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Protection of the Transformation Stations Against the Atmospheric Overvoltages

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Abstrat: The electric constraint limitation everywhere where they produce is himself a very important asset for a natural tendency toward economy, that wat conduct to choices intervening directly on the constituent materials measurements of the électro-energizing protection systems. In a paradoxical context, the Corona effect plays a beneficial role for a better stake in œuvre of electric work protection means.

Key words: Overvoltage, effect crowns, thunderbolt, protection, HT line

INTRODUCTION

All electric energy transport network to middle and big distances are exposed to impacts of the known natural and mysterious phenomenon at any time by the thunderbolt.

Once the impact took place, an overvoltage under shape of a shock wave normalized like one of the most dangerous electric constraints on the Electro-energizing systems, propagates itself the long of the line as generating a quantity of loads additives that will have a considerable influence on the general aspect of line sits of the thunderbolt, this supplement of loads around the driver actually represents the phenomenon of corona effect.

Overvoltages of thunderbolt: The protection of networks of electric energy transport against the atmospheric overvoltages present indeed an unavoidable priority for a électrotechnicien whot wants to contribute to the coordination of isolations and the electromagnetic compatibility.

The external overvoltages known as enormous electric discharge due essentially to the thunderbolt, come either from a direct impacton an electric system or by influence or induction of the environment sits of the thunderbolt where it is going to provoke the transit of a current of shock that can reach 300 kAs and an overvoltage of kV thousand expressed by:

$$U_f = Z_C I \; ; \; [\text{Kv}]$$

Z_C: is the composed characteristic impedance by the line and soil.

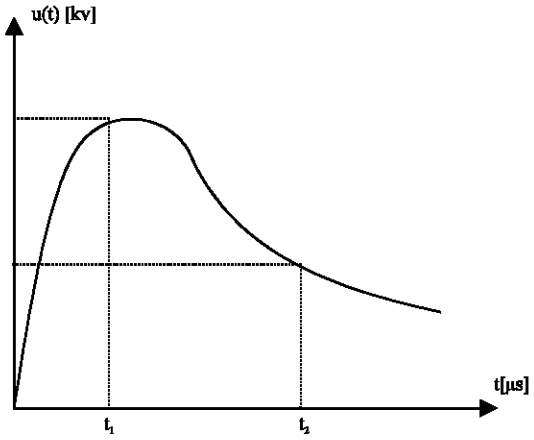

Fig. 1: Wave of normalized overvoltage

This overvoltage is normalized by a wave of type shock 1,2/50 mses Fig. 1 and suggests a

Bi-exponential mathematical expression:

$$U(t) = U_o[A\exp(-\alpha t) + B\exp(-\gamma t)]$$

Duration of the forehead: T1 = 1,2±S 0,36 µses
Duration of the queu (mi-value): T2 = 50±S 10 µses

The increase of the intensity of the electric field around the driver seat of the impact, is a fatal consequence of the abrupt increase of the tension of the line provoked by this overvoltage.

To a certain level of the electric field, the birth of a complex phenomenon called,: Corona effect, will have place.

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The corona effect transient: In the scientific mind of researchers and specialists in domains of isolation coordination and the electromagnetic compatibility, the Corona effect shows all the phenomena bound to the apparition of a conductivity of gas in the environment that surrounds a driver carried to High tension, this conductivity is due to the phenomenon of ionization provoked by the existence in the air of a certain number of ions+ pair and free electrons created by cosmic radiance.

When these electrons are submitted to electric fields, they are accelerated and if these fields are intense the energy that they acquire becomes sufficient to provoke the neuter molecule ionization that they are also going to ionize other molecules and so forth the process takes the pace of an avalanche, so that this process can maintain itself. It is necessary that this pace reaches a criticized size and that the apparition field of Corona effect has a sufficient value to the drivers neighborhood.

All expressions of the criticized apparition field of Corona effect found in the literature of électrotechnique have the following shape:

$$E = E_0\left(1+\frac{A}{R^B}\right)\ [Kv/cm]$$

the more used are often:

- The famous empiric law of Peek[1]:

$$E_c = E_p.m.\delta\left(1+\frac{K}{\sqrt{\delta r}}\right)$$

$$E_c = 31\frac{3,92P}{273+t}m\left(1+\frac{0,308}{\sqrt{\frac{3,92P}{273+t}r}}\right)$$

P: Airpressure in Hg cm
m: Coefficient of the driver's surface state.
r: The driver radius

- In the precise atmospheric conditions one can use the formula of Hartmann[2]:

$$E_c = 2,594.10^6\left(1+\frac{0,1269}{r_i^{0,4346}}\right)$$

INFLUENCE OF THE CORONA EFFECT ON LINÉIQUESES PARAMETERS OF THE LINE

Before the apparition of the corona effect the quantity of load around the driver is solely capacitive and is linear according to the applied tension: q(t) = C.U(t)
if U_1 are the corresponding doorstep tension to Ec
Cg: Is the geometric capacity of the line

For $U < U_1$: qg = Cg.U
For $U = U_1$: q = qg+qesp = Cg.U+qesp

q_{esp} shows the supplementary load quantity in the space due to the corona effect and is a non-linear function of the applied tension and its derivative (dq/du).

