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OPERATIONAL TRANSCONDUCTANCE AMPLIFIER FOR BIOMEDICAL EMG APPLICATION USING CMOS 90nm TECHNOLOGY

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Abstract- The universe of biomedical gadgets is growing quickly with new activities and new innovations. As of now biomedical gadgets are fabricated with countless capacities, exactness, precision, minimization and usability. In portable biomedical devices, power consumption has become a serious problem due to battery life. The operational transconductance amplifier is a mostly used analog processing block. In recent years, the development of OTA with very low conductivity, low power, low voltage and improved linearity has been mainly used in biomedical applications. In this paper present a novel OTA design for biomedical EMG application with operating frequency of this application is 150Hz. The proposed design is simulated using CMOS 90nm environment with power supply of VDD is 0.35V and VSS is -0.35V.
Keywords: OTA, EMG, Biomedical Device, Low Power, CMOS Environment.

1. INTRODUCTION

Due to the rapid and numerous developments of microelectronics in recent years, more and more applications require a very small amplitude signal measuring module, for example, implantable devices in biomedical applications [1]. Monitoring various biomedical signals of the human body is a very interesting topic, because it helps to reveal important information about human health from the collected data. Doctors use this data to diagnose diseases [2]. Biomedical signals such as electrocardiogram (ECG), electromyogram (EMG), electroencephalogram (EEG) [3]. The implementation of the low-frequency design is not easy to design, since the Gm value requirement is in the nA / V range, and the capacitor value is greater than 100pF. Many foundries cannot provide a capacitor value of more than 50 pF, also due to the large area of a large-scale condenser, which cannot be easily realized. Another problem with low nA / V steepness is worsened by noise, distortion, and imperfection [4].

2. BIOMEDICAL SIGNAL PROCESSING SYSTEM

Biomedical signs are perceptions of the physiological exercises of living beings, going from the succession of qualities and proteins, to nerve and cardiovascular rhythms, to tissue and organ pictures. The reason for biomedical sign handling is to separate significant data from biomedical signs. With the assistance of biomedical sign handling, scholars can find new science and specialists can handle different sicknesses. A typical biomedical signal processing system is shown in Fig. 2.1. Analog processing blocks are the most important part of biomedical systems. In this preamplifier and filter are the two most important analog processing blocks. Since the biomedical signal operates at a very low frequency, low pass filter is most commonly used for biomedical signal processing. OTA is one of the most important blocks for filter design [5].

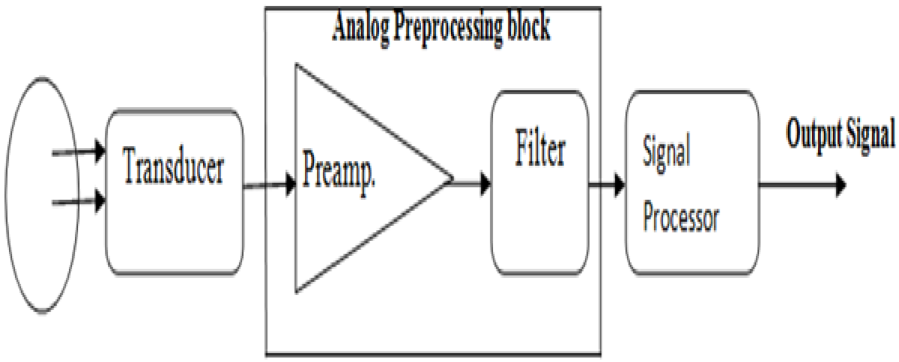

Fig. 2.1 General Purpose Biomedical System Block Diagram

The preamplifier amplifies the input signal to a higher level with very low noise and distortion. In an electrocardiograph application (ECG application) where the amplitude of a preamplifier signal is processed by a low-pass filter at a rate of about 100 mV, the high efficiency of biomedical filters or ultra short frequency filters is a CMOS technology [6].

Table-2.1 Most Commonly Used Frequency for Biomedical Signals [7]

Signal	Frequency
ECG (Electrocardiography)	250Hz
EEG (Electroencephalography)	200Hz
EMG (Electromyography)	150Hz
ERG (Electroretinography)	100Hz

3. OPERATION TRANSCONDUCTANCE AMPLIFIER (OTA)

OTA an amplifier whose differential input voltage generates an output current [7]. Therefore, it is the voltage control current source. Normally, a current input for controlling the current conversion of the amplifier is added. The OTA has a high impedance input phase and is similar to a standard op amp in that it can be used for negative feedback [8]. Gilbert Multiplier cell is utilized as OTA which is recently utilized in immersion area as a multiplier, yet in sub limit locale its transconductance is characterized by tanh geometrical personality and in this plan OTA is work on the sub edge district [9].

