IRIS WAVEGUIDE PHASE SHIFTER

Shtyk T. V.[1]; Savenchuk T. V.[1]; Kornieva O. A.[2]; Piltyay S. I.[1], PhD, Associate Professor; Bulashenko A. V.[1]

[1]Igor Sikorsky Kyiv Polytechnic Institute, Kyiv, Ukraine

[2]Public Joint Stock Company "Bank Vostok", Kyiv, Ukraine

Modern phased array antennas are widely used in telecommunication systems. The basic elements of such systems are waveguide filters [1], phase shifters [2, 3] and polarizers [4-7]. Phase shifters provide the required phase shift. The aim of the work is to study the main characteristics of a phase shifter based on waveguide with four irises in the operating frequency range of 10.7-12.8 GHz.

Structurally, a phase shifter based on a waveguide with four irises, located symmetrically relative to the two central iris, is shown in Fig. 1.

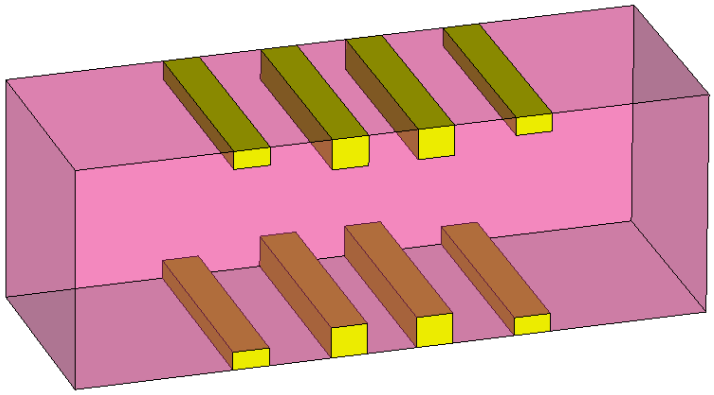

Figure. 1. Waveguide phase shifter design with four irises

Applying the wave matrix technique [8, 9] and equivalent circuits technique [10, 11], the basic parameters of the wave matrix of phase scattering device were obtained

$$\left[S_{\Sigma}\right]=\begin{bmatrix} S_{11.\Sigma} & S_{12.\Sigma} \\ S_{21.\Sigma} & S_{22.\Sigma} \end{bmatrix}.$$

Through the matrix elements, you can determine the main parameters of the phase shifter. These include the phase shift of the transmission coefficient and the voltage standing wave ratio (VSWR).

As a result of the study, the frequency dependences of the developed device were obtained in the operating frequency range of 10.7–12.8 GHz using two methods FDTD and FEM [12].

Fig. 2 contains the dependence of the phase shift of transmission coefficient of the waveguide phase shifter in the frequency range 10.7-12.8 GHz for phase in 90º and 45º.

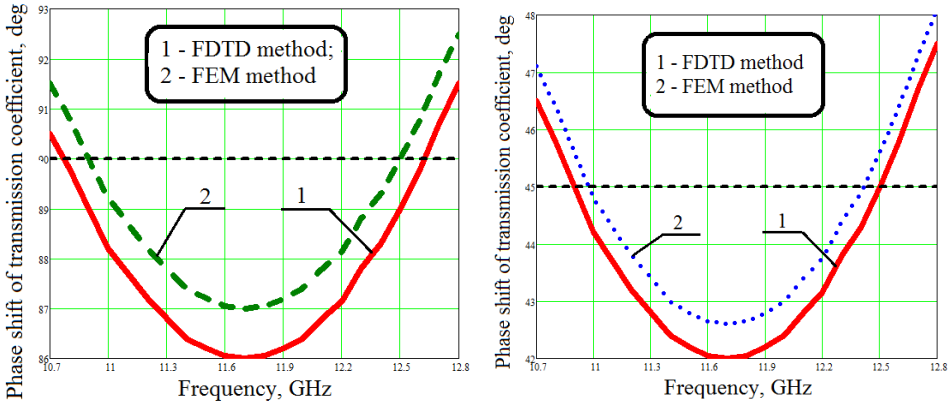

Figure. 2. Dependence of phase shift of transmission coefficient on frequency for 90º and 45º

In Fig. 3 presents a graphical dependence of VSWR of the developed phase shift device for the FDTD method and FEM method for 90º and 45º.

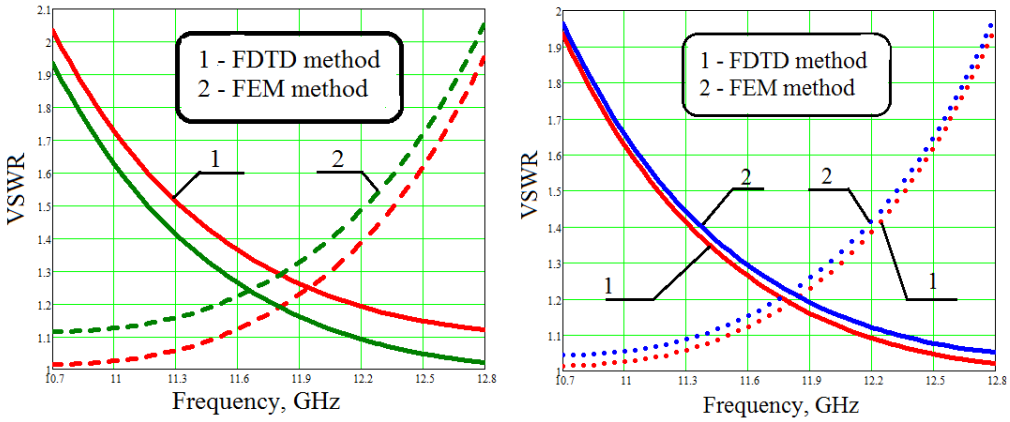

Figure. 3. Dependence of the VSWR on the frequency for 90º and 45º

The results of the analysis of the graphs are summarized in the table 1.

