Abstract

This paper presents compact designs of microwave devices on a flexible substrate. Flexible substrates allow you to design conformal devices and reduce the dimensions of common printed designs. We show the layouts of a compact bandpass filter and a directional coupler produced with this technology and evaluate its effect on the resulting characteristics of devices. In addition to the simulation results, experimental parameters of device prototypes are shown.

1 Introduction

Filters are essential for all kinds of RF devices: IoT nodes, cellular communication, satellite networks, etc. Bandpass filters (BPF) are the most common filters from all filter classes, as they determine the selectivity of the receiving device (for example, selectivity on the adjacent channel). The main function of the BPF is to ensure signal transmission in a certain frequency band and suppress signals outside this band. Many researchers wrote about different filters design, such as hairpin filter, filter on coupled lines, stub filter, etc. Printed directional couplers are widely used in beamforming circuits to split input power between its arms with some ratio. The operating frequency determines the size of the device and the area it occupies - the lower the frequency, the larger the occupied area. In this regard, it is often necessary to look for structural and technological methods to reduce the dimensions of such devices. Today in the IEEE Xplore you can find a large number of works related to the miniaturization of microwave devices, for example [1–13]. In this article, we will present a study of two microwave devices made using flexible substrates [14], [15].

2 Layout

All devices were designed using polyimide film AP9151R with a height of 125 μm, ε = 3.4 and tan δ = 0.004. The center frequency of the filter is 1 GHz. The input and output impedance is 50 Ohms. Fig. 1 show the layout of the proposed filter.
capacitive or inductive impedance and reflects power. The frequency response of the filter obtained after electrodynamic analysis in the specialized software ANSYS HFSS is shown in Fig. 2.

**Figure 2.** Frequency response of a bandpass filter.

The obtained characteristics showed that the filter with rectangular spirals operates at a central frequency of 1 GHz. The bandwidth, defined as 3 dB of the minimum loss level, is 164 MHz (FBW 16.4%). The minimum loss in the passband is -0.47 dB. The reflection coefficient at the center frequency is -18.5 dB. The area of such a device is 50 x 50 = 2500 mm². Fig. 3 presents the layout of a compact branch-line coupler. It was developed in the AWR Design Environment for a central frequency of 2 GHz and on the same substrate as the filter. The area of the compact coupler is 10.65 x 7 = 74.55 mm². For comparison, the standard design of such a coupler occupies an area of 23.1 x 23.1 = 533.61 mm² - this is 86% more than the compact design. Fig. 4 shows the characteristics of coupler.

**Figure 3.** Compact coupler design.

According to the results obtained, it is clear that the maximum isolation level is at a frequency of 2 GHz. The bandwidth calculated by the decoupling level of -20 dB is 116 MHz. Miniaturization has led to amplitude imbalance, which resulted in a very narrow frequency band.

### 3 Parameter Measurement

Prototypes of the devices (Fig. 5, 7) under consideration were produced to test the performance. We obtained frequency responses of the manufactured devices using a high-precision vector network analyzer Rohde & Schwarz ZVA & 24 (Fig. 6, 8).

**Figure 5.** Top and bottom side of the bandpass filter.

**Figure 6.** S-parameters from the frequency.
4 Conclusions

The designs of compact microwave devices on flexible substrate are investigated. Spiral resonators on a flexible substrate were used to design a bandpass filter with a central frequency of 1090 MHz and a FBW of 11%. The area of such a device is 50 x 50 = 2500 mm2. In addition, we designed a compact coupler, whose area is 86% less than that of a standard coupler, but the bandwidth is rather small (80 MHz).

6 Acknowledgements

The work was supported by Act 211 Government of the Russian Federation, contract № 02.A03.21.0006. The research was performed on equipment of the Urals Federal University common use center.

7 References


