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Development of the Model for Simulation of Transient Processes in Cables and Power Lines

U. Jakšić[1], N. Marković[2*], J. Živanić[3] and N. Milenković[4]

[1]High Technical School of Professional Studies, Nušićeva 6, 38227 Zvecan, Serbia.
[2]High Technical School of Professional Studies, Urosevac, Leposavic, Serbia.
[3]Faculty of Technical Sciences, University of Kragujevac, Svetog Save 65, 32000 Čačak, Serbia.
[4]Faculty of Information Technologies, Alfa University, Palmira Toljatija 3, 11070 New Belgrade, Serbia.

Authors' contributions

This work was carried out in collaboration between all authors. Autor UJ designed the work and wrote the first version of the work. Author NM conducted the statistic analysis and simulation in MATLAB program package and made technical preparation of the paper. Authors JŽ and NM were responsible for bibliography. All authors read and approved the final manuscript.

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ABSTRACT

Aims: The paper presents a model of the power line and the equivalent scheme for the simulation of the transient processes. Many constructions of conductive lines are such that mutual parameters (inductance, capacitance) are the same for any pair of phases, and the phase parameters themselves are approximately the same for all three phases. Therefore, the approximation of three-phase conductors with symmetric single-phase conductors is justified. A special way in which the power lines are considered is a method called a sequence model of three-phase line.
Methodology: Techniques used in this paper are based on analytic methods and the formation of algorithms. Modeling and simulation are processes that are necessary for testing faults in measuring transformers in relay protection (current/voltage) when they are very remote and electrically connected by cables. The first step in problem-solving was to define the theoretical model for

**Corresponding author: E-mail: nen.mark74@yahoo.com;*

estimation of the impact of variable parameters on the transmission of electric energy. Further step represented in the paper is simulation of transient processes on different lengths of the power lines when modeling lines and cables, one starts from the fact that parameters differ in certain parts, in lengths, i.e. that the parameters are variable in length, which results in change of longitudinal parameters of basic quadripoles in equivalent schemes.

Conclusion: The specificity of the model is that the initial conditions matrix is determined depending on the condition at the beginning of the line and load in equivalent scheme and arises from the idle time or short circuit at the output of the quadripoles. The solution for transient state with the application of quadripole in the equivalent scheme is obtained by matrix procedure using equivalent schemes and by simulation method in the MATLAB program.

Keywords: Simulation; model; transient processes; quadripole, cable.

1. INTRODUCTION

Dealing with the problem of transient processes in cables is not a new phenomenon. A lot of research has been conducted in this field and many papers have been dealing with this subject [1-3].

Even in the last century, the problem of phase parameters of inductance and capacitance of conductive structures in the power line was dealt with by Kvasnica [3], who suggested that this problem should be accessed from the computer standpoint, because he came to the conclusion that much faster and simpler solutions were obtained (although we must admit that in that period, computer technology was not as developed as today).

From the theory of electric circuits, it is known that is possible to find quadripole that is described by equal equations (there is no a single circuit of a quadripole). From a variety of equivalent circuits, particularly popular among electric power engineers, are Π and T equivalent circuits. The currents at the end of the cable are the functions of line terminal voltages in terms of parameters of cables with constants that correspond to parameters of Π and T equivalent circuits with elements A,B,C,D [4,5].

Cable represents a conductor with distributed parameters. When presenting cable as an element with concentrated parameters, according to selected method, the wave character of electric energy transmission along the cable length must be taken into account. It the parts of the cable are of different length, and parameters of equivalent length schemes are not equal, then the scheme contains non-homogenous elements of quadripole. Equivalent cable scheme impacts the regime parameters at the beginning and at the end of the cable, but based on the selected method it is possible to determine voltage, current, the active and reactive power transmitted by the cable. Based on elementary characteristics of the cable it is possible to obtain all basic electric values necessary for the analysis of exploitation characteristics as possible transient processes at different faults.

2. EQUIVALENCE QUADRIPOLES

Cable is equivalented with *RLGC* parameters of symmetrical quadripoles according to the scheme in Fig. 1. The load impedance is known value, and it is assumed that the values of distributed parameters of quadripoles are also known [4,5].

