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Ultra Low Frequency Wide Band Low Pass Active Filter for Bio-Medical Applications Simulated on Cadence tool

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ABSTRACT

An ultra low frequency wide band low pass active filter is designed and simulated on 180nm cadence virtuoso tool for biomedical applications in this paper. This proposed designed low pass active filter is being able to stop low frequency signal of µHz and can pass up to Hz using the CMOS nanotechnology. This is a second order low pass active filter. It can be useful to identify the human disease by detecting ultra low frequency bio-signal. The simulated result shows ultra low power consumption of 200pW with high bandwidth at 1mV input supply.

KEYWORDS: *Low Noise CMOS Amplifier, Active Filter, Biomedical Applications.*

I. INTRODUCTION

In the Bio-Medical applications, day to day the use of ultra low supply voltage for integrated circuits is the major issue and increasing the demand for high reliable with low power consumption implantable portable electronic system. These implantable portable devices are very necessary to detect and monitor neuromuscular activities in the human body. It can also be used to know the vital information about the human health with acquired data to diagnose different type of diseases [1],[2]. Biomedical signal has very low frequency signal range at least mHz to Hz. Hence biomedical implantable devices have required low power consuming low noise pre-amplifiers and filters. Bio-frequency low pass filters are play the major role in any biomedical communication system. The commonly used bio signal based acquisition system is shown in following "fig-1".

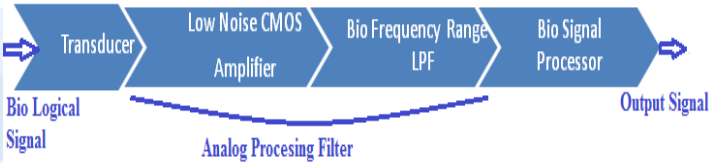

Fig-1 Block Diagram of Bio-Signal Based Acquisition System accompany your final submission.

Biomedical Signals are Electro cardiogram (ECG), Electro encephalogram (EEG), and Electromyogram (EMG). These bio-signals have a low amplitude and low frequency signal. So firstly to be amplified by low noise CMOS amplifiers and then filtered using bio frequency range low pass active filter for further processing [3]. It has been widely emerging to fulfill the demand of portable medical devices. The significance for the designing

of ultra low power low noise devices using CMOS for biomedical applications can be manufactured with highly reliable and cheap. That will be efficient regarding the high best performance. The most challenges lie in optimizing the low power consumption with high efficiency circuit design to fulfill the object of the researchers.

Therefore we proposed a circuit designing of ultra low frequency wide band low pass active filter using wideband CCMOS amplifier. CCMOS is a new innovative pair designed by us for the wideband applications. CCMOS Pair consists of two CMOS inverter. The source of first CMOS inverter is the gate terminal of second CMOS inverter. It behaves as a transistor or CCMOS pair. It is also knows as complementary compound metal oxide semiconductor pair. The symbol of CCMOS pair (RKTG Pair) is shown in following "fig-2".

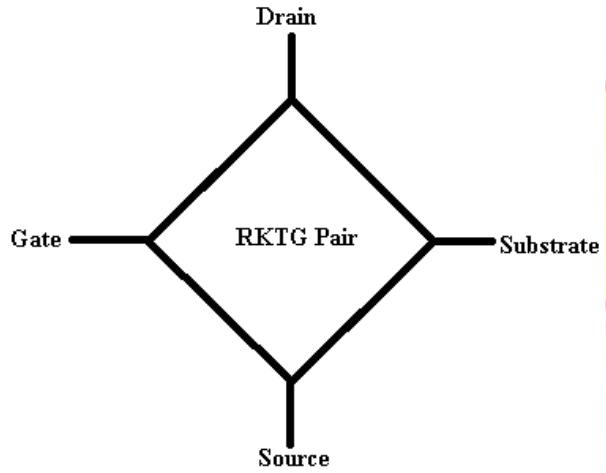

Fig-2 Symbol of CCMOS Pair (RKTG Pair)

This pair is very useful to enhance the band of the frequency with low noise and low power consumption in various type of amplifier designing system at very low input supply [4],[5], [6]. In section-II, the proposed circuit of low pass active filter for biomedical application is presented with the working operation. The simulation of proposed low pass active filter using 180nm Cadence Virtuoso Tool is also discussed in section III. After that Section IV presents the result comparison of the proposed circuit with the other previous designed low pass active filter. Finally the conclusion of this paper is shown in Section V.

