begin{cases} \nabla \times \vec{\mathbf{e}}(\vec{\mathbf{r}},t) = -\dfrac{\partial \vec{\mathbf{b}}(\vec{\mathbf{r}},t)}{\partial t} \\ \nabla \times \vec{\mathbf{h}}(\vec{\mathbf{r}},t) = \dfrac{\partial \vec{\mathbf{d}}(\vec{\mathbf{r}},t)}{\partial t} + \vec{\mathbf{j}}(\vec{\mathbf{r}},t) \\ \nabla \cdot \vec{\mathbf{d}}(\vec{\mathbf{r}},t) = \rho(\vec{\mathbf{r}},t) \\ \nabla \cdot \vec{\mathbf{b}}(\vec{\mathbf{r}},t) = 0 \end{cases}$$

Phasor domain

$$\begin{cases} \nabla \times \vec{\mathbf{E}}(\vec{\mathbf{r}}) = -j\omega_0 \vec{\mathbf{B}}(\vec{\mathbf{r}}) \\ \nabla \times \vec{\mathbf{H}}(\vec{\mathbf{r}}) \end{cases}$$

$\vec{\mathbf{f}}(x,y,z,t)$ → T-to-P → $\vec{\mathbf{F}}(x,y,z)$

$\dfrac{\partial \vec{\mathbf{f}}}{\partial t}$ → T-to-P → $j\omega_0 \vec{\mathbf{F}}(x,y,z)$

$\nabla \cdot \vec{\mathbf{f}}$ → T-to-P → $\nabla \cdot \vec{\mathbf{F}}(x,y,z)$

$\nabla \times \vec{\mathbf{f}}$ → T-to-P → $\nabla \times \vec{\mathbf{F}}(x,y,z)$

$\vec{\mathbf{d}}(\vec{\mathbf{r}},t)$ → T-to-P → $\vec{\mathbf{D}}(\vec{\mathbf{r}})$

$\dfrac{\partial \vec{\mathbf{d}}(\vec{\mathbf{r}},t)}{\partial t}$ → T-to-P → $j\omega_0 \vec{\mathbf{D}}(\vec{\mathbf{r}})$

Maxwell equations
Time domain & Phasor domain

Time domain

$$
\begin{cases}
\nabla \times \vec{\mathbf{e}}(\vec{\mathbf{r}},t) = -\dfrac{\partial \vec{\mathbf{b}}(\vec{\mathbf{r}},t)}{\partial t} \\
\nabla \times \vec{\mathbf{h}}(\vec{\mathbf{r}},t) = \dfrac{\partial \vec{\mathbf{d}}(\vec{\mathbf{r}},t)}{\partial t} + \vec{\mathbf{j}}(\vec{\mathbf{r}},t) \\
\nabla \cdot \vec{\mathbf{d}}(\vec{\mathbf{r}},t) = \rho(\vec{\mathbf{r}},t) \\
\nabla \cdot \vec{\mathbf{b}}(\vec{\mathbf{r}},t) = 0
\end{cases}
$$

Phasor domain

$$
\begin{cases}
\nabla \times \vec{\mathbf{E}}(\vec{\mathbf{r}}) = -j\omega_0 \vec{\mathbf{B}}(\vec{\mathbf{r}}) \\
\nabla \times \vec{\mathbf{H}}(\vec{\mathbf{r}}) = j\omega_0 \vec{\mathbf{D}}(\vec{\mathbf{r}})
\end{cases}
$$

$\vec{\mathbf{f}}(x,y,z,t)$ → T-to-P → $\vec{\mathbf{F}}(x,y,z)$

$\dfrac{\partial \vec{\mathbf{f}}}{\partial t}$ → T-to-P → $j\omega_0 \vec{\mathbf{F}}(x,y,z)$

$\nabla \cdot \vec{\mathbf{f}}$ → T-to-P → $\nabla \cdot \vec{\mathbf{F}}(x,y,z)$

$\nabla \times \vec{\mathbf{f}}$ → T-to-P → $\nabla \times \vec{\mathbf{F}}(x,y,z)$

$\vec{\mathbf{d}}(\vec{\mathbf{r}},t)$ → T-to-P → $\vec{\mathbf{D}}(\vec{\mathbf{r}})$

$\dfrac{\partial \vec{\mathbf{d}}(\vec{\mathbf{r}},t)}{\partial t}$ → T-to-P → $j\omega_0 \vec{\mathbf{D}}(\vec{\mathbf{r}})$

Maxwell equations
Time domain & Phasor domain

Time domain

$$\begin{cases} \nabla \times \vec{\mathbf{e}}(\vec{\mathbf{r}},t) = -\dfrac{\partial \vec{\mathbf{b}}(\vec{\mathbf{r}},t)}{\partial t} \\ \nabla \times \vec{\mathbf{h}}(\vec{\mathbf{r}},t) = \dfrac{\partial \vec{\mathbf{d}}(\vec{\mathbf{r}},t)}{\partial t} + \vec{\mathbf{j}}(\vec{\mathbf{r}},t) \\ \nabla \cdot \vec{\mathbf{d}}(\vec{\mathbf{r}},t) = \rho(\vec{\mathbf{r}},t) \\ \nabla \cdot \vec{\mathbf{b}}(\vec{\mathbf{r}},t) = 0 \end{cases}$$

Phasor domain

$$\begin{cases} \nabla \times \vec{\mathbf{E}}(\vec{\mathbf{r}}) = -j\omega_0 \vec{\mathbf{B}}(\vec{\mathbf{r}}) \\ \nabla \times \vec{\mathbf{H}}(\vec{\mathbf{r}}) = j\omega_0 \vec{\mathbf{D}}(\vec{\mathbf{r}}) \end{cases}$$

$\vec{\mathbf{f}}(x,y,z,t)$ → T-to-P → $\vec{\mathbf{F}}(x,y,z)$

$\dfrac{\partial \vec{\mathbf{f}}}{\partial t}$ → T-to-P → $j\omega_0 \vec{\mathbf{F}}(x,y,z)$

