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A REVIEW ON OPERATIONAL TRANSCONDUCTANCE AMPLIFIER (OTA) USING 180NM TECHNOLOGY

Review Paper of OTA

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Abstract *— A mixed Signal IC can be a combination of Analog circuits and Embedded Software. This paper presents design concept and review of Operational Transconductance Amplifier (OTA) using different types of OTA such as a (i) Single Stage OTA (ii) Two stage OTA (iii) Folded Cascode OTA (iv) Telescopic OTA. Here also described two types of techniques such as a (i) bulk driven technique and (ii) Gain boosting technique. Using different types and techniques and types to measure different parameter such as Gain, Gain Margin, Phase Margin CMRR, Power Consumption etc. And the simulated output measured by using 0.18µm or 180nm technology.*

Keywords*- Gain, Gain Margin, Phase Margin, CMRR, Power Consumption.*

I. INTRODUCTION

For any analog circuit speed power and accuracy most important function of Operational Transconductance Amplifier (OTA). OTA is a monolithic direct coupled differential voltage controlled current source. It is a one type of building block.OTA consists of two words "Operational" and "Transconductance". "Operational" refers that it takes the difference of two voltages as the input for the current conversion. "Transconductance" defined as the ratio of the output current over the input voltage.

The OTA is an amplifier whose differential input voltage produce an output current. So, its also called Voltage Controlled Current Source (VCCS). OTA is popular for Implemented Voltage Controlled Oscillator (VCO). It is widely used to realize linear and non linear analog signal processing technique. The circuit symbol of OTA is shown in Fig.[1].

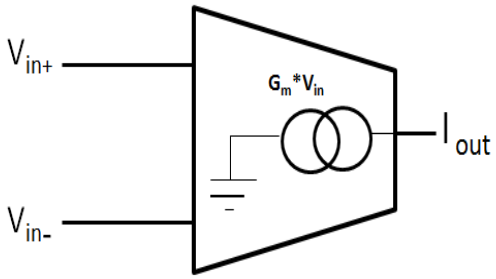

Fig.[1] Ideal OTA

The output current is measured by I_0

$I_0 = g_m (V_{in+} - V_{in-})$

$I_0 = g_m V_{in}$ Where, $V_{in} = (V_{in+} - V_{in-})$

The transconductance gain of an OTA is proportional to the amplifier bias current I_b is given by

$g_m = hI_b$ Where, h = proportionality function depends on temperature.

It is generally used in "open-loop"; without negative feedback in linear applications because the magnitude of the resistance tied to its output controls its output voltage V_0 Therefore a resistance can be chosen that hold on the output from going into the saturation region, even with high differential input voltages V_{in}.

II. DIFFERENT TYPES OF OTA

There are four types of OTA. All types of OTA are classified according to its operation.

A. Single-Stage OTA

B. Two-Stage OTA
C. Folded Cascode OTA
D. Telescopic OTA

A. Single-Stage OTA

According to the architecture of Single stage OTA, complexity is less compare to the others types of OTA. Here in this figure the Single stage OTA is present here as shown in Fig.[3]

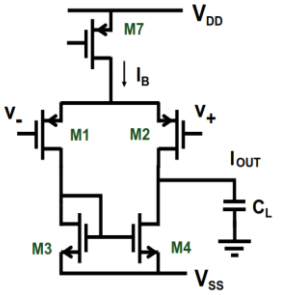

Fig.[2] Single Stage OTA [1]

As shown in Fig.[2] Transistors and are differential pair. And transistors and are current mirror. is biasing transistor.The drawback of Single stage OTA is lower gain due to the output impedance is low. But its leads to Unity Gain Bandwidth and high speed. It's also consuming lower power consumption. But drawback of this OTA is lower gain.

B. Two-Stage OTA

In this type, first stage consisting of P channel transistors and second stage consisting of N channel current mirror load improves transconductance and voltage swing respectively. Its schematic diagram is shown as Fig.[3].

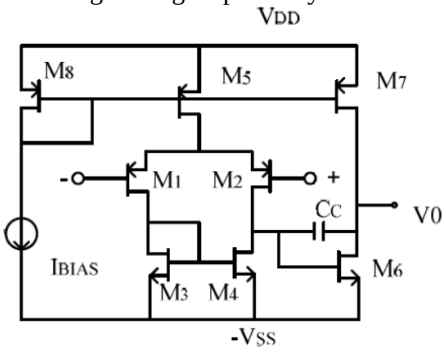

Fig.[3] Schematic of Two-Stage OTA [2]

So the voltage gain is denoted by A_v
$A_v = A_{v1} A_{v2}$ Where $Av1 = g_{m1} (r_{02} \| R_{04})$ and $Av2 = g_{m6} R_0$ .So, the overall voltage gain is a strong function of the early voltage and the overdrive.

C. Folded Cascode OTA

Here as shown in Fig.[3] the schematic diagram of Folded Cascode OTA. In this type OTA, in the first stage. In the first stage of folded Cascode OTA, there are four transistors at the output side to have high output resistance. All the transistors are working in the saturation region ($V_{(ds(sat))} \geq 0.1V$). A differential NMOS pair s are used as input. And in the second stage of OTA is in cascade with the first stage and its used to achieve higher gains while boosting the output swing voltage.

