A Better Bandwidth And High Gain Filter Using 22 nm Technology

Devendra Rathore[1], Prof. Madhvi S. Bhanwar[2]
[1, 2] Dept of ECE
[1, 2] SAGE University

Abstract- *Neural amplifier is the amplifier which is use to amplify and reduce the noise of the signal received by the human body and send it to the further circuit. So its gain and bandwidth should be high. It find application in biomedical field and many other area as well.*

The important part of this neural amplifier is operational trans-conductance amplifier(OTA). The purpose of OTA is to acquire signal from the body, so its gain should be high and able to reduce the noise coming from the body. Another problem was to choose the values of input and feedback capacitors so to get the better gain and bandwidth. Power consumption was also the another parameter for optimisation.

This thesis shown the solution for all the above mention solution. This thesis designed on 22 nm technology. The bandwidth obtain is 6.4 kHz, gain is 45.5 dB and power consume by whole circuit is 520 nW.

Keywords- OTA, Neural amplifier, Noise, Gain, Bandwidth, Power consumption.

I. INTRODUCTION

Neural signal acquisition has a wide range of applications in current medicine and medical science. Proper and correct nerve indicators offer an platform for medical diagnosis, which is used to deal with numerous intractable illnesses [1]. The study of neural network is helpful for understanding the idea of mind capabilities through direct analysis electro-neurographic signals. In the meantime, there are still many illnesses associated with the nervous system, consisting of polio, parkinson's syndrome, and so forth. Treatments of these intractable diseases primarily based on neural signal analysis will considerably enhance lifestyles. Nowadays brain-computer interface generation is proposed as a approach to acquire and analyze neural sign and corresponding body control.

Figure 1 suggests the multi-channel neural recording system, it is composed of a biological sensor and electrical system. Biological sensor converts neural signal into weak electric signal via electrodes. In recent times multi-channel recording have become very well-known due to its fast and correct estimation at numerous locations simultaneously. Electronic system is for small-scale amplification of the weak signal without including significant noise, so circuit is low noise amplifier (LNA) accompanied by a variable benefit amplifier (VGA) as depicted in fig.1. VGA is to maintain the steady dynamic range regardless of the biological signal so that ADC will no longer be overloaded.

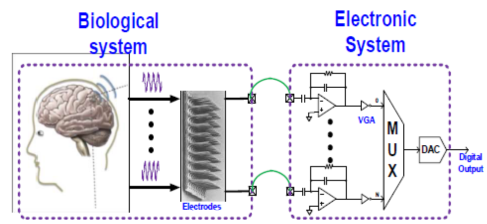

Fig. 1 Neural recording system[2]

So, A neural amplifier is an electrophysiological tool, used to accumulate and growth the signal integrity of electrical signal activity. The neural recording amplifier need to consume very low electricity in spite of been densely populated with cutting-edge electronics. A few values of heat flux will purpose tissue harm that effects necrosis [3].

The electric nerve signal capturing is necessary to design the neural recording system. The nerve signals have very low amplitudes ranged between 1 and 10μV [5]. Because of their small amplitudes, nerve signals have to be amplified before they are processed ahead and this amplifying system should have the design capabilities of high input impedance, low enter refer noise (IRN), high advantage and excessive CMRR [6]. Intracellular or extracellular system is used to calculate and estimate neuron sign transmission activity. The extracellular movement potentials (EAPs) generated via the neuron membrane, have wave traits sweeping from 100Hz to ten kilo Hz, which lasts only for few milliseconds. EAPs occur for approximately maximum 120 second [9]. The voltage amplitudes of EAPs range among 50μV and 500μV,which mainly relies upon on the distance between recording system element and neuron[7],while intracellular action potentials(IAPs) have amplitudes of 70mV[8]. Next form of biopotentials are local field potentials(LFPs) have waveforms and range of amplitube vary from 1mHz to 200Hz and 500µV to 500mV respectively. Neural signal mechanism flexibility and potentialism to technique brain statistics is accomplished with the aid of LFPs.

