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Literature Review of Low Pass Filters Based on CMOS for Biomedical Applications

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Abstract: A survey of low pass filters with good linearity, low weight, and low power consumption has been done in this study .we examine the numerous low pass filter types ,their uses and design factors in this survey. we start by looking at low pass filters fundamental concepts and characteristics of their frequency response. in this study ,many low pass filter types and associated technologies are discussed. Low pass filter with low noise ,low power requirements, and low weight have been shown to be an implementing RKTG pairs in low pass filter circuits by varying the aspect ration of MOSFETs manufactured at 45nm,90nm,and 180nm technologies. this survey is valuable resource for engineers and scientists study in signal processing and communication systems since it offers a through review of low pass filters and their uses

Keywords: RKTG pair ,CMOS ,low power ,low pass filter ,biomedical devices.

I. INTRODUCTION

Circuit designers have always been drawn to the overlapping future of semiconductor technology by the features' constant reduction in size.[11] Continuous Technology feature size scaling has made it possible for digital circuits to become denser and faster as supply voltage has decreased sequentially, which has prompted the digital industry to advance low supply voltage.[11]one of the essential circuits for detecting the low level signals in the biomedical information sensing system is a low noise and low power amplifier[2] the use of biopotential detecting system in medical monitoring and diamagnetic application is crucial.[1] the low consumption capabilities ,dense integration and low price of an amplifier made with CMOS technology make it appealing.[2] filters are used to remove undesired noise in order to obtain high noise performance, however ,designing low frequency filters for biomedical signal like heart rate,EEG,and ECG poses a significant problem[3]. The necessity for reaching a low cut-off frequency while also having a minimal space and power consumption in portable biomedical devices. LPFs with extremely low cut-off frequencies are at the core of biomedical signal processing.[11] we employ extremely low frequencies with a low skip clear out for the sensor interface on the front end anywhere they originally serve as a representative pre-conditional level to reduce noise identity on the frequencies of responses in the biological system.[4] in recent study, it has been possible to identify and measure minuscule signals that are impacted by high level noise.[5] one of the animated biological signals that is useful in examining both brain activity and nerve disease is the EEG.[5] pursuing long life time and cost effectiveness modern biosignal sensors must function with extremely low power consumption and frequently be tightly connected with energy –harvesting and management devices.[6] to enable the use of low voltage devices, designers must take into account new technological choices, according to the literature ,one way that significantly lowers the threshold voltage and facilitates low voltage operation is bulk driven CMOS operation.[7] numerous studies concentrating o potential low pass filters choice for wearable biomedical application have been conducted, biomedical system have grown to be a popular solution for measuring physiological signals while targeting low power, compact size, and low cost.[8] because of their limited amplitude {some µv to some mv} ,the signals to be taken into account in the amplification stage are extremely specific signals like EEG,ECG and others. as well as their extremely low frequency range {mhz to hundreds of hz} .amplifiers used in this situation must therefore have high gain, an appropriate bandwidth ,good stability, low power consumption and low noise.[9],operational transconductance amplifier (OTA) is a front end components and a key signal conditioner here, its primary function is to increase the strength of extremely low biopotentials originating from sophisticated sensors using MEMS technology.[9] there are a variety of intriguing applications that call for low noise receivers in order to take system sensitivity into account ,low noise amplifiers are essential components of receivers because they predominate the receiver chains overall noise figure.[10] the analogue processing block ,which include the two crucial pre-amplifier and filter block is one of the most crucial components of biomedical system since the system used in these systems operate at very low frequencies.[4]

preamplifier enhance the signal to a better level with very low frequencies and sporadic distortion, and low pass filter is the most widely filter in biomedical signal processing system.[4] We used complementary compound pairs to develop a high frequency range at low frequency second order active low pass filter in order to eliminate the aforementioned issues. In order to eliminate temperature dependence and provide low frequency signal amplifications with minimal power consumption, it gives very high current gain in the case of BJT (Bipolar Junction Transistor) and very high voltage gain in the case of MOS (Metal Oxide Semiconductor). It is a monolithic filter for IC production.[11]

