Processing Methods for Comparing Chopped Waveforms in Impulse Transformer Tests

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***Abstract* — This paper analyzes different methods to evaluate the response of transformers in impulse tests. Comparison between full voltage and current waveforms and reduced ones uses processing algorithm to get the best adjust, which has difficulties under chopped waveforms. Measurements with different chopping times are presented, comparing the quality of the adjusting processes.**

Keywords — Power transformer, test, evaluation, measurement, high voltage.

I. Introduction

Dielectric tests in power transformer are usually done at factory to prove that the transformer fulfills specifications. Impulse tests simulate the strain that the transformer receives under lighting storms. For this test, it is used a voltage source with a fast rise time that reaches its peak value at 1.2 µs and then decays slowly, reaching the 50% of the peak value at 50 µs as shown in Fig. 1 (red line). Other waveform mentioned in the standards [1], [2], and used as a voltage source for tests, is the chopped voltage. It is similar than the previous one, but chopped in a time between 2 µs and 6 µs as shown in Fig. 2. This last waveform occurs during lighting storms if a flashover is produced in a device near the transformer. Different voltages are applied as stated in the standards; some full-level (100% to 110% of the nominal peak voltage) and some reduced-level impulses (between 50% and 75%). The input voltage is recorded as well as some currents at non-tested bushings (blue lines in Fig. 1 and Fig. 2).

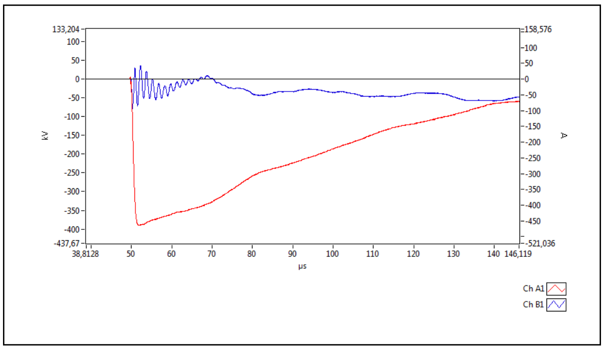

Fig. 1. Typical waveforms in full-length impulse transformer tests, Red: voltage, Blue: current.

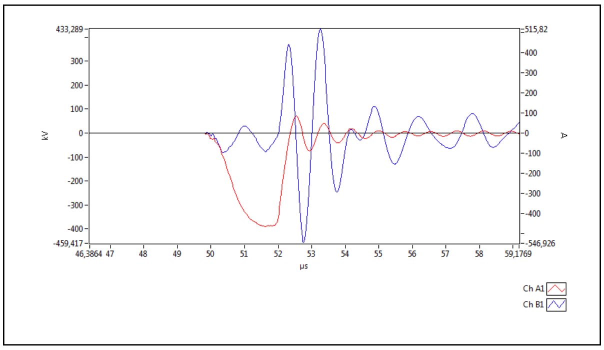

Fig. 2. Typical waveforms in chopped impulse transformer tests. Red: voltage, Blue: current.

The transformer fulfils the test if voltage and current records, at reduced-level and full level, have the same shapes. Any significant difference may be considered as a failure. Traditionally, the comparison was made by visual inspection of photographs directly taken from the oscilloscope screen. Nowadays, modern oscilloscopes and computers allow digital processing to superpose waveforms [3].

II. CHOPPED TEST

To superpose two waveforms taken from the full and reduced levels of the test, some adjustments must be done. First, the amplitude must be adjusted. The voltage of those tests may differ in a ratio 2:1, so that a constant must be calculated to fit both voltages amplitudes as well as possible. The second adjustment is related to the time shift between both waveforms. A very low time shift may produce a large difference between curve records. If the comparing waveforms have exactly the same shape, i.e. the transformer fulfill the test, the adjustments could be easy to perform for the comparing algorithm. However, if any shape difference exists, the adjustment may be bad and difficult to decide if there is a failure or not.