The aim of this thesis is to design Operational trans-conductance amplifier based filter which increase the mid band gain and bandwidth at 22nm technology and choose the value of input and feedback capacitor to get the required mid band gain.

II. SURVEY

R. Nagulapalli and his friends[2] change the architecture of OTA(figure 2.1) and with that OTA, they achieve gain of 44 dB and bandwidth of almost 6 MHz. Supply of 1.2 V is applied to achieve these parameter.

Nishanth Kulasekeram and his friends[24] design reconfigurable low noise multichannel amplifier(figure 2.2). They used biased current technique which control the bandwidth of amplifier.

Jongpal Kim and Hyoungho Ko[25] use capacitive coupled instrumentation amplifier with current reused and self biased scheme. This amplifier designed on 180 nm technology. with this ,they achieve bandwidth of 4.4 kHz.

Gauri Punekar and her friends[26] use neural amplifier(figure 2.3) in closed loop and open loop, compare their result. They found that closed loop neural amplifier has low gain,CMRR,PSRR and input referred noise as compared to open loop neural amplifier.

III. PROPOSED DESIGN

The proposed design is shown in figure 3.1.

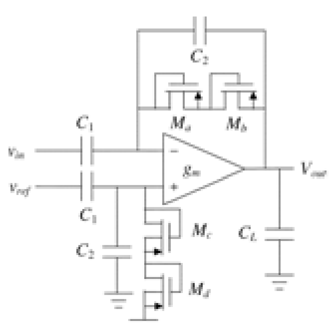

Fig. 3.1 Neural amplifier[3].

As seen from the figure, feedback resistor is realize using two PMOS transistor(Ma and Mb) connected in series with each other and in parallel to them , a capacitor(C2) is connected . The capacitor are acting as feedback capacitor. One end of this combination is connected to the output of OTA and other is connected to a capacitor C1 where Vin is applied. A capacitor C1 where Vref is applied connected to the parallel combination of C2 and Mc and Md connected in series. The pseudo-resistor are connected so that high resistance[22] can be obtain.

Since the OTA is the part of neural amplifier, so the OTA architecture is described as follows. The OTA (figure 4.1)consists of PMOS differential inputs and single ended output. MOSFET M1 and MOS transistor M2 acts as input PMOS device, M3 and M4 forms cascode stage wherein M5 and M6 are current mirror load, MOSFETs M7 and M8 are cascode transistors. Transistors M9 and M10 are replicate transistors to which bias current of 2 µA is connected. Capacitive coupling is used to attain dc offset rejection and a shorted gate-source pseudo resistor with capacitive feedbacks is used in between the differential inputs and single output. Pseudo-resistors and feedback capacitors help filtration of undesirable signals out of the amplification frequency range. The pseudo resistors are used to remove the linear variations of resistance over Vds variations [23]. The gain is enhanced and flattened via specifically these motives: the W/L ratios of the input transistors are increased to obtain high transistors gm, reducing the noise and the values of the lengths of two NMOS transistors are increase. Improvement in gain is additionally achieved by maintaining the magnitudes of the input signals inside the variety of few nanovolts to 60µvolts, through preserving their LPFs and neural spikes amplitudes as traditional. In the proposed OTA, the drain- gate is shorted of M5 whereas in the circuit shown, the drain-gate is shorted of M6.

In addition to the above circuit arrangement, additional two transistor, PMOS and NMOS is connected at the output. The source of PMOS is connected to the Vdd and the source of NMOS is connected to ground. The gate of PMOS is connected to drain of M2 and gate of NMOS is connected to drain of M4.

