Stepped Transformers on TEM-Transmission Lines

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***Abstract*—The paper presents comparative analysis of the properties of impedance stepped transformers both with monotonous and nonmonotonous step-to-step impedance variation. A miniature stepped transformer of a new structure based on a cascade of an even number of uniform transmission line sections has been synthesized. Section lengths are considerably shorter than a quarter of the central wavelength, and the section impedances alternate. The proposed transformers are the simplest to implement among the available analogs. As an example, the results of the solution of the Chebyshev approximation problem for the four-and six-section transformers of different specifications are given.**

I. Introduction

TRANSFORMERS are traditionally divided into two groups, the first comprising the transmission-line devices with a continuously tapered impedance function (nonuniform transformers), the second including those on the transmission lines with piecewise constant variation of the impedance function (stepped transformers). The latter are considerably shorter than the tapered transformers and find broad application.

Stepped transformers are further divided into monotonic (with a monotonic step-to-step impedance variation) and nonmonotonic (with nonmonotonic step-to-step impedance variation). The monotonic transformers, which are to be regarded as classic, have been proposed and investigated in sufficient detail by the American scientists [1]–[3], while the nonmonotonic ones have been described mainly by the Russian authors [4]–[7].

The present paper gives the comparative analysis of the properties for both monotonic and nonmonotonic stepped transformers. The results of investigation of the properties for miniature nonmonotonic stepped transformers having a new structure and characterized both by minimum length, optimum frequency characteristics, and distinguished from the available analogs by their simplicity of design are also presented.

II. General Properties of the Stepped Transformers

Properties of the stepped transformers on cascade connection of n uniform transmission line sections of equal lengths $l_i = \lambda_o/4$ (λ_o is the wave length corresponding to the central frequency of the matching band), with the section impedances varying monotonously from step to step, have been most adequately investigated [1]–[3]. Fig. 1(a) shows the structure of such a transformer (z, Z are impedances of the transmission lines to be matched, z_i $(i = 1, 2, \cdots, n)$ are impedances of quarterwave sections).

According to the classifications introduced in [4], the transformers under consideration refer to stepped transformers of Class I. They are antimetry devices; according to Riblet [3], the antimetry condition may be written in the form

$$z_i z_{n+1-i} = zZ \qquad i = 1, 2, \cdots, n. \tag{1}$$

The main drawback of Class I transformers is their considerable length $L = n\lambda_o/4$, where n is the number of transformer sections. Stepped transformers of Class II synthesized using m cascaded uniform transmission line sections of various lengths with alternating impedances (m is always an even number) are shorter by a factor of 1.5–2 [5]. In a particular case the section impedances are equal to the impedances of the transmission lines to be matched [5], [6], and [8] [see Fig. 1(b)]. The elementary two-section devices of such a type have been proposed previously [8]; but they did not find wide application on account of their narrow bandwidth. More complex multistepped units have not been investigated. Recently the Chebyshev approximation problem for the prescribed amplitude frequency characteristic for multistep superwide band impedance transformers of Class II has been solved by the authors [5]. The problem has been formulated as follows: to define the component values for the vector $A = (A_1, A_2, \cdots, A_m)$ allowing one to achieve

$$\min_{A} \max_{\theta \in [\theta_1, \theta_2]} |\Gamma(\theta, A)| \tag{2}$$

where $\theta = 2\pi\lambda_o/\lambda$ is the generalized electric variable; θ_1, θ_2 correspond to the lower and the upper matching band boundaries; λ is the transmission line wavelength; $|\Gamma(\theta, A)|$ is the modulus of the input reflection coefficient, $|\Gamma(\theta, A)| = (1 - 1/|T_{11}|^2)^{1/2}$, where T_{11} is the element of the wave transfer matrix for the transformer. The vector A components are the normalized section lengths $L_i = l_i/\lambda_o$ $(i = 1, 2, \cdots, m)$, where l_i denotes the geometrical lengths of the sections.

