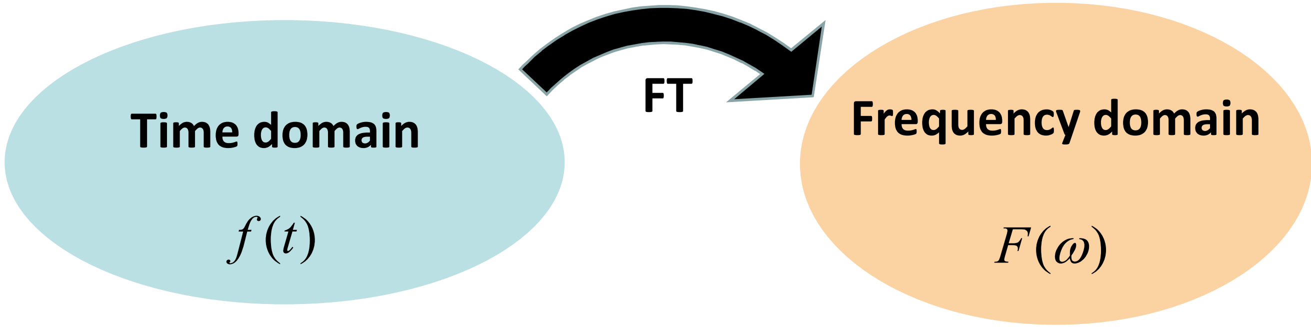
Maxwell equations: Time domain, Frequency domain, Phasors

Frequency domain



$$F(\omega) = \int_{-\infty}^{+\infty} f(t) e^{-j\omega t} dt$$

Fourier Transform (FT)

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

2) Time domain derivative and Fourier Transform

Frequency domain

- Fourier Transform and functions of *n* variables

- Fourier Transform and vector functions

- Fourier Transform and vector functions of *n* variables

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

2) Time domain derivative and Fourier Transform

Fourier Transform and vector functions of *n* variables

Time domain

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

$\omega \rightarrow t$

Frequency domain

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

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

$F_x(\omega,x,y,z)$ → **1D-IFT** → $f_x(t,x,y,z) = \frac{1}{2\pi}\int_{-\infty}^{+\infty} F_x(\omega,x,y,z)e^{j\omega t}d\omega$

$F_y(\omega,x,y,z)$ → **1D-IFT** → $f_y(t,x,y,z) = \frac{1}{2\pi}\int_{-\infty}^{+\infty} F_y(\omega,x,y,z)e^{j\omega t}d\omega$

$F_z(\omega,x,y,z)$ → **1D-IFT** → $f_z(t,x,y,z) = \frac{1}{2\pi}\int_{-\infty}^{+\infty} F_z(\omega,x,y,z)e^{j\omega t}d\omega$

Fourier Transform and vector functions of *n* variables

Time domain

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

$t \rightarrow \omega$

Frequency domain

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

2) Time domain derivative and Fourier Transform $t \rightarrow \omega$

$\vec{\mathbf{f}}(t,x,y,z)$ → **FT** → $\vec{\mathbf{F}}(\omega,x,y,z)$

$\dfrac{\partial \vec{\mathbf{f}}}{\partial t}$ → **FT** → $j\omega\vec{\mathbf{F}}(\omega,x,y,z)$

$\nabla \cdot \vec{\mathbf{f}}$ → **FT** → $\nabla \cdot \vec{\mathbf{F}}(\omega,x,y,z)$

$\nabla \times \vec{\mathbf{f}}$ → **FT** → $\nabla \times \vec{\mathbf{F}}(\omega,x,y,z)$

Fourier Transform and vector functions of *n* variables

Time domain

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

$t \rightarrow \omega$

Frequency domain

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

2) Time domain derivative and Fourier Transform

$t \rightarrow \omega$

$\vec{\mathbf{f}}(x,y,z,t) \longrightarrow$ **FT** $\longrightarrow \vec{\mathbf{F}}(x,y,z,\omega)$

$\dfrac{\partial \vec{\mathbf{f}}}{\partial t} \longrightarrow$ **FT** $\longrightarrow j\omega\vec{\mathbf{F}}(x,y,z,\omega)$

$\nabla \cdot \vec{\mathbf{f}} \longrightarrow$ **FT** $\longrightarrow \nabla \cdot \vec{\mathbf{F}}(x,y,z,\omega)$

$\nabla \times \vec{\mathbf{f}} \longrightarrow$ **FT** $\longrightarrow \nabla \times \vec{\mathbf{F}}(x,y,z,\omega)$

Maxwell equations
Time domain & Frequency 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 & Frequency domain

Time domain

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

$t \rightarrow \omega$

Frequency domain

Maxwell equations
Time domain & Frequency domain

Time domain

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

$t \rightarrow \omega$

Frequency domain

$t \rightarrow \omega$

$\vec{\mathbf{f}}(x,y,z,t) \longrightarrow$ **FT** $\longrightarrow \vec{\mathbf{F}}(x,y,z,\omega)$

$\dfrac{\partial \vec{\mathbf{f}}}{\partial t} \longrightarrow$ **FT** $\longrightarrow j\omega\vec{\mathbf{F}}(x,y,z,\omega)$

$\nabla \cdot \vec{\mathbf{f}} \longrightarrow$ **FT** $\longrightarrow \nabla \cdot \vec{\mathbf{F}}(x,y,z,\omega)$

$\nabla \times \vec{\mathbf{f}} \longrightarrow$ **FT** $\longrightarrow \nabla \times \vec{\mathbf{F}}(x,y,z,\omega)$

Maxwell equations
Time domain & Frequency domain

Time domain

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

$t \rightarrow \omega$

Frequency domain

$\vec{\mathbf{f}}(x,y,z,t)$ → FT → $\vec{\mathbf{F}}(x,y,z,\omega)$ $t \rightarrow \omega$

$\dfrac{\partial \vec{\mathbf{f}}}{\partial t}$ → FT → $j\omega\vec{\mathbf{F}}(x,y,z,\omega)$

$\nabla \cdot \vec{\mathbf{f}}$ → FT → $\nabla \cdot \vec{\mathbf{F}}(x,y,z,\omega)$

$\nabla \times \vec{\mathbf{f}}$ → FT → $\nabla \times \vec{\mathbf{F}}(x,y,z,\omega)$

$\vec{\mathbf{e}}(\vec{\mathbf{r}},t)$ → FT → $\vec{\mathbf{E}}(\vec{\mathbf{r}},\omega)$

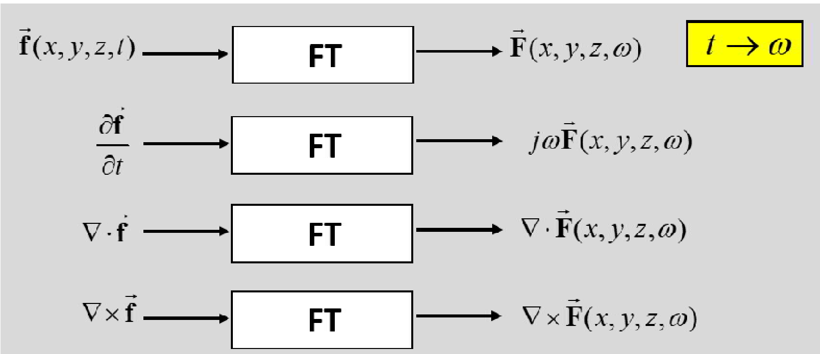
Maxwell equations
Time domain & Frequency domain

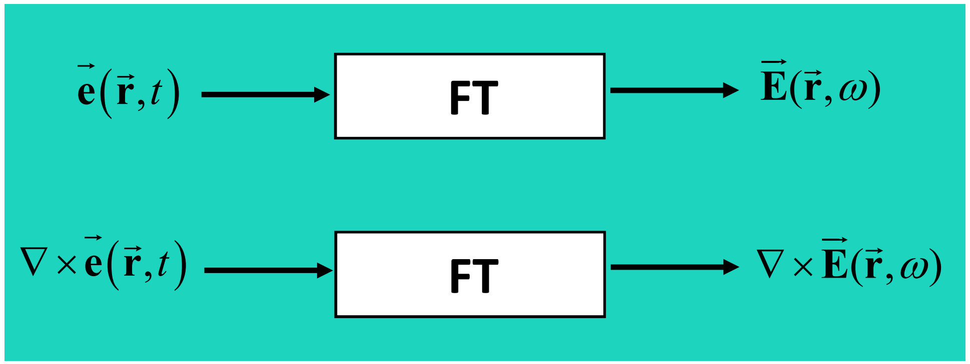
Time domain

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

$t \rightarrow \omega$

Frequency domain





Maxwell equations
Time domain & Frequency domain

Time domain

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

$t \rightarrow \omega$

Frequency domain

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

$\vec{\mathbf{f}}(x,y,z,t)$ → FT → $\vec{\mathbf{F}}(x,y,z,\omega)$ $\quad t \rightarrow \omega$

$\dfrac{\partial \vec{\mathbf{f}}}{\partial t}$ → FT → $j\omega\vec{\mathbf{F}}(x,y,z,\omega)$

$\nabla \cdot \vec{\mathbf{f}}$ → FT → $\nabla \cdot \vec{\mathbf{F}}(x,y,z,\omega)$

$\nabla \times \vec{\mathbf{f}}$ → FT → $\nabla \times \vec{\mathbf{F}}(x,y,z,\omega)$

$\vec{\mathbf{e}}(\vec{\mathbf{r}},t)$ → FT → $\vec{\mathbf{E}}(\vec{\mathbf{r}},\omega)$

$\nabla \times \vec{\mathbf{e}}(\vec{\mathbf{r}},t)$ → FT → $\nabla \times \vec{\mathbf{E}}(\vec{\mathbf{r}},\omega)$

Maxwell equations
Time domain & Frequency domain

Time domain

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

$t \rightarrow \omega$

Frequency domain

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

$\vec{\mathbf{f}}(x,y,z,t)$ → FT → $\vec{\mathbf{F}}(x,y,z,\omega)$ $\quad t \rightarrow \omega$

