First Course on
Power Systems

Module 3: Transmission Lines and Cables

By
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Professor of ECE
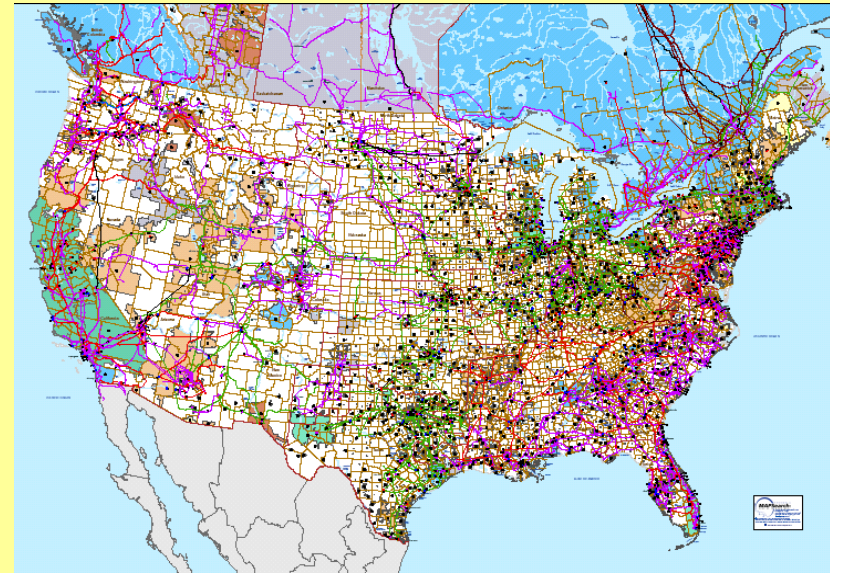**University of Minnesota**

Reference Textbook:
First Course on Power Systems by Ned Mohan,
www.mnpere.com

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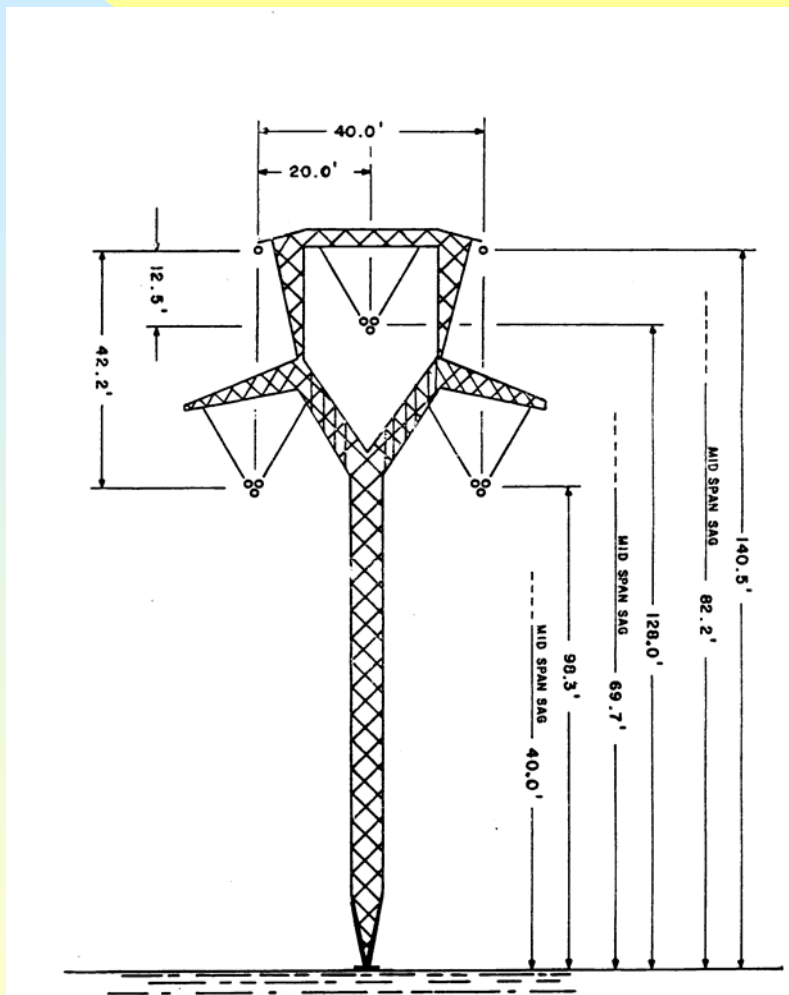# Module 3: Transmission Lines and Cables