The solution of the corresponding approximation problems [5] has led the authors to the statement that the optimum Chebyshev characteristics can be provided only by the structure, for which the relations (3) are true

$$l_i = l_{m+1-i}, \qquad i = 1, 2, \cdots, m/2. \tag{3}$$

It can be easily proved that for the structure under consideration the conditions (3) together with the equations

$$z_i = Z, \quad z_2 = z \tag{4}$$

are the necessary and sufficient antimetry conditions. It is generalized in [5] that in order to achieve the global minimum

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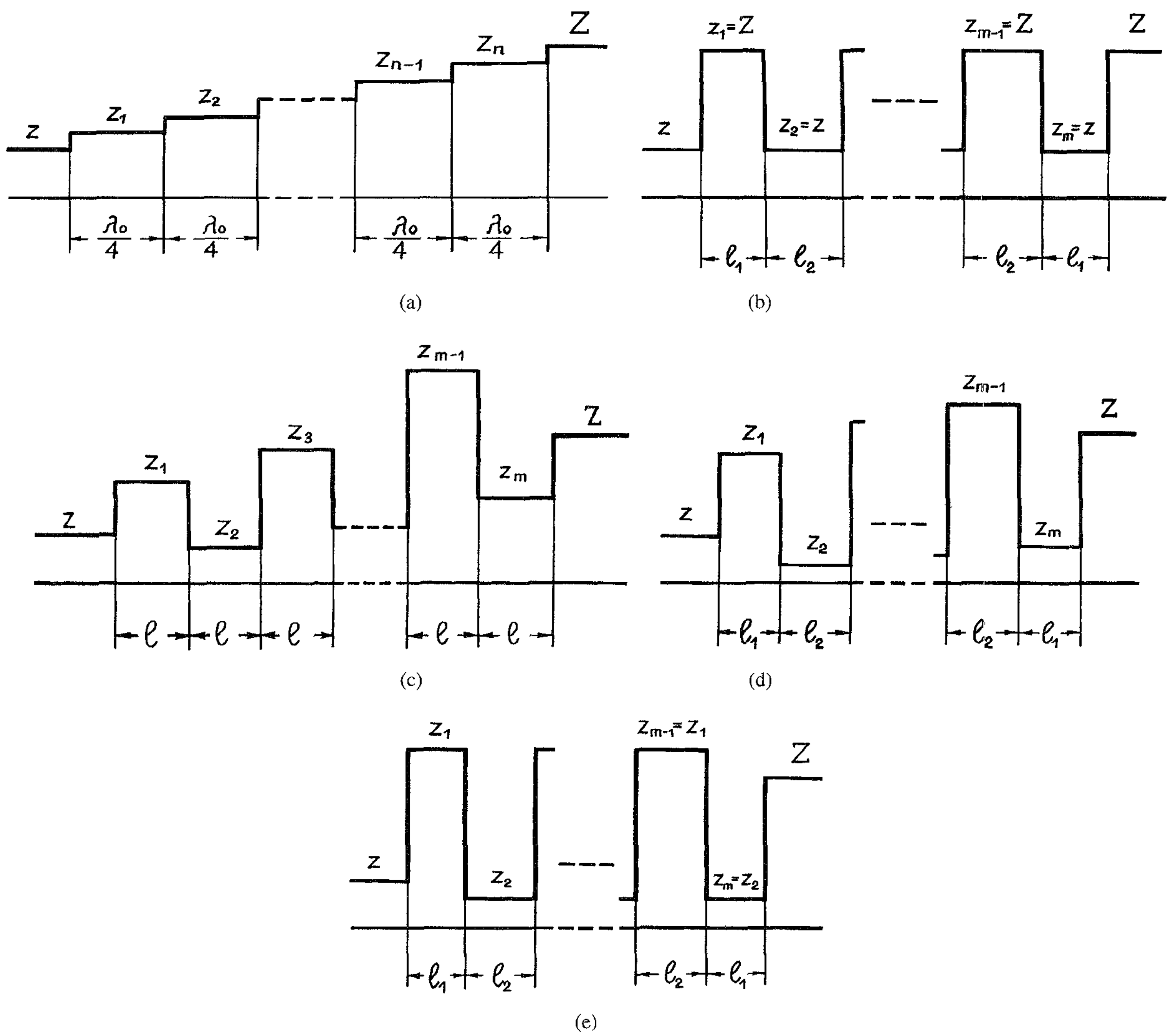

Fig. 1. Structures of stepped transformers: (a) Transformer of Class I. (b) Transformer of Class II. (c) Miniature transformer with the sections of equal lengths. (d) Generalized structure of miniature transformer. (e) New structure of miniature transformer.

of the goal function $|\Gamma(\theta, A)|$ in the synthesis of any types of the stepped transformers of cascaded TEM-transmission line sections it is necessary to fulfil the antimetry condition.