$\nabla \cdot \vec{\mathbf{f}}$ → T-to-P → $\nabla \cdot \vec{\mathbf{F}}(x,y,z)$

$\nabla \times \vec{\mathbf{f}}$ → T-to-P → $\nabla \times \vec{\mathbf{F}}(x,y,z)$

$\vec{\mathbf{j}}(\vec{\mathbf{r}},t)$ → T-to-P → $\vec{\mathbf{J}}(\vec{\mathbf{r}})$

Maxwell equations
Time domain & Phasor domain

Time domain

$$
\begin{cases}
\nabla \times \vec{\mathbf{e}}(\vec{\mathbf{r}},t) = -\dfrac{\partial \vec{\mathbf{b}}(\vec{\mathbf{r}},t)}{\partial t} \\
\nabla \times \vec{\mathbf{h}}(\vec{\mathbf{r}},t) = \dfrac{\partial \vec{\mathbf{d}}(\vec{\mathbf{r}},t)}{\partial t} + \vec{\mathbf{j}}(\vec{\mathbf{r}},t) \\
\nabla \cdot \vec{\mathbf{d}}(\vec{\mathbf{r}},t) = \rho(\vec{\mathbf{r}},t) \\
\nabla \cdot \vec{\mathbf{b}}(\vec{\mathbf{r}},t) = 0
\end{cases}
$$

Phasor domain

$$
\begin{cases}
\nabla \times \vec{\mathbf{E}}(\vec{\mathbf{r}}) = -j\omega_0 \vec{\mathbf{B}}(\vec{\mathbf{r}}) \\
\nabla \times \vec{\mathbf{H}}(\vec{\mathbf{r}}) = j\omega_0 \vec{\mathbf{D}}(\vec{\mathbf{r}}) + \vec{\mathbf{J}}(\vec{\mathbf{r}})
\end{cases}
$$

$\vec{\mathbf{f}}(x,y,z,t)$ → T-to-P → $\vec{\mathbf{F}}(x,y,z)$

$\dfrac{\partial \vec{\mathbf{f}}}{\partial t}$ → T-to-P → $j\omega_0 \vec{\mathbf{F}}(x,y,z)$

$\nabla \cdot \vec{\mathbf{f}}$ → T-to-P → $\nabla \cdot \vec{\mathbf{F}}(x,y,z)$

$\nabla \times \vec{\mathbf{f}}$ → T-to-P → $\nabla \times \vec{\mathbf{F}}(x,y,z)$

$\vec{\mathbf{j}}(\vec{\mathbf{r}},t)$ → T-to-P → $\vec{\mathbf{J}}(\vec{\mathbf{r}})$

Maxwell equations
Time domain & Phasor domain

Time domain

$$\begin{cases} \nabla \times \vec{\mathbf{e}}(\vec{\mathbf{r}},t) = -\dfrac{\partial \vec{\mathbf{b}}(\vec{\mathbf{r}},t)}{\partial t} \\ \nabla \times \vec{\mathbf{h}}(\vec{\mathbf{r}},t) = \dfrac{\partial \vec{\mathbf{d}}(\vec{\mathbf{r}},t)}{\partial t} + \vec{\mathbf{j}}(\vec{\mathbf{r}},t) \\ \nabla \cdot \vec{\mathbf{d}}(\vec{\mathbf{r}},t) = \rho(\vec{\mathbf{r}},t) \\ \nabla \cdot \vec{\mathbf{b}}(\vec{\mathbf{r}},t) = 0 \end{cases}$$

Phasor domain

$$\begin{cases} \nabla \times \vec{\mathbf{E}}(\vec{\mathbf{r}}) = -j\omega_0 \vec{\mathbf{B}}(\vec{\mathbf{r}}) \\ \nabla \times \vec{\mathbf{H}}(\vec{\mathbf{r}}) = j\omega_0 \vec{\mathbf{D}}(\vec{\mathbf{r}}) + \vec{\mathbf{J}}(\vec{\mathbf{r}}) \end{cases}$$

$\vec{\mathbf{f}}(x,y,z,t)$ → **T-to-P** → $\vec{\mathbf{F}}(x,y,z)$

$\dfrac{\partial \vec{\mathbf{f}}}{\partial t}$ → **T-to-P** → $j\omega_0 \vec{\mathbf{F}}(x,y,z)$

$\nabla \cdot \vec{\mathbf{f}}$ → **T-to-P** → $\nabla \cdot \vec{\mathbf{F}}(x,y,z)$

$\nabla \times \vec{\mathbf{f}}$ → **T-to-P** → $\nabla \times \vec{\mathbf{F}}(x,y,z)$

$\vec{\mathbf{d}}(\vec{\mathbf{r}},t)$ → **T-to-P** → $\vec{\mathbf{D}}(\vec{\mathbf{r}})$

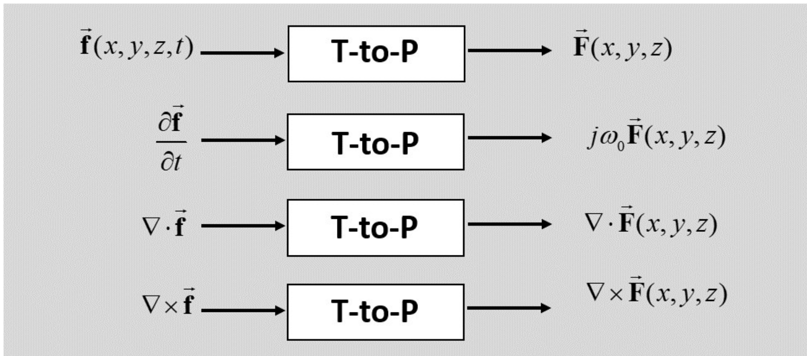
Maxwell equations
Time domain & Phasor domain