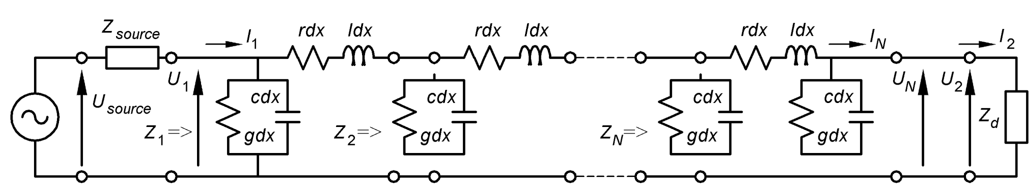

Fig. 1. Equivalent scheme of distributed line parameters from N quadripole that have variable ($a \equiv A$) parameters

Voltage and current of N -th quadripole are calculated through general $a_{jk}(b_{jk})$ coefficients:

$$\begin{aligned} U_{N-1} &= a_{11,N}U_N + a_{12,N}I_N \\ I_{N-1} &= a_{21,N}U_N + a_{22,N}I_N \end{aligned} \tag{1}$$

From this equations system the input impedance of loaded N–th quadripole is:

$$Z_{N-1} = \frac{a_{11,N}U_N + a_{12,N}I_N}{a_{21,N}U_N + a_{22,N}I_N} = \frac{a_{11,N}(U_N / I_N) + a_{12,N}}{a_{21,N}(U_N / I_N) + a_{22,N}} \tag{2}$$

The input impedance of arbitrary N quadripole is equal to:

$$Z_{N-1} = \frac{a_{11,N}(Z_N) + a_{12,N}}{a_{21,N}(Z_N) + a_{22,N}} \tag{3}$$

If relations (3) are used as recurrent form then we will have:

$$Z_1 = \frac{a_{11,2}(Z_2) + a_{12,2}}{a_{21,2}(Z_2) + a_{22,2}} \tag{4}$$

If the values of voltage/current of voltage or current source at the input of the line $U_g \equiv I_g$, are known, the impedance of the source Z_{sorce} , Z_2 Z_1 can be determined based on the expression $U_1 \equiv I_1$ at the input of cable or based on expression $U_2 \equiv I_2$ at the output/end of the cable. Also, the distribution of currents and voltages along the entire length of the cable l to the load Z_d shall be:

$$\begin{aligned} U_n &= a_{22,n-1}U_{n-1} + a_{12,n-1}I_{n-1} \\ I_n &= a_{21,n-1}U_{n-1} + a_{11,n-1}I_{n-1} \end{aligned} \tag{5}$$

Elements of the T or Π model of equivalent scheme can be calculated according to relation parameters (5) [2,4,6]. The phase parameters of inductance and capacitance of conductive structures in line are approximately determined by mutual geometric arrangement in the three-phase transmission system and can be considered constant [3,7]. Active resistance of conductors is a variable parameter and can be determined from a known relation:

$$r = \frac{R}{l} = \frac{1}{l}R_{20}\left[1 + \alpha\left(\theta_{sr} - 20^0 C\right)\right] \tag{6}$$

where $R_{20} / l[\Omega / km]$ is resistance of conductors at the temperature of 20°S per unit of length, α is a temperature coefficient of the phase conductor resistance (cable cores), θ_{sr} is mean environment temperature-a place where the cable is installed, l is the length of the phase conductor of lines.

The active component of the $n-$th part of the line is equal to:

$$r_{\theta,n} = \frac{R_{20,n}}{l_n} = \frac{1}{l_n}R_{20}\left[1 + \alpha\left(\theta_{sr,n} - 20^0 C\right)\right] \tag{7}$$

where $\theta_{sr,n}$ is a mean environment temperature of the place where the $n-$ th part of the cable is installed, l_n is the length of phase conductor of the line.

3. TRANSIENT PROCESSES IN THE POWER LINE

Transient processes in line, [2,4], in the simplest case, can occur when the line is switched off by breaker at its input (due to the simple application of MATLAB programme, this example of the process is considered and simulated in the continuation of the paper [8]. The switching off of the overground line with the breaker can be analyzed in the electric circuit with distributed parameters represented by T or Π scheme as a passive quadripole [1,9-12].

