UNIT V

TRAVELLING WAVE

Introduction

- Transient Phenomenon :
  - Aperiodic function of time
  - Short duration
- Example :Voltage & Current Surge : (The current surge are made up of charging or discharging capacitive currents that introduced by the change in voltages across the shunt capacitances of the transmission system)
  - Lightning Surge
  - Switching Surge

Impulse Voltage Waveform

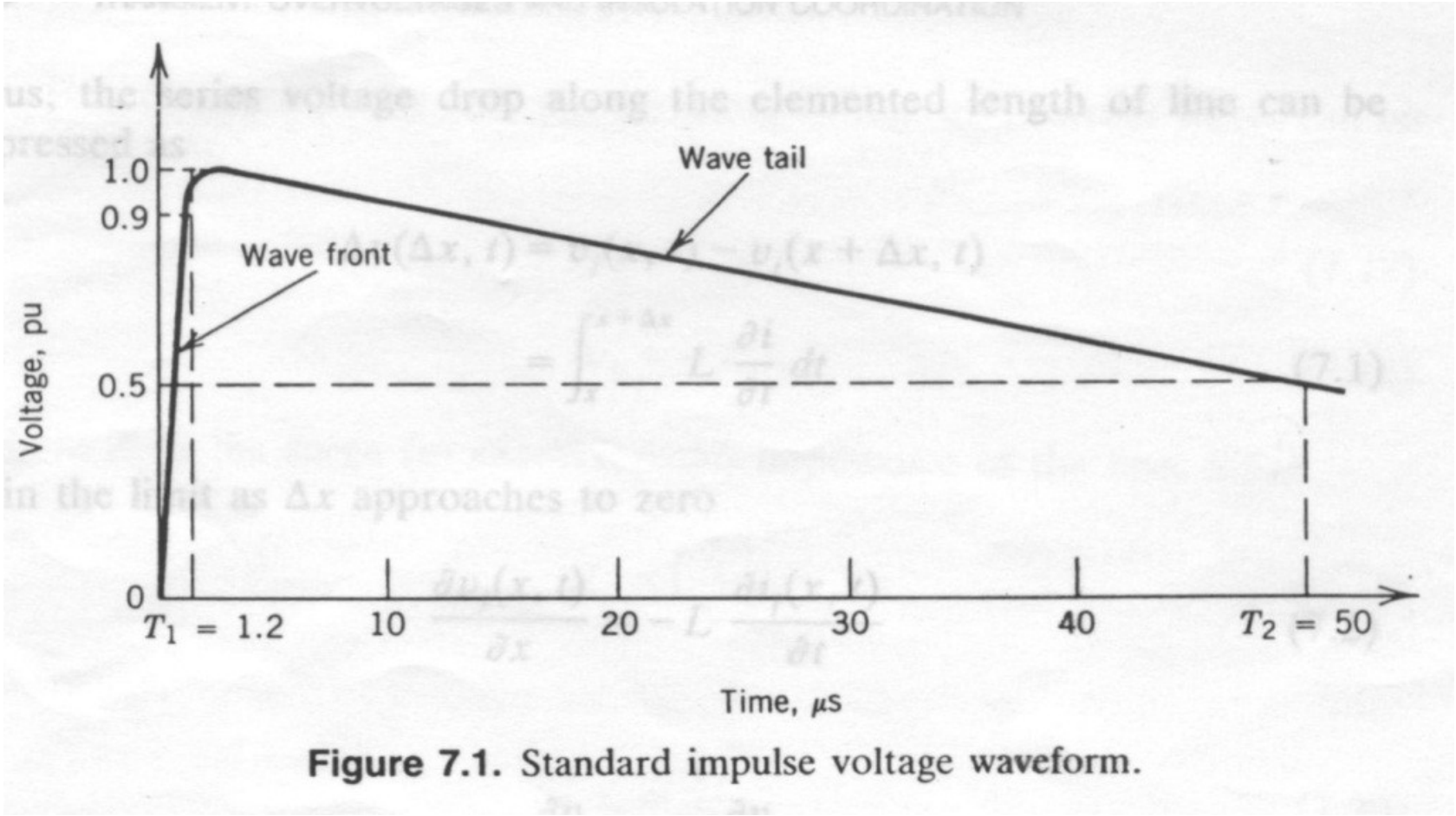

Figure 7.1. Standard impulse voltage waveform.

