DETERMINATION OF THE NEW MODEL PARAMETERS TAKING INTO ACCOUNT THE CORONING OF THE ELECTRICAL TRANSMISSION LINE WIRES

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Abstract

In given work the results of development of the specified corona model for calculation of its influence on the wave processes in multiwires line and determination of its parameters are submitted. Results of obtained calculation equations are brought for Electrical Transmission Line (ETL) with allowance for superficial effect in the ground and wires with reference to developed corona model.The method developed in Institute of Physics of Azerbaijan Academy of Sciences and passed an evaluation test at modeling of superficial effect in the ground and wires was used for increasing of accuracy of the corona frequent characteristics modeling.

1. Introduction

The novelty of a developed method consists in following. At first, the parameters $r_1 - r_3$, $C_1 - C_3$ are determined using the corona model consisting the three parallel branches r, C, without an additional connected element g which is necessary at capacities discharging during the time from corona extinction up to it next ignition. Further, by replacing one branch (for example, branch r_3,C_3 into two or three branches r, C) the parameters of new elements determined. This process proceeds until necessary number of branches of the frequent characteristics ensuring concurrence of model and simulated object will be obtained. After determination of branches number and parameters of model the element g is connected to it. The value of element g is determined by a variation method.

2. Determination Of The New Model Parameters Taking Into Account The Coroning Of The Electrical Transmission Line Wires

For determination of parameters characterizing the real ETL coroning the various formulas are offered. Below the most frequently used formula [1][2] is brought:

$$G = 0{,}83\left(\frac{f}{50}\right)^{0,62}\left[1 - e^{-3,05\left(\frac{UM}{UH}-1\right)}\right], \frac{1}{\text{MOhm}\cdot\text{km}};$$

$$C = 2{,}4\left(\frac{50}{f}\right)^{0,42}\left(\frac{U_M}{U_H} - 1\right)\cdot 10^3, \frac{pF}{km},$$

(1)

Here G, C are the additional conductivity and capacity of a line at certain frequencies and voltage; f is the frequency, Hz; U_M/U_H is the overvoltage ratio.

By using of the given formula for calculation of wave processes in a required range of frequencies, it is possible to calculate the necessary corona parameters for a line.

At creating of model taking into account the wires coroning one of the basic conditions is agreement of total conductivity and capacity of model in a certain frequent range with conductivity and capacity obtained from (1). Such conformity is possible to express by the following formula (according to model fig. 1):

$$j\omega_\nu c_1 + \sum_{k=2}^{3}\left(r_k + \frac{1}{j\omega_\nu c_k}\right)^{-1} + g = G(\omega_\nu) + j\omega_\nu C(\omega_\nu),$$

(2)

Here c_1, $c_к$, $r_к$, g are parameters of model; $G(\omega_\nu)$,$C(\omega_\nu)$ are parameters of a line at certain frequency.

For determination of model parameters earlier in Institute of Physics the various formulas were obtained and error of model [3] is appreciated. At expansion of modeling range of overvoltage ratio increasing of parallel branches number caused to imposibility of parameters determination. The choice of additional elements' parameters by a variation method requires the large expenses of time, and in some cases becomes impossible.

3. Parameters Of The Line And Three Angle Model

The parameters of initial model are determined from the decision of the equation:

$$\sum_{K=1}^{3}(r_K + \frac{1}{j\omega_\nu C_K})^{-1} = G(\omega_\nu) + j\omega_\nu C(\omega_\nu) \qquad (3)$$

where $G(\omega_\nu)$, $C(\omega_\nu)$ are parameters of ETL at ω_ν (ν=1,2,3) for certain meaning of $u/U_з$.

From the formula (3) we shall obtain:

$$-[C_1(\chi_2 + \chi_3) + C_2(\chi_1 + \chi_3) + C_3(\chi_1 + \chi_2)] =$$
$$= \omega_\nu^{-2}G(\omega_\nu) - G(\omega_\nu)y_2 + C(\omega_\nu)y_1 + \omega_\nu^2 C(\omega_\nu)y_3 \qquad (4)$$

$$C_1+C_2+C_3-\omega_v^2[C_1\chi_2\chi_3+C_2\chi_1\chi_2+C_3\chi_1\chi_2]=$$
$$=G(\omega_v)y_1-\omega_v^2G(\omega_v)y_3+C(\omega_v)-\omega_v^2C(\omega_v)y_2$$

where

$$C_1r_1=\chi_1,\quad C_2r_2=\chi_2,\quad C_3r_3=\chi_3.$$
$$y_1=\chi_1+\chi_2+\chi_3,\quad y_2=\chi_1\chi_2+\chi_1\chi_3+\chi_2\chi_3,\quad y_3=\chi_1\chi_2\chi_3.$$

