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QUESTION N° : Q5

Experience and challenges from zero crossing damped temporary overvoltage test on 525kV cable according to TB852

Slide 1

TB852 issued in November 2021 defines three new tests to temporary transient overvoltages

1. Very slow front temporary overvoltage (TOV)
2. Very slow front temporary overvoltage with chopped tail (chopped TOV)
3. Zero crossing damped temporary overvoltage

At SuperGrid Institute we have carried out the latter test according to the TB852.
The test object was a complete 525kV HVDC cable system and consisted of a 2500mm² cable with a range of accessories, including 2 joints and 2 composite sealing ends. (photo)

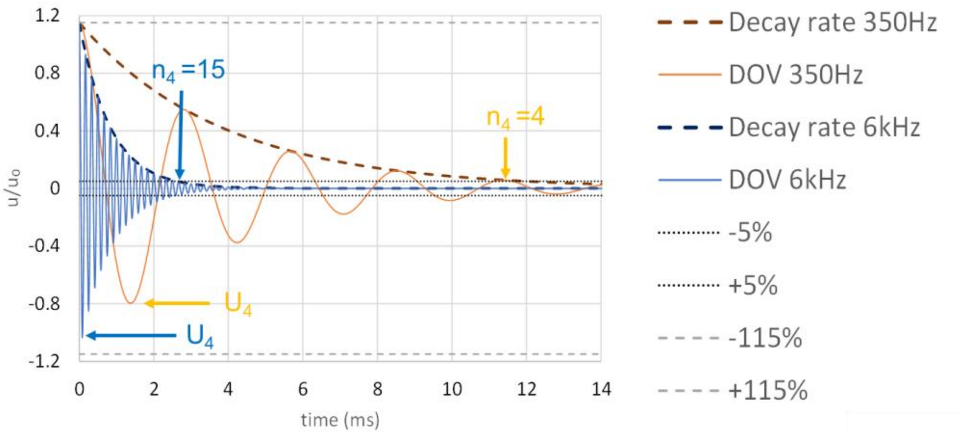
The aim of this contribution is to share our experience with the test, give feedback on of definition of test criteria and share the challenges in measuring transient over voltages that need to be taken into account.

Slide 2

The zero crossing damped temporary overvoltage test was preceded by preconditioning load cycles and it was decided to test for both a lower and a higher frequency

- ~5.7kHz (±5%) with n_4 = 15 (negative and positive)
- ~350Hz (± 50Hz) with n_4 = 4 (negative and positive)

The actual frequencies were 5.56kHz and 362Hz respectively. Exact frequency cannot be predetermined 100% and may vary according to cable design, cable length and temperature. We believe very important that TSO and cable manufactures define a frequency range or clear limit to be achieved.
In this case it had been decided on ±5% for 5.7kHz target and ±50Hz for 350Hz target.

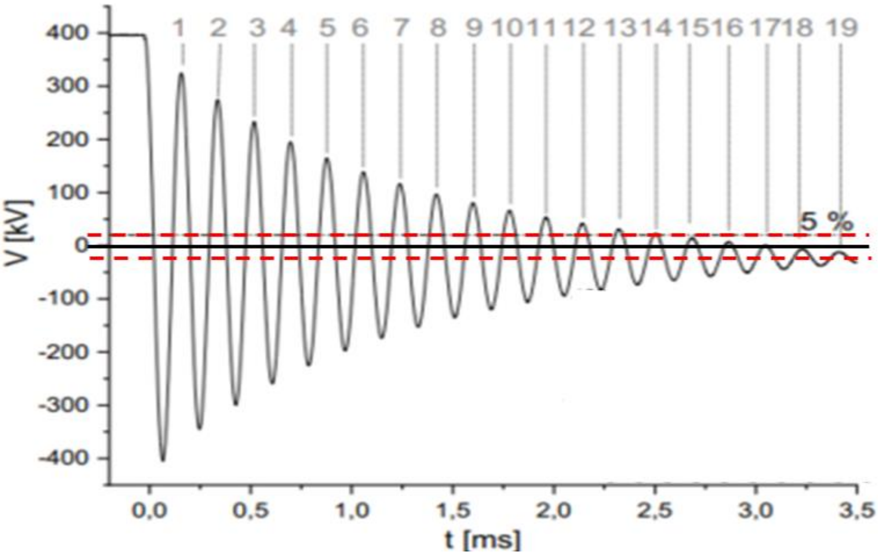


When observing targeted attenuation curves for the tests, one understands that

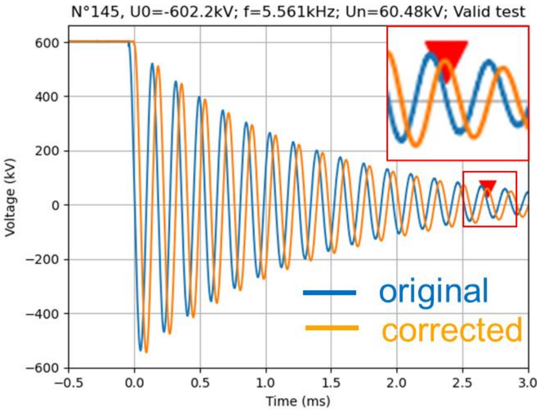
- Defining n_4 as *“number of zero crossing damped temporary overvoltage oscillations before peak voltage falls below 5% of DC voltage”* leaves very little margin for error if one aims at reaching 5% with an exact number of oscillations.
  ➔ We recommend that parties understand that the defined n_4 is a minimum to reach during test.

