Current Mode Front End Amplifier for Neural Signal Recording

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Abstract— *In this paper the present Mode forepart electronic equipment for neural signal recording is planned. within the biosignal recording the amplitude of neural signals is extremely tiny and also the electrodes square measure simply interfered by external noise sources like 60-Hz noise from power lines or different disturbance sources. In such case the present Mode forepart electronic equipment is needed to scale back the noise.The Current Mode forepart electronic equipment (CMFEA) records the neural signals from the conductor tissue interface rejecting the DC offset voltage and amplifies those low amplitude signals.The dc offset current generated by the electrode-tissue interface may be bypassed by employing a current –mode preamplifier at the side of the feedback circuit operated at terribly low frequency. A programmable current gain stage is adopted to produce adjustable gain for adjustive signal scaling. the present mode filter is meant to regulate the low pass discontinue frequency for numerous neural signals.The planned Current Mode forepart electronic equipment (CMFEA) will retain the benefits of low power consumption and low power offer in current-mode circuits when put next to different voltage mode circuits.The Current Mode forepart electronic equipment (CMFEA) has low input resistivity that results in low input noise voltage and additionally features a sensible noise rejection capability. The planned CMFEA are designed in 90nm technology.*

Keywords— *Current Mode, Neural amplifier, Bio signal recording, ECOG, low power, front end amplifier, DC offset.*

I. INTRODUCTION

In medicine applications wherever an outsized dynamic vary is needed, the look of an occasional noise electronic equipment is essential. This paper presents the look and simulation of a low-noise current mode pre-amplifier to be used in medicine signal acquisition. Specifically, it's meant to be utilized in the front-end of associate degree analog signal process that may be utilized in a EcoG-based(ElectrocorticoGraphic-based) BCI (Brain-Computer Interface) system. Neural signal acquisition is a crucial a part of trendy physiological analysis and its applications. Neural signal potentials recorded from electrodes square measure weak in amplitude and wish to be pre-amplified before any signal process.Neural signals from living thing recording square measure terribly weak (typically between ten and five hundred V). As a result, amplification is required before such signals may be processed any. Next generation multi-electrode recording systems are going to be entirely deep-rooted inside the bone and incorporate an outsized range of neural amplifiers. For such applications, ultralow-power operation is extremely necessary to reduce temperature reduction within the brain, preserve long-battery life, and maximize the time between recharges. within the neural signal recording the input-referred noise of the electronic equipment be unbroken low. Currently, the four primary recording modalities of brain square measure Electro-EncephaloGraphy (EEG),Electro-CorticoGraphy (ECoG), native Field Potentials (LFPs), and Single-neuron impulse recordings (Single Units) All four of those techniques as given in TABLE one need recording micro-volt level extra-cellular potentials generated by neurons within the brain's plant tissue layers.

TABLE 1
COMPARISON OF ELECTRO PHYSIOLOGICAL SIGNALS

Recording modalities	Bandwidth	Amplitude	Invasiveness
Single Unit	0.1-7 KHZ	<500 µv	Invasive
LFP(Local Field Potential)	<200 HZ	<5 mv	Moderately invasive
ECOG(ElectrocartiCOgraphy)	0.5-200 HZ	<100 µv	Moderately invasive
EEG(ElectroEncephaloGraphy)	<100 HZ	10-20 µv	Non invasive

In this current mode circuits, no external electrical device or no reset signal is employed within the style. The voltage noise is reciprocally proportional to the dc operational current whereas the present noise is proportional to the dc operational current. Current mode circuits are able to do low power consumption underneath reduced power offer. Noise is inherent all told the signal measuring

instrumentation. For the measuring of neural signals the most noise sources square measure conductor noise, biological noise, electronic noise and also the noise from the external sources. The external noise sources embody the sixty cps line power, electronic equipment etc. For neural recordings the signal levels of interest within the order of micro-volts, the voltage generated attributable to magnetism interference from the road power is within the order of few milli-volts. Thus the background level is significantly giant and over powers the signal. This can result in the matter of electronic equipment saturation and amiss of the complete circuit.The reference voltage of the input node is ready to Vr=1/2(VDD) via the feedback loop.