The relation between the load of a driver and its capacity (C = q/U) implies that this variation in the quantity of loads around drivers, drag a variation of capacity linéique of the line that translates itself by an expressed obvious capacity automatically by:

$$C = Cg+\Delta C$$

ΔC is the additional capacity that gives direct account of the corona effect.

From the famous experimental tests of M[r] Claude Gary with laboratories of the EDF translated by several cycles of load q = f(U) Fig. 2 and without going in in detailed mathematical analysis one can deduct the following expressions:

$$q = UC_g + (U-U_1)(C_1-C_g) + (U-U_2)(C_2-C_1)$$

$$C = C_g + (1-\frac{U_1}{U})(C_1-C_g) + (1-\frac{U_2}{U})(C_2-C_1)$$

C_1 and C_2 are the corresponding additional capacities to voltages U_1 and U_2

Influence of the corona effect on the propagation of overvoltages: During its propagation, the wave of shock of thunderbolt overvoltage accompanied by the effect crowns horizontally transient undergo important distortions in its shape and vertically the long of drivers line.

A reduction of the overvoltage amplitude as well as a distortion of the forehead of brought up of wave; this hypothesis provokes in our mind that the idea of this bilateral amortization generates a beneficial effect, in a sense that it reduces constraints that propagate themselves toward the electric stations.

The attenuation by dissipation of energy: From the moment where the impacte of the thunderbolt will take place on the line, the quantity of loads around the driver increases according to the applied electric field. The movement of loads (free electrons) in the space that surrounds the driver seat of the corona effect accelerates itself more and more and provoking severe rub and collisions among particles of loads, this situation causes a heat release and the luminous beams, we can speak then of a dissipated energy the long of the propagation expressed for a cycle of loads by[3] Fig. 3.

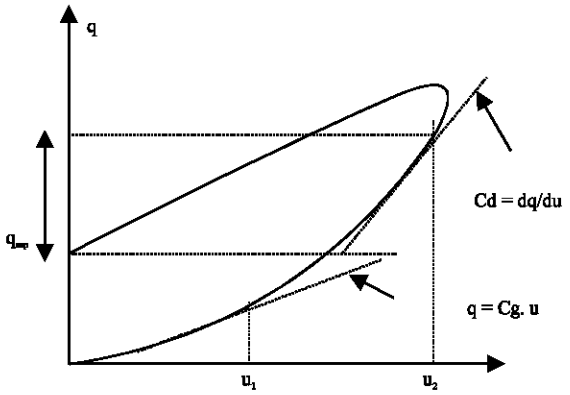

Fig. 2: Cycle of load q = f(u) gotten of tests of C.Gary to laboratories of EDF

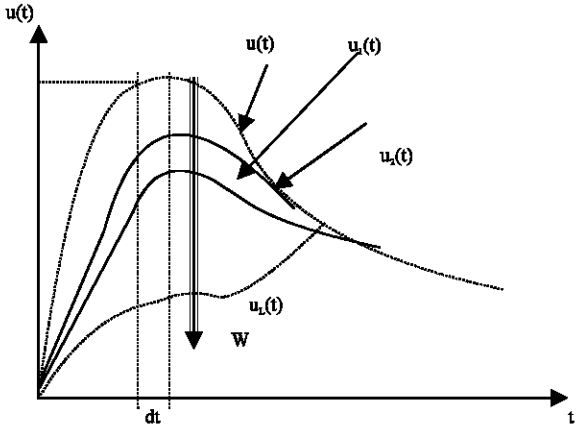

Fig. 3: Attenuation of propagation bythe dissipation energy

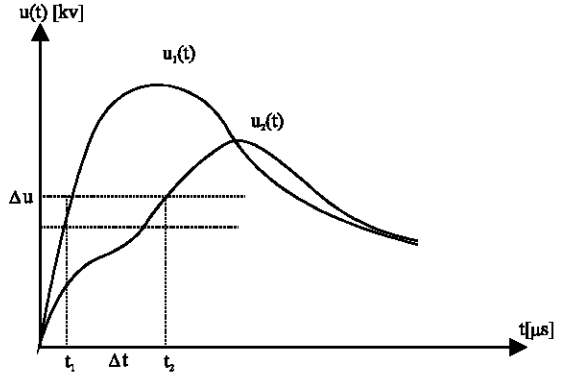

Fig. 4: Distortion of propagation by delay of propagation

$$W = \int_{cycle} Udq = \frac{1}{Z_C}\int_0^{\infty} U^2 dt$$

Zc is the characteristic impedance of the line that holds in account the corona effect.