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Transmission Lines

- Need for Transmission Lines
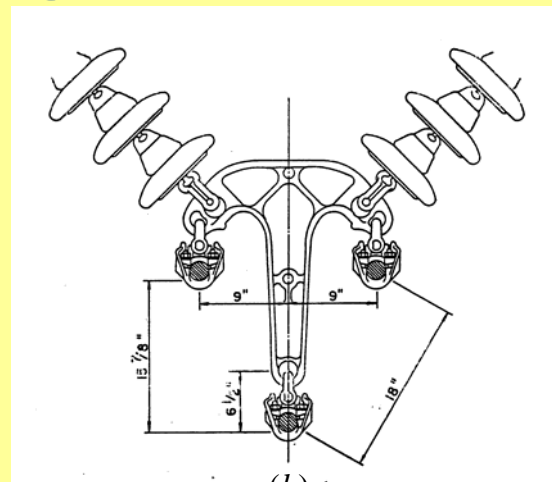 - Overhead Lines
  - Cables
  - HVDC Lines

Overhead AC Transmission Lines

- Distribution Lines
- Transmission Line Voltages
    - 115 kV, 230 kV, 345 kV, 500 kV and 765 kV
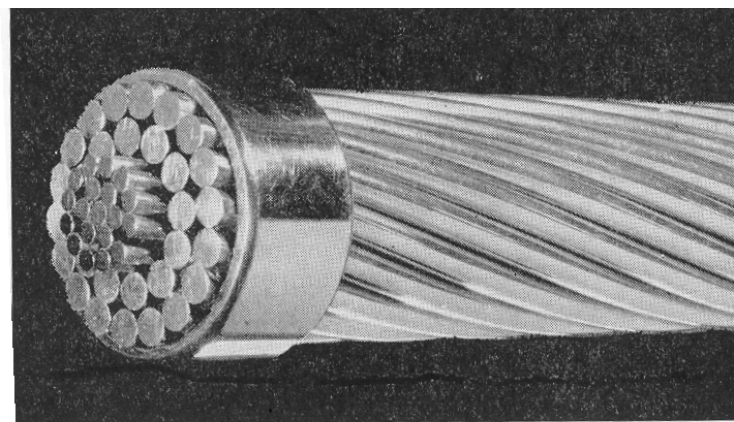- Three-Phase