From system (4) after its transformation the following equations are received

$$\begin{vmatrix} A_1 & A_2 & A_3 \\ B_1 & B_2 & B_3 \\ D_1 & D_2 & D_3 \end{vmatrix}\begin{vmatrix} y_1 \\ y_2 \\ y_3 \end{vmatrix}=\begin{vmatrix} A_0 \\ B_0 \\ D_0 \end{vmatrix} \qquad (5)$$

where

$A_1=C(\omega_3)-C(\omega_1);A_2=G(\omega_3)-G(\omega_1);A_3=\omega_3^2C(\omega_3)-\omega_1^2C(\omega_1);$

$B_1=c(\omega_3)-c(\omega_2)$; $\quad B_2=G(\omega_3)-G(\omega_2)$;

$B_3=\omega_3^2c(\omega_3)-\omega_2^2c(\omega_2)$

$D_1=\sigma_2[G(\omega_2)-G(\omega_3)]-\sigma_1[G(\omega_1)-G(\omega_3)];$;

$\sigma_1=(\omega_3^2-\omega_1^2)^{-1};$

$D_2=\sigma_2[\omega_3^2C(\omega_3)-\omega_2^2C(\omega_2)]-\sigma_1[\omega_3^2C(\omega_3)-\omega_1^2C(\omega_1)];$

$D_3=\sigma_2[\omega_2^2G(\omega_3)-\omega_2^2G(\omega_2)]-\sigma_1[\omega_3^2G(\omega_3)-\omega_1^2G(\omega_1)];$

$A_0=\omega_3^{-2}G(\omega_3)-\omega_1^{-2}G(\omega_1);$

$B_0=\omega_3^{-2}G(\omega_3)-\omega_2^{-2}G(\omega_2);$

$D_0=\sigma_1[C(\omega_1)-C(\omega_3)]-\sigma_2[C(\omega_2)-C(\omega_3)];$

$\sigma_2=(\omega_3^2-\omega_2^2)^{-1}$

After determination of y_1, y_2 and y_3 by means of equation $x^3-y_1x^2+y_2x-y_3=0$ the parameters of corona model are calculated. Then, for obtaining of a modeling error in a given range of frequencies, the frequent characteristic of the model is calculated at giv

en overvoltage ratio:

$$G_м+j\omega_vC_M=\sum_{к=1}^{3}\left(r_k+\frac{1}{j\omega_vc_k}\right)^{-1}$$

(6)

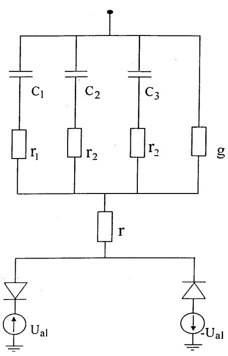


Fig.1 Three Angle Model

Here G_M, C_M are total conductivity and capacity of corona model.

At last the modeling error is calculated:

$$\Delta G=\frac{G(\omega_v)-G_м}{G(\omega_v)}\cdot 100\%;\qquad \Delta C=\frac{C(\omega_v)-C_м}{C(\omega_v)}\cdot 100\%$$

(7)

Calculated values of corona model's parameters at $U_M/U_H=1{,}8$ are brought in table 1.

These obtained values can be accepted as base parameters. However, spent experiments have shown that if to accept the overvoltage ratio as instant meanings this base svalue should be specified in particular cases.

If the third branch of corona model to replace by two branches r,c we receive the model whose parameters can be determined by decision of the equation:

$$\sum_{K=1}^{3}(r_{K+2}+\frac{1}{j\omega_vC_{K+2}})^{-1}=G(\omega_v)+j\omega_vC(\omega_v)-\sum_{K=1}^{2}(r_K+\frac{1}{j\omega_vC_K})^{-1} \qquad (8)$$

4. Parameters Of The Line And Seven Angle Model

By using the sequential increase of corona model branches number it is possible to receive the model consisting of seven branches ,r,c, fig.2.

Thus the parameters are determined under the similar formulas (4) - (5) obtained by decision of the following equation:

$$\sum_{K=1}^{3}(r_{K+4}+\frac{1}{j\omega_vC_{K+4}})^{-1}=G(\omega_v)+j\omega_vC(\omega_v)-\sum_{K=1}^{4}(r_к+\frac{1}{j\omega_vC_к})^{-1} \qquad (9)$$

Calculated values of corona model's parameters at $U_M/U_H=1{,}8$ are brought in table 2.

