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Use of Insulated Earth Continuity Conductors

Circulating current in bare Copper ECCs result in additional losses, heating and elevated corrosion risk. Total or partial cancellation of the induced voltage is only possible using insulated ECCs.

The main contents of the technical bulletin follow…

1 Introduction

Circulating current on a solid bonded cable circuit metallic sheath results from the induced sheath standing voltage (V_{SHEATH}), driving a current (I_{SHEATH}) through an impedance (Z_{SHEATH}). The magnitude of I_{SHEATH} is determined by:

$$I_{SHEATH} = \frac{V_{SHEATH}}{Z_{SHEATH}}$$

As V_{SHEATH} and Z_{SHEATH} are both proportional to length, I_{SHEATH} is independent of length.

In the same way as the phase conductors induce a voltage on the metallic cable sheath, a voltage is also induced on an Earth Continuity Conductor ("ECC") – the magnitude, E_P, is related to the position from the phase conductors through (Working Group 07 1973):

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$$E_p = j\omega I.2.10^{-7}\left(\frac{1}{2}\ln\left[\frac{S_{1p}.S_{3p}}{S_{2p}^2}\right] + j\frac{\sqrt{3}}{2}\ln\left[\frac{S_{3p}}{S_{1p}}\right]\right) \text{.....[V/m]} \quad (1)$$

Where: ω is the angular frequency of the system,

I is the R.M.S current in phase conductor No. 2,

S_{1p} is the axial spacing of the parallel conductor and phase 1 conductor,

S_{2p} is the axial spacing of the parallel conductor and phase 2 conductor,

S_{3p} is the axial spacing of the parallel conductor and phase 3 conductor.

Just as a solid bonded metallic cable sheath is earthed at both ends, a bare Copper ECC is earthed along the entire length of the conductor where it is buried. Again, as with the sheath circulating current, the circulating current within a bare Copper ECC is also independent of length.

2 ECC Position and Induced Voltage Cancellation

As the phase conductors induce a voltage on the ECC which can result in circulating current through the ECC, the choice of position, and transposition of the ECC position, can mitigate the magnitude of the induced voltage. The total or partial cancellation of the induced voltage is possible if and only if:

1. An insulated ECC is installed and,
2. The ECC is best positioned to cancel the induced voltage and,
3. The ECC is correctly transposed over the route length.

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In a Flat arrangement, the ECC is transposed at 50% of the route length, then, from equation (1), for the first half-length:

$$E_1 = \frac{length}{2}.\frac{\omega.\mu_0}{2.\pi}.\left(\frac{1}{2}\ln\left[\frac{(S+S_1)(S-S_1)}{S_1^2}\right] + j\frac{\sqrt{3}}{2}\ln\left[\frac{S-S_1}{S+S_1}\right]\right) \text{.....[V]} \quad (2)$$

And for the second half length:

$$E_2 = \frac{length}{2}.\frac{\omega.\mu_0}{2.\pi}.\left(\frac{1}{2}\ln\left[\frac{(S-S_1)(S+S_1)}{S_1^2}\right] + j\frac{\sqrt{3}}{2}\ln\left[\frac{S+S_1}{S-S_1}\right]\right) \text{.....[V]} \quad (3)$$

Adding (2) and (3) results in the total induced voltage along the length:

$$E = E_1 + E_2 = length.\frac{\omega.\mu_0}{2.\pi}.\ln\left(\frac{S^2 - S_1^2}{S_1^2}\right) \text{.....[V]} \quad (4)$$

Mathematically, the induced voltage can be zero if:

$$S_1 = \frac{\sqrt{2}}{2}.S = 0.7S \text{ .....[m]} \quad (5)$$

This is shown graphically in Figure 1 below:

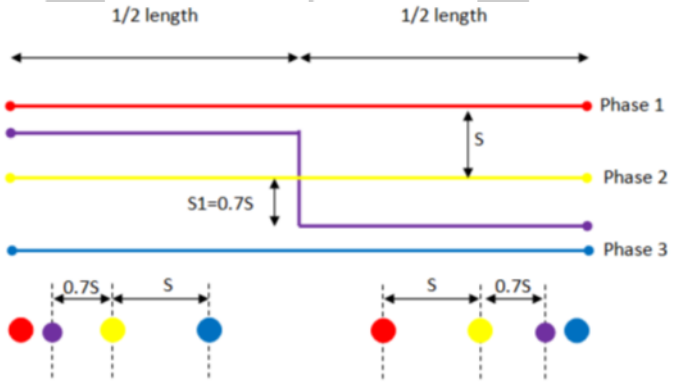

Figure 1: Positioning of the insulated ECC for induced voltage cancellation.

Practically, the most convenient placement of the ECC is on the inside of the outer phase conductor cable

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3 Conclusion

The circulating current on bare Copper ECCs will cause additional losses, mutual heating within the HV cable thermal environment and elevated corrosion risk and hence is strongly discouraged by CBI-electric: african cables.

Clause 3.3 of Electra No. 28 (Pg. 63) also recommends the use of an insulated ECC stating: "*The parallel earth continuity conductor is usually insulated so as to avoid any corrosion risk and it will be subject to voltage induction from the power cables in the same way as any other parallel conductor.*"

4 References

Working Group 07, Study Committee No. 21 Specially Bonded Cable Systems. 1973. "The design of Specially Bonded Cable Systems." *Electra No. 28* 55-81.