Travelling Wave

- Disturbance represented by closing or opening the switch S.
- If Switch S closed, the line suddenly connected to the source.
- The whole line is not energized instantaneously.
- Processed :
  - When Switch S closed
  - The first capacitor becomes charged immediately
  - Because of the first series inductor (acts as open circuit), the second capacitor is delayed
- This gradual buildup of voltage over the line conductor can be regarded as a voltage wave is traveling from one end to the other end

Travelling Wave

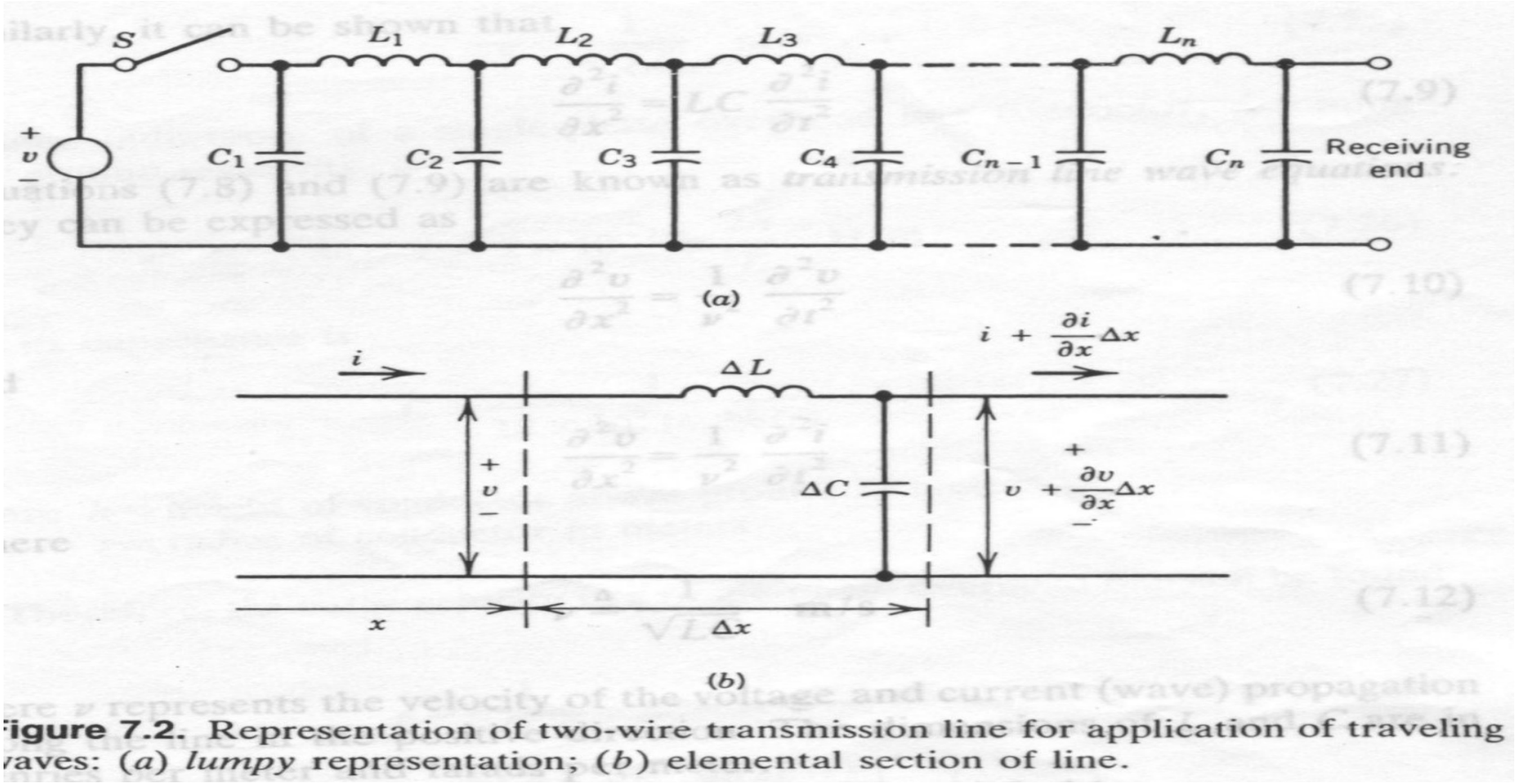

Figure 7.2. Representation of two-wire transmission line for application of traveling waves: (*a*) *lumpy* representation; (*b*) elemental section of line.

Voltage Function

- $v_f = v_1(x - \upsilon t)$
- $v_b = v_2(x + \upsilon t)$
- $\upsilon = 1/\sqrt{(LC)}$
- $v(x,t) = v_f + v_b$
- $v_f = Z_c i_f$
- $v_b = Z_c i_b$

Current Function

- $v_f = v_1(x - \upsilon t)$
- $v_b = v_2(x + \upsilon t)$
- $\upsilon = 1/\sqrt{(LC)}$
- $v(x,t) = v_f + v_b$
- $v_f = Z_c i_f$
- $v_b = Z_c i_b$

Velocity of Surge Propagation

- In the air = 300 000 km/s
- $\upsilon = 1/\sqrt{(LC)}$ m/s
- Inductance single conductor Overhead Line (assuming zero ground resistivity) :
  $L=2 \times 10^{-7} \ln (2h/r)$ H/m
  $C=1/[18 \times 10^{9} \ln(2h/r)]$ F/m
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Velocity of Surge Propagation

