Ural Federal University
named after the first President of Russia B.N.Yeltsin

4x4 Butler Compact Broadband Matrix Based on Low-Pass Filters

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Matrix

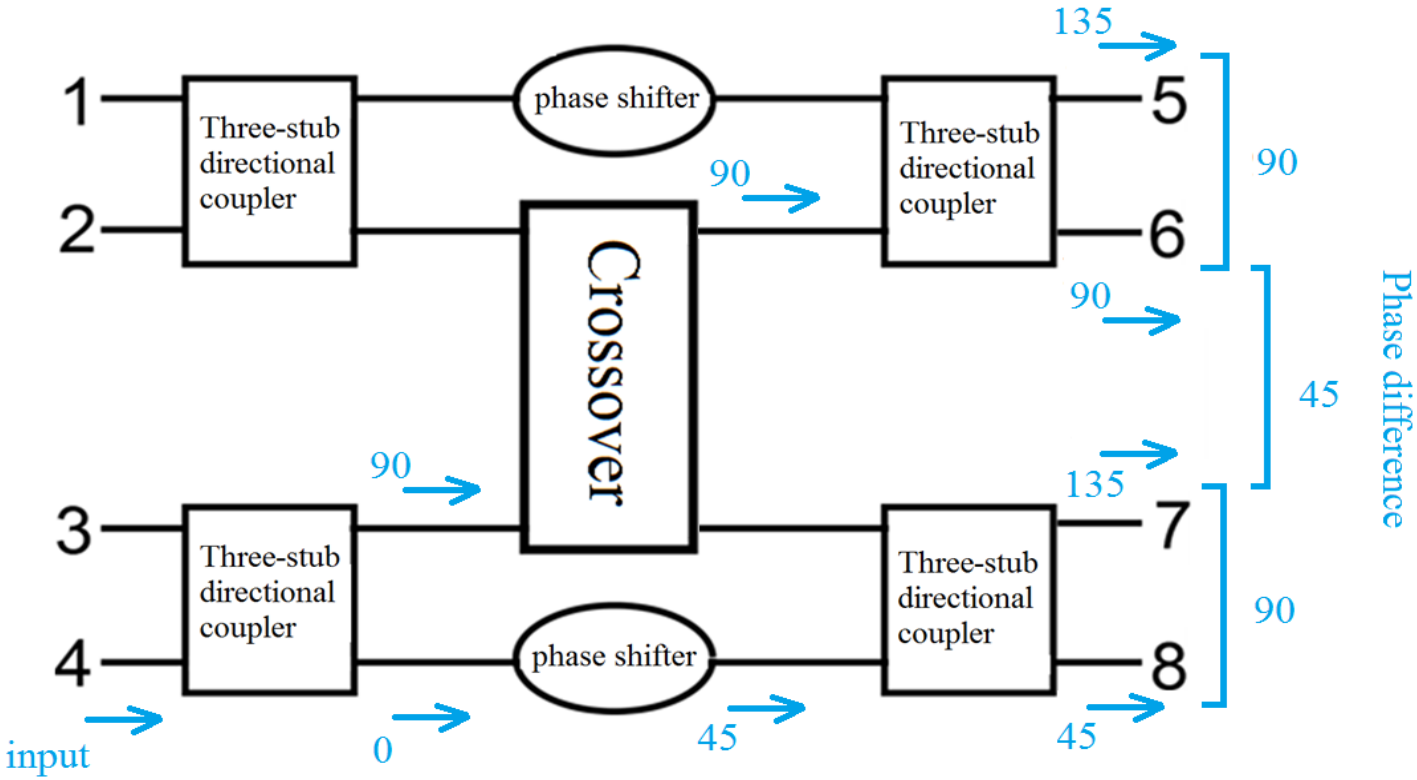


Fig. 1. Butler 4x4 matrix diagram.