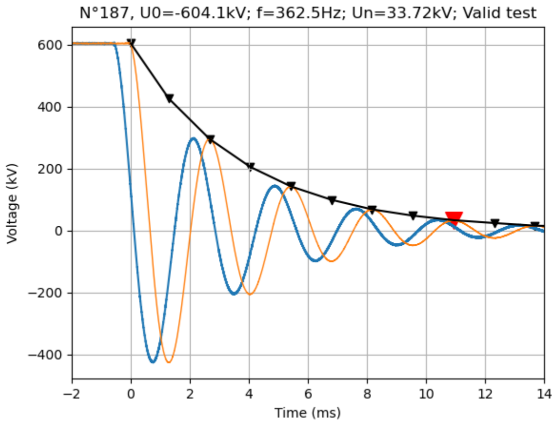
- The decay rate for the 350Hz DOV test is much lower than that on the 6kHz test, however TB852 defines range of approval as cable systems having lower frequency (f_4) AND lower first opposite oscillation peak value U_4 AND lower n_4 than those of the tested cable system, meaning basically systems with lower frequency and a higher decay rate than the tested system. Hence a test at 6kHz with n_4 = 15 does not cover a requirement for 350Hz with n_4 = 4
  ➔ We recommend that a cable system is tested moth at both a high frequency and a lower frequency with a well specified n_4 for each frequency.

Slide 2
During development test (lower left figure) it was observed that the measured voltage did not oscillate around zero, but around a value slightly offset from zero. This is due to the design of the universal (R-C) voltage divider. Simulations of the circuit taking into account the measurement device as well as the dividers internal capacitors and resistors, confirm this offset.



Further to post-processing each curve of the measurement (right curves), we observed that the offset was in range of 1% - 1.4% for the higher frequency and 0.3% for the lower frequency and for each curve a correction was applied in order to evaluate U_4 and n_4 correctly.
As the pass/fail criteria is based on n4 having a peak voltage of >5%*U_0 an offset of 1% represents 20% of the criteria value and if not corrected could result in validating curves that should not be validated, hence disqualifying the test.





➔ We recommend that post processing is performed on data before validation of the 10 shots.

It is equally understandable that it is not possible to guarantee that peak voltage for n_4 > 5% and at the same time have peak voltage for n_4+1 < 5% - especially when number of oscillations becomes higher.

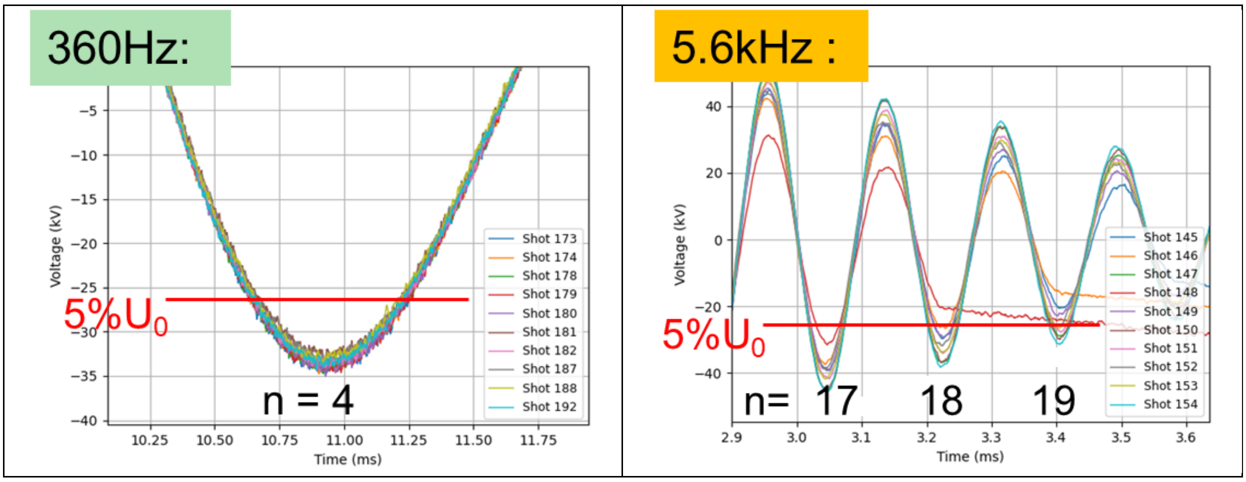
➔ We recommend in the test protocol to define n_4 as a minimum number in order to avoid confusion when comparing with the definition of n_4 in TB852.

Slide 3

When plotting all 10 shots for each frequency we observe that

- Variations in peak values are very small for first oscillations and grow with number of oscillations..
- There is little variation in attenuation for f_4 = 360Hz (less than 5% for U4)
- There is important variation in attenuation for f_4 = 5.6kHz (more than 25% for U15)
- Number of oscillations above 5%U_0 varies for f_4 = 5.6kHz (n_4 between 17 and 19)

It is equally observed that oscillation may in some cases extinguish during the tail of damped oscillations.



➔ We recommend to

- Define n_4 as minimum
- Aim for peak value of >> 5% U_0 at targeted oscillation number, n_4