In the longitudinal part are parameters of active resistance rdx and inductance ldx and in transversal part of the line is a parameter of conductance gdx and capacitance of the line to earth cdx . At the beginning is the electric source of the given voltage U_{source} , current I_{source} and self-impedance Z_{source} . At the end of the line is load impedance Z_d , Fig. 1.

For selected directions of voltages $\left(u, u - \frac{\partial u}{\partial x}dx\right)$ and currents $\left(i, i - \frac{\partial i}{\partial x}dx\right)$ $\left(i_s, i_l, i_k, \frac{\partial i}{\partial x}\right)$ according to Kirchhoff's second law, the equations of the transient process in the line can be written:

$$u-\frac{\partial v}{\partial x}dx-rdxi_l-ldx\cdot\frac{\partial i_l}{\partial t}-u=0\Rightarrow-\frac{\partial u}{\partial x}=r\cdot i_l+l\frac{\partial i_l}{\partial t}$$
$$-\frac{\partial i}{\partial x}dx-cdx\frac{\partial v}{\partial t}-gdx\cdot v=0\Rightarrow-\frac{\partial i}{\partial x}=g\cdot v+c\frac{\partial v}{\partial t} \tag{8}$$

Differentiating relation (8) according to the variable x is obtained:

$$-\frac{\partial^2 u}{\partial x^2}=r\frac{\partial i_l}{\partial x}+l\ \frac{\partial^2 i_l}{\partial x\partial t}$$
$$-\frac{\partial^2 i}{\partial x\partial t}=g\frac{\partial u}{\partial x}+c\frac{\partial^2 u}{\partial x\partial t} \tag{9}$$

Thomson telegrapher's equations and Laplace-Carson method are used for resolving the transient processes on line if the boundary conditions and the regime of the line (idle time, short circuit, grounded output end, etc.) are known. When the line is connected to the source with the sinusoidal function of the voltage, the general method of transformation from time to complex domain can be used, and operations can be simplified with the assumption:

$$u=U_m\cos(wt+\psi)=U_m R_e\left\{e^{j\omega t+\psi}\right\}=R_e\left\{U_m e^{j\omega t}e^{j\psi}\right\}=R_e\left\{U_m e^{j\omega t}\right\}$$
$$u=R_e\left\{\vec{U}_m\right\},i=R_e\left\{\vec{I}_m\right\}F_m=\sqrt{2}\cdot F \tag{10}$$

The expression $\sqrt{2}\cdot F$ represents the relation between the maximum and effective value. Voltage and current at an arbitrary point x on the power line are differentiated by variable x,t :

$$\frac{\partial u}{\partial x}=\sqrt{2}R_e\left\{\frac{d\vec{U}}{dx}e^{j\omega t}\right\},\frac{\partial u}{\partial t}=\sqrt{2}R_e\left\{j\omega\vec{U}\cdot e^{j\omega t}\right\}=\sqrt{2}R_e\left\{j\omega\vec{U}\right\}$$
$$\frac{\partial i}{\partial x}=\sqrt{2}R_e\left\{\frac{d\vec{I}}{dx}e^{jwt}\right\},\frac{\partial i}{\partial t}=\sqrt{2}R_e\left\{j\omega\vec{I}\cdot e^{j\omega t}\right\}=\sqrt{2}R_e\left\{j\omega\vec{I}\right\} \tag{11}$$

By applying this transformation (to ease the writing) with omission of phasor designation, and by introducing the shift $p=j\omega$ the equation system reduces to:

$$-\frac{dU}{dx}=(r+j\omega\cdot l_e)I_l\Rightarrow I_l=-\frac{1}{r+j\omega l_e}\frac{dU}{dx}\Rightarrow\frac{dI_l}{dx}=-\frac{1}{r+pl_e}\frac{d^2U}{dx^2}$$
$$-\frac{dI}{dx}=(g+j\omega\cdot c)\cdot U \tag{12}$$

