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A 2.5V operation Wideband CMOS Active-RC filter for Wireless LAN

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Abstract. An active-RC channel selection filter for wireless LAN is described whose cut-off frequency is tunable from 6MHz to 20MHz. This frequency tuning range is sufficient to cover from 6MHz to IEEE802.11a (20MHz) including the effect of process, voltage, temperature variations. For wide tuning range, a differential R-2R ladder has been developed which gives widely variable resistance with minimum silicon area. The in-band input third-order intercept point (iIP3) of the filter is 18dBV at the highest gain mode. The input referred noise is $13\text{nV}/\sqrt{\text{Hz}}$ at the lowest gain mode. Implemented in a 0.25μm CMOS technology, the filter operates with 2.5V supply voltage, consuming 9mA

Keywords: Channel selection filter, active-RC, CMOS, Wireless LAN

1 Introduction

Recently, the interest for wireless local area network (WLAN) has been increasing due to its nature of user convenience and adaptability to newly emerging wireless standards. In WLAN, almost all the important radio characteristics are defined by the software stack in DSP. Nonetheless, RF front-end including low noise amplifier (LNA), mixer, and channel selection filter are required to relieve the burden of analog-to-digital converter (ADC) and DSP. which is the conceptual block diagram of WLAN with direct conversion receiver (DCR) architecture. Among various architectures of RF front-end, direct conversion architecture seems to be the optimum choice for WLAN because of its simplicity, the lack of intermediate frequency (IF) stages, and low power dissipation. However, the performance requirements of ADC such as dynamic range and effective resolution become stringent [1]. Therefore, the cut-off frequency of channel selection filter should be tunable depending on the channel bandwidth of each wireless standard. Several research results on dual-mode analog channel selection filter have been reported [2-3], but to the authors' knowledge there has been no true software definable channel selection filter tunable for multiple wireless standards.

In this paper, an active-RC channel selection filter for WLAN application is described whose cut-off frequency is tunable from 6MHz to 20MHz. For wide tuning range, a differential R-2R ladder has been developed which gives widely variable resistance with minimum silicon area. Wide bandwidth operational

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amplifier (op-amp) is designed to dissipate small power by employing a current re-using feedforward frequency compensation scheme. Implemented in a 0.25μm CMOS technology, the channel selection filter operates with 2.5V supply voltage, consuming 9mA. The measurement results are given in this paper.

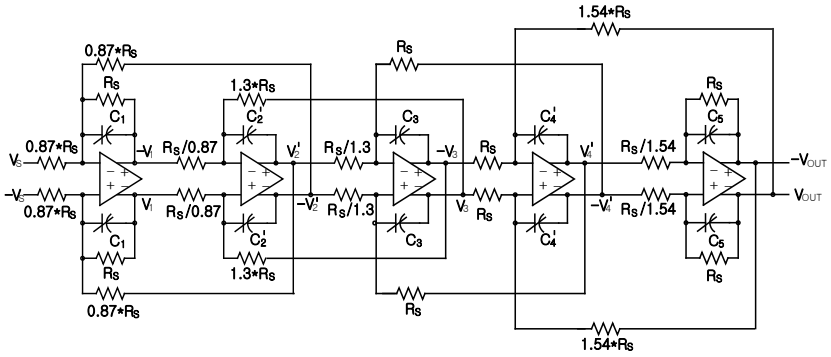

Fig. 1. Fifth-order Chebyshev active-RC filter whose dynamic range is optimized by voltage scaling.

2 Active-RC Channel Selection Filter with Fully-Differential R-2R Ladder for WLAN

2.1. Fifth-order Chebyshev active-RC filter

Although the detailed frequency characteristics of channel selection filter may be different for each wireless standard in WLAN, a fifth-order Chebyshev filter as shown in Fig. 1 has been chosen because it provides relatively large stopband attenuation with moderate group delay variation in passband. If equalized group delay is desired, all pass filter built with the same circuitry may be cascaded after the Chebyshev filter.

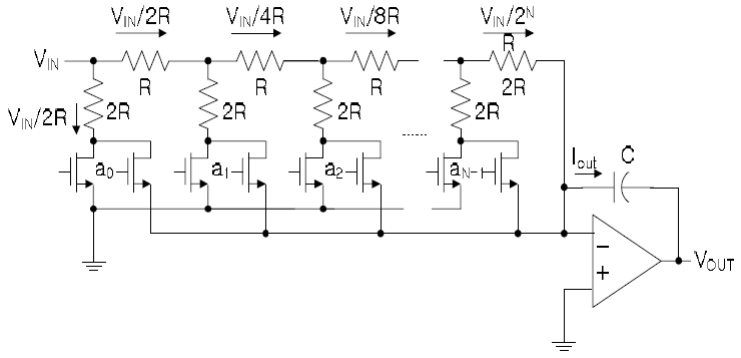

Fig. 2. Single-ended active-RC integrator with R-2R ladder.

For maximum dynamic range, the internal node voltages are scaled as shown in Fig. 2. The cut-off frequency is tunable in a very wide frequency range by employing differential R-2R ladder which is explained below.

