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A Novel Design of Low Voltage,Wilson Current Mirror based Wideband Operational Transconductance Amplifier

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Abstract—An optimum OTA topology is done in order to optimize MOS transistor sizing.Also, the design of folded cascode OTA, which works for frequencies that lead to a base band circuit design for RF application, is based on transistor sizing methodology.

Simulation results are performed using SPICE software and BSIM3V3 model for CMOS 0.18µm process, show that the designed folded cascode OTA has a 52dB DC gain and provides a gain bandwidth product of around 400MHz.

Keywords—**CMOS IC design, optimization, folded cascode OTA, gm/ID methodology, base band RF application.**

I. INTRODUCTION

Microelectronic development since these 30 last years is truly spectacular. This success results mainly of a knowledge-make and a technological master of a fundamental element: the silicon. It is the base of integrated circuit design with large scale of integration. With the passing of years, the complexity of integrated circuit has continuously increased, mainly due to the rising performance of MOS transistors.

This paper is organized as follows. An optimum Architecture of the folded cascode OTA was introduced in section II and its function was analyzed to extract the circuit performances. Section III describes an approach for designing this OTA, clarifies specific design issues, and results. While section IV provides concluding remarks.

II. OPTIMUM TOPOLOGY OTA

Several fundamental issues exist when selecting an optimal architecture for the operational transconductance amplifier. This choice aimed both at large gain and large bandwidth performances. In order to achieve high gain, the differential telescopic topologies can be used. This topology cascodes both the differential pair transistors and current mirror to increase load resistance (Fig. 1) .The telescopic architecture is a better candidate for a low power consumption and low noise OTA.[3] The performance of simple OTA is limited by its input and output voltage swing. To overcome these limits of simple OTA and have an improved performance a Folded Cascode OTA is used.

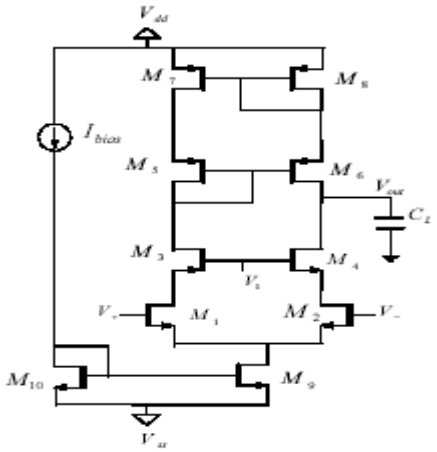


Fig: 1 Telescopic OTA

Although, telescopic OTA has a limited input and output swing. In order to alleviate some of the drawbacks of telescopic operational amplifier, a folded cascode OTA based on Wilson mirror can be used.

II.I. Basic configuration CMOS folded cascode OTA

The operational transconductance amplifier (OTA) is used as basic building block in many switched capacitor filters OTA is basically an op-amp without an output buffer and can only drive capacitive loads [2], [3].

An OTA is an amplifier where all nodes are low impedance except the input and output nodes. A useful feature of OTA is that its transconductance can be adjusted by the bias current. Filters made using the OTA can be tuned by changing the bias current Ibias[1]. Two practical concerns when designing an OTA for filter applications are the input signal amplitude and the parasitic input/output capacitances.

Large signals cause the OTA gain to become non-linear. The external capacitance should be large compared to the input or output parasitic of the OTA. This limits the maximum frequency of a filter built with an OTA and causes amplitude or phase errors. These errors can usually be reduced with proper selection of Ibias. The performance of simple OTA is limited by its input and output voltage swing. To overcome these limits of simple OTA and have an improved performance a Folded Cascode OTA is used.

The folded cascode OTA is shown in Fig. 2 The name "folded cascode" comes from folding down n-channel cascode active loads of a diff-pair and changing the MOSFETs to p-channels. Folded cascode OTA has a differential stage consisting of PMOS transistors M9 and M10 intend to charge Wilson mirror. MOSFETs M11 and M12 provide the DC bias voltages to M5-M6-M7-M8 transistors.[5]

Apply AC input Voltage between V+ and V-, cause the diff-amplifier drain current to become gmVin. This AC differential drain current is mirrored in the cascaded MOSFETs M1 to M6.

The output Voltage of the OTA is given by:

$$\mathbf{Vout = G_m V_{in} Ro} \qquad (1)$$

The "Unity gain frequency" of the OTA is:

$$\mathbf{Fu = 2\pi g_{m9}/ C_L} \qquad (2)$$

Gm is computed as

$$\mathbf{Gm = 2\pi GBW C_L} \qquad (3)$$

The open-loop voltage gain is given by:

$$\mathbf{A_V = \{g_{m9} g_{m4} g_{m6}\}/ I_D^2(g_{m4}\lambda_N^2 + g_{m6}\lambda_P^2)} \qquad (4)$$

Where gm9, gm4 and gm6 are respectively the transconductances of transistors M9, M4 and M6. ID is the bias current flowing in MOSFETs M4, M6, and M9. Like, CL is the capacitance at the output node.λ_N and λ_P are the parameters related to channel length modulation respectively for NMOS and PMOS devices. Taking the complementarities between the Transistors M4 and M6 into account: $\mathbf{g_{m4} = g_{m6}}$