$\dfrac{\partial \vec{\mathbf{f}}}{\partial t}$ → FT → $j\omega\vec{\mathbf{F}}(x,y,z,\omega)$

$\nabla \cdot \vec{\mathbf{f}}$ → FT → $\nabla \cdot \vec{\mathbf{F}}(x,y,z,\omega)$

$\nabla \times \vec{\mathbf{f}}$ → FT → $\nabla \times \vec{\mathbf{F}}(x,y,z,\omega)$

$\vec{\mathbf{b}}(\vec{\mathbf{r}},t)$ → FT → $\vec{\mathbf{B}}(\vec{\mathbf{r}},\omega)$

Maxwell equations
Time domain & Frequency domain

Time domain

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

$t \rightarrow \omega$

Frequency domain

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

$t \rightarrow \omega$

$\vec{\mathbf{f}}(x,y,z,t)$ → FT → $\vec{\mathbf{F}}(x,y,z,\omega)$

$\dfrac{\partial \vec{\mathbf{f}}}{\partial t}$ → FT → $j\omega\vec{\mathbf{F}}(x,y,z,\omega)$

$\nabla \cdot \vec{\mathbf{f}}$ → FT → $\nabla \cdot \vec{\mathbf{F}}(x,y,z,\omega)$

$\nabla \times \vec{\mathbf{f}}$ → FT → $\nabla \times \vec{\mathbf{F}}(x,y,z,\omega)$

$\vec{\mathbf{b}}(\vec{\mathbf{r}},t)$ → FT → $\vec{\mathbf{B}}(\vec{\mathbf{r}},\omega)$

$\dfrac{\partial \vec{\mathbf{b}}(\vec{\mathbf{r}},t)}{\partial t}$ → FT → $j\omega\vec{\mathbf{B}}(\vec{\mathbf{r}},\omega)$

Maxwell equations
Time domain & Frequency domain

Time domain

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

$t \rightarrow \omega$

Frequency domain

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

$t \rightarrow \omega$

$\vec{\mathbf{f}}(x,y,z,t)$ → FT → $\vec{\mathbf{F}}(x,y,z,\omega)$

$\dfrac{\partial \vec{\mathbf{f}}}{\partial t}$ → FT → $j\omega \vec{\mathbf{F}}(x,y,z,\omega)$

$\nabla \cdot \vec{\mathbf{f}}$ → FT → $\nabla \cdot \vec{\mathbf{F}}(x,y,z,\omega)$

$\nabla \times \vec{\mathbf{f}}$ → FT → $\nabla \times \vec{\mathbf{F}}(x,y,z,\omega)$

$\vec{\mathbf{b}}(\vec{\mathbf{r}},t)$ → FT → $\vec{\mathbf{B}}(\vec{\mathbf{r}},\omega)$

$\dfrac{\partial \vec{\mathbf{b}}(\vec{\mathbf{r}},t)}{\partial t}$ → FT → $j\omega \vec{\mathbf{B}}(\vec{\mathbf{r}},\omega)$

Maxwell equations
Time domain & Frequency domain

Time domain

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

$t \rightarrow \omega$

Frequency domain

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

$\vec{\mathbf{f}}(x,y,z,t)$ → **FT** → $\vec{\mathbf{F}}(x,y,z,\omega)$ $\quad t \rightarrow \omega$

$\dfrac{\partial \vec{\mathbf{f}}}{\partial t}$ → **FT** → $j\omega \vec{\mathbf{F}}(x,y,z,\omega)$

$\nabla \cdot \vec{\mathbf{f}}$ → **FT** → $\nabla \cdot \vec{\mathbf{F}}(x,y,z,\omega)$

$\nabla \times \vec{\mathbf{f}}$ → **FT** → $\nabla \times \vec{\mathbf{F}}(x,y,z,\omega)$

$\vec{\mathbf{h}}(\vec{\mathbf{r}},t)$ → **FT** → $\vec{\mathbf{H}}(\vec{\mathbf{r}},\omega)$

Maxwell equations
Time domain & Frequency domain

Time domain

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

$t \rightarrow \omega$

Frequency domain

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

$t \rightarrow \omega$

$\vec{\mathbf{f}}(x,y,z,t) \longrightarrow$ FT $\longrightarrow \vec{\mathbf{F}}(x,y,z,\omega)$

$\dfrac{\partial \vec{\mathbf{f}}}{\partial t} \longrightarrow$ FT $\longrightarrow j\omega \vec{\mathbf{F}}(x,y,z,\omega)$

$\nabla \cdot \vec{\mathbf{f}} \longrightarrow$ FT $\longrightarrow \nabla \cdot \vec{\mathbf{F}}(x,y,z,\omega)$

$\nabla \times \vec{\mathbf{f}} \longrightarrow$ FT $\longrightarrow \nabla \times \vec{\mathbf{F}}(x,y,z,\omega)$

$\vec{\mathbf{h}}(\vec{\mathbf{r}},t) \longrightarrow$ FT $\longrightarrow \vec{\mathbf{H}}(\vec{\mathbf{r}},\omega)$

$\nabla \times \vec{\mathbf{h}}(\vec{\mathbf{r}},t) \longrightarrow$ FT $\longrightarrow \nabla \times \vec{\mathbf{H}}(\vec{\mathbf{r}},\omega)$

Maxwell equations
Time domain & Frequency domain

Time domain

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

$t \rightarrow \omega$

Frequency domain

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

$t \rightarrow \omega$

$\vec{\mathbf{f}}(x,y,z,t) \longrightarrow$ FT $\longrightarrow \vec{\mathbf{F}}(x,y,z,\omega)$

$\dfrac{\partial \vec{\mathbf{f}}}{\partial t} \longrightarrow$ FT $\longrightarrow j\omega \vec{\mathbf{F}}(x,y,z,\omega)$

$\nabla \cdot \vec{\mathbf{f}} \longrightarrow$ FT $\longrightarrow \nabla \cdot \vec{\mathbf{F}}(x,y,z,\omega)$

$\nabla \times \vec{\mathbf{f}} \longrightarrow$ FT $\longrightarrow \nabla \times \vec{\mathbf{F}}(x,y,z,\omega)$

$\vec{\mathbf{h}}(\vec{\mathbf{r}},t) \longrightarrow$ FT $\longrightarrow \vec{\mathbf{H}}(\vec{\mathbf{r}},\omega)$

$\nabla \times \vec{\mathbf{h}}(\vec{\mathbf{r}},t) \longrightarrow$ FT $\longrightarrow \nabla \times \vec{\mathbf{H}}(\vec{\mathbf{r}},\omega)$

Maxwell equations
Time domain & Frequency domain

Time domain

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

$t \rightarrow \omega$

Frequency domain

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

$\vec{\mathbf{f}}(x,y,z,t) \longrightarrow$ FT $\longrightarrow \vec{\mathbf{F}}(x,y,z,\omega)$ $t \rightarrow \omega$

$\dfrac{\partial \vec{\mathbf{f}}}{\partial t} \longrightarrow$ FT $\longrightarrow j\omega \vec{\mathbf{F}}(x,y,z,\omega)$

$\nabla \cdot \vec{\mathbf{f}} \longrightarrow$ FT $\longrightarrow \nabla \cdot \vec{\mathbf{F}}(x,y,z,\omega)$

$\nabla \times \vec{\mathbf{f}} \longrightarrow$ FT $\longrightarrow \nabla \times \vec{\mathbf{F}}(x,y,z,\omega)$

$\vec{\mathbf{d}}(\vec{\mathbf{r}},t) \longrightarrow$ FT $\longrightarrow \vec{\mathbf{D}}(\vec{\mathbf{r}},\omega)$

Maxwell equations
Time domain & Frequency domain

Time domain

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

$t \rightarrow \omega$

Frequency domain

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

$t \rightarrow \omega$

$\vec{\mathbf{f}}(x,y,z,t) \longrightarrow$ **FT** $\longrightarrow \vec{\mathbf{F}}(x,y,z,\omega)$

$\dfrac{\partial\vec{\mathbf{f}}}{\partial t} \longrightarrow$ **FT** $\longrightarrow j\omega\vec{\mathbf{F}}(x,y,z,\omega)$

$\nabla\cdot\vec{\mathbf{f}} \longrightarrow$ **FT** $\longrightarrow \nabla\cdot\vec{\mathbf{F}}(x,y,z,\omega)$

$\nabla\times\vec{\mathbf{f}} \longrightarrow$ **FT** $\longrightarrow \nabla\times\vec{\mathbf{F}}(x,y,z,\omega)$

$\vec{\mathbf{d}}(\vec{\mathbf{r}},t) \longrightarrow$ **FT** $\longrightarrow \vec{\mathbf{D}}(\vec{\mathbf{r}},\omega)$

$\dfrac{\partial\vec{\mathbf{d}}(\vec{\mathbf{r}},t)}{\partial t} \longrightarrow$ **FT** $\longrightarrow j\omega\vec{\mathbf{D}}(\vec{\mathbf{r}},\omega)$