2.2 Differential R-2R ladder

The cut-off frequency of active-RC filter can be tuned by varying the unity-gain frequency of active-RC integrators. Since the transfer function of active-RC integrator is given by-1/*sCR*, the cut-off frequency can be changed by either variable capacitor or resistor. If the maximum cut-off frequency *fmax* is *M*fmin* and variable capacitor (resistor) is used for frequency tuning, the maximum and minimum capacitances (resistances) are *M*Cmin* (*M*Rmin*) and *Cmin* (*Rmin*), respectively.

2.3 Operational amplifier

The DC gain, unity-gain frequency, and the phase shift at the unity-gain frequency are the most important performance parameters of integrator. All these performance parameters are mainly determined by op-amp used for active-RC integrator. Thus, the DC gain and bandwidth of op-amp should be as large as possible. Unfortunately, more power must be dissipated for larger DC gain and bandwidth with widely used conventional Miller frequency compensation. In order to alleviate this issue of Miller compensation, a left half plane (LHP) zero can be generated by a feedforward signal path to compensate the phase shift due to parasitic pole [4-5].

The bias current of the second stage, transistors M11 and M12, is re-used in the feedforward signal path formed by the transistors M9 and M10. The HSPICE simulation results including all the parasitic capacitance indicate 77dB DC gain and 870MHz unity gain frequency with 1pF load capacitance. The phase margin is simulated to be 56º .

3 Measurement Results

The filter is designed with a 0.25μm CMOS technology and its layout is shown in Fig. 3. In order to include the effects due to parasitic capacitance and resistance. Implemented in a 0.25μm CMOS technology has been performed. The filter operates with 2.5V supply voltage, consuming 9mA. The frequency response for some R-2R ladder control codes measures the cut-off frequency is tunable from 6MHz to 20MHz as shown in Fig.4. The passband ripple is smaller than 0.5dB while the stopband is attenuated by more than 41dB. The linearity of the filter is checked by the third order input intercept point (iIP3) for both in-band and out-of-band signal and the second order input intercept point (iIP2) for out-of-band signal.

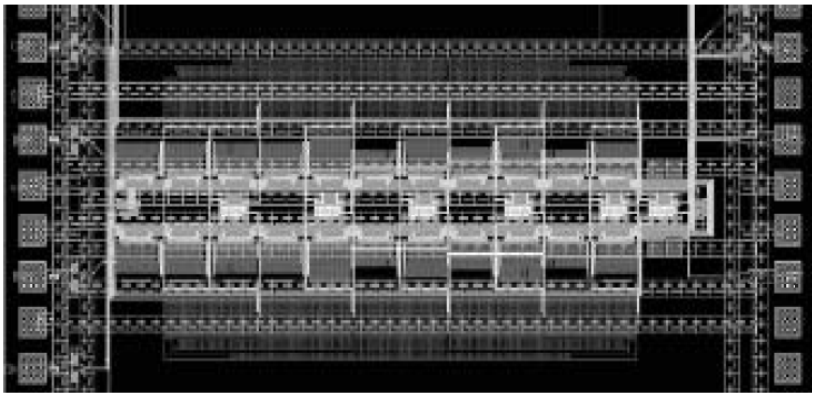

Fig. 3. Layout of the active-RC channel selection filter.

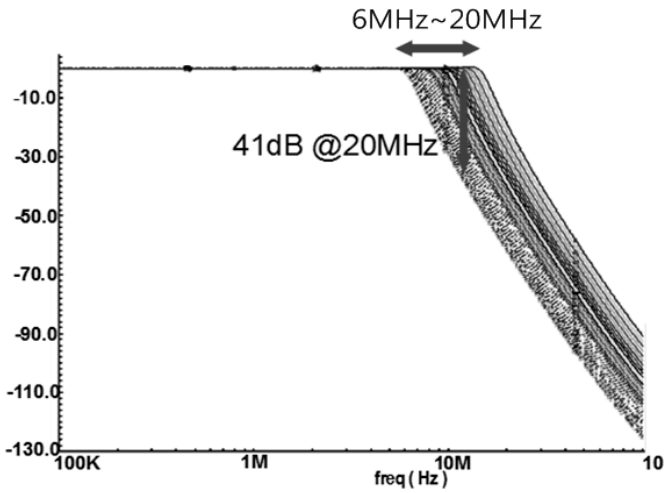

Fig. 4. Frequency response of the filter for some R-2R control codes.

4 Conclusion

This paper describes a CMOS active-RC channel selection filter for for 5GHz wireless LAN. An active-RC channel selection filter for WLAN is described whose cut-off frequency is tunable from 6MHz to 20MHz. For wide tuning range, a differential R-2R ladder has been developed which gives widely variable resistance with minimum silicon area. The in-band input third-order intercept point (iIP3) is 18dBV at the highest gain mode. Implemented in a 0.25μm CMOS technology, the filter operates with 2.5V supply voltage, consuming 9mA.

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