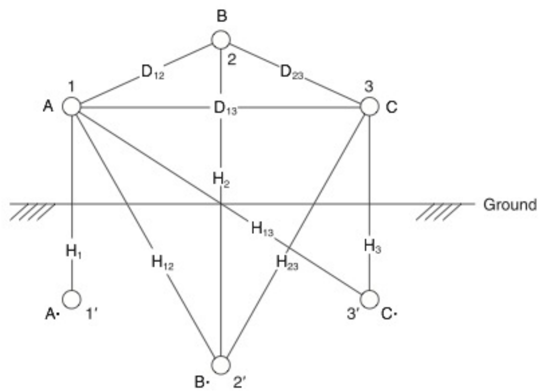

FIGURE 4.38

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

(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.

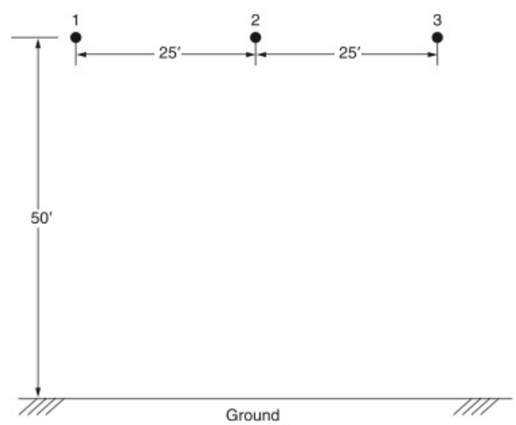

FIGURE 4.39

Configuration for Problem 4.48 (a)

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

$$C_{a\eta} = \frac{2\pi\varepsilon_0}{\ell\eta\left(\frac{\text{GMD}}{\text{GMR}}\right)} \text{ F/m line-to-neutral}$$

Where $\text{GMD} = (D_{AB}D_{BC}D_{AC})^{1/3}$

$\text{GMR} = [rN(A)^{N-1}]^{1/N}$

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

$$X_C = 0.0683 \log\left(\frac{\text{GMD}}{\text{GMR}}\right) = X'_a + X'_d$$

where $X'_a = 0.0683 \log\left(\frac{1}{\text{GMR}}\right)$ and $X'_d = 0.0683 \log(\text{GMD})$.

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.

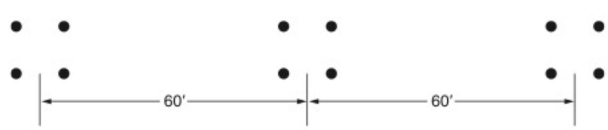

FIGURE 4.40 Configuration for Problem 4.49

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.

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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