By solving the equations (12) the following is obtained:

$$\left[\frac{1}{r+pl_e}\right]\frac{d^2U}{dx^2}=(g+pc)U\Rightarrow\frac{1}{r+pl_e}\frac{d^2U}{dx^2}=(g+pc)U\Rightarrow\frac{d^2U}{dx^2}-(r+pl_e)(g+pc)U=0 \tag{13}$$

The complex propagation constant of voltage or current wave on the line is $\beta^2=(r+pl_e)(g+pc)$. D'Alambert's equation defines the expansion of harmonic waves:

$$\frac{d^2U}{dx^2}-\beta^2U=0\ ,\ U=Ae^{\beta x}+Be^{-\beta x} \tag{14}$$

Relation (14) determines the values of voltages at any point at the distance x from the input end $\frac{dU}{dx} = \beta\left(Ae^{\beta x} - Be^{-\beta x}\right)$ and by substituting in relation (14), the required value of the current on the power line is obtained:

$$I_l = -\left[\frac{1}{r + pl_e}\right]\frac{dU}{dx} = -\left[\frac{1}{r + pl_e}\right]\beta\left(Ae^{\beta x} - Be^{-\beta x}\right)$$
$$I = -\frac{1}{\sqrt{\frac{r + pl_e}{g + pc}}}\left(Ae^{\beta x} - Be^{-\beta x}\right) = -\frac{1}{Z_{wT}}\left(Ae^{\beta x} - Be^{-\beta x}\right) \tag{15}$$
$$Z_{wT} = \sqrt{\frac{r + pl_e}{g + pc}} = \sqrt{\frac{(r + pl_e)l}{(g + pc)l}} = \sqrt{\frac{R + pL_e}{G + pC}}$$

where Z_{wT} is wave impedance and depends on the line parameters, and voltage and current depend on boundary conditions in relation to the beginning or end of the power line. Let $U_{(x=0)} = U_1$, $I_{(x=0)} = I_1$ Then, according to relations (14) and (15):

$$U_1 = A + B\,,\; I_1 = -\frac{1}{Z_{wT}}(A - B) \tag{16}$$

where the values of constants are $A = \frac{1}{2}(U_1 - I_1 Z_{wT})$ i $B = \frac{1}{2}(U_1 + I_1 Z_{wT})$.

At an arbitrary distance x that is, at the part from the beginning, the voltage is:

$$U_x = \frac{1}{2}(U_1 - I_1 Z_{wT})\cdot e^{\beta\cdot x} + \frac{1}{2}(U_1 + I_1 Z_{wT})\cdot e^{-\beta\cdot x}$$
$$U_x = U_1\frac{e^{\beta\cdot x} + e^{-\beta\cdot x}}{2} - I_1 Z_{wT}\frac{e^{\beta\cdot x} - e^{-\beta\cdot x}}{2} \tag{17}$$

At the output end $x = l$ of the power line, the voltage is:

$$U_{x=l} = U_2 = U_1\frac{e^{\beta\cdot l} + e^{-\beta\cdot l}}{2} - I_1 Z_{wT}\frac{e^{\beta\cdot l} - e^{-\beta\cdot l}}{2} \tag{18}$$

If the values of constants A and B are replaced in relation (15), the general expression for current is:

$$I_x = -\frac{1}{Z_{wT}}\left[\frac{1}{2}(U_1 - I_1 Z_{wT})\cdot e^{\beta x} - \frac{1}{2}(U_1 + I_1 Z_{wT})\cdot e^{-\beta x}\right]$$
$$I_x = -\frac{U_1}{Z_{wT}}\frac{e^{\beta x} - e^{-\beta x}}{2} + I_1\frac{e^{\beta x} - e^{-\beta x}}{2} \tag{19}$$

At the output end of the winding $x = l$ the complex value of the current is:

$$I_{x=l} = I_2 = -\frac{U_1}{Z_{wT}}\frac{e^{\beta l} - e^{-\beta l}}{2} + I_1\frac{e^{\beta l} - e^{-\beta l}}{2} \tag{20}$$

Equations can be converted to the form with hyperbolic functions, and then:

$$U_x = U_1 \cosh \beta x - I_1 Z_{wT} \sinh \beta x \,,\ I_x = I_1 \cosh \beta x - \frac{U_1}{Z_{wT}} \sinh \beta x \tag{21}$$

At the output end of the winding $x = l$ the complex values of voltages and currents are:

$$U_{x=l} = U_2 = U_1 \cosh \beta \cdot l - I_1 Z_{wT} \sinh \beta \cdot l \,,\ I_{x=l} = I_2 = I_1 \cosh \beta \cdot l - \frac{U_1}{Z_{wT}} \sinh \beta \cdot l \tag{22}$$

Parameters of T or Π scheme can be determined based on relations (21) and (22), Fig. 2.