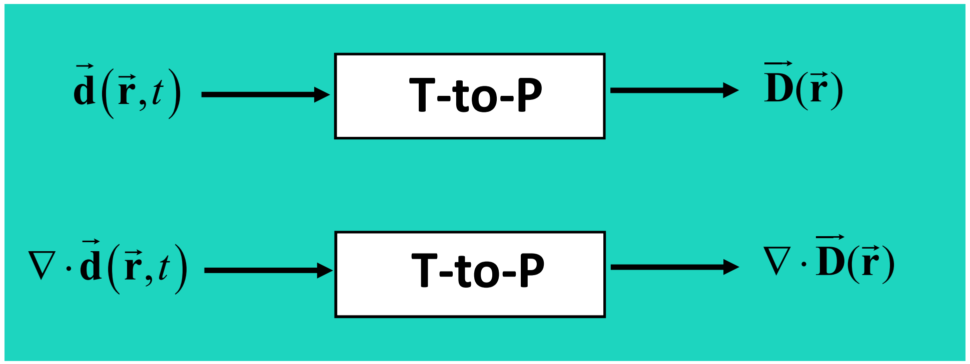
Time domain

$$
\begin{cases}
\nabla \times \vec{\mathbf{e}}(\vec{\mathbf{r}},t) = -\dfrac{\partial \vec{\mathbf{b}}(\vec{\mathbf{r}},t)}{\partial t} \\
\nabla \times \vec{\mathbf{h}}(\vec{\mathbf{r}},t) = \dfrac{\partial \vec{\mathbf{d}}(\vec{\mathbf{r}},t)}{\partial t} + \vec{\mathbf{j}}(\vec{\mathbf{r}},t) \\
\nabla \cdot \vec{\mathbf{d}}(\vec{\mathbf{r}},t) = \rho(\vec{\mathbf{r}},t) \\
\nabla \cdot \vec{\mathbf{b}}(\vec{\mathbf{r}},t) = 0
\end{cases}
$$

Phasor domain

$$
\begin{cases}
\nabla \times \vec{\mathbf{E}}(\vec{\mathbf{r}}) = -j\omega_0 \vec{\mathbf{B}}(\vec{\mathbf{r}}) \\
\nabla \times \vec{\mathbf{H}}(\vec{\mathbf{r}}) = j\omega_0 \vec{\mathbf{D}}(\vec{\mathbf{r}}) + \vec{\mathbf{J}}(\vec{\mathbf{r}})
\end{cases}
$$





Maxwell equations
Time domain & Phasor domain

Time domain

$$\begin{cases} \nabla \times \vec{\mathbf{e}}(\vec{\mathbf{r}},t) = -\dfrac{\partial \vec{\mathbf{b}}(\vec{\mathbf{r}},t)}{\partial t} \\ \nabla \times \vec{\mathbf{h}}(\vec{\mathbf{r}},t) = \dfrac{\partial \vec{\mathbf{d}}(\vec{\mathbf{r}},t)}{\partial t} + \vec{\mathbf{j}}(\vec{\mathbf{r}},t) \\ \nabla \cdot \vec{\mathbf{d}}(\vec{\mathbf{r}},t) = \rho(\vec{\mathbf{r}},t) \\ \nabla \cdot \vec{\mathbf{b}}(\vec{\mathbf{r}},t) = 0 \end{cases}$$

Phasor domain

$$\begin{cases} \nabla \times \vec{\mathbf{E}}(\vec{\mathbf{r}}) = -j\omega_0 \vec{\mathbf{B}}(\vec{\mathbf{r}}) \\ \nabla \times \vec{\mathbf{H}}(\vec{\mathbf{r}}) = j\omega_0 \vec{\mathbf{D}}(\vec{\mathbf{r}}) + \vec{\mathbf{J}}(\vec{\mathbf{r}}) \\ \nabla \cdot \vec{\mathbf{D}}(\vec{\mathbf{r}}) \end{cases}$$

$\vec{\mathbf{f}}(x,y,z,t)$ → T-to-P → $\vec{\mathbf{F}}(x,y,z)$

$\dfrac{\partial \vec{\mathbf{f}}}{\partial t}$ → T-to-P → $j\omega_0 \vec{\mathbf{F}}(x,y,z)$

$\nabla \cdot \vec{\mathbf{f}}$ → T-to-P → $\nabla \cdot \vec{\mathbf{F}}(x,y,z)$

$\nabla \times \vec{\mathbf{f}}$ → T-to-P → $\nabla \times \vec{\mathbf{F}}(x,y,z)$

$\vec{\mathbf{d}}(\vec{\mathbf{r}},t)$ → T-to-P → $\vec{\mathbf{D}}(\vec{\mathbf{r}})$

$\nabla \cdot \vec{\mathbf{d}}(\vec{\mathbf{r}},t)$ → T-to-P → $\nabla \cdot \vec{\mathbf{D}}(\vec{\mathbf{r}})$

Maxwell equations
Time domain & Phasor domain

Time domain

$$\begin{cases} \nabla \times \vec{\mathbf{e}}(\vec{\mathbf{r}},t) = -\dfrac{\partial \vec{\mathbf{b}}(\vec{\mathbf{r}},t)}{\partial t} \\ \nabla \times \vec{\mathbf{h}}(\vec{\mathbf{r}},t) = \dfrac{\partial \vec{\mathbf{d}}(\vec{\mathbf{r}},t)}{\partial t} + \vec{\mathbf{j}}(\vec{\mathbf{r}},t) \\ \nabla \cdot \vec{\mathbf{d}}(\vec{\mathbf{r}},t) = \rho(\vec{\mathbf{r}},t) \\ \nabla \cdot \vec{\mathbf{b}}(\vec{\mathbf{r}},t) = 0 \end{cases}$$

Phasor domain

$$\begin{cases} \nabla \times \vec{\mathbf{E}}(\vec{\mathbf{r}}) = -j\omega_0 \vec{\mathbf{B}}(\vec{\mathbf{r}}) \\ \nabla \times \vec{\mathbf{H}}(\vec{\mathbf{r}}) = j\omega_0 \vec{\mathbf{D}}(\vec{\mathbf{r}}) + \vec{\mathbf{J}}(\vec{\mathbf{r}}) \\ \nabla \cdot \vec{\mathbf{D}}(\vec{\mathbf{r}}) \end{cases}$$

$f(t,x,y,z)$ → **T-to-P** → $F(x,y,z)$

$\rho(\vec{\mathbf{r}},t)$ → **T-to-P** → $\rho(\vec{\mathbf{r}})$

Maxwell equations
Time domain & Phasor domain

Time domain

$$\begin{cases} \nabla \times \vec{\mathbf{e}}(\vec{\mathbf{r}},t) = -\dfrac{\partial \vec{\mathbf{b}}(\vec{\mathbf{r}},t)}{\partial t} \\ \nabla \times \vec{\mathbf{h}}(\vec{\mathbf{r}},t) = \dfrac{\partial \vec{\mathbf{d}}(\vec{\mathbf{r}},t)}{\partial t} + \vec{\mathbf{j}}(\vec{\mathbf{r}},t) \\ \nabla \cdot \vec{\mathbf{d}}(\vec{\mathbf{r}},t) = \rho(\vec{\mathbf{r}},t) \\ \nabla \cdot \vec{\mathbf{b}}(\vec{\mathbf{r}},t) = 0 \end{cases}$$

Phasor domain

$$\begin{cases} \nabla \times \vec{\mathbf{E}}(\vec{\mathbf{r}}) = -j\omega_0 \vec{\mathbf{B}}(\vec{\mathbf{r}}) \\ \nabla \times \vec{\mathbf{H}}(\vec{\mathbf{r}}) = j\omega_0 \vec{\mathbf{D}}(\vec{\mathbf{r}}) + \vec{\mathbf{J}}(\vec{\mathbf{r}}) \\ \nabla \cdot \vec{\mathbf{D}}(\vec{\mathbf{r}}) = \rho(\vec{\mathbf{r}}) \end{cases}$$

$f(t,x,y,z)$ → **T-to-P** → $F(x,y,z)$

$\rho(\vec{\mathbf{r}},t)$ → **T-to-P** → $\rho(\vec{\mathbf{r}})$

Maxwell equations
Time domain & Phasor domain

Time domain

$$\begin{cases} \nabla \times \vec{\mathbf{e}}(\vec{\mathbf{r}},t) = -\dfrac{\partial \vec{\mathbf{b}}(\vec{\mathbf{r}},t)}{\partial t} \\ \nabla \times \vec{\mathbf{h}}(\vec{\mathbf{r}},t) = \dfrac{\partial \vec{\mathbf{d}}(\vec{\mathbf{r}},t)}{\partial t} + \vec{\mathbf{j}}(\vec{\mathbf{r}},t) \\ \nabla \cdot \vec{\mathbf{d}}(\vec{\mathbf{r}},t) = \rho(\vec{\mathbf{r}},t) \\ \nabla \cdot \vec{\mathbf{b}}(\vec{\mathbf{r}},t) = 0 \end{cases}$$

Phasor domain

$$\begin{cases} \nabla \times \vec{\mathbf{E}}(\vec{\mathbf{r}}) = -j\omega_0 \vec{\mathbf{B}}(\vec{\mathbf{r}}) \\ \nabla \times \vec{\mathbf{H}}(\vec{\mathbf{r}}) = j\omega_0 \vec{\mathbf{D}}(\vec{\mathbf{r}}) + \vec{\mathbf{J}}(\vec{\mathbf{r}}) \\ \nabla \cdot \vec{\mathbf{D}}(\vec{\mathbf{r}}) = \rho(\vec{\mathbf{r}}) \end{cases}$$

$\vec{\mathbf{f}}(x,y,z,t)$ → T-to-P → $\vec{\mathbf{F}}(x,y,z)$

$\dfrac{\partial \vec{\mathbf{f}}}{\partial t}$ → T-to-P → $j\omega_0 \vec{\mathbf{F}}(x,y,z)$

$\nabla \cdot \vec{\mathbf{f}}$ → T-to-P → $\nabla \cdot \vec{\mathbf{F}}(x,y,z)$

$\nabla \times \vec{\mathbf{f}}$ → T-to-P → $\nabla \times \vec{\mathbf{F}}(x,y,z)$

$\vec{\mathbf{b}}(\vec{\mathbf{r}},t)$ → T-to-P → $\vec{\mathbf{B}}(\vec{\mathbf{r}},\omega)$

Maxwell equations
Time domain & Phasor domain

Time domain

$$
\begin{cases}
\nabla \times \vec{\mathbf{e}}(\vec{\mathbf{r}},t) = -\dfrac{\partial \vec{\mathbf{b}}(\vec{\mathbf{r}},t)}{\partial t} \\
\nabla \times \vec{\mathbf{h}}(\vec{\mathbf{r}},t) = \dfrac{\partial \vec{\mathbf{d}}(\vec{\mathbf{r}},t)}{\partial t} + \vec{\mathbf{j}}(\vec{\mathbf{r}},t) \\
\nabla \cdot \vec{\mathbf{d}}(\vec{\mathbf{r}},t) = \rho(\vec{\mathbf{r}},t) \\
\nabla \cdot \vec{\mathbf{b}}(\vec{\mathbf{r}},t) = 0
\end{cases}
$$

Phasor domain

$$
\begin{cases}
\nabla \times \vec{\mathbf{E}}(\vec{\mathbf{r}}) = -j\omega_0 \vec{\mathbf{B}}(\vec{\mathbf{r}}) \\
\nabla \times \vec{\mathbf{H}}(\vec{\mathbf{r}}) = j\omega_0 \vec{\mathbf{D}}(\vec{\mathbf{r}}) + \vec{\mathbf{J}}(\vec{\mathbf{r}}) \\
\nabla \cdot \vec{\mathbf{D}}(\vec{\mathbf{r}}) = \rho(\vec{\mathbf{r}})
\end{cases}
$$

$\vec{\mathbf{f}}(x,y,z,t) \longrightarrow$ T-to-P $\longrightarrow \vec{\mathbf{F}}(x,y,z)$

$\dfrac{\partial \vec{\mathbf{f}}}{\partial t} \longrightarrow$ T-to-P $\longrightarrow j\omega_0 \vec{\mathbf{F}}(x,y,z)$