The authors [5] have also evaluated the optimum of the solutions obtained. Such an evaluation has been complicated by the fact that the goal function $G(A) = \max_{\theta} |\Gamma(\theta, A)|$ is multidimensional. With allowance for the device antimetry it is possible to reduce twice the number of independent variables of the function $G(A)$, and the vector A dimensions become equal to $m/2$. For the simplest case of $m = 2$ the function $G(A)$ turns one-dimensional (1-D) (the vector A has only one component A_1), which allows us to analyze it both numerically and graphically. The numerical analysis of the function $G(A_1)$ shows that it is multiextremal within the interval (0, 1). It was not found expedient to consider the function $G(A_1)$ for $A_1 > 1$ since the longitudal dimensions of the transformer turn to be too large under such A_1 values. Fig. 2 depicts the function $G(A_1)$ for $Z/z = 2, \chi = \theta_2/\theta_1 = rm1.5$. As can be seen from the plot, the function $G(A_1)$ has two local minimums. The first one is located in the interval $0 < A_1 < 0.2$ and is global; A_1 for such a case is equal to 0.0771, which coincides with the data obtained in [8] by use of the empirical formula

$$l = \frac{\lambda_o}{2\pi} \operatorname{arcctg} \left(R + \frac{1}{R} + 1 \right)^{1/2}.$$

The requirement to fulfil the antimetry condition [5] has been also confirmed by the results obtained in [6], where the optimum parameters for the stepped transformers of Class II with maximally-flat (Butterworth's) characteristics are given.

Investigation of the m-section transformer of Class II ($m = 2, 4, \cdots$) has shown that its amplitude frequency characteristic is analogous to that of the $m/2$-section transformer of Class I designed for matching the transmission lines with the same z and Z and the same mismatching tolerance $|\Gamma|_{\max}$. Yet the matching band of Class II transformer is only 10–15% narrower than that of the corresponding Class I transformer, and its total length is shorter by a factor of 1.5–2. Besides, Class II transformers are characterized by a simpler production technology, due to the fact that only two dimensions of the transmission line cross section corresponding to the impedances z and Z are to be realized along their lengths. In case

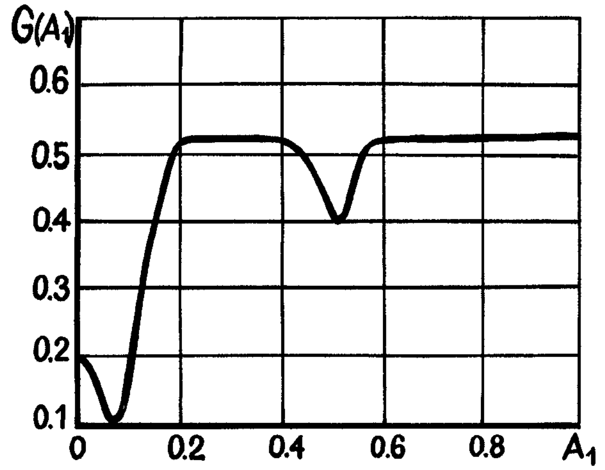

Fig. 2. The goal function of the transformer of Class II ($m = 2$).

of Class I transformer the number of such dimensions is equal to $n + 2$.

Another advantage offered by Class II transformers is that it is easy to take into account the effect of electrical nonuniformities arising at the planes of junction of the transmission line sections having different lengths $l_1, l_2, \cdots, l_m$ and impedances z and Z [Fig. 1(b)], on the amplitude frequency characteristics. In our case there is only one type of such nonuniformities being caused by jumpwise variation of the geometric dimensions of the cross section of the transmission lines having the impedance z at the regions of their junction with the transmission line sections having the impedances Z. In Class I transformers the number of such nonuniformities is equal to $n + 1$ [Fig. 1(a)], and they are caused by the jumpwise variation of the geometrical dimensions of the cross sections of the transmission line sections having the impedances $z_1, z_2, \cdots, z_n$ at the regions of their junction with the neighbor sections of the transmission line.

