(The Recent) Power Engineering at CSU, Chico

And Learning Objective # 7 :
Transmission Lines & Cable Systems

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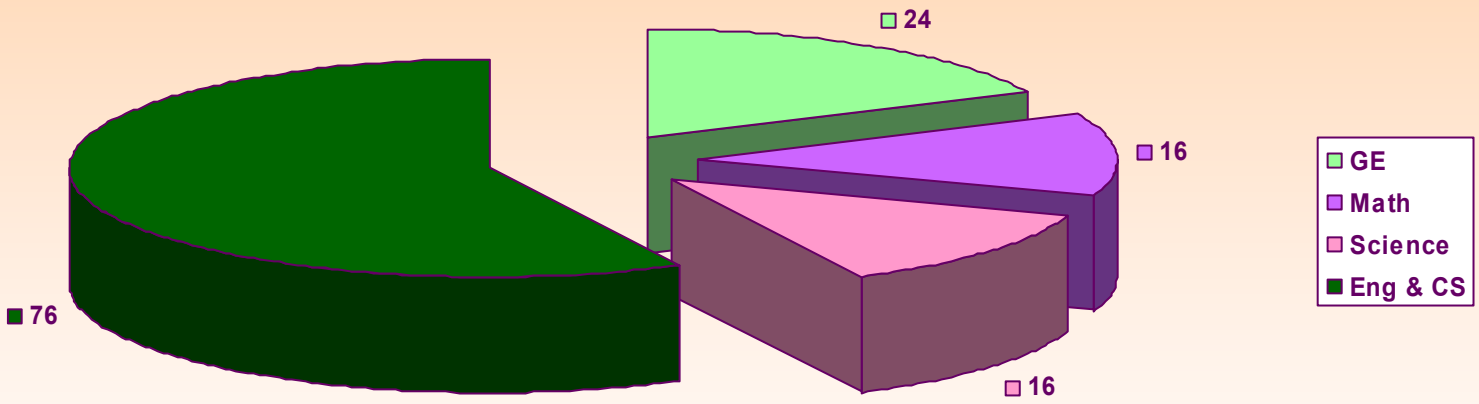
Chairman, ECE Department

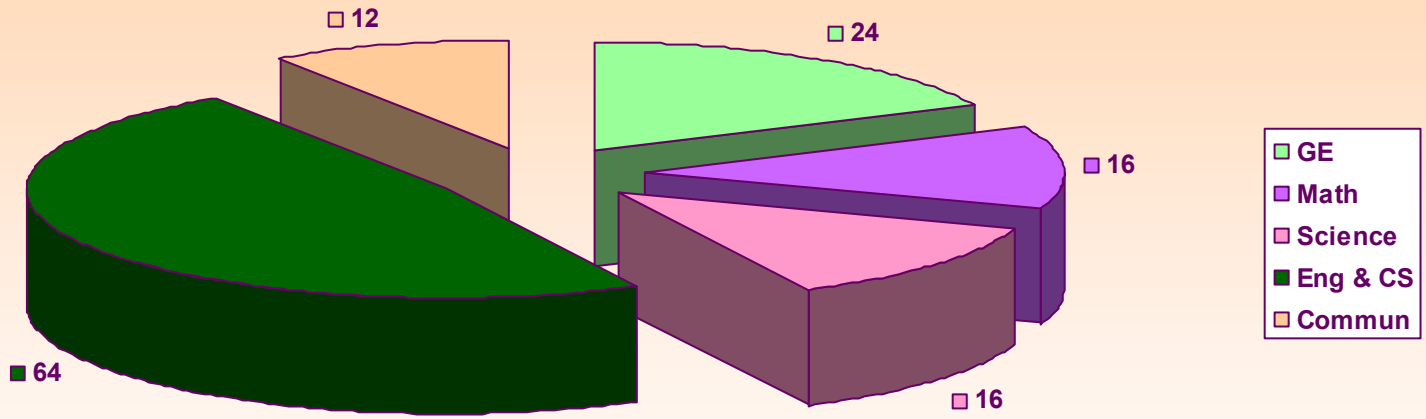
2 Undergrad Programs

- BS in Electrical/Electronic Engineering (132 Units)
- BS in Computer Engineering (132 Units)

