DESIGN OF THE FULLY DIFFEERENTIAL CURRENT MIRROR OTA 45nm TECHNOLOGY FOR DETECTION OF ECG SIGNAL

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Abstract:
This study ensures that the electrocardiogram (ECG) signals and arythmias are tracked and controlled analogically at the forefront. In line with ECG signal collection schemes, AFE uses methods for medium to minimal architecture and heavy voltage rise to minimize power consumption as well as lower input noise requirements. The AFE has been constructed by a three variable AC-presenting a wide spectrum of biofunctions. AFE is being implemented via 130 nm CMOS and has a mid-tunable increase of between 31 and 52 dB with tunable low-pass frequencies and frequencies of high-pass portion. The electricity at 68 nWconsumes just 0,5 V of the input impedance for feedback-reference noise of about 2,8 µVrms, as well as a power output factor (POF). The 68nW AFE low noise was also combined with an ECG bio signals physiological control system. The ECG data from the AFE was tested by monitoring techniques for heart rate detection

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1. Introduction :

ecg systems are cost-effective wireless portable systems. it is easier for cardiovascular disease treatment to collect and forward the ecg data directly to the physician. the ecg devices are easy to use and they are both convenient and advantageous in case of emergency. high intensity sports, in

which many athletes die of sudden heart arrest are one of the main sports activities like soccer and marathon for example. an ecg tracking system embedded in the shirt offers greater protection in real time. at the same time, it will help them monitor the shift in the incidence of the ecgs and other diseases caused during the case. they will develop their sports. a heart attack is due to the malfunctions of the electrical system of the heart, which can typically be detected by the ecg because of irregular heartbeats. soccer, basketball, cycling, running and other sporting activities may be these spor ts events. both signals are of a physical type in biomedical applications. high frequency organic medical signals with millivolt noise. these signals are translated by sensors into electric signals. the sensor system requires the sensing of human body's biomedical signals, including electro encephalography (eeg), electro cardio graphy (ecg), electro myography (emg) (emg). the best way to diagnose cardiac abnormalities is known as an ecg. the available ecgs range from ecg recording devices with single to 12 leads. the acquisition instruments of the hospital ecg are typically broad and facilitate high-precision and long-term monitoring. although they restrict the mobility and participation of the patients. wearable health surveillance systems, on the other hand, allow patient monitoring by using several sensors in real-time. the data acquisition process, which represents the first stage/process in ecg monitoring systems' lifecycle, includes selecting: (1) the sensor types (e.g. wireless, or wired), (2) the sensor placement location, (3) the sensor number, and (4) the hardware needed for data acquisition, storage, and transmission. however, real-time and continuous acquisition of ecg sensors is handled in some ecg monitoring systems.

2. Literature Review :

In a nutshell, most Indians are not able to affirm that they will be vulnerable to higher risks in future without preventive cardiac treatment. Around 69 percent of village dwellers and rural healthcare needs for the growth, installation and proliferation of remote wireless ECG self-sufficiency monitoring systems, due to insufficient and inequitable infrastructure, along with qualified medical personnel. The recent popularisation in the global healthcare market of the all-round, predictive, preventive and customized ECG surveillance systems has inspired a small, ultra-low-powered and self-powered fronts. The increased costs of IC (supplying efficient, Devices for non-invasive physiological systems have been encouraged by the availability of high-performance microcontrollers and radios at low prices, advent-friendly advanced sensor technologies, broadband deep drilling across all strata of society, and a market pull for wearable biomedical devices. Costs per feature are falling at an exponential rate. A similar trend ushers in the Internet of Things (IoT), which is defined as the deployment of dispersed sensors and actuators that interact with one another. In addition, personal health services are available (eHealth, mHealth, u-Health, e-Rx, telemedicine etc.), require the creation of WLANs to collect and analyze many biosignals in the daily routine of the users. There are various solutions available for WBSN applications that are multichip prototyped, but they are relatively bulky and undergo too high power dissipation. A universal platform incorporating different wearable

biomedical sensors, power harvest module, signal acquisition and digitization block, local low capacity processing unit and low power radio to cater to the various signals in a cost effective way. Long term power autonomy limits the battery's size and weight. A small battery needs regular replacement and decreases the user comfort while the large battery improves the soC form factor (to make it wearable or disobtrusive). Power dissipation is accomplished by using the following I reducing supply voltage; (ii) minimizing data rates by extracting or compressing data; (iii) on-chip data transmitters; and (iv) by using ultra-wide-band radio impulses (UWB) transmitters to improve power efficiency. This reduction can be achieved by using one or more of the following techniques.