Matrix

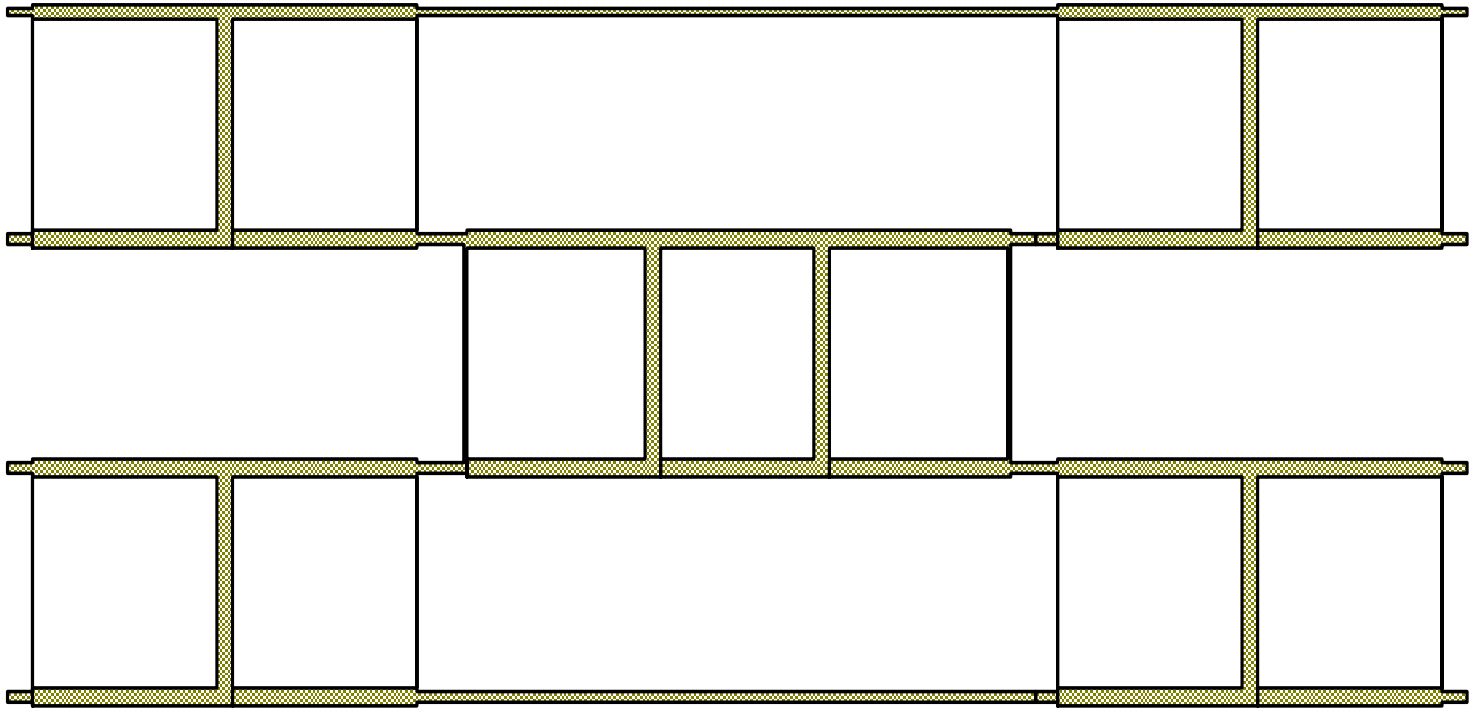
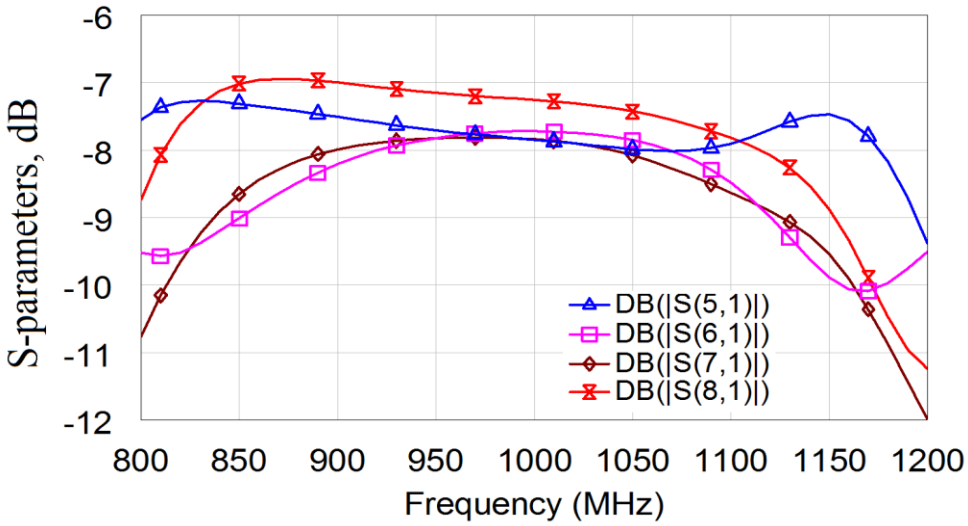
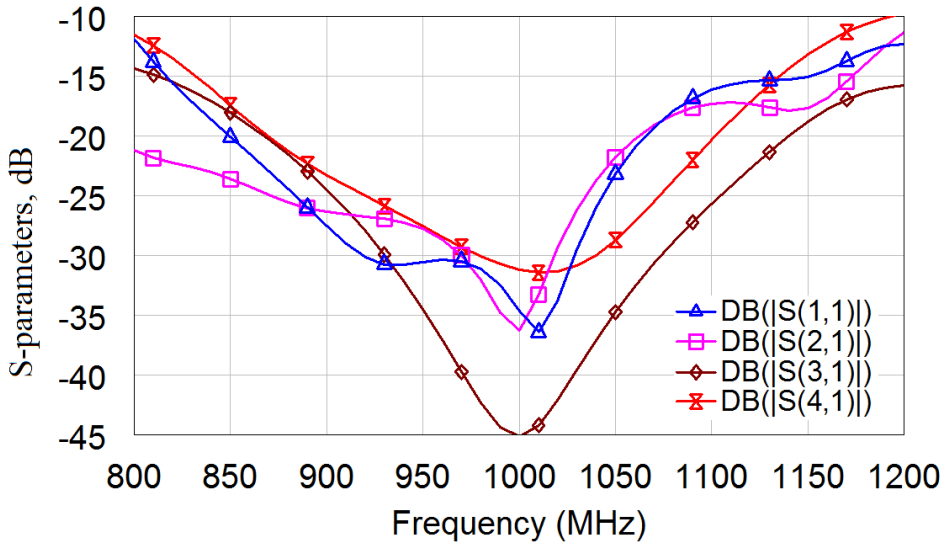


