Comparison of Transient Overvoltage Distribution in Sectionalized Joints of 220 kV vs 66 kV Cable Systems

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ABSTRACT

The fast transient overvoltages between metallic screens of the sectionalized joints, as well as the voltage distribution between each metallic screen with respect to earth, depend on the chosen surge voltage limiters, the type and length of bonding lead cable used to connect them and the design of the sectionalized joint itself. This article presents the analysis of the overvoltage distribution on a 220 kV cable system supported by tests and a comparison analysis is done between the results coming from these tests and the results obtained for a 66 kV cable system tested in a previous test campaign [1].

KEYWORDS

Sectionalized joint, cable metallic screen, fast transient overvoltage, surge voltage limiter, link-box, bonding lead cable, lightning impulse.

INTRODUCTION

The protection of the insulation against fast transient overvoltage in sectionalized joints used in high voltage cable systems is carried out by means of Surge Voltage Limiters (SVL) placed in the link-boxes. The selection of the SVL is performed according to the maximum temporary overvoltage that can appear in the cable metallic screen [2] and must be coordinated with the type and length of the considered bonding lead cable. Unipolar bonding lead cables reach higher overvoltages in sectionalized joints than coaxial ones, due to their higher per unit inductance. This negative influence is accentuated with longer lengths of the unipolar bonding lead cable between sectionalized joint and link-box [1] and its layout.

In addition, the voltage distribution between sectionalized metallic screens on joints is different depending on the joint arrangement: cross-bonding system, where the metallic screen of each side of the joint is connected to a SVL, or single-point system, in which the metallic screen of one side of the joint is connected to a SVL and the other side is directly connected to earth.

Analytical equations for the transient overvoltages were deduced in [3], in which formulas to determine the overvoltage between metallic screens of sectionalized joints were presented for different cases.

The work reported here is an extension of a previous test campaign carried out for a 66 kV cable system [1]. New tests were conducted for a 220 kV cable system and the analysis of the obtained overvoltage distribution is presented. The main influence factors, as the type of bonding lead cable and their length have been considered. The effect of using SVL of different rated voltage to achieve an appropriate limited overvoltage at each metallic screen has also been taken into account.

In addition, a comparison analysis between the 220 kV and the 66 kV cable systems is done.

ANALYSIS OF OVERVOLTAGE DISTRIBUTION ON SECTIONALIZED JOINT

The overvoltages between sectionalized metallic screens and the metallic screen and earth on joints can be calculated by formulas (1) to (3) introduced in [3]

$$U_{ss\_c} = 1.035 \cdot \left(n \cdot U_{res} + \frac{\beta_0}{(1+PM_c)} \cdot \frac{L \cdot L_b}{Z_1} \cdot \frac{BIL}{\tau} \right) \quad (1)$$

$$U_{ss\_u} = n \cdot U_{res} + \frac{\beta_0}{(1+PM_c)} \cdot \frac{L \cdot L_b}{Z_1} \cdot \frac{BIL}{\tau} \quad (2)$$

$$U_{se} = K_{emp} \cdot U_{ss} \quad (3)$$

Where:

- U_{ss}: overvoltage between metallic screens on the sectionalized joint (subscripts *c* and *u* for coaxial and unipolar bonding lead cable, respectively).
- U_{se}: overvoltage between metallic screen and earth on the sectionalized joint.
- K_{emp}: voltage distribution factor.
- *n*: units of the SVL to be considered (*n=2* for cross-bonding and *n=1* for single-point).
- U_{res}: residual voltages of the SVL.
- L_b: inductance per unit length of the bonding lead cable.
- *L*: length of the bonding lead cable.
- Z_1: characteristic impedance of the power cable.
- *BIL*: insulation level at lightning impulse.
- τ : front time of a standardized lightning impulse.
- PM_c: minimum protection margin (p.u)
- β_0 is the transmission coefficient of the lightning impulse from the overhead line to the power cable.

In order to take into account, the relationship between the actual inductance per unit length of a generic bonding lead cable and an ideal connection using a coaxial bonding lead cable (inductance per unit length $L_{b\text{-}coax}$) a factor k_s is considered. This factor depends on how the sectionalizing joint is designed and also the way the bonding lead is connected to the sectionalized metallic screens (directly or by means of additional unipolar cables) and the type of the