POLARIZATION CONVERSION DEVICE BASED ON A WAVEGUIDE WITH PINS

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Today, one of the key elements of antenna systems engaged in polarization signal processing are polarization devices. These devices are used to convert the types of polarization. The following designs of polarizers in the form of waveguide structures with posts [1], irises [2, 3], ridged structures [4], polarizers with thin metal septum [5] are known. The designs of polarizing devices in the form of slots [6] are complex in design. Phase shifters [7] and filters [8] also had such constructions. In addition, polarizers are built directly into antennas [9].

The 3-D model of the polarizer device is present in Fig. 1.

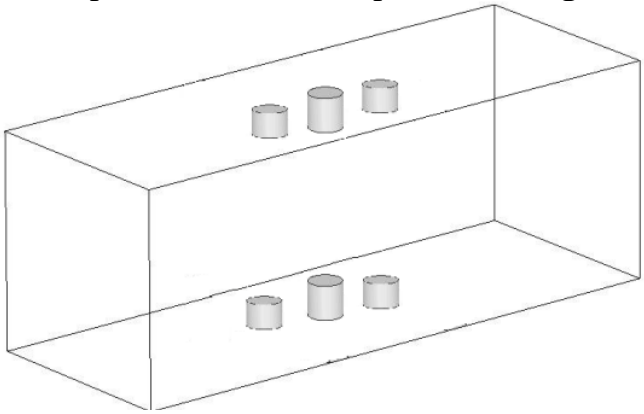

Figure. 1. 3-D model of the polarization conversion device

The design of the waveguide polarizer is shown in Fig. 2. The structure contains two posts of height h_1 and diameter d, one post of height h_2 and diameter d, the distance between the posts is l. Moreover, the height of the central post h_2 is greater than the height of the other posts h_1.

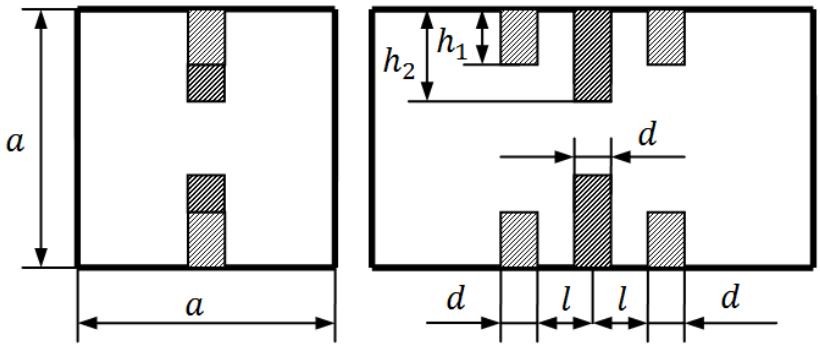

Figure. 2. Polarizer design based on a waveguide with three posts

The presence of a cylindrical post allows you to adjust the characteristics of the device by changing the length of the post.

The characteristics of the polarizer are as follows: phase, matching and polarization. Phase and matching are the differential phase shift and the voltage stand wave ratio (VSWR). The polarizing characteristics of a polarizer are the axial ratio and the crosspolar discrimination (XPD).

We form general wave matrices [10-12] on the basis of the theory of microwave, having broken the circuit of the polarizer into smaller circuits

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

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

$$\left[T_2\right]=\left[T_4\right]=\begin{bmatrix} e^{j\theta} & 0 \\ 0 & e^{-j\theta} \end{bmatrix},$$

$$\left[T_1\right]=\left[T_5\right]=\frac{1}{2}\begin{bmatrix} 2+Y_{p1} & -Y_{p1} \\ -Y_{p1} & 2-Y_{p1} \end{bmatrix},$$

$$\left[T_3\right]=\frac{1}{2}\begin{bmatrix} 2+Y_{p2} & -Y_{p2} \\ -Y_{p2} & 2-Y_{p2} \end{bmatrix},$$

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

Differential phase shift is determined by the expression

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

VSWR is determined by the formula

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

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 $A=1,\ B=\left|S_{21}\right|$.

XPD is calculated by the formula

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

Fig. 3 shows the matching characteristics of the mathematical model, and Fig. 4 shows the polarization characteristics of this model.