Maxwell equations
Time domain & Frequency domain

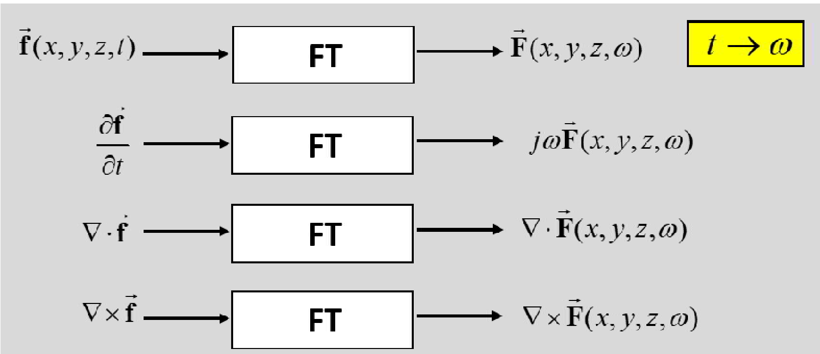
Time domain

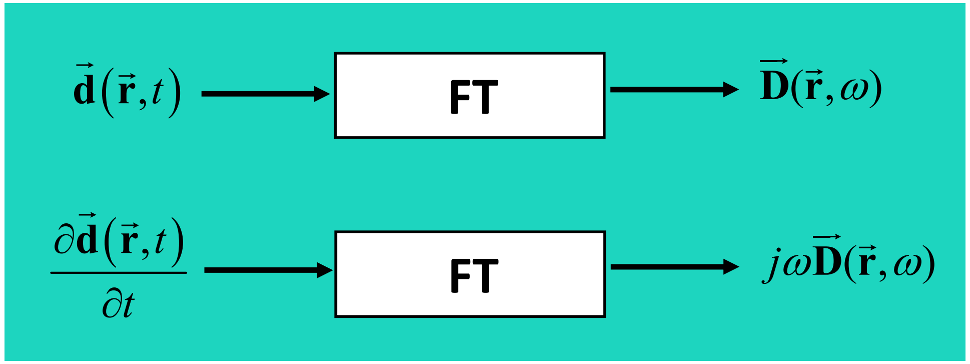
$$\begin{cases} \nabla \times \vec{\mathbf{e}}(\vec{\mathbf{r}},t) = -\dfrac{\partial \vec{\mathbf{b}}(\vec{\mathbf{r}},t)}{\partial t} \\ \nabla \times \vec{\mathbf{h}}(\vec{\mathbf{r}},t) = \dfrac{\partial \vec{\mathbf{d}}(\vec{\mathbf{r}},t)}{\partial t} + \vec{\mathbf{j}}(\vec{\mathbf{r}},t) \\ \nabla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

$t \rightarrow \omega$

Frequency domain

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





Maxwell equations
Time domain & Frequency domain

Time domain

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

$t \rightarrow \omega$

Frequency domain

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

$t \rightarrow \omega$

$\vec{\mathbf{f}}(x,y,z,t) \longrightarrow$ **FT** $\longrightarrow \vec{\mathbf{F}}(x,y,z,\omega)$

$\dfrac{\partial \vec{\mathbf{f}}}{\partial t} \longrightarrow$ **FT** $\longrightarrow j\omega \vec{\mathbf{F}}(x,y,z,\omega)$

$\nabla \cdot \vec{\mathbf{f}} \longrightarrow$ **FT** $\longrightarrow \nabla \cdot \vec{\mathbf{F}}(x,y,z,\omega)$

$\nabla \times \vec{\mathbf{f}} \longrightarrow$ **FT** $\longrightarrow \nabla \times \vec{\mathbf{F}}(x,y,z,\omega)$

$\vec{\mathbf{j}}(\vec{\mathbf{r}},t) \longrightarrow$ **FT** $\longrightarrow \vec{\mathbf{J}}(\vec{\mathbf{r}},\omega)$

Maxwell equations
Time domain & Frequency domain

Time domain

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

$t \to \omega$

Frequency domain

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

$t \to \omega$

$\vec{\mathbf{f}}(x,y,z,t) \longrightarrow$ **FT** $\longrightarrow \vec{\mathbf{F}}(x,y,z,\omega)$

$\dfrac{\partial \vec{\mathbf{f}}}{\partial t} \longrightarrow$ **FT** $\longrightarrow j\omega \vec{\mathbf{F}}(x,y,z,\omega)$

$\nabla \cdot \vec{\mathbf{f}} \longrightarrow$ **FT** $\longrightarrow \nabla \cdot \vec{\mathbf{F}}(x,y,z,\omega)$

$\nabla \times \vec{\mathbf{f}} \longrightarrow$ **FT** $\longrightarrow \nabla \times \vec{\mathbf{F}}(x,y,z,\omega)$

$\vec{\mathbf{j}}(\vec{\mathbf{r}},t) \longrightarrow$ **FT** $\longrightarrow \vec{\mathbf{J}}(\vec{\mathbf{r}},\omega)$

Maxwell equations
Time domain & Frequency domain

Time domain

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

$t \rightarrow \omega$

Frequency domain

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

$t \rightarrow \omega$

$\vec{\mathbf{f}}(x,y,z,t)$ → FT → $\vec{\mathbf{F}}(x,y,z,\omega)$

$\dfrac{\partial\vec{\mathbf{f}}}{\partial t}$ → FT → $j\omega\vec{\mathbf{F}}(x,y,z,\omega)$

$\nabla\cdot\vec{\mathbf{f}}$ → FT → $\nabla\cdot\vec{\mathbf{F}}(x,y,z,\omega)$

$\nabla\times\vec{\mathbf{f}}$ → FT → $\nabla\times\vec{\mathbf{F}}(x,y,z,\omega)$

$\vec{\mathbf{d}}(\vec{\mathbf{r}},t)$ → FT → $\vec{\mathbf{D}}(\vec{\mathbf{r}},\omega)$

Maxwell equations
Time domain & Frequency domain

Time domain

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

$t \rightarrow \omega$

Frequency domain

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

$t \rightarrow \omega$

$\vec{\mathbf{f}}(x,y,z,t) \rightarrow$ **FT** $\rightarrow \vec{\mathbf{F}}(x,y,z,\omega)$

$\dfrac{\partial \vec{\mathbf{f}}}{\partial t} \rightarrow$ **FT** $\rightarrow j\omega \vec{\mathbf{F}}(x,y,z,\omega)$

$\nabla \cdot \vec{\mathbf{f}} \rightarrow$ **FT** $\rightarrow \nabla \cdot \vec{\mathbf{F}}(x,y,z,\omega)$

$\nabla \times \vec{\mathbf{f}} \rightarrow$ **FT** $\rightarrow \nabla \times \vec{\mathbf{F}}(x,y,z,\omega)$

$\vec{\mathbf{d}}(\vec{\mathbf{r}},t) \rightarrow$ **FT** $\rightarrow \vec{\mathbf{D}}(\vec{\mathbf{r}},\omega)$

$\nabla \cdot \vec{\mathbf{d}}(\vec{\mathbf{r}},t) \rightarrow$ **FT** $\rightarrow \nabla \cdot \vec{\mathbf{D}}(\vec{\mathbf{r}},\omega)$

Maxwell equations
Time domain & Frequency domain

Time domain

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

$t \rightarrow \omega$

Frequency domain

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

$t \rightarrow \omega$

$\vec{\mathbf{f}}(x,y,z,t)$ → FT → $\vec{\mathbf{F}}(x,y,z,\omega)$

$\dfrac{\partial \vec{\mathbf{f}}}{\partial t}$ → FT → $j\omega \vec{\mathbf{F}}(x,y,z,\omega)$

$\nabla \cdot \vec{\mathbf{f}}$ → FT → $\nabla \cdot \vec{\mathbf{F}}(x,y,z,\omega)$

$\nabla \times \vec{\mathbf{f}}$ → FT → $\nabla \times \vec{\mathbf{F}}(x,y,z,\omega)$

$\vec{\mathbf{d}}(\vec{\mathbf{r}},t)$ → FT → $\vec{\mathbf{D}}(\vec{\mathbf{r}},\omega)$

$\nabla \cdot \vec{\mathbf{d}}(\vec{\mathbf{r}},t)$ → FT → $\nabla \cdot \vec{\mathbf{D}}(\vec{\mathbf{r}},\omega)$

Maxwell equations
Time domain & Frequency domain

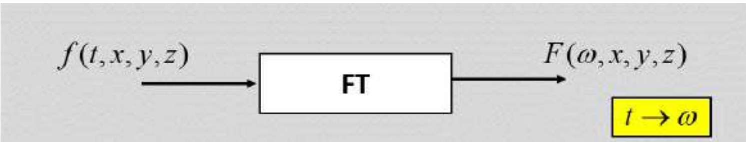
Time domain

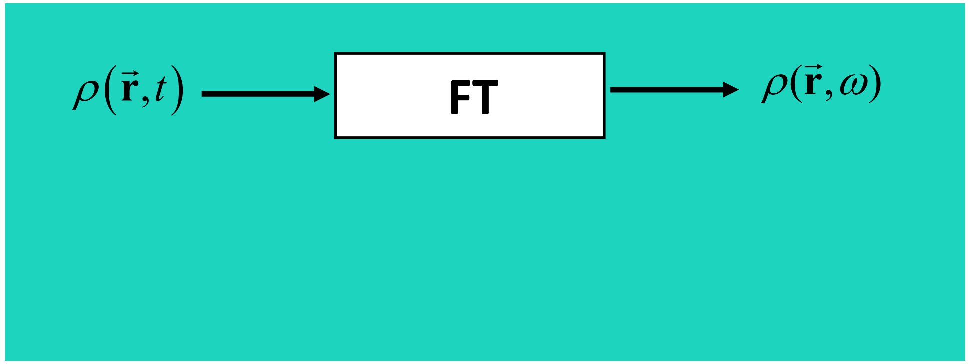
$$
\begin{cases}
\nabla\times\vec{\mathbf{e}}(\vec{\mathbf{r}},t) = -\dfrac{\partial\vec{\mathbf{b}}(\vec{\mathbf{r}},t)}{\partial t} \\
\nabla\times\vec{\mathbf{h}}(\vec{\mathbf{r}},t) = \dfrac{\partial\vec{\mathbf{d}}(\vec{\mathbf{r}},t)}{\partial t} + \vec{\mathbf{j}}(\vec{\mathbf{r}},t) \\
\nabla\cdot\vec{\mathbf{d}}(\vec{\mathbf{r}},t)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