The transformer length can be further reduced by using the structure described in [9] representing the cascade connection of m transmission line sections (m is even) of the same length l ($l < \lambda_o/4$), the impedances of which satisfy the following inequalities:

$$\begin{cases} z_1 < z_3 < \cdots < z_{m-1} \\ z_2 < z_4 < \cdots z_m \end{cases} \quad (z_1 > z_m \text{ in case } z < Z). \quad (5)$$

This transformer structure is shown in Fig. 1(c). This transformer is an antimetric device, the antimetry condition being

$$z_i z_{m+1-i} = zZ, \qquad i = 1, 2, \cdots, m/2. \quad (6)$$

The use of this structure allows one to reduce the transformer length by a factor of 2–4 as compared to the analogous device of Class I. The substantial drawback of such a miniature transformer is the necessity to realize a high impedance ratio $R_m = z_{\max}/z_{\min}$ reaching in a number of cases the values of 30–50.

Search of possible ways of eliminating this drawback has led the authors [7] to the generalized structure shown in Fig. 1(d). Such a transformer is a cascade of m transmission line sections (m is even) of different lengths l_i and impedances z_i ($i = 1, 2, \cdots, m$). It has been stated in [7] that only structures, for which the relations (7) are true, will have optimum Chebyshev characteristics

$$\begin{cases} l_i = l_{m+1-i} \\ z_i z_{m+1-i} = zZ \end{cases}, \qquad i = 1, 2, \cdots, m/2. \quad (7)$$

It is easy to prove that the relations (7) are the antimetry conditions for the given structure. This confirms the conclusion made in [5] that the antimetry condition is necessary for achieving the global minimum of the goal function $G(A) = \max_{\theta \in [\theta_1, \theta_2]} |\Gamma(\theta, A)|$ during the synthesis of the stepped transformers of all types.

The comparison of (7) with the antimetry conditions for the stepped transformers of Class I and II, as well as with (6) shows that the equations (7) are the generalized antimetry conditions for the stepped transformers of all structure types.

Transformer section impedances satisfy the inequality

$$z_{m-1} > z_{m-3} > \cdots > z_1 > z_m > z_{m-2} > \cdots > z_2 \quad (8)$$

i.e., the impedances of both sections of even and odd numbers decrease in the direction from the transmission line with a higher impedance Z to z impedance line, the impedance of any section of an odd number being always larger than that of any section of an even number. The following regularity is observed here: the lengths of odd number sections increase in the direction from the transmission line of a smaller impedance z under matching to Z impedance line, and the lengths of even number sections decrease in the same direction.

III. New Structure for Miniature Stepped Transformer

Another possibility to reduce the stepped transformer length is the use of the stepped structure [see Fig. 1(e)], which differs from the one investigated in [5], [6] by its section impedances satisfying the conditions

$$\begin{cases} z_1 = z_3 = \cdots = z_{m-1} \\ z_2 = z_4 = \cdots = z_m \end{cases} \qquad m = 2, 4, \cdots, \quad (9)$$

where $z_1 z_2 = zZ, z_m < z, z_{m-1} > Z$.

To solve the optimization problem in form (2), the algorithm based on the linearization method offered by Pshenichni [10] has been used. The description of this method as applied to the problem of stepped transformer synthesis is given in the Appendix.

