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Coupling Coefficient of Quarter-Wave Resonators as a Function of Parameters of Comb Stripline Filters

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Abstract—The relationship of the coupling coefficient of quarter-wave resonators operating on the main resonance frequency f_0 as a function of different parameters of comb filters made of sections of symmetric striplines has been analyzed. It has been found out that the coupling coefficient increases with the rise of relative dielectric permittivity of striplines, their thickness and the resonance frequency. The measured characteristics of the stripline 4-resonator comb filter with central frequency f_0 = 2.4 GHz built on dielectric material with ε_r = 9.7 are also presented.

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INTRODUCTION

The combline bandpass filters are widely used in microwave equipment [1]. Resonators in a comb filter consist of sections of microstrip transmission lines that are short circuited at one end and lumped capacitance loaded at the other end. The resonators are oriented in one direction and arranged in parallel to one another without mutual displacement. The presence of lumped capacitance at the end of resonator results in its length becoming somewhat shorter than λ/4 at the main resonance frequency.

The design of such filters can be different, for example coaxial, microstrip or created on the basis symmetric strip transmission lines. In case the shortening capacitance is not present, the length of resonators is exactly equal to λ/4 at frequency f_0, and the distributed comb-type structure with *TEM* waves does not have any pass bands. This is explained by an extremely small coefficient of coupling between λ/4 resonators that is determined by mutual compensation of magnetic and electric couplings.

This approach is presented in [2] and is based on approximate models. Thus, it essentially reduced the interest to combline structures with λ/4 resonators that are built on the basis of symmetric strip transmission lines in coaxial form.

The microstrip comb structures with λ/4 resonators, where quasi-*TEM* waves propagate, were an exception. In such structures the coefficients of coupling between microstrip resonators are non-zero, and they are bandpass filters [3]. Microstrip comb filters with λ/4 resonators are among the main frequency selective devices used in printed circuit boards. This is determined by their small size, simple technical implementation, and a substantial removal of parasitic passband from the baseband.

Resonators built of sections of symmetric strip transmission lines possess higher intrinsic (unloaded) Q-factor than mirostrip resonators [4]. It may be interesting to combine the enhanced Q-factor of stripline λ/4 resonators and small size of comb-type structure in one comb filter of stripline design. In what follows, for brevity, we use the term stripline, which means symmetric stripline.

For ensuring the coupling between stripline λ/4 resonators an additional layer of dielectric and a layer of conducting pattern are used. As a result, we obtain a multilayered structure of filter [5, 6]. The implementation of multilayered filters involves the use of the low-temperature cofired ceramic (LTCC) technology that eliminates burning out of conducting metal layers. Additional layers for providing coupling between λ/4 resonators make the filter design and its manufacture more difficult.

The above noted peculiarities necessitate the return to the comb-type structure with stripline λ/4 resonators. The available now software programs of Microwave Office (AWR Company) and HFSS (Ansoft Company) perform simulation of electromagnetic processes at the electrodynamic level and are characterized by high accuracy of their reproducibility. They make it possible to analyze the coefficient of coupling between stripline λ/4 resonators with higher accuracy than it was done in [2].