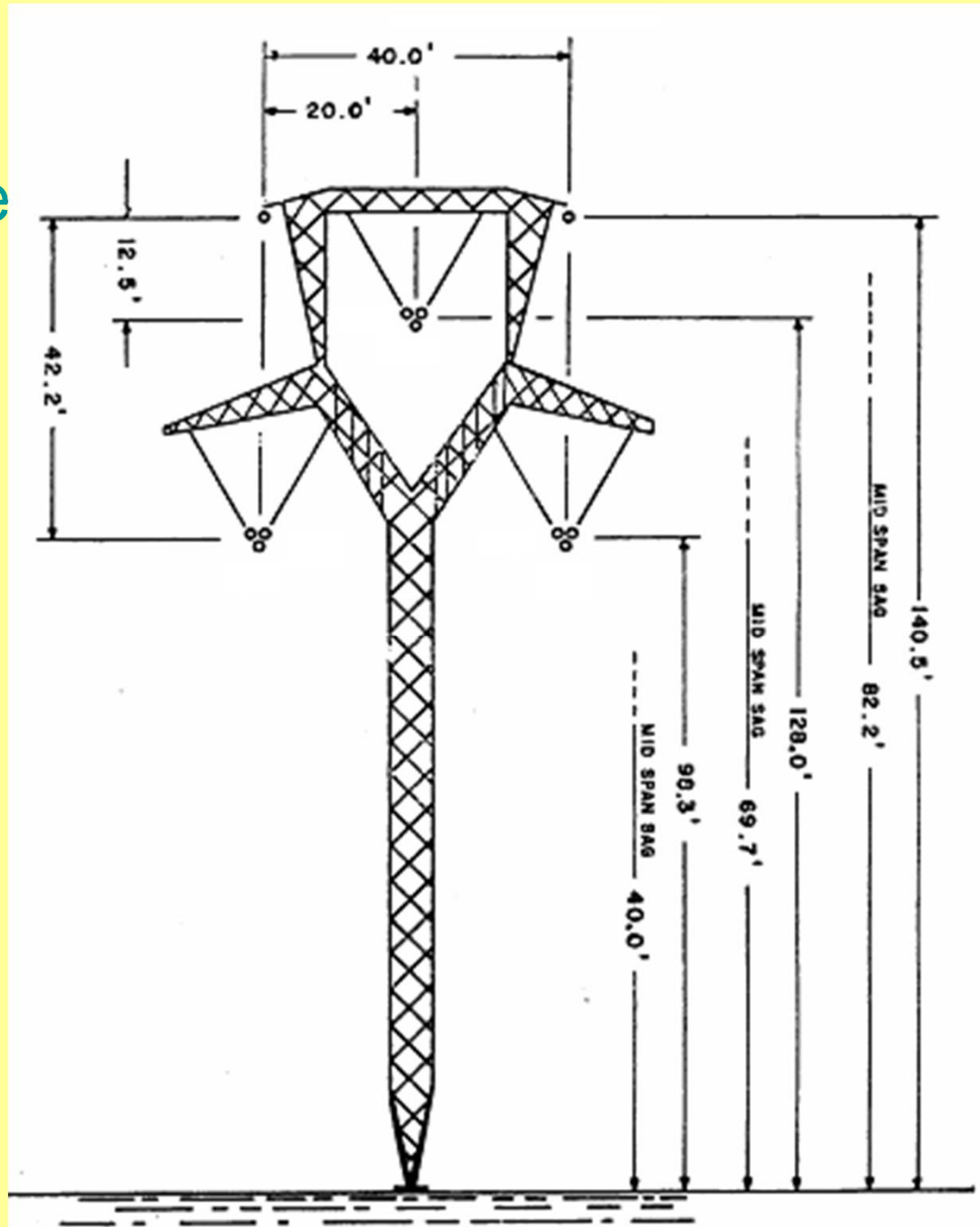# Transmission Tower, Conductor and Bundling

(a)

(b)

(c)