Fig. 2. The layout of the Butler matrix.

Characteristics





Miniaturization

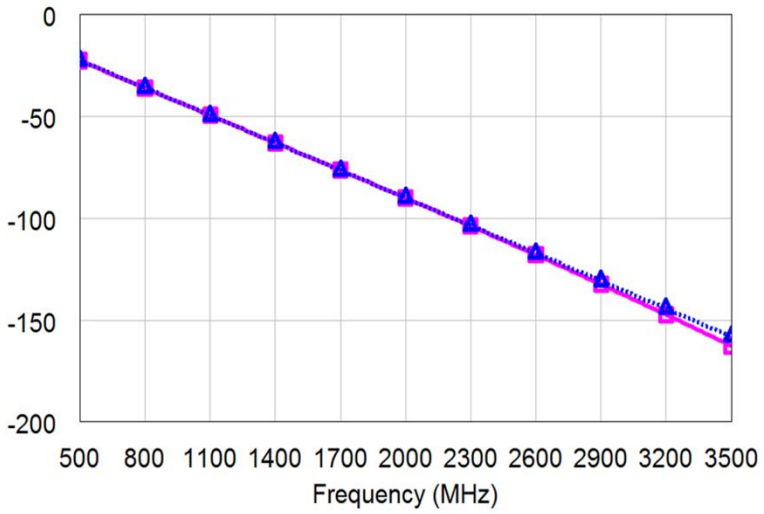
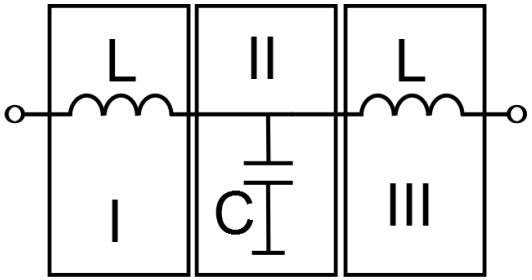


