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Design of low Transconductance OTA for Biopotential Signal Acquisition System

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ABSTRACT:This paper presents the Design of low transconductance Operational Transconductance Amplifier (OTA) in 0.25µm CMOS technology. For bio-potential signal which is very weak in amplitude and very low in frequency. To capture this signal a OTA with transconductance in nanoSimens for Gm-C application required. with recent year the MOS technology is placing in to nanometer. The design of OTA in this work is the current division and current cancellation technique(CDCC). This technique is suitable for the amplifier with low transconductance for Gm-C application. The proposed technique makes use of the current which conventionally goes to ground, through a parallel path. The OTA is important building block for various analog circuit and systems. The OTA work in weak inversion mode with bais current of 0.31µA. PMOS transistor used in OTA to avoid the flicker noise .the simulated trans-conductance of this OTA in 0.25 µm technology is 15nS. The proposed OTA achieved the 26.3 dB dc gain and unity gain bandwidth product of 600 Hz while driving 15pF capacitive load. The OTA is designed in 0.25µm CMOS process using T-SPICEsimulator. The power consumption is 37 µW.

KEYWORDS*:* OTA, Transconductance, Tanner EDA tool 15.0,T-SPICE,Weak inversion region, CDCC.

I.INTRODUCTION

Tremendous research is going on, in the field of biomedical for enhancing the quality of biopotential acquisition systems which became a challenging task for the scientists. Bioamplifier circuit is a crucial part of this system which is being used for amplification of biopotential signals that are generated due to electrochemical activities inside the cells. Biopotential signals are of different types depending upon the types of cells or tissues from which they are generated. Electroencephalogram(EEG), Electrocardiogram(EKG), Electromyogram(EMG) signals are generated due to the neural activities inside the brain, pumping activities of the heart and skeletal muscles activities respectively. All biopotentialsignals like ECG, EMG, EEG are generated due to action potential occurs in body cells. Biopotential signals are having amplitudes in the range of microvolts or millivolts with low frequency rangeThe electroencephalogram (EEG) is a unique and valuable measure of the brain's electrical function. It is a graphic display of a difference in voltages from two sites of brain function recorded over time. Electroencephalography (EEG) involves the study of recording these electrical signals that are generated by thebrain.Human brain consist of four bands of waves:

1.delta waves 1-4 Hz

2.theta waves 4-8Hz

3.alpha waves 8-12 Hz

4.beta wave 13-40Hz

This type of signal is very low in range.it is generally in range of 2 to 200uvolt .this signal need to be acquired under noisy environment.so we have to design filter which is used for capturing this signal and reject unwanted high frequency noise component.The use of very large scale integration(VLSI) technique is open the door of miniaturization and portability of such system. With the VLSI technique we design a system which is easy to use, lightweight ,low powerand also a low cost Operational Transconductance amplifiers (OTAs) is that type of amplifier in which output is current and input is voltage.it is different from opamp in which output is voltage. OTA is basically a

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voltage controlled current source. OTA is very useful building block in analog electronic design.It is used to design filter based on Gm-C technique, switch capacitor technique and current conveyor technique. OTA is very important building blocks for various analog circuits and it is used in wide range of consumer electronics devices, industrial and scientific. Depending on system needs, an OTA must satisfy many design requirements. OTA with its low transconductance feature used to design low frequency filter ,which is important to capture the biological signal which is very weak in amplitude and low in frequency. to build a filter for biopotential signal transconductance of OTA in n S range required.OTA used here for Gm-C application is employ both current cancelation and current division to achieve low transconductance . low frequency application flicker noise become dominant factor,which is overcome by using PMOS transistor. to achieve a transconductance in nano Siemens range OTA must operate in sub-threshold region on weak inversion region . weak inversion means OTA in a subthreshold region with a drain current in nano ampere. this OTA uses a Gm block along with a capacitor to realize a Gm-C filter. This filter is used to capture the EEG or ECG signal which is weak in amplitude and low in frequency. infect the EEG signal which consist of four wave of brain alpha ,beta ,gamma and theta can be recovered with the low frequency Gm-C filter. We can built filter component like register, inductor with a Gm cell of OTA.OTA is better than opamp in term of performance and linearity.

