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FinFET based Operational Transconductance Amplifier for Low Power Applications

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***Abstract*:** Design and simulation of novel operational transconductance amplifier (O.T.A.) based on SOI FinFET technology has been performed. The simulation results indicate that there is an increase in DC gain by 44.4%, C.M.R.R. by 1.5% , P.S.R.R. by 52.6%. The bandwidth of FinFET based O.T.A. is 161.301 MHz and CMOS O.T.A. is 1.00 MHz. The proposed circuit is designed using LTspice simulation at 1.5V supply Voltage. PTM 32 nm SOI FinFET has been employed for simulation. Comparative analysis of analog performance parameters of FinFET based O.T.A. and conventional CMOS based O.T.A. is also carried out.

Keywords: FinFET, CMOS, O.T.A., PTM, C.M.R.R., P.S.R.R., DC Gain.

I. INTRODUCTION

An O.T.A. is basically an op-amp without output buffer, so it can drive loads [1]. The design of CMOS based O.T.A. provides reduced power dissipation thereby increasing performance of the O.T.A. [2] , however scaling of conventional CMOS processes poses challenges such as short channel effects and other performance issues [3]. Therefore, use of conventional CMOS based O.T.A. at nanoscale causes big performance issues.

Fin type Field Effect Transistor (FinFET) has been recognized as a hopeful device, as it enables additional gate length scaling due to its superior immunity to short channel effect by making the channel controlled by gate from more than one side[4].

In this paper, OTA is designed at 32 nm SOI FinFET technology for analog applications . O.T.A. circuit serves as the fundamental building block for various complex circuits. Therefore this circuit has been chosen to find the variety of analog performance parameters such as DC gain, Common Mode Rejection Ratio (C.M.R.R.), Power Supply Rejection Ratio (P.S.R.R.) and Bandwidth.

Paper is divided into six sections. In section 2, brief overview of O.T.A. has been given. In section 3 proposed FinFET based O.T.A. has been discussed. In section 4 results and discussion have been provided. Finally, section 5 has concluded the paper.

II. OPERATIONAL TRANSCONDUCTANCE AMPLIFIER

Operational transconductance Amplifier (O.T.A.) is like OP-AMP in a lot of aspects. Only difference is the O.T.A. circuit uses an outside bias current Ibias, which is accountable for its flexibility and tunability. It adds new aspect to design and application of O.T.A. circuit, Fig. 1 demonstrates the symbol of an O.T.A.. The O.T.A. is generally expressed in by transconductance and not by voltage gain. The equation for the output current is [5-10]:-

$$I_{out} = g_m (V_{id})$$

Where, gm is transconductance and Vid is the differential input voltage.

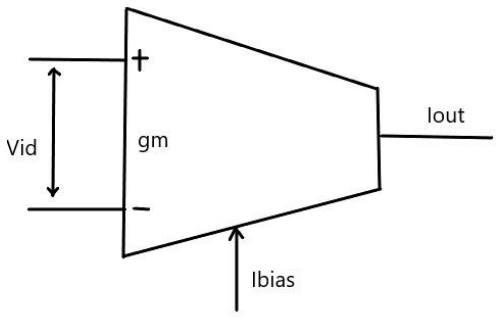

Fig 1. Symbol of O.T.A.

2.1 Design of Conventional CMOS based O.T.A.

The circuit of CMOS used in this study based on O.T.A. is shown in Fig. 2.