$\nabla \cdot \vec{\mathbf{f}} \longrightarrow$ T-to-P $\longrightarrow \nabla \cdot \vec{\mathbf{F}}(x,y,z)$

$\nabla \times \vec{\mathbf{f}} \longrightarrow$ T-to-P $\longrightarrow \nabla \times \vec{\mathbf{F}}(x,y,z)$

$\vec{\mathbf{b}}(\vec{\mathbf{r}},t) \longrightarrow$ T-to-P $\longrightarrow \vec{\mathbf{B}}(\vec{\mathbf{r}})$

$\nabla \cdot \vec{\mathbf{b}}(\vec{\mathbf{r}},t) \longrightarrow$ T-to-P $\longrightarrow \nabla \cdot \vec{\mathbf{B}}(\vec{\mathbf{r}})$

Maxwell equations
Time domain & Phasor domain

Time domain

$$\begin{cases} \nabla \times \vec{\mathbf{e}}(\vec{\mathbf{r}},t) = -\dfrac{\partial \vec{\mathbf{b}}(\vec{\mathbf{r}},t)}{\partial t} \\ \nabla \times \vec{\mathbf{h}}(\vec{\mathbf{r}},t) = \dfrac{\partial \vec{\mathbf{d}}(\vec{\mathbf{r}},t)}{\partial t} + \vec{\mathbf{j}}(\vec{\mathbf{r}},t) \\ \nabla \cdot \vec{\mathbf{d}}(\vec{\mathbf{r}},t) = \rho(\vec{\mathbf{r}},t) \\ \nabla \cdot \vec{\mathbf{b}}(\vec{\mathbf{r}},t) = 0 \end{cases}$$

Phasor domain

$$\begin{cases} \nabla \times \vec{\mathbf{E}}(\vec{\mathbf{r}}) = -j\omega_0 \vec{\mathbf{B}}(\vec{\mathbf{r}}) \\ \nabla \times \vec{\mathbf{H}}(\vec{\mathbf{r}}) = j\omega_0 \vec{\mathbf{D}}(\vec{\mathbf{r}}) + \vec{\mathbf{J}}(\vec{\mathbf{r}}) \\ \nabla \cdot \vec{\mathbf{D}}(\vec{\mathbf{r}}) = \rho(\vec{\mathbf{r}}) \\ \nabla \cdot \vec{\mathbf{B}}(\vec{\mathbf{r}}) \end{cases}$$

$\vec{\mathbf{f}}(x,y,z,t) \longrightarrow$ T-to-P $\longrightarrow \vec{\mathbf{F}}(x,y,z)$

$\dfrac{\partial \vec{\mathbf{f}}}{\partial t} \longrightarrow$ T-to-P $\longrightarrow j\omega_0 \vec{\mathbf{F}}(x,y,z)$

$\nabla \cdot \vec{\mathbf{f}} \longrightarrow$ T-to-P $\longrightarrow \nabla \cdot \vec{\mathbf{F}}(x,y,z)$

$\nabla \times \vec{\mathbf{f}} \longrightarrow$ T-to-P $\longrightarrow \nabla \times \vec{\mathbf{F}}(x,y,z)$

$\vec{\mathbf{b}}(\vec{\mathbf{r}},t) \longrightarrow$ T-to-P $\longrightarrow \vec{\mathbf{B}}(\vec{\mathbf{r}})$

$\nabla \cdot \vec{\mathbf{b}}(\vec{\mathbf{r}},t) \longrightarrow$ T-to-P $\longrightarrow \nabla \cdot \vec{\mathbf{B}}(\vec{\mathbf{r}})$

Maxwell equations
Time domain & Phasor domain

Time domain

$$\begin{cases} \nabla \times \vec{\mathbf{e}}(\vec{\mathbf{r}},t) = -\dfrac{\partial \vec{\mathbf{b}}(\vec{\mathbf{r}},t)}{\partial t} \\ \nabla \times \vec{\mathbf{h}}(\vec{\mathbf{r}},t) = \dfrac{\partial \vec{\mathbf{d}}(\vec{\mathbf{r}},t)}{\partial t} + \vec{\mathbf{j}}(\vec{\mathbf{r}},t) \\ \nabla \cdot \vec{\mathbf{d}}(\vec{\mathbf{r}},t) = \rho(\vec{\mathbf{r}},t) \\ \nabla \cdot \vec{\mathbf{b}}(\vec{\mathbf{r}},t) = 0 \end{cases}$$

Phasor domain

$$\begin{cases} \nabla \times \vec{\mathbf{E}}(\vec{\mathbf{r}}) = -j\omega_0 \vec{\mathbf{B}}(\vec{\mathbf{r}}) \\ \nabla \times \vec{\mathbf{H}}(\vec{\mathbf{r}}) = j\omega_0 \vec{\mathbf{D}}(\vec{\mathbf{r}}) + \vec{\mathbf{J}}(\vec{\mathbf{r}}) \\ \nabla \cdot \vec{\mathbf{D}}(\vec{\mathbf{r}}) = \rho(\vec{\mathbf{r}}) \\ \nabla \cdot \vec{\mathbf{B}}(\vec{\mathbf{r}}) = 0 \end{cases}$$

Maxwell equations
Time domain & Phasor domain

Time domain

$$\begin{cases} \nabla \times \vec{\mathbf{e}}(\vec{\mathbf{r}},t) = -\dfrac{\partial \vec{\mathbf{b}}(\vec{\mathbf{r}},t)}{\partial t} \\ \nabla \times \vec{\mathbf{h}}(\vec{\mathbf{r}},t) = \dfrac{\partial \vec{\mathbf{d}}(\vec{\mathbf{r}},t)}{\partial t} + \vec{\mathbf{j}}(\vec{\mathbf{r}},t) \\ \nabla \cdot \vec{\mathbf{d}}(\vec{\mathbf{r}},t) = \rho(\vec{\mathbf{r}},t) \\ \nabla \cdot \vec{\mathbf{b}}(\vec{\mathbf{r}},t) = 0 \end{cases}$$

