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An Ultra-low Voltage Hybrid OTA Based Low Pass Filter

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ABSTRACT

This paper presents anultra-low voltage hybrid second order Gm -C low pass filter constructed from an operational transconductance amplifier and a PMOS source follower. The proposed LPF is simulated using 180 nm standard CMOS process parameters. The performance of the proposed low pass filter is compared with the existing LPF implementations. The results shows that the proposed filter is able to operate at the lowest voltage power supply (0.5 V) and at the same tame attains a maximum cut-off frequency(350 Hz) in comparison to the existing ones.

Keyword: Amplifier, Analog, Hybrid OTA, Low pass filter, low voltage

I INTRODUCTION

A lowpass filter (LPF) is necessary component in the signal processing to drive the low frequency signal,exclusively related to biomedical applications. The LPF operated in the subthreshold region is practical due to its compatibility with the reduced capacitive area and its low power consumption.

There are several techniques to implement low power LPFs. It can be constructed by using two OTAs and two capacitors [1], Gm-C filter constructed by employing single branch filter[2].Another technique for realising Gm-C filter is with an ordinary operational transconductance amplifier [3]. In one of the recent work, Gm-C filter using both the loop OTA topology and single branch technique is purposed .In this work, we present hybrid OTA filterthat combines two different approach for requirement of operating in ultra-low voltage. and the approaches are bulk driven mos transistor and a pseudo differential amplifier technique.

In section 2, we discuss the design of ultra-low voltage hybrid OTAfilter analysis and synthesis. The simulation of hybrid OTA filter is shown in section 3 while section 4concludes the paper.

II HYBRID OTAFILTER

The hybrid OTA is mixture of weak inversion and strong inversion part of the OTA operates in weak inversion which gives the advantage over ordinary OTA (constant bandwidth , constant input range and improved linearity) and added advantages are reduced power dissipation ,wide gain and a very simple architecture.Fig. 1. shows the low pass filter from two OTAs and capacitors. The transfer function of the filter is given as:

$$\frac{Vout}{Vin} = \frac{Gm2Gm1}{s^2 c2c1 + sG2c1 + Gm1Gm2} \quad (1)$$

Where vin and vout are the input and output of low pass filter respectively.In this work Gm1 is the tranconductane gain ofOTA and gm2 is the gain of pmos source follower. The OTAstructure is shown in Fig. 2. which is purposed recently [4] and the pmos source follower is shown in Fig. 3.The advantages of hybrid OTA are that it has a very wide transconductance gain adjustment range while for the saturated version. And it has reduced power dissipation due to the operation of the first stage in weak inversion.

