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Design of CMOS Instrumentation Amplifier for ECG Monitoring System Using 0.18 µm Technology

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1. Abstract
This paper presents the features of Instrumentation Amplifier for biomedical applications. This Instrumentation Amplifier is a device created from Operational Tran conductance Amplifier. It is designed to have input high impedance , output low impedance, low DC offset, low noise , high common mode rejection ratio and high power supply rejection ratio. The circuit has been integrated in a 0.18µm CMOS technology. Its features are a open loop gain of 20 db with a 0.23KHz bandwidth , CMRR of 124 dB , PSRR of 65 dB, DC offset of 0.3mV .The integrated CMOS amplifier operates to 1.8V power supply . The design and Simulation of this IA is done using CADENCE Spectre environment with UMC 0.18µm technology file. This Instrumentation Amplifier having power dissipation of 0.52 mW.

Keywords: Ana log IC design, OTA, Instrumentation Amplifier, CMRR, and PSRR.

2. Introduction
Due to recent development in VLSI technology the size of transistors decreases and power supply also decreases. The OTA is a basic building block in most of analogue circuit with linear input-output characteristics. The instrumentation amplifier is essential element at the read out circuit of any system that deals with low level signals .Differing from a general purpose the instrumentation amplifier, must be capable of rejecting common mode signals. OTA using a current division technique is employed to small trans conductance, which needs only a small capacitor in HPF such that the integration on silicon is highly feasible.

3. Circuit Implementation
3.1 OTA Design:
Design of OTA: Figure 1 shows the schematic diagram of Operational Tran conductance Amplifier (OTA). In this OTA the supply voltage is V_{dd}= 1.8V .An ota usually has very smaller Gm. It is based on a current divison voltage-to – current converter technique, as shown in figure. The source – Drain voltage of MC1 is adjusted by tuning MC1's size such that MR1 and MR2 are biased in liner region. The differential voltage, (V1-V2) is converted to current, respectively flowing across MR1 and MR2. The sizes , of MM_1 and MM_2 must be much larger than M1_1 and M1_2 such that the divided currents of M1_1 and M1_2 are smaller than the currents of MM_1 and MM_2. The Transistor M13 is an Output amplifier stage. The design parameters of this OTA are shown in below table I.
There are several different OTA's are used in which this OTA is a simple OTA with low supply voltage and high gain. The OTA is