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Dual-Bandpass Filter Built on Rectangular Dielectric Resonators

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Abstract—A new technique of implementing dual-bandpass filters built on rectangular dielectric resonators has been proposed. The possibility of simultaneous tuning of two passbands on one structure of coupled dielectric resonators using their intrinsic high-mode oscillations was investigated for the sake of reducing the size of design. The proposed analytical solution was compared with the results of simulation by the finite element method. Coupling coefficients of rectangular resonators were calculated and investigated by a numeric technique for the low dipole $TE_{01\delta}$ and high quadruple $TE_{02\delta}$ magnetic modes depending on the parameters of filter design. The proposed dual-bandpass filter built on dielectric resonators can be used in base stations and wireless access points of communication networks.

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INTRODUCTION

The growing volume of provided wireless services gives rise to the need of simultaneous use of several frequency bands in communication systems [1], the key element of which is a multiple bandpass filter. A variety of implementations of dual-bandpass filters are available in microstrip form [2] and also with the use of combline-structures [3]. However, the use of the specified kinds of resonators in the millimeter band is hampered due to increasing losses in metal. The requirements of minimum losses in the passband are best satisfied by filters built on dielectric resonators (DR) [4] that are characterized by much larger values of unloaded Q-factor as compared with other kinds of resonators.

Up to date there are two main designs of dual-bandpass filters built on DR. One of them consists of cylindrical dielectric resonators cut along the axis that are located inside a metal cavity and coupled via the cross-shaped [5] or rectangular apertures in a metal diaphragm [6]. The working oscillations represent two hybrid degenerate oscillations $HEE_{11\delta}$ and $HEH_{11\delta}$. The second design makes use of contoured resonators formed of eight-shaped two connected rectangular dielectric rings [7]. The working oscillations are two lower $TE_{01\delta}$ modes of rectangular rings; a disadvantage of this design includes enhanced radiation losses and, consequently, the increased inserted losses in the bandwidth of filters. In addition, another disadvantage of the specified designs is the need of introduction of additional coupling elements, such as diaphragm with slots and trimming screws for achieving appropriate characteristics of the filter and reducing the mutual interference between neighboring resonators, and also the general complexity of DR shape.

Capabilities of rectangular DR are insufficiently studied, though the rectangular shape implies a more flexible tuning of filters at the expense of additional spatial parameter emerging during the selection of appropriate dimensions as compared to the cylindrical shape resonators. In addition, the use of higher modes is of practical interest; for example, quadruple $TE_{02\delta}$ has a higher unloaded Q-factor due to higher concentration of electromagnetic field (EMF) inside DR [8].

EMF of intrinsic $TE_{02\delta}$ mode has the waveform similar to the field of two closely located magnetic dipoles (Fig. 1b) excited in antiphase that corresponds to the field distribution of one of standard quadruples. In this case the field of intrinsic $TE_{02\delta}$ mode decays noticeably faster while moving away from the resonator surface, at the same time the Q-factor rises as compared to the fundamental mode $TE_{01\delta}$. The experimental investigations show that this mode is most expedient for application when the following condition is satisfied: $a_0 = b_0 \approx 0.5L_0$, i.e., in the area of prolate forms of rectangular resonators, where a_0, L_0, and b_0 are the dimensions of DR (Fig. 2).