Evaluation algorithm of zero-crossing damped temporary overvoltage measurement using universal divider

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ABSTRACT

New recommendations for testing DC extruded high voltage cable systems lead to new measurement issues. Concerning the zero-crossing damped temporary overvoltage, the waveform must be accurately defined over a wide range of voltage, going from 115% to 5% of the rated voltage. While it is quite simple to achieve a tolerance of 3% at rated voltage, it is more difficult to ensure this tolerance at 5% of the rated voltage. For such voltage amplitude, unwanted or parasitic effects may affect the measurement chain, which can finally lead to improper interpretations of the test results. In this paper, we focus on the behavior of real universal dividers, which are associated to a significative transient bias when subjected to such waveform. Those dividers can perform measurements over the full waveform, including both DC and transient components. However, while ideal universal dividers perform exact measurements without bias and variance, real dividers show a significative bias when changing from DC to transient state.

KEYWORDS

Cable system testing, measurement, universal dividers, TOV, damped AC

INTRODUCTION

Increasing needs for renewable energy require power transmission over long distances with high power density. As the distance between the energy source and consumption centers can reach hundreds of kilometers, a fault occurring on an Extra High Voltage Direct Current (EHVDC) will induce transient oscillations named zero-crossing damped temporary overvoltage as per Cigré recommendation TB 852 [1]. The oscillating frequency of such transients depends on the fault location.

According to Cigré TB 852 [1] test procedure for zero-crossing damped temporary overvoltage, the applied stress must be accurately measured over a wide range from 115 % to 5 % of the rated voltage with a tolerance of 3 %. While measurements at 115 % of the rated voltage with a tolerance of 3 % poses no difficulties, parasitic effects and tolerances from the measurement chain may not be negligible at 5 % of rated voltage and thus lead to improper interpretations or even false validation of the test results.

We propose in this paper a numerical algorithm for the zero-crossing damped temporary overvoltage measurement evaluation performed with universal dividers. It is based on a theorical approach of damped oscillating circuit as well as a careful description of universal dividers during transition between DC to transient state.

MEASUREMENT OF TOV WITH REAL UNIVERSAL DIVIDER

Ideal and real universal divider

Those dividers can be used to perform measurements over a wide bandwidth, from DC to several of MHz. Basically, universal dividers are made with two parallel measuring branches and two main stages. The upper stage holds the high voltage, while the lower stage performs the measurement [2]. A first branch, made with capacitances, is adapted to fast transient waveforms, and a second branch, based on resistances, is suited to very low frequency waveform. The cutoff frequency at which one of the branches (capacitive or resistive) gives the main measurement depends on the values of the resistances and the capacitances of the divider through a RC constant time. In other word, signals with time constant slower than the divider time constant τ=RC involve mainly the resistive branch, while signals with time constant greater than τ involves mainly the capacitive branch. Typical universal divider time constants are about hundreds of milliseconds.

While ideal universal dividers are able perform exact measurements independently of the shape of the waveform (i.e., time constant), real dividers show differences in the measurement according of the input signal and the setup conditions.

Amplitude and shape biases

First, a measurement bias affects the amplitude of the signal. Real dividers are indeed associated to different ratio according to the waveform (LI, AC, DC), which are the result of discrepancies of the capacitances and resistances ratio in both branches. The use of different ratio allows correct measurement for different type of waveform if they are performed independently. Stray capacitance along the HV part of the divider may affect the measurements quality because it changes the capacitive branch ratio. In the same way, temperature also slightly changes the resistance values, and finally the ratio of the resistive branch. All these features, due to intrinsic characteristics of the divider, and test setup considerations, cannot be avoided, but may be corrected with adjusted ratio. The deviation with an ideal divider may be evaluated with the relative difference between DC and LI ratio/ It is typically about some precents.

Measurement bias may also affect the shape of the signal when both branches of the divider are involved (resistive and capacitive) into a specific temporal window. This situation occurs for composite waveform, but generally, this problem is not important. For example, in the case of superimposed waveform, the LI/SI ratio is used the evaluate the impulse characteristics, but a slight error may be observed on the initial DC value, because the curve evaluation is performed with the LI/SI ratio. Moreover, because the SI time characteristics is fast in comparison to divider time characteristics, the shape of the signal is not affected significantly. UD time constant is typically