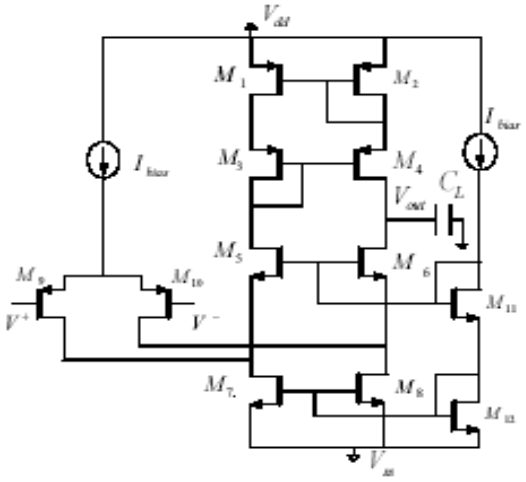


Figure 2. Folded cascode OTA

III.1. Sizing algorithm

MOS transistors are either in strong inversion or in weak inversion. The design methodology based G**m/I$_D$** characteristic, proposed by allows a unified synthesis methodology in all regions of operation the MOS transistor. We consider the relationship between the ratio of the transconductance G**m** over the DC drain current **I$_D$**, and the normalized drain current **I$_D$ / (W/L)** as a fundamental design relation[3]. **Gm/ I$_D$** is based on its relevance for the following reasons:

• It is strongly related to the performance of analog circuits;
• It gives an indication of the device operation Region;
· It provides a simple way to determine the Transistors dimensions.

III.2. OTA design

After applying the design strategy, we obtained the parameters computed and summarized in Table 1.

W9, W10	**45µm**
W1, W2, W3, W4	**25µm**
W5, W6, W7, W8, W11, W12	**2.78µm**

Table 1: W for NMOS and PMOS

The designed folded cascode OTA was biased at 1.8V power supply voltage using CMOS technology of 0.18µm with the BSIM3V3 MOSFET model.