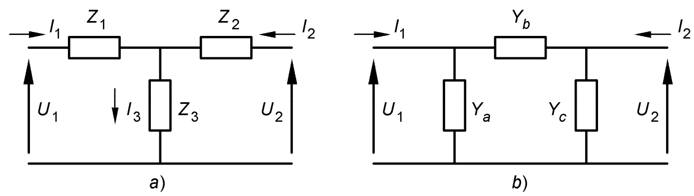

Fig. 2. Possible schemes of quadripole: a) T scheme, b) Π scheme [9]

Quadripole with $z-$ parameters is described by the system of equations and matrix:

$$\begin{aligned} U_1 &= z_{11} I_1 + z_{12} I_2 \\ U_2 &= z_{21} I_1 + z_{22} I_2 \end{aligned} \Leftrightarrow \begin{Vmatrix} U_1 \\ U_2 \end{Vmatrix} = \begin{Vmatrix} z_{11} & z_{12} \\ z_{21} & z_{22} \end{Vmatrix} \begin{vmatrix} I_1 \\ I_2 \end{vmatrix} \tag{23}$$

Input and output voltage U_1 and U_2 are dependent, and input and output current I_1 and I_2 are independent variables. $z-$ parameters are called open-circuit impedance parameters because they are determined as the ratio of voltage and current at the open output $I_2 = 0$ or input $I_1 = 0$:

$$z_{11} = \frac{U_1}{I_1}\Big|_{I_2=0} \,,\ z_{12} = \frac{U_1}{I_2}\Big|_{I_1=0} \ z_{21} = \frac{U_2}{I_1}\Big|_{I_2=0} \,,\ z_{22} = \frac{U_2}{I_2}\Big|_{I_1=0} \tag{24}$$

By applying Kirchhoff's second law to two contours, which include parameter Z_3, the following is obtained:

$$\begin{aligned} U_1 &= Z_1 I_1 + Z_3 (I_1 + I_2) = (Z_1 + Z_3) I_1 + Z_3 I_2 \\ U_2 &= Z_2 I_2 + Z_3 (I_1 + I_2) = Z_3 I_1 + (Z_2 + Z_3) I_2 \end{aligned} \tag{25}$$

After arranging in matrix form, the following is obtained:

$$\begin{Vmatrix} U_1 \\ U_2 \end{Vmatrix} = \begin{Vmatrix} Z_1 + Z_3 & Z_3 \\ Z_3 & Z_2 + Z_3 \end{Vmatrix} \begin{vmatrix} I_1 \\ I_2 \end{vmatrix} \tag{26}$$

where $z-$ are parameters defined by the minor of the matrix:

$$\|Z\| = \begin{Vmatrix} Z_1 + Z_3 & Z_3 \\ Z_3 & Z_2 + Z_3 \end{Vmatrix} \tag{27}$$

Quadripole can be described by y parameters: input and output voltage U_1 and U_2 are independent, and input and output currents I_1 and I_2 are dependent variables and by matrix form:

$$\begin{matrix} I_1 = y_{11}U_1 + y_{12}U_2 \\ I_2 = y_{21}U_1 + y_{22}U_2 \end{matrix} \Leftrightarrow \begin{matrix} I_1 = y_{11}U_1 + y_{12}U_2 \\ I_2 = y_{21}U_1 + y_{22}U_2 \end{matrix} \tag{28}$$

y parameters are admittance parameters of closed circuit and can be determined from the relation of current and voltage at short-circuited output $U_2 = 0$ or input $U_1 = 0$:

$$y_{11} = \frac{I_1}{U_1}\Big|_{V_2=0},\ y_{12} = \frac{I_1}{u_2}\Big|_{V_1=0},\ y_{21} = \frac{I_2}{U_2}\Big|_{V_2=0},\ y_{22} = \frac{I_2}{u_2}\Big|_{V_1=0} \tag{29}$$