II. COMPARISON AND LITERATURE SURVEY

A. Low Pass Filter

If there were a perfect low pass filter ,it would flawlessly pass signals below the cutoff frequency and totally block or eliminate frequencies above it .to gate the best performance for a particular application, numerous trade-offs are made in an ideal filter.[12] it is difficult to construct an extremely low frequency filter (10hz) especially for integrated circuit implementations where greater temporal constants must be chip realized .[13]key components in biomedical devices are low pass filters with high cut off frequency .[15]filter networks are those that prepare minor signals in a frequency dependent manner .filter can be used to segregate signals ,passing the signal that is interesting and putting the undesirable frequencies bye terns. the number of active devices employed in the design of analogue filters is decreased due to issues with power consumption and noise distribution .[14] an active RC or a M-C architecture is often used to implement integrated LPF,which are fundamental building block for the processing of analogue signals . the OTA (operational transconductance amplifier) determines how well these filter operate .because of its linear input –output properties ,the operational transconductance amplifier is employed in low power analogue filtering operation .OTA is the primary building block in analogue circuits. because both have differential input ,OTA and OP-AMP have the same function .however OTA 's output differs from OP-AMP's .it is the form of a difference in voltage rather than current.

Types of filter circuits

During the circuit's design process ,four different types of low pass filters were explored.

1) Butterworth filter
2) Chebyshev I type filter
3) Chebyshev II type filter
4) Elliptical type filter

B. Butterworth Type Filter

In his 1930 work titled "on the theory of filter amplifiers " British engineer and physicist Butterworth introduced the first Butterworth filter. a Butterworth filter is a kind of filter created to have a frequency response that is as much in the pass band as possible .Butterworth filters maintain their maximum flatness in the pass band with with substantially slower amplitude expansions than at the cut off frequency .a form of signal processing filter called the Butterworth filter is made to have a frequency response that is as flat as possible in the passband.the term "maximally flat magnitude filter " is also used to describe it .this kind of low pass filter has a pass band frequency response that is as flat as possible .it provides good attenuation of higher frequencies and has a smooth roll off.

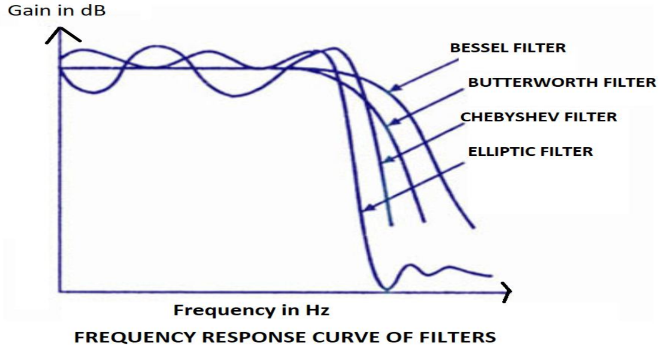

Fig.1 – Frequency response curve of various filter

C. Chebyshev Type I Filter

These filters are mostly employed to separate frequencies from one band from another type of chebyshev filter I have an equal amount of pass band ripple and monolithic in the stop band, but it has pass band ripple but its roll off is quite quick at the expense of more pass band ripple.

D. Chebyshev Typeii Filter

Chebyshev filters are maximally flat in the passband and have ripples of equal magnitude in the stop band specify the stop band starting frequency and the largest ripple amplitude for the chebyshev II filter.It has a stop band with ripples and a roll off similar to a type I filter and both the stop band and the pass band are ripple-free.

E. Elliptical Filter

An electronic filter used in signal processing is called an elliptical filter. It is also referred to as an elliptic function filter or a Cauer filter. An analogue filter with a steep cutoff that can squelch frequencies outside of a specified range is the elliptical filter. The filter differs from other filter types by having a special response curve with ripples in both the pass band and the stop band Elliptical filters are frequently employed in systems like radio frequency (RF) communication systems, audio systems, and instrumentation where a significant amount of attenuation in the stop band is required. They can also be used to eliminate noise from photos during image processing. Because it is necessary to specify a number of parameters, such as the pass band and stop band frequencies, the maximum ripple in the pass band and stop band, and the lowest attenuation in the stop band, the design of elliptical filter is more difficult than the design of other filter types. On the other hand, after the parameters are defined, the filter can be created using software programmes like MATLAB or Python. In general, the elliptical filter is an effective tool for signal processing tasks that need for fine control of the frequency response.

