THE NEW NUMERICAL METHOD FOR THE ANALYSIS OF TRANSIENTS IN RADIO TECHNICAL CHAINS WITH DISTRIBUTED PARAMETERS ALLOWED FOR LOSSES

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ABSTRACT

The new numerical method for analysis of transients in radio technical chains with distributed parameters is offered with allowance for losses. The new recurrence relations easily implemented on a computer have been obtained.

Keywords: numerical method, transient processes, radio technical

I. INTRODUCTION

Solving the problem of state of parameters distribution in radio technical circuits is of great scientific and practical importance since at signaling through a circuit, inevitably there are transients due to which the signals transmitted to a customer are subject to considerable distortion. For this, the important problem which is of interest to communication engineering is account of losses in a circuit for accurate precise estimation of the impulse signals' distortions arising along a transmission line, for more correct sampling of the detecting device's parameters, with the purpose of obtaining of a desirable waveform.

However the said above problem in the scientific literature hasn't been covered enough, those results in a lot of difficulties, both at design and at their operation.

For this purpose use of analytical methods causes great mathematical difficulties [1-4].

In this connection the matters of numerical simulation analysis of transients arising in radio technical chains with distributed parameters with allowance for losses in a circuit, in requirements of wide spread computerization into practice of engineering design, now draw the increasing attention.

The transients which occur in radio technical chains with distributed parameters, are represented with differential equations in partial derivatives, of hyperbolic type (telegraph equations) [3,4].

Now one of the new effective numerical methods of a transient analysis in entities with distributed parameters represented with telegraph equations is the numerical method [1-4], based on use of a discrete analog of an integral equation of convolution.

Advantage of the presented numerical method is that it allows to define the transients arising in entities with distributed parameters represented with telegraph equations without transition to the domain of sampled transforms, and also to realize transition from Laplace transform of required functions in the range of original functions without finding of radicals of a characteristic equation, without expansion of an operator's wave propagation factor and an operator's wave impedance into series, that considerably simplifies mathematical calculations and improves accuracy of calculations.

II. BODY OF THE TEXT

In the given paper, the further simplification and development [1-4], for mathematical simulation analysis of transients in radio technical chains with distributed parameters with allowance for losses in a circuit is given.

Let's consider the process of switching on of the loaded radio technical chains with distributed parameters with the active pure resistance R_2 at the end, to a source of the random voltage $U_0(t)$ through the lumped resistance R_1 and inductance L_1 .

The transients which occur in radio technical chains with distributed parameters, are represented by telegraph equations:

$$-\frac{\partial U}{\partial x} = L\frac{\partial i}{\partial t} + Ri\,, \quad -\frac{\partial i}{\partial x} = C\frac{\partial U}{\partial t} + GU\,,$$

$$0 \le x \le l \tag{1}$$

where $U = U(x, t)$ - voltage; $i = i(x, t)$ - current; L, C, R, G - resistance, inductance, conductivity and capacity between a wire and the ground, attributed to a unity of circuit length; l - circuit length.

The initial conditions are assumed in the form of:

$U(x, t)_{t=0} = 0$, $i(x, t)_{t=0} = 0$

The boundary conditions have a form of:

$i(x, t)_{x=0} = i_н(t)$, $U_к(t) = R_2\, i_к(t)$,

Where $U_к(t) = U(l, t)$, $i_к(t) = i(l, t)$.

During solution of the set task at the first stage it is necessary to obtain the Laplacian transform for functions $U(x, t)$, $i(x, t)$.

Using this method for assumed initial and boundary conditions, from solution of a system of differential equations (1) we shall obtain expressions for the above functions in the operator form:

$$i(x,s)=\frac{ch\gamma(l-x)}{ch\gamma l}i_H(s)-\frac{1}{\rho(s)}\frac{sh\gamma x}{ch\gamma l}U_k(s), \tag{2}$$

$$U(x,s)=\rho(s)\frac{sh\gamma(l-x)}{ch\gamma l}i_H(s)+\frac{ch\gamma x}{ch\gamma l}U_k(s), \tag{3}$$

where $\gamma=\gamma(s)=\sqrt{(sk_1+k_3)(sk_2+k_4)}$ - an operator's wave propagation factor; $k_1=L$, k_2=C, k_3=R, k_4=G; $\rho(s)=\sqrt{\dfrac{sk_1+k_3}{sk_2+k_4}}$ -- an operator wave impedance of a circuit; s - an operator of Laplace transformation; $U_н(s)$, $U_к(s)$ - the Laplacian transform of functions $U(x,t)$, $i(x,t)$, $U_н(t)$.