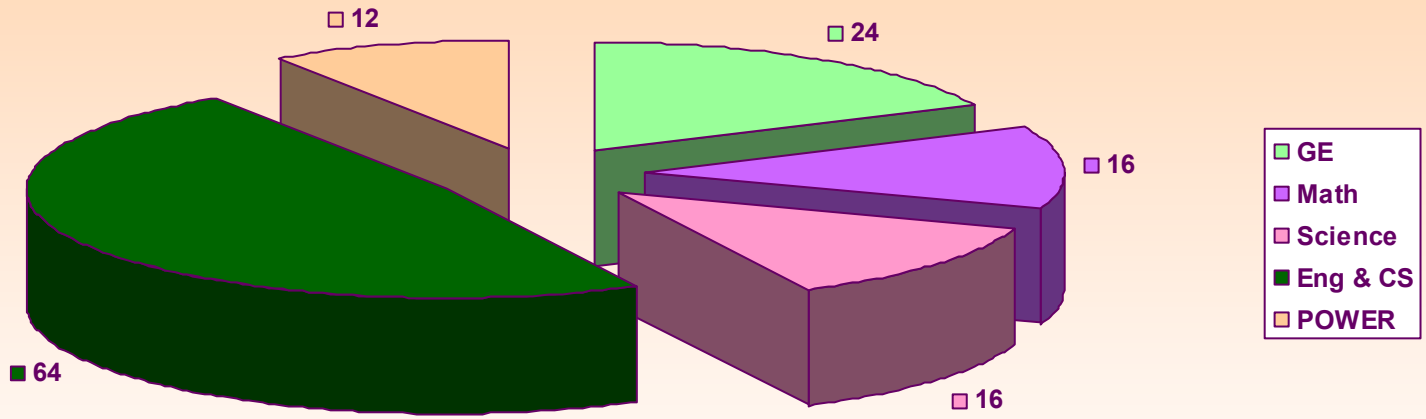
EE Curriculum



EE Curriculum (Communications)



EE Curriculum (Power Systems)



Power Curriculum Summary

Replace

- EECE 453 Communication System Design 4
- EECE 465 Digital Signal Processing 4
- *And* EECE 4 Unit Restricted Elective 4

Total Units 12

By the following 3 course sequence (12 total Units):

- EECE 481 Electromechanical Energy Conversion (4)
- EECE 483 Power Systems operation (4)
- EECE 484 Power Systems Distrib. & Analysis (4)

EECE 481: Energy/Machines

Topics:

- Traditional and renewable electrical energy sources.
- Power transformers (magnetic circuit application).
- Elecromechanical energy conversion (Lagrange's Equation ?).
- Steady state performance of synchronous machines.
- Steady state performance of dc machines.
- Steady state performance of three phase induction machines.
- Dynamic Modeling of machines (d-q axis).
- Electric machine winding transformations.
- State space modeling and control schemes of the 3 machines.

EECE 483: First Course in PS "Operation"

Topics:

- Power systems single line diagrams and per unit calculations.
- Network matrices including Y-bus and Z-bus.
- Transmission Lines (Modeling & Performance)
- The load flow study.
- Large system loss formula.
- Real and reactive power dispatch.
- Power system equipment protection.

EECE 484: Second Course in PS

Topics:

- Power system symmetrical components
- Sequence impedances of transmission systems
- Fault analysis
- Concept of power system dynamics and stability
- Power System Stability analysis
- An overview of power system distribution networks.