The supply voltage is being decreased as CMOS technology advances, reducing the voltage headroom for an IC's analogue block . Although, in digital circuits, technological scaling results in reduced power consumption and better performance. The analogue portions of an IC's signal-to-noise ratio (SNR), dynamic range, and gain are all adversely affected. Dynamic range needs typically influence the power consumption of a signal processing system. The dynamic range is the ratio of the biggest signal that the system can handle without substantial distortion to the smallest discernible signal defined by the input-referred noise. As a result, finding innovative designs that utilise more digital blocks is important. Other problems, however, must be solved before going forward with a completely digital implementation.

Advances in CMOS technology, communications, and low-power circuit design techniques have sparked a lot of interest in biopotential signal acquisition devices like electrooculography (EOG), electroencephalography (EEG), electrocardiogram (ECG), electromyography (EMG), and axon action potential (AAP) (AAP). The amplitude and bandwidth of biopotential signals vary from tens of volts to tens of millivolts, and from DC to a few kHz, respectively.

Generally, the recorded ECG signal is polluted by several kinds of disturbances and artefacts that may occur inside the ECG signal's frequency range, altering the signal's properties. As a result, extracting meaningful information from the signal is challenging. Because of poor grounding, power line interferences include 60 Hz pickup (in the United States) or 50 Hz pickup (in India). At 60 Hz/50 Hz harmonics, it appears as an impulse or spike, with subsequent spikes at integral multiples of the fundamental frequency. It has a frequency content of 60 Hz/50 Hz, and the amplitude of its harmonics may be up to 50% of the peak-to-peak ECG signal amplitude . The power line interferences may be removed with a 60 Hz notch filter . Coughing or inhaling with significant chest movement, or moving an arm or leg in the case of limb-lead ECG collection, may induce baseline drift in chest-lead ECG readings . Variations in temperature and bias in the instruments and amplifiers may induce baseline drift. It has a frequency range of around 0.5 Hz. A high pass filter with a cut-off frequency of 0.5 Hz is employed to eliminate baseline drift .

Motion artefacts are transitory changes in baseline caused by electrode skin impedance when the electrode is moved. It may provide a signal with a higher amplitude in an ECG waveform . This artefact has a peak amplitude of 500 percent of the Peak to Peak ECG amplitude and a period of 100–500 ms [9]. Motion artefacts may be removed with the use of an adaptive filter. Muscle contraction is usually caused by electrical activity in the muscle. Muscle contraction signals are thought to represent brief bursts of zero-mean band-limited Gaussian noise . Interferences in the electromyogram (EMG) cause rapid variation that is much quicker than the ECG wave. It has a frequency range of dc to 10 KHz and a duration of 50 milliseconds . A morphological filter of a unit square-wave structure (optimal width is 0.07 s) is employed to eliminate interference caused by EMG .Normal sinus rhythm is the heart's normal rhythm when there is no illness or abnormality in the morphology of the ECG signal (NSR). The heart rate of NSR is usually between 60 and 100 beats per minute. The R-R interval's regularity changes somewhat depending on the breathing cycle. Sinus tachycardia is a rhythm that occurs when the heart rate exceeds 100 beats per minute. This is not an arrhythmia, but rather a natural reaction of the heart to increased blood flow . Bradycardia is a condition in which the heart beat is excessively slow, and it may harm critical organs. When the heart rate is excessively high, the ventricles aren't fully filled before contraction, resulting in decreased pumping efficiency and poor perfusion. The research evaluates performance using the MIT/BIH arrhythmia database . The database includes 48 records, each of which contains two-channel ECG signals for 30 minutes, chosen from 47 people' 24-hour recordings. In the database, there are 116,137 different QRS complexes . The subjects were 25 men and 22 women ranging in age from 32 to 89 years old, with recordings 201 and 202 being from the same male subject. The modified limb lead II and one of the modified leads V1, V2, V4, or V5 are included in each recording. Continuous ECG data are band pass filtered between 0.1 and 100 Hz before being digitised at 360 Hz. Twenty-three recordings (numbered 100–124) are meant to be a typical sample of normal clinical recordings, while the other 25 recordings (numbered 200–234) include complicated ventricular, junctional, and supraventricular arrhythmias. Both timing and beat class information are annotated in the database, which has been validated by independent specialists . The Association for the Advancement of Medical Instrumentation (AAMI) recommends that MIT-BIH heartbeat types be merged . The AAMI guideline emphasises the difficulty in distinguishing between ventricular ectopic beats (VEBs) and non-ventricular ectopic beats . The shape of the ECG waveform and heart rate are both indicators of the condition of the cardiac heart. If correctly examined, an ECG may provide information about a variety of cardiac problems. However, since the ECG is a non-stationary signal, the abnormalities may not be regular and may not appear all of the time, but rather at random intervals during the day. As a result, clinical ECG observation may take several hours and be extremely boring. Furthermore, visual analysis is unreliable, and the risk of the analyst missing crucial information is considerable.

