INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY RESEARCH AND ANALYSIS

ISSN(print): 2643-9840, ISSN(online): 2643-9875

Volume 05 Issue 08 August 2022

DOI: 10.47191/ijmra/v5-i8-11, Impact Factor: 6.261

Page No. 1988-1991

On One of the Possible Ways to Improve the Agreement between Branches of Five-Port Waveguide Junctions

Marina Shengelia[1], Maia Kevkhishvili[2], Manana Beridze[3], Darejan Khocholava[4]

[1,2,3,4] PhD Professor Georgian Technical University

ABSTRACT: At present, the requirements for flying machines, in terms of increasing flight speeds, maneuverability, and flight intensity, significantly expand the range of tasks to be solved by the radio-electric equipment of these machines. Therefore, during their design and construction, problems arise with the placement of a large number of antennas and radio-electronic devices. In addition, for maneuvering and flight dynamics, it is not allowed to place additional protrusions on the devices. From the obtained results, we can assume that the electrodynamic properties of the considered system can be changed by the variation of the system's feeding mode.

At present, the requirements for flying machines, in terms of increasing flight speeds, maneuverability, and flight intensity, significantly expand the range of tasks to be solved by the radio-electric equipment of these machines. Therefore, during their design and construction, problems arise with the placement of a large number of antennas and radio-electronic devices. In addition, for maneuvering and flight dynamics, it is not allowed to place additional protrusions on the devices.

One way to solve these problems is to create a complex, multifunctional, antenna-feeder system that incorporates aerial antennas, filters, switches, branchers, and control blocks, and provide the emission, reception, processing, and distribution of electromagnetic energy between various electrical devices.

In such complex antenna systems, it is possible to use high-frequency (ZMS) multi-port circuit breakers for power supply and removal, which have the ability to perform the functions of electromagnetic energy branches, collectors and transformers.

In order to increase the efficiency of multi-port waveguides embedded in radio-electronic and communication systems, it is first necessary to increase the bandwidth and reduce energy losses. In addition, when branching, dividing and converting the signal energy in such systems, it is necessary to ensure an acceptable agreement between different arms, that is, to pass a fairly high level of the working wave in the desired arm and suppress it in the others. Finally, for stable operation of the equipment, it is necessary to provide stable characteristics over a fairly wide frequency range [1 - 3].

The analysis carried out for different types of joints showed that an agreement acceptable for practice can be achieved only in a narrow band of frequencies and at a fixed ratio between the shoulder dimensions. Therefore, the task of ensuring a high-quality agreement is impossible to solve without constructive or other types of changes in the structure [4-7].

High-frequency devices lack the necessary elements for their operation, so their production must be preceded by computer design of the relevant electrodynamic structure, which includes three stages: 1. Mathematical modeling; 2. Analysis; 3. Optimization.

The aim of the present paper is to discuss one of the possible ways to improve the agreement between the branches according to the theoretical model developed for the five-port waveguide.

The structure under consideration is depicted in Figure 1

In order to vary the system construction and feeding modes, the so-called Logic multipliers for feeding and lateral branch orientation are introduced:

p1 (j) = 1 (corresponding areas of j = 1,2,3,4,10 in Fig. 1) - means that the system is supplied with power from the corresponding branch, p1 (j) = 0 - not supplied;

p2 (j) = 1 (j = 2,3) - means that the corresponding branch is connected from the bottom, and p2 (j) = 0 - from the top.

Using the field notation in each region, using different tangential field continuity conditions and residual theory on dividing surfaces, we obtain a field representation by multiples of the fields scattered in adjacent branches:

$$E_y^{(1)} = E_y^{(10)} + \sum_{m=1}^{\infty} A_m^{(1)} \sin\left(\alpha_m^{(1)} x\right) exp\left(ih_m^{(1)} z\right) \quad (1)$$

$$E_y^{(2)} = E_y^{(20)} + \sum_{m=1}^{\infty} A_m^{(2)} \sin\left[\alpha_m^{(1)}(x - L_1)\right] exp\left((-1)^{p2(2)}\right)\left[ih_m^{(2)}(z - p2(2)b)\right] \quad (2)$$

