Design of O.T.A. For Low Power Applications Using 32nm FinFET Technology

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Abstract- *The Operational Transconductance Amplifier based circuits offer advantages of simplicity in design, lower component count, reliable, high frequency performance and wide range electronic tenability over conventional op-amp based circuits.. In this paper we design the O.T.A based on 32nm SOI FinFET technology. FinFET has the many advantages compared to the MOSFET'S like it provides better retention characteristics that reduces the short channel effects and also provides better control over current flow, provides better scalability and low power consumption. We have studied some of the most important characteristics such as common mode rejection ratio (C.M.R.R), current gain and bandwidth were calculated and the respective characteristics are compared with the traditional CMOS based Operational Transconductance Amplifier. The designed Operational Transconductance Amplifier circuit is tested in a SPICE simulation .Comparative analysis of analog performance parameters of FinFET based O.T.A and conventional CMOS based O.T.A is also carried out .Our implementation demonstrates that utilization of FinFET increases the gain by 46.2% and common mode rejection ratio by 1.8%.The proposed operational transconductance amplifier has very wide scope in the field of IOT and in wide variety of smart electronic gadgets..*

Keywords- SOI FinFET, CMOS, O.T.A., VCCS, C.M.R.R

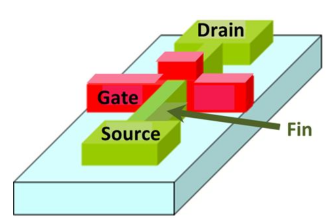
I. INTRODUCTION

An O.T.A. is a voltage controlled current source, further basically it is an op-amp without output buffer, so it can drive loads. The design of CMOS based O.T.A. provides reduced power dissipation thereby increasing performance of the O.T.A. however scaling of conventional CMOS causes various performance issues which degrades the performance of conventional CMOS based O.T.A. at nano scale. Fin type Field Effect Transistor (FinFET) has been recognized as a hopeful device that reduces short channel effect. In this paper, Operational Transconductance Amplifier is designed at 32 nm Silicon on Insulator FinFET technology for various analog applications .as the fundamental building block for various complex circuits. Therefore this circuit has been chosen to find the variety of analog performance parameters like Common Mode Rejection Ratio, DC gain, Power Supply Rejection Ratio and Bandwidth. This Paper is divided into total six sections. In section II, brief overview of FinFET has been given. In section III brief overview of O.T.A is given. In section IV proposed FinFET based O.T.A. has been discussed. In section V results and discussion have been provided. Finally, section VI has concluded the paper.

II. FinFET TECHNOLOGY

In 2011 Intel surprised the semiconductor industry by introducing a three dimensional transistor structure which intel calls Tri-Gate,but is more commonly referred to in industry as FinFET's.

FinFET transistor technology is going to extend the Moore's law beyond sub-28-32nm process tecghnology mode. The FinFET structure is similar to the DELTA except for the presence of dielectric layer called the "hard mask" on top of the silicon fin.The hard mask is used to prevent the formation of parasitic inversion channels at the top corners of the device..Basically we have SOI FinFET and Bulk FinFET. In SOI FinFET there is a BOX (Buried Oxide layer) coming in between active region and p-substrate. Where as in The bulk FinFET Fin gets directly connected with the substrate this FinFET is made on bulk silicon instead of an SOI wafer.Fins are etched on a bulk silicon wafer and trimmed using an oxidation step. The main advantages of FinFET's are it provides better retention characteristics which reduces short channel effects, it also provides better control over current flow, provides better scalability and low power consumption.



FinFET structure

III. OPERATIONAL TRANSCONDUCTANCE AMPLIFIER

The operational transconductance amplifiers has extra bias control terminal which provides electronic tenability through bias control current I_b to the O.T.A based realizations due to this feature it is mainly responsible for the inherent tenability associated with the O.T.A and provides greater flexibility in the design of active circuits. Operational transconductunance amplifier is a monolithic direct coupled differential voltage controlled current source .There is a feedback connection to control it's overall performance. The characteristics of OTA are similar to those of an conventional operational amplifier except that O.T.A has very high output impedance .Because of this the output signal is given in terms of current which is proportional to the differential input voltage.Thus O.T.A is best described in terms of transconductance gain rather than it's voltage gain. The O.T.A can also be conveniently be made to work as DVCVS by simply incorporating additional buffer stage. The monolithic O.T.A's can be classified as Bipolar O.T.A'S and MOS O.T.A'S. The O.T.A based circuits offer advantages of simplicity in design, lower component count, reliable, high frequency performance and wide range electronic tenability over conventional op-amp based circuits. The ideal transfer characteristic is given below in equations (1) and (2).