II. CIRCUIT DESIGN

The proposed CMFEA consist of four stages

1 Current mode preamplifier
2 Active feedback loop
3 Programmable current gain stage
4.Current mode filter

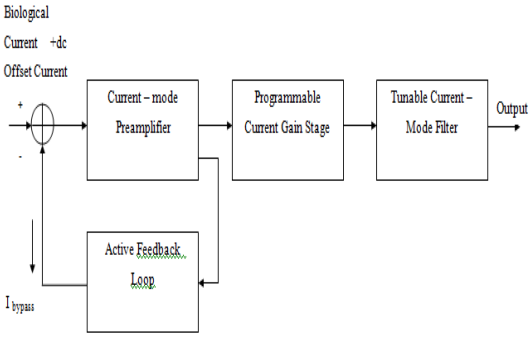

Fig 1:Block diagram of CMFEA

It is better-known that the acquisition device for neural signal recording is in an exceedinglyll|one amongst|one in every of} the foremost necessary parts in a medicine electronic system. within the acquisition device [12], the Front-End electronic equipment (FEA) is one in all the key parts, that senses and amplifies the neural signals like Electrocorticography (ECoG), EKG (ECG), impulse, native field potential (LFP) etc., through electrode-tissue interfaces. Since the amplitude of neural signals is extremely tiny and also the electrodes square measure simply interfered by external noise sources.The electrode-tissue interface produces a dc offset current whose amplitude varies with each material and size of electrodes The saturation of CMFEAs whereas amplifying neural signals below zero.1 cps ought to be eliminated. A current-mode forepart electronic equipment is meant so as to amplify the low frequency neural signals.

A. Preamplifier

A preamplifier (preamp) is associate degree electronic electronic equipment that prepares atiny low electrical signal for any amplification or process. A preamplifier is commonly placed near the sensing element to scale back the consequences of noise and interference. it's accustomed boost the signal strength to drive the cable to the most instrument while not considerably degrading the signal/noise (SNR) [1]. The noise performance of a preamplifier is critical; in line with Friis's formula, once the gain of the preamplifier is high, the SNR of the ultimate signal is set by the SNR of the input and also the noise figure of the preamplifier. The term 'preamplifier' is employed to explain instrumentality that simply switches between totally different line level sources and applies a volume management, in order that no actual amplification is also concerned.The preamplifier provides voltage gain (e.g. from ten millivolts to one volt) however no important current gain.Three basic kinds of preamplifiers square measure available: current sensitive preamplifier, parasitic capacitance preamplifier, charge-sensitive preamplifier.

The biological current from the conductor tissue interface shown in Fig a pair of with the dc offset current is given as associate degree input to the present mode preamplifier as shown in Figure a pair of The electrodes square measure simply interfered by external noise sources like 60-Hz noise from power lines or different disturbance sources The preamplifier amplifies the inband signal with less degradation.

The current-mode preamplifier shown in Fig 2 has low dc operation current to enhance low-noise performance and decrease power consumption The current preamplifier with the cancellation feedback loop is designed to bypass the dc offset current generated by the electrode-tissue interface so that the dc offset current does not affect the amplifier operation. To avoid the effect of long length in limiting the signal swings, M3 is designed with a large device width

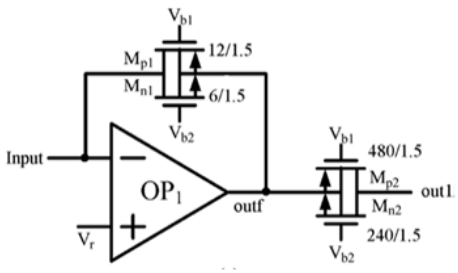

Fig 2:Current Mode Preamplifier

PMOS	$(W/L)_{Mp1=12/1.5}$	$(W/L)_{Mp2=48}$ 0/1.5
NMOS	$(W/L)_{Mn1=6/1.5}$	$(W/L)_{Mn2=24}$ 0/1.5

W3. Since the input noise is freelance of W3, giant W3 doesn't increase the noise.W1 is additionally designed to be larger to scale back each thermal and flicker noises. Most amplifiers consume concerning one hundred W of power to realize low input-referred noise five V for bandwidths of 5–10 kilocycle per second. If such amplifiers square measure to be utilized in a multi-electrode array, with an influence close to one hundred W per electronic equipment for many designs[11], the ability needed for the neural amplifiers will become the limiting issue for the full multi-electrode system. A new small power neural recording electronic equipment style as planned in [7] wherever the ability consumption per electronic equipment is giant specified the full power consumption of a multi-electrode array is also larger for the look of brain–machine interfaces.

1) *Schematic of Opamp:* The operational electronic equipment shown in Fig three is meant with a two-stage topology the ratio of M1(M3) is clone of that of M2(M4) within the electronic equipment M1-M2 with the current-mirror load M3-M4 exploitation PMOS as input devices will cut back the glint noise.

The opamp is meant to realize low offset voltage with appropriate gain [4][14]. Therefore, the sizes of M1-M4 that square measure the most contributions of offset square measure enlarged to decrease the offset caused by device pair. The values of length and breadth square measure taken as twenty and forty for the differential try. The breadth of PMOS is double the worth of NMOS. A capacitance of 1pF is employed within the style. The op amp utilized in the preamplifier amplifies the low frequency signals from the conductor tissue interface[13].

