

POST-IRIS WAVEGUIDE POLARIZER

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Recently, polarization signal processing has become widespread. It is used in satellite information and telecommunication information processing systems. One of the key elements of such systems are polarization conversion devices. The basic function of such devices is to transform the types of polarization. There are different designs of polarizers. The most common are polarizers in the form of ridged structures [1-2], polarizers with thin metal septum [3-4], polarizers based on irises in the waveguide [5-8] and polarizers based on waveguides with posts [9]. There are also designs of polarizers with irises in the form of thin slots [10]. But such constructions are complex. The most broadband and simple design is a waveguide polarizer based on irises.

The design of the waveguide polarizer is shown in Fig. 1. The design contains two irises of height h and thickness w , two posts of height h_p and diameter d , the distance between the iris and the post is l .

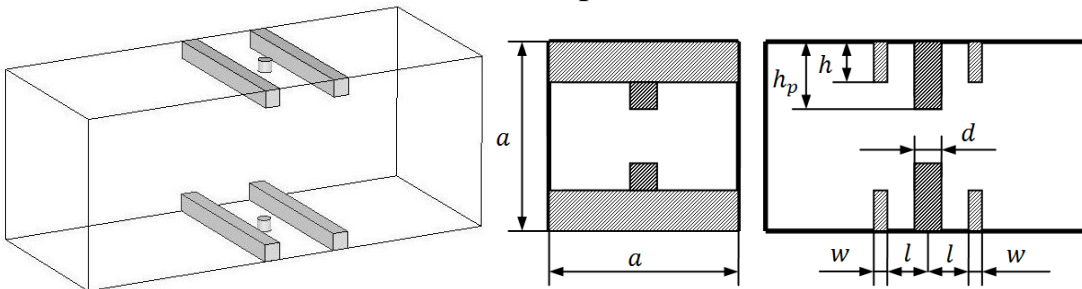


Figure 1. Polarizer design

The presented design provides the main polarization characteristics. Cylindrical post provides tuning and matching characteristics by changing the length of the post in the waveguide.

The matching characteristics of the polarizer are the differential phase shift and the voltage stand wave ratio (VSWR). The polarization characteristics of the polarizer are the axial ratio and the crosspolar discrimination (XPD).

Based on the theory of microwave circuits, we write the wave matrices of scattering and transmission of our model, breaking it into smaller circuits

$$[S_{\Sigma}] = \begin{bmatrix} S_{\Sigma 11} & S_{\Sigma 12} \\ S_{\Sigma 21} & S_{\Sigma 22} \end{bmatrix} = \frac{1}{T_{\Sigma 11}} \begin{bmatrix} T_{\Sigma 21} & |T| \\ 1 & -T_{\Sigma 12} \end{bmatrix},$$

$$[T_{\Sigma}] = [T_1] \cdot [T_2] \cdot [T_3] \cdot [T_4] \cdot [T_5] = \begin{bmatrix} T_{\Sigma 11} & T_{\Sigma 12} \\ T_{\Sigma 21} & T_{\Sigma 22} \end{bmatrix},$$

$$[T_1]=[T_5]=\begin{bmatrix} T_{11} & T_{12} \\ T_{21} & T_{22} \end{bmatrix}; [T_2]=[T_4]=\begin{bmatrix} e^{j\theta} & 0 \\ 0 & e^{-j\theta} \end{bmatrix}; [T_3]=\frac{1}{2}\begin{bmatrix} 2+Y_p & -Y_p \\ -Y_p & 2-Y_p \end{bmatrix},$$

where Y_p is the conductivity of the post, θ is electric line length.

Differential phase shift is determined by the expression

$$\Delta\varphi = \varphi_{\Sigma 21.L} - \varphi_{\Sigma 21.C}.$$

VSWR is determined by the formula

$$VSWR = [1 + |S_{11}|] / [1 - |S_{11}|].$$

The axial ratio is determined

$$r = 10 \lg \left(\frac{A^2 + B^2 + \sqrt{A^4 + B^4 + 2A^2B^2 \cos(\Delta\varphi)}}{A^2 + B^2 - \sqrt{A^4 + B^4 + 2A^2B^2 \cos(\Delta\varphi)}} \right),$$

where $A = |S_{\Sigma 21.L}|$, $B = |S_{\Sigma 21.C}|$.

XPD is calculated by the formula

$$XPD = 20 \lg \left(\frac{10^{0.05r} + 1}{10^{0.05r} - 1} \right).$$

Fig. 2 shows the matching characteristics of the mathematical model, and Fig. 3 shows the polarization characteristics of this model.