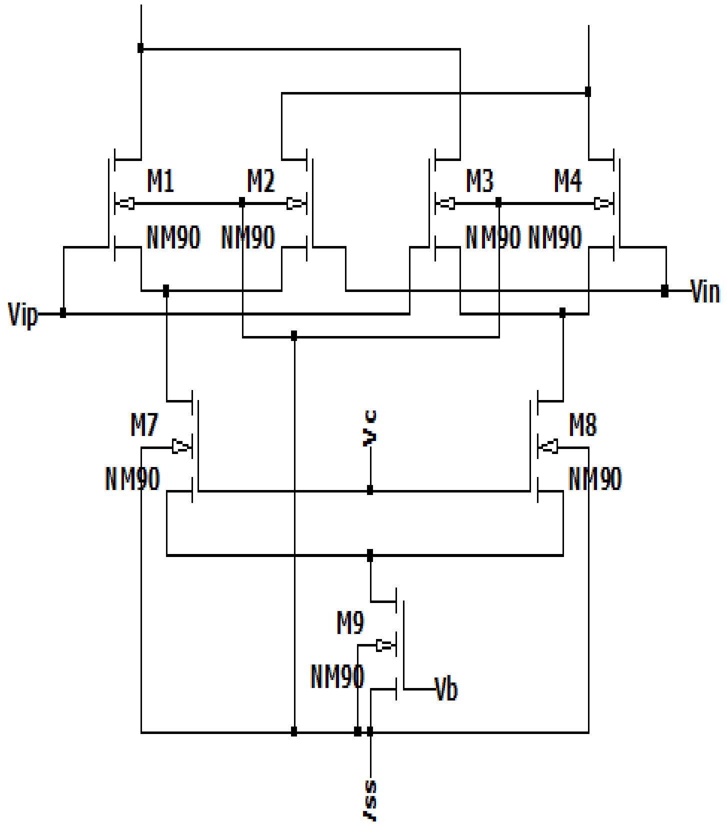

Fig 2: Multi-tanh Doublet Linearity Technique

To increase the linear range of the circuit, the multi-tanh doublet technique is used.

In the figure 2, the differential pair represented by sets M1 – M2 & M3 – M4 shown a voltage offset with the same absolute value but in opposite direction of transfer characteristics. I_1, I_2, I_3 and I_4 are the current of transistors M_1, M_2, M_3 and M_4 respectively.

$$I_1 - I_2 = I_B \tanh\left[\frac{V_{in} + V_{oS}}{2n\emptyset_t}\right] \quad (1)$$

And

$$I_3 - I_4 = I_B \tanh\left[\frac{V_{in} - V_{oS}}{2n\emptyset_t}\right] \quad (2)$$

The output current of this circuit is given by:

$$I_{out} = (I_1 - I_2) + (I_3 - I_4) \quad (3)$$

Now, from using the eq. (1) and eq. (2) the final output current of the circuit is

$$I_{out} = I_B\{\tanh\left[\frac{V_{in} + V_{oS}}{2n\emptyset_t}\right] + \tanh\left[\frac{V_{in} - V_{oS}}{2n\emptyset_t}\right]\} \quad (4)$$

Using this technique we increase the linearity of the circuit and also the power consumption of the circuit is very low using this technique.

4. PROPOSED DESIGN AND SIMULTION

The proposed OTA design for biomedical ECG application is shown in the fig. 4.1. This OTA is design using CMOS 90nm environment with supply voltage VDD = +0.35V and VSS = -0.35V.

