AC resistance measurements on skin-effect reduced large conductor power cables with standard equipment

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The increasing demand for HV/EHV cables with very high ampacity requires conductors having large cross sections. Furthermore cable conductor designs with low impact of skin effect become more and more relevant to minimize additional losses caused by the conductor AC resistance. For this reason improved conductors designs with special features e.g. additional insulation between the stranded wires, oxidised or enamelled wires are used in order to reduce the skin effect.

Actually the international standards IEC 60840 and IEC 62067 require the identification of cable characteristics. In terms of AC resistance the presence, if any, and nature of measures taken to reduce skin effect shall be declared. If so, one approach to do this is an ac-resistance measurement in order to verify the specified properties of the cable.

At the moment the measurement procedure is not standardized, but a generally accepted method to describe the behaviour of the skin effect and eddy current losses is the expression by the well-known ks-factor, as describe in the international standard IEC 60287

AC resistance measurements on full size cables produce plausible results, but the execution of these measurements are difficult to apply under practical conditions. Measurements on short cable samples are easier to execute, but they tend to be more sensitive regarding the measurement inaccuracy. The use of a suitable test set-up and adequate connectors as well as a general understanding of influencing factors are mandatory to understand and interpret measurement results.

To utilize the full abilities of reduced skin effect of conductors and to ensure the quality during production new measuring techniques are needed, which are both, easy to handle and good in accuracy.

Here, the used procedure is based on high-accuracy vectorial voltage-current measurement. The current flow is coaxial using the cable screen as the current return path, avoiding any cable-external magnetic field. Thereby, the proximity effect by the parallel conductor is excluded. By performing the AC resistance measurement with variable frequency it becomes possible to self-check the measurement results with data from calculations and other measurements. For instance a measurement with a frequency very close to 0 Hz deliver results that can be double checked with other equipment e.g. DC test apparatus.

This paper reports about progress and experiences of the development of a new and available measurement system in order to determine the AC resistance of cable conductors with large cross sections having a reduced skin effect.

Investigation results and plausible verifications show, that the new measurement system is suitable to use and determine the ac resistance respectively ks-factor.

The influence of cable screen constructions, e.g. screen wires or aluminium metal sheath, measurement set-up and conductor temperature have been investigated in the meantime. Measurements have been done in different configurations and show the influence of the mentioned influencing factors.

Studies about influence and behaviour of the magnetic flux inside and outside of the cable during the execution of a measurement back-up the results and are very useful for a general understanding.