On fig 3. the frequency dependences of conductivity (G), capacity (C) and modeling error are brought. Here also the values of conductivity and capacity calculated by the formula (1) are brought for comparison.

Thus models having high accuracy are obtained, which can be successfully applied at numerical calculations of electromagnetic processes in multiwires lines at certain regimes.

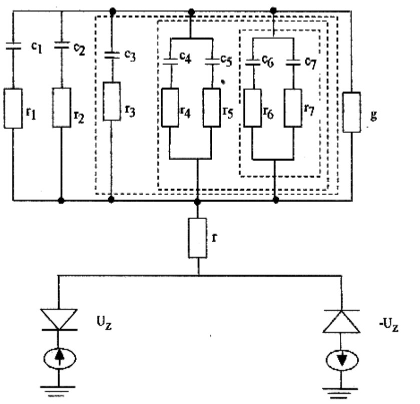
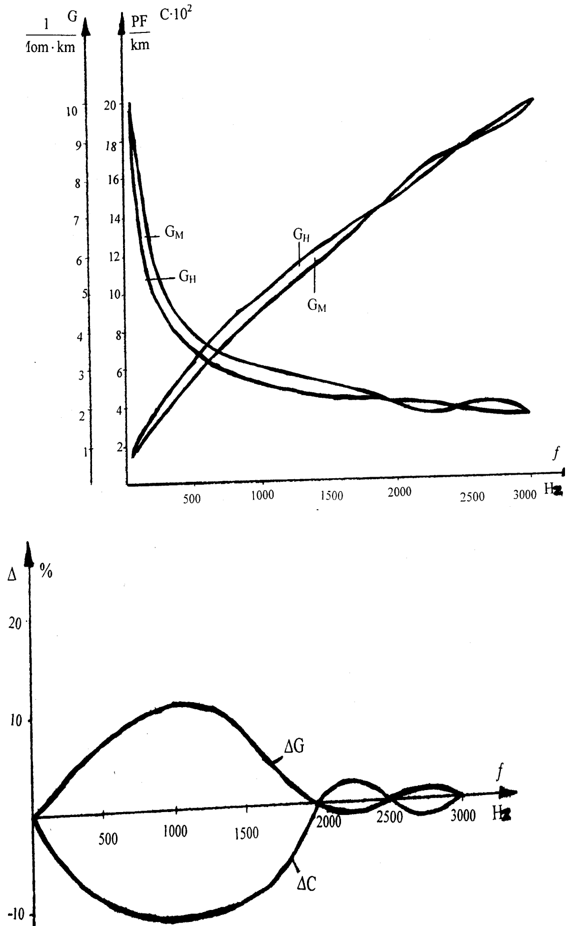


Fig.2. Seven Angle Model



b)

a)

Fig. 3. The frequency dependences of conductivity and capacity (a), and also modeling error(b) at U_M/U_H=1,8.

Table 1. Parameters of the line and three angle model

f	initial parameters		Parameters of the corona model					
Hz	$G(\frac{1}{MOhm km})$	C(pF/km)	r_1	r_2	r_3	c_1	c_2	c_3
50	0,758	1920	MOhm· км			pF/km		
200	1,497	1072,6	1,09	2,52	0,145	4620	-663	1130
1000	4,854	545,59						

Table 2. Parameters of the line and seven angle model

f	initial parameters		Parameters of the corona model													
Hz	$G(\frac{1}{MOkm})$	C(pF/km)	r_1	r_2	r_3	r_4	r_5	r_6	r_7	c_1	c_2	c_3	c_4	c_5	c_6	c_7

2000	7·46	407·78	MOhm· км							pF/km						
2500	8·567	371·31														
3000	9·59	343·94	1,09	2,5	0,33	0,71	0,193	0,42	0,05	4620	-663	812	-209	113	-250	398

5. References:

[1] Alexandrov Q.N. Koronni razryad na liniyax elektroperedaci, M.-L., Enerqiya, 1964.] Alexandrov Q.N. 228p.

[2] Alexandrov Q.N. Sverxvisokie napryajeniya. L., Enerqiya, 1973, 184 p.

[3] Qashimov A.M., Lacuqin V.F., Sadixov B.M. parametri modeli koroni. V kn.: Cislennie exsperimenti pri issledovaniyax perexodnix i kvaziustanovivshixsya prozessov v elektriceskix setyax, Baku, Elm, 1991, p 63-87.