Back to the Course Learning Objectives

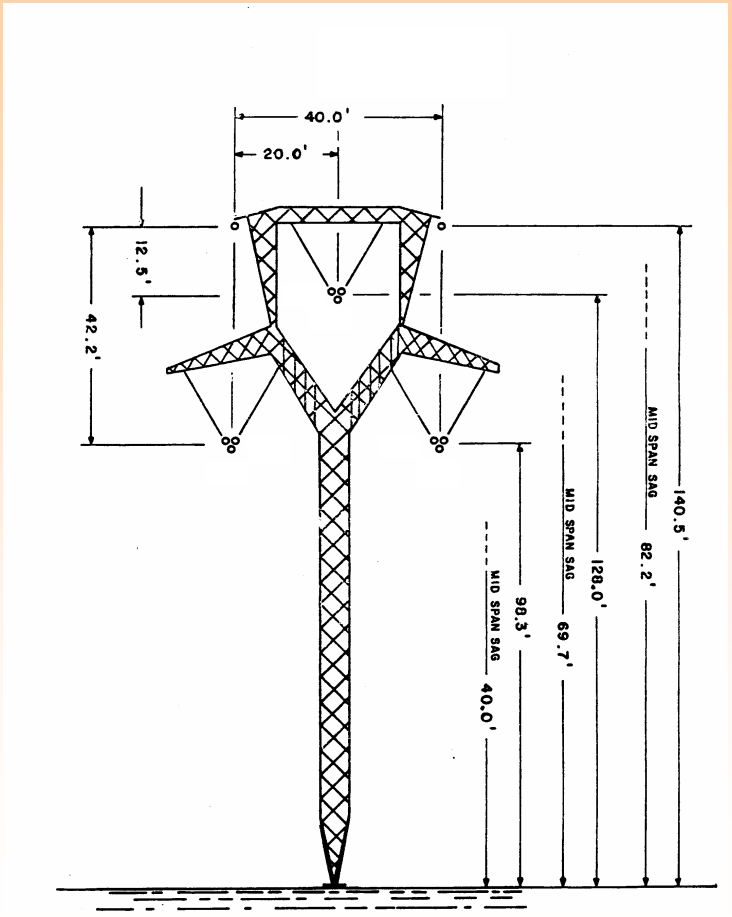
Learning Objective # 7 :

Transmission Lines & Cable Systems

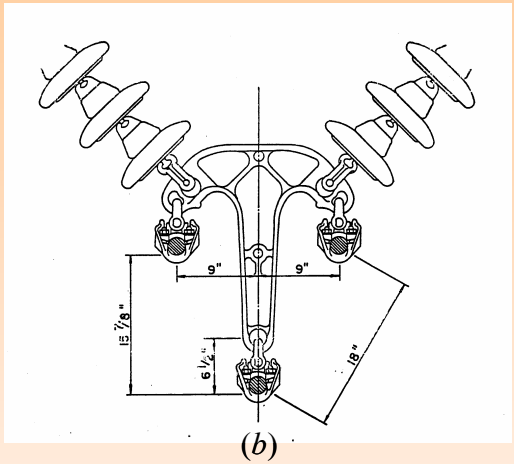
CHAPTER 4

AC TRANSMISSION LINES AND UNDERGROUND CABLES

Transmission Tower, Conductor and Bundling



(*a*)



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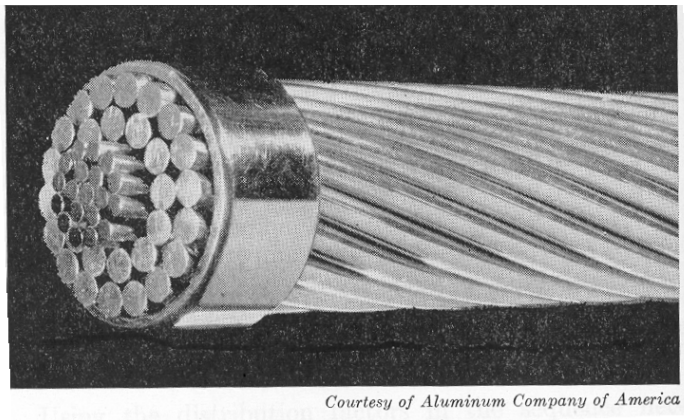

(*c*)