By applying Kirchhoff's first law on two nodes, the following is obtained:

$$\begin{aligned} I_1 &= Y_aU_1 + Y_b(U_1 - U_2) = (Y_a + Y_b)U_1 - Y_bU_2 \\ I_2 &= Y_cU_2 + Y_b(U_2 - U_1) = -Y_bU_1 + (Y_b + Y_c)U_2 \end{aligned} \tag{30}$$

After arranging in matrix form, the following is obtained:

$$\|Y\| = \begin{Vmatrix} Y_a + Y_b & -Y_b \\ -Y_b & Y_b + Y_c \end{Vmatrix} \tag{31}$$

In this way, the matrix of output variables $\|\chi\{U, I_N\}\|$ of the last one in the N quadripole sequence with engaged load Z_d can be determined from the initial conditions $\|\chi\{U, I_1\}\|$.

4. SIMULATION AND ANALYSIS OF TRANSIENT PROCESS

For alternating current power lines, an algorithm for calculation at the beginning and the end of the cable (equivalent scheme) has been designed, which is based on the recurrence form of variable parameters of quadripole. As the result of the analysis, the power line model with concentrated parameters has been compiled, where the transient process in conductor cable was modeled. In serial branches of quadripole are inductances and active resistances; while in transversal branches are capacitances and conductance. Due to the fact that they have great losses, this parameter has larger impact on transient process.

Developed model for the simulation of single-phase line is equivalent to the three-phase line, in transient state conditions. The models are developed with quadripole parameters or alternatively through characteristic impedances, expansion constant and the length of the line in the transient state conditions and represented by equivalent circuits. This approach is more interesting because engineers recognize the electric circuits. Since the three-phase line can be considered with three single-phase lines by symmetric transformation of components, it is possible to simulate three-phase lines through three single-phase lines.

For the analysis of transient process on the power line, the adapted part of the package Three-phase Line: Single phase energization of a three-phase line and scheme of the model that contains a block source with given unit values of the voltage: V(p.u), 50 Hz, Block Breaker 1 and 2, power line block with distributed parameters and power line presented by Π equivalent scheme with constant parameters of the lengths.

Below is information regarding the source of parameters of inductance, capacitance and resistance:

Inductances at the length unit

[H/km, matrix N*N or [*L*1, *L*0]: [0.9337e-3 4.1264e-3]
Capacitances at the length unit
[F/km, matrix N*N or [*C*1, *C*0]: [12.74e-9 7.751e-9]

Resistances at the length unit
[Ω/km, matrix N*N or [*R*1, *R*0] : [4.23e-3 128.2e-3]

The process was analyzed for two examples:

1. Compact power line of total length e*l*: [km]: 100,
2. Powerline with 3 lengths 3**l*: [km]: 3*33.3.

The parameters of active resistance for three lengths in were varied in values:
For the length, *l*1:
Resistances at the length unit [Ω/km, matrix N*N or [*R*1, *R*0] : [4.23e-3 128.2e-3]
For the length, *l*2:
Resistances at the length unit [Ω/km, matrix N*N or [*R*1, *R*0] : [3.18e-3 96.4e-3]
For the length, *l*3:
Resistances at the length unit [Ω/km, matrix N*N or [*R*1, *R*0]: [2.546e-3 77.3e-3]

5. RESULTS AND DISCUSSION

Fig. 3 represents a simulation scheme of transient processes on the power line of 100 [km] in length, while Fig. 4 represents a simulation scheme of transient processes on the power line of 3*33.3 [km] in length. The initialization of simulation activates the adapted part of MATLAB Single phase energization of a three-phase line with selected parameter of cables, where the following voltage changes were observed: subassembly S_{c1} where the voltage flow is U_A and subassembly S_{c2} where the voltage flow is U_B.