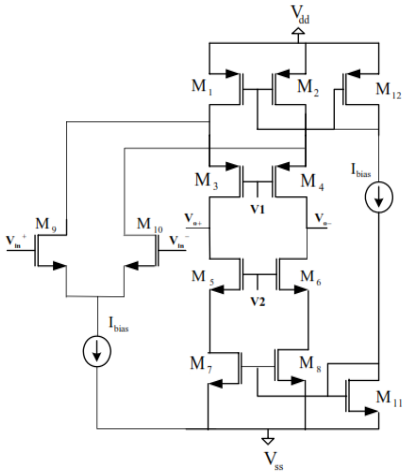

Fig.[4] Schematic of Folded Cascode OTA [3]

So the voltage gain is denoted by A_v
$A_v = (g_{m9}\, g_{m6}) / (\lambda^2_d\, (\lambda^2_n+\lambda^2_p))$ Where, λ_n, λp is channel length modulation.

D. Telescopic OTA

To increase the impedance, some transistor is added at the output using active load. All transistors are stacked on top each other. The connection of the single ended Telescopic OTA is "Cascode".

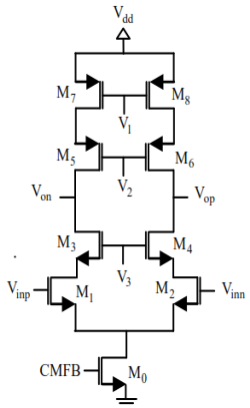

Fig.[5] Schematic of Telescopic OTA [4]

The single-stage telescopic OTA employs differential input pairs, Cascode devices and current source loads. The Cascode devices simply routes the current loads and Cascode devices will increase the output resistance. So the OTA gain increases. OTA is loaded with PMOS Cascode current sources.
$A_v = g_{m1}\, (g_{m3}\, r_{03}\, r_{01}) \,||\, (g_{m5}\, r_{05}\, r_{07})$.

III. TECHNIQUES OF OTA

There are two types of techniques of OTA**.**

- Bulk Driven Technique
- Gain Boosting

A. Bulk Driven Technique

In the Bulk Driven MOSFET, we have to apply input to the bulk terminal to create conduction channel inversion layer. The voltage between gate to source V_{GS} must be greater than the threshold voltage.

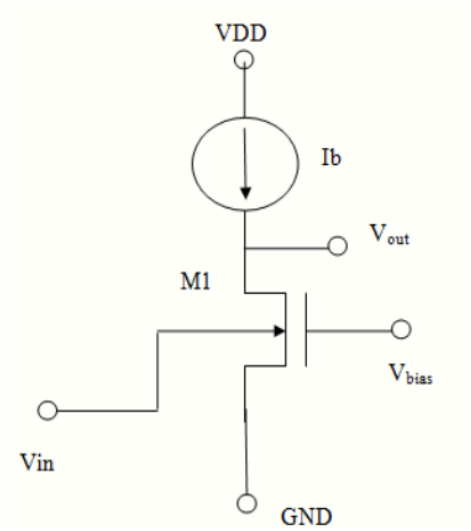

Fig.[6] Bulk Driven MOSFET OTA [5]

The favorable properties of the Bulk driven input stage do not come without their difficulties. Increasing the input common mode voltage V_{bs}, whether for the purposes of increasing the gain of the Op Amp, or simply to attain rail to rail input common mode, comes at the rate of power dissipation.

B. Gain Boosting Technique

The principle of this technique is to add a feedback amplifier to the Cascode device. It's inclined

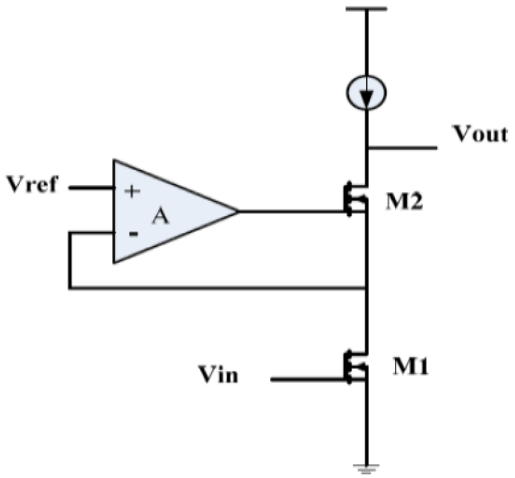

Fig.[7] Gain Booster MOSFET [6]

M1 and M2 form the main Cascode amplifier. A is a gain-boosted amplifier. A drives the gate of M2 and forces the voltage at the drain of M1 and Vref to be equal. Because of the gain-boosted amplifier, voltage variations at the output will affect the voltage at the drain of M1 to a lesser extent variations

Here in this paper comparison of different parameter using TSMC 180nm Technology according to its technology.

Table 1. Survey of various parameters of Operational Transconductance Amplifier

Authors	Publication Year	Technology Used	Parameters				
			Gain	Gain Margin	Phase margin	CMRR	Power Consumption
Sanjeev Sharma[7]	2013	130nm Technology	78.8 db	NA	55.09	NA	700µW
Hitesh Modi [8]	2013	TSMC 0.18µm	47.86db	15.40db	217.53	NA	1.3mW
Rekha S. and Laxminidhi T.[9]	2012	TSMC 0.18µm	44db	66db	45	NA	30µW
NEERAJ SHRIVASTAVA [10]	2012	UMC 0.18µm	81.7db	14.94db	48.49db	90db	62µW
Reetesh V. Golhar[11]	2012	Tanner 0.18µm	45db	NA	NA	NA	NA
A J Sowjanya.K [6]	2012	180nm Technology	45db	NA	180	NA	1.64mW
Seyed Javad Azhari [12]	2010	TSMC 0.18µm	42db	NA	NA	169db	250µW

IV. CONCLUSION

This paper described that there are four types of OTA and two techniques are there. Gain boosting techniques is more preferable to enhance gain. And the Folded Cascode OTA is higher gain and low power consumption. But it's complex structure compare to the Single-Stage and Two-Stage OTA.

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