$t \rightarrow \omega$

Frequency domain

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





Maxwell equations
Time domain & Frequency domain

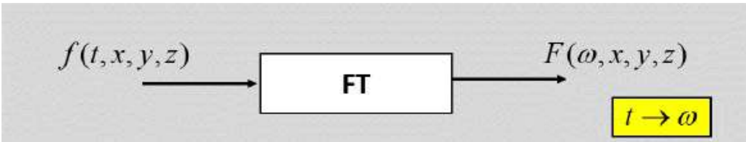
Time domain

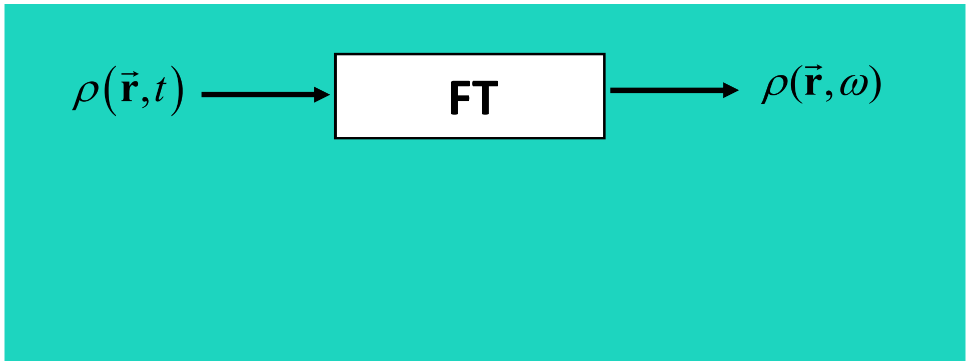
$$\begin{cases} \nabla \times \vec{\mathbf{e}}(\vec{\mathbf{r}},t) = -\dfrac{\partial \vec{\mathbf{b}}(\vec{\mathbf{r}},t)}{\partial t} \\ \nabla \times \vec{\mathbf{h}}(\vec{\mathbf{r}},t) = \dfrac{\partial \vec{\mathbf{d}}(\vec{\mathbf{r}},t)}{\partial t} + \vec{\mathbf{j}}(\vec{\mathbf{r}},t) \\ \nabla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

$t \to \omega$

Frequency domain

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





Maxwell equations
Time domain & Frequency domain

Time domain

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

$t \rightarrow \omega$

Frequency domain

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

$t \rightarrow \omega$

$\vec{\mathbf{f}}(x,y,z,t)$ → FT → $\vec{\mathbf{F}}(x,y,z,\omega)$

$\dfrac{\partial \vec{\mathbf{f}}}{\partial t}$ → FT → $j\omega \vec{\mathbf{F}}(x,y,z,\omega)$

$\nabla \cdot \vec{\mathbf{f}}$ → FT → $\nabla \cdot \vec{\mathbf{F}}(x,y,z,\omega)$

$\nabla \times \vec{\mathbf{f}}$ → FT → $\nabla \times \vec{\mathbf{F}}(x,y,z,\omega)$

$\vec{\mathbf{b}}(\vec{\mathbf{r}},t)$ → FT → $\vec{\mathbf{B}}(\vec{\mathbf{r}},\omega)$

Maxwell equations
Time domain & Frequency domain

Time domain

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

$t \rightarrow \omega$

Frequency domain

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

$t \rightarrow \omega$

$\vec{\mathbf{f}}(x,y,z,t) \longrightarrow$ **FT** $\longrightarrow \vec{\mathbf{F}}(x,y,z,\omega)$

$\dfrac{\partial \vec{\mathbf{f}}}{\partial t} \longrightarrow$ **FT** $\longrightarrow j\omega \vec{\mathbf{F}}(x,y,z,\omega)$

$\nabla \cdot \vec{\mathbf{f}} \longrightarrow$ **FT** $\longrightarrow \nabla \cdot \vec{\mathbf{F}}(x,y,z,\omega)$

$\nabla \times \vec{\mathbf{f}} \longrightarrow$ **FT** $\longrightarrow \nabla \times \vec{\mathbf{F}}(x,y,z,\omega)$

$\vec{\mathbf{b}}(\vec{\mathbf{r}},t) \longrightarrow$ **FT** $\longrightarrow \vec{\mathbf{B}}(\vec{\mathbf{r}},\omega)$

$\nabla \cdot \vec{\mathbf{b}}(\vec{\mathbf{r}},t) \longrightarrow$ **FT** $\longrightarrow \nabla \cdot \vec{\mathbf{B}}(\vec{\mathbf{r}},\omega)$

Maxwell equations
Time domain & Frequency domain

Time domain

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

$t\rightarrow\omega$

Frequency domain

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

$\vec{\mathbf{f}}(x,y,z,t)$ → FT → $\vec{\mathbf{F}}(x,y,z,\omega)$ $t\rightarrow\omega$

$\dfrac{\partial\vec{\mathbf{f}}}{\partial t}$ → FT → $j\omega\vec{\mathbf{F}}(x,y,z,\omega)$

$\nabla\cdot\vec{\mathbf{f}}$ → FT → $\nabla\cdot\vec{\mathbf{F}}(x,y,z,\omega)$

$\nabla\times\vec{\mathbf{f}}$ → FT → $\nabla\times\vec{\mathbf{F}}(x,y,z,\omega)$

$\vec{\mathbf{b}}(\vec{\mathbf{r}},t)$ → FT → $\vec{\mathbf{B}}(\vec{\mathbf{r}},\omega)$

$\nabla\cdot\vec{\mathbf{b}}(\vec{\mathbf{r}},t)$ → FT → $\nabla\cdot\vec{\mathbf{B}}(\vec{\mathbf{r}},\omega)$

Maxwell equations
Time domain & Frequency domain

Time domain

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

$t \rightarrow \omega$

Frequency domain

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

Maxwell equations
Time domain & Frequency domain

Time domain

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

$t \rightarrow \omega$

Frequency domain

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

Maxwell equations
Time domain & Frequency domain

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

$\vec{\mathbf{e}}(\vec{\mathbf{r}},t)$	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 & Frequency domain

Time domain

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

$t \rightarrow \omega$

Frequency domain

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

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

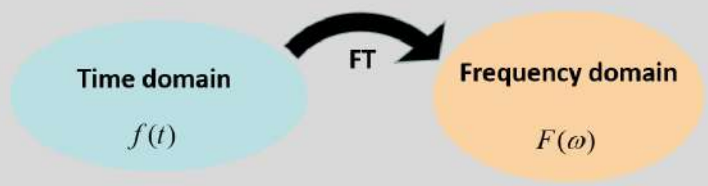
Maxwell equations
Time domain & Frequency domain

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

$\vec{\mathbf{e}}(\vec{\mathbf{r}},t)$	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

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

..memo



$$F(\omega) = \int_{-\infty}^{+\infty} f(t) e^{-j\omega t} dt$$

Fourier Transform (FT)

Maxwell equations
Time domain & Frequency domain

Time domain

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

$t \rightarrow \omega$

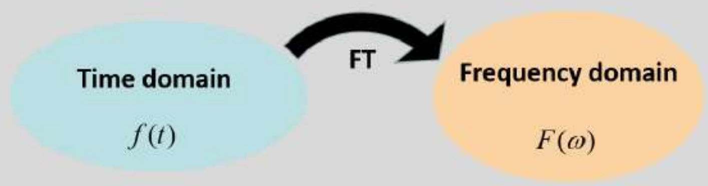
Frequency domain

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

$\vec{\mathbf{e}}(\vec{\mathbf{r}},t)$	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

$\vec{\mathbf{E}}(\vec{\mathbf{r}},\omega)$ (Volt x s) /m

..memo



$F(\omega)=\int_{-\infty}^{+\infty} f(t)e^{-j\omega t}dt$ Fourier Transform (FT)

Maxwell equations
Time domain & Frequency domain

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

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

Maxwell equations
Time domain & Frequency domain

Time domain

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

$t \rightarrow \omega$

Frequency domain

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

Maxwell equations
Time domain & Frequency domain

Time domain

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

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

$$t \rightarrow \omega$$

Frequency domain

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

Maxwell equations
Time domain & Frequency domain

Time domain

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

$$t \rightarrow \omega$$

Frequency domain

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

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

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

Maxwell equations
Time domain & Phasors

Phasors

Time domain

$f(t)$

Phasors

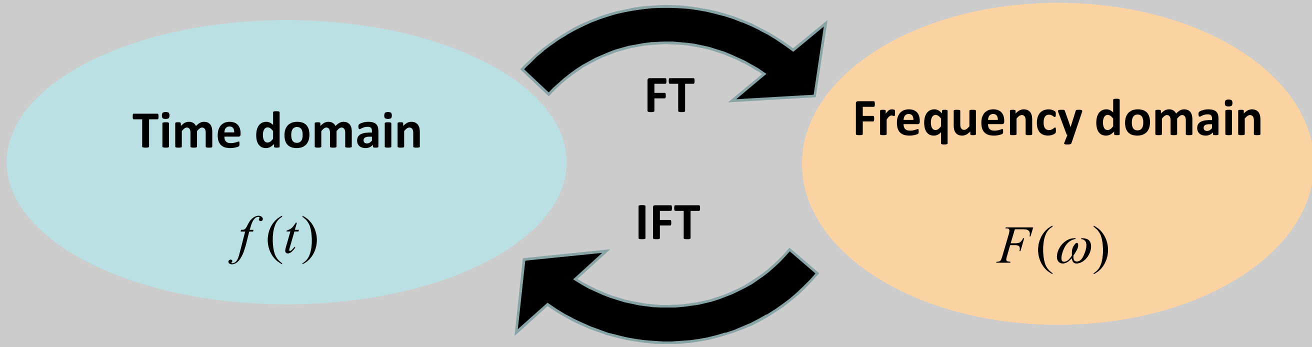
Time domain

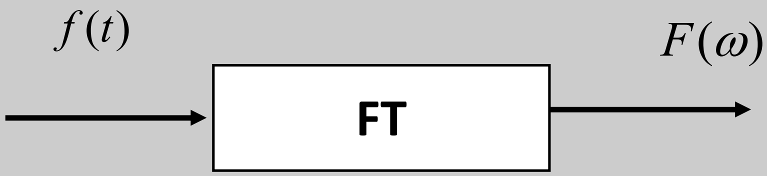
$f(t)$

Signals usually adopted in ICT applications

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

..... Memo ....