3. Introduction of Biopotential Instrumentation Amplifiers

The "human machine" needs many signals to work properly. They are essential to control and to synchronize the multiple processes that are right now occurring inside our body. Many of these signals are generated autonomously in some organs to maintain vital functions, such as the coordination of the cardiac or respiratory muscles, whereas others are voluntarily generated in the brain. These signals travel through nerves to multiple destinations, e.g., to move the fingers that write the final point of this paragraph. Inside our body, signals are carried by ionic currents that must be transduced to electronic currents in order to be measurable with electronic equipment. This process occurs in the interface between the skin and the electrodes placed to pick up the biopotentials. When standard wet electrodes are used, a metallic electrode is placed on the skin and an electrolyte is added between the electrode and the skin. This simple and usual procedure creates an interface in which complex electrochemical processes take place. A detailed analysis and model of the skin-electrolyte-electrode interface can be found in Valentinuzzi (2004), but for our electronic design purposes it suffices to consider a simplified electrical model.

4. Definition of Problem

The trade in noise power in instrument amplifiers. In several of these publications, the focus on one parameter (noise and power dissipation) is imposed, while the other parameters are reduced to a minimum. Nevertheless, recent work has been motivated by the need for low power and noise ECG systems. And it's critical to have a completely integrated network that can efficiently cover an ECG signal's total frequency range. It requires broad resistors and capacitors to implement the long time-constant, fast moving feature. Several types have been proposed for large resistor application and most need to be paired with a wide capacitor to obtain this constant duration. The challenge is to develop a completely integrated ECG system amplifier, which manages low noise for improved signal reception and low voltage for active monitoring.

5. TRANSISTOR LEVEL IMPLEMENTATION

5.1 Operational Transconductance Amplifier

A common topology for OTA is the OTA mirror. Compared to folded cascode and telescopic topologies, the new OTA mirror provides an advantage over the headroom, and voltage supplies have a low impact on the design of low-power applications. The scheme of the whole OTA differential current mirror .

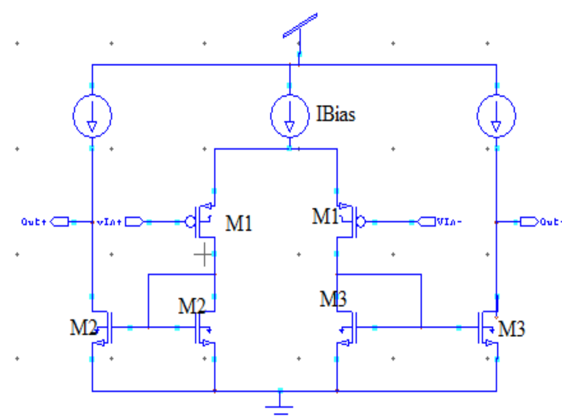

Figure 5.1 The fully differential current mirror OTA

The Gm depends on the mirror ratio, referred to as K. The higher monitoring ratio, the greater Gm, and thus the greater the DC gain. Nevertheless, the increase of K means that the transistor of mirror is increased proportionally, and thus the parasites of the mirror node are decreased and the bandwidth is decreased. Rising the K factor also means increasing the OTA's energy intake.

The performance strength of the OTA is primarily calculated by the performance transistor size and the output power current total. To improve resistance the duration of the transistor might be decreased, but it often raises the parasitic in the output nodes.

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Table 5.1 Transistor dimensions

Device	Dimensions(W/L)
M1	4/1
M2	4/1
M3	4/1
M Ibias	8/1

5.2 The Common Mode Feedback:

For full variable amplifiers, the common feedback circuit (CMFB) is needed to stabilizing the amplifier output frequency. It is critical because the DC voltage difference between both outputs is considerably higher due to the high output impedance, which allows the amplifier to be removed and thus drastically deteriorate the performance A standard CMFB circuit seems to have a detector in common mode, which determines the common voltage level of the amplifier. This voltage is returned to the amp in order to correct the error relative to the reference intended. The topology of the CMFB compares all outputs with the correct reference, GND in this case and summarizes and returns errors to the current to rectify errors.

