

EE 3113

INTRODUCTION INTO RF

CIRCUIT DESIGN

Lecture Notes for A-term 1999

LECTURE 4

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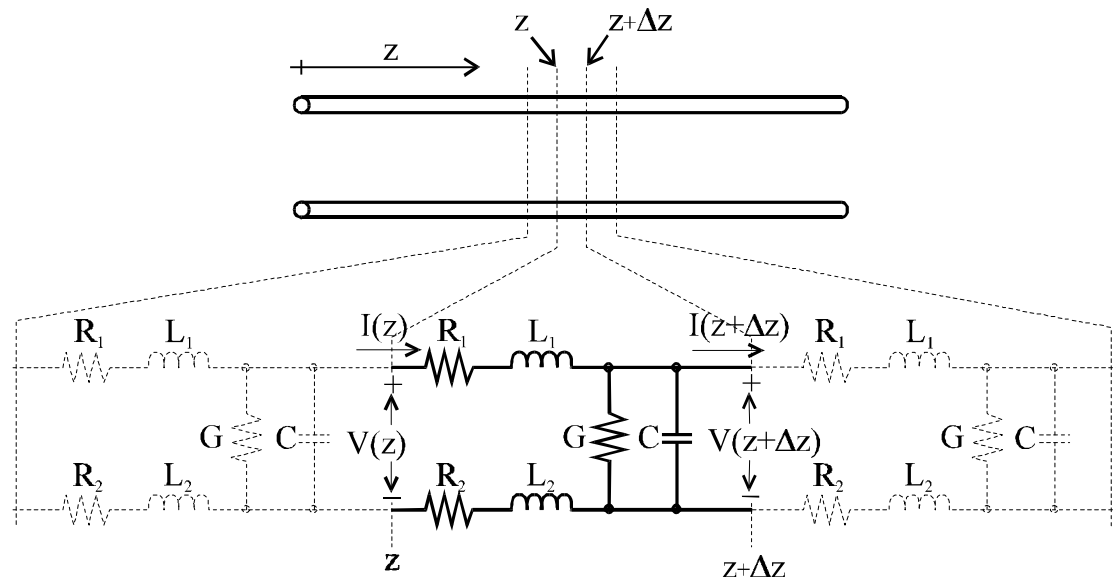
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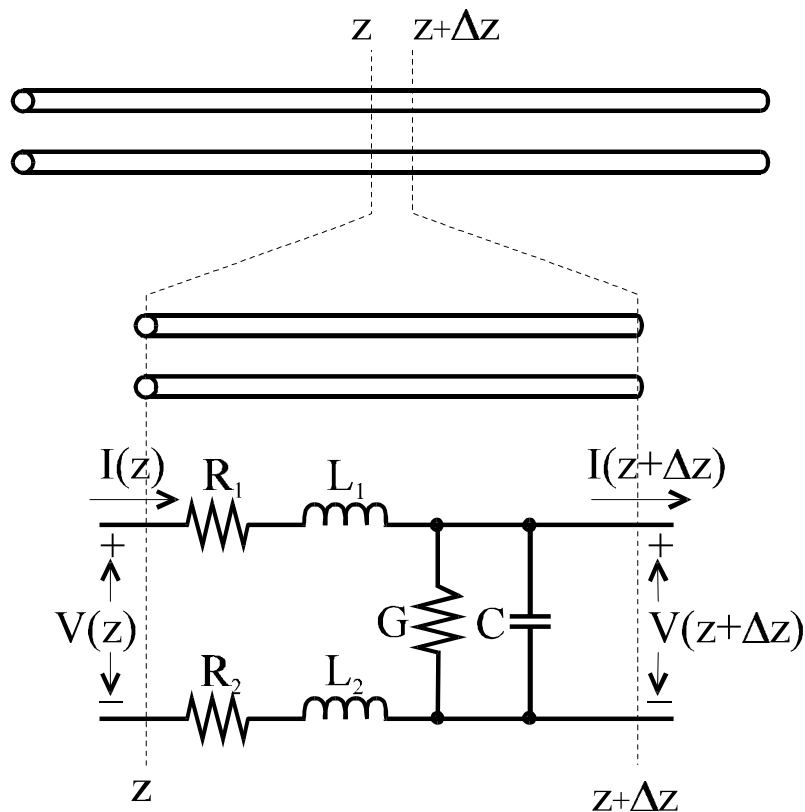
General Transmission Line Equations

- Detailed analysis of a differential section



Note: Analysis applies to all types of transmission lines such as coax cable, two-wire, microstrip, etc.