$$F(\omega) = \int_{-\infty}^{+\infty} f(t)\, e^{-j\omega t}\, dt$$

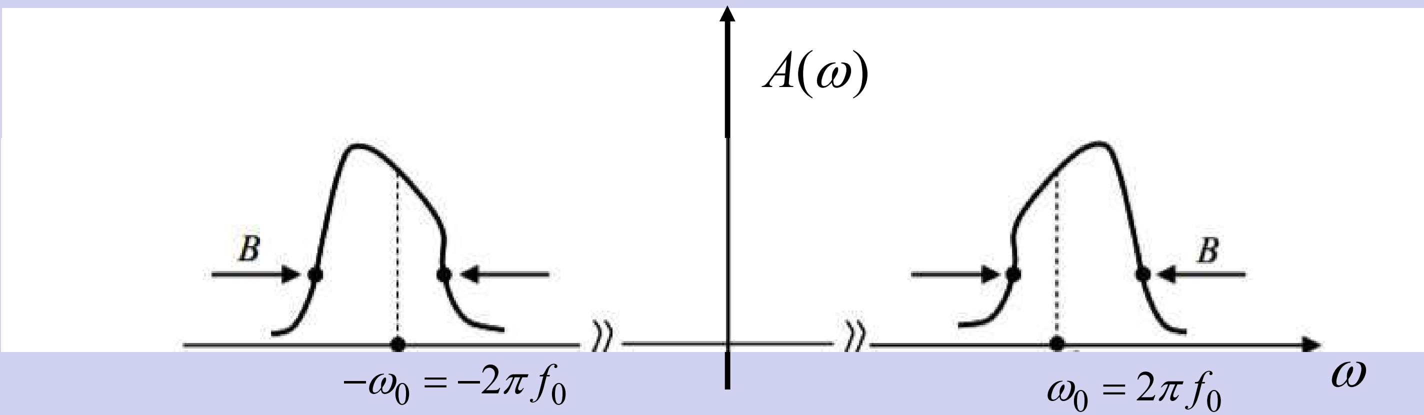
$$f(t) = \frac{1}{2\pi} \int_{-\infty}^{+\infty} F(\omega) e^{j\omega t}\, d\omega =$$

$$= \frac{1}{2\pi} \left[\int_{-\infty}^{+\infty} F(\omega) \cos(\omega t)\, d\omega + j \int_{-\infty}^{+\infty} F(\omega) \sin(\omega t)\, d\omega \right]$$

Bandwidth

$f(t)$ → **FT** → $F(\omega)=\int_{-\infty}^{+\infty} f(t)\,e^{-j\omega t}\,dt = A(\omega)\,e^{j\alpha(\omega)}$

$$f(t)=\frac{1}{2\pi}\left[\int_{-\infty}^{+\infty} A(\omega)\cos\left[\omega t+\alpha(\omega)\right]d\omega + j\int_{-\infty}^{+\infty} A(\omega)\sin\left[\omega t+\alpha(\omega)\right]d\omega\right]$$



Phasors

Time domain

$f(t)$

Signals usually adopted in ICT applications

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

Phasors

Time domain

$f(t)$

Signals usually analyzed in ICT applications

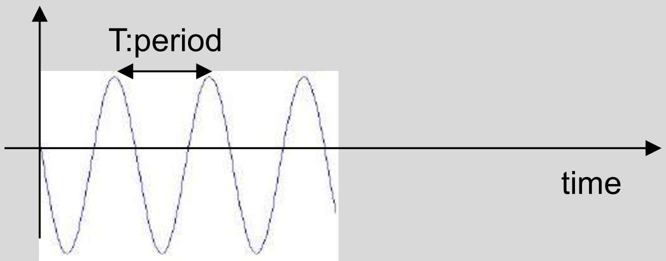
$$f(t) = A\cos\left(2\pi f_0 t + \alpha\right)$$

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

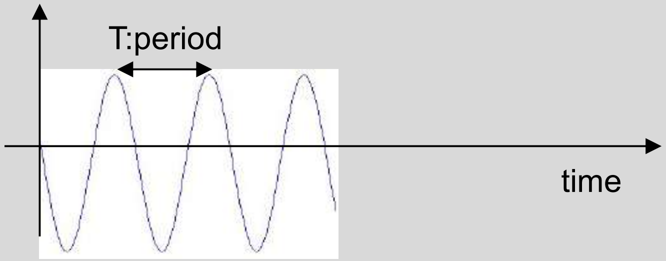
Time domain

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

Phasor domain

?