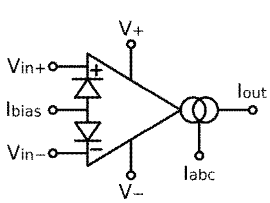
$$I_{out} = g_m (V_+ - V_-) \quad ……(1)$$

$$I_{out} = g_m.V_{in} \,……………..(2)$$

Where gm is the transconductance,

V_+ and V_- are input voltages of OTA.

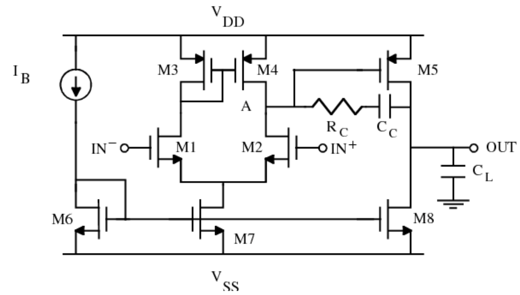
Scematic symol of OTA is shown in the below figure



OTA symbol

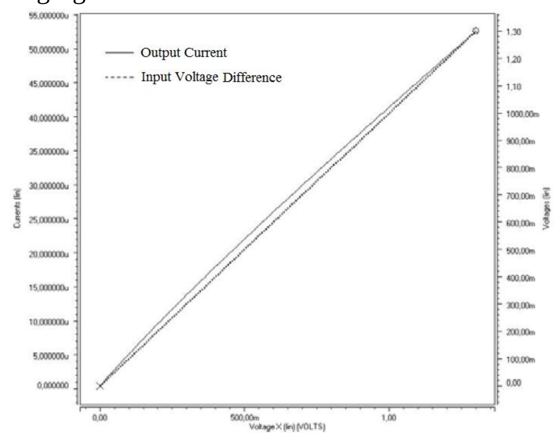
A. Design of Conventional CMOS based O.T.A

The circuit of CMOS used in this study based on O.T.A. is shown in Fig.3



Conventional CMOS based O.T.A

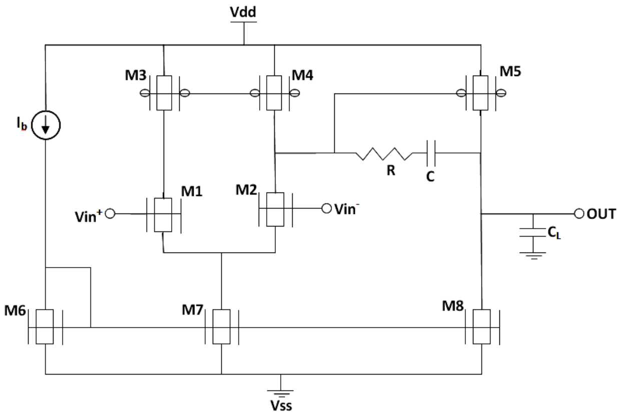
Characteristics graph of such O.T.A are shown in the following figure.4



Output current vs. input voltage difference graph

IV. PROSPOSED FINFET BASED O.T.A.

In this FinFET based Operational Transconductance Amplifier circuit has been designed shown in Fig.5 and simulated using spice software and the simulation results are compared with conventional CMOS based O.T.A. shown in Fig. 3 .Fig 5 shows 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 V_{id} is applied to the two gate terminals of M1 and M2 transistors. These transistors are two n-channel SOI FinFET transistors used to produce an output current for a differential input V_{id}. The proposed circuit has wide scope in field of IOT.



