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Stripline Bandpass Filters with Step-Impedance Resonators

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Abstract—Research results for stripline bandpass filters with step-impedance resonators formed on Al_2O_3 (Alumina, polycor) and operating in the frequency band 1500–2500 MHz are presented in this article. Use of step-impedance resonators breaks repetition factor in frequency positioning of passbands in such filters. This allows suppressing harmonics of output signal in transmitters and widening stopband for parasitic signals in receivers.

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INTRODUCTION

Bandpass microwave filters with quarter-wavelength resonators λ/4 [1, 2] are widely used in communications system devices. Such filters possess parasitic passbands on odd harmonics of main signal $3F_0$, $5F_0$, etc., which is their disadvantage.

In some receiving devices it is important to have a wide stopband meaning that first parasitic passband $3F_0$ should be as distant from main signal's band as possible. In transmitters parasitic signals are radiated on frequencies $2F_0$, $3F_0$, etc. that correspond to harmonics of main signal's frequency F_0. To filter them out it is sufficient to break repetition factor in passbands positioning. In this case it is not compulsory to achieve wide stopband.

The mentioned tasks may be solved by using filters with resonators that have stepwise change of wave impedance. Works [3, 4] contain results of research on filters with discrete coaxial resonators made of ceramics with high dielectric permeability, in which outer conductor possesses stepwise shape. Filters with stripline structure do not require additional screen [5], which provides them with advantage over filters with discrete coaxial resonators that require screening. Hence it is reasonable to solve the same problems for stripline filters.

This work contains results of research on bandpass filters with step-impedance resonators that possess stripline structure and are formed on Al_2O_3 substrates with relative dielectric permeability of $\varepsilon_r = 9.7$.

STEP-IMPEDANCE RESONATORS

Resonant frequencies F_i, $i = 0, 1, 2, \ldots$ of step-impedance resonator (Fig. 1) are determined by resonance equation

$$m\tan(q\theta)\tan\left[(1-q)\theta\right]-1=0, \tag{1}$$

which has the same denotations as Fig. 1: $\theta = \omega l/v$ is resonator's electric length; l is length; ω is cyclic frequency; v is propagation velocity of electromagnetic wave; m is ratio of wave impedance of stripline segment that is adjacent to short-circuit end to wave impedance of stripline segment that is adjacent to open end Z_0; $0 \le q \le 1$ is relative coordinate of wave impedance step.

We'll distinguish two kinds of step-impedance resonators. First one possesses greater wave impedance near short-circuit end, $m > 1$. Stripline segment of second-kind step-impedance resonator that is adjacent to open end has greater wave impedance with $m < 1$.

Distance of first parasitic resonant frequency F_1 from frequency of main resonance F_0 is characterized by quantity $P = F_0 / F_1$. For example a quarter-wavelength resonator has $P = 3$. Another characteristic of step-impedance resonator is quantity $K = 1/(\lambda/4)$ that represents a ratio of its length to length of quarter-wavelength resonator. Quantities P and K depend on coordinate of wave impedance step and on