The second stage in solution of the given problem is connected carrying out transition from Laplace transform (2), (3) in the domain of original functions.

In this connection, in the expressions for functions $i(x,s)$, $U(x,s)$ from (2), (3) transferring from hyperbolic functions to power functions, we shall obtain:

$$i(\delta,s)\frac{1}{s}=\frac{1}{s}\cdot\frac{e^{-2\gamma l\delta}+e^{-2\gamma l(1-\delta)}}{1+e^{-2\gamma l}}i_H(s)- \tag{4}$$
$$-\sqrt{\frac{k_2}{k_1}}\left(1+\frac{k_4}{k_2}\cdot\frac{1}{s}\right)\cdot\frac{1}{\sqrt{(s+\alpha)^2-\beta^2}}\cdot\frac{e^{-\gamma l(1-2\delta)}-e^{-\gamma l(1+2\delta)}}{1+e^{-2\gamma l}}U_k(s)),$$

$$U(\delta,s)\cdot\frac{1}{s}=\sqrt{\frac{k_1}{k_2}}\cdot\frac{1+\frac{k_3}{k_4}\cdot\frac{1}{s}}{\sqrt{(s+\alpha)^2-\beta^2}}\cdot\frac{e^{-2\gamma l\delta}-e^{-2\gamma l(1-\delta)}}{1+e^{-2\gamma l}}i_H(s)+$$
$$+U_k(s)\frac{e^{-\gamma l(1-2\delta)}-e^{-\gamma l(1+2\delta)}}{1+e^{-2\gamma l}}\cdot\frac{1}{s} \tag{5}$$

Where

$\gamma=\gamma(s)=\dfrac{1}{\upsilon}\sqrt{(s+\alpha)^2-\beta^2}$, $\upsilon=1/\sqrt{k_1k_2}$ – a wave propagation velocity; $\rho=\sqrt{\dfrac{k_1}{k_2}}$ – a wave impedance of a circuit ignoring losses; $\alpha=\dfrac{1}{2}(\dfrac{k_3}{k_1}+\dfrac{k_4}{k_2})$, $\beta=\dfrac{1}{2}(\dfrac{k_3}{k_1}-\dfrac{k_4}{k_2})$, $\delta=\dfrac{x}{2l}$. - a wave attenuation constant.

In the specific case if $\kappa_4=0$, $\alpha=\beta$. For $\beta=0$, in the so-called balanced circuits at which the following relation of parameters occurs:

$$\frac{k_3}{k_1}=\frac{k_4}{k_2}$$

For balanced ($\beta=0$) the coefficient appears equal to the same value, as for the circuit without losses.

Expression (4), (5) can be presented in the form of:

$$U(\delta,s)\left[\frac{1}{s}+k_1(s)\right]=\rho\left[k_2(s)+\frac{k_3}{k_1}k_3(s)-k_4(s)-\frac{k_3}{k_1}k_5(s)\right]$$
$$i_H(s)+[k_6(s)+k_7(s)]U_k(s) \tag{6}$$

$$i(\delta,s)\left[\frac{1}{s}+k_1(s)\right]=[k_8(s)+k_9(s)]i_H(s)-\frac{1}{\rho}[k_{10}(s)+\frac{k_4}{k_2}k_{11}(s)]- \tag{7}$$
$$-k_{12}(s)-\frac{k_4}{k_2}k_{13}(s)]U_k(s),$$

Where

$$k_1(s)=\frac{e^{-2\gamma l}}{s},\ k_2(s)=\frac{e^{-2\gamma l\delta}}{\sqrt{(s+\alpha)^2-\beta^2}},\ k_3(s)=\frac{1}{s}\cdot\frac{e^{-2\gamma l\delta}}{\sqrt{(s+\alpha)^2-\beta^2}},\ k_4(s)=\frac{e^{-2\gamma l(1-\delta)}}{\sqrt{(s+\alpha)^2-\beta^2}},$$