Fig. 3. Phase shifts of quarter-wave microstrip segment (dashed) and LPF (continous)



$$[A]=\begin{bmatrix}\cos\beta l & i\sin\beta l\\ \frac{i\sin\beta l}{\rho} & \cos\beta l\end{bmatrix} \qquad [A]_T=\begin{bmatrix}1+ZY & 2Z+YZ^2\\ Y & 1+ZY\end{bmatrix}$$

$$\left.\begin{aligned} L_T &= \frac{\rho}{\omega} tg\left|\frac{\theta}{2}\right| \\ C_T &= \frac{1}{\omega\rho}\sin|\theta| \end{aligned}\right\} Tcell$$

Matrix

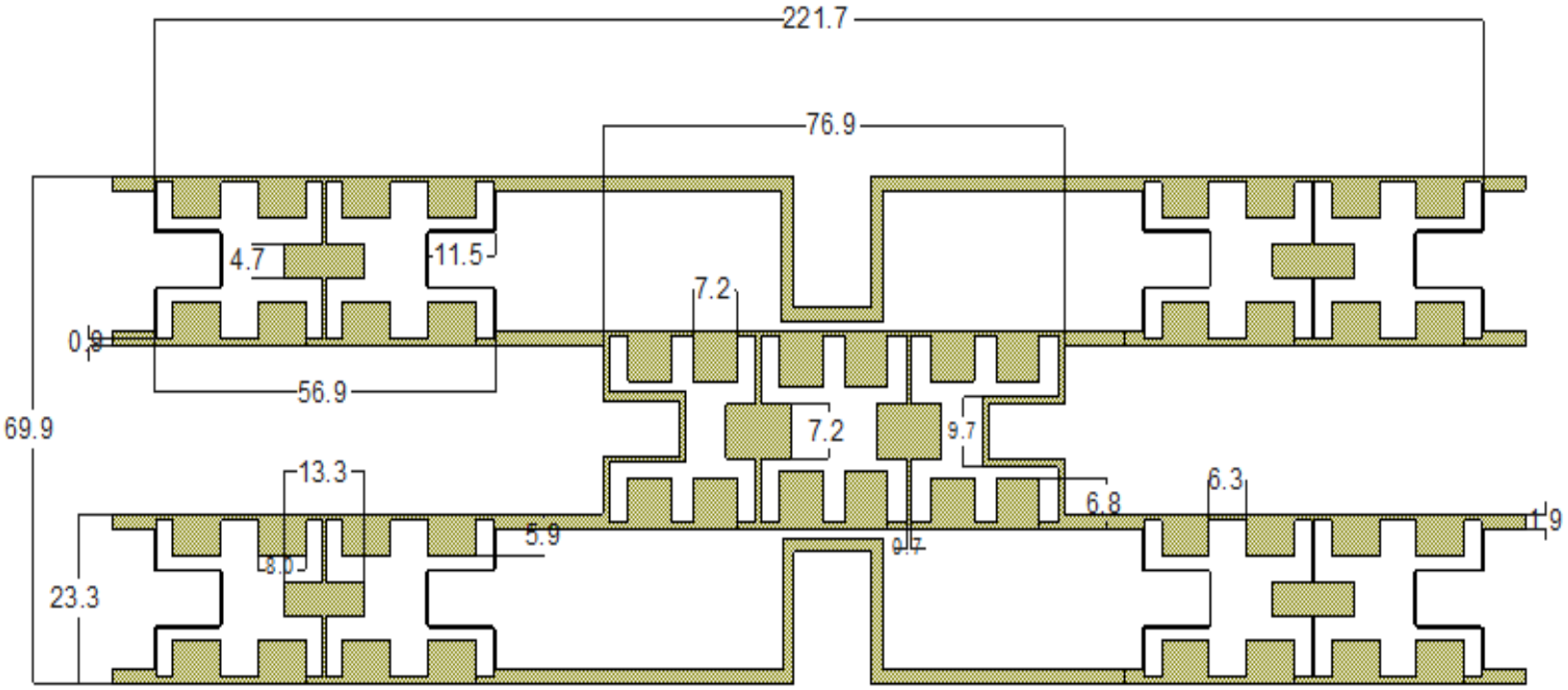
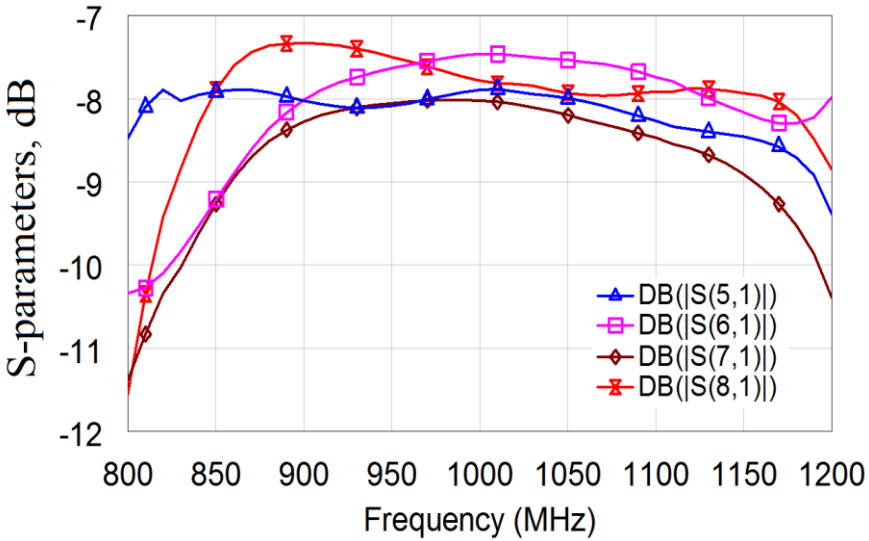
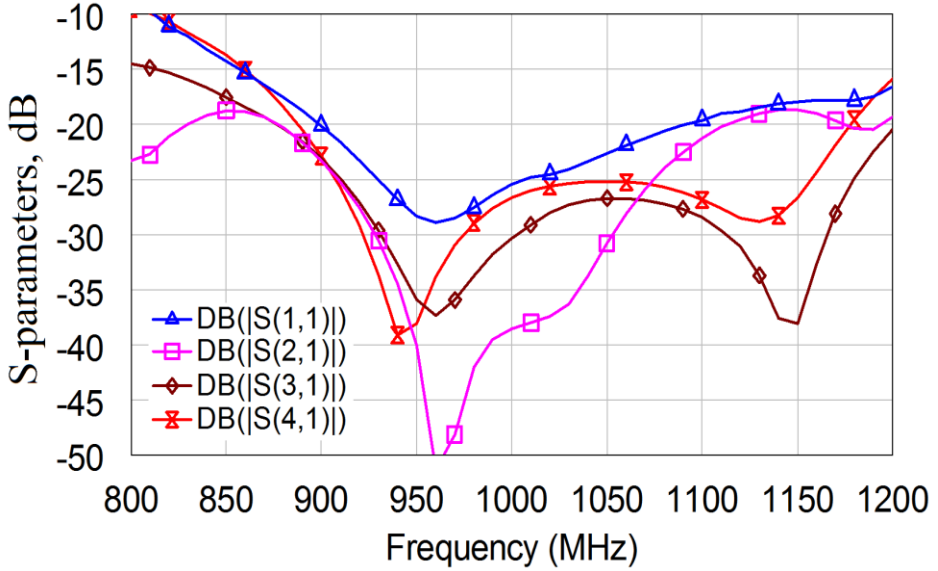


Fig. 4. The layout of the compact Butler matrix.