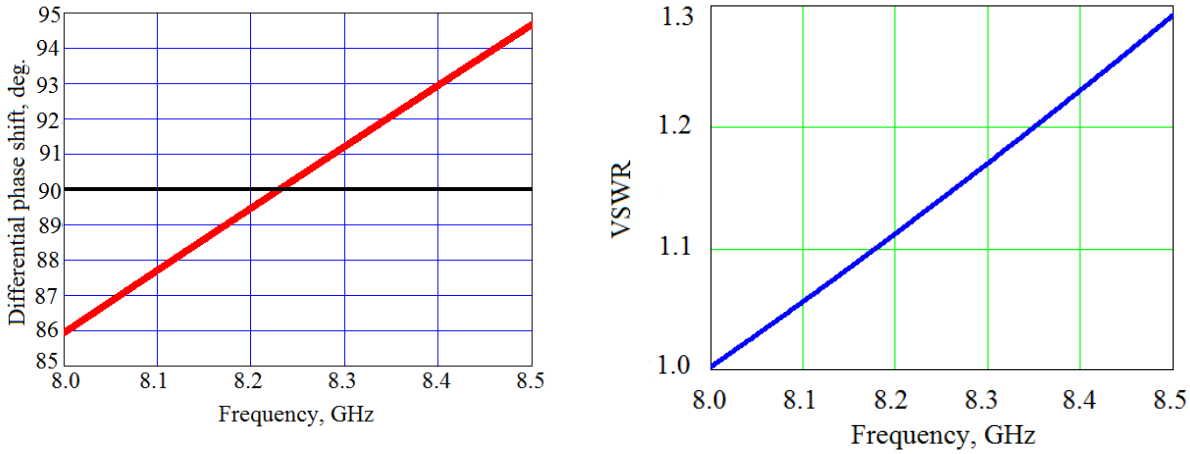

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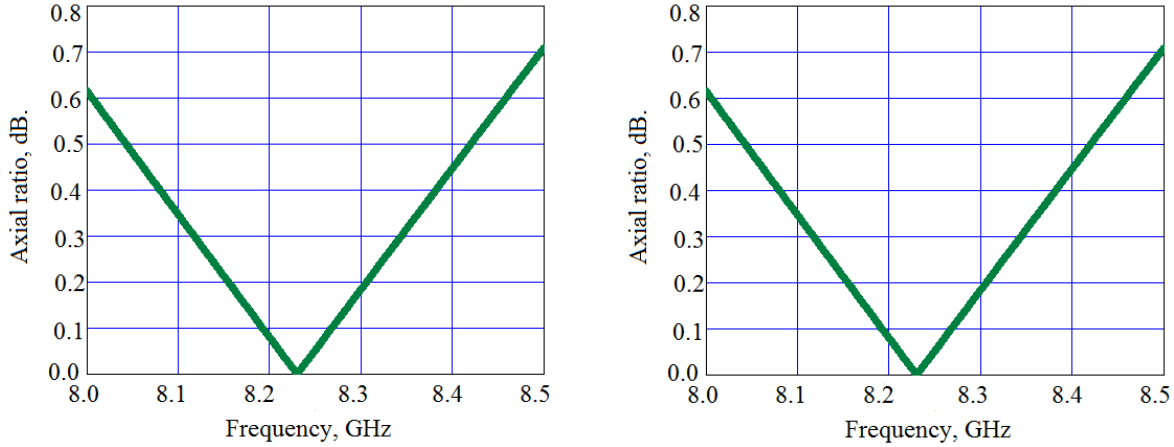
Figure 3. Matching characteristics of the mathematical model

Fig. 3a demonstrates that the maximum deviation of the differential phase shift from 90º is 4.5º. Fig. 3 b shows that the maximum value of VSWR is 1.28.

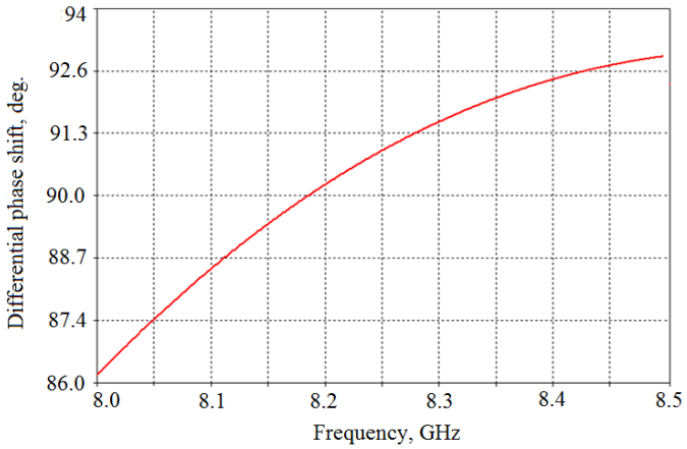


а) б)