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

Transposition

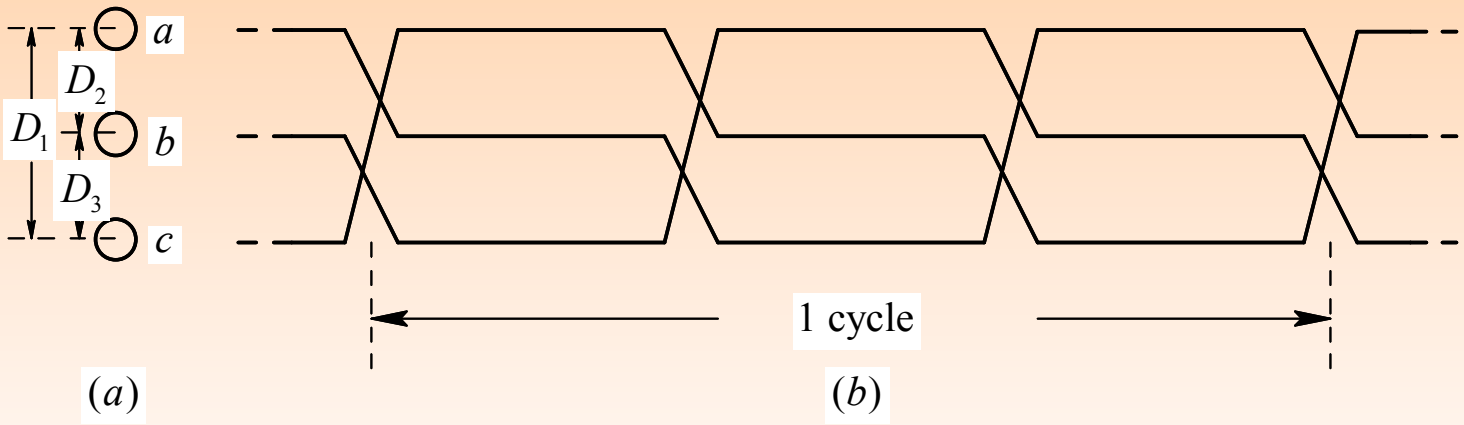

Fig. 4-2 Transposition of transmission lines.

Distributed Parameters

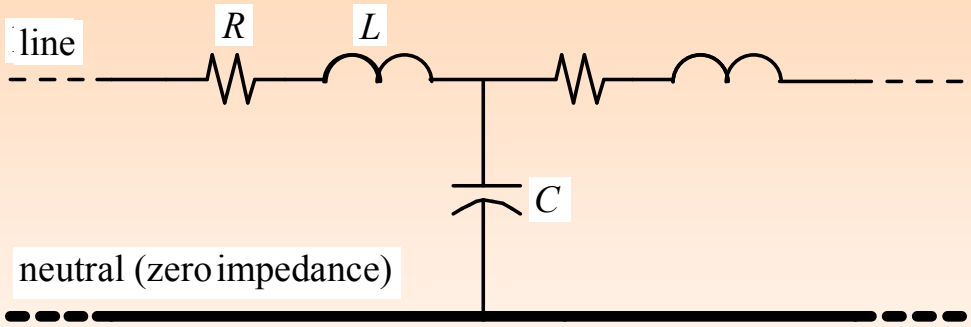

Fig. 4-3 Distributed parameter representation on a per-phase basis.

Calculation of Transmission Line Resistance: Skin Effect

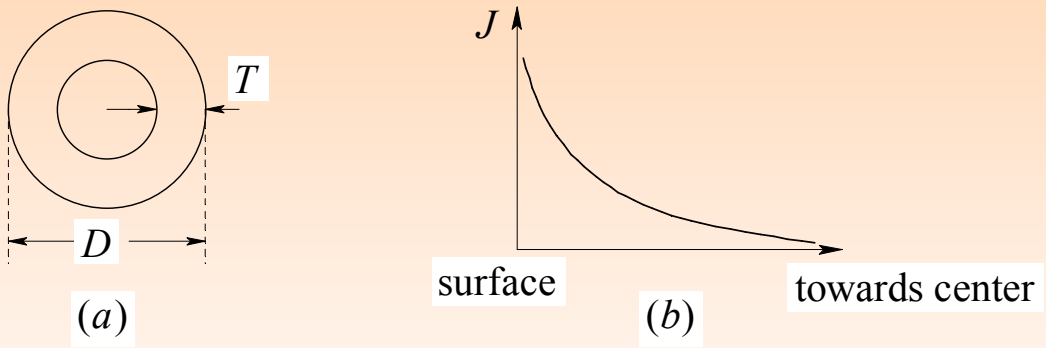

Fig. 4-4 (a) Cross-section of ACSR conductors, (b) skin-effect in a solid conductor.