This is an simpler way to implement the CMFB without requiring use of broad resistors and capacitors as conventional detectors that span many areas. The drawback is that all differentiated pairs require same CMFB circuit loop efficiency as the initial amplifier. Thus ON resistance and the parasite capacitance of the modulator switches are important factors for the design of transistors for a chopper. A short device duration is required to achieve a low ON resistance that reduces residual offset substantially. A small ON resistance also results in more reductions and a decrease in the resulting residual compensation. The resistance to switching is also a source of noise and should be reduced to a minimum.

The function of the switches is another important issue. To eliminate the load injection that residual opposite output, the NMOS or PMOS option is compared to a CMOS option. However, this often improves the capacity of bacteria, owing to the amount of computers. A basic NMOS is preferred offering a fair compromise between the dual limitations.

5.2.1 Input ReferredNoise

Equation 41 indicates that the gm of the input devices is the most critical noise parameter. Increasing the gm decreases noise, but increases the tendency, measurements orboth. The use of more than one K factor also decreases the noise. This increases the power consumption and thus contributes to higher parasites in the non-dominant pole position. PMOS input devices with a slightly lower flicker coefficient are used to minimize flicker noise.

5.3 Designing Considerations:

For the MOS transistor the EKV model is described by the following equations

$Ic = I_D / I_S$

$gm = (I_D / n\varphi t) . ((1 - \exp(-\sqrt{IC})) / \sqrt{IC})$

$Is = 2\mu Cox(W/L)\varphi^2_t$

Where

I_D= Drain Current; I_S= normalization current ; n= slope factor ; Cox=oxide Capacitance; φ^2_t thermal voltage at room temp; Ic= Inversion Co-efficient

If Ic<<1; transistor operates then in low reverse a rea

Ic>>1; then transistor operates in the high revers e zone region.

5.4 Critical LayoutIssues

The parasites of the input chopper, balancing with two input and feedback condensers configuration of OTA, constitute the most important considerations.

For the chopper data, a great deal of effort is made to eliminate parasite misalignment by making the layer routings similar for all switches. The variations in the parasite capacities of input chopper can lead greater cuts and the residual offsets.

Another significant feature of the OTA architecture is the input power control due to parasites. The goal is to eliminate parasites to ensure exact performance of the topology as much as possible. As mentioned earlier, because of the breaks in the simulated nodes, the input capacity explicitly affects the parasitic resistance. This in effect influences the importance of the chosen chopping frequency.

This reveals the predicted mid-band increase of 48dB with the 0.06Hz to 100Hz frequency, the estimated ECG applications frequency range. Nevertheless, the low frequency is restricted by the parasite resistance caused by cuts. The device's frequency reaction without all the cuts shows that same early-band gain, however the small chopping frequency is 0.006Hz, which has been under ten years. It indicates the frequency response of the instrument amplifier without cuts.

The response to a 2mVpp sinusoidal signal at 10Hz from the instrument amplifier. It displays a signal with a 100V / V gain and little noise.

The machine CMRR plot values for the specified bandwidth range from 78dB to 95dB and it is good enough for this submission. Good CMRR is possible with existing instrument feedback amplifiers.

OUTPUT RESULTS

Table 5.2 Output Results

Parameters	Result
Gain	42db
Bandwidth	0.005-100Hz
CMRR	>75dB
Input Referred Noise	1.1µVrms
Power Consumption	0.271µW

Conclusion:

The instrument amplifier consumes 2.8uW of power with a mean bandwidth gain of 40dB and a bandwidth of 0.05-100Hz. The average frequency amplitude is 1.2µVrms with a flicker angle reduced to 1kHz.

As a result, the efficacy of this amplification is limited by the OTA virtual node cutting stage, which is parasitic resistant. The required choice of input power and the frequency of cuts reduces its effect on the amplifier. However, a compromise between noise and noise and an excellent balance is needed in order to achieve maximum performance. The instrumentation amplifier was planned for the 0.5µm CMOS ON semiconductor cycle.

In certain ECG monitoring and recording systems, this amplifier could be used as a FE amplifier to manage the cardiac signal in the presence of very low noise, thereby retaining a long service life.

