Multi-Spurious Harmonic Suppression in Miniaturized Planar Bandpass Filters

Thesis submitted

by

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2022

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INDEX NO. 43/16/E

Title of the Thesis:	Multi-Spurious Harmonic Suppression in Miniaturized Planar Bandpass Filters
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Abstract

In the modern-day of communication systems, Information and Communications Technology (ICT) provides the platform where people can access, store, transmit, understand and manipulate information over wireless medium. Thus, it becomes obvious to integrate different compact sized functional blocks of the communication network on a common platform in the transmitter and receiver's module. Henceforth, the interconnection of various devices is performed by the wireless local area network (WLAN). This obviously demands very compact sizes of different blocks in the WLAN communication system. Bandpass filters play an important role in every communication system to improve its quality and efficiency.

In this respect, the designers have chosen the parallel-coupled lines topology for the compact bandpass filters design due to the advantages of easy design and fabrication methods. However, such filters suffer from asymmetrical passband and presence of multiple spurious harmonics in the stopband due to the inhomogeneous nature of the microstrip structure, resulting asymmetrical modal phase velocities imbalance. Accordingly, different nonuniform reactive perturbations have been employed by the researchers in the conventional parallel-coupled line bandpass filters to suppress the spurious harmonics such as periodic grooves, wiggly lines, corrugations, over-coupled structure, stepped-impedance resonator, defected ground structure, fractals, spurline etc. However, the sizes of such filters are quite large due to their conventional structure, restricting their applications in modern wireless communications. In this context, folded and inline parallel-coupled line filters centered at 2.5 GHz and 5.25 GHz (fractional bandwidth of 20%) have been proposed in the present thesis and subsequently, periodic triangular corrugations have been incorporated along the coupled edges of the lines to achieve modal phase velocity compensation. As a result, the second harmonic suppression of 62 dB and 30 dB and size reduction of 62% and 74% have been recorded for the folded and the inline filters respectively. Later, as an alternative approach, asymmetric perturbations have been employed by modulating the widths of the coupled lines, resulting the second harmonic suppressions of 53 dB and 58 dB and size reductions of 58% and 71% for the folded and the inline filters respectively. However, for both the proposed works, the sizes of the filters are still quite large and the stopbands have been limited to only $2.2f_0$ (f_0 is the center frequency). Moreover, the fractional bandwidths are restricted to 20% as because the insertion loss of narrowband filters (fractional bandwidth less

than 10%) by parallel-coupled lines increases due to large coupling gaps. Accordingly, the study of the hairpin-line bandpass filters as the modifications of the parallel-coupled-line filters are taken care as the next step. Such filters occupy much less area than the parallel-coupled line filters along with the advantages of improved skirt selectivity and low insertion loss due to their U-shaped. However, the spurious harmonics are still present due to the modal phase velocities imbalance between the coupled hairpin lines. Hence, double folded hairpin-line filters centered at 2.5 GHz with fractional bandwidth of 8% and 4% have been proposed in the second phase of the thesis. For such designs, the open-ends of the conventional hairpin-lines have been folded twice towards the inward direction. After that, Minkowski fractals have been incorporated along the coupled edges of the adjacent folded cells to achieve a stopband up to $3f_0$ with the rejection level of 36 dB. Moreover, a size reduction of 30% and enhanced skirt characteristics has been obtained. In order to achieve more compactness and harmonic suppression, different types of spurline such as conventional L-shaped spurline, T-shaped spurline and meander spurline have been studied. As the results, an extended stopband with a rejection level of 38 dB up to $4.48f_0$ and a size reduction of 18% has been achieved, a wide stopband up to $3.2f_0$ with a rejection level of 39 dB and a size reduction of 46% has been achieved, and an improvement in the stopband rejection level of 40 dB, extended up to $4f_0$ and a compactness of 38% has been achieved. Although, the stopband bandwidth and the rejection level both have been improved for the folded hairpin-line filters with spurline, but still few limitations have been observed such as: (1) the compactness has been obtained along the transverse plane only. The lengths of the filters are still quite large, limiting their integration with other blocks in the WLAN systems, (2) the skirt characteristics have been enhanced only at the upper passband edge. Hence, in the last phase of the thesis, a modified cross-coupled filter have been proposed by rearranging the double-folded hairpin-line cells in cross-coupled configuration to incorporate electric, magnetic and hybrid couplings. Such filter's structure has exhibited very compact size and enhanced symmetrical skirt selectivity by placing two sharp transmission zeros at the passband edges. Subsequently, Subsequently, L-shaped and meander spurline have been incorporated along the coupled edges with hybrid coupling. As a result, the stopband rejection level of 35 dB up to $3.76f_0$ with L-shaped spurline and 38 dB up to $4f_0$ with meander spurline have been recorded. The size reductions of 33% have been achieved over the conventional open-loop resonator cross-coupled filter with the same specifications.