II.LITERATURE SURVEY

Author [1] present the 5^{th} order low pass filter for high speed wireless system the filter use 10 identical OTA for their design .Linearity of OTA enhanced byusing a current division and source degeneration method. The OTA tuned by using 5 bit current DAC for achieving trans-conductance variation. Differential cascade OTA with common mode feedback circuit is used to fix the DC voltage level of output. The circuit is implemented in 90nm technology and mentor Graphics tool is used.

Author [2] describe the OTA in three different region that is strong inversion, weak inversion and moderate inversion region. A folded cascode structure of OTA is used. Here the Gm/ID technique id used to design OTA.

Author [3] describe a bulk driven OTA for GM-C application. an ultra-low Power result is obtained using a bulk driven OTA. This circuit is worked in 350nm technology.to design a OTA composite NMOS transistor is used.

Author [4] describe A OTA application in Tunable GM-C filter for wireless sensor network based on bulk driven OTA. Double differential structure of OTA is used. A common mode feedback circuit is used in circuit to remove the disadvantage of double differential pair.

Author [5] proposed a continuous time notch filter based on current steering technique. A second order notch filter consist of unity gain inverter and two alpha block. The circuit is implemented in SMIC mixed signal 0.18um 1P6M process.current steering technique improve the linearity and noise with the cost of increase area and power dissipation. The circuit is having a centre frequency tunabilty.

Author [6] describe a low pass power notch filter by using OTA-C structure. The filter circuit is simplified by using signal flow graph. It also apply unitary theory to design a elliptical filter. OTAcan also tuned to transconductance variation. A 2.5nS Gm is achieved and with the help of OTA-C technique the fifth order elliptical filter is designed provide.

Author [7] proposed 5^{th} order low pass notch filter which is designed from low trans-conductance OTA. Filter use in EEG system which capture the wave from 1 hz to 40hz of human brain. Low pass notch filter serve the two purpose a low pass to remove high frequency component and notch filter to remove power line interference. A low trans-conductance is achieved by implying the current division and current cancellation technique.it also apply OTA-C technique in comparison to switch capacitor technique . The OTA circuit can also tuned by voltage to provide variation in Gm.

Author [8] proposed an Operational trans-conductance Amplifier architecture (OTA) with wide tuning range for low frequency applications. OTA uses a current division scheme to reduce trans-conductance(Gm) which is suitable for low frequency application .this OTA uses common mode feedback circuit(CMFB). The CMFB reducescommon mode offset generated due to mismatch between transistor. The OTA also employ the PMOS instead of NMOS in order to reduce flicker noise component. Gm of OTA in range 0.05 to 5nS is achieved by tuning of voltage from 5mvolt to 500mvolt.fourth order band pass filter is design by using Gm of 1nS and capacitor is realized by impedance scaling technique.

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Author [9] demonstrateda low frequency filter using CMOS OTA operating in the sub threshold region. A band pass filter design which is used to pass waves of brain in range1-4 Hz ,4-8Hz,8-12Hz,13-40Hz is design with different Gm value and load capacitance.

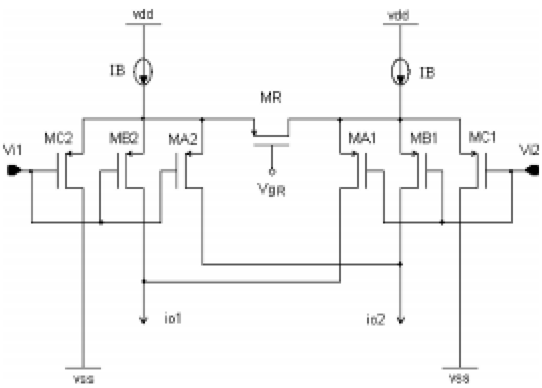
Author [10] describes a sixth order low pass filter for medical applications. The filter design uses low trans-conductance operational amplifier (OTA).this OTA use current division and current cancellation technique to achieve low trans-conductance value. The filter design use a OTA-C technique. This technique avoid The pre and post filtering required by switched capacitor technique moreover it is continuous time technique which avoid the noise switching problem. In this work, a grounded capacitor is designed by using scalar impedance technique.

