Fields and Waves

Lesson 1.5

Wave Properties

Darryl Michael/GE CRD

Wave Equation

PURPOSE: Many Sources for Transmission Lines and Waves use Sinusoidal Sources to model effects

• can use FFT to decompose complex source into superposition of sinusoidal source

⇨ Need to look at Properties and Math of Waves

In general, sources (e.g. TL Voltage) can be represented as:

$$V = V_0 \cdot cos(\omega t - \beta z)$$

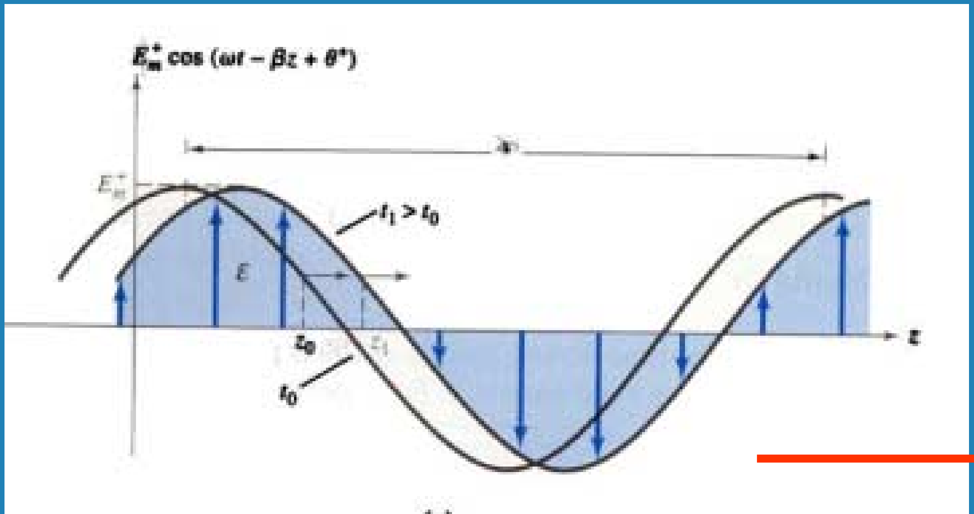
Wave traveling to the right

Wave Equation

This form of the equation: $V = V_0 \cdot cos(\omega t - \beta z)$

is an example of a simpler equation:

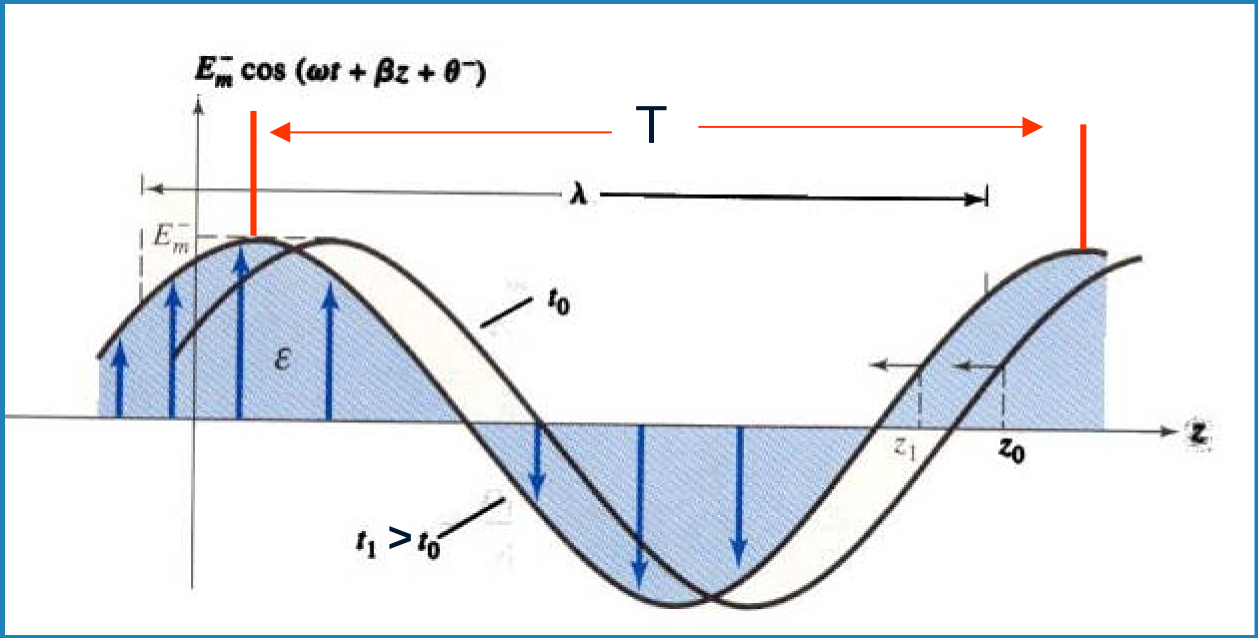
$V = V_0 \cdot cos(\omega s)$ where, $s = t \mp \frac{z}{u}$



(a)

Wave traveling to the right

Waves



T = period of the wave

Wave traveling to the left

Do Problem 1

Problem 1

Obtain the following relationships:

$$\omega = 2\pi f = \frac{2\pi}{T}$$

Also, β , can be viewed as the spatial equivalent of ω

$$\beta = \frac{2\pi}{\lambda}$$

Finally, $u = \dfrac{\omega}{\beta}$

PHASORS

Recall from circuits: $V = V_0 \cdot cos(\omega t + \theta) = Re\{V_0 \cdot e^{j\theta} \cdot e^{j\omega t}\}$

PHASOR: $\hat{V}$

Circuit equations then look like:

$\hat{V} = \hat{I} \cdot R$ or $\hat{V} = \hat{I} \cdot j\omega L$ $\Leftarrow e^{j\omega t}$ is implied

- remove time dependencies - focus on phase relationships

PHASORS: Fields and Waves

In Fields and Waves, we add :

- spatial dependence (x,y, z)
- include Vectors

For example:

$$V = V_0 \cos(\omega t - \beta z + \theta) = Re\left\{V_0 \cdot e^{j\theta} \cdot e^{-j\beta z} \cdot e^{j\omega t}\right\}$$

$$\hat{V}(z)$$ PHASOR

$$\vec{E} = E_m \cos(\omega t - \beta z + \theta) \cdot \hat{a}_x = Re\left\{E_m \cdot e^{j\theta} \cdot e^{-j\beta z} \cdot \hat{a}_x \cdot e^{j\omega t}\right\}$$

PHASOR $$\hat{\vec{E}}(z)$$

Do Problem 2