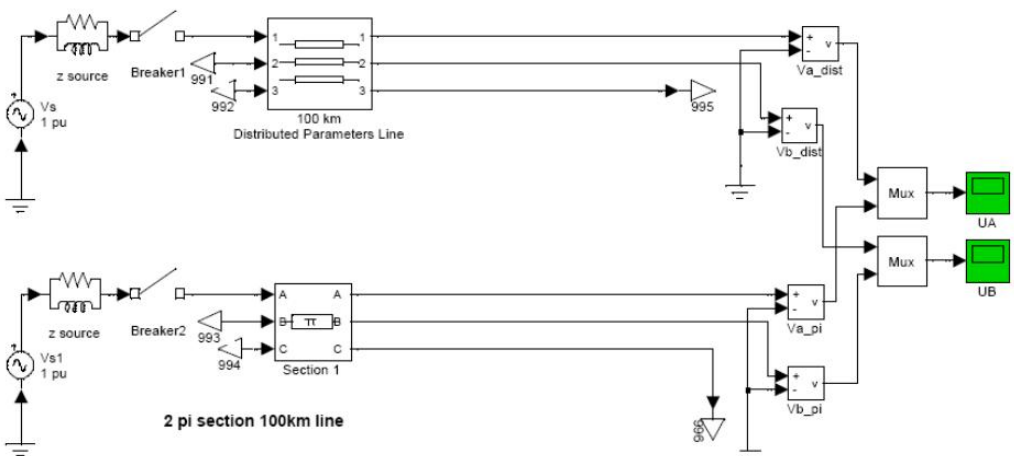

Fig. 3. Simulation scheme of transient process on the power line of compact length 100 [km]

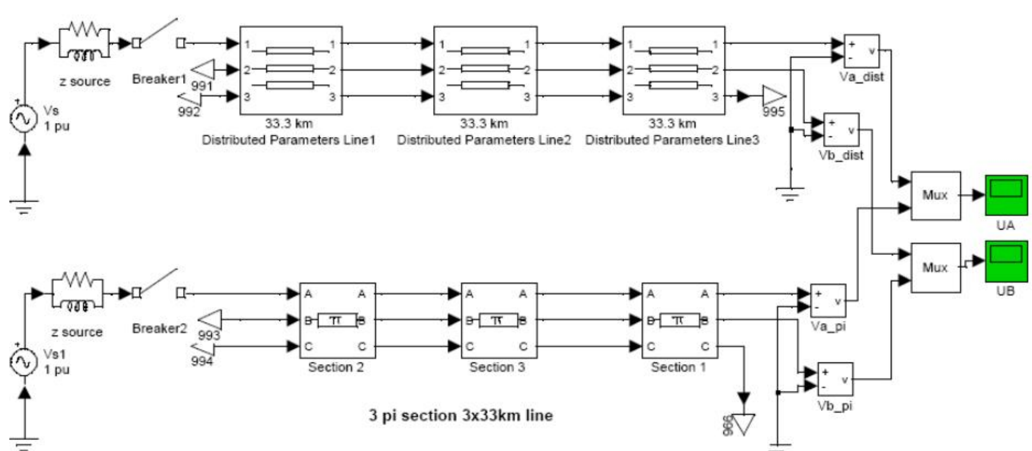

Fig. 4. Simulation scheme of transient process on the power line with the lengths 3*33.3 [km]

PSB block library acts as a connection between the electrical signals (voltages of elements and current passing through the cables) and Simulink blocks (transfer function) and vice versa, respectively. Prior to the calculation, the system is excited; the spatial model of electric circuit condition and equivalent Simulink system are calculated. The calculation is analogous to the above-mentioned calculation process in the MATLAB Simulink Power System Program.

Based on given schemes, the wave diagrams of voltages of phases A and B were recorded, with different lengths of the power line, Fig. 5 and Fig. 6.

By observing and analyzing the voltage diagrams referring to the power line of compact length, Fig. 5 and diagrams referring to compact powerline divided into 3 lengths, Fig. 6, it is possible to see the important differences in the diagram of voltage flow U_A and U_B at the beginning of transient process (in the first period which is very important for the operation of protection devices). The difference is reflected in the fact that higher harmonics are present in phase B .