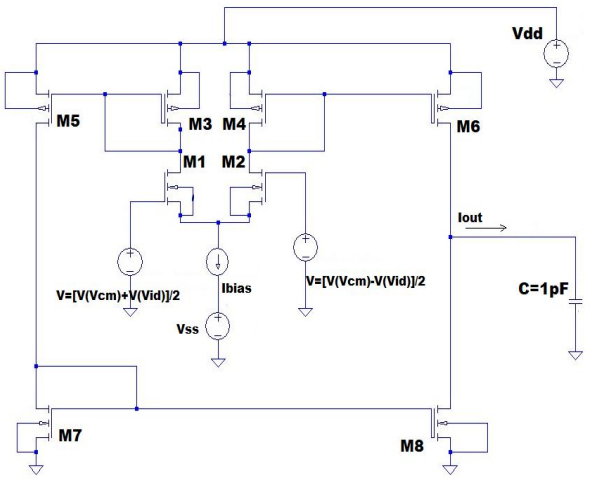

Fig 2. Conventional CMOS based O.T.A

III. PROSPOSED FINFET BASED O.T.A.

In this proposed work, SOI FinFET based O.T.A. circuit has been designed and compared with bulk CMOS based O.T.A. Fig 2 gives bulk CMOS based O.T.A.. The O.T.As are designed at 32 nm by LTspice software. Fig 3 demonstrates proposed SOI with short gate FinFET based O.T.A. at supply voltage of 1.5V. It uses n channel SOI FinFET as sinks and p-channel SOI FinFET as sources. The differential input Vid is applied into the two gate terminals of transistors M1 and M2. These transistors M1 and M2 are two n-channel SOI FinFET transistors used to produce an output current for a differential input Vid. The proposed circuit has vide scope in the field of IoT and smart electronic gadgets [11-12].

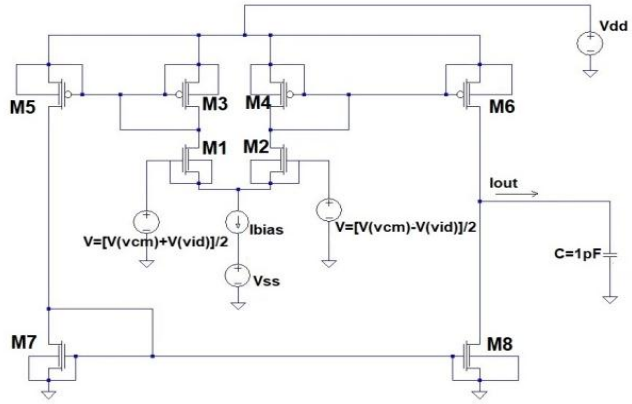

Fig 3. Proposed FinFET based O.T.A.

IV. RESULTS AND DISCUSSION

In this work, a relative study has been done between bulk CMOS based O.T.A. and FinFET based O.T.A.. Analog performance parameters such as DC gain, Power Supply Rejection Ration, Common Mode Rejection Ratio and bandwidth have been studied. The use of FinFET based O.T.A. improves performance measuring parameters particularly. Fig 4 demonstrates DC gain using CMOS based O.T.A. and Fig 5 demonstrates DC gain using FinFET based O.T.A. FinFET based O.T.A. increases the DC gain. Fig 6 demonstrates P.S.R.R. of CMOS based O.T.A. and Fig 7 demonstrates FinFET based O.T.A. FinFET based O.T.A. demonstrates more P.S.R.R. in comparison with CMOS based O.T.A.. Fig 8. demonstrates C.M.R.R. of CMOS based O.T.A. and Fig 9 demonstrates FinFET based O.T.A.. It is observed that C.M.R.R. of FinFET based O.T.A. is better than C.M.R.R. of CMOS based O.T.A.. Also, the bandwidth of FinFET based O.T.A. is better than the bandwidth of CMOS based O.T.A..

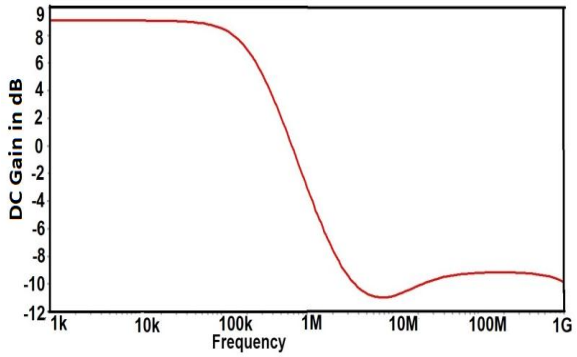

Fig 4. DC Gain of CMOS based O.T.A.

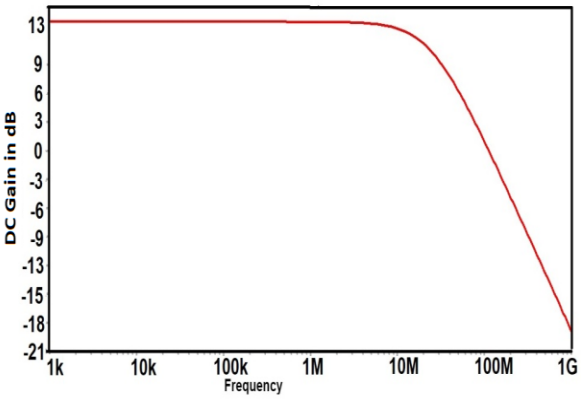

Fig 5. DC Gain of Proposed FinFET based O.T.A.