References :

[1.] K. A. Ng and P. K. Chan, "A CMOS analog front-end IC for portable EEG/ECG monitoring applications," *IEEE Trans. on Circuits and Systems I: Regular Papers,* ,vol. 52, pp. 2335-2347,2005.

[2.] B. Razavi, *Design of Analog CMOS Integrated Circuits*. New York: McGraw- Hill Science/Engineering Math,2001.

[3.] M. S. J. Steyaert and W. M. C. Sansen, "A micropower low-noise monolithic instrumentation amplifier for medical purposes," *IEEE J. Solid-State Circuits,* ,vol. 22, pp. 1163-1168,1987.

[4.] C. C. Enz and G. C. Temes, "Circuit techniques for reducing the effects of op- amp imperfections: autozeroing, correlated double sampling, and chopper stabilization," *IEEE Proceedings,* vol. 84, pp. 1584-1614,1996.

[5.] M. A. T. Sanduleanu and E. A. J. M van Tuijl, *Power Trade-offs and Low-power in Analog CMOS ICs*.

[6.] Dordrecht : Kluwer Academic Publishers,2003.

[7.] A. Papoulis, *The Fourier Integral and Its Applications.* New York: McGraw-Hill, 1962.

[8.] J. Huijsing, "Low noise and low offset operational and instrumentation amplifiers," in *Operational Amplifiers,* 2nd ed., Dordrecht: Springer, 2011, pp. 355-391.

[9.] J. F. Witte, K. A. A. Makinwa, and J. H. Huijsing, *Dynamic Offset Compensated CMOS Amplifiers*. Boston: Springer,2009.

[10.] K. Jordy, "Low-power amplifier chopper stabilization for a digital-to-analog converter," Thesis, MIT, Cambridge, MA, August2008.

[11.] J. G. Webster, Medical Instrumentation: Application and Design, 4th ed. Wiley John Wiley & Sons, INC., 2009.

[12.] S. S. Rajput, A. Singh, A. K. Chandel, and R. Chandel, "Design of Low-Power High-Gain Operational Amplifier for Bio-Medical Applications," in 2016 IEEE Computer Society Annual Symposium on VLSI, 2016, pp. 355–360.

[13.] K. D. Wise, "Silicon Microsystems for Neurosicence and Neural Prostheses," IEEE Engineering in Medicine and Biology Magazine, vol. 24, no. 5, pp. 22–29, 2005.

[14.] K. A. Ng and Y. P. Xu, "A Low-Power , High CMRR Neural Amplifier System Employing CMOS Inverter-Based OTAs With CMFB Through Supply Rails," IEEE JOURNAL OF SOLID-STATE CIRCUITS, vol. 51, no. 3, pp. 724–737, 2016.

[15.] J. Magri, I. Grech, O. Casha, E. Gatt, and J. Micallef, "Design of CMOS Front-End Circuitry for the Acquisition of Biopotential Signals," in 2016 IEEE International Conference on Electronics, Circuits and Systems (ICECS), 2016, pp. 161–164.

[16.] L. Magnelli, F. A. Amoroso, F. Crupi, G. Cappuccino, and G. Iannaccone, "Design of a 75-nW, 0.5-V subthreshold complementary metal – oxide – semiconductor operational amplifier," Internation Journal of circuit theory and applications, vol. 42, no. 9, pp. 967– 977, 2014.

[17.] K. Pratyusha, S. Kumar, and A. Kumari, "Low Power Amplifier For Biopotential Signal Acquisition System," in 2015 International Conference on Advances in Computing, Communications and Informatics (ICACCI), 2015, pp. 324–329.

[18.] Y. Tsividis and C. McAndrew, Operation and Modeling of the MOS Transistor, 2nd ed. Oxford university press, 2011.

[19.] G. Palmisano, G. Palumbo, and S. Pennisi, "Design Procedure for Two-Stage CMOS Transconductance Operational Amplifiers : A Tutorial," Analog Integrated Circuits and Signal Processing, vol. 27, no. 3, pp. 179–189, 2001.

[20.] M. Alioto, "Understanding DC Behavior of Subthreshold CMOS Logic Through Closed-Form Analysis," IEEE transaction on circuits and systems, vol. 57, no. 7, pp. 1597–1607, 2010.

[21.] C. Yadav and S. Prasad, "Low Voltage Low Power Sub-threshold Operational Amplifier in 180nm CMOS," in 2017 Third international conference on sensing, signal processing and security (ICSSS), 2017, pp. 35–38.