Calculation of Transmission Line Inductance

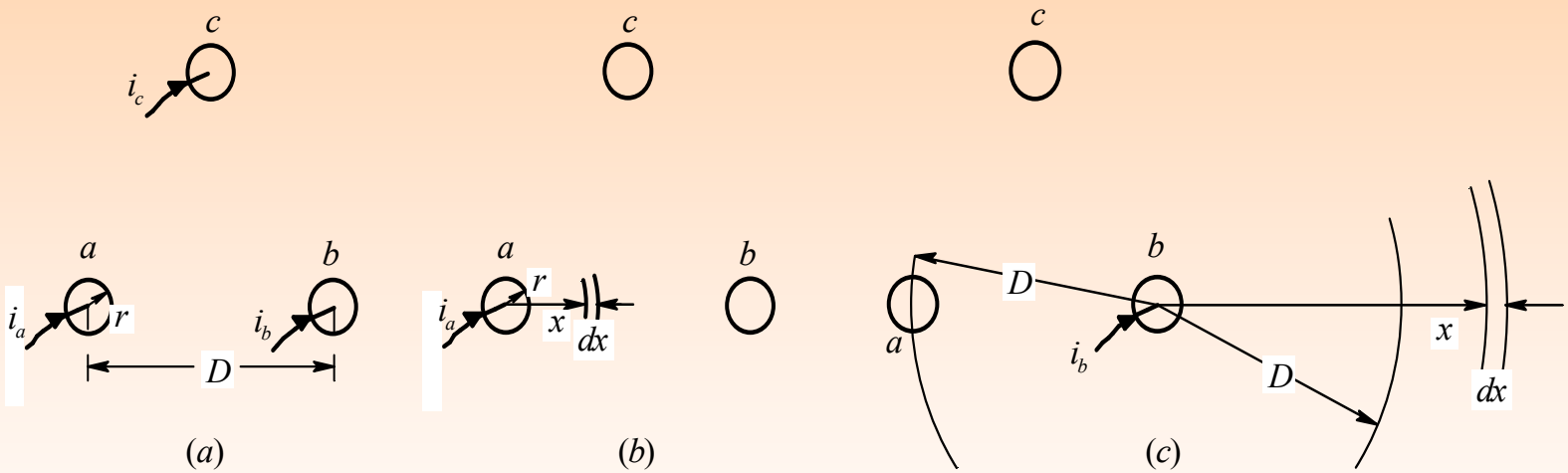

Fig. 4-5 Flux linkage with conductor-a.

Electric Field Due to Transmission Line Voltage

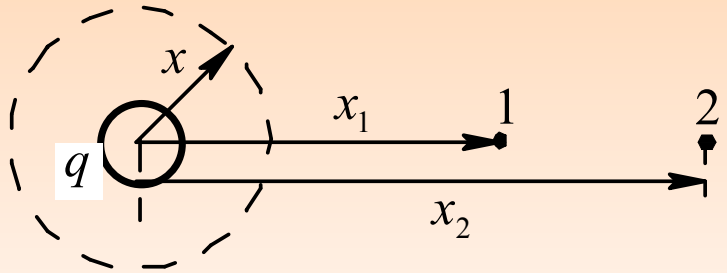

Fig. 4-6 Electric field due to a charge.

