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Dual Purpose CCMOS Active Filter Used in Biomedical Monitoring System

Shiksha Jain

Electronics and Communication Department, Institute of Engineering and Technology, Dr. Rammanohar Lohia Awadh University, Ayodhya

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Complementary Compound Pair,
Low power consumption,
High low frequency bandwidth

ABSTRACT

Day to day, demand of biomedical monitoring products are increasing in Bio-Health Organization. Low power and low noise and high bandwidth are the necessary factors that play the major role in biomedical system. The proposed structure of active filter is designed for dual purpose as a Low Pass Filter and Band Pass Filter with the help of complementary compound CMOS amplifier. Its behave as a active component to enhance the band of the filter in the range of μHz to KHz with very low power consumption of 199.81pW. It is simulated on 180nm Cadence Virtuoso too.

1. INTRODUCTION

Major challenges in health monitoring of human is increasing day to day rapidly. Because the life style of human is totally depended on the natural and non natural artificial products like: food, cosmetic items, etc. Health monitoring product plays the major role to recognize and reduce the health problem of human. These products work on biomedical frequency with low power low noise. Biomedical signals have very low frequency signals used in biomedical applications [1] [2]. In the biomedical applications, low pass filter and band pass filter play the most important role to detect the biomedical signals like: ERG (Electro Retinography) signals, ECG (Electro Cardiography) signals, EEG (Electro Encephalography) signals and EMG (Electro Myography) signals etc. shown in following fig-1.

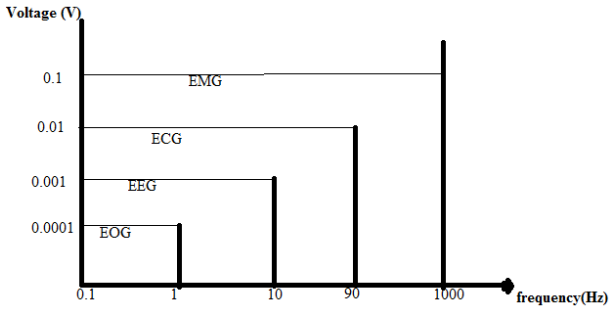

Fig-1 Frequency Range for Biomedical Signals

Mostly, biomedical monitoring systems are based on analog signal processing due to continuous signal. It consists of the two major blocks like preamplifier and filter. The type of filter may be low pass filter or band

pass filter or both depend on the measuring product. The general diagram of biomedical system is shown in fig-2.

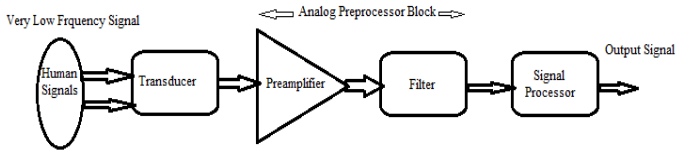

Fig-2 General Diagram of Biomedical System

In all biomedical systems, preamplifier is a major part to amplifying the weak input signal with negligible noise and low distortion. For example in electrocardiograph (ECG) measurement, the amplitude of preamplifier signals has to be processed approximately 100mV by a low pass filter [3] [4]. Filters employed in biomedical system are used for sensing bioelectrical signal.

In recent years, CMOS nanotechnology is very popular to design and implementation of very low power, low noise, and high frequency band with high gain amplifier used filters for various applications of biomedical field. Now till various different techniques have been used to design active filters (low pass filter, high pass filter, band pass filter, band stop filter) for the purpose of biomedical portable devices. These techniques are switched-capacitor-based technique, gm-c transconductance techniques, Offset reduction techniques for full swing output, OTA using miller compensation techniques etc. [5][6][7] [8]. The portable sensors used in biomedical system are mostly battery operated so it works on ultra low power and low noise. In this paper, we proposed the designing of filter using active component for low power, low noise with high frequency band. This proposed filter is based on complementary compound CMOS transistor as active component with RC network.

1.1 Complementary Compound CMOS Transistor

This transistor is innovative and design by my supervisor Professor Raj kumar Tiwari. It consists of two NMOS and PMOS transistor as a two CMOS inverter connect in the form of Darlington Pair. This type of transistor is very useful to enhance the bandwidth of the filter (for low frequency and high frequency both) with high gain and low power consumption. The source of 1st inverter is becomes the gate of 2nd inverter. Hence, 1st inverter is connected as a source follower and 2nd inverter act as a common source amplifier shown in fig-3. It has various advantages as compare the others [9][10][11][12].