Signals usually adopted in ICT applications



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

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

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

Phasors

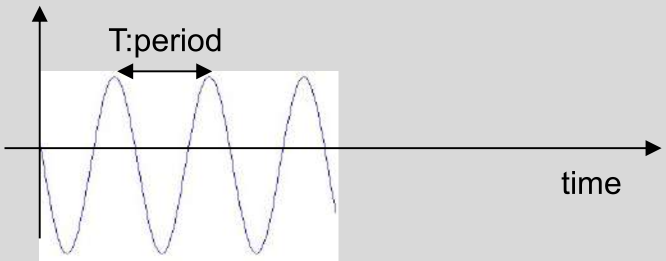
Time domain

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

Phasor domain

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

Signals usually adopted in ICT applications



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

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

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

Phasors

Time domain

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

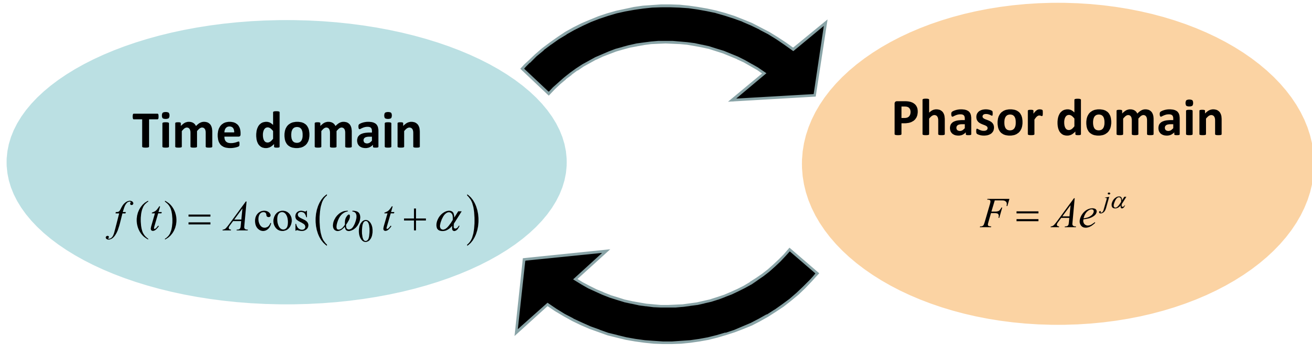
Phasor domain

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

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

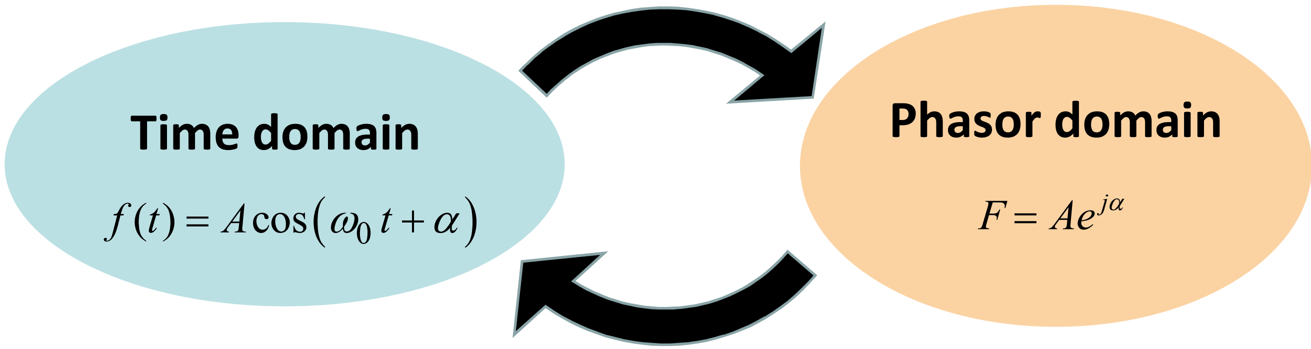
2) Time domain derivative and Phasors

Phasors



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

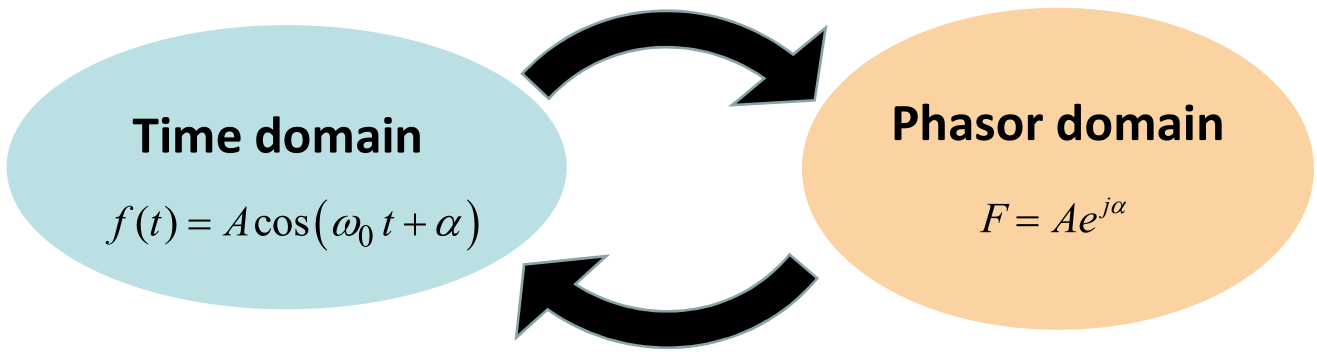
Phasors



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

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

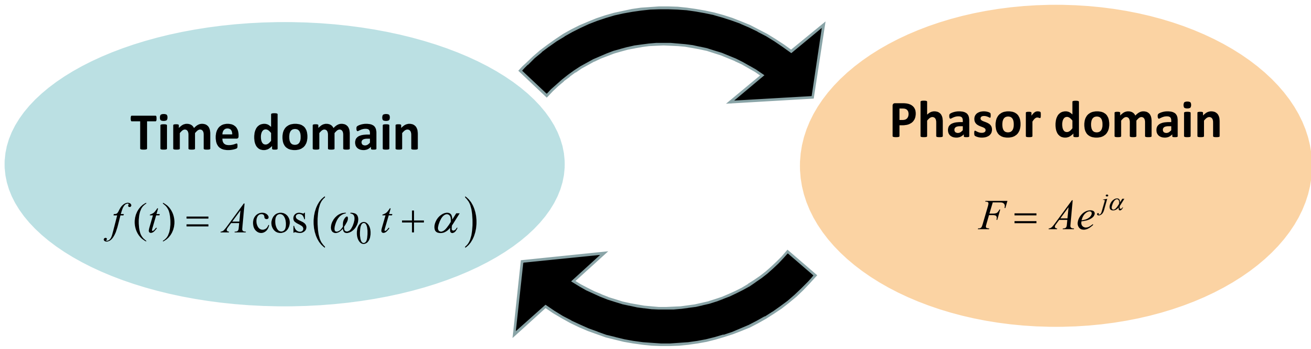
Phasors



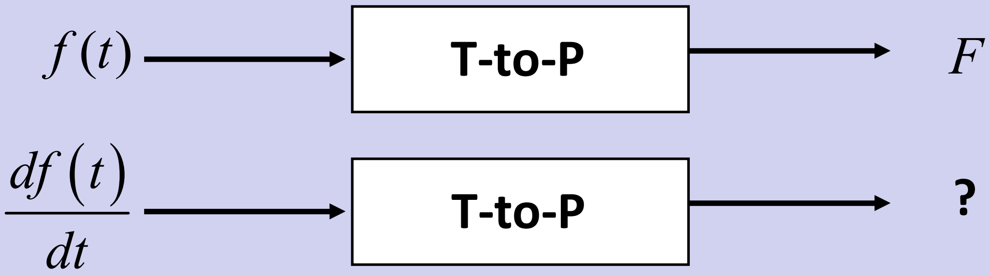
$$f(t) = A\cos(\omega_0 t + \alpha) \longrightarrow \boxed{\textbf{T-to-P}} \longrightarrow F = Ae^{j\alpha}$$

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

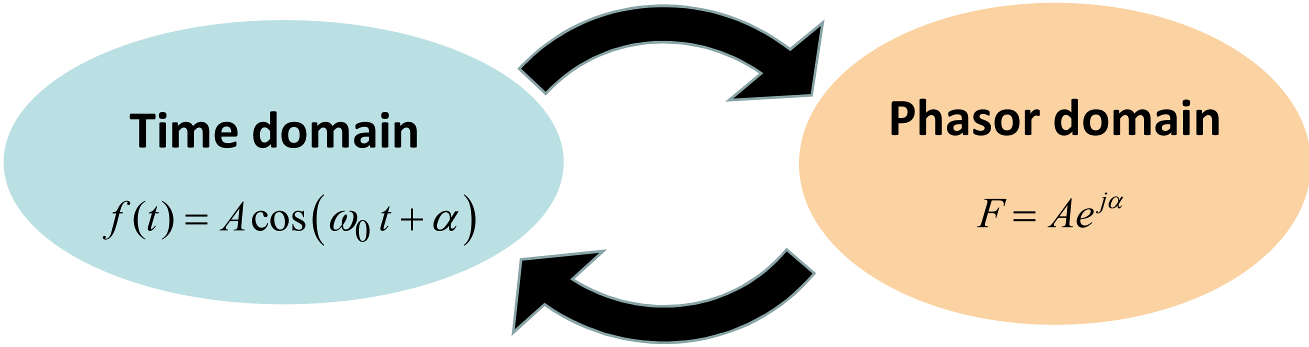
Phasors



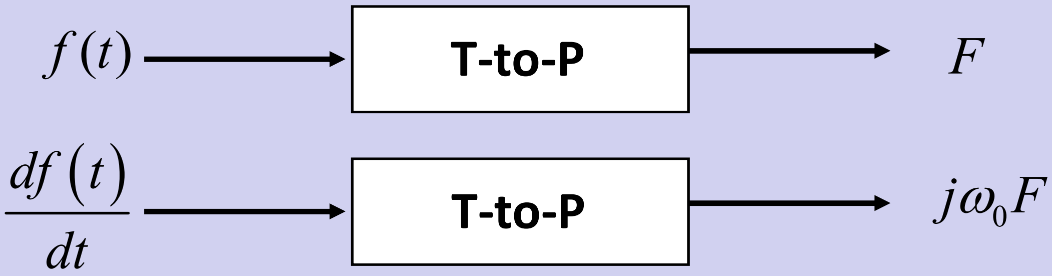
2) Time domain derivative and Phasors



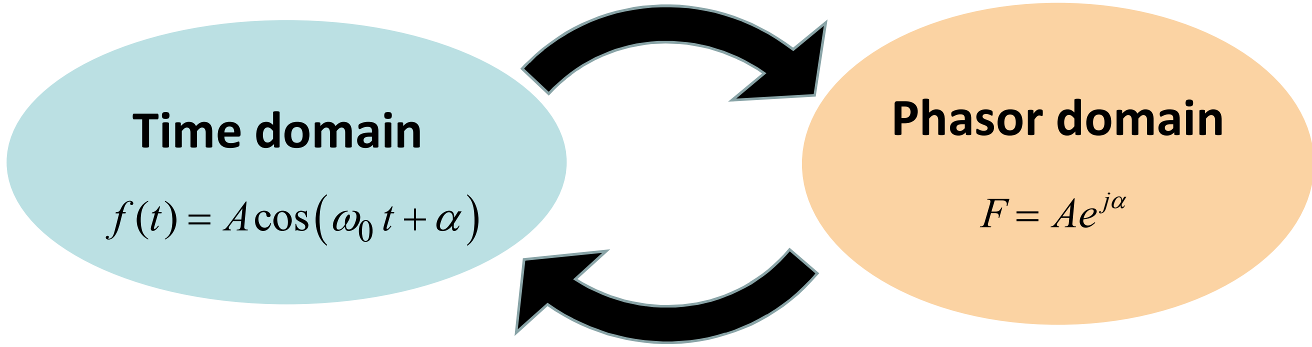
Phasors



2) Time domain derivative and Phasors



Phasors



… memo …

$f(t)$ → **FT** → $F(\omega)$

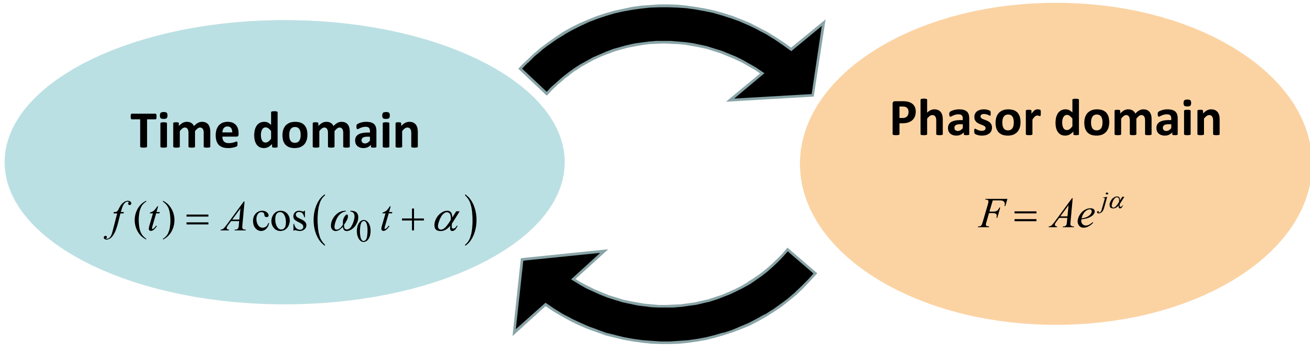
$\frac{df}{dt}$ → **FT** → $j\omega F(\omega)$

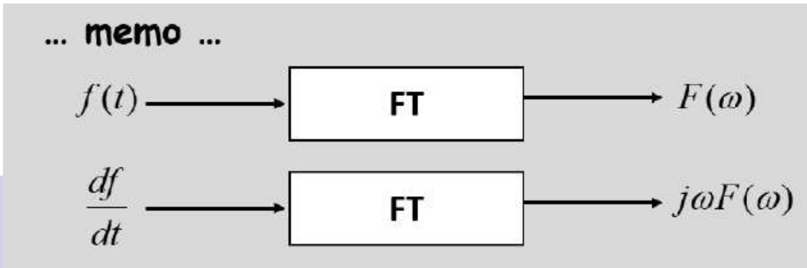
2) Time domain derivative and Phasors

$f(t)$ → **T-to-P** → F

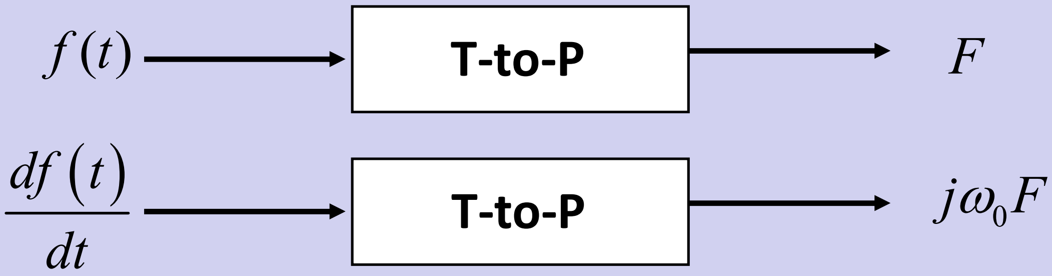
$\frac{df(t)}{dt}$ → **T-to-P** → $j\omega_0 F$

Phasors





2) Time domain derivative and Phasors



ω_0 now is fixed!