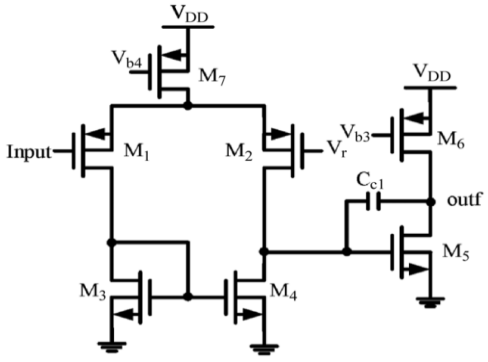

Fig 3: Schematic of Op amp used in the preamplifier

B. Active Feedback loop

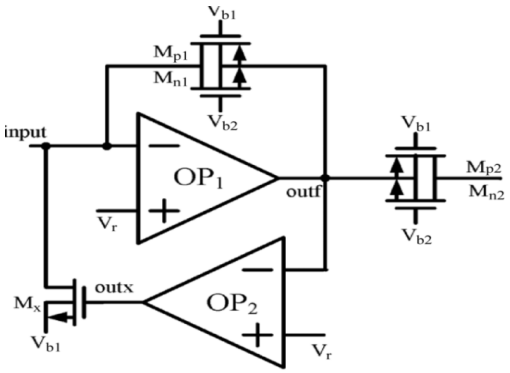

Fig 4: Schematic of Preamplifier with a feedback loop

The purpose of the feedback circuit is to require the flowing-in dc offset current that would exist within the electrode-tissue interface. The current mode preamplifier at the side of the active feedback loops shown in Fig one is meant to reject the DC offset current generated by the conductor tissue interface. This eliminates the noise throughout the amplification.

C. Programmable Current Gain Stage

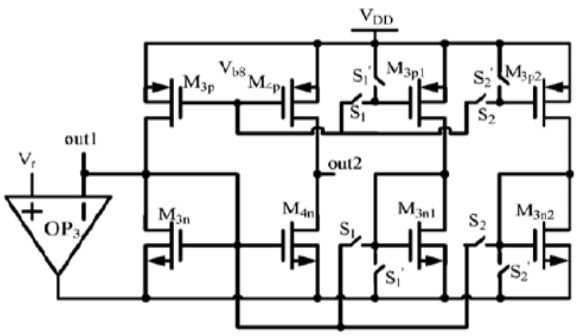

Fig 5:Schematic of Programmable current gain stage

A programmable current gain stage shown in Fig five is adopted to produce adjustable gain for adjustive signal scaling. MOS-bipolar or MOS pseudo resistors square measure adopted to comprehend ultra-large resistances that square measure extremely obsessed with the voltage across them inflicting a giant signal distortions[8] and enormous variations of high pass filter characteristics. The bio potential signal generated from the input conductor tissue interface produces a current that is perceived and amplified.

D. Current Mode Filter

The current mode filter as shown in Fig six whose transistors Mc1,Mc3,Mc5,Mc7 square measure operated within the weak inversion region. The ischaemia is employed for measure the present signal to voltage signal. The ECoG signal is perceived and amplified by the CMFEA and also the amplified signal is measured by the CRO. From the CMFEA, the low frequency neural signals square measure amplified rejecting the noise obtained by the conductor tissue interface. The low pass discontinue frequency is given by $f_{LP} = \frac{I_{fil}}{2\pi\pi n_T C fil}$

(1)

Where I_{fil} is current of M_{c7} and M_{c8}

U_T is the threshold voltage

C_{fil} is the capacitor used in the current mode filter

The proposed CMFEA can retain the advantages of low power consumption and low power supply in current-mode circuits. It also has a good noise rejection capability. The low-pass cutoff frequency given by Equation 1 of the CMFEA can be tuned from 1 kHz to 10 kHz.

E. Equivalent electrode tissue interface with the CMFEA

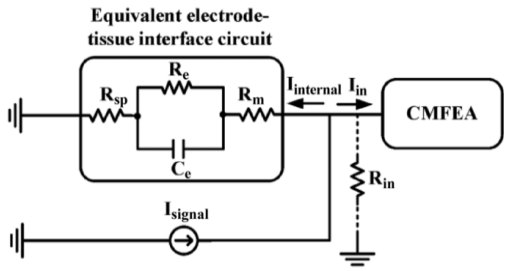

Fig 7:Equivalent Electrode Tissue Interface with the CMFEA

In Fig 7, R_{sp} is the spreading resistance between electrode and tissue

R_e Resistance of the electrode-tissue interface

C_e Capacitance of the electrode-tissue interface

R_m is the resistance of the electrode

V_{in} is the neural potential signal

R_{in} is the input impedance of the CMFEA

I_{in} is the current signal injecting into the current-mode preamplifier

$I_{internal}$ is the internal signal current flowing through the interface circuit.