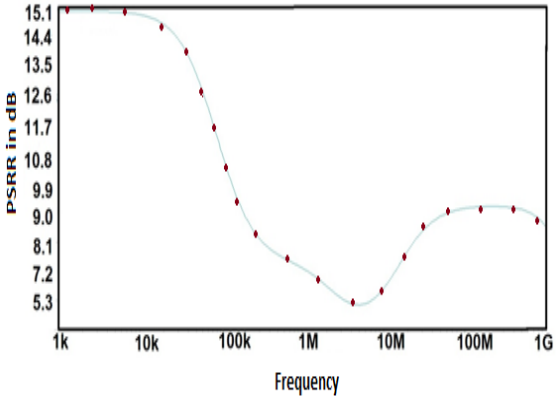

Fig 6. P.S.R.R. of CMOS based O.T.A.

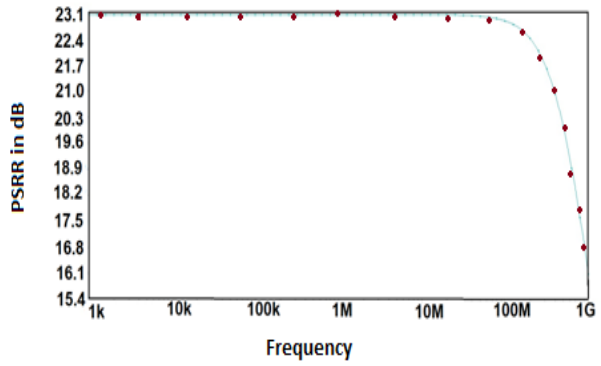

Fig. 7. P.S.R.R. of Proposed FinFET based O.T.A.

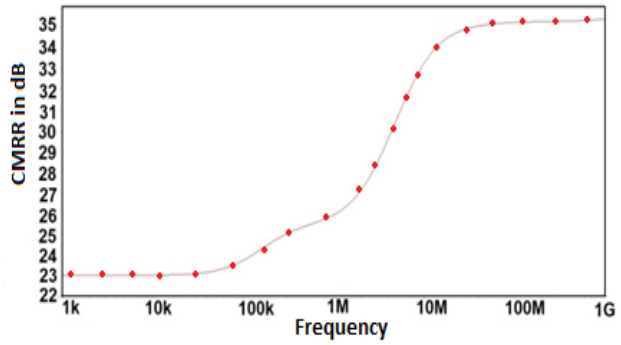

Fig 8. C.M.R.R. of CMOS based O.T.A.

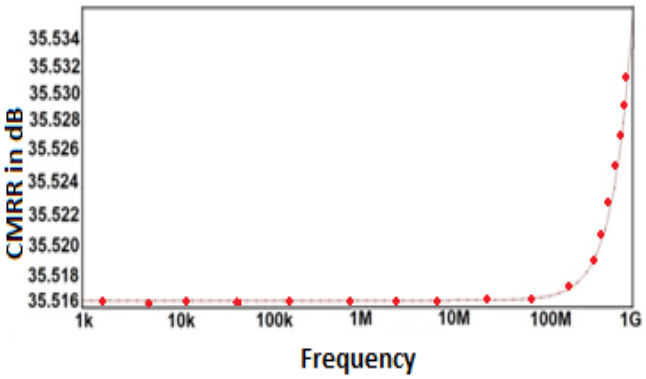

Fig 9. C.M.R.R. of Proposed FinFET based O.T.A.

Table 1. Comparison of CMOS based O.T.A. and Proposed FinFET based O.T.A.

Serial No.	Parameter	CMOS (O.T.A.)	FinFET (O.T.A.)
1.	DC Gain in dB	9 dB	13 dB
2.	P.S.R.R. in dB	15.14 dB	23.1 dB
3.	C.M.R.R. in dB	35 dB	35.534 dB
4.	Bandwidth	1.00MHz	161.3MHz
5.	Compensating Capacitance in pF	1 pF	1 pF

V. CONCLUSION

The work presents design and simulation of CMOS based O.T.A. and SOI FinFET based O.T.A. at 32 nm technology node. The simulation results show that there is an increase in DC gain by 44.4%, C.M.R.R. by 1.5%, P.S.R.R. by 52.6%, and bandwidth of FinFET based O.T.A. is 161.301 MHz. it is revealed that the use of FinFET based O.T.A. exhibit better performance in comparison to conventional CMOS based O.T.A. The proposed SOI FinFET based O.T.A. can be used for analog nanoelectronic circuits.

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