$$E_y^{(3)} = E_y^{(30)} + \sum_{m=1}^{\infty} A_m^{(3)} \sin\left[\alpha_m^{(2)}(x - L_3)\right] exp\left((-1)^{p2(3)}\right)\left[ih_m^{(3)}(z - p2(3)b)\right] \quad (3)$$

$$E_y^{(4)} = E_y^{(40)} + \sum_{m=1}^{\infty}\left[B_m^{(2)} + B_m^{(4)} exp\left(-h_m^{(4)} L_1\right) + B_m^{(6)} exp\left(-ih_m^{(4)} L_2\right)\right] \sin\left(\alpha_m^{(4)} z\right) exp\left(h_m^{(4)} x\right) \quad (4)$$

$$E_y^{(5)} = p1(4)\sin\left(\alpha_{\mu 2}^{(4)} z\right) exp\left(-ih_{\mu 2}^{(4)} x\right) + p1(10)\sin\left(\alpha_{\mu 2}^{(4)} z\right) exp\left(-ih_{\mu 2}^{(4)}(x - L_2 - a)\right) +$$
$$+ \sum_{m=1}^{\infty} \overline{A_m^{(1)}}\left\{u_m^{(1)} sin\left(\alpha_m^{(1)} x\right) exp\left[ih_m^{(1)}(b - z)\right] - \sum_{n=1}^{\infty} u_{mn}^{(2)}\left[exp\left(-ih_n^{(4)} x\right) - (-1)^m \times\right.\right.$$
$$\left.\left.\times\, exp\left(-ih_n^{(4)}(x - a)\right)\right] \sin\left(\alpha_m^{(4)} z\right)\right\} - i\sum_{m=1}^{\infty} \overline{A_m^{(2)}} \sum_{n=1}^{\infty} u_{mn}^{(3)} sin\left(\alpha_n^{(4)} z\right) exp\left(ih_n^{(4)}(x - L_1)\right) -$$
$$-i\sum_{m=1}^{\infty} \overline{A_m^{(3)}} \sum_{n=1}^{\infty} u_{mn}^{(4)} sin\left(\alpha_n^{(4)} z\right) exp\left(ih_n^{(4)}(x - L_2)\right) \quad (5)$$

$$E_y^{(6)} = \left\{A_m^{(6)} exp\left(-ih_m^{(4)}(x - a)\right) + \left[B_m^{(6)} exp\left(-h_m^{(4)} L_1\right) + B_m^{(4)} exp\left(-h_m^{(4)} L_2\right)\right] \times\right.$$
$$\left.\times \sin\left(\alpha_m^{(4)} z\right) exp\left(ih_m^{(4)} x\right)\right\} \quad (6)$$

$$E_y^{(7)} = p1(4)\sin\left(\alpha_{\mu 2}^{(4)} z\right) exp\left(-ih_{\mu 2}^{(4)} x\right) + p1(10)\sin\left(\alpha_{\mu 2}^{(4)} z\right) exp\left(-ih_{\mu 2}^{(4)}(x - L_2 - a)\right) +$$
$$+ \sum_{m=1}^{\infty} \overline{A_m^{(2)}}\left\{v_m^{(1)} sin\left[h_m^{(2)}(1 - p2(2))b - (-1)^{p2(2)}z\right] sin\left[\alpha_m^{(2)}(x - L_1)\right] - \quad - \sum_{n=1}^{\infty} v_{mn}^{(2)} sin\left(\alpha_m^{(4)} z\right) \times \times \left[exp\left(-ih_n^{(4)}(x - L_1)\right) - (-1)^m exp\left(-ih_n^{(4)}(x - L_1 - a)\right)\right]\right\} + \quad + \sum_{m=1}^{\infty} \overline{A_m^{(1)}} \sum_{n=1}^{\infty} v_{mn}^{(3)} sin\left(\alpha_m^{(4)} z\right) \times exp\left(-ih_n^{(4)}(x - a)\right) -$$
$$- \sum_{m=1}^{\infty} \overline{A_m^{(1)}} \sum_{n=1}^{\infty} v_{mn}^{(3)} sin\left(\alpha_m^{(4)} z\right) exp\left(-ih_n^{(4)}(x - L_2)\right) \quad (7)$$