III.OTA DESIGN CONSIDERATION

For acquisition of biopotential signal which is very low in frequency a filter with a cutoff frequency in a range 50-200 hz required . the filter pole frequency is given by following equation.

$$f = Gm/ 2\pi \cdot C \qquad (1)$$

where f is a pole frequency of filter ,Gm is transconductace of OTA & C is capacitor at the output of OTA.so it is clear that to design a filter in 50-200 Hz frequency range we require a tranconductance in nanoSiemens range if we assume a load capacitance of 15 pf.To achieve low transconductance current division and current cancellation(CDCC) topology of OTA is selected.current division and current cancellation technique is shown in figure(1) In this topology transcondutance at the output is given by (2)



Figure(1) Schematic of CDCC technique

$$GmOTA = io1\text{-}io2/Vi1\text{-}Vi2 \qquad (2)$$

In CDCC technique area of MC transistor is make larger then MB AND MA Transistor so that less current appear at output with the help of this technique we can supress the noise component at output of OTA .MR transistor is used to increase linearity of OTA.

MPUE: In this attack, the objective is to obstruct the DSA process of SUs- i.e., prevent SUs from detecting and using vacant licensed spectrum bands, causing denial of service.

Using the Trust-Worthy algorithm it defines a threshold value to the SUs to overcome the PUE attacks. It enables CR-Networks nodes to efficiently utilize the available spectrum channels. Nodes, which can easily find various licensed channel opportunities without interfering the primary system increases. This reveals that it has a potential to be able to convert the various network conditions into a performance improvement.

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III.PROPOSED OTA

To achieve a low transconductance we employ current division and current cancellation topology of OTA. currentdivision refer to divide the total drain current of PMOS_9 transistor by greater aspect ratio of PMOS_1 & PMOS_2 transistor so that less current goes to output through the PMOS_4 transistor . Less current appear in output result in reduced transconductance .In this circuit aspect ratio of PMOS_1, PMOS_2is 9 times greater than PMOS_4 transistor result in huge reduction in transconductance value. Now a current cancellation is achieved by using PMOS_3 ,NMOS_1and NMOS_3 transistor so that the magnitude of output current reduced by opposite polarity of drain current of NMOS_3 transistor result in reduced output current at the output .the aspect ratio of PMOS_3 little greater than the PMOS_4 transistor. OTA operate in weak inversion region with a bias current of 310nAto achieve transconductance in nano Siemens range. At low frequency application flicker noise become a dominant one which is reduced by using PMOS transistor instead of NMOS. Noise contribution of PMOS_1,PMOS_2,PMOS_7,PMOS_8 at output is reduced by current division technique transistor. PMOS_12 & PMOS_13 transistor is used to increase linearity of OTA. The proposed OTA is shown in figure(2)