$$k_5(s)=\frac{1}{s}\cdot\frac{e^{-2\gamma l(1-\delta)}}{\sqrt{(s+\alpha)^2-\beta^2}},\quad k_6(s)=\frac{1}{s}e^{-\gamma\ell(1-2\delta)},\quad k_7(s)=\frac{1}{s}e^{-\gamma\ell(1+2\delta)},$$

$$k_8(s)=\frac{e^{-2\gamma l\delta}}{s},\quad k_9(s)=\frac{e^{-2\gamma l(1-\delta)}}{s},\quad k_{10}(s)=\frac{e^{-\gamma l(1-2\delta)}}{\sqrt{(s+\alpha)^2-\beta^2}},$$

$$k_{11}(s)=\frac{1}{s}\frac{e^{-\gamma l(1-2\delta)}}{\sqrt{(s+\alpha)^2-\beta^2}},k_{12}(s)=\frac{e^{-\gamma l(1+2\delta)}}{\sqrt{(s+\alpha)^2-\beta^2}},$$

$$k_{13}(s)=\frac{1}{s}\frac{e^{-\gamma l(1+2\delta)}}{\sqrt{(s+\alpha)^2-\beta^2}}$$

$\kappa_1(s),.....,\kappa_{13}(s)$ - transfer functions.

On the basis of the theorem of convolution, transferring from the equations (6), (7) concerning transforms to the equations concerning original functions we shall obtain:

$$\int_0^t U(t-\theta,\delta)1(\theta)d\theta-\int_0^t U(t-\theta,\delta)k_1(\theta)d\theta=$$
$$\rho\left[\int_{\frac{2l\delta}{\upsilon}}^t i_H(t-\theta)k_2(\theta)d\theta+\right. \tag{8}$$
$$+\frac{k_3}{k_1}\int_{\frac{2l\delta}{\upsilon}}^t i_H(t-\theta)k_3(\theta)d\theta+\int_{\frac{2l(1-\delta)}{\upsilon}}^t i_H(t-\theta)k_4(\theta)d\theta-$$
$$\left.-\frac{k_3}{k_1}\int_{\frac{2l(1-\delta)}{\upsilon}}^t i_H(t-\theta)k_5(\theta)d\theta\right]+$$
$$+\int_{\frac{l(1+2\delta)}{\upsilon}}^t U_k(t-\theta)k_6(\theta)d\theta+\int_{\frac{l(1+2\delta)}{\upsilon}}^t U_k(t-\theta)k_9(\theta)d\theta$$

$$\int_0^t i(t-\theta,\delta)1(\theta)d\theta+\int_0^t i(t-\theta,\delta)k_1(\theta)d\theta=$$
$$\rho\int_{\frac{2l\delta}{\upsilon}}^t i_H(t-\theta)k_8(\theta)d\theta+ \tag{9}$$
$$+\int_{\frac{2l(1-\delta)}{\upsilon}}^t i_H(t-\theta)k_9(\theta)d\theta-\frac{1}{\rho}\left[\int_{\frac{2l(1-\delta)}{\upsilon}}^t U_k(t-\theta)k_{10}(\theta)d\theta+\frac{k_4}{k_2}\int_{\frac{2l(1-\delta)}{\upsilon}}^t U_k(t-\theta)k_{11}(\theta)d\theta+\right.$$
$$\left.+\int_{\frac{l(1+2\delta)}{\upsilon}}^t U_k(t-\theta)k_{12}(\theta)d\theta-\frac{k_4}{k_2}\int_{\frac{l(1+2\delta)}{\upsilon}}^t U_k(t-\theta)k_{13}(\theta)d\theta\right]$$

where $\kappa_1(t).....,\kappa_{13}(t)$ - known originals of transfer functions $\kappa_1(s),.....,\kappa_{13}(s)$.

Integral equations (8), (9) can be solved numerically if to substitute integrals for sums.