Characteristics





Matrix

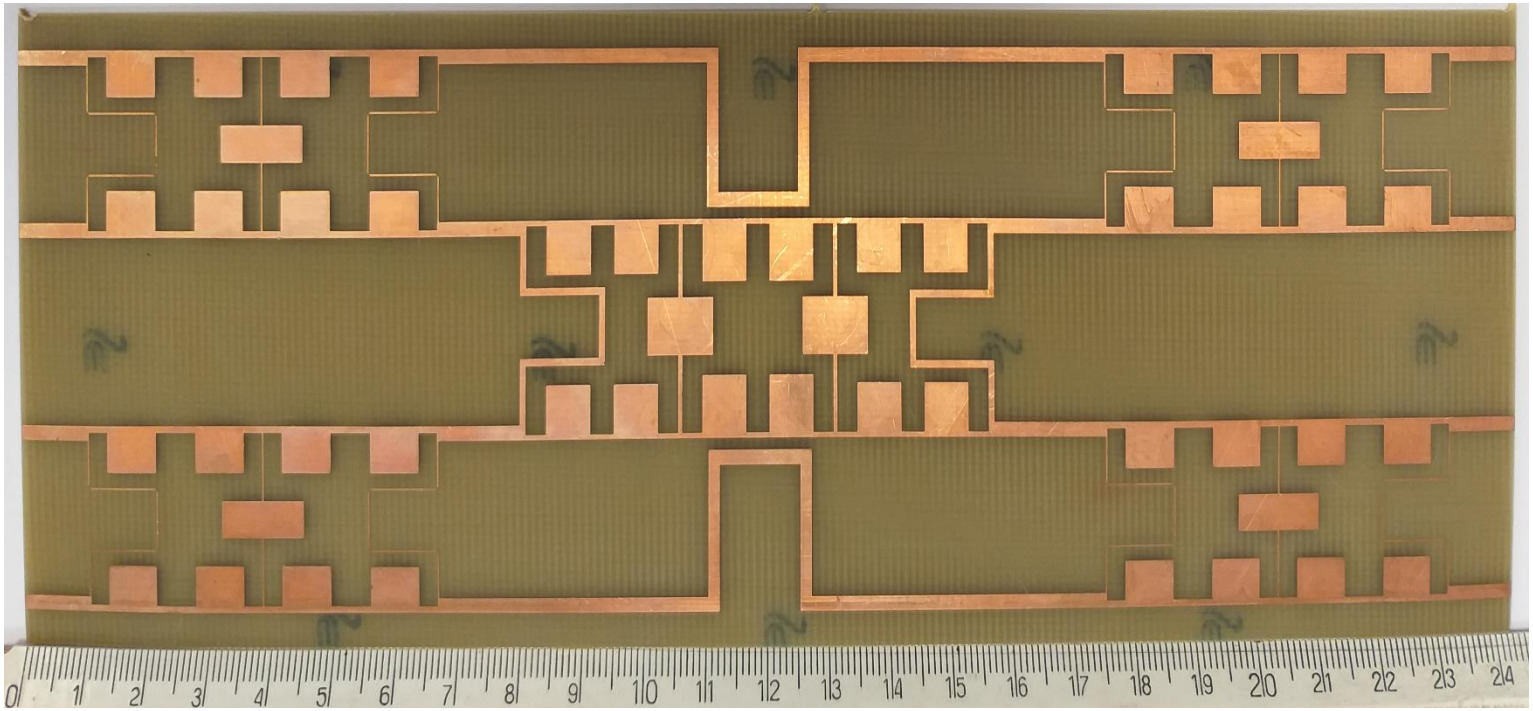
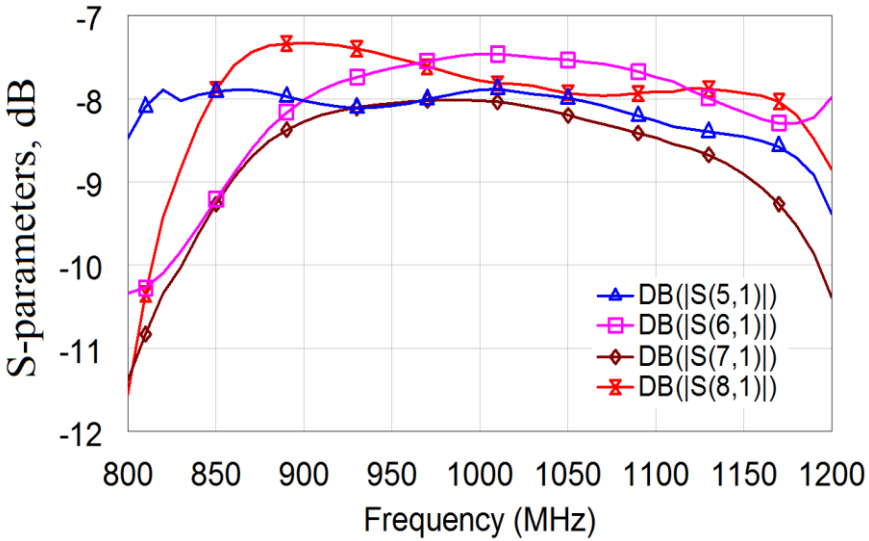
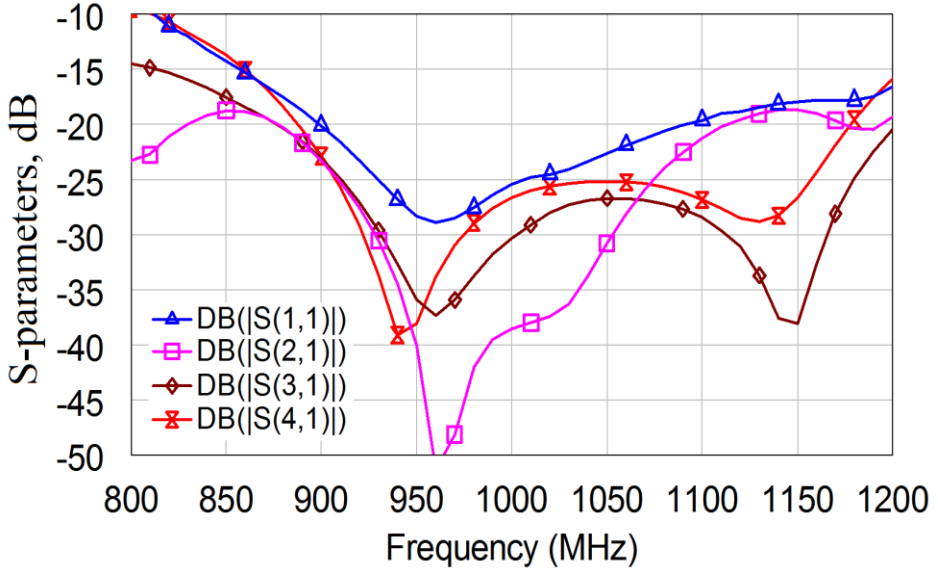


Fig. 5. The prototype of the compact Butler matrix.

Characteristics





Compact matrix

Table 1 Comparison of design matrix

Design	Bandwidth, MHz	Area, mm^2	Size reduction, %
Standard	200	42352	-
Compact	**170**	**15496.8**	**63.4**

Conclusion

A compact 4x4 matrix is proposed in the work, whose area is reduced due to the use of cells. The area of the full-size matrix is 42352 mm2, and the size of the compact matrix is 63.4% smaller and amounts to 15496.8 mm2. The fabricated prototype matrix showed a high convergence of practical and theoretical characteristics of the device. However, there are such negative factors, reduction of the band and an growth in losses in the transmission coefficients.

Thank you for attention!