Phasors

Time domain

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

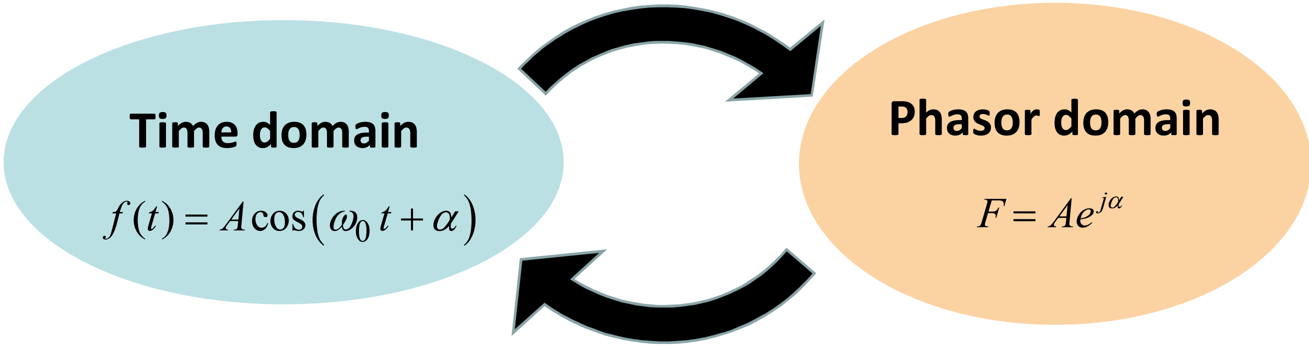
Phasor domain

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

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

2) Time domain derivative and Phasors

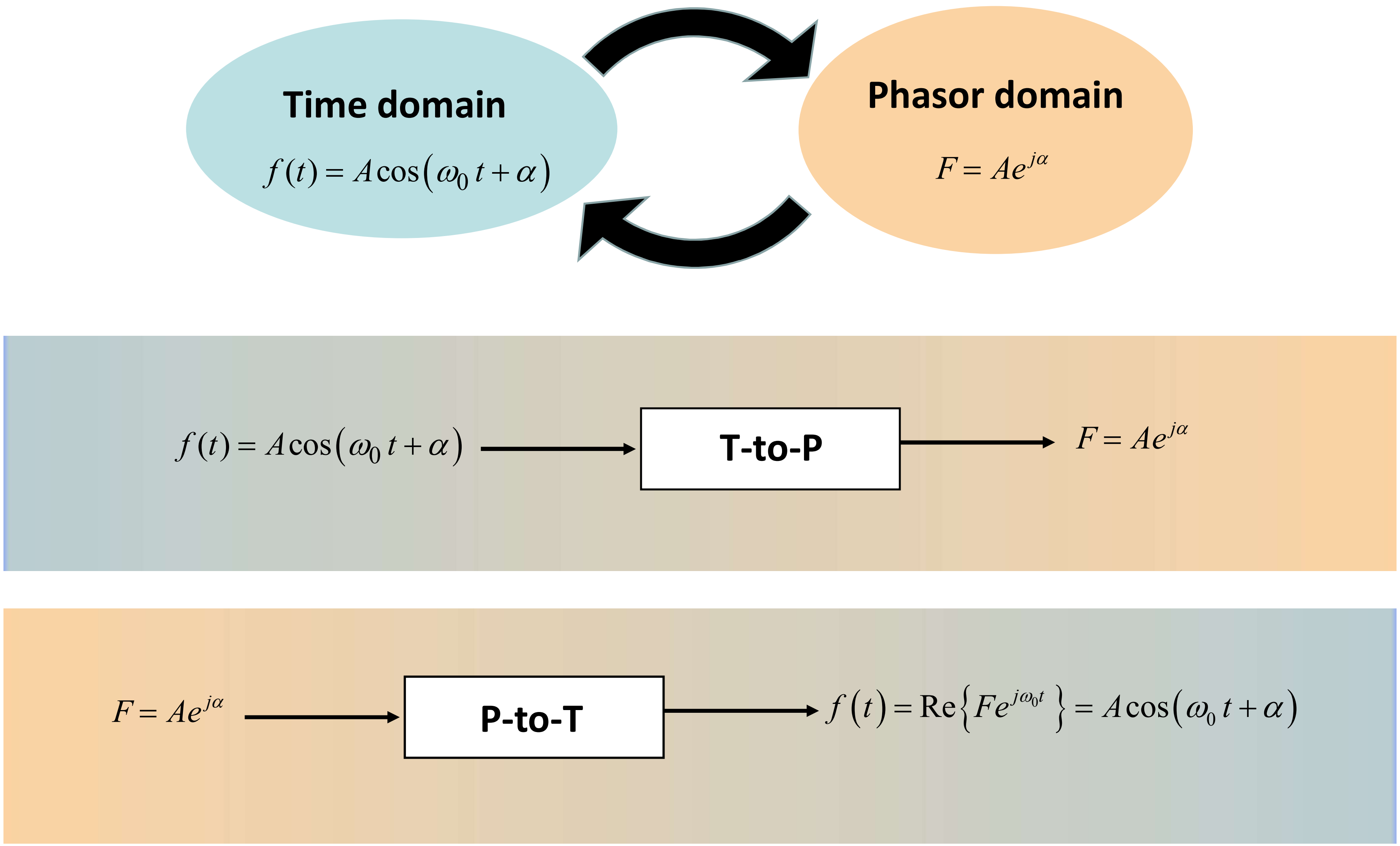
Phasors



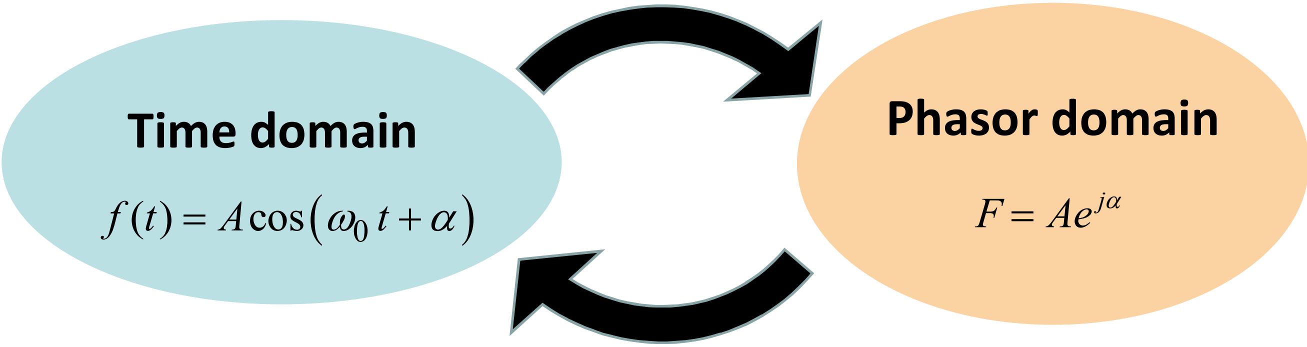
1) How to jump back from the Phasor domain to the Time domain

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

Phasors


Time domain
$f(t) = A\cos(\omega_0 t + \alpha)$
Phasor domain
$F = Ae^{j\alpha}$
$f(t) = A\cos(\omega_0 t + \alpha)$
T-to-P
$F = Ae^{j\alpha}$
$F = Ae^{j\alpha}$
P-to-T
$f(t) = \mathrm{Re}\{Fe^{j\omega_0 t}\} = A\cos(\omega_0 t + \alpha)$

Phasors



… memo …

$f(t)$ → FT → $F(\omega)$

$\frac{df}{dt}$ → FT → $j\omega F(\omega)$

2) Time domain derivative and Phasors

$f(t)$ → **T-to-P** → F

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

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

- Phasors and functions of *n* variables

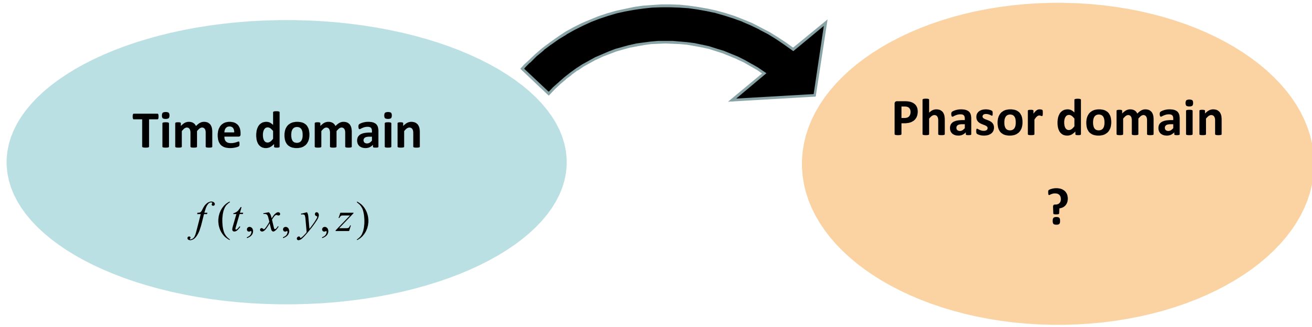
- Phasors and vector functions

- 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 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

Time domain

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

Phasor domain

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

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

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

Phasors and functions of *n* variables

Time domain

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

Phasor domain

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

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

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

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

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

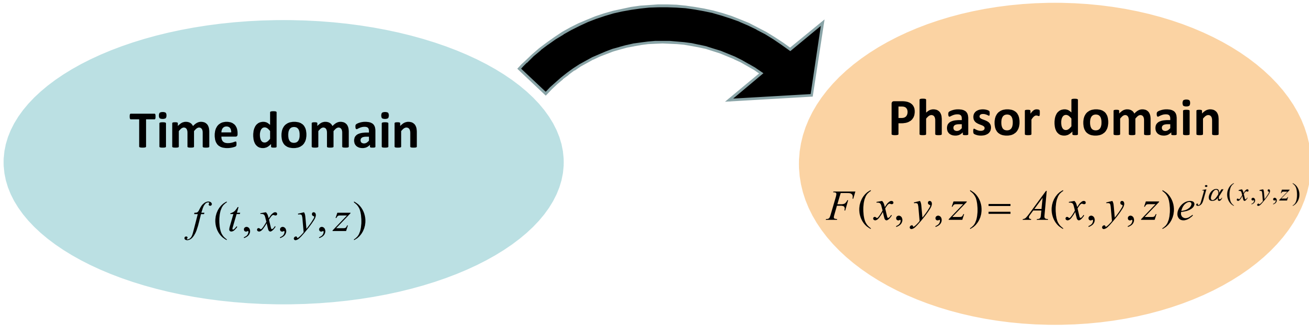
$$f(t,x,y,z) = A(x,y,z)\cos\left(\omega_0 t + \alpha(x,y,z)\right)$$