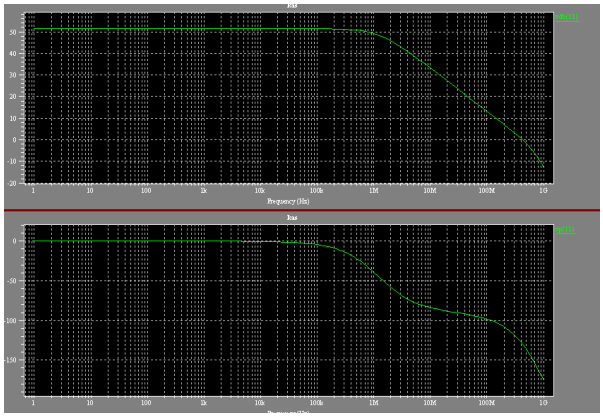


Fig 3: Gain,GBW and Phase Margin

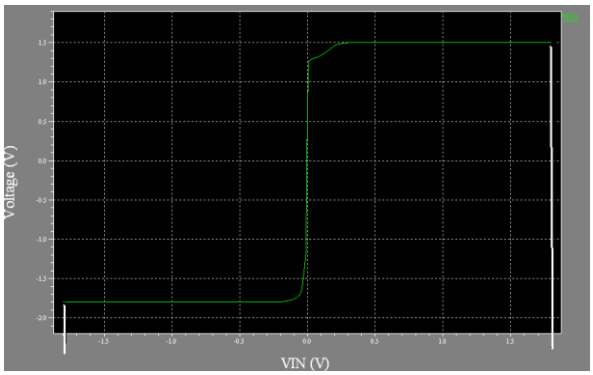


Fig 4: I/O swing & Offset

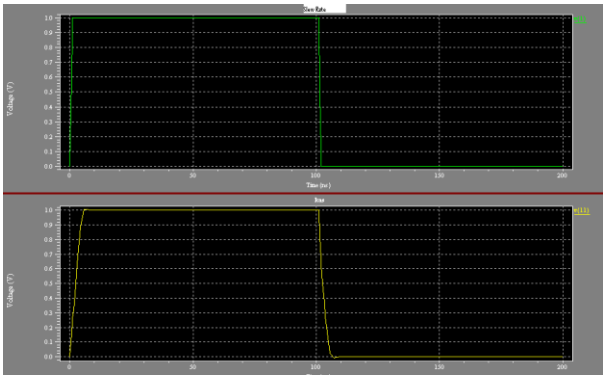


Fig 5: Slew Rate

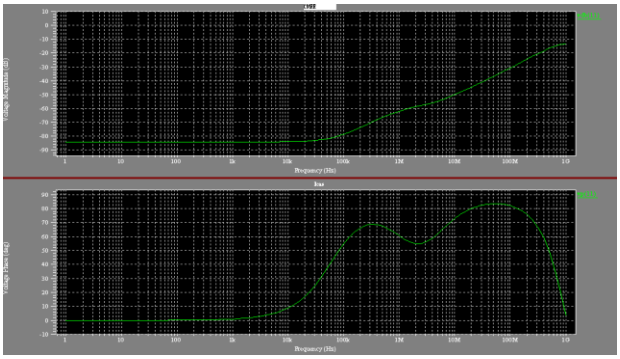


Fig 6: CMRR

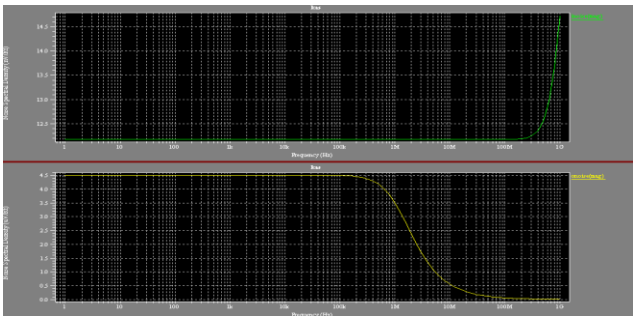
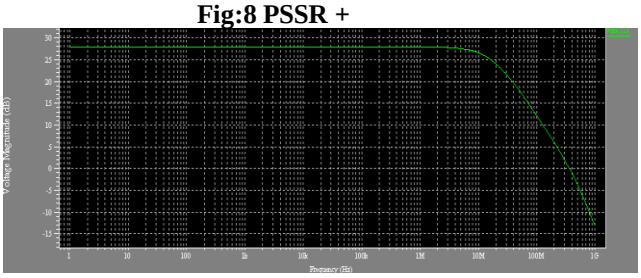


Fig7: Noise Spectral Density

Fig:8 PSSR +



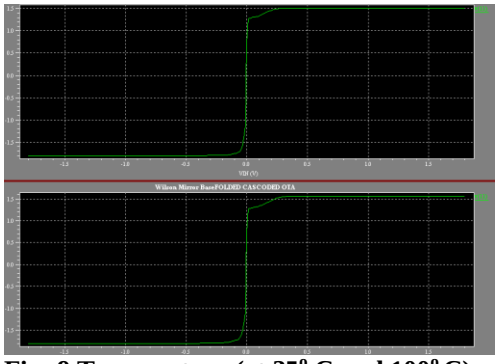


Fig: 9 Temperature (at 35° C and 100° C) Analysis

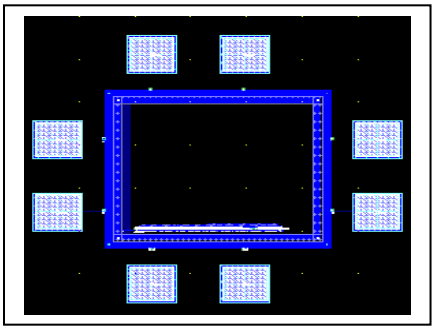


Fig: 10 Layouts(0.18 µm)

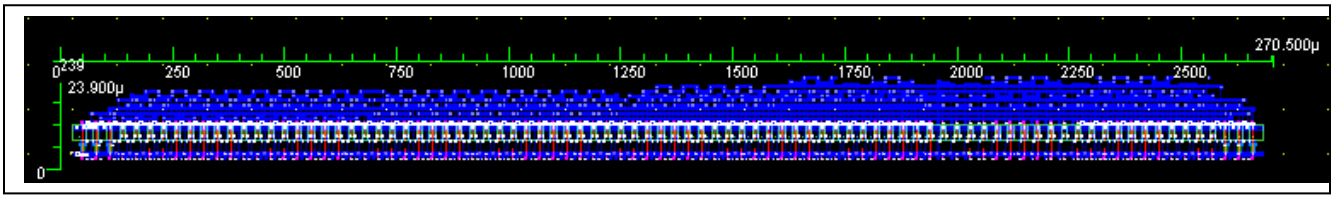
Results Summary

Specifications	Results
Gain	52dB
GBW	400MHz
Phase Margin	50dB
CMRR	136dB
PSSR	PSSR+ 127dB
Offset Voltage	0.02V
I/O Swing	[1.8V/1.5V]
Slew Rate	90V/µS
Input Noise spectral Density	3.4nV/Rt
Output Noise Spectral Density	4.5µV/Rt
Technology	0.18 µm
Supply Voltage	±1.8V
Area	270µ X 23µ
Temperature (at 100° C)	Offset 0.03V Outswing:1.6V

Table 2: Results

IV. CONCLUSION

Since the folded cascode OTA based on Wilson mirror has a limited output swing. For the folded cascode OTA using a Wilson mirror, the maximum output voltage is set lower than: Vdd+VT+2Vds,sat, so, we can use cascode mirror to compensate the fall to +2Vds,sat. This paper presents an efficient OTA design, so, the goal to reach moderate gain and large bandwidth. Tranconductance cells are relatively simple circuits which allow operating for high frequencies. Future work involve the search of low power consumption and Ultra low-supply voltage structure, an update to nano technology-process for RF application



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