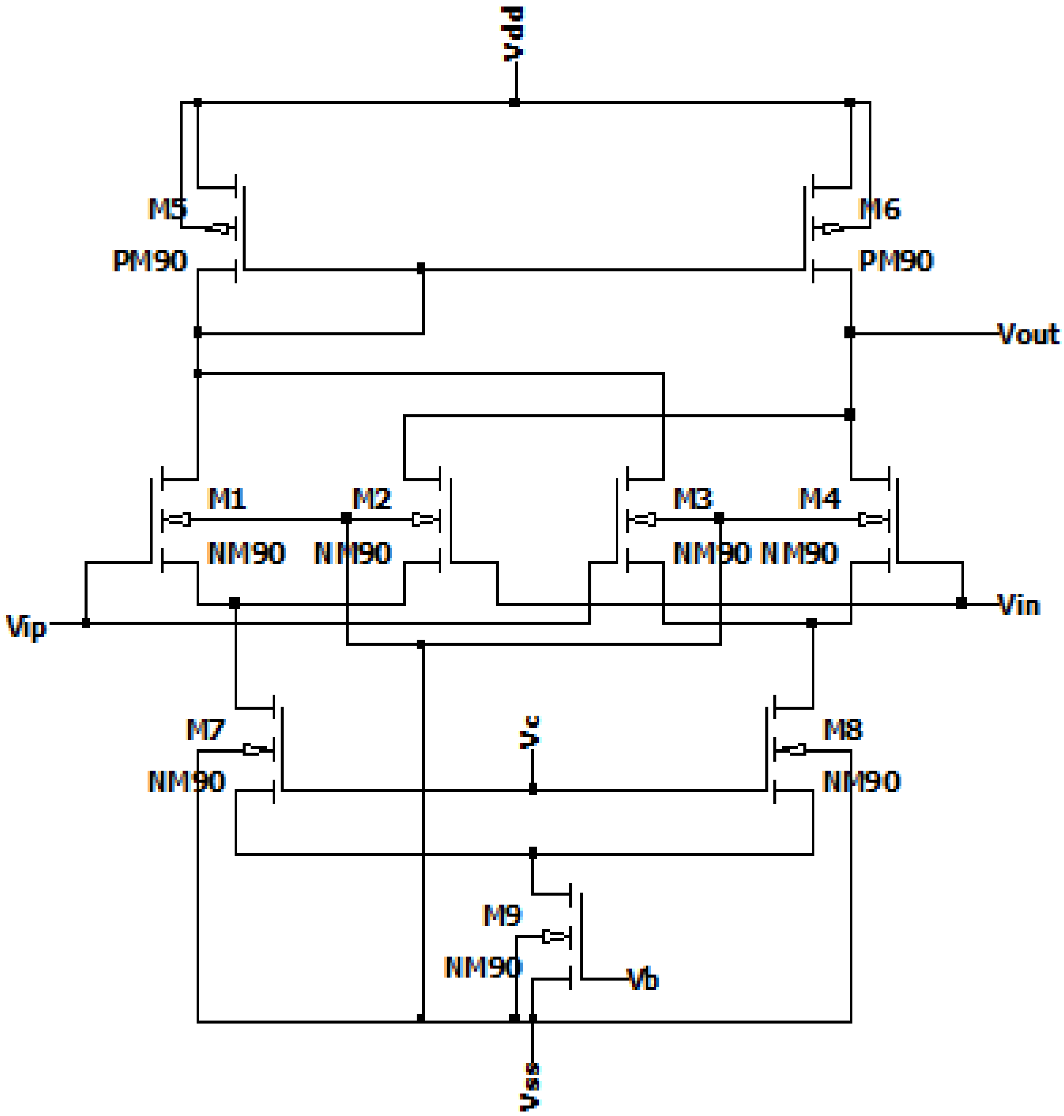

Fig. 4.1 Proposed OTA design for EMG application

The fig. 4.2 shown the output current from each input transistor (M1, M2, M3 and M4) of OTA for EMG Application and in figure 5 shown the overall output current of the proposed OTA for EMG application.