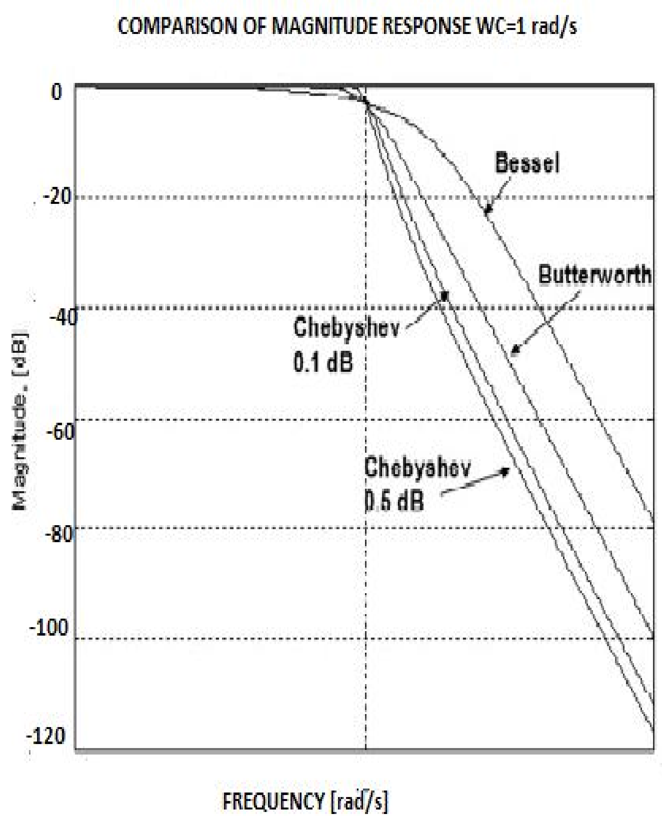

Figure 2 – Magnitude response curve of various filter

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F. Comparison Chart For Low Paas Filters Used In Biomedical Equipment

These table enumerates the various low pass filter studies that have been done, along with the corresponding parameters.

Table 1- Different low pass filter types are compared in the table below.

Year	Reference	Technology	Types of filters	Order	Power supply	Band width	Power consumption	Chip area
2004	[16]	0.35µm	Chebyshev -II	5th	3v	-	45mW	-
2009	[17]	0.18µm	Gm-c	3rd	1.8v	150khz-23mhz	18mW	
2010	[18]	-	Elliptical	5th	1.8v	-	44.2mW	0.895mm2
2011	[19]	90nm	Analog filter	4th	-	-	14mW	
2015	[07]	0.18µm	Butterworth filter	2nd	0.5v	100hz	0.225µW	
2016	[03]	0.18µm	Gm-c ladder filter	5th	1.8v		12.38µW	
2018	[26]	0.18µm	Gm-c	1st	1.0v	250mhz-14khz	1.75µW	-
2019	[01]	90nm	Elliptical	4th	+-0.6v	24hz	1.7nW	-
2019	[08]	180nm	UltraLPF	4th	0.5v	-	9.0nW	0.048mm2
2020	[06]	0.18µm	SF-C	4th	0.5v	-	3.69nW	0.074mm2
2020	[04]	90nm	UltraLPF	2nd	-0.25v –(-0.23v)	200khz-250khz	13.43nW-9.4nW	-
2020	[20]	0.18µm	Butterworth	6th	1.8v	22khz-52khz	2.24nW	0.65mm2 -

III. CONCLUSION

According to the literature review, a low pass filter with a low noise level, low power requirement, and low weight is an essential component of portable biomedical equipment. The CMOS low pass filter based on Butterworth filter gave researchers a better opportunity to work on it.

Our future work will be based on the implementation of RKTG pair (Complementary compound pair) in low pass filter circuits by changing aspect ratio of MOSFETs at 45nm, 90nm and 180nm technologies. This pair is combination of two CMOS inverter connected in the form of darlington pair and behave as a complementary compound pair. This RKTG pair (Complementary Compound Pair) has become a popular pair for different applications like delay system, amplifier designing, filter designing, etc. due to wide band frequency, low power consumption, low output noise, large current /voltage gain.