- In the cable : $\upsilon = 1/\sqrt{(LC)} = 3 \times 10^8 \sqrt{K}$ m/s
  K=dielectric constant (2.5 to 4.0)

$$v = \frac{1}{\sqrt{LC}} = \left[\left(\frac{2\times10^{-7} \ln(2h/r)}{18\times10^{9} \ln(2h/r)} \right)^{1/2} \right]^{-1}$$

Surge Power Input & Energy Storage

- $P=vi$ Watt
- $W_s = \frac{1}{2} Cv^2$; $W_m = \frac{1}{2} Li^2$
- $W=W_s+W_m = 2\,W_s = 2\,W_m = Cv^2 = Li^2$
- $P=W\,\upsilon = Li^2 / \sqrt{(LC)} = i^2 Z_c = v^2 / Z_c$

Superposition of Forward and Backward-Traveling Wave

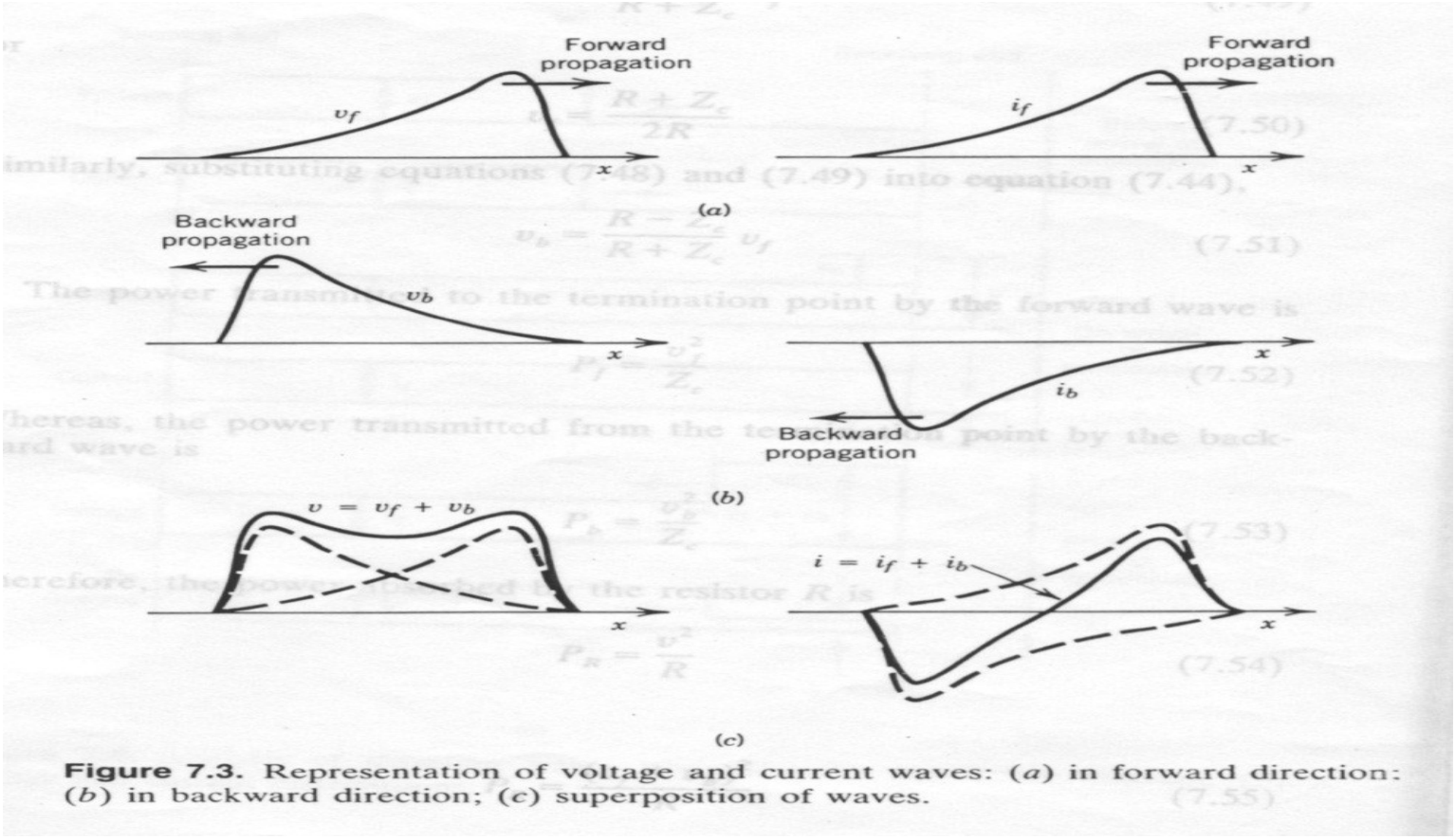

Figure 7.3. Representation of voltage and current waves: (*a*) in forward direction; (*b*) in backward direction; (*c*) superposition of waves.

Thank you