In this connection, using connection by the continuous time t and discrete n in the form of $t=nT/\lambda$ (where $T=2\tau$, τ – time of a wave run to one end of distributed network; λ - any integer), we make a discrete sampling of integral equations (8), (9) for sampled interval T/λ, substituting operation of continuous integration by

summation using a rectangular formula.
For this instead of (8) and (9) we shall obtain:

$$\sum_{m=0}^{n} 1[m]U[n-m,\delta] + \sum_{m=\lambda}^{n} k_1[m]U[n-m,\delta] =$$
$$\rho\left(\sum_{m=\lambda\delta}^{n}(k_2[m]+\frac{k_3}{k_1}\cdot\frac{T}{\lambda}k_3[m]) - \right.$$
$$\left. - \sum_{m=\lambda(1-\delta)}^{n}(k_4[m]+\frac{k_3}{k_1}\cdot\frac{T}{\lambda}k_5[m])\right) i_H[n-m] + \tag{10}$$
$$+\left(\sum_{m=0,5\lambda(1-2\delta)}^{n} k_6[m] + \sum_{m=0,5\lambda(1+2\delta)}^{n} k_7[m]\right) U_k[n-m]$$

$$\sum_{m=0}^{n} 1[m]i[n-m,\delta] + \sum_{m=\lambda}^{n} k_1[m]i[n-m,\delta] = \tag{11}$$
$$-\left(\sum_{\lambda\delta}^{n} k_8[m] + \sum_{m=\lambda(1-\delta)}^{n} k_9[m]\right) i_H[n-m] -$$
$$-\frac{1}{\rho}\left(\begin{matrix}(\sum_{m=0,5\lambda(1-2\delta)}^{n} k_{10}[m]+\frac{k_4}{k_2}\cdot\frac{T}{\lambda}k_{11}[m]) + \\ (\\ \sum_{m=0,5\lambda(1+2\delta)}^{n}(k_{12}[m]+\frac{k_4}{k_2}\cdot\frac{T}{\lambda}k_9[m])\end{matrix}\right) U_k[n-m]$$

where *i (n,)*, *U (n,)* - values of initial functions *i (x, t)*, *U (x, t)* in the trellis form;

for $n < \lambda$

$$k_1[n] = \begin{bmatrix} 0 \\ e^{-\alpha T} + aT\sum_{m=\lambda+1}^{n} e^{-\frac{\alpha T}{\lambda}m} \dfrac{I_1\left(\frac{\beta T}{\lambda}\sqrt{m^2-\lambda^2}\right)}{\sqrt{m^2-\lambda^2}} \end{bmatrix}$$

for $n > \lambda$

$$k_2[n] = e^{-\frac{\alpha T}{\lambda}n} I_0(\beta\frac{T}{\lambda}\sqrt{n^2-(\lambda\delta)^2}), \quad k_3[n] = \sum_{m=\lambda\delta}^{n} k_2[m],$$
$$k_4[n] = e^{-\frac{\alpha T}{\lambda}n} I_0(\beta\frac{T}{\lambda}\sqrt{n^2-[\lambda(1-\delta)]^2}), \; k_5[n] = \sum_{m=\lambda(1-\delta)}^{n} k_4[m],$$

for $n < 0,5\lambda(1-2\delta)$

$$k_6[n] = \begin{bmatrix} 0 \\ e^{-a\tau(1-2\delta)} + a\tau(1-2\delta)\cdot \\ \sum_{m=0,5\lambda(1+2\delta)+1}^{n} e^{-\frac{\alpha T}{\lambda}m} \dfrac{I_1\left(\frac{\beta T}{\lambda}\sqrt{m^2-[0,5\lambda(1-2\delta)]^2}\right)}{\sqrt{m^2-[0,5\lambda(1-2\delta)]^2}} \end{bmatrix}$$

for $n > 0,5\lambda(1-2\delta)$
for $n < 0,5\lambda(1+2\delta)$

$$k_7[n] = \begin{bmatrix} 0 \\ e^{-a\tau(1+2\delta)} + a\tau(1+2\delta) \\ \sum_{m=0,5\lambda(1+2\delta)+1}^{n} e^{-\frac{\alpha T}{\lambda}m} \dfrac{I_1\left(\frac{\beta T}{\lambda}\sqrt{m^2-[0,5\lambda(1+2\delta)]^2}\right)}{\sqrt{m^2-[0,5\lambda(1+2\delta)]^2}} \end{bmatrix}$$

for $n > 0,5\lambda(1+2\delta)$
for $n < \lambda\delta$

$$k_8[n] = \begin{bmatrix} 0 \\ e^{-aT\delta} + aT\delta\sum_{m=\lambda\delta}^{n} e^{-\frac{\alpha T}{\lambda}m} \dfrac{I_1\left(\frac{\beta T}{\lambda}\sqrt{m^2-[\lambda\delta]^2}\right)}{\sqrt{m^2-[\lambda\delta]^2}} \end{bmatrix}$$