II. DESIGNING OF PROPOSED CIRCUIT

The rising current trends of bio implantable devices in biomedical applications require ultra low power high reliable electronics circuits for the various purposes on a single chip. Keeping these aspects in our mind we start our work. In this paper, we proposed a second order low pass active filter to pass the very low frequency signal from μHz to 100 Hz for biomedical applications. The proposed circuit is designed by the new innovative CCMOS Pair. To increase the band of the low frequency signal and detect bio signal, we used two R-C networks with specific value at the input terminal of the amplifier. Amplifier consists of two CCMOS pair which connected in parallel to each other with the simple current mirror circuit to provide high current gain. A current mirror provides a current flowing in to or out of an input terminal by duplicating the current in an output terminal. An ideal current mirror is behaved as an ideal inverting current amplifier. It is also called the current controlled current source device. A simple current mirror circuit can also provides bias current and active loads to any circuits.

The design of a second order low pass active filter is totally depends on the structure of the CCMOS amplifier .The schematic block diagram of proposed ultra low frequency wide band low pass active filter is illustrated in "fig.3".

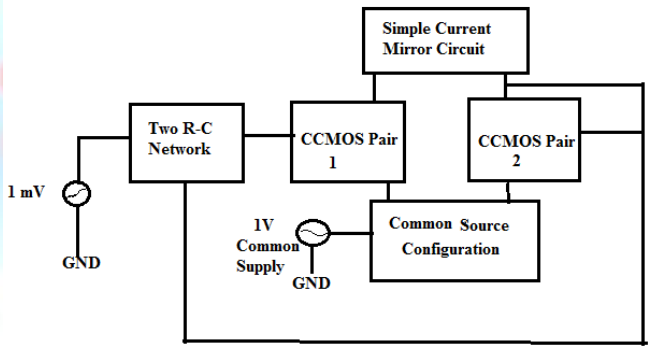

Fig- 3 Schematic Block Diagram of Proposed Low Pass Active Filter

The frequency range of the designed filter can be increase and decrease by using RC circuit that are being mathematically calculated with a new design of a Low Pass Filter with the R and C values. Ideally the transfer function of second order low pass active filter using R-C network is-

$$\frac{V0}{Vi} = \frac{1/R1R2C1C2}{S^2+S\left(\frac{1}{R1C1}+\frac{1}{R2C1}+\frac{1}{R2C2}\right)+\frac{1}{R1R2C1C2}} \text{----------(1)}$$

Cut off frequency $f_c = \frac{1}{2\pi\sqrt{R1C1R2C2}}$----------(2)

-3dB frequency $f\,(3dB) = f_c\sqrt{(\sqrt[2]{2}-1)}$---------(3)

Hence we can calculate the cut off frequency on 3 dB to pass the frequency band.

The bio frequency based low pass active filter is being employed from the new innovative CCMOS pair (RKTG Pair) in this paper. It provides noise free wide band filtering output. The proposed filter is designed by two order RC circuit with 1mV input supply. The following table-1 shows the variation of frequency band with the different value of R and C and it is analyzed by the simulated results present in next section.