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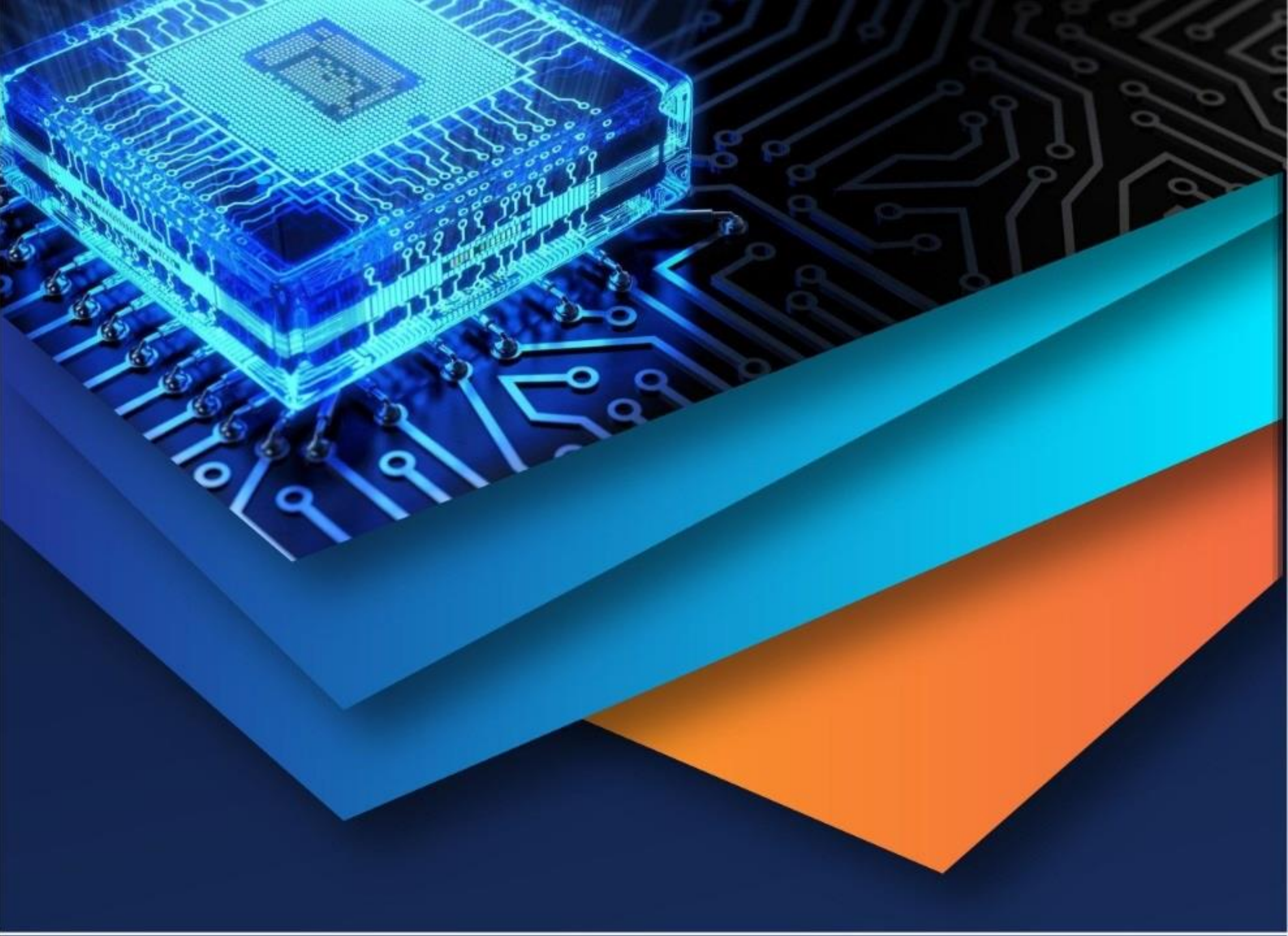

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