Kirchhoff's laws on a microscopic level



- Over a differential section we can again use basic circuit theory
- Model takes into account line losses and dielectric losses
- Ideal line involves only L and C

Advantages versus disadvantages of electric circuit representation

- Clear intuitive physical picture
- yields a standardized two-port network representation
- serves as building blocks to go from microscopic to macroscopic forms
- Basically a one-dimensional representation (cannot take into account interferences)
- Material nonlinearities, hysteresis, and temperature effects are not accounted for

Derivation of differential transmission line form

KVL:

$$V(z) = (R + j\omega L)I(z)\Delta z + V(z + \Delta z)$$

$$-\lim\left(\frac{V(z + \Delta z) - V(z)}{\Delta z}\right) = -\frac{dV(z)}{dz} = (R + j\omega L)I(z)$$

KCL:

$$I(z) = (G + j\omega C)\Delta z V(z + \Delta z) + I(z + \Delta z)$$

$$-\frac{dI(z)}{dz} = (G + j\omega C)V(z)$$

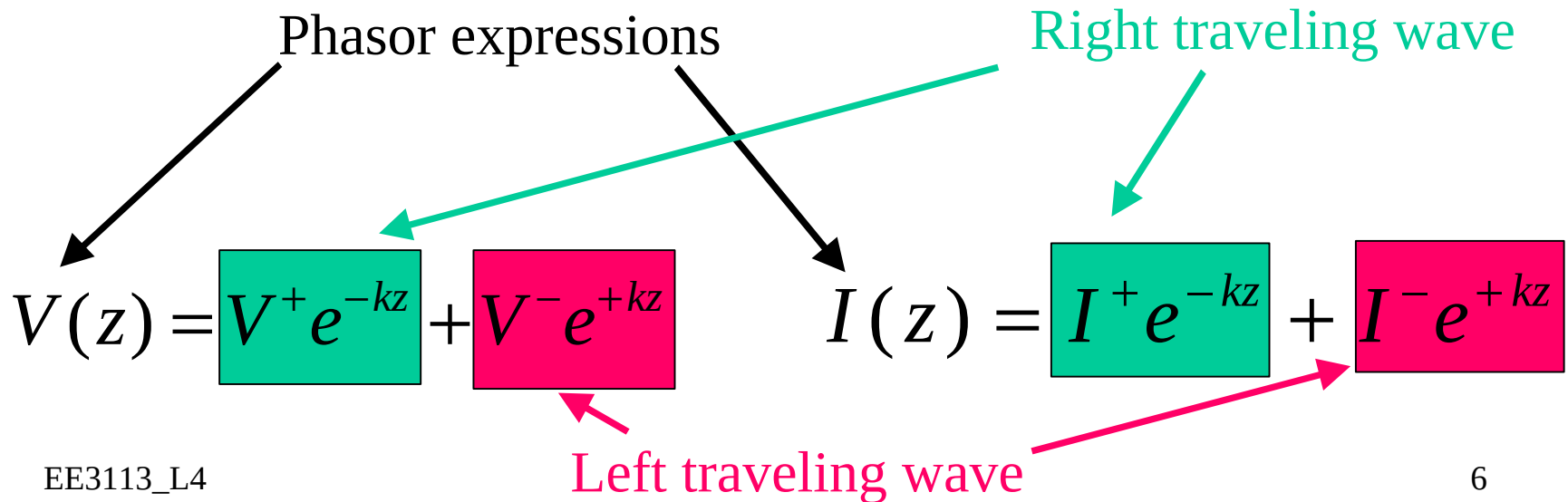
Coupled
DE

Traveling Voltage and Current Waves

$$\frac{d^2 V(z)}{dz^2} - k^2 V(z) = 0 \quad \longleftrightarrow \quad \frac{d^2 I(z)}{dz^2} - k^2 I(z) = 0$$

where

$$k = k_r + jk_i = \sqrt{(R + j\omega L)(G + j\omega C)}$$



General line impedance definition

$$I(z) = \frac{k}{(R + j\omega L)} (V^+ e^{-kz} - V^- e^{+kz})$$

$$Z_0 = \sqrt{\frac{(R + j\omega L)}{(G + j\omega C)}} = \frac{V^+}{I^+} = -\frac{V^-}{I^-}$$



Characteristic line impedance

