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Periodic Structures on Coupled Slot Resonators in the Grounding Layer of Microstrip Transmission Line

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Abstract—The spectrum of natural frequencies of the resonator has been calculated. The specified resonator includes a microstrip transmission line with discontinuity in the form of two rectangular coupled slot resonators in the grounding layer. Based on the above spectrum and using the transverse resonance method the scattering matrix of the principal wave of the microstip transmission line on this discontinuity was calculated. The scattering characteristic of the periodic structure consisting of a finite number of cells in the form of coupled slot resonators in the grounding layer of microstrip line indicates that with due regard for their mutual coupling the losses in the first stopband can be reduced by 3–5 dB as compared with the characteristic obtained by tandem connection of the scattering matrices of separate slot resonators in the grounding layer of microstrip line.

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Three-layer planar structures consisting of the slot resonators having different shape and located in the grounding layer of microstrip transmission line represent one of the possible kinds of periodic structures for the microwave range [1, 2]. The transverse resonance method was employed in papers [3, 4] for performing the analysis of single slot resonators of rectangular shape in the metalized layer of the microstrip line and different periodic structures based on such resonators. In accordance with this method the calculation of scattering characteristics of discontinuity in the regular transmission line involves the separation of a virtual resonance region that includes this discontinuity with auxiliary reactive walls (electric or magnetic) sufficiently far removed from it [5]. The matrix representation of discontinuity (scattering matrix, impedance matrix, etc.) can be obtained from the solution of the resonator frequency problem. The scattering characteristic of periodic structure can be calculated by tandem connection of the scattering matrices of elementary cell of the structure, i.e., the matrices of scattering on the discontinuity.

The analysis of closely spaced slot resonators in the metalized layer of microstrip transmission line with lateral coupling between them (in fact, discontinuities in the form of resonator on the coplanar transmission line). The purpose of this study is to investigate the impact of mutual coupling of slot resonators in the grounding layer of microstrip transmission line on the scattering characteristics of the periodic structure built on the basis of such resonators.

The topology of the stripline resonator with discontinuity in the form of two closely spaced slot resonators in the grounding layer is shown in Fig. 1. The sectional view of the resonator by plane A–A' is shown on the right. The microstrip transmission line of width w is located in plane $y = h$ on the dielectric substrate having height h and permittivity ε_r, while two coupled rectangular slot resonators with slot width s and length $2L_r$ are located in plane $y = 0$. The distance between slots $l_z = 2z_0 - s$ is such that their mutual coupling should be taken in account during the analysis of the resonator natural frequency spectrum. Due to the symmetry of the resonator, the analysis will be needed for only half of the region, i.e., $0 \le z \le L$. The analysis of symmetric discontinuity in the grounding layer of microstrip transmission line in the form of two coupled slot resonators can be reduced to solving two boundary problems for the resonator with conditions of the electric (e.w.) and magnetic (m.w.) walls in longitudinal planes $z = 0$ and $z = L$, as was done in paper [5]. If the lengths of "electric" and "magnetic" resonators l_1 and l_2 are known at each specified frequency, the elements of scattering matrix S of the principal wave of the microstip transmission line on discontinuity in planes $z = z_0 + s/2$ and $z = -z_0 - s/2$ (Fig. 1) can be determined from the solutions of the above specified boundary problems by the following formulas:

$$S_{11} = -\frac{\Gamma_2 - \Gamma_1}{2} = S_{22},$$