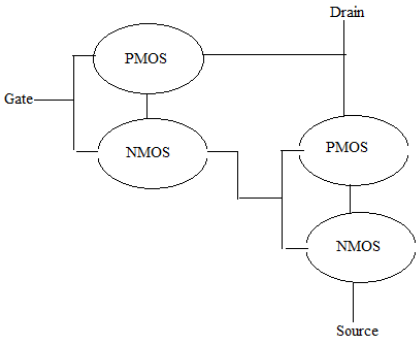

Fig-3 Model of Complementary Compound CCMOS Transistor

1.2 Importance of Filters

An ideal filter has some major characteristics like:

At fixed gain - Amplitude response has unity.

Pass band - transition of frequency from low to high and high to low or pass all frequencies in this transition period.

Stop band - transition of frequency from high to low and low to high or stop all frequencies in this transition period.

Cut off frequency - at which the frequency response changes from pass-band to stop-band Filters can be divided in four categories based on their operation. First category is Low pass filter (LPF) to pass the band of low frequency signals and stop the high frequency signals. Second Category is High pass filter (HPF) to pass the band of high frequency signals and stop the low frequency signals. Third category is Band pass filter (BPF) that allows passing the certain frequency range signals and stopping the other low frequency and high frequency signals. And last category is Band stop filter (BSF) that stops the certain frequency range signals and pass the other low frequency and high frequency signals. The frequency response of all separate operations is shown in fig-4.

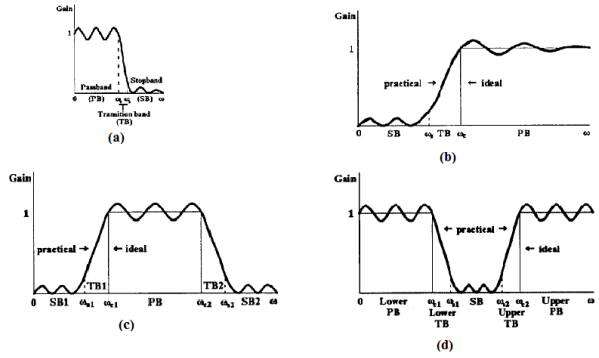

Fig-4 Standard Frequency Response of Active Filter

Filters have played the dominant role in all communication system to consider the wanted or required signal and reject or avoid the unwanted signal. It has many practical applications. A simple, single pole, low-pass filter (the integrator) or band pass filter is often used to stabilize amplifiers by rolling off the gain at higher frequencies where excessive phase shift may cause oscillations. In this paper, we have used complementary compound CMOS amplifier as an active element to increase the band of frequency and reduce the power consumption of the filter.

II. PROPOSED DESIGN OF DUAL PURPOSE CCMOS ACTIVE FILTER

This proposed design of active filter is applicable for the low frequency operations of band pass filter and low pass filter for biomedical application. It is based on CMOS nanotechnology and simulate on 180nm cadence virtuoso tool. The filter designing consist of two complementary compound CMOS pair, simple current mirror, and two RC networks. Complementary compound CMOS pair (RKTG Pair) are connected in parallel behave as a cascaded CMOS amplifier. The output of second complementary compound pair is the input of first complementary compound pair with RC network. The whole circuit has connected to the simple current mirror, which provides high current gain. Simple current mirror can be replaced by the advanced CMOS current mirror. The circuit diagram of proposed low power low noise dual purpose CMOS active filter is shown in fig-5. This type of CMOS amplifier using RKTG Pair applied in any type of filter is suitable to enhance the size of bandwidth, voltage amplification, signal isolation, low power consumption etc.

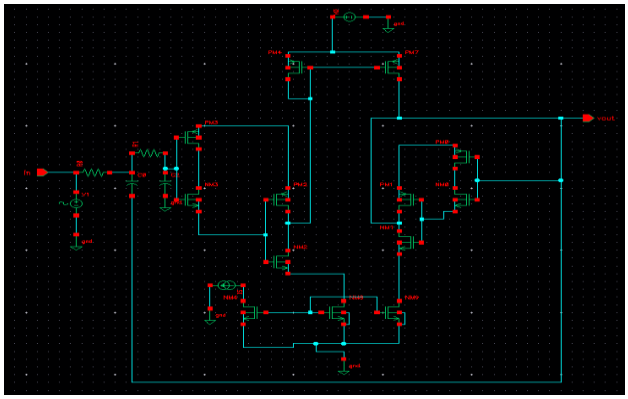

Fig-5 Proposed Designing of Dual Purpose CMOS Active Filter

The proposed dual purpose active filter can be used as a low pass filter as well as band pass active filter for low frequency applications such as Digital signal processing, Analog signal processing and Biomedical signal processing etc. by decreasing the value of capacitor up to μF at very low input supply 1mV.