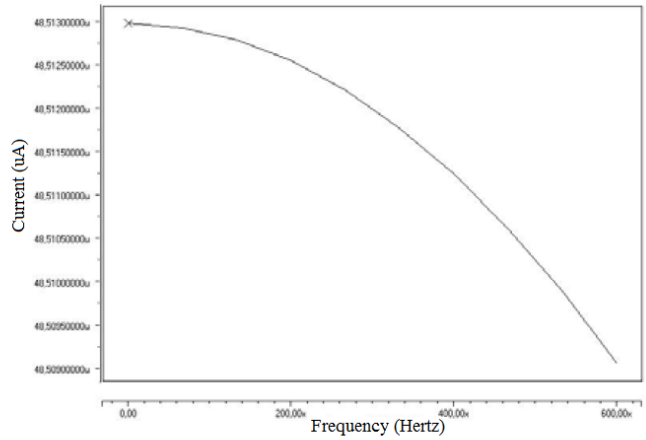
FinFET based O.T.A.

V. RESULT AND DISCUSSION

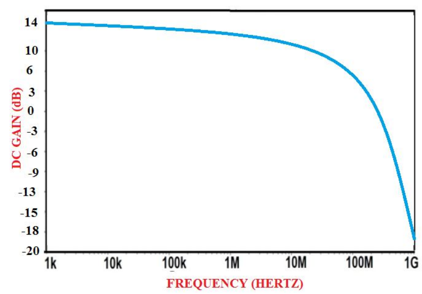
In this work, a comparative study has been done between conventional CMOS based O.T.A. and FinFET based O.T.A. relative performance parameters like Common Mode Rejection Ratio, bandwidth and D.C gain have been studied. The use of FinFET based O.T.A. improves performance measuring parameters. Particularly. Table 1 illustrates comparision between observed CMOS and FinFET paparametes, Fig 4 demonstrates Output current vs. input voltage difference graph using CMOS based O.T.A. and Fig 5 demonstrates proposed FinFET using O.T.A. Fig.6 demonstrates frequency response of CMOS based O.T.A. Fig.7 demonstrates frequency response of FinFET 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.

Table 1: Observed CMOS and FinFET parameters

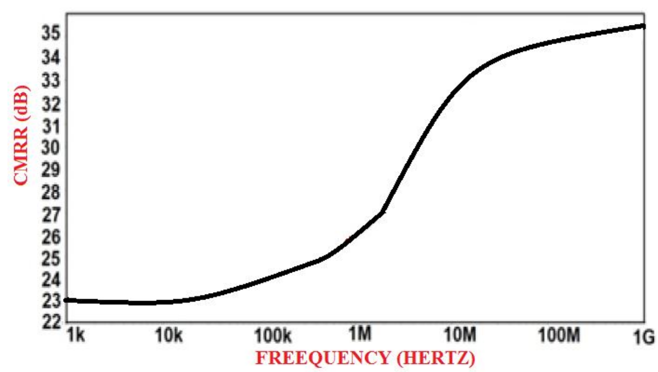
Parameter	CMOS	FInFET
D.C gain in (dB)	9.5	13.9
C.M.R.R in (dB)	35	35.65
Bandwidth	1MHz	163.34MHz
Compensating capacitance	1pF	1pF



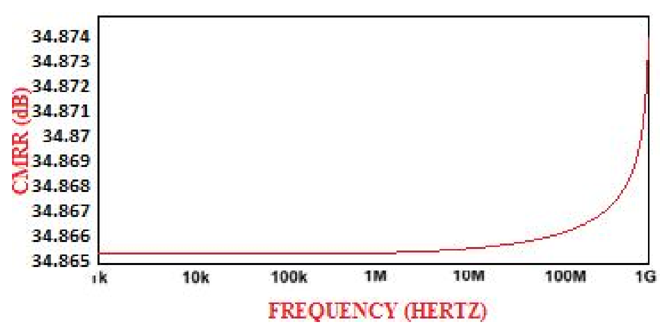
DC gain of cmos based OTA



DC gain of FinFET based O.T.A.



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



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

VI. 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 gain by 46.2%, C.M.R.R. by 1.8 % and bandwidth of FinFET based O.T.A. is 163.34 MHz. also the current study proves that the SOI FinFET technology can be easily replace the circuits of conventional MOS technology in low power applications. The proposed SOI FinFET based O.T.A. can be used for analog nano-electronic circuits. Further this study can be extended for reducing the noise interference considering low pass filter at the input of differential amplifier.

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