Balanced Microwave RF Filters with Quasi-Elliptic-Type Differential-Mode Passband and Multi-Notch Common-Mode Suppression

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Balanced/differential RF circuits are becoming increasingly important in modern communication systems. This is attributed to their higher immunity—compared to their single-ended counterparts—to undesired phenomena, such as electromagnetic interference, crosstalk, and different sources of noise. Recent RF design efforts for these filters are focusing on the realization of highly-selective and low insertion loss (IL) passbands for the differential-mode and as high as possible power rejection levels for the common-mode. However, in the majority of the existing RF balanced filtering architectures, the common-mode suppression is limited to 15-20 dB and only within a narrow band (typically at the passband area). In addition, these topologies are made from tightly coupled-lines that are sensitive to manufacturing tolerances and suffer from high in-band IL.

Taking into consideration the aforementioned limitations, this paper reports on a new class of microwave balanced bandpass filters (BPFs) with quasi-elliptic-type differential-mode response and multi-notch common-mode suppression. The proposed architecture is based on: i) two single-ended quasi-elliptic BPFs that each exhibit a three-pole/two-transmission zero (TZ) transfer function and ii) a multi-resonant balanced network that exhibits four TZs. The balanced network is shaped by the BPF's resonators as well as two half-wavelength long transmission lines (TLs) that are added at its input/output. In this manner, the balanced BPF's differential-mode inherits the transfer function characteristics from its single-ended BPF, whereas its common-mode is efficiently suppressed by four TZs. By resistively loading the BPF's resonators at the line of symmetry, a common-mode suppression that is larger than 55 dB can be obtained within its passband and a suppression that is larger than 38 dB within an octave of bandwidth.

For proof-of-concept demonstration purposes, a microstrip-type prototype was designed, manufactured and measured at 1.7 GHz. The prototype exhibits a quasi-elliptic differential-mode passband with bandwidth of 294 MHz, IL <0.86 dB, return loss (RL) >18 dB, and common-mode suppression >38 dB within a frequency range of 1.2-2.6 GHz. In relation to state-of-the-art balanced BPFs, the proposed filter allows for increased selectivity passbands to be obtained with lower in-band IL and higher common-mode suppresion within a 2:1 bandwidth. In addition, the proposed filter's realization does not require coupled-lines, making it more robust to manufacturing and assembly tolerances.