Table-1: Input Supply = 1mV 50Hz

S.No.	R1 or R2	C1 or 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	5.97 μHz	11.68Hz

This type of designed filter behaves as a highest band of low frequency up to μHz to Hz at the low value of capacitor. In this period, second order low pass filter behave as a band pass filter to pass the band of low frequency. Hence, it can be valuable to design biomedical portable devices for biomedical applications. This type of CMOS active filter can be designed as a high pass filter and band stop filter with the help of changing the value of passive components used in filter. This proposed second order low pass filter is simulated on 180nm cadence virtuoso tool and show in next section with simulation results.

III. DISCUSSION OF SIMULATED RESULT

The proposed design circuit is simulated on 180nm Cadence Virtuoso Tool for the implementation. To measure the specification of the proposed filter, we consider the transient analysis, AC analysis, Noise analysis and power measurement etc. Fig-6 and fig-7 show the low cut off frequency of 57.08μHz and high cut off frequency of 116.62Hz at the value of capacitor is 100nF and the value of resistor is 1KΩ. This frequency range is very higher for low frequency signals processing like biomedical signal processing with high amplification up to 4.84V at 1mV input supply.

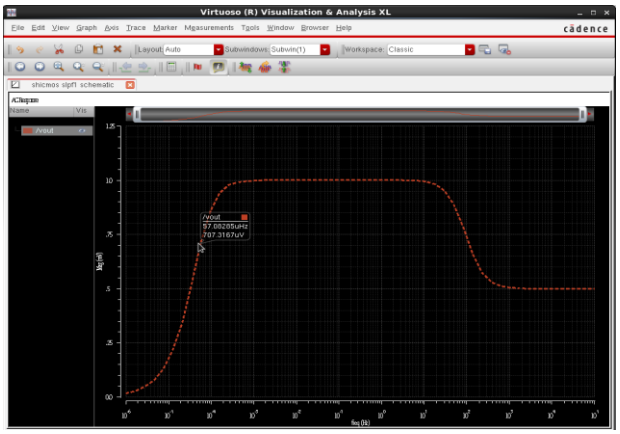

Fig-6 Transients Response for Lower Cut off Frequency (57.08µHz)

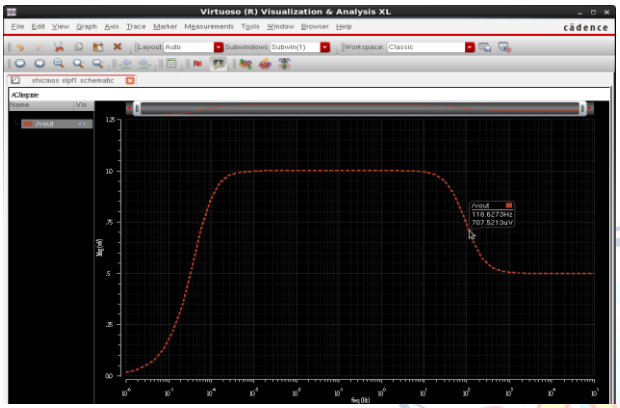

Fig-7 Transients Response for Higher Cut off Frequency (116.62Hz)

The proposed dual purpose active filter is having a low noise. It is measured by the noise analysis (Output noise analysis, Input noise analysis, and transfer noise analysis) through the simulation process shown in fig-8, fig-9 and fig-10. Its represent the 119.19mV/squrt output noise, 174.42mV/squrt input noise at the low cut off frequency 57.08µHz.

