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FIGURE 4.38

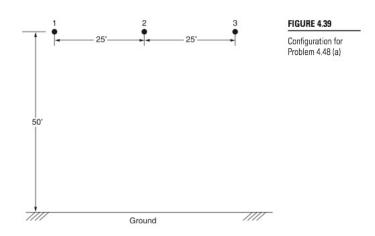
Three-phase single-circuit line configuration including ground effect for Problem 4.48

A. 1'

B. 2'

Problems

- (a) Now consider Figure 4.39 in which the configuration of a three-phase, single circuit, 345-kV line with conductors having an outside diameter of 1.065 in. is shown. Determine the capacitance to neutral in F/m, including the ground effect.
- (b) Next, neglecting the effect of ground, see how the value changes.



**4.49** The capacitance-to-neutral, neglecting the ground effect, for the three-phase, single-circuit, bundle-conductor line is given by

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### 234 Chapter 4 | Transmission Line Parameters

$$C_{a\eta} = \frac{2\pi\epsilon_0}{\ell\eta\left(\frac{GMD}{GMR}\right)} F/m \text{ line-to-neutral}$$

Where GMD = 
$$(D_{AB}D_{BC}D_{AC})^{1/3}$$
  
GMR =  $[rN(A)^{N-1}]^{1/N}$ 

in which N is the number of subconductors of the bundle conductor on a circle of radius A, and each subconductor has an outside radius of r. The capacitive reactance in mega-ohms for 1 mi of line at 60 Hz can be shown to be

$$\mathbf{X}_{C} = 0.0683 \log \left( \frac{\text{GMD}}{\text{GMR}} \right) = \mathbf{X}'_{a} + \mathbf{X}'_{d}$$

where 
$$X_u' = 0.0683 \log \left(\frac{1}{GMR}\right)$$
 and  $X_u' = 0.0683 \log (GMD)$ .

Note that A is related to the bundle spacing S given by

$$A = \frac{S}{2\sin\left(\frac{\pi}{N}\right)} \quad \text{for } N > 1$$

Using the above information for the configuration shown in Figure 4.40, compute the capacitance-to-neutral in F/m and the capacitive reactance in  $\Omega \cdot$  mi to neutral for the three-phase, 765-kV, 60-Hz, single-circuit, bundle-conductor line (N=4) with subconductor's outside diameter of 1.16 in. and subconductor spacing (S) of 18 in.

# FIGURE 4.40 Configuration for Problem 4.49 60' 60'

## **SECTION 4.12**

4.50 Calculate the conductor surface electric field strength in kVrms/cm for the single-phase line in Problem 4.32 when the line is operating at 20 kV. Also calculate the ground-level electric field strength in kVrms/m directly under one conductor. Assume a line height of 10 m.

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References

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4.51 Rework Problem 4.50 if the diameter of each conductor is (a) increased by 25% to 1.875 cm or (b) decreased by 25% to 1.125 cm without changing the phase spacings. Compare the results with those of Problem 4.50.

# CASE STUDY QUESTIONS

- a. Approximately how many physical transmission interconnections are there between the United States and Canada? Across which states and provinces are the interconnections located?
- b. How many kWhs of electrical energy was exported from Canada to the United States in 2012? Was the majority of that energy export derived from clean, non-emitting sources of electrical power?
- c. What caused the August 2003 blackout in the United States and Canada? How many generating units were forced to shut down during that blackout?
- d. What are the advantages of high-capacity, low-sag conductors? As of 2013, how many electric utilities in the world had deployed high-capacity, low-sag conductor technology?

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