Reduction Factor

Electromagnetic protection of telecommunication lines

INTRODUCTION

The electromagnetic protection of telecommunication lines is increasingly critical because of the expansion and raise of perturbation sources and the broad use of power electronics.

One may discern the perturbations stemming from energy distribution lines and those from other sources, e.g. from thyristors' locomotives. This note does not address the issue of protecting cables against lightning.

Generally speaking, the perturbation voltages are created by electrical or magnetic fields. In the case of cables with grounded conductive material armouring, the perturbations are induced by magnetic fields.

The main protection means are :

- Measures on the perturbing source (locomotive, power line, etc…)
- Measures on the cable armouring

The later is addressed here.

THEORETICAL BASES

The calculation of induced voltages requires to know :

- The geometry of the inductive and induced lines.
- The electrical resistivity of the soil.
- The "reduction factor" of the elements surrounding the lines under consideration. This factor has to be determined experimentally and its value K is between 0 and 1.
- The perturbing current, its frequency and waveform.

Knowing the induced perturbing voltages (E_{23} in V/km), one can determine the voltage induced on the conductors (E_{12} in V/km) taking into account the reduction factor (or protection factor) of the cable sheath.

This factor is a specific attribute of the considered cable and is defined by :

$$rk = \frac{\text{longitudinal induced voltage on protected conductor}}{\text{longitudinal induced voltage on unprotected conductor}}$$

$$rk = \frac{\text{E12}}{\text{E23}}$$

The measurement of the correction factor is a representation of the steel permeability of the sheath. It varies with the induced voltage and its frequency. The optimization challenge requests to find the minimum factor for a given frequency.

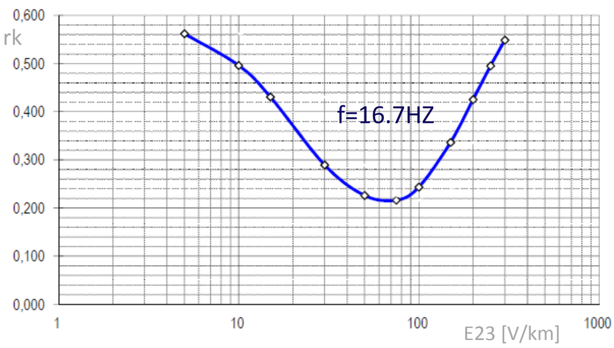

Fig 1 Example of test result

MEASURING PRINCIPLE

The measurement of reduction factor in laboratory is described in the standard DIN 57473.

A current is injected in the cable sheath and the voltages induced in the conductor are measured according to the following schematics :

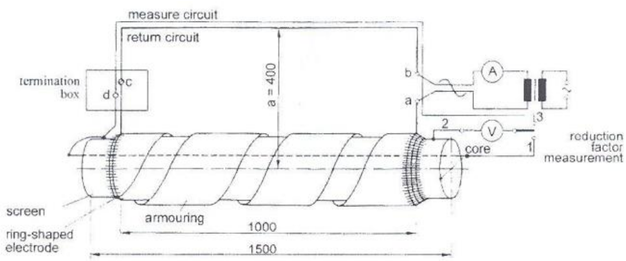

Fig 2 Schematics of the measuring circuit

In order to obtain comparative results between laboratories, some precautions need to be taken :

- The distance a between the loop conductor and the cable under test does not give a fixe inductance, since this depends also on the diameter of both conductors.

Using a loop with variable distance *a* is then recommendable if one wants to use the reduction factor to determine the permeability of the steel. Indeed, it allows establishing the hysteresis curve of the steel after manufacturing. The goal is to check the manufacturing of different types of armourings. If one wants to realize comparisons to optimize the sheaths, the accuracy of measuring the reduction factor needs to be better than 5%. This comparison will only be valuable if a loop is used with a reference inductance of 2mH/km.

- To ensure comparative results and an accurate measurement of the reduction factor, a precise description of sample design is mandatory. It simulates a 1km cable : its length must be accurate and its DC resistance should represent the 1km cable with an accuracy better than 1%.
- The section of the copper cord used to inject the current in the sample by surrounding the sheath must be sufficient to allow for a uniform distribution in it.
- For the measuring procedure, two precautions are advisable: de-magnetisation of the cable and fast measurement to avoid an heating up of the sheath which increases the reduction factor through the sample resistance.

Fig 3 PT 1000/PAS/UT Test fixture

TEST EQUIPMENT PT 1000/PAS/UT

The test equipment for the reduction factor as provided complies with the standards while taking into account the remarks here above.

It comprises a power unit, a control unit and a digital voltmeter. All are arranged in a 19 inches industrial rack and piloted by our software CIQ 3.0, which allows for an efficient reporting and traceability of the performed measurements. Using a database, it can also be interconnected with the main MES and ERP systems.

Fig 4 PT 1000/PAS/UT Central unit

Denis Milz, Senior Sales Manager, AESA Cortaillod

REFERENCES

- Standards DIN 57 472/473 (VDE 0472)
- Technical Bulletin of the cable factories of Brugg, Cortaillod and Cossonay