In solving the synthesis problem the antimetry property of the given device has been used, which is to be found in case both (9) and (10) conditions are fulfilled

$$l_i = l_{m+1=i}, \qquad i - 1, 2, \cdots, m/2. \quad (10)$$

That made it possible to reduce twice the dimensions of the varied parameter vector A. In the general case of m-section transformer only one of the impedances (z_1 or z_2) and only $m/2 - 1$ section lengths (e.g., $L_1, L_2, \cdots, L_{m/2-1}$) should be varied while solving the synthesis problem. The

TABLE I
OPTIMUM PARAMETERS FOR THE FOUR-SECTION TRANSFORMERS

$\lvert\Gamma\rvert_{max}$	$L_{1,4}$	$L_{2,3}$	z_1,Ω	z_2,Ω	L
0.064	0.0479	0.1171	52.38	23.86	0.3300
0.070	0.0405	0.0841	72.91	17.14	0.2500
0.074	0.0282	0.0553	114.55	10.91	0.1670
0.075	0.0213	0.0412	155.67	8.03	0.1250

TABLE II
OPTIMUM PARAMETERS FOR THE SIX-SECTION TRANSFORMERS

$\lvert\Gamma\rvert_{max}$	$L_{1,6}$	$L_{2,5}$	$L_{3,4}$	z_1,Ω	z_2,Ω	L
0.067	0.0375	0.1280	0.0875	54.24	23.05	0.5000
0.075	0.0347	0.0909	0.0740	74.32	16.82	0.3900
0.082	0.0230	0.0540	0.4800	123.09	10.16	0.2500
0.084	0.0175	0.0398	0.0360	166.58	7.50	0.1856

other impedance value as well as length $L_{m/2}$ may be defined then from the relations

$$z_{2(1)} = zZ/z_{1(2)}, \quad L_{m/2} = L/2 - \sum_{i=1}^{m/2-1} L_i$$

where L is normalized summary transformer length, which was taken fixed when solving the synthesis problem. Thus the vector of varied parameters is $A = (z_1, L_1, L_2, \cdots, L_{m/2-1})$.

The results for Chebyshev approximation (2) for the four-section transformer ($m = 4$), designed for matching the transmission lines with the impedances $z = 25\ \Omega$ and $Z = 50\ \Omega$ in the frequency range of one octave, are given in Table I. Table II shows the optimum parameters for the six-section transformer designed for matching the same lines in the frequency range of one and a half octave.

The investigation of the properties of the transformer based on the proposed stepped structure has shown that only the transformers for which the lengths of odd number sections increase in the direction from the transmission line with smaller impedance z to the line with Z impedance, and lengths of sections of even numbers decrease in the same direction, have the optimum characteristics (Tables I, II).

In view of the results given in the present paper, as well as in [5]–[7], we may state that the former regularity of section length variation is inherent in all the stepped transformers designed on the cascade connection of uniform transmission lines of different lengths irrespective of the type of their impedances (whether they assume two alternating values, or are subjected to some other law of variation).

Fig. 3 shows the amplitude frequency characteristics for two-section transformer of Class I (curve 1) as compared to those for the corresponding four-section miniature transformer (curve 2) both designed for matching the transmission lines with impedances relating as 1 : 2 in the frequency range of one octave; the length of the miniature transformer being $0.125\lambda_o$, and that of the corresponding Class I transformer being $0.5\lambda_o$. For comparison, Tables III and IV show the optimum parameters of the known four-section miniature transformers (computed on the data given in [7], [9]), designed for matching the same transmission lines ($R = Z/z = 2$) as the proposed transformer (Table I) in the frequency range of one octave.

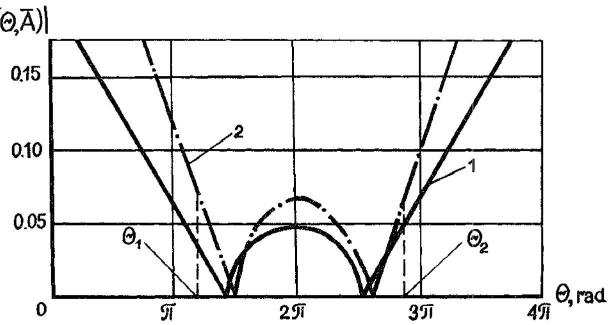

Fig. 3. Amplitude frequency characteristic of the stepped transformers. Curve I—transformer of Class I; curve 2—new structure of miniature transformer.