$$E_y^{(8)} = \sum_{m=1}^{\infty}\left\{\left[A_m^{(6)} + A_m^{(8)} exp\left(ih_n^{(4)} L_1\right)\right] exp\left(-ih_n^{(4)}(x - a)\right) + B_m^{(2)} exp\left(ih_n^{(4)}(x - L_2)\right)\right\} \times \quad \times sin\left(\alpha_m^{(4)} z\right)$$
(8)

$$E_y^{(9)} = p1(4)\sin\left(\alpha_{\mu 2}^{(4)} z\right) exp\left(-ih_{\mu 2}^{(4)} x\right) + p1(10)\sin\left(\alpha_{\mu 2}^{(4)} z\right) exp\left(-ih_{\mu 2}^{(4)}(x - L_2 - a)\right) + \quad + \sum_{m=1}^{\infty} \overline{A_m^{(3)}} \times$$
$$\sum_{m=1}^{\infty} \overline{A_m^{(3)}}\left\{s_m^{(1)} sin\left[h_m^{(2)}(1 - p2(2))b - (-1)^{p2(2)}z\right] sin\left[\alpha_m^{(2)}(x - L_1)\right] - \quad - \sum_{n=1}^{\infty} s_{mn}^{(2)} sin\left(\alpha_m^{(4)} z\right) \times \quad \left[exp\left(-ih_n^{(4)}(x - L_2)\right) - (-1)^m exp\left(-ih_n^{(4)}(x - L_2 - a)\right)\right]\right\} + \quad + \sum_{m=1}^{\infty} \overline{A_m^{(1)}} \sum_{n=1}^{\infty} s_{mn}^{(3)} sin\left(\alpha_m^{(4)} z\right) \times exp\left(-ih_n^{(4)}(x - a)\right) -$$
$$- \sum_{m=1}^{\infty} \overline{A_m^{(2)}} \sum_{n=1}^{\infty} s_{mn}^{(4)} sin\left(\alpha_m^{(4)} z\right) exp\left(-ih_n^{(4)}(x - L_1 - a)\right) \quad (9)$$

$$E_y^{(10)} = E_y^{(100)} + \sum_{m=1}^{\infty}\left\{A_m^{(6)} exp\left(ih_m^{(4)} a\right) + A_m^{(8)} exp\left(ih_m^{(4)}(L_1 + a)\right) +\right.$$
$$\left. + A_m^{(10)} exp\left(ih_m^{(4)}(L_2 + a)\right)\right\} \times exp\left(-ih_n^{(4)} x\right) sin\left(\alpha_m^{(4)} z\right) \quad (10)$$

Thus, the stress vector in the entire physical area is represented by the coefficients of the reflected field in the side branches.

(1)-(10) field in the entire physical area meets the conditions:

1. represents the solution of the Helmholtz equation;
2. the condition of radiation;
3. zero boundary conditions on the metal walls of the joints;
4. The condition of field finitude in each bounded area.

It can be seen from (1)-(10) that the field consists of two components, the eigen numbers of one of which are the transverse wavenumbers of the corresponding side branch, and the other - of the main waveguide. From a physical point of view, the wave front bends on the surface separating the two environments, therefore, the electric field tension vector has two denominators, which is what is reflected in the images of the fields.

From the obtained results, we can assume that the electrodynamic properties of the considered system can be changed by the variation of the system's feeding mode.

Drawings.

Fig. 1. Considered structure for different configurations of side branches.

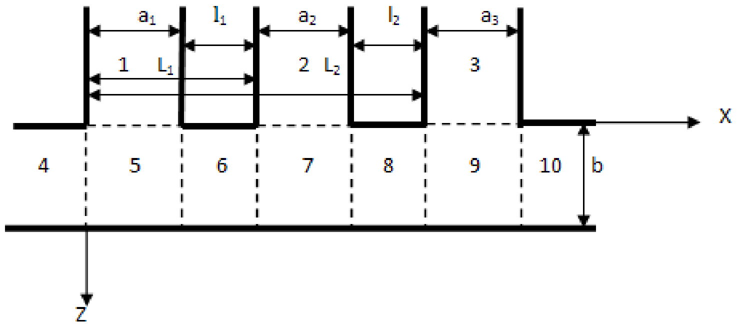

Fig. 1. a.