Calculation of Transmission Line Capacitance

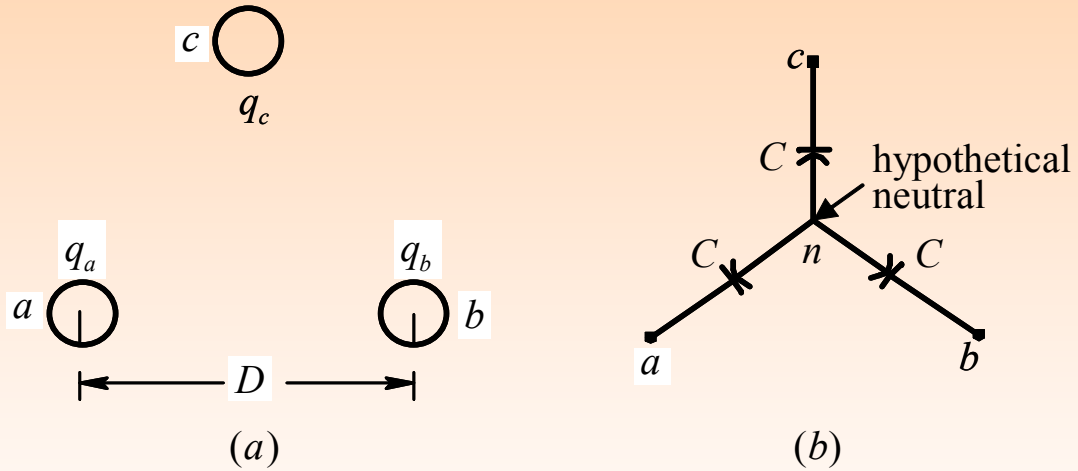

Fig. 4-7 Shunt capacitances.

Typical Parameters for various Voltage Transmission Lines

Table 4-1

Transmission Line Parameters with Bundled Conductors (except at 230 kV) at 60 Hz [2, 6]

Nominal Voltage	$R(\Omega/km)$	$\omega L(\Omega/km)$	$\omega C(\mu\mho/km)$
230 kV	0.055	0.489	3.373
345 kV	0.037	0.376	4.518
500 kV	0.029	0.326	5.220
765 kV	0.013	0.339	4.988

Calculating Transmission Line Parameters using EMTDC

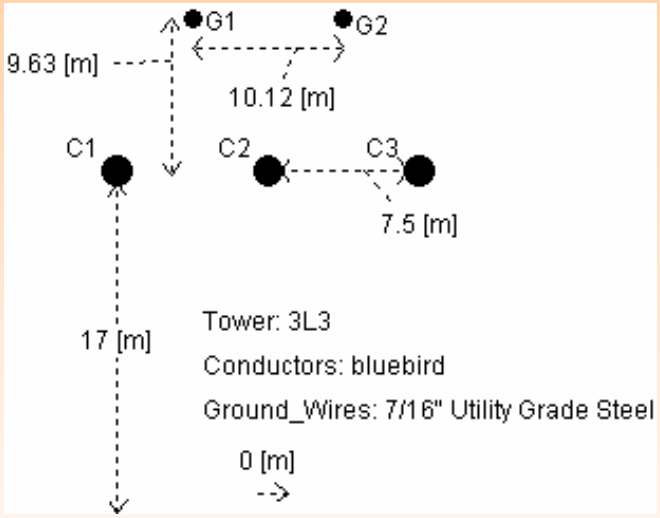

Fig. 4-8 A 345-kV, single-conductor per phase, transmission system.