TABLE III
OPTIMUM PARAMETERS FOR THE FOUR-SECTION TRANSFORMERS OF EQUAL-LENGTH SECTIONS [9]

$\lvert\Gamma\rvert_{max}$	$L_{1,2,3,4}$	z_1,Ω	z_2,Ω	z_3,Ω	z_4,Ω	L
0.065	0.0833	42.38	19.80	63.13	29.49	0.3330
0.071	0.0625	55.75	13.58	92.03	22.42	0.2500
0.074	0.0418	82.58	8.45	148.01	12.14	0.1670
0.076	0.0313	109.64	6.17	202.48	11.40	0.1250

TABLE IV
OPTIMUM PARAMETERS FOR THE FOUR-SECTION TRANSFORMERS ON GENERALIZED STRUCTURE [7]

$\lvert\Gamma\rvert_{max}$	$L_{1,4}$	$L_{2,3}$	z_1,Ω	z_2,Ω	z_3,Ω	z_4,Ω	L
0.068	0.0625	0.0833	51.75	18.20	68.73	24.15	0.2916
0.070	0.0525	0.0725	62.00	15.28	81.85	20.15	0.2500
0.075	0.0320	0.0510	103.00	10.13	123.39	12.14	0.1660
0.076	0.0205	0.0420	152.90	7.78	160.95	8.18	0.1250

IV. CONCLUSION

The investigation of the performances for the stepped transformers of various structures on cascade connection of uniform TEM-transmission line sections has advanced lately. The general patterns of the length and impedance distribution both for the transformers of Class I and Class II and those of the generalized structure have been defined.

The investigation of the monotonic Class I structures began approximately 40 years ago with the basic works by Cohn, Collin, and Riblet [1]–[3]. Nonmonotonic structures of Class II and the generalized structures have been researched later, primarily by the Russian scientists, with the application of the numerical optimization methods [4]–[7].

The use of the new structure ($m = 4$) proposed in the present paper allows one to achieve the device summary length equal to $0.125\lambda_o$ (see Table I), which is one-fourth of the length of Class I two-section analog. The same transformer specifications can be provided by the application of the well-known miniature structure [9], offering the same length reduction, but for this it is necessary to realize the following impedances: $z_1 = 109.64\ \Omega, z_2 = 6.17\ \Omega, z_3 = 202.49\ \Omega, z_4 = 11.40\ \Omega$; i.e., the maximum impedance ratio $R_{\max} = z_3/z_2 = 32.8$. In the structure under consideration the maximum impedance ratio $R_{\max} = 19.39$. As compared to the available analogs [7], [9], the proposed transformer is the most prospective in terms of productional simplicity, since only four cross-section dimensions corresponding to impedances z, z_1, z_2, Z are to be realized along the m-section transformer length. The number of such dimensions in transformers [7], [9] is equal to $m + 2$.

APPENDIX

The linearization method offered by Pshenychni [10], which is efficient as applied to the problems of discrete minimax, will be used here to solve the problem (2), similar to that described in [5].

First, we will transform (2) into the discrete problem by introducing the set of $N \gg p$ points over the interval $[\theta_1, \theta_2]$

$$\min_{A} \max_{1\leq i\leq N} F_i(A) \qquad \text{(A1)}$$

where $F_i(A) = |\Gamma(\theta_i, A)|, p$ is the number of the variables.

Let us consider the linearization method as applied to problem (A1). Let us denote the function $F(A)$ as follows: $F(A) = \max_{1\leq i\leq k} F_i(A)$.

Suppose A_o is the initial approximation, the points $A_j, j = 0, 1, \cdots, k$ have already been defined. Then

$$A_{k+1} = A_k + \alpha_k p_k$$

where p_k is n-dimension vector indicating the direction, α_k is a step in this direction and is set equal to 2^{-i_o}, where i_o is the first of the subscripts of $i = 0, 1, \cdots$, for which the following inequality is valid:

$$F(A_k + 2^{-i}P_k) \leq F(A_k) - 2^{-i}\varepsilon\|p_k\|^2, \qquad \tfrac{1}{2} < \varepsilon < 1.$$

The slope direction p_k is defined by solving the auxiliary problem

$$\min_{\beta_k, p_k} (\beta_k + 0.5\|p_k\|^2),$$
$$(F_i(A_k), p_k) - \beta_k \leq 0; \quad i \in J_\delta(A_k) \qquad \text{(A2)}$$

where $\delta > 0, J_\delta(A_k) = \{i\colon 1 \leq i \leq N, F_i(A_k) \geq F(A_k) - \delta\}$.