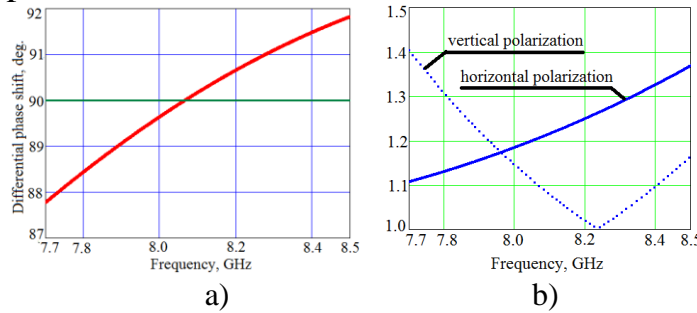


Figure 2. Matching characteristics of the mathematical model

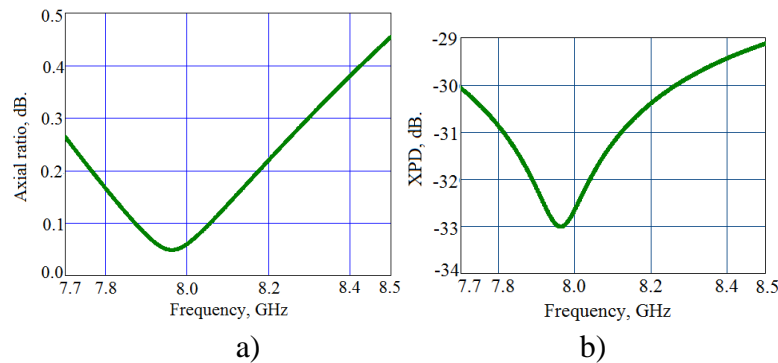


Figure 3. Polarization characteristics of the mathematical model

Fig. 2 a demonstrates that the maximum deviation of the differential phase shift from 90° is 2.2° . Fig. 4 b shows that the maximum value of VSWR for both polarizations is 1.41. Fig. 3 a contains the dependence of the axial ratio on the

frequency, and Fig. 3 b contains the dependence of the XPD on the frequency. From Fig. 3 we see that at a frequency of 8.5 GHz the axial ratio acquires its maximum value of 0.45 dB. Also at this frequency, the XPD acquires a maximum value of 29 dB.

Fig. 4 shows the matching characteristics of the polarizer. Fig. 4 a contains the dependence of the differential phase shift on the frequency, and Fig. 4 b contains the dependence of VSWR on the frequency in the operating frequency range from 7.7 GHz to 8.5 GHz of the test prototype.

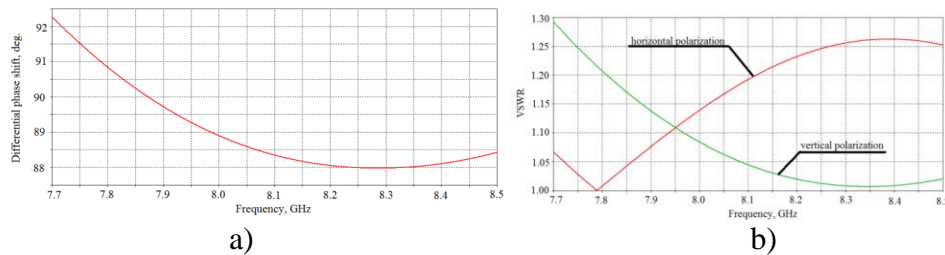


Figure 4. Matching characteristics of the prototype

Fig. 4a demonstrates that the maximum deviation of the differential phase shift from 90° is 2.2° . Fig. 4 b shows that the maximum value of VSWR for both polarizations is 1.29.

Fig. 5 shows the polarization characteristics of the device in the operating frequency range from 7.7 GHz to 8.5 GHz. Fig. 5 a contains the dependence of the axial ratio on the frequency, and Fig. 5 b contains the dependence of the XPD on the frequency. The figure shows that at a frequency of 8.45 GHz, the axial ratio acquires its maximum value of 0.4 dB. Also at this frequency, the XPD acquires a maximum value of 29 dB.

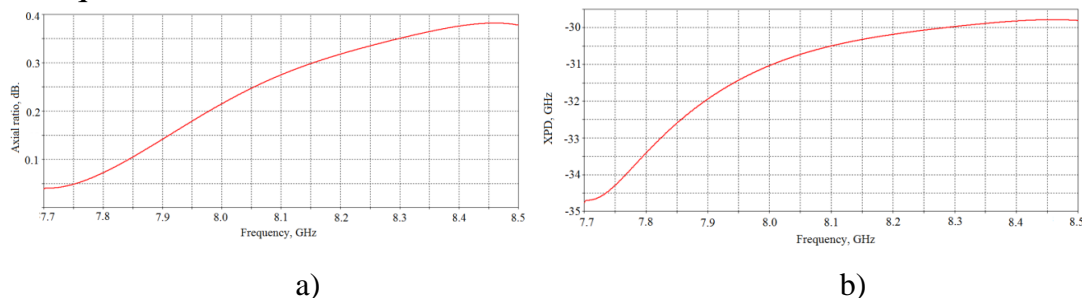


Figure 5. Polarization characteristics of the prototype

Such characteristics provide the optimal design of the polarizer, which are presented in table 1.

Table 1. Optimal characteristics of the polarizer

a, mm	w, mm	l, mm	h, mm	hp, mm	d, mm
28.9	3.1	5.3	2.60	2.65	2.4

As you can see, the matching and polarization characteristics of the mathematical model and prototype simulated in CST Microwave Studio coincide with the corresponding accuracy.

Thus, the developed device has the following matching and polarization characteristics. The range of change of the differential phase shift is $90^\circ \pm 2.2^\circ$.

The polarizer provides VSWR less than 1.29. Axial ratio is less than 0.4 dB. XPD is higher than 29 dB.

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Анотація

Представлені результати розробки регульованого поляризатора на основі квадратного хвильоводу із двома діафрагмами та штирями. Створений прилад працює в діапазоні від 7.7 ГГц до 8.5 ГГц.

Ключові слова: поляризатор, діафрагма, штир, хвильовод.

Abstract

The results of the development of an adjustable polarizer based on a square waveguide with two irises and posts are presented. The created device operates in the range from 7.7 GHz to 8.5 GHz.

Keywords: polarizer, iris, post, waveguide.