For more calculation the dissipated energy, we propose to linearised the U(t) wave in two points of the line where it propagates xo and x_1 ($x_1 = x_o + \nabla x$), the dissipation of heat is worth then:

$$W = W_{X_1} - W_{X_0}$$

$$W = \frac{1}{Z_C}\int_{X_0}^{X_0+\nabla X}\left[U^2_{x_1}(t) - U^2_{X_0+\nabla X}(t)\right]dt$$

$$Z_C = \sqrt{\frac{L}{Cg + \nabla C}}$$

For more realization, it is preferable to establish an example of practical calculation as for a propagation of 3 km of a wave of 850 kV overvoltage to the point of impact.

Distortion by delay of propagation of the forehead wave: The analysis of the propagation the length of the electric line of an electromagnetic wave is based in the first place on equations applied telegraphists to an element dx of the line:

$$\begin{cases} \frac{du}{dx} = L\frac{di}{dt} \\ \frac{di}{dx} = C\frac{du}{dt} \end{cases}$$

besides dq/dt is only a capacity that wi will call dynamic capacity Cd variable according to U and given by the instantaneous slope of the cycle Fig. 2; it is always superior to Cg. In writing then the system:

$$\frac{di}{dx} = C_d\frac{du}{dt}$$

it's a solution defines the propagation speed:

$$v = \frac{1}{\sqrt{LC_d}}$$

The sudden distortion by wave Fig. 4 during ∇x (= x2-x1), presents itself as if every slice of its pace moves with a speed different from the other and lower to the light speed generally supposed $c = 3.10^8$ m s^{-1} as the initial speed of the wave to the impact.

This speed depends on the instantaneous capacity on dynamic C_d in presence of the corona effect and impties the delay of propagation of the forehead wave. ∇t characterizes the distortion and can be expressed:

$$\nabla t = t_{x2} - t_{x1} = \nabla X\left(\frac{1}{v_{x2}} - \frac{1}{v_{x2}}\right) = \nabla X\left(\frac{1}{v} - \frac{1}{c}\right)$$

v: is the speed of propagation after a ∇x course and depends on the new lineique parameter influenced by the corona effect.

INTERPRETATION

The numeric applications on the previous literal results, show that an atmospheric overvoltage wave distorted itself during its accompagnied propagation of the corona effect so: that her its forehead (t_f = 1,2 μs to the origin) is only 3,5 μs after 3 km of propagation and is 8 μs after 10 km whereas attenuations in amplitude the wave falls to 63% of its crest value to the origin after 3 km and to 30% after 10 km.

A: The amplitude of the constraint whole affecting stations.
n: The total number of constraints and ΔA is a reduction of the constraint amplitude

CONCLUSION

To the arrival of the transformation station, the wave of overvoltage is distorted completely favorably in the interest of the whole of the electric isolation coordination in general, so long as this distortion caused by the corona effect participates directly to the reduction of electric constraints Fig. 5, what permits us the opportunity to review and reoptimiser the conception and the dimensionnement of protection devices.

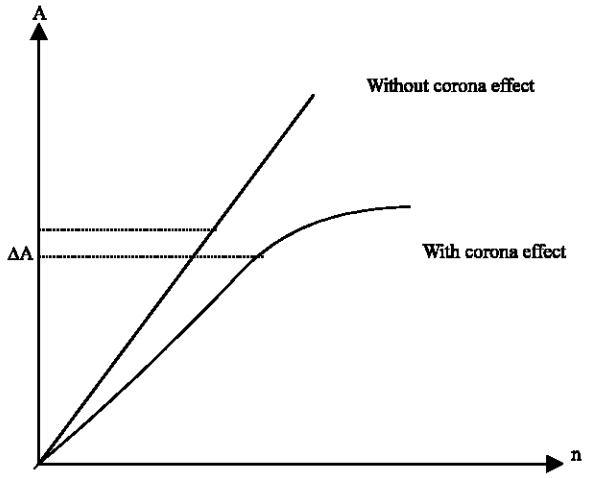

Fig. 5: Reduction of the constraint amplitude caused by the corona effect

In conclusion, the consequences of the study of the influence of the corona effect on the propagation of Thunderbolt overvoltages are a considerable improvement in research in electric constraint matter affecting the électro-energizing works and by following, to foresee a better given out in œuvre of protection systems.

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