Distributed-Parameter Representation

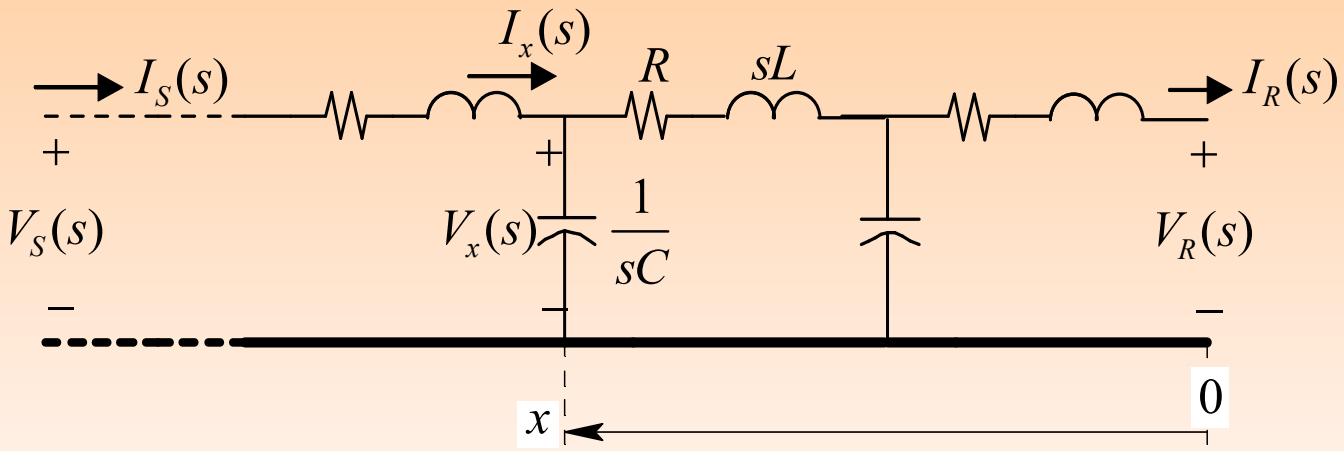

Fig. 4-9 Distributed per-phase transmission line (G not shown).

Voltage Profile

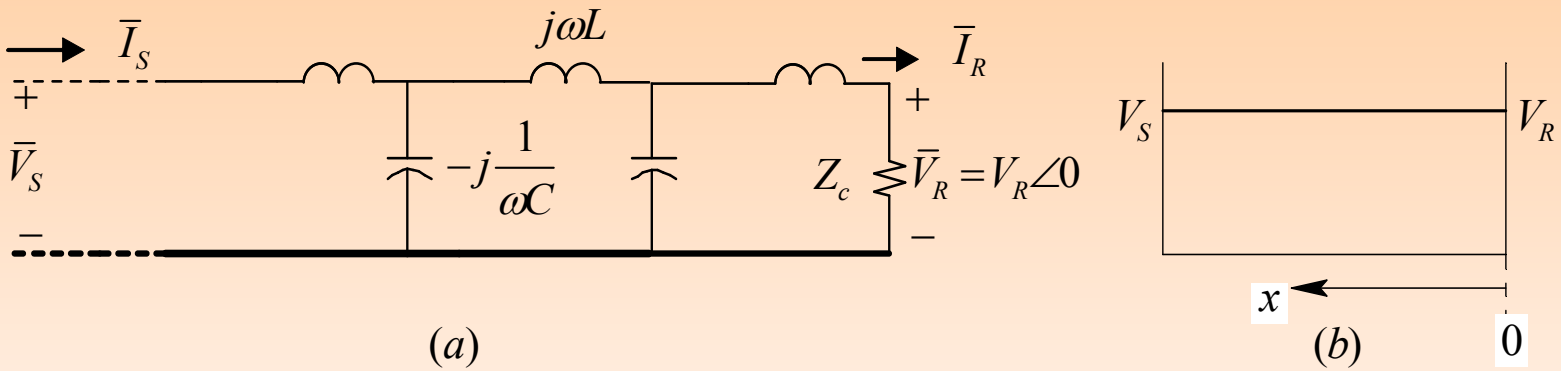

Fig. 4-10 Per-phase transmission line terminated with a resistance equal to Z_c.

Long-Line Representation

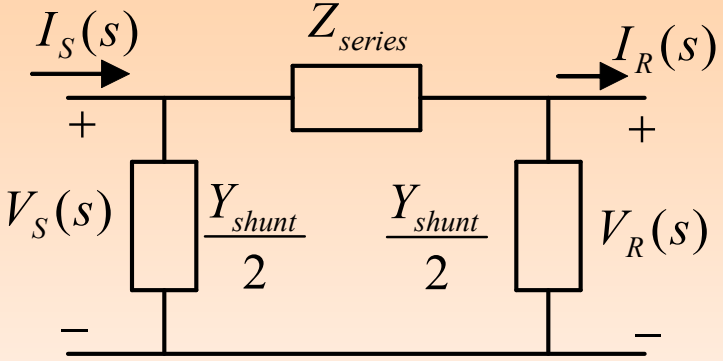

Fig. 4-11 Long line representation.