for $n > \lambda\delta$
for $n < \lambda(1-\delta)$

$$k_9[n] = \begin{bmatrix} 0 \\ e^{-aT(1-\delta)} + aT(1-\delta) \\ \sum_{m=\lambda(1-\delta)+1}^{n} e^{-\frac{\alpha T}{\lambda}m} \dfrac{I_1\left(\frac{\beta T}{\lambda}\sqrt{m^2-[\lambda(1-\delta)]^2}\right)}{\sqrt{m^2-[\lambda(1-\delta)]^2}} \end{bmatrix}$$

for $n > \lambda(1-\delta)$

$$k_{10}[n] = e^{-\frac{\alpha T}{\lambda}n} I_0(\beta\frac{T}{\lambda}\sqrt{n^2-[0,5\lambda(1-2\delta)]^2}),$$
$$k_{11}[n] = \sum_{m=0,5\lambda(1-2\delta)}^{n} k_{10}[m],$$
$$k_{12}[n] = e^{-\frac{\alpha T}{\lambda}n} I_0(\beta\frac{T}{\lambda}\sqrt{n^2-[0,5\lambda(1+2\delta)]^2}),$$
$$k_{13}[n] = \sum_{m=0,5\lambda(1+2\delta)}^{n} k_{12}[m],$$

here

$$\sum_{m=0}^{n} U[n-m,\delta]1[m] = U[n,\delta] + \sum_{m=0}^{n-1} U[m,\delta]1[n-m] \tag{12}$$

$$\sum_{m=0}^{n} i[n-m,\delta]1[m] = i[n,\delta] + \sum_{m=0}^{n-1} i[m,\delta]1[n-m] \tag{13}$$

Expression (10) with account (12) will be:

$$U[n,\delta]+\sum_{m=0}^{n-1}1[m]U[n-m,\delta]+\sum_{m=\lambda}^{n}k_1[m]U[n-m,\delta]=$$
$$\rho\left(\sum_{m=\lambda\delta}^{n}(k_2[m]+\frac{k_3}{k_1}\cdot\frac{T}{\lambda}k_3[m])-\right.$$
$$\left.-\sum_{m=\lambda(1-\delta)}^{n}(k_4[m]+\frac{k_3}{k_1}\cdot\frac{T}{\lambda}k_5[m])\right)i_H[n-m]+$$
$$+\left(\sum_{m=0,5\lambda(1-2\delta)}^{n}k_6[m]+\sum_{m=0,5\lambda(1+2\delta)}^{n}k_7[m]\right)U[n-m]$$
(14)

From this we define the following recurrence relation enabling to evaluate function *U (n, δ)* subsequently:

$$U[n,\delta]=\rho$$
$$\left(\sum_{m=\lambda\delta}^{n}(k_2[m]+\frac{k_3}{k_1}\cdot\frac{T}{\lambda}k_3[m])-\sum_{m=\lambda(1-\delta)}^{n}(k_4[m]+\frac{k_3}{k_1}\cdot\frac{T}{\lambda}k_5[m])\right) \quad (15)$$
$$i_H[n-m]+\left(\sum_{m=0,5\lambda(1-2\delta)}^{n}k_6[m]+\sum_{m=0,5\lambda(1+2\delta)}^{n}k_7[m]\right)U_k[n-m]-$$
$$-\sum_{m=0}^{n-1}1[m]U[n-m,\delta]-\sum_{m=\lambda}^{n}k_1[m]U[n-m,\delta]$$

For determining the value of trellis function *i (n, δ)* expression (11) with account (13) will be:

$$i[n,\delta]+\sum_{m=0}^{n-1}1[m]i[n-m,\delta]+\sum_{m=\lambda}^{n}k_1[m]i[n-m,\delta]= \quad (16)$$
$$-\left(\sum_{\lambda\delta}^{n}k_8[m]+\sum_{m=\lambda(1-\delta)}^{n}k_9[m]\right)i_H[n-m]-\frac{1}{\rho}$$
$$\left((\sum_{m=0,5\lambda(1-2\delta)}^{n}k_{10}[m]+\frac{k_4}{k_2}\cdot\frac{T}{\lambda}k_{11}[m])+(\sum_{m=0,5\lambda(1+2\delta)}^{n}(k_{12}[m]+\frac{k_4}{k_2}\cdot\frac{T}{\lambda}k_9[m])\right)$$
$$U_k[n-m]$$