The DC offset current is set by the resistance of the electrode-tissue interface and also the input resistance of the preamplifier moreover because the dc offset voltage across of the electrode-tissue interface as shown in Figure and also the input dc offset voltage of the preamplifier[11]. generates a dc offset current once a dc offset current is given to the preamplifier.The feedback circuit is meant to bypass ninety nine of input dc offset current.The amount of bypass current may be derived as

$$I_{bypass} = \frac{R_{M1} g_{mx} A_{fed}}{1 + R_{M1} g_{mx} A_{fed}}$$

Where

R_{M1} is the resistance of M_{n1}, M_{p1}

g_{mx} - transconductance of M_X

A_{fed} - gain

I_{OS} - input dc offset current

III RESULTS AND DISCUSSIONS

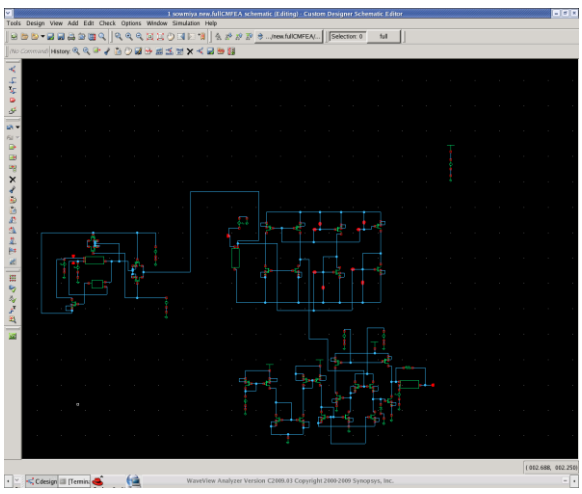

Fig 8:Schematic of CMFEA

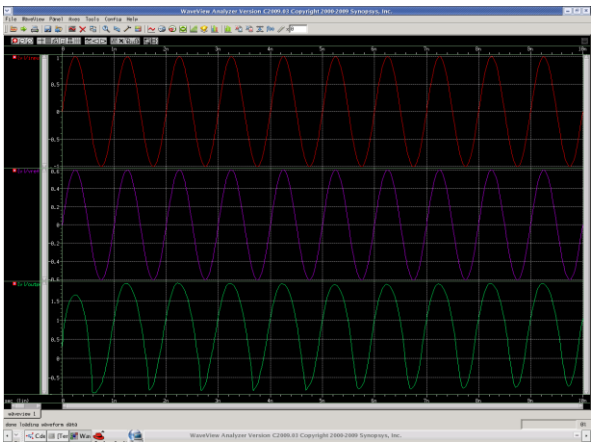

Fig 9:Output of CMFEA

TABLE 3
PERFORMANCE COMPARISON OF CMFEA WITH OTHER VOLTAGE MODE CIRCUITS

Topology	Current Mode	Voltage Mode
Technology	90 nm	1.5µm
Supply Voltage	1.2 v	±2.5 v
Gain	40 (dB)	39.5(dB)
Power consumption	1.84nw	80µw

The schematic of the present Mode forepart electronic equipment is drawn exploitation the Synopsys Custom Designer tool. The scheamatic of the CMFEA is as shown in figure eight consisting of preamplifier to amplify the flowing in dc current rejecting the dc offset,programmable current gain stage and current mode filter. The input to the preamplifier is Vin = 2v and Vref = one.2 v, the output obtained for the CMFEA is Vout= a pair of.86v.The gain of the electronic equipment is meant to be forty sound unit. The positive slew rate of the op amp utilized in the preamplifier stage is five.66G and negative slew rate is concerning -4.83G.

IV.CONCLUSION AND FUTURE WORK

The forepart Ampifier is meant to amplify the low amplitude neural signals exploitation 90nm technology. for various neural signals each information measure and current gain square measure the tunable factors. The forepart electronic equipment features a sensible noise rejection capability compared to different voltage mode circuits utilized in the neural signal recording. Since this planned electronic equipment has low input resistivity, it ends up in low input noise voltage. The dc offset current flows into the low-frequency feedback path and is rejected while not moving the in-band signal from the conductor tissue interface. so reducing the noise generated from the conductor tissue interface. This planned electronic equipment may be applied to animal testing to live the epileptic ECoG of rats. This can be additionally enforced in EEG signals for measure the seizures.

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