ABSTRACT

A possible system realization of a high quality (Q) factor bandpass filter is proposed. Two circuit realizations through Techniques 1 and 2 of fully balanced, high-Q, wide-dynamic-range current-tunable Gm-C bandpass filters are presented. Technique 1 is relatively simple based on two fully balanced components, i.e. a two-input adder and a low-Q-based bandpass filter. The high quality Q_{HQ1} factor of Technique 1 is approximately equal to a typically high (> 100) and constant value of a common-emitter current gain (β) and is, for the first time, independent of variables such as a center frequency. Possible solutions for good stability of Q_{HQ1} with temperature are suggested through the use of Heterojunction Bipolar Transistors (HBTs) where the β is relatively constant. Not only can the need for additional Q-tunable circuits be greatly reduced, the sensitivity of the Q factor can be greatly improved.

Sensitivities of either the Q factor or the center frequency to the variation of parameters in Technique 1 are constant between 1 to –1 and are no longer strongly affected by the Q factor or variables. As a simple example at 10.7 MHz, Technique 1 demonstrates the high quality factor Q_{HQ1} factor of 121, the low total output noise of 5.303 μV_{rms}, the 3^{rd}-order intermodulation-free dynamic range ($IMFDR_3$) of 74.45 dB and the wide dynamic range of 87.45 dB at 1% IM_3. The upper limit of Q_{HQ1} is expected at approximately 160 at a maximum β of 190. The upper limit of center frequency is expected at approximately 600 MHz at a capacitance of 1 pF. The center frequency is current tunable over 3 orders of magnitude. The temperature coefficient of normalized center frequency is approximately –30 ppm/°C.

Technique 2 is also relatively simple based on three fully balanced components, i.e. a two-input adder, a low-Q-based bandpass filter and a differential amplifier. The high quality factor Q_{HQ2} of Technique 2 is possible through a tunable bias current. As a simple example at 10.7 MHz, the paper demonstrates the quality factor Q_{HQ2} of 223, the low total output noise of 2.559 μV_{rms}, the 3rd-order intermodulation-free dynamic range ($IMFDR_3$) of 80.82 dB, and the wide dynamic range of 101.02 dB at 1% IM_3. The centre frequency is current tunable over 3 orders of magnitude. For very high Q realizations, the sensitivities of the Q factor to the variation of parameters in Technique 2 are in the same order as other existing approaches whilst the sensitivities of center frequency to the variations of parameter are constant values from –1 to 1. The upper limit of center frequency is expected at approximately 500 MHz at a capacitance of 1 pF. The center frequency is current tunable over 3 orders of magnitude. The temperature coefficient of normalized center frequency is approximately –30 ppm/°C. Comparisons of Techniques 1 and 2 to other 10.7-MHz Gm-C approaches are also included. The two proposed 10.7-MHz techniques described in Techniques 1 and 2 offer the high-Q wide-dynamic-range current-tunable Gm-C bandpass filter.