From this we define the following recurrence relation allowing to evaluate function *i (n, δ)* sequentially:

$$i[n,\delta]=\left(\sum_{\lambda\delta}^{n}k_8[m]+\sum_{m=\lambda(1-\delta)}^{n}k_9[m]\right)i_H[n-m]- \quad (17)$$
$$-\frac{1}{\rho}$$
$$\left((\sum_{m=0,5\lambda(1-2\delta)}^{n}k_{10}[m]+\frac{k_4}{k_2}\cdot\frac{T}{\lambda}k_{11}[m])+(\sum_{m=0,5\lambda(1+2\delta)}^{n}(k_{12}[m]+\frac{k_4}{k_2}\cdot\frac{T}{\lambda}k_9[m])\right)$$
$$U_k[n-m]-\sum_{m=0}^{n-1}1[m]i[n-m,\delta]-\sum_{m=\lambda}^{n}k_1[m]i[n-m,\delta]$$

An error in estimations connected to value *λ.* The more the sampled number *λ* is, the less is the difference between the characteristics of a the continuous function and the corresponding characteristics of the trellis ones.

The obtained recurrence relations (16), (17) define voltage and current variations at any point of radio technical chains with distributed parameters with allowance for losses in a circuit.

The recurrence relations include unknown functions *U_H[n]*, *i_K[n]*. Determination of their values is carried out on the following procedure.

According to fig. 1, for a starting point of radio technical chains with distributed parameters, it is possible to represent the following expression in the operator form:

$$i_н(s)=[U_0(s)-U_н(s)]K_0(s),$$
(18)

Where $K_0(s)=\dfrac{1}{R_1+L_1s}$

Expression (18) in the discrete form in the domain of original functions can be represented in the form of:

$$i_н[n]=\frac{1}{L_1}\cdot\frac{T}{\lambda}\left(\sum_{m=0}^{n}K_0[m](U_0[n-m]-U_H[n-m])\right) \quad (19)$$

Where $K_0[n]=e^{-\frac{R_1}{L_1}\cdot\frac{Tn}{\lambda}}$

Further for *δ = 0*, defining from the recurrence relation (17), from the expression for current *i_H[n]* and, solving jointly with expression (19), we shall obtain the following recurrence relation for voltage *$U_н$ [n]*:

$$U_н[n]=\frac{A_0}{1+A_0}\cdot[U_0[n]]+\sum_{m=1}^{n}K_0[m](U_0[n-m]-U_H[n-m])-\frac{\rho}{1+A_0}\cdot B[n], \quad (20)$$

where *B [n]* - known trellis function.

According to boundary conditions, it is possible to present the following expression for function *$U_к$ (t)* in the trellis form:

$$U[n]=R_2i_k[n] \quad (21)$$

III. CONCLUSION

Further, determinations of the expression for voltage *U_K[n]* for *δ = 0,5* (*x = l*) from the recurrence relation (16), the expression for current *$i_к$ [n]* is determined. Then the expression obtained for *$i_к$ [n]* is solved jointly with expression (21) and the value of voltage *$U_к$ [n]* is determined.

REFERENCES

1. *Pashaev A.M., Mehdiev A.Sh., Aliyev Y.A., Mamedov A.I.* New method determination flow oil, gas product in the main pipelines for measurement orifice meter with account real conditions – their dynamic regimes. Transactions of Azerbaijan National Academy of Sciences, series of physical – technical and mathematical sciences, 2005, № 3 (in Russian)
2. *Aliyev Y.A.* Numerical definition of transients in a column of boring pipes as object as object with the distributed parameters. Problems of power, 2004, № 1 (in Russian)
3. *Aliyev Y.A., Mamedov A..I.* Digital modeling of transients in the drilling electric drive with the distributed parameters with electromagnetic muft at failure of the drilling instrument. Materials of Second International Conference on Technical and physical Problems in Power Engineering, 6-8 September, 2004, Tabriz, Iran.
4. *Mamedov A.I., Aliyev Y.A.* New numerical method of calculation of transmission processes into drilling electric drive which includes the section with distributed parameters. Materials of Second International Symposium on electrical, electronic and engineering. 11-13 March, Nicosia, North Cyprus, 2004.