Since the initial problem is that of a continuous minimax, the number of discrete points N should considerably exceed the number p of the variables to provide the accuracy sufficient for practical applications. The numerical experiment has shown that for $p = 4$ the sufficient accuracy is obtained with $N \geq 100$. Already with $N = 100$ and $F_i(A_k) \leq \delta$, the subscript plurality consists of N points. This complicates the solution of the auxiliary problem (A2) and requires large scope of computations. In view of this, we will make use of the problem specificity, i.e., of the fact that the initial problem is that of the continuous minimax. When forming the subscript plurality $J_\delta(A_k)$, we will take into account only the points, at which the local maximums for a given step are achieved. Then $p + 1$ points will get into the plurality $J_\delta(A_k)$ at the most, in view of the fact that the number of the local maximums in the nondegeneracy problem (A1) exceeds that of the variables by unity.

Problem (A2) is a problem of convex programming. Since its direct solution is difficult, we will transform it into a dual problem. It may be shown that the dual problem is the problem of square programming and has the form

$$\min_{U} \frac{1}{2} \left\| \sum_{i \in J_\delta(A_k)} U_i F_i'(A_k) \right\|^2 - \sum_{i \in J_\delta(A_k)} U_i F_i(A_k)$$

under constraints

$$\sum_{i \in J_\delta(A_k)} U_i = 1, \quad U_i \geq 0, \qquad i \in J_\delta(A_k)$$

where U is the vector of dual variables $U_i, i \in J_\delta(A_k)$. To solve this problem, it is convenient to apply the method of conjugate gradients in combination with the design procedure [10].

The following values for constants δ and N have been chosen to find the optimum transformer parameters: $\delta = 1, N = 60$–120 (depending on the number of the variables). In all the cases of the antimetry structure we observed the square speed of the convergence. This is also confirmed by the fact that beginning from a certain k, the step α_k became equal to unity.

REFERENCES

[1] S. B. Cohn, "Optimum design of stepped transmission line transformers", *IRE Trans. Microwave Theory Tech.*, vol. MTT-3, pp. 16–21, 1955.

[2] R. E. Collin, "Theory and design of wide-band multisectional quarter-wave transformers," *Proc. IRE*, vol. 43, pp. 179–185, 1955.

[3] H. J. Riblet, "General synthesis of quarter-wave impedance transformers", *IRE Trans. Microwave Theory Tech.*, vol. MTT-5, pp. 36–43, 1957.

[4] B. M. Katz, V. P. Meschanov, and A. L. Feldstain, *Optimum Synthesis of TEM Microwave Devices*, V. P. Meschanov, Ed. Moscow: Radio i svjaz, 1984.

[5] V. P. Meschanov, S. A. Saliy, I. A. Tsots, and L. V. Shykova, "Synthesis of stepped transition units of class II," *Radio Eng. Electron Phys.*, vol. 29, no. 12, pp. 9–18, Dec. 1984.

[6] V. P. Meschanov, G. G. Chumaevskaya, I. A. Tsots, "Stepped impedance transformers of class II with maximally-flat amplitude-frequency characteristics," *Radiotekhnika i elektronika*, vol. 33, no. 1, pp. 195–198, 1989.

[7] V. P. Meschanov, I. A. Rasukova, V. D. Tupikin, "New structure of miniature stepped real impedance transformers," *Radiotekhnika i elektronika*, vol. 36, no. 8, pp. 1492–1496, 1991.

[8] G. L. Matthaei, L. Young, and E. M. T. Jones, *Microwave Filters, Impedance Matching Networks and Coupling Structures.* New York: McGraw-Hill, 1964.

[9] G. L. Matthaei, "Short-step Chebyshev impedance transformers", *IEEE Trans. Microwave Theory Tech.*, vol. MTT-14, no. 8, pp. 372–383, Aug. 1966.

[10] B. N. Pshenichni and Y. N. Danilin, *Numerical Methods for Extreme Problems.* Moscow: Nauka, 1975.

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