Table-1

4.86V Output Voltage at 1mV Input Supply

S.No.	R1, R2	C1,C2	Low Cut off frequency (f_1)	High Cut off frequency (f_2)
1	1KΩ	10nF	584.27μHz	11.44KHz
2	1KΩ	100nF	57.03 μHz	116.62Hz
3	1KΩ	500nF	11.67 μHz	23.45Hz
4	1KΩ	1μF	5.94 μHz	11.68Hz

III. SIMULATION RESULTS BY CADENCE TOOL

The proposed circuit of second order low pass active filter using CCMOS pair is simulated by 180nm cadence virtuoso tool to measure the various performance parameters like: Transient analysis, Frequency response, Noise analysis, Power consumption etc. The transient's analysis of proposed circuit is shown in following "fig.4" at the value of value of R1=R2=1KΩ and C1=C2=1μF, with 1mV input power supply. This analysis shows the output voltage of **4.86V** at 1mV input supply.

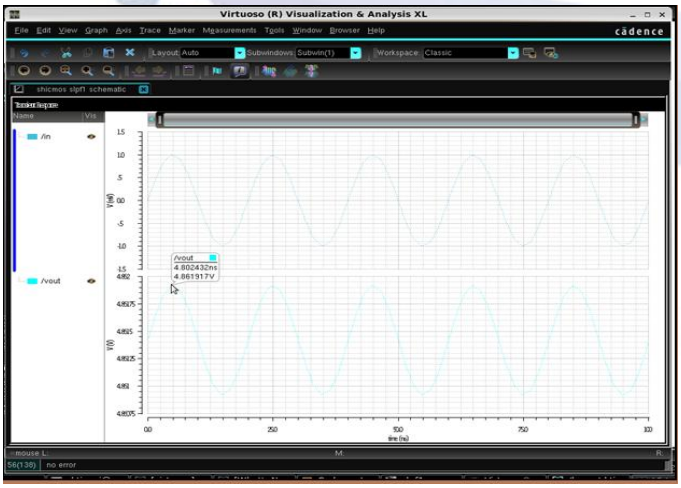

Fig.4 Transient Analysis of Proposed Second Order Low Pass Filter (CCLPAF)

We analyze the frequency response of proposed filter to measure the band of the low frequency. The low cut off frequency is 5.94μHz and high cut off frequency is 11.68Hz. It is shown in following "fig.5" and "fig.6". These figures show the frequency range between μHz to Hz. Hence it is very useful for biomedical application as a low pass filter.

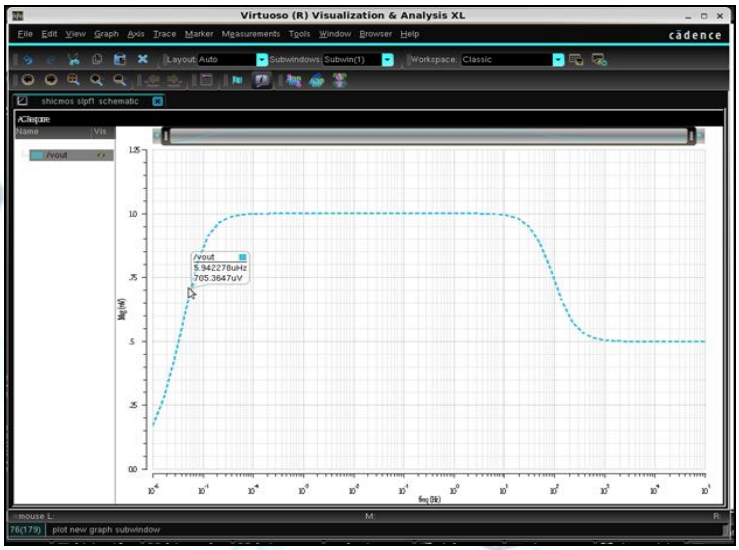

Fig.5 Frequency Response of Proposed Second Order Low Pass Filter (CCLPAF)

(F_1 = 5.96 μHz)

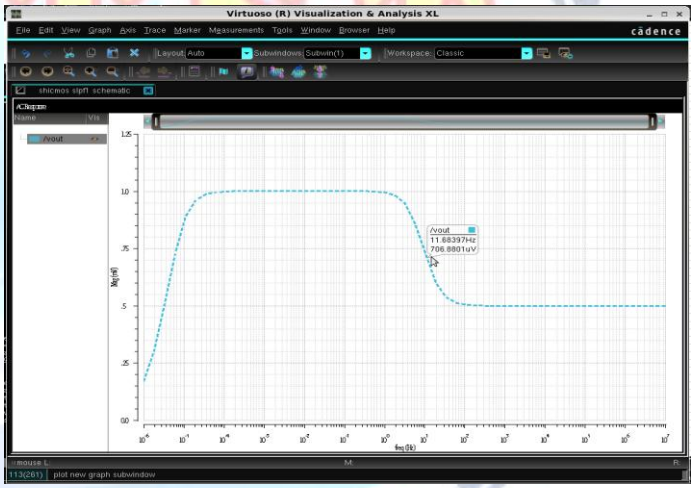

Fig.6 Frequency Response of Proposed Second Order Low Pass Filter (CCLPAF)

(F_2 = 11.68 Hz)

When we put the accurate and required value of resistor and capacitor in two RC networks then we can found the necessary frequency band to pass and reject the low frequency signal for the biomedical portable devices. The power analysis by the simulation shows the power consumption of 200pF in the proposed filter. It is shown in following fig.7.

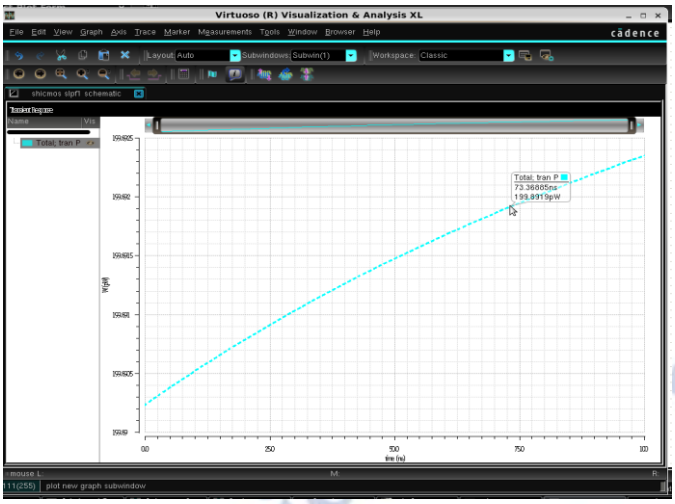

Fig.7 Power Analysis of Proposed Second Order Low Pass Filter (CCLPAF)

The above simulation results of proposed work is analyzed and compared with other previous works. This comparison shows the better performance of proposed work related to biomedical field. It is shown in following table-2.

Table-2
Comparative Analysis of Simulation Results

S.No.	Technique	Input supply	Power consum.	Cut off Frequency at 3 dB
1.	Operational Transconductance Amplifier With 4th Order [5]	Low Input Voltage	600nW	100Hz
2.	Operational Transconductance Amplifier With 2nd Order [6]	Low Input Voltage		Less Than 10Hz
3.	Offset Reduction Technique [7]	400mV	249.7nW	17Hz
4.	CMOS Doublet Technique [8]	0.35V	13.43mW, 9.4nW	250Hz(ECG), 200Hz(EEG)
5.	Differential Technique Using CCMOS Pair **(My Work)**	1mV	200pW	11.68Hz

IV. CONCLUSION

This proposed designing of ultra-low power wide band low pass active filter is very useful in Bio Medical Applications due to their performance. The simulated results show the high performance in the direction of biomedical field like: Pass band of frequency is 5.96 μHz to 11.68 Hz, very low power consumption up to 200pW, high output voltage of 4.86V at 1mV input voltage and very low noise etc. It is required performance to design the implantable portable device of medical field. This filter is designed using the low power low noise wideband CCMOS amplifier.

V. FUTURE SCOPE

This proposed second order low pass active filter can further be designed on higher order to analyze high performance with changing the W/L ratio of MOS transistor. We can also use the advanced current mirror using CCMOS pair instead of simple current mirror. In future, it will very useful to bring out the optimum results to fulfill the demand of Bio-Medical applications.

VI. ACKNOWLEDGE

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