Phasor domain

$$\begin{cases} \nabla \times \vec{\mathbf{E}}(\vec{\mathbf{r}}) = -j\omega_0 \vec{\mathbf{B}}(\vec{\mathbf{r}}) \\ \nabla \times \vec{\mathbf{H}}(\vec{\mathbf{r}}) = j\omega_0 \vec{\mathbf{D}}(\vec{\mathbf{r}}) + \vec{\mathbf{J}}(\vec{\mathbf{r}}) \\ \nabla \cdot \vec{\mathbf{D}}(\vec{\mathbf{r}}) = \rho(\vec{\mathbf{r}}) \\ \nabla \cdot \vec{\mathbf{B}}(\vec{\mathbf{r}}) = 0 \end{cases}$$

Maxwell equations
Time domain & Phasor domain

Time domain	**Phasor domain**
$\begin{cases} \nabla \times \vec{\mathbf{e}}(\vec{\mathbf{r}},t) = -\dfrac{\partial \vec{\mathbf{b}}(\vec{\mathbf{r}},t)}{\partial t} \\ \nabla \times \vec{\mathbf{h}}(\vec{\mathbf{r}},t) = \dfrac{\partial \vec{\mathbf{d}}(\vec{\mathbf{r}},t)}{\partial t} + \vec{\mathbf{j}}(\vec{\mathbf{r}},t) \\ \nabla \cdot \vec{\mathbf{d}}(\vec{\mathbf{r}},t) = \rho(\vec{\mathbf{r}},t) \\ \nabla \cdot \vec{\mathbf{b}}(\vec{\mathbf{r}},t) = 0 \end{cases}$	$\begin{cases} \nabla \times \vec{\mathbf{E}}(\vec{\mathbf{r}}) = -j\omega_0 \vec{\mathbf{B}}(\vec{\mathbf{r}}) \\ \nabla \times \vec{\mathbf{H}}(\vec{\mathbf{r}}) = j\omega_0 \vec{\mathbf{D}}(\vec{\mathbf{r}}) + \vec{\mathbf{J}}(\vec{\mathbf{r}}) \\ \nabla \cdot \vec{\mathbf{D}}(\vec{\mathbf{r}}) = \rho(\vec{\mathbf{r}}) \\ \nabla \cdot \vec{\mathbf{B}}(\vec{\mathbf{r}}) = 0 \end{cases}$

$\vec{\mathbf{e}}(\vec{\mathbf{r}},t)$	Volt/m
$\vec{\mathbf{d}}(\vec{\mathbf{r}},t)$	Coulomb/m^2
$\vec{\mathbf{h}}(\vec{\mathbf{r}},t)$	Ampere/m
$\vec{\mathbf{b}}(\vec{\mathbf{r}},t)$	Weber/m^2
$\vec{\mathbf{j}}(\vec{\mathbf{r}},t)$	Ampere/m^2
$\rho(\vec{\mathbf{r}},t)$	Coulomb/m^3

Maxwell equations
Time domain & Phasor domain

Time domain

$$\begin{cases} \nabla \times \vec{\mathbf{e}}(\vec{\mathbf{r}},t) = -\dfrac{\partial \vec{\mathbf{b}}(\vec{\mathbf{r}},t)}{\partial t} \\ \nabla \times \vec{\mathbf{h}}(\vec{\mathbf{r}},t) = \dfrac{\partial \vec{\mathbf{d}}(\vec{\mathbf{r}},t)}{\partial t} + \vec{\mathbf{j}}(\vec{\mathbf{r}},t) \\ \nabla \cdot \vec{\mathbf{d}}(\vec{\mathbf{r}},t) = \rho(\vec{\mathbf{r}},t) \\ \nabla \cdot \vec{\mathbf{b}}(\vec{\mathbf{r}},t) = 0 \end{cases}$$

Phasor domain

$$\begin{cases} \nabla \times \vec{\mathbf{E}}(\vec{\mathbf{r}}) = -j\omega_0 \vec{\mathbf{B}}(\vec{\mathbf{r}}) \\ \nabla \times \vec{\mathbf{H}}(\vec{\mathbf{r}}) = j\omega_0 \vec{\mathbf{D}}(\vec{\mathbf{r}}) + \vec{\mathbf{J}}(\vec{\mathbf{r}}) \\ \nabla \cdot \vec{\mathbf{D}}(\vec{\mathbf{r}}) = \rho(\vec{\mathbf{r}}) \\ \nabla \cdot \vec{\mathbf{B}}(\vec{\mathbf{r}}) = 0 \end{cases}$$

$\vec{\mathbf{e}}(\vec{\mathbf{r}},t)$	Volt/m	$\vec{\mathbf{E}}(\vec{\mathbf{r}})$
$\vec{\mathbf{d}}(\vec{\mathbf{r}},t)$	Coulomb/m^2	$\vec{\mathbf{D}}(\vec{\mathbf{r}})$
$\vec{\mathbf{h}}(\vec{\mathbf{r}},t)$	Ampere/m	$\vec{\mathbf{H}}(\vec{\mathbf{r}})$
$\vec{\mathbf{b}}(\vec{\mathbf{r}},t)$	Weber/m^2	$\vec{\mathbf{B}}(\vec{\mathbf{r}})$
$\vec{\mathbf{j}}(\vec{\mathbf{r}},t)$	Ampere/m^2	$\vec{\mathbf{J}}(\vec{\mathbf{r}})$
$\rho(\vec{\mathbf{r}},t)$	Coulomb/m^3	$\rho(\vec{\mathbf{r}})$

Maxwell equations
Time domain & Phasor domain

Time domain

$$\begin{cases} \nabla \times \vec{\mathbf{e}}(\vec{\mathbf{r}},t) = -\dfrac{\partial \vec{\mathbf{b}}(\vec{\mathbf{r}},t)}{\partial t} \\ \nabla \times \vec{\mathbf{h}}(\vec{\mathbf{r}},t) = \dfrac{\partial \vec{\mathbf{d}}(\vec{\mathbf{r}},t)}{\partial t} + \vec{\mathbf{j}}(\vec{\mathbf{r}},t) \\ \nabla \cdot \vec{\mathbf{d}}(\vec{\mathbf{r}},t) = \rho(\vec{\mathbf{r}},t) \\ \nabla \cdot \vec{\mathbf{b}}(\vec{\mathbf{r}},t) = 0 \end{cases}$$