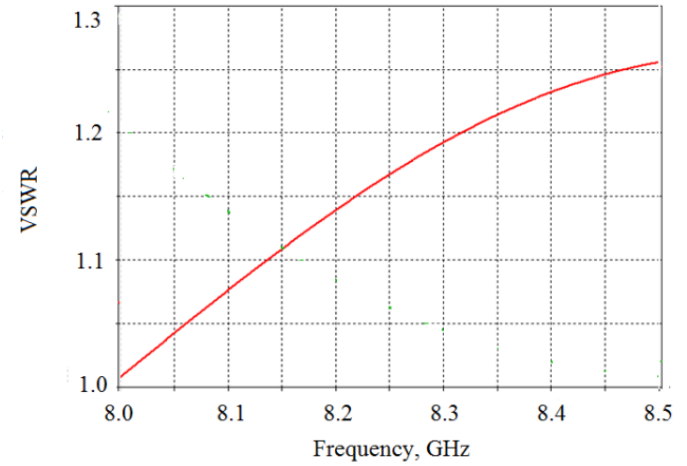
Figure 4. Polarization characteristics of the mathematical model

Fig. 4 a contains the dependence of the axial ratio on the frequency, and Fig. 4 b contains the dependence of the XPD on the frequency. From fig. 4 we see that at a frequency of 8.5 GHz the axial ratio acquires its maximum value of 0.71 dB. Also at this frequency, the XPD acquires a maximum value of 29 dB.

Fig. 5 shows the matching characteristics of the polarizer. Fig. 5 a contains the dependence of the differential phase shift on the frequency, and Fig. 5 b contains the dependence of VSWR on the frequency in the operating frequency range from 8.0 GHz to 8.5 GHz of the studied prototype.



a)



b)

Figure 5. Matching characteristics of the prototype

Fig. 5a demonstrates that the maximum deviation of the differential phase shift from 90º is 4.2º. Fig. 5 b shows that the maximum value of VSWR is 1.26.

Fig. 6 shows the polarization characteristics of the device in the operating frequency range from 8.0 GHz to 8.5 GHz. Fig. 6 a contains the dependence of the axial ratio on the frequency, and Fig. 6 b contains the dependence of the XPD on the frequency. The figure shows that at a frequency of 8.0 GHz, the axial ratio acquires its maximum value of 0.55 dB. Also at this frequency, the XPD acquires a maximum value of 31 dB.

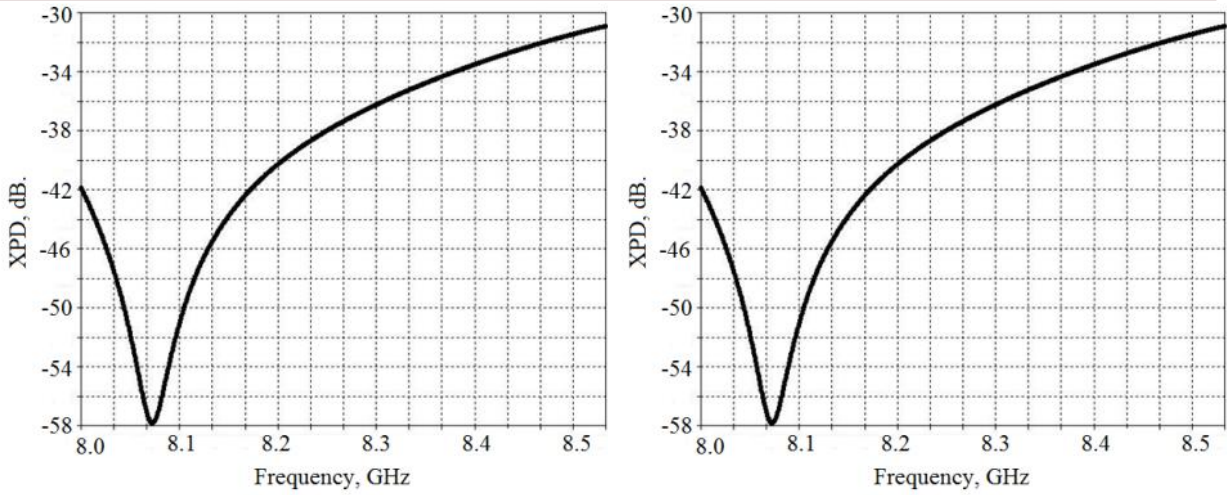


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Figure 5. Polarization characteristics of the prototype

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

Table 1. Optimal characteristics of the polarizer

a, mm	***l, mm***	***h_1, mm***	***h_2, mm***	***d, mm***
30.0	2.92	2.0	4.28	2.0

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 waveguide polarizer with three posts has the following characteristics. The range of change of the differential phase shift is 90°±4.2°. The polarizer provides VSWR less than 1.26. Axial ratio is less than 0.55 dB. XPD is higher than 31 dB.

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