Courtesy of Aluminum Company of America

Fig. 4-1 500-kV transmission line (Source: University of Minnesota EMTP course).
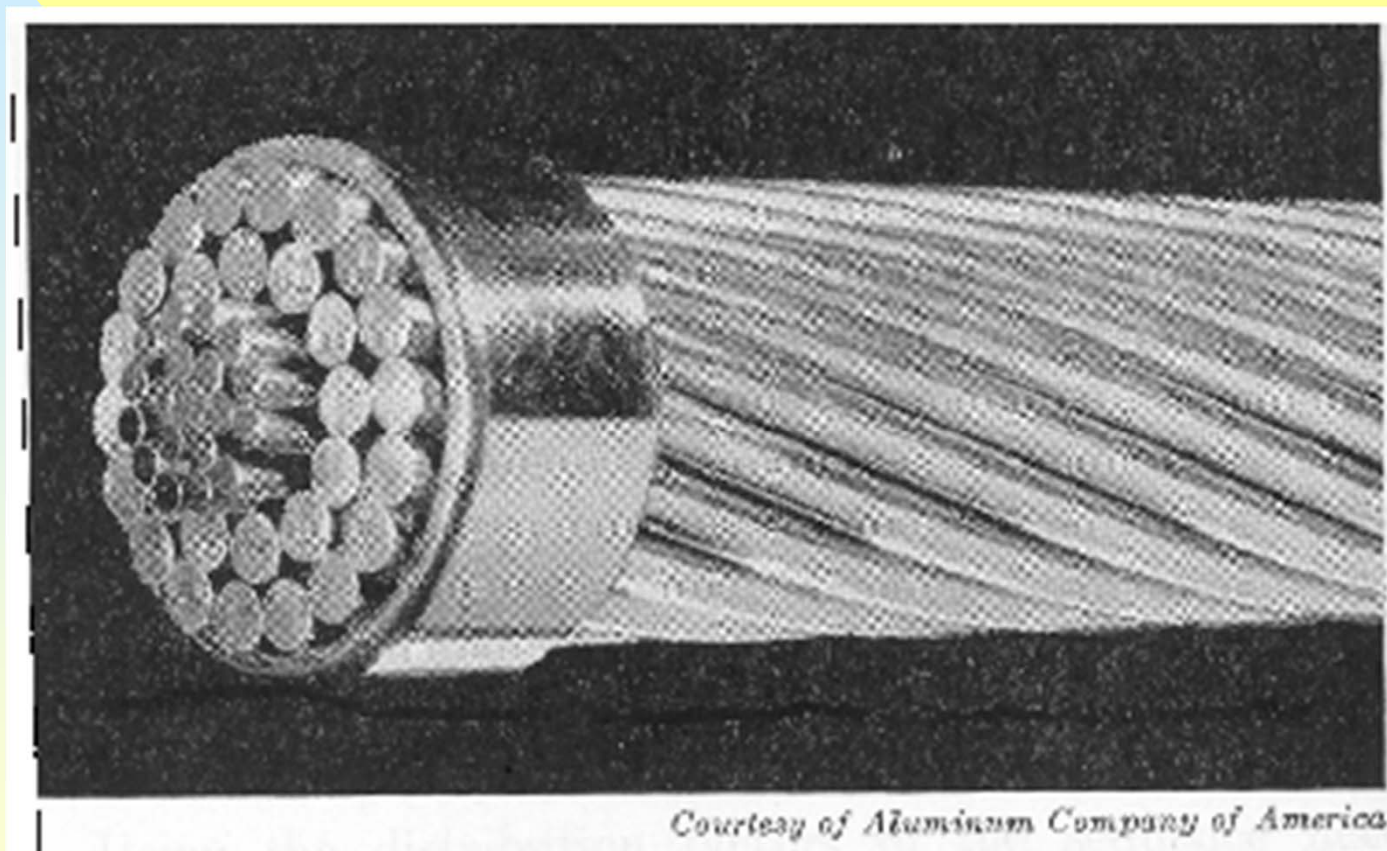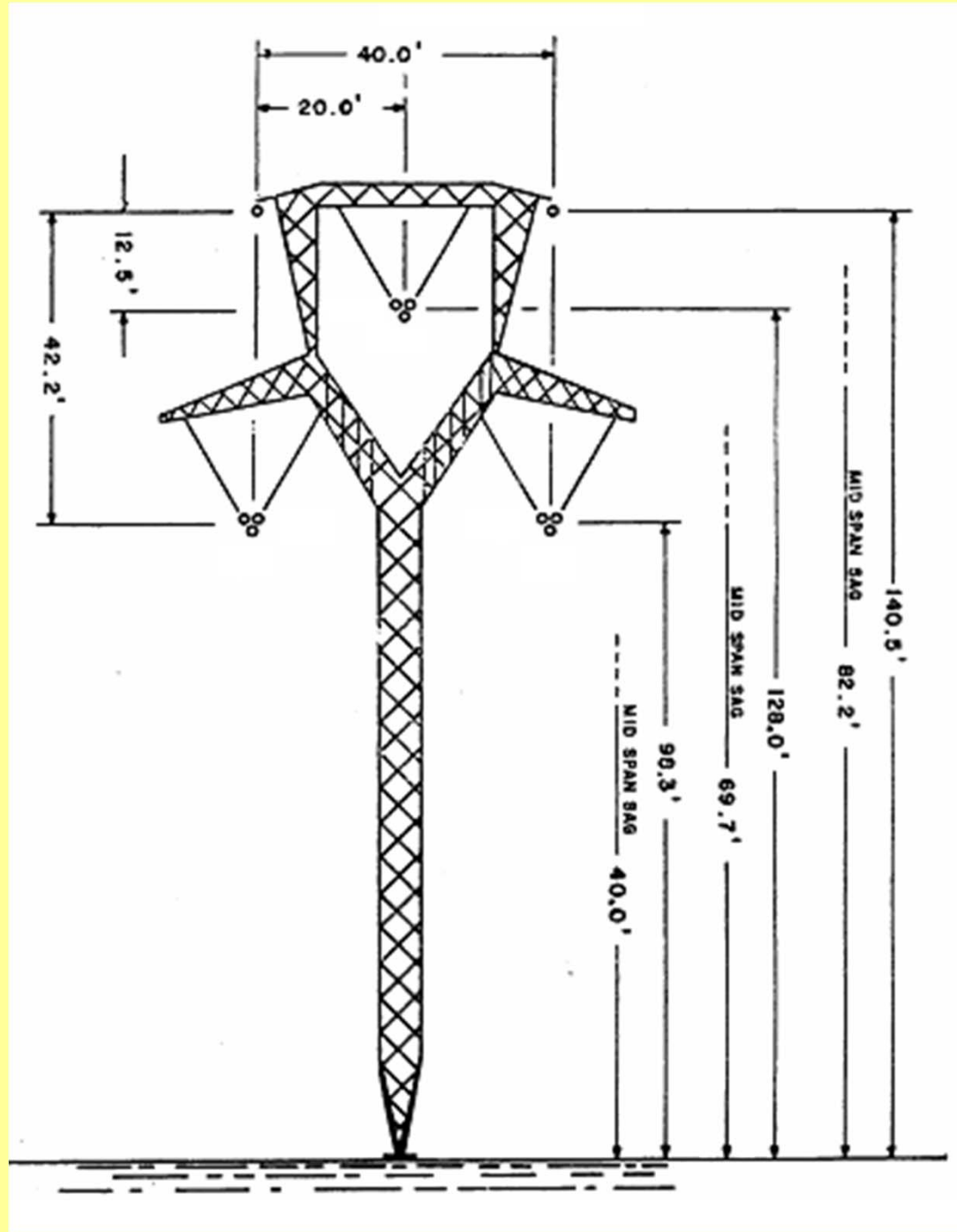
Towers:

- 5 towers per mile

6

Conductors:

- ACSR

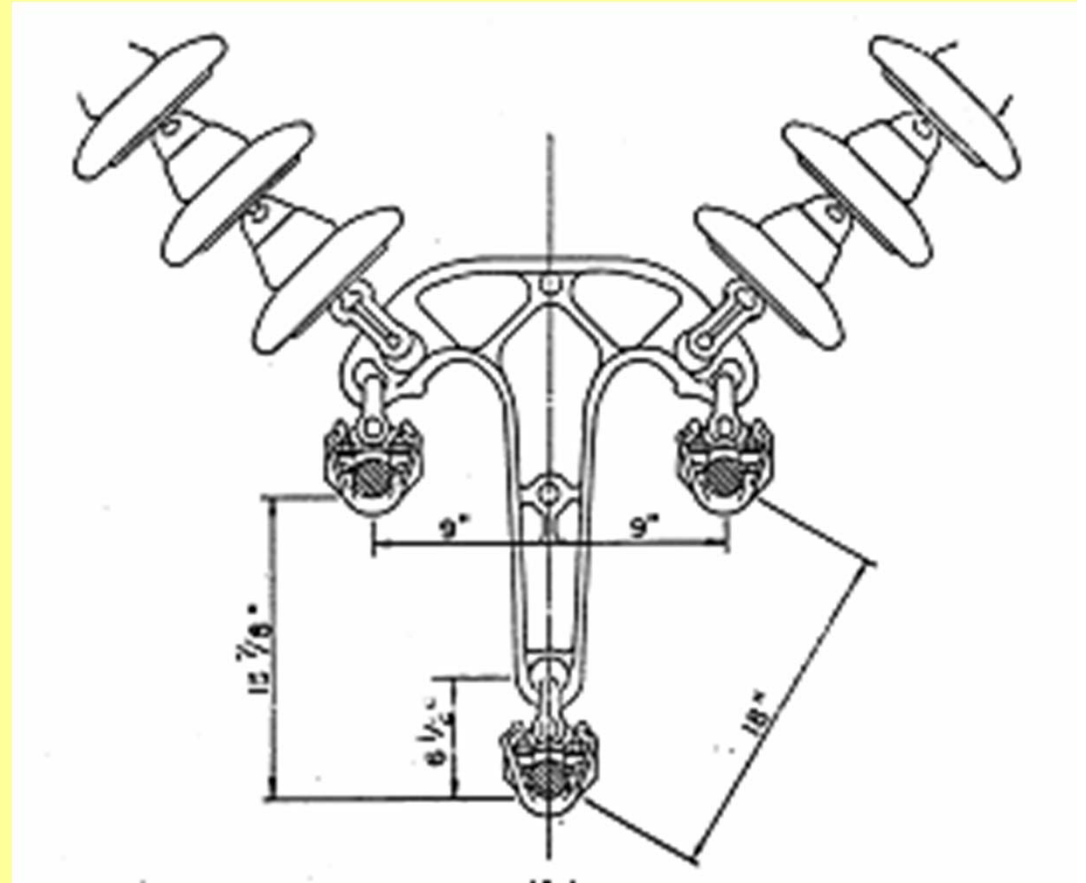Courtesy of Aluminum Company of America

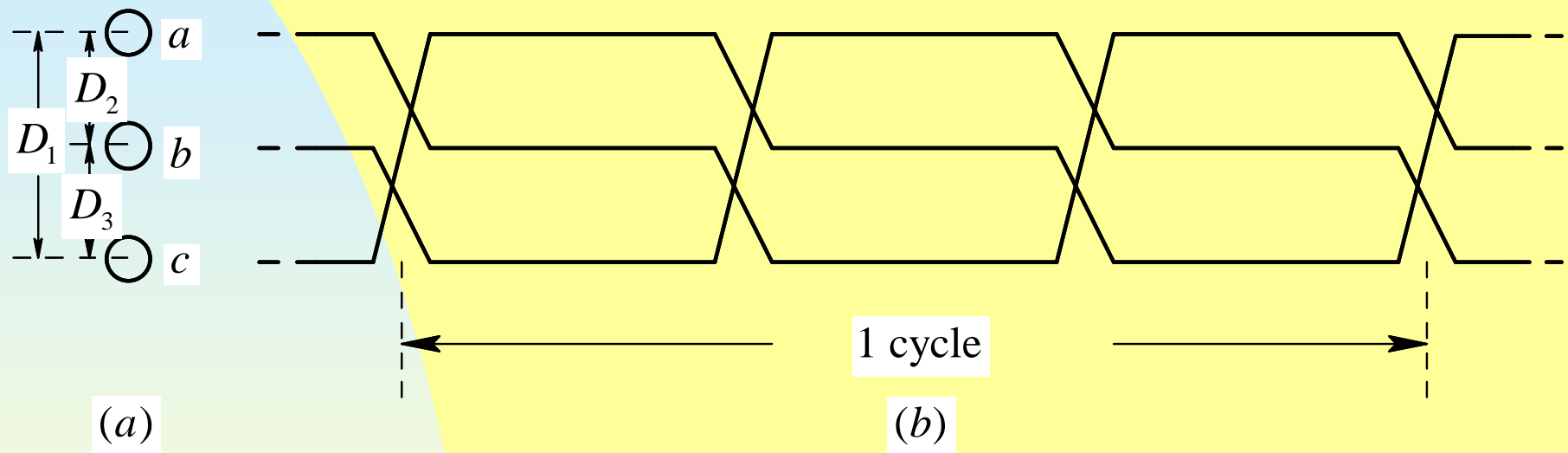# Shield Wires

8

Bundling:

- To minimize electric strength at the conductor surface

- Less than 16 kV/cm

- 345 kV Lines

  - ◆ 2 conductor-bundle at 18 inches

- 500 kV Lines

  - ◆ 3 conductor bundle at 18 inches

cost

- **345 kV Lines**
  - ◆ 0.5 M$ to 2 M$ per mile
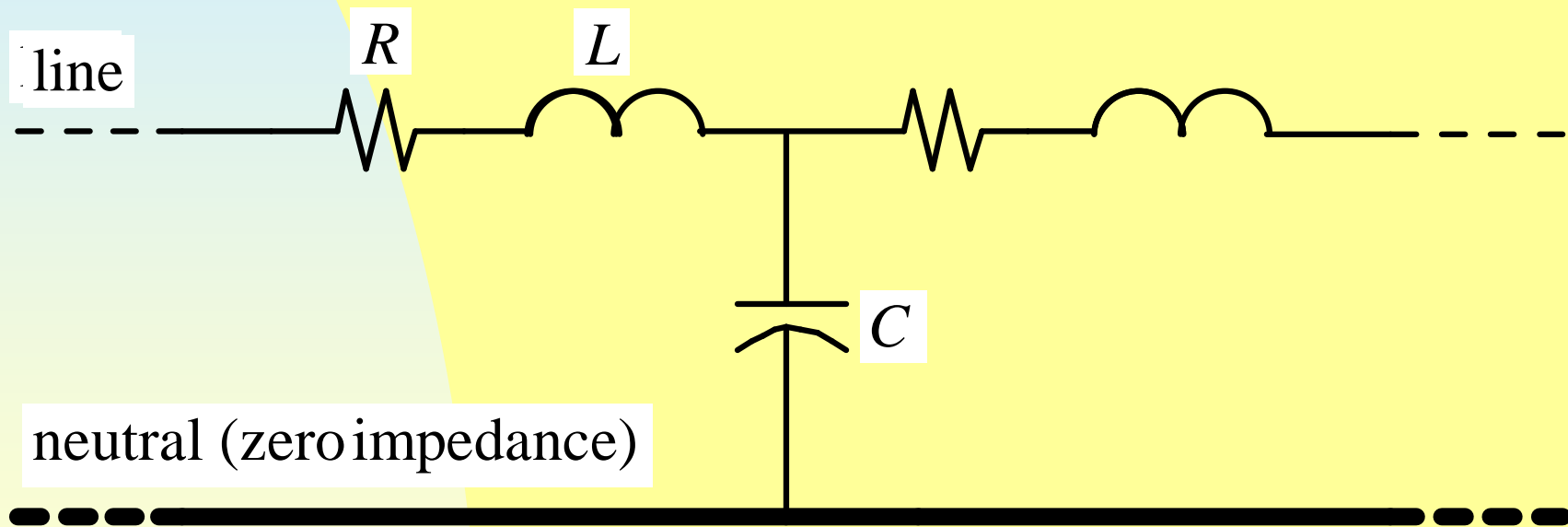
Transposition

(a)

(b)

1 cycle

- Seldom Transposed
- Barrel Length of 100 miles or less
- Assumed Balanced

Transmission Line Parameters:

- Distributed Parameters
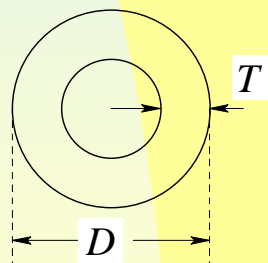- Analyzed on a per-phase basis

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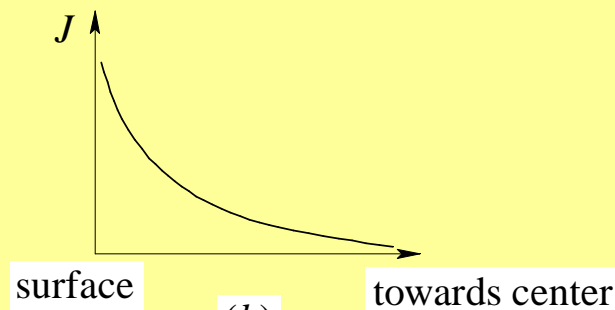# Calculation of Transmission Line Resistance: Skin Effect

- Important to minimize losses
  - 9% lost in transmission and distribution
  - keep resistances small

$$R = \frac{\rho l}{A} \qquad \delta = \sqrt{\frac{2\rho}{(2\pi f)\mu}}$$

(a)   (b)

surface   towards center

Fig. 4-4 (a) Cross-section of ACSR conductors, (b) skin-effect in a solid conductor.

Shunt Conductance G:

- Corona Effect

- Can be represented by G in shunt with Capacitance

- Negligible and therefore neglected