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

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

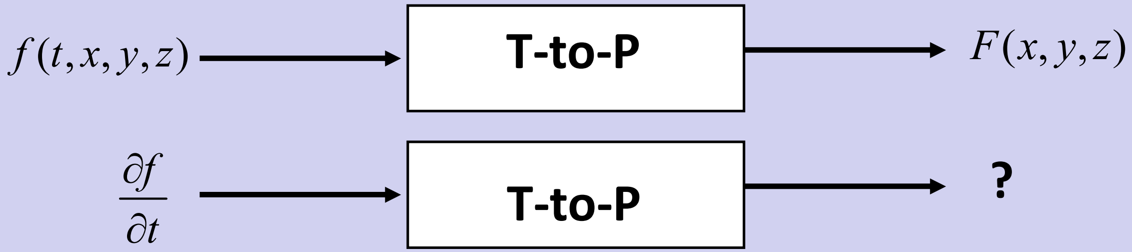
$$f(t,x,y,z) = \mathrm{Re}\left\{F(x,y,z)e^{j\omega_0 t}\right\}$$

Phasors and functions of *n* variables

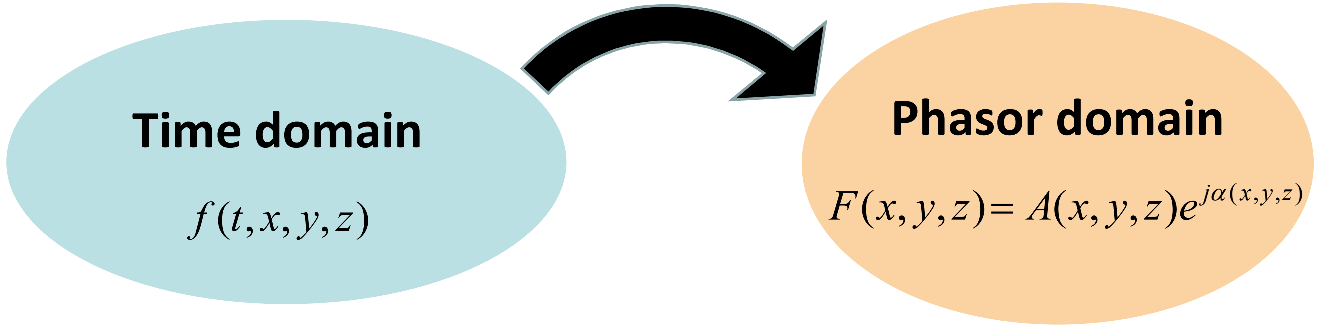


$$f(t,x,y,z) = A\left(x,y,z\right)\cos\left(\omega_0 t + \alpha\left(x,y,z\right)\right)$$

2) Time domain derivative and Phasors

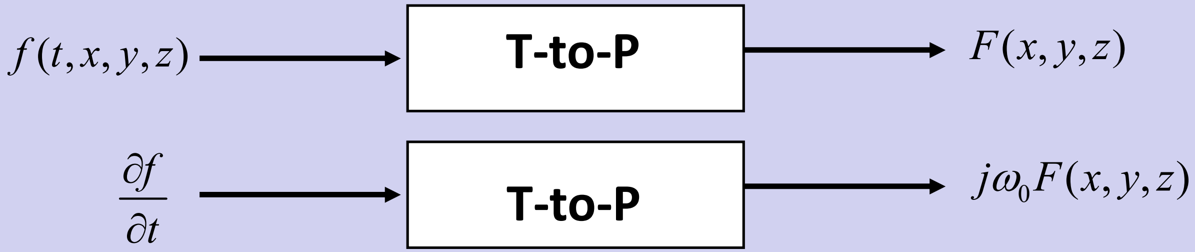


Phasors and functions of *n* variables



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

2) Time domain derivative and Phasors



Phasors and functions of *n* variables

Time domain

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

Phasor domain

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

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

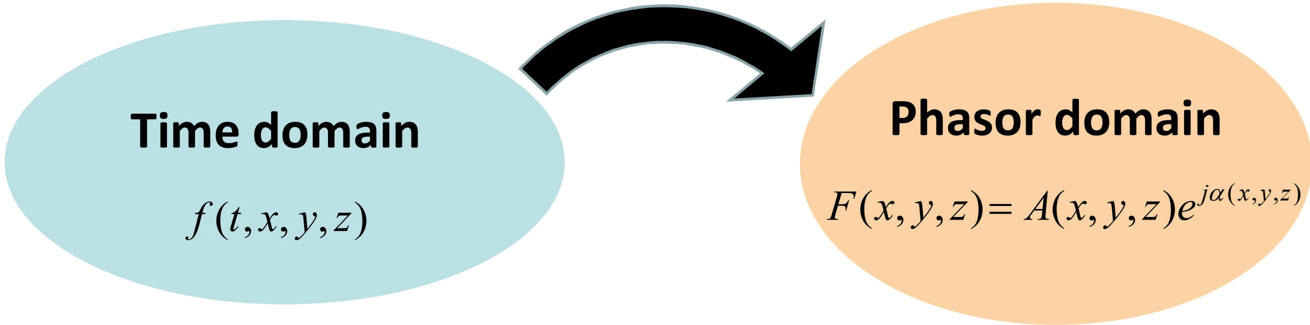
2) Time domain derivative and Phasors

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

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

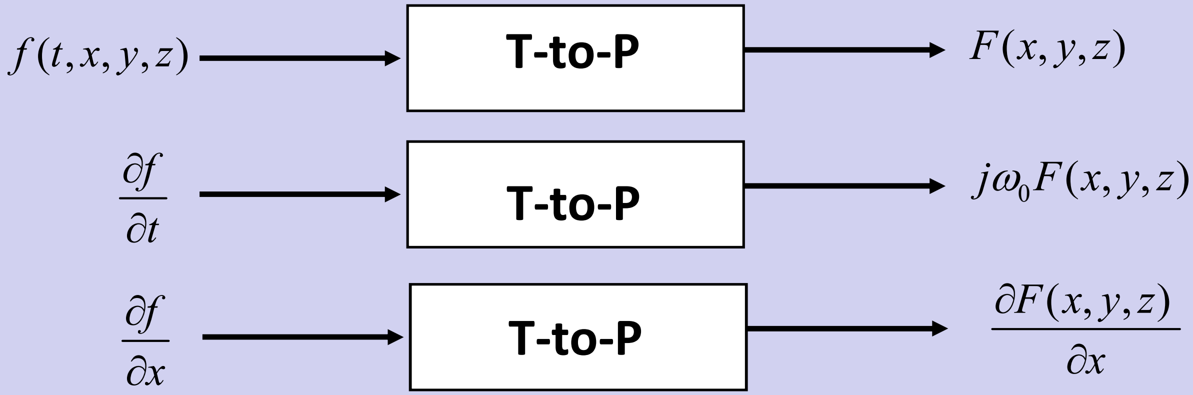
$\dfrac{\partial f}{\partial x}$ → **T-to-P** → **?**

Phasors and functions of *n* variables



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

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

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

?

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

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

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

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

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

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

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

$\vec{\mathbf{f}}(t)$ → **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

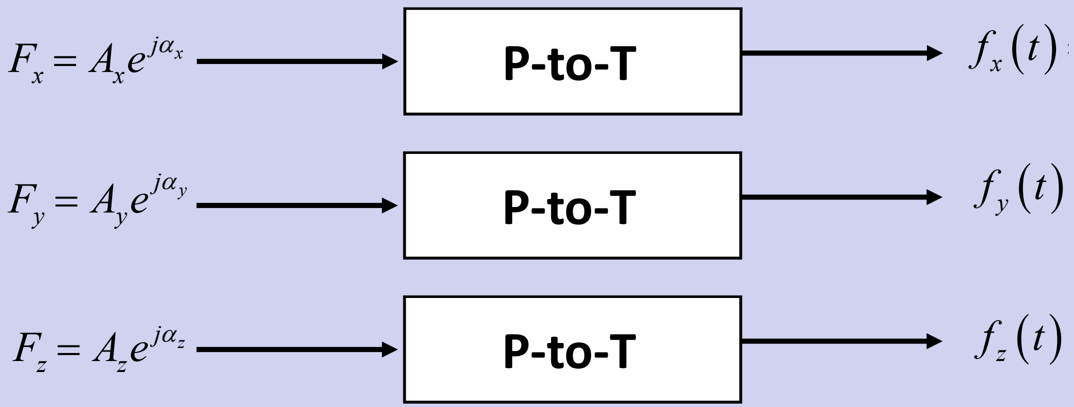
Time domain

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

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** → $f_x(t) = \mathrm{Re}\left\{F_x e^{j\omega_0 t}\right\} = A_x \cos(\omega_0 t + \alpha_x)$

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

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

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

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

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

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

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

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

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

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

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** → $\vec{\mathbf{F}}$

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

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

$\frac{df_x(t)}{dt}$ → **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** → $j\omega_0 F_x\hat{i}_x + j\omega_0 F_y\hat{i}_y + j\omega_0 F_z\hat{i}_z$

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

$\dfrac{df_x(t)}{dt}$ → **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

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

$$\frac{d\vec{\mathbf{f}}(t)}{dt} \longrightarrow \boxed{\text{T-to-P}} \longrightarrow j\omega_0\vec{\mathbf{F}} = j\omega_0 F_x\,\hat{i}_x + j\omega_0 F_y\hat{i}_y + j\omega_0 F_z\hat{i}_z$$

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

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

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

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

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** → $j\omega_0\vec{\mathbf{F}}$