Transmission Line Representations

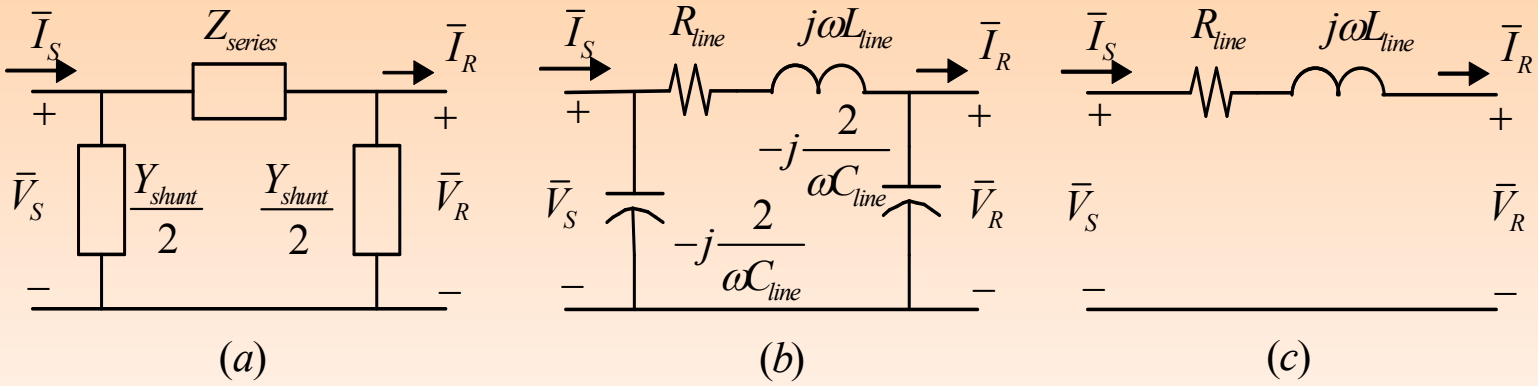

Fig. 4-12 Per-phase transmission line representation based on length.

Underground Cables

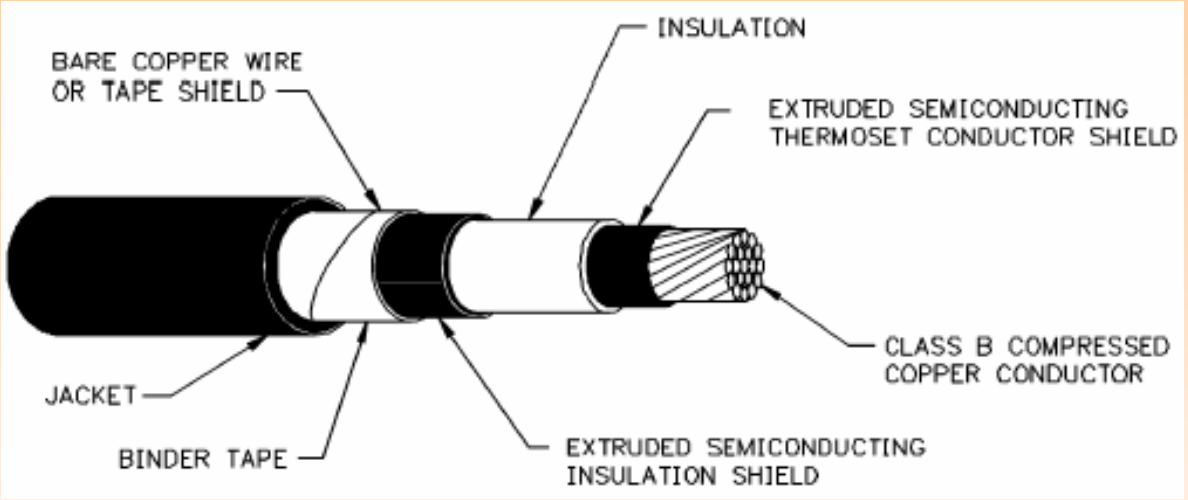

Fig. 4-13 Underground cable.