Band-stop Filters in Microstrip Technology with Non-periodic Frequency Responses

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Periodic structures have been always an important research issue within the microwave community. One of their well-known drawbacks is that the frequency responses of classical band-stop periodic structures exhibit undesirable stop-bands at the harmonics of the design frequency. On the other hand, Photonic Band-Gap (i. e., band-stop) structures in microwave technology recovered the interest in the periodic structure theory in the last years, proposing a new nondiscrete approach [1] that made possible a huge number of brand new devices. In this paper, single and doublefrequency-tuned Photonic Band-Gap microstrip filters with controlled suppression of the spurious bands at the harmonics of the designed frequencies are presented, based on the Coupled-Mode Theory [2].

Periodic band-stop structures following sinusoidal PBGtype etching profiles in the ground plane of a microstrip line [1, 2] or modulating the upper strip [3] have been profusely reported in the literature. Assuming that only the fundamental quasi-TEM microstrip mode is propagating, its forward and backward waves are related by means of the socalled coupling coefficient, $K(z)$, which is proportional to the first derivative of the impedance to the propagation axis, z [2]. Provided the etching profile or modulated strip-width are periodic, $K(z)$ may be expressed through its Fourier series where K_n are the coefficients of this series. Almost exact analytical expressions may be obtained for the central frequency, $f_n = c \cdot n/(2 \cdot \Lambda \cdot \sqrt{\varepsilon_{eff}})$, rejection level, $|S_{21}|_n = \mathrm{sech}(|K_n| \cdot L)$, and bandwidth between zeroes of reflection, $BW_n = c \cdot |K_n|/(\pi \cdot \sqrt{\varepsilon_{eff}}) \cdot \sqrt{1 + (\pi/K_n \cdot L)^2}$, of the n-th stop-band, which relate these parameters to the n-th coefficient of the Fourier series K_n (being c the speed of light in vacuum, and ε_{eff} the effective relative dielectric permittivity). The previous equations show that in order to suppress all the harmonic pass-bands, we would have to design adequately the perturbation so that $K_n = 0$ for $n \neq \pm 1$, obtaining for instance a nearly sinusoidal strip-width modulation.

Harmonic stop-bands may be observed in measurements for strip-width sinusoidal modulation of a microstrip line with period $\Lambda = \pi/200$ and length $L = 8 \cdot \Lambda$. Perfectly sinusoidal perturbation leads to a quasi-sinusoidal coupling coefficient, which provides not very deep harmonic stopbands. The strip-width modulation is now altered so that $K(z)$ is perfectly sinusoidal ($K_{\pm 1} = 35\, m^{-1}$ and $K_n = 0$ for $n \neq \pm 1$). Now, in measurements, harmonic stop-bands are perfectly suppressed.

Interesting design capabilities can be shown. For instance, for a filter with two stop-bands at 3 GHz and 5 GHz, 20-dB attenuation and 1GHz bandwidth each, a doubly periodic ($\Lambda_1 = 19.12$ mm and $\Lambda_2 = 11.47$ mm) modulation along a $L = 172.08$ mm-long device with $|K_{\pm 1}|_{1,2} = 19.17\,\mathrm{m}^{-1}$ may fulfil these requirements. The agreement between simulation and measurement results is very good.

REFERENCES

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