HIGH-FEQUENCY CMOS INTEGRATED FILTERS FOR COMPUTER HARD DISK DRIVE AND WIRELESS COMMUNICATION SYSTEMS

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Abstract

Operational transconductance amplifier and capacitor (OTA-C) filters have outstood among different types of filter due to high frequency and low power capabilities in the main stream digital CMOS technology. They have been widely used in computer hard disk drive (HDD) and wireless communication transceivers. OTA-C filters based on cascade and passive ladder simulation are well-known. However, multiple loop feedback (MLF) OTA-C filters which have certain advantages still have the scope for further research. So far there have been no explicit formulas for current-mode leapfrog (LF) filter design and performance evaluation of current-mode MLF OTA-C filters are still lacking.

From application viewpoints, read channels for computer hard disk drives require very high frequency continuous-time filters. This automatically disqualifies active-RC/MOSFET-C filters and OTA-C filters become the only solution. In wireless communications, active-RC/MOSFET-C filters have been proved useful for mobile systems whose baseband frequency falls below a few MHz. However, for wireless LANs with the frequency of several tens of MHz, OTA-C filters are a strong candidate. Whilst in HDD read channels, cascaded OTA-C architectures have been most utilized and in wireless receivers, OTA-C structures based on ladder simulation have been popular, MLF OTA-C filters have not been practically used in either of the applications.

This thesis describes some novel designs and applications of multiple loop feedback OTA-C filters with extensive CMOS simulations. Analogue filters for computer hard disk drive systems are first reviewed; the state of the art and design considerations are provided. Three VHF linear phase lowpass OTA-C filters are then designed, which include a seventh-order and a fifth-order current-mode filter based on the follow-the-leader-feedback (FLF) structure and a seventh-order voltage-mode filter using the inverse FLF (IFLF) configuration. These filters all have very low power consumption.

The synthesis and design of general current-mode LF OTA-C filters are conducted next. Iterative design formulas for both all-pole and finite-zero functions are derived and explicit formulas for up to sixth-orders are given. These formulas are very easy to use for designing any type of characteristics. Subsequently, linear phase lowpass OTA-C filter design for HDD read channels using LF structures are investigated in details. A current-mode filter and a voltage-mode filter using the fifth-order LF structure are presented. The two filters can operate up to 800MHz and have very small passband phase ripple.

Analogue filters for wireless communication baseband applications are also reviewed thoroughly in this thesis, where the design of a fourth-order current-mode FLF Butterworth lowpass OTA-C filter for multi-standard receivers is presented. Then two fifth-order current-mode elliptic lowpass OTA-C filters based on respective LF and FLF structures for wireless communication baseband are designed. Fifth-order voltage-mode IFLF and LF elliptic lowpass filters are also presented. All these MLF baseband filters designed can operate up to 40MHz to cover all important wireless and mobile standards. Simulations show that the LF structures have better dynamic range and stopband attenuation performances than the FLF and IFLF configurations.

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