Table 1. Optimal characteristics of the waveguide filter

Method	phase shift for 90º	VSWR for 90º	phase shift for 45º	VSWR for 45º
FDTD	90º ± 4º	2.05	45º ± 3º	1.95
FEM	90º ± 3º	2.049	45º ± 3º	1.95

Thus, the proposed waveguide phase shifter provides such a phase of 90º ± 4º and 45º ± 3º. VSWR is 2.05 and 1.95, respectively. Therefore, the proposed device can be used in modern phased array antennas.

References

1. Zhuk S.Ya. Synthesis of extremely wide stopband E-plane bandpass filters / S.Ya. Zhuk, M.Y. Omelianenko, T.V. Romanenko, O.V. Tureeva // Visnyk NTUU KPI Seriia – Radio-tekhnika Radioaparatobuduvannia. – 2021. – Vol. 84. – pp. 22-29. DOI: 10.20535/RADAP.2021.84.22-29.
2. Farahani M. A novel hedgehog waveguide and its application in designing a phase shifter compatible with hollow waveguide technology / M. Farahani, M. Nedil, T.A. Denidni // IEEE Transactions on Microwave Theory and Techniques. – 2019. – Vol. 67, no. 10. – pp. 4107–4117. DOI: 10.1109/TMTT.2019.2929044.

3. Zhang Q. Studies on mechanical tunable waveguide phase shifters for phased-array antenna applications / Q. Zhang, C. Yuan, L. Liu // IEEE International Symposium on Phased Array Systems and Technology (PAST), Waltham, USA. 2016. DOI: 10.1109/ARRAY.2016.7832555.
4. Bulashenko A.V. Simulation of compact polarizers for satellite telecommunication systems with the account of thickness of irises / A.V. Bulashenko, S.I. Piltyay, I.V. Demchenko // KPI Science news. – 2021. – Vol. 1. – pp. 7–15. DOI: 10.20535/kpisn.2021.1.231202.
5. Bulashenko A.V. Resource allocation for low-power devices of M2M technology in 5G networks / A.V. Bulashenko // KPI Science news. – 2020. – Vol. 3. – pp. 7–13. DOI: 10.20535/kpisn.2020.3.203863.
6. Bulashenko A.V. Waveguide polarizer with three irises for antennas of satellite television systems / A.V. Bulashenko, S.I. Piltyay, H.S. Kushnir, O.V. Bulashenko // Science-Based Technologies. – 2021. – Vol. 49., no. 1. – pp. 39–48. DOI: 10.18372/2310-5461.49.15290.
7. Piltyay S.I. High performance waveguide polarizer for satellite information systems / S.I. Piltyay, A.V. Bulashenko, et al. // Bulletin of Cherkasy State Technological University. – 2020. – Vol. 4. – pp. 14–26. DOI: 10.24025/2310-4412.4.2020.217129.
8. Bulashenko A. V. Wave matrix technique for waveguide iris polarizers simulation. Theory / A. V. Bulashenko, S. I. Piltyay, and I. V. Demchenko // Journal of Nano- and Electronic Physics. – 2020. – Vol. 12, no. 6. – pp. 06026-1–06026-5, December 2020. DOI: 10.21272/jnep.12(6).06026.
9. Bulashenko A.V. Wave matrix technique for waveguide iris polarizers simulation. Numerical results / A.V. Bulashenko, S.I. Piltyay, I.V. Demchenko // Journal of Nano- and Electronic Physics. –2021. – Vol. 13, no. 5. pp. 05023-1–05023-6, 2021. DOI: 10.21272/jnep.13(5).05023.
10. Bulashenko A.V. Equivalent microwave circuit technique for waveguide iris polarizers development / A. V. Bulashenko and S. I. Piltyay // Visnyk NTUU KPI Seriia – Radiotekhnika, Radioaparatobuduvannia. – Vol. 83, pp. 17–28. – 2020. DOI: 10.20535/RADAP.2020.83.17-28.
11. Bulashenko A.V. Waveguide polarizer for radar and satellite systems / A.V. Bulashenko, S.I. Piltyay, Y.I. Kalinichenko, I.V. Zabegalov // Visnyk NTUU KPI Seriia – Radiotekhnika Radioaparatobuduvannia. – 2021. – Vol. 86. – pp. 5-13. DOI: 10.20535/RADAP.2021.86.5-13.
12. Piltyay S.I. Numerical performance of FEM and FDTD methods for the simulation of waveguide polarizers / S. I. Piltyay, A. V. Bulashenko, and Y. Y. Herhil // Visnyk NTUU KPI Seriia – Radiotekhnika Radioaparatobuduvannia. – 2021. – Vol. 84, pp. 11–21. DOI: 10.20535/RADAP.2021.84.11-21.

Анотація

Представлені результати розробки фазозсувача на основі хвилеводу із чотирма діафрагмами в діапазоні від 10.7 ГГЦ до 12.8 ГГц.

Ключові слова: фазозсувач, діафрагма, хвилевод.

Abstract

The results of the development of a phase shifter based on a waveguide with four irises are presented in the range from 10.7 GHz to 12.8 GHz.

Keywords: phase shifter, iris, waveguide.