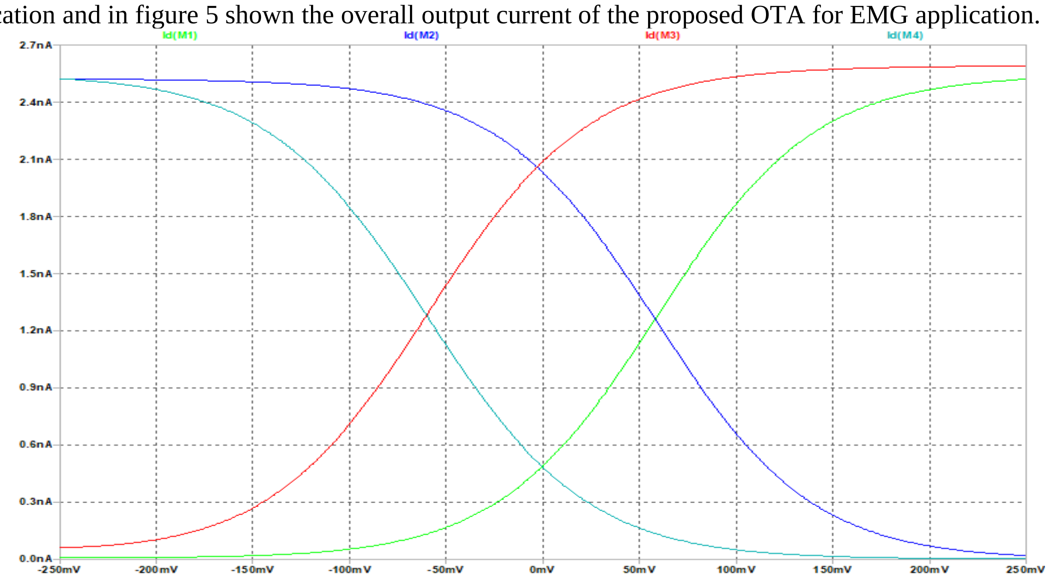

Fig. 4.2 Output Current of Each Input Transistor in Proposed OTA for EMG Application

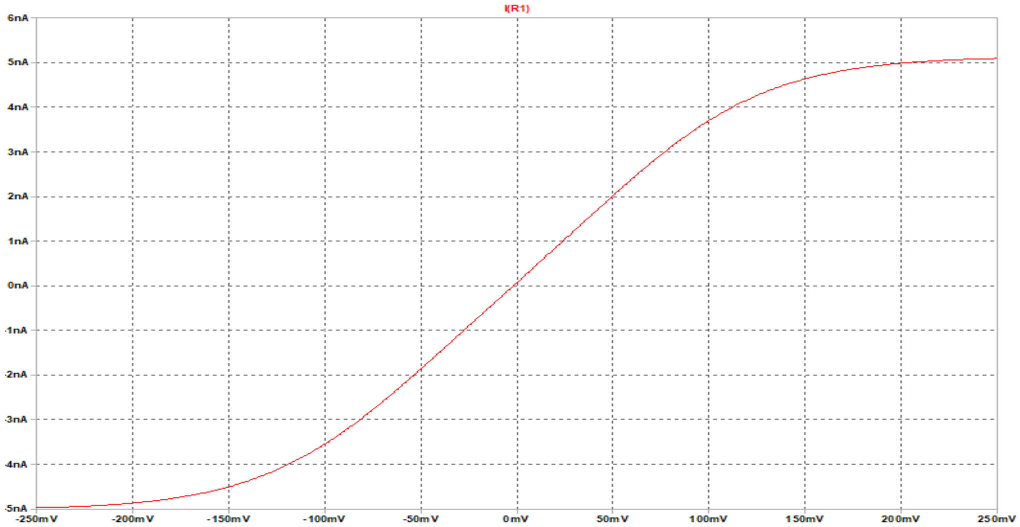

Fig. 4.3 Overall Output Current of OTA for Electromyography (EMG) Application

The overall transconductance response of the proposed OTA is shown in the Fig. 4.4. The overall transconductance for the EMG application is obtained 38.64 nS. The frequency response of the proposed OTA with control voltage Vc = -0.155V is obtained 150Hz that is used for the biomedical EMG application. The frequency response of proposed OTA for EMG application is shown in the Figure 7. The power consumption of the OTA for EMG application is obtained 4.15nW.

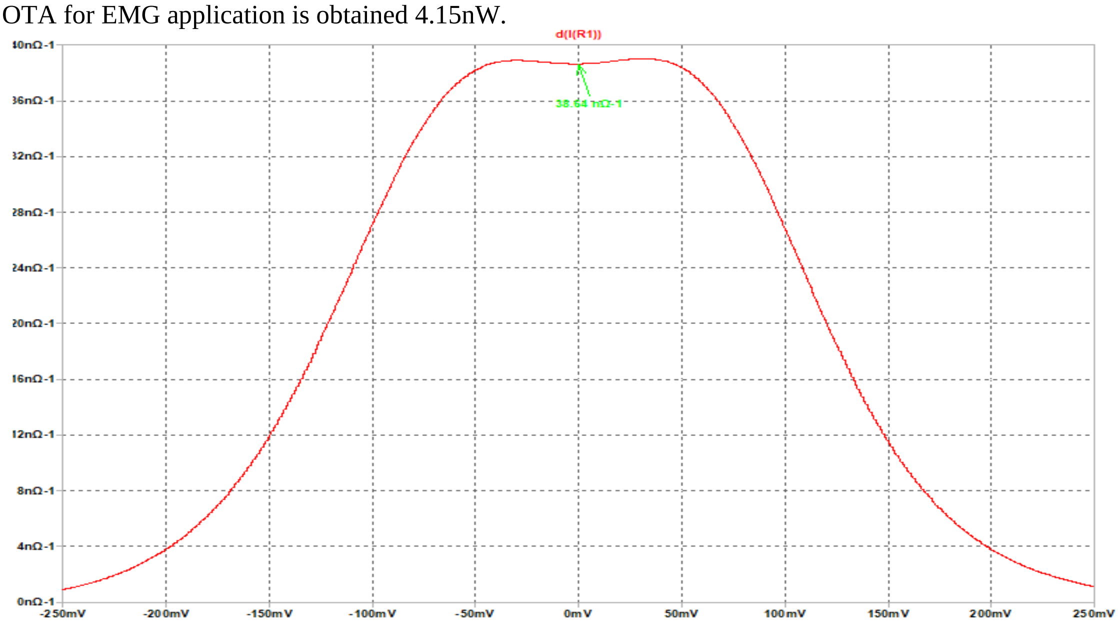

Fig. 4.4 Overall Transconductance of OTA for EMG Application

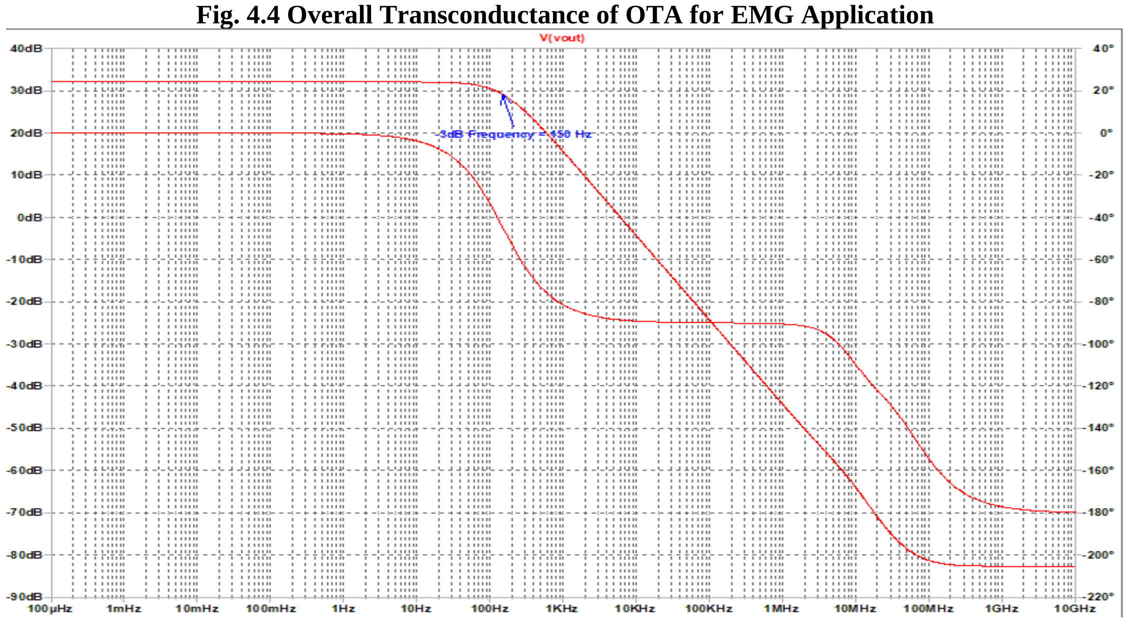

Fig 7: Frequency Response of OTA for Biomedical EMG Application

The complete summary of the proposed OTA design for biomedical EMG application is shown in the table 4.1.

Table-4.1 Summary of OTA Design for Biomedical EMG Application

Parameters	Value
CMOS Environment	90nm
Voltage Supply	±0.35V
Consumption of Power	4.15 nW
Total Current	9.98 nA
Gm	38.64 nS
Vc	-0.155 V
Application	EMG
Tuning Method	By varying Vc

CONCLUSION

In this paper present a novel OTA design for biomedical EMG application with operating frequency of this application is 150Hz. The proposed design is simulated using CMOS 90nm environment with power supply of VDD is 0.35V and VSS is -0.35V. In proposed OTA the value of the control voltage Vc = -0.155V is used for the biomedical EMG application. In this application the transconductance of the proposed OTA is 38.64 nS, frequency response of the OTA is 150Hz and the power consumption of the proposed OTA is 4.15nW.

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