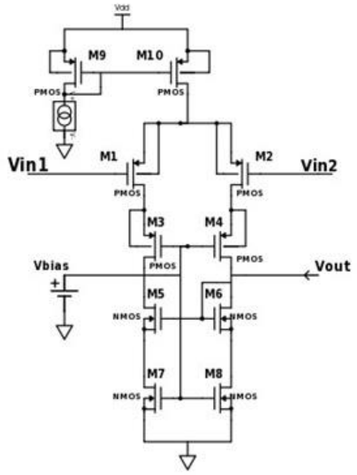

Fig. 4.1 OTA[20]

IV. RESULTS

The parameter obtain from this neural amplifier are

4.1 Frequency Response

The frequency response(figure 4.1) obtain indicate the mid-band gain of the neural amplifier.

The gain produce by this amplifier(figure 4.1) is 45.5 dB. The low frequency obtain is 239 Hz and the high frequency obtain is 6.68 kHz. So the bandwidth is 6.4 kHz.

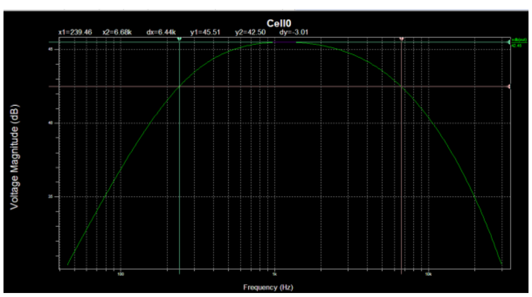

Fig. 4.1 Frequency response

4.2 Input Referred Noise

Since the input referred noise is very important parameter to be focused on, so its value should be very small. Figure 4.2 shows the input referred noise of this amplifier.

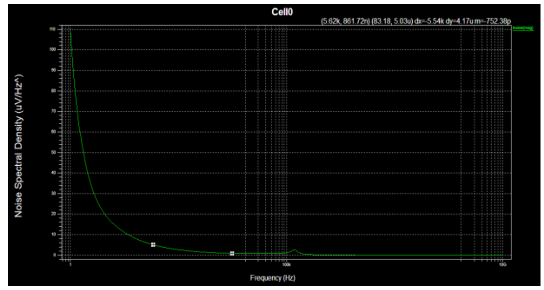

Fig. 4.2 Input referred noise

The Input referred noise at 6.68 kHz is 861 nV/√Hz, and at 239 Hz is 5 uV/√Hz.

4.3 NEF

Formula to calculate to NEF is shown in section 3.3. By putting up the values, the NEF obtain is 2.2.

4.4 PEF

Since PEF depends on NEF, so after calculating NEF, PEF will be calculate. The value obtain of PEF is 4.84

4.5 Power Consumption

The power consume by whole circuit is 520 nW which is very low as compare to the other papers.

V. COMPARISON

Table 5.1 show the results obtain by them. The table indicate that this work is better than previous work as this filter has gain of 45.5 dB, bandwidth of 6.4 kHz and power consumption of 520 nW.

VI. CONCLUSION

The proposes active filter which is good candidate for neural recording system shows bandwidth of 6.4 kHz and mid-band gain of 45.5 db. It also shows input referred noise of 861 nV/√Hz. This filter is very less power consuming which is 520 nW. Since this neural amplifier is designed on 22nm technology, the area acquire by this amplifier on the chip will be very very less.

Table 5.1 Comparison between previous works

Parameter/References	[24]	[25]	[26]	[27]	This work
Technology(µm)	0.35	0.18	0.18	0.065	0.022
Supply(V)	3.3	0.6	1	1	1
P_{diss}(W)	-	0.118 µ	6 µ	1.12 µ	520 n
Diff. Gain(dB)	-	14-28	35.16	40	45.5
Bandwidth(Hz)	1-5k	6.4-4.5 k	-	5 k	6.4 k
IRN(µV)	3.98	10.68	1	8.1	5
NEF	4.04	1.79	0.28	4.62	2.2
PEF	-	1.93	-	21.34	4.84

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