With chopped waveform, another difficult appears. A main assumption is that the generator must produce the same waveforms when the voltage is changed between reduced and full levels. This is generally true for full-length waveforms, but for chopped ones it is difficult to get exactly the same chopping time between the full-level and the reduced-level waveforms. Differences of tenths of microseconds may cause significant differences between full and reduced-level current waveforms that can be interpreted as a failure in the transformer. This behavior is well known, as referred in many standards [2], [4]. These time differences are due to the chopping device. Fig. 3 and Fig. 4 show an example. There is a time difference of 1.3 µs at the chopping time between both figures. In these cases, it is not clear how to make the comparison between the voltage and current waveforms of each figure. A simple comparison method consists to shift in time one of the waveform pair (voltage and current) to adjust first the front part, up to the chopping time, and then the last part of the waveforms, from the chopping time to the end. In this example, this comparison technique works well because the current waveforms in Fig. 3 and Fig 4. decays to zero very quickly, before the chopping time. However, there are cases where this simple comparison method fails. Fig. 5 shows an example. There is a chopping time difference of 1.5 µs that is a similar value than the previous example. Nevertheless, the current responses are so different that the curves cannot be superposed by shifting in time one of them. A more sophisticated comparison method has been proposed for cases like this in a previous work [5]. Its effectiveness depends on the transformer response and the chopping times.

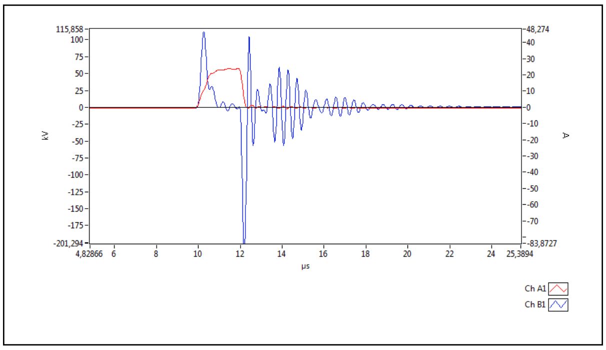

Fig. 3. Chopped waveform at 2.3 µs. Red: voltage, Blue: current.

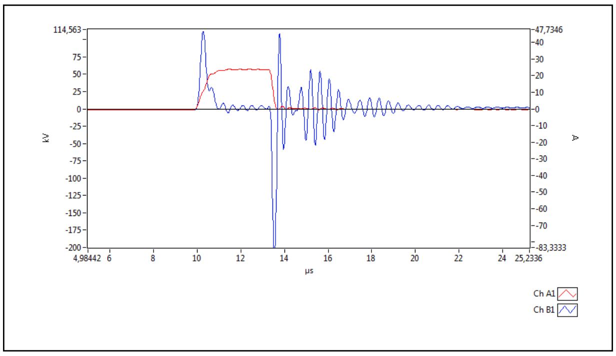

Fig. 4. Chopped waveform at 3.6 µs. Red: voltage, Blue: current.

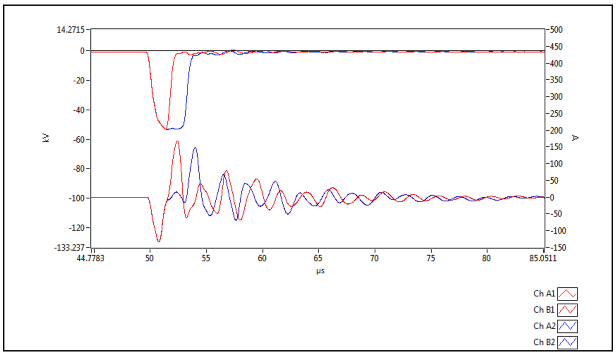

Fig. 5. Impulses with 1.5 µs of chopping time difference.

III. EVALUATION OF DIFFERENT METHODS FOR CHOPPED WAVEFORMS COMPARISON

The difficulty for generating reduced and full-level chopped waveforms with the same chopping time is still a practical issue for many laboratories that perform impulse tests on transformers. Because of theses, different practices and methods are applied in order to make comparison of full and reduced-level waveforms chopped at different times. Nevertheless, there is no evidence of the accuracy of these methods under different conditions.

An evaluation of the accuracy of different algorithms tested on many power transformers at different chopping times will be shown at the conference. This information will be valuable to compare algorithms and decide whether small differences are due to internal failures or due to the comparing method.

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