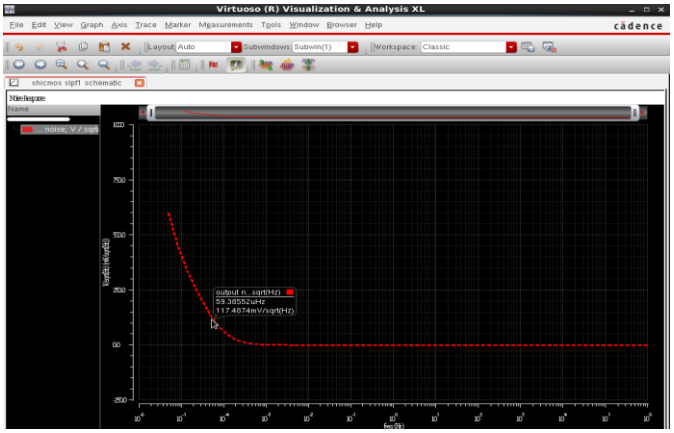

Fig-8 Output Noise Analysis of Dual Purpose Active Filter Using CADENCE TOOL

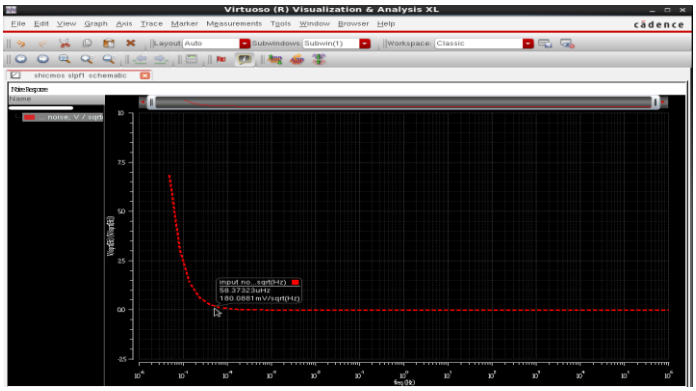

Fig-9 Input Noise Analysis of Dual Purpose Active Filter Using CADENCE TOOL

The frequency of the biomedical signal is specific for every health monitoring system such as ECG monitoring system operates on 250 Hz, EEG monitoring system operates on 200 Hz. In this filter design, the CCA (Complementary Compound Amplifier) is the basic building of the dual purpose active filter for biomedical portable devices. CCA is useful to enhance the bandwidth of the filter with ultra low power consumption in 199.9pWshown in fig-11. It is very low power consumption at the low frequency bio signal.

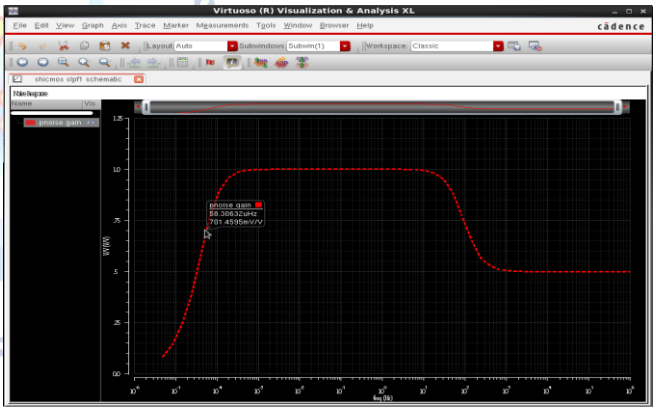

Fig-10 Transfer Noise Analysis of Dual Purpose Active Filter Using CADENCE TOOL

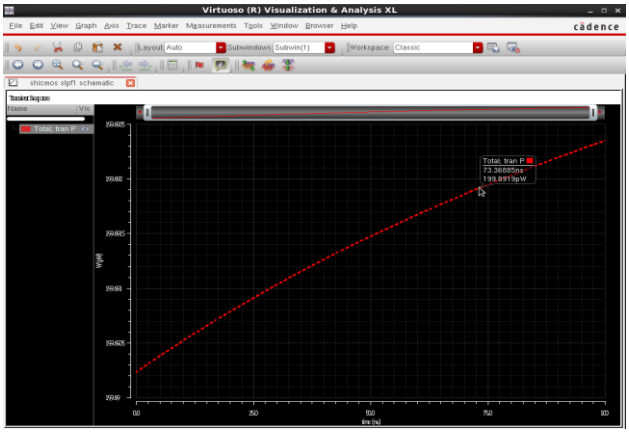

Fig-11 Power Analysis of Dual Purpose Active Filter Using CADENCE TOOL

IV. CONCLUSIONS

In this design, the low power low noise Complementary Compound amplifier using complementary compound pair is used to design dual purpose active filter for biomedical applications such as EEG and ECG. The simulation results provide less than 200Hz cut off frequency for the low pass filter at capacitor value of 100nH and resistor value of 1KΩ. While at the same value of RC network, this filter behave as a band pass filter (low cut off frequency = 57.08μHz and high cut off frequency = 116.62Hz). The power consumption by whole designed filter is very low means 199.9pF.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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