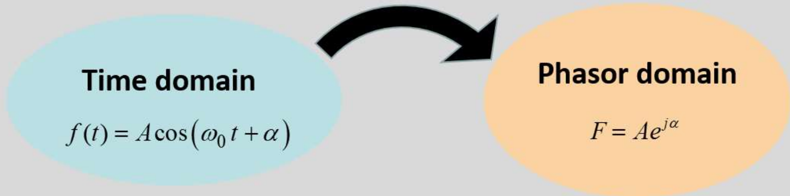
Phasor domain

$$\begin{cases} \nabla \times \vec{\mathbf{E}}(\vec{\mathbf{r}}) = -j\omega_0 \vec{\mathbf{B}}(\vec{\mathbf{r}}) \\ \nabla \times \vec{\mathbf{H}}(\vec{\mathbf{r}}) = j\omega_0 \vec{\mathbf{D}}(\vec{\mathbf{r}}) + \vec{\mathbf{J}}(\vec{\mathbf{r}}) \\ \nabla \cdot \vec{\mathbf{D}}(\vec{\mathbf{r}}) = \rho(\vec{\mathbf{r}}) \\ \nabla \cdot \vec{\mathbf{B}}(\vec{\mathbf{r}}) = 0 \end{cases}$$

$\vec{\mathbf{e}}(\vec{\mathbf{r}},t)$	Volt/m
$\vec{\mathbf{d}}(\vec{\mathbf{r}},t)$	Coulomb/m^2
$\vec{\mathbf{h}}(\vec{\mathbf{r}},t)$	Ampere/m
$\vec{\mathbf{b}}(\vec{\mathbf{r}},t)$	Weber/m^2
$\vec{\mathbf{j}}(\vec{\mathbf{r}},t)$	Ampere/m^2
$\rho(\vec{\mathbf{r}},t)$	Coulomb/m^3

$\vec{\mathbf{E}}(\vec{\mathbf{r}})$

.. **memo**



Maxwell equations
Time domain & Phasor domain

Time domain

$$\begin{cases} \nabla \times \vec{\mathbf{e}}(\vec{\mathbf{r}},t) = -\dfrac{\partial \vec{\mathbf{b}}(\vec{\mathbf{r}},t)}{\partial t} \\ \nabla \times \vec{\mathbf{h}}(\vec{\mathbf{r}},t) = \dfrac{\partial \vec{\mathbf{d}}(\vec{\mathbf{r}},t)}{\partial t} + \vec{\mathbf{j}}(\vec{\mathbf{r}},t) \\ \nabla \cdot \vec{\mathbf{d}}(\vec{\mathbf{r}},t) = \rho(\vec{\mathbf{r}},t) \\ \nabla \cdot \vec{\mathbf{b}}(\vec{\mathbf{r}},t) = 0 \end{cases}$$

Phasor domain

$$\begin{cases} \nabla \times \vec{\mathbf{E}}(\vec{\mathbf{r}}) = -j\omega_0 \vec{\mathbf{B}}(\vec{\mathbf{r}}) \\ \nabla \times \vec{\mathbf{H}}(\vec{\mathbf{r}}) = j\omega_0 \vec{\mathbf{D}}(\vec{\mathbf{r}}) + \vec{\mathbf{J}}(\vec{\mathbf{r}}) \\ \nabla \cdot \vec{\mathbf{D}}(\vec{\mathbf{r}}) = \rho(\vec{\mathbf{r}}) \\ \nabla \cdot \vec{\mathbf{B}}(\vec{\mathbf{r}}) = 0 \end{cases}$$

$\vec{\mathbf{e}}(\vec{\mathbf{r}},t)$	Volt/m
$\vec{\mathbf{d}}(\vec{\mathbf{r}},t)$	Coulomb/m^2
$\vec{\mathbf{h}}(\vec{\mathbf{r}},t)$	Ampere/m
$\vec{\mathbf{b}}(\vec{\mathbf{r}},t)$	Weber/m^2
$\vec{\mathbf{j}}(\vec{\mathbf{r}},t)$	Ampere/m^2
$\rho(\vec{\mathbf{r}},t)$	Coulomb/m^3

$\vec{\mathbf{E}}(\vec{\mathbf{r}})$ Volt/m

.. **memo**

Maxwell equations
Time domain & Phasor domain

Time domain

$$\begin{cases}\nabla\times\vec{\mathbf{e}}(\vec{\mathbf{r}},t)=-\dfrac{\partial\vec{\mathbf{b}}(\vec{\mathbf{r}},t)}{\partial t}\\[2mm]\nabla\times\vec{\mathbf{h}}(\vec{\mathbf{r}},t)=\dfrac{\partial\vec{\mathbf{d}}(\vec{\mathbf{r}},t)}{\partial t}+\vec{\mathbf{j}}(\vec{\mathbf{r}},t)\\[2mm]\nabla\cdot\vec{\mathbf{d}}(\vec{\mathbf{r}},t)=\rho(\vec{\mathbf{r}},t)\\[2mm]\nabla\cdot\vec{\mathbf{b}}(\vec{\mathbf{r}},t)=0\end{cases}$$

Phasor domain

$$\begin{cases}\nabla\times\vec{\mathbf{E}}(\vec{\mathbf{r}})=-j\omega_0\vec{\mathbf{B}}(\vec{\mathbf{r}})\\[2mm]\nabla\times\vec{\mathbf{H}}(\vec{\mathbf{r}})=j\omega_0\vec{\mathbf{D}}(\vec{\mathbf{r}})+\vec{\mathbf{J}}(\vec{\mathbf{r}})\\[2mm]\nabla\cdot\vec{\mathbf{D}}(\vec{\mathbf{r}})=\rho(\vec{\mathbf{r}})\\[2mm]\nabla\cdot\vec{\mathbf{B}}(\vec{\mathbf{r}})=0\end{cases}$$