MATLAB Simulink programmes quite accurately simulate transient processes on cables for the transmission of energy and cables for relay protection, but self-development of both model and program has particular advantages such as detailed insight into all components of the model and program and the introduction of various changes that would otherwise not be included into available programme packages.

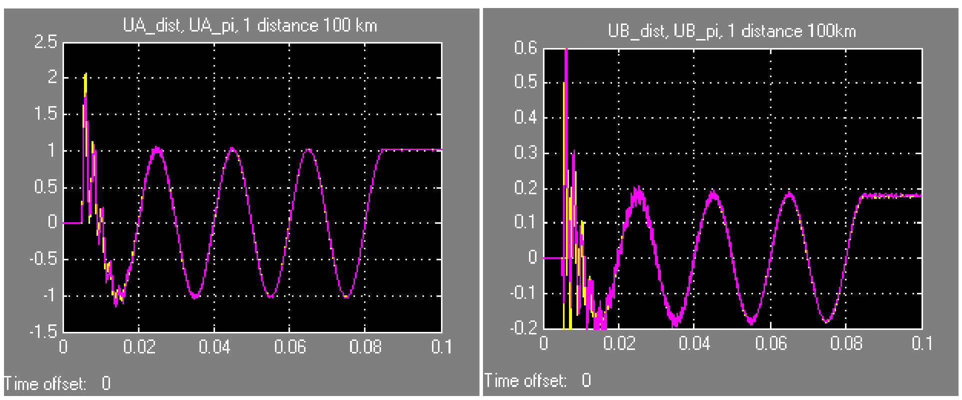

Fig. 5. Voltage of phase A and B in transient process during the switching off at the end of the compact power line 100 [km] (yellow color: voltage based on T scheme with distributed parameters, pink color: voltage based on Π scheme)

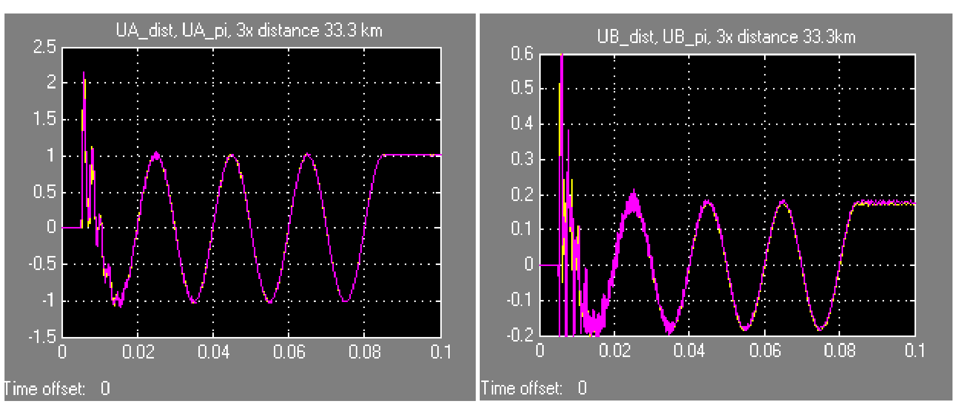

Fig. 6. Voltage of phase A and B in transient process during the switching off at the end of the compact powerline 3*33.3 [km] (yellow color: voltage based on T scheme with distributed parameters, pink color: voltage based on Π scheme)

6. CONCLUSION

The specificity of all solutions is that initial conditions matrix $\|\chi\{U,I_1\}\|$ is determined in two ways: independently of the conditions on all parts of the load line and depending on the type of equivalent scheme and conditions for load connected to the last N quadripole in the sequence. This specificity is confirmed by the voltage diagrams in the simulation in MATLAB programme package. The analyzed method for modeling of transient process on the power line and verification in adapted MATLAB package provide simple determination of the impact of variable parameters on the power transmission. Measurement results are obtained which along the power line are transmitted to the relay protection or some other part of local automatics. The simple knowledge of theory of quadripoles and transient processes was used for the obtaining of the model and the existing part of the software in MATLAB Simulink Power System was adapted for simulation.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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