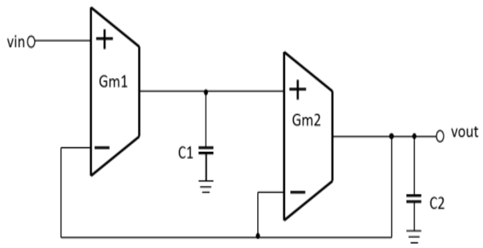

Fig. 1. A second-order low pass filter

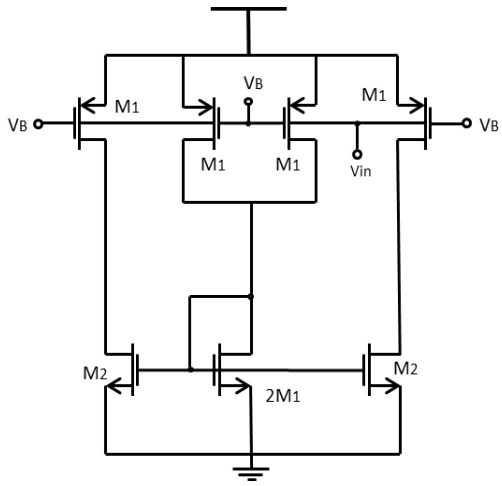

Fig. 2.The OTA structure

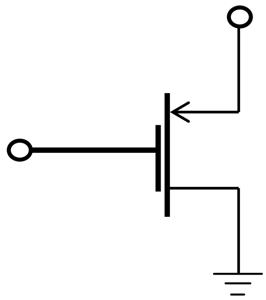

Fig.3. Common Drain PMOS as source follower

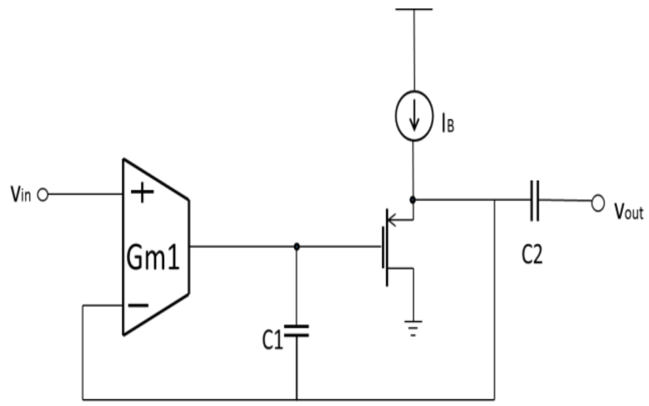

Fig.4. The proposed low pass filter employing the presented OTA

III CIRCUIT SIMULATION

The proposed low pass filter circuit is shown in fig. 4 has been designed for operate in low voltage. It is simulated in PSPICE180 nm CMOS technology parameters.The dimension of the transistors are: M1=$(\frac{4}{0.36})$,M2=$(\frac{3.6}{0.36})$,M3=$(\frac{3}{0.36})$ while the values of C1 and C2 are equal to 5PF.Thepower supply voltage (V_{DD}) and common base voltage (V_B) are 0.5 V and 0.28 V respectively.

The cutoff frequency (fc) of proposed LPF is 360 Hz at I_B = 0.5 pA. The frequency response of this filter is shown in Fig.5.Also, the graph to demonstratethe Fifth time harmonic distortion of this filter is also shown in Fig. 6.In this graph the amplitude of sinusoidal signal is varied from 10 mV up to 60 mV peak to peak.

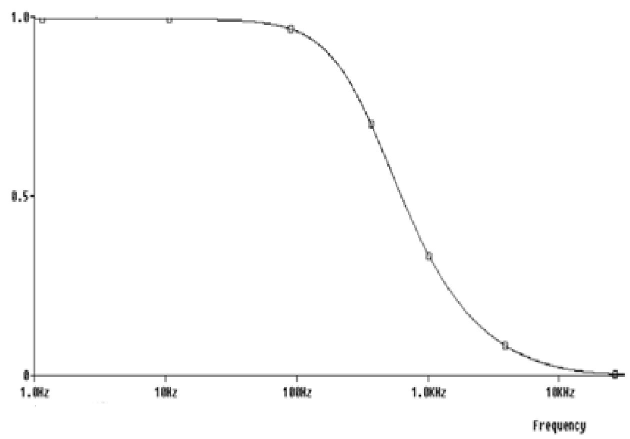

Fig. 5. Frequency response of the low pass filter

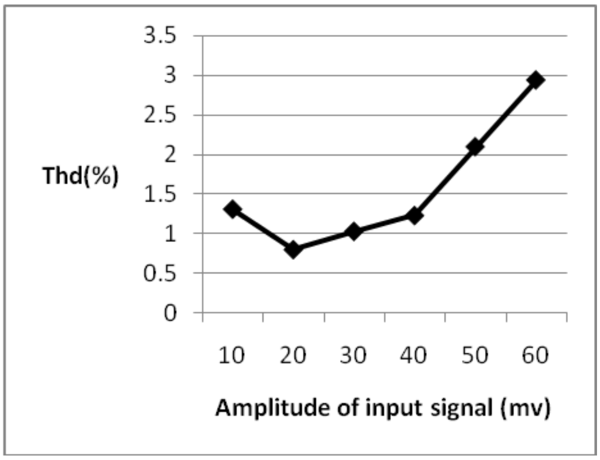

Fig. 6. Fifth harmonic time distortion

The performance of the filetr is compared with the existing filter design presented in [5-7]. The simulation results are listed in Table I. It can be observed that the proposed LPF is able to operate at the lowest power supply value and is able to achieve a maximum bandwidth in comparison to the existing LPF architectures.

Table I. Performance Comparison of the LPFs

Parameters	[5]	[6]	[7]	This work
V_{DD}(v)	3	1.5	1	0.5
Tech (μm)	0.35	0.35	0.35	0.18
Order	4	4	2	2
Bw(hz)	100	100	250	360
Gain(dB)	0	0	0	0
Power (nW)	15	9.19	1.93	233

IV CONCLUSION AND DISCUSION

In this paper, a design for a second order low pass filter is presented. The filter employs hybrid OTA and successful to operate in the subthreshold region. A bulk driven OTA structure has been used in the simulation which allows the filter to operate with very low bias current values. A performance comparison of the proposed filter with the available ones is performed through simulation in PSPICE using 180 nm CMOS technology parameters. The simulation results indicate that the proposed LPF is able to operate at the lowest voltage and at the same time show the maximum cut-off frequency value for the same value of the mid-frequency gain.

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