$\vec{\mathbf{e}}(\vec{\mathbf{r}},t)$	Volt/m	$\vec{\mathbf{E}}(\vec{\mathbf{r}})$	Volt/m
$\vec{\mathbf{d}}(\vec{\mathbf{r}},t)$	Coulomb/m^2	$\vec{\mathbf{D}}(\vec{\mathbf{r}})$	Coulomb/m^2
$\vec{\mathbf{h}}(\vec{\mathbf{r}},t)$	Ampere/m	$\vec{\mathbf{H}}(\vec{\mathbf{r}})$	Ampere/m
$\vec{\mathbf{b}}(\vec{\mathbf{r}},t)$	Weber/m^2	$\vec{\mathbf{B}}(\vec{\mathbf{r}})$	Weber/m^2
$\vec{\mathbf{j}}(\vec{\mathbf{r}},t)$	Ampere/m^2	$\vec{\mathbf{J}}(\vec{\mathbf{r}})$	Ampere/m^2
$\rho(\vec{\mathbf{r}},t)$	Coulomb/m^3	$\rho(\vec{\mathbf{r}})$	Coulomb/m^3

Maxwell equations
Frequency domain & Phasor domain

Frequency domain

$$\begin{cases} \nabla \times \vec{\mathbf{E}}(\vec{\mathbf{r}},\omega) = -j\omega \vec{\mathbf{B}}(\vec{\mathbf{r}},\omega) \\ \nabla \times \vec{\mathbf{H}}(\vec{\mathbf{r}},\omega) = j\omega \vec{\mathbf{D}}(\vec{\mathbf{r}},\omega) + \vec{\mathbf{J}}(\vec{\mathbf{r}},\omega) \\ \nabla \cdot \vec{\mathbf{D}}(\vec{\mathbf{r}},\omega) = \rho(\vec{\mathbf{r}},\omega) \\ \nabla \cdot \vec{\mathbf{B}}(\vec{\mathbf{r}},\omega) = 0 \end{cases}$$

Phasor domain

$$\begin{cases} \nabla \times \vec{\mathbf{E}}(\vec{\mathbf{r}}) = -j\omega_0 \vec{\mathbf{B}}(\vec{\mathbf{r}}) \\ \nabla \times \vec{\mathbf{H}}(\vec{\mathbf{r}}) = j\omega_0 \vec{\mathbf{D}}(\vec{\mathbf{r}}) + \vec{\mathbf{J}}(\vec{\mathbf{r}}) \\ \nabla \cdot \vec{\mathbf{D}}(\vec{\mathbf{r}}) = \rho(\vec{\mathbf{r}}) \\ \nabla \cdot \vec{\mathbf{B}}(\vec{\mathbf{r}}) = 0 \end{cases}$$

The Maxwell equations in the Fourier domain and Phasor domain are formally equivalent.

However, they exhibit noticeable differences:

i) The dimensions of the involved quantities (f.i., $\vec{\mathbf{E}}$) are different in the two domains.

ii) In the Frequency domain ω is an independent variable, whereas in the Phasor domain ω_0 is fixed.

Color legend

New formulas, important considerations,
important formulas, important concepts

Very important for the discussion

Memo

Mathematical tools to be exploited

Mathematics

Maxwell equations
Time domain & Phasor domain

Time domain

$$\begin{cases} \nabla \times \vec{\mathbf{e}}(\vec{\mathbf{r}},t) = -\dfrac{\partial \vec{\mathbf{b}}(\vec{\mathbf{r}},t)}{\partial t} \\ \nabla \times \vec{\mathbf{h}}(\vec{\mathbf{r}},t) = \dfrac{\partial \vec{\mathbf{d}}(\vec{\mathbf{r}},t)}{\partial t} + \vec{\mathbf{j}}(\vec{\mathbf{r}},t) \\ \nabla \cdot \vec{\mathbf{d}}(\vec{\mathbf{r}},t) = \rho(\vec{\mathbf{r}},t) \\ \nabla \cdot \vec{\mathbf{b}}(\vec{\mathbf{r}},t) = 0 \end{cases}$$

$$\frac{\partial \rho(\vec{\mathbf{r}},t)}{\partial t} + \nabla \cdot \vec{\mathbf{j}}(\vec{\mathbf{r}},t) = 0$$

Frequency domain

$$\begin{cases} \nabla \times \vec{\mathbf{E}}(\vec{\mathbf{r}},\omega) = -j\omega \vec{\mathbf{B}}(\vec{\mathbf{r}},\omega) \\ \nabla \times \vec{\mathbf{H}}(\vec{\mathbf{r}},\omega) = j\omega \vec{\mathbf{D}}(\vec{\mathbf{r}},\omega) + \vec{\mathbf{J}}(\vec{\mathbf{r}},\omega) \\ \nabla \cdot \vec{\mathbf{D}}(\vec{\mathbf{r}},\omega) = \rho(\vec{\mathbf{r}},\omega) \\ \nabla \cdot \vec{\mathbf{B}}(\vec{\mathbf{r}},\omega) = 0 \end{cases}$$

$$j\omega\rho(\vec{\mathbf{r}},\omega) + \nabla \cdot \vec{\mathbf{J}}(\vec{\mathbf{r}},\omega) = 0$$

Phasor domain

$$\begin{cases} \nabla \times \vec{\mathbf{E}}(\vec{\mathbf{r}}) = -j\omega_0 \vec{\mathbf{B}}(\vec{\mathbf{r}}) \\ \nabla \times \vec{\mathbf{H}}(\vec{\mathbf{r}}) = j\omega_0 \vec{\mathbf{D}}(\vec{\mathbf{r}}) + \vec{\mathbf{J}}(\vec{\mathbf{r}}) \\ \nabla \cdot \vec{\mathbf{D}}(\vec{\mathbf{r}}) = \rho(\vec{\mathbf{r}}) \\ \nabla \cdot \vec{\mathbf{B}}(\vec{\mathbf{r}}) = 0 \end{cases}$$

$$j\omega_0\rho(\vec{\mathbf{r}}) + \nabla \cdot \vec{\mathbf{J}}(\vec{\mathbf{r}}) = 0$$