A practical method to compute the metallic sheath circulating current for non standard cases

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ABSTRACT

This paper presents a practical method to determine the metallic sheath circulating current in case of different axial phase distances along the route, such as in case of duct banks or directional drilling installations, and in case of different cable sizes in the same section. It is applicable to any typical major section, with equal or unequal minor section lengths. The paper includes a typical case comparison with IEC 60287 method in case of different minor section lengths. Also, an actual non standard case study shall be presented.

KEYWORDS

Axial phase distance. cross-bonded system, circulating current, induced voltage, major section, minor section, mean screen/sheath diameter.

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INTRODUCTION

IEC 60287 provides a method to determine the circulating current. The method is specified only for differences in the length of minor sections of a major cross-bonded section. In addition, it is applicable to one cable size and one axial phase distance. This paper presents other cases such as different axial phase distances and different cable sizes in the same section. It is applicable to any typical major section/sections, with equal or unequal minor section lengths. The circulating current is determined by dividing the resultant of the vector sum of the induced voltages of each length that has different axial distance per phase, or different formation arrangement, or different cable size, by the resultant of the vector sum of the computed metallic screen/sheath impedance of the subject sections.

CIRCULATING CURRENT

Where a cross-bonded installation contains sections whose unbalance is not negligible, a residual voltage is produced which results in a circulating current loss $I_{\text{circulating}}$ in that section which must be taken into account:

$$I_{\text{circulating}} = V \,/\, Z_s \qquad [1]$$

Where:

V is the resultant sum of induced voltages in all minor sections.

$$V = E_1 + E_2 + E_3 \qquad [2]$$

E_1 is the induced voltage in minor section 1.

E_2 is the induced voltage in minor section 2.

E_3 is the induced voltage in minor section 3.

In addition, if the minor section contains more than one cable configuration or axial phase spacing, the induced voltages of each case in that minor section shall be computed and added accordingly.

In case of continuous cross bonded systems, then:

E_1 is the sum of the induced voltages in the first minor section of each major section in case of more than one major section. This can be simplified to minor sections 1, 4, 7, 10 etc as they have the same phase angle.

E_2 is the sum of the induced voltages in the second minor section of each major section in case of more than one major section. This can be simplified to minor sections 2, 5, 8, etc as they have the same phase angle.

E_3 is the sum of the induced voltages in the third minor section of each major section in case of more than one major section. This can be simplified to minor sections 3, 6, 9, etc as they have the same phase angle.

and

Z_s is the metallic screen/sheath impedance:

$$Z_s = R_s + jX \qquad [3]$$

Where:

R_s is the resistance of screen/sheath per unit length of cable at its maximum operating temperature (Ω/m);

X is the reactance of screen/sheath per unit length of cable (Ω/m)

For trefoil formation:

$$X = 2\,\omega\;10^{-7}\,ln\left(\frac{2\,\mathrm{s}}{\mathrm{d}}\right)\quad (\Omega/\mathrm{m}) \qquad [4]$$

For flat formation:

$$X_1 = 2\,\omega\;10^{-7}\,ln\left\{2\,\sqrt[3]{2}\left(\frac{\mathrm{s}}{\mathrm{d}}\right)\right\}\quad (\Omega/\mathrm{m}) \qquad [5]$$

Where:
ω is the angular frequency of the system: