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Low Power High Gain Amplifier for Low Voltage Wearable Bio Medical Applications

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Abstract: In this paper, A High Gain Low Power Operational Amplifier was designed in main for the usage of in biomedical applications. The amplifier is designed to produce high gain with less power consumption. Switched bias is used to further reduce noise levels by making the inputs. It is used to reduction of noise with less power, thus helps in low power usage in reduction of noise. This amplifier is intended to amplify neural spikes which are in low amplitudes(mV) and in frequency range of about 5-100Hz. Main purpose of the implantable integrated circuits is to measure the neural signals like AP's (Action potentials) and LFP's (Local field potentials). The simulations are carried under different temperatures for 25*, 36.9* (body temperature) and 40*.

Keywords: Biomedical, CMRR, Flicker Noise, Telescopic Amplifier, Switched Bias, Tanner

I. INTRODUCTION

There is a serious study in past years about the biomedical implantable integrated circuits. The main purpose of this system is to process the bio-signals and send to the analysis section for the more functionality purposes. The analysis of the external system to monitor the results and map the necessary outputs. Considering a patient with problem diagnosed by biological signals like electrocardiogram (ECG), electromyogram(EMG) and Electroencephalogram (EEG) there are sensors or Implants take continuous data from the patient and send to external monitoring system for timely monitoring of patient condition and quick diagnosis Effective collection of neural signals helps not only to diagnosis this neural disorders but also with the help of Bio-engineering and Neuroprosthetics impaired body parts can also be restored giving new life to the people. First stage of this system will be a High Gain Amplifier to amplify these potentials obtained from sensor array implemented in brain. If they amplifier should need to characteristic of high gain and less noise margin, low power and high CMRR.A neural signal amplifier is the most important part in the brain machine interface. The signals recorded from the external part of the brain are very weak typically between 10 to few hundred μV. in order to process these signals amplification is needed. Future requirements may demand for implantable recording system requiring large number of neural amplifiers. [1]. Main purpose of the implantable integrated circuits is to measure the neural signals like AP's (Action potentials) and LFP's (Local field potentials) helps many neurological analysis and Neuroprosthetics. Reading accurate results of this neural potentials helps to diagnosis of many neural disorders like Parkinson's disease and ALS (Amyotrophi Lateral Sclerosis) [2]. Typical neural signal recordings have low signal-to-noise ratio because of the low amplitude of the signals and the high noise due to distant neurons activity. Thus, selective filtering and good detection algorithms are needed to extract all the possible information from the recordings [3] [4]. Also, the lower input common mode and the flicker noise made it a main choice for

Low frequency and low voltage circuits. [5]. low voltage operation is desirable as most portable biomedical monitoring systems operate under battery power. The major challenge of designing such IAs in standard CMOS processes is the flicker noise [6]. Examples of low-power applications that can benefit from the reduced supply voltage include portable products, biomedical and sensor implementations, hearing-aid devices, and energy harvesting system [7].For such applications, ultralow-power operation is very important to minimize heat dissipation in the brain, preserve long-battery life, and maximize the time between

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recharges. To get clean neural signal recordings, it is important that the input-referred noise of the amplifier be kept low. [13][14]. for such applications, ultralow-power operation is very important to minimize heat dissipation in the brain, preserve long-battery life, and maximize the time between recharges [15].

II. TELESCOPIC CASCADED AMPLIFIER

Although Telescopic operational - amplifier has smaller swing, which means reduced dynamic range, this is offset somewhat by the lower noise factor. The above reason implies that the Telescopic op-amp is a better candidate for low power, low noise single stage Operational Tran conductance Amplifier. The single stage architecture normally suggests low power consumption.

Advantages:

1. The design under consideration combines the low power, high-speed advantage of the Telescopic architecture with the high Swing capability of the Folded Cascode and the Two Stage Design.

2. It achieves its high performance while maintaining High Common mode and supply rejection and ensuring constant performance parameters.

Disadvantages:

Telescopic op-amp is severely limited output swing. It is smaller than that of Folded Cascode because the tail transistor directly cuts into output swing from both sides of the operational amplifier.

$$\overline{V_n^2}=4KT\left(2\frac{3}{3gm1,2}+2\frac{2gm7,8}{3gm2\ 1,2}+2\frac{Kp}{(Wl)7,8\ C8}\frac{gm\ 7,8}{gm\ 1,2}\right)$$ (Telescopic amplifier)

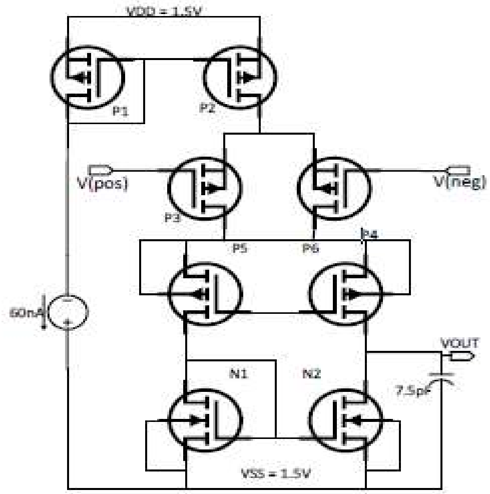

Fig 1: Telescopic amplifier

Based on all the following features the differential Telescopic architecture is proposed to satisfy all requirements. Preferring this architecture topology based on many factors such as

Power to noise trade off:

Telescopic amplifier consists of the dual arms causing less power utilization than other amplifier models such as folded cascade and two stage amplifiers

High Gain:

As using the Telescopic amplifier with differential. Inputs we obviously expect the gain to be more than other operational amplifiers.

Stability concerns:

The transistor count is always a main factor to be Considered regarding stability issues, here we use lesser transistor count in building amplifier causing less stability issues.

Output swing:

Telescopic amplifier has drawback of low output swing due to the transistors stack but the design was to deal with low amplitude signals so these signals will be in range of required output level.

III. DESIGN OF TELESCOPIC AMPLIFIER

In the telescopic amplifier, the preserve of low output swing is being introduced spontaneous which is the main drawback, in order to overcome this switch is introduced in which noise get reduced.

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The basic Model amplifier have been designed.the total input power density E_n^2 given by

$$E_n^2 = T_n + F_n$$

$$T_n = \frac{8KT\gamma}{gm(i)} + 8KT\gamma\left(\frac{gm(l)}{gm(i)}\right)$$

$$F_n = \frac{2Kp6^1/f}{CoxWiLif} + \frac{2kn^1/f}{CoxWiLif}\left(\frac{gm(C1)}{gm(Ci)}\right)\text{^}2$$

In the equation T_n is thermal noise and F_n is Flicker noise, The Value $\gamma = 2/3$ for strong inversion and weak inversion 1/2k (k=0.7).$K_p^{1/f}$,$K_l^{1/f}$ In above equations I is refer to the input section L is refer to the load section so i=1and L=5

$$E_n^2 \sim \frac{8Kt\gamma}{gmP3} + \frac{2Kp^1/f}{CoxWp3Lp3f}$$

IV. BIASING TECHNIQUE

There are two techniques are used in this paper, due to overcome the noise.

Auto zeroing:

Auto-zero amplifiers use a secondary auxiliary amplifier to correct the input offset voltage of a main amplifier.

Chopper stabilization:

A chopper circuit is used to refer to numerous types of electronic switching devices and circuits used in power control and signal applications

Switched Biasing Technique:

Here Switched biasing technique reduces the flicker noise directly. The theory and model was taken from the work. First of all, let's understand flicker noise and its characteristics. Thus switched bias applied for to eradicate noise by this problem. A switch model was designed in this work used for the reduction of noise but this won't affect any parameters of calculation as this applied to just input transistors of the amplifier as we know that only input transistors cause flicker noise.

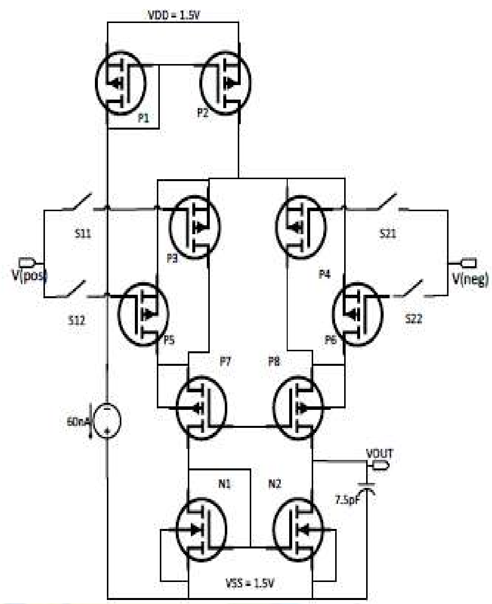

Fig 2: Switched Base Model

These are techniques used to reduce the noise and increasing the gain of amplifier.

V. PROPOSED MODEL

The gain of the amplifier may be increased to about 85db.wilson current mirror has introduced. It is the mandatory to improve the gain of the amplifier without disturbing the CMRR. If CMRR is decreased, then higher gain amplifier will be subjected to the common mode distortion and the output provided will not be as expected. In the second stage amplifier Wilson current mirror is taken into consideration as it increases the high gain. As the current mirror produced low input impedance and high output impedance.

Hence for the betterment of the amplifier next stage of amplifier is demonstrated to improve gain and CMRR of the bias model.

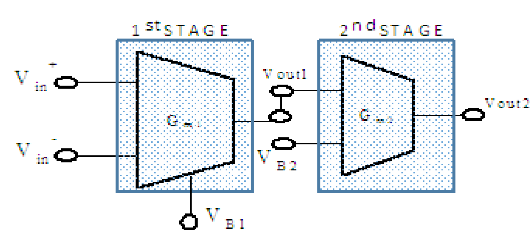

Fig.3: Block diagram of proposed amplifier

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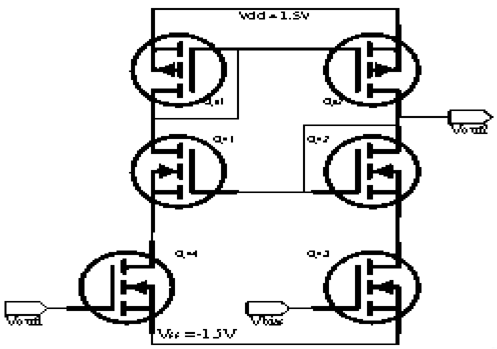

Fig. 4: Designed Second Stage Amplifier

Fig (4): shows the proposed model of the amplifier with 2stages first stage is switched bias operational amplifier and second stage is common source with current mirror amplifier. Thus the proposed amplifier was two stage amplifiers with high gain and less power utilization.

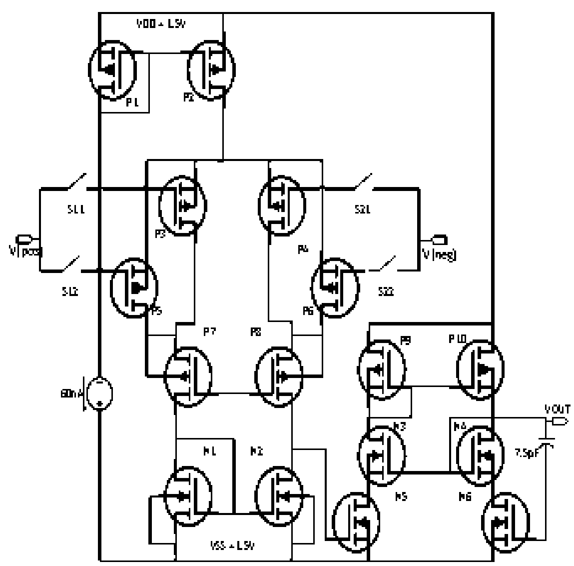

Figure 5: Final design of proposed amplifier.

VI. Simulation And Results

The based telescopic amplifier in 90nm can be designed in TANNER software. By using this software various parameters can be analysed. The transient analysis of 90nm outputs are shown in Fig.1

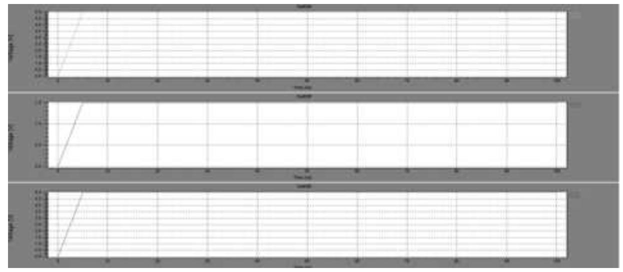

Fig. 6: Base Telescopic amplifier

VII. Simulation Profile

Transient/Fourier Analysis:

The Fourier analysis is used to the find out the output.

Stop Time 100n
Maximum Time Step 0.001
List of Temperatures 36.9

Table I: Transient Fourier analysis

AC Analysis:

AC analysis is used to predict the frequency.

Start Frequency 1
Stop Frequency 10meg
Number of Frequencies 100
Sweep Type: dec

Table II: AC analysis

Temperature Sweep:

Temperature sweep is in turn used to predict the temperature in an respective manner.

List_of_Temperatures 25, 36.9, 40

VIII. Results Of Proposed Amplifier

Table III: Results of proposed amplifier

Parameter	**Design**
Temperature	36.9
Supply Voltage	±0.5V
Power	0.13µW

IX. Layout Design Of Proposed Model

Using the micro wind we have layout design of the amplifier. The layout designed will be equal to the design built in S-Edit top analyses.

X. Conclusion

We proposed a high gain low power amplifier dedicated to the biomedical applications. Here model implement two stage amplification technique first stage is for noise reduction and second stage for gain improvement still that can be achieved with low power usage. Low power directly says low heat dissipation from circuit helps to implant as bio amplifier for neural recordings.

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