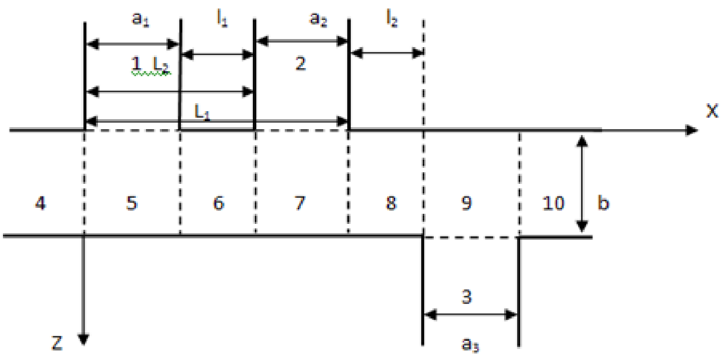

Fig. 1. b.

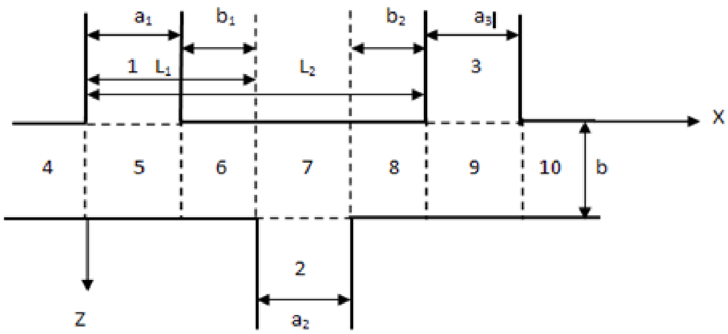

Fig. 1. c.

REFERENCES

1) Bogdanov F. G., Kevanishvili G. Sh., Chikhladze G. G. Investigation of electrodynamic properties of waveguide tees. In the book: Waves and diffraction -90. Proceeding of X All-Union Symposium. (Vinnitsa, 1990). Moscow, 1990, vol. 3, pp. 234-237 (in Russian);
2) Bogdanov F. G., Kevanishvili G. Sh., Chikhladze G. G. To the theory of waveguide T-junction in E-plane. Bulletin of the Academi of Sciences of Georgia. 1991, vol. 141, pp. 93-96 (in Russian);
3) Bogdanov F. G., Kevanishvili G. Sh., Chikhladze G. G. Diffraction properties of crusiform junction of rectangular waveguides in E-plane. Radioelectronika i Electronika. 1991, vol. 37, N 4, pp. 659-667 (in Russian);
4) F. G. Bogdanov, G. V. Jandieri, G. Sh. Kevanishvili, G. V. Kekelia, K. Yasumoto – Simulation and analysis of multiport waveguide junction with artificial discontinuites formed of inductive strips and diaphragms, PIERS. Progress in Electromagnetic Research Symposium Proceeding, vol. 1, 2004, Piza, Italia, pp. 27-31;
5) F. G. Bogdanov, G. Sh. Kevanishvili, G. V. Jandieri, G. V. Kekelia, K. Yasumoto, Optimization Stratege for Waveguide Junction with Canonical Types of Artificial Discontinuities, Internetional Journal of Microwave and Optical Technology, vol. 1, N 2, pp. 259-266, August 2006;

6) Faik Bogdanov, G. Sh. Kevanishvili, G. V. Jandieri, Dong I. Kim, George Jandieri, Kiytoshi Yasumoto. Analysis and Design of Multiport Waveguide Junctions with Artificial Inclusion Made of Cylindrical Rods. Research on Information Science and Electrical Engineering of Kyushu University vol. 11, N 1, March 2006, pp. 7-16;
7) F. G. Bogdanov, G. S. Kevanishvili, G. V. Kekelia, S. L. Prosvirnin, Analysis And Design of Cruciform Waveguide Junction with a Conducting Diaphragm and a Dielectric Layer in the Main Arm, Progress In Electromagnetics Research B, Vol. 29, pp. 139-155, 2011.