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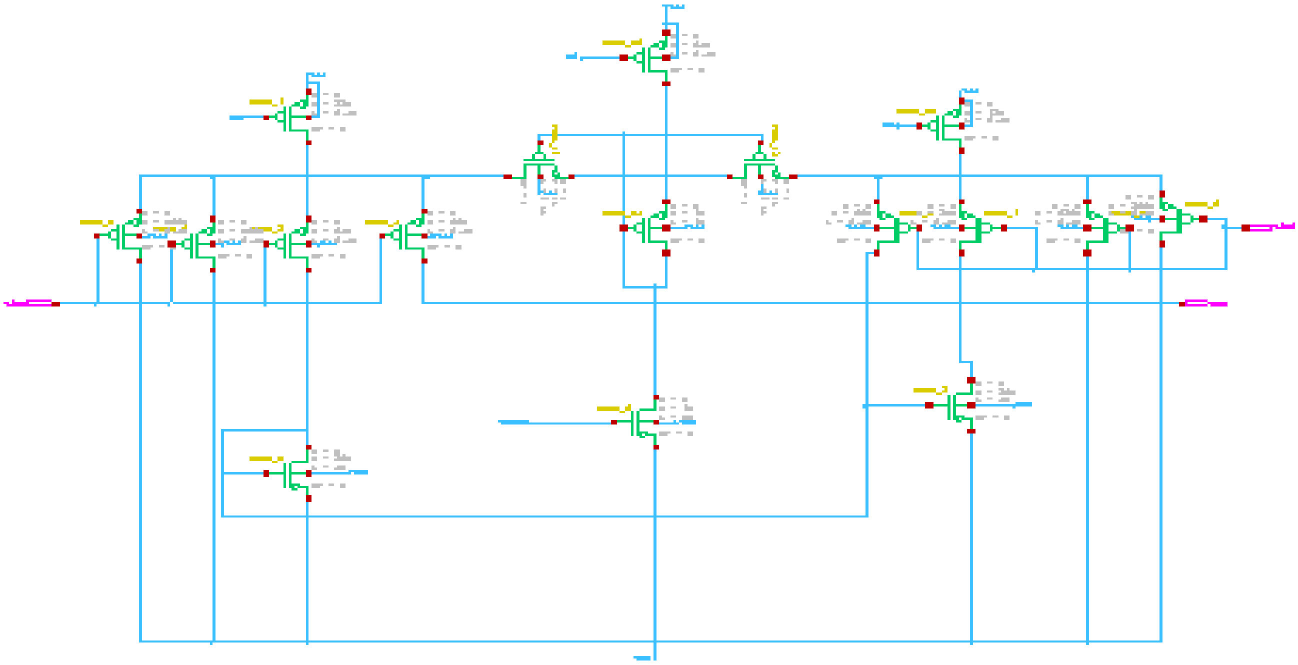

Figure(2) Proposed OTA using current division and current cancellation technique

IV. RESULT AND DISCUSSION

We have performed simulations of purposed OTA in T-SPICE simulator of Tanner 15.0 EDA tool in 250nm technology. Circuit biased with simple PMOS current mirror with a biased current 310nA. The aspect ratio required to operate OTA in weak inversion region in given in table I and different parameter summarized in table II. Gain phase transcondutance& noisespectral density of OTA is shown in figure (3) figure(4) and figure (5) .

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Table 1 Aspect ratio of proposed OTA

Device	Dimensions W/L (μm /μm)
PMOS_1	180/0.5
PMOS_2	180/0.5
PMOS_3	25/0.5
PMOS_4	20/0.5
PMOS_5 & PMOS_6	22/0.5, 31/0.5
PMOS_7	230/0.5
PMOS_8	300/0.5
PMOS_9	33/0.5
PMOS_10	85/0.5
PMOS_11	33/0.5
PMOS_12	1/0.5
PMOS_13	1/0.5
PMOS_14	6/6
NMOS_1	30/5
NMOS_2	9/2
NMOS_3	30/5

Table II show the different parameter of OTA

Parameter	Value
DC Gain (dB)@10Hz	26.36
Unity Gain bandwidth (Hz)	600
3dB cutoff frequency (Hz)	40
Phase margin	88^0
Bais current(n A)	310
CMRR(dB)	60
Equivalent input noise @VoltageSource_1(μV)	2.73
Transfer function value(unit less)	20.50
Gain bandwidth product(kHz)	15.82
Current consumption (μA)	14.89
Power consumption(μW)	37
Total output noise (μV/ $\sqrt{Hz}$.)	56
Load capacitance (pF)	15
Supply voltage (V)	2.5

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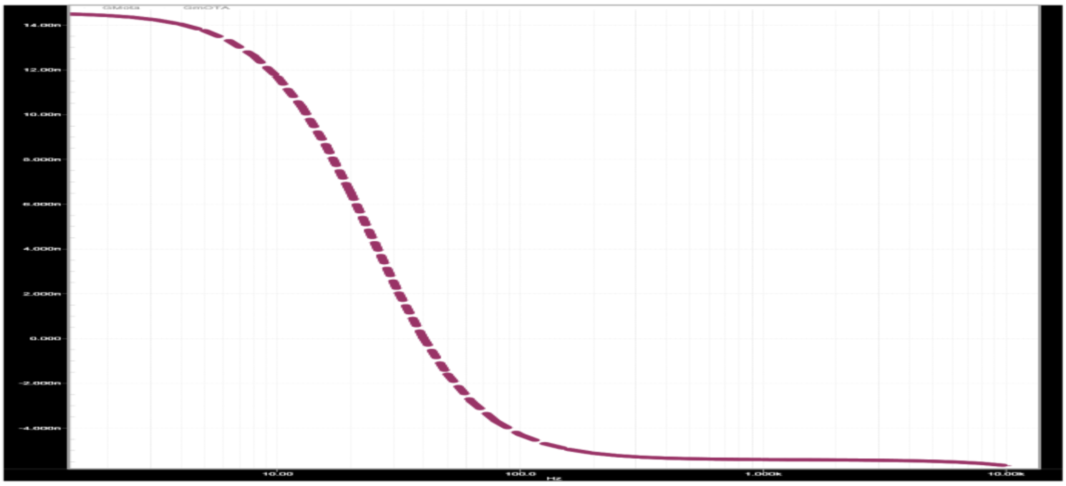
Figure (3) Gain and phase of OTA is the OTA gain is 26.36 dB and phase margin of 88^0



Figure(4) transcondutnce of OTA by using Current division current cancellation technique

figure(4) shows the transconductance of OTA is 15nS achieved by CDCC technique. Which is further utilized for low frequency filter.

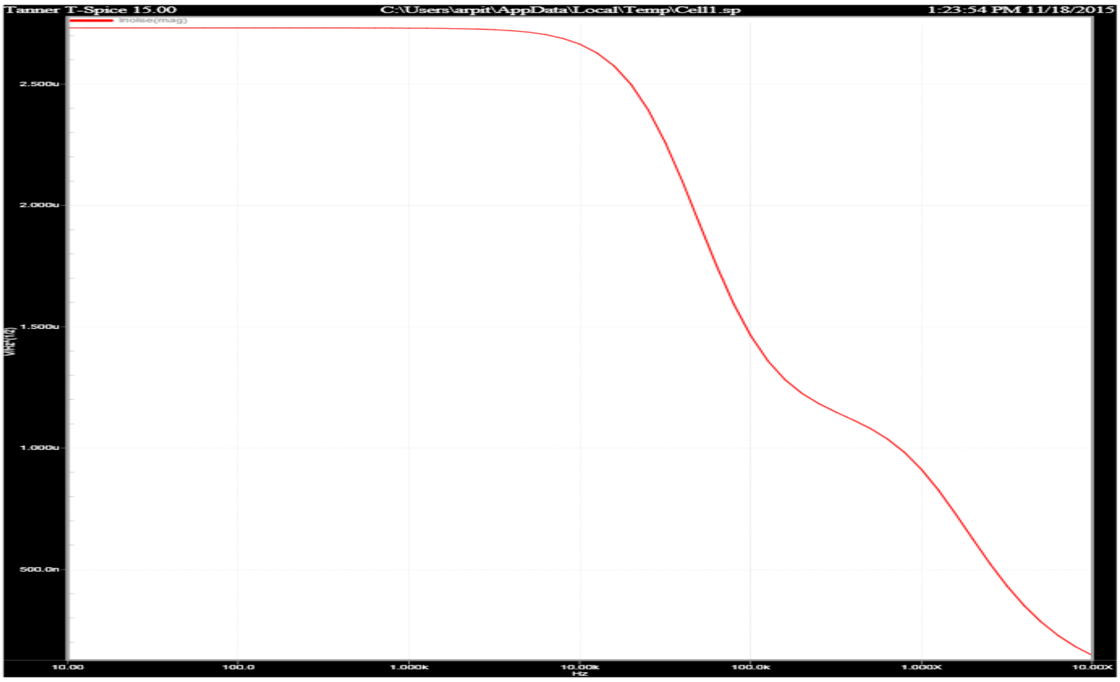


Figure (5)noise spectral density in µ V/$\sqrt{Hz}$ is

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V. CONCLUSION

For acquisition of biopotential signal ,we have successfully design low transconductance OTA. Simulation result show the transconductane of 15nS .With the small transconductance we further design higher order filter with Gm-C technique.We can also increase the order of filter by using more Gm cell.OTA presented here biased with simple PMOS current mirror circuit with a bias current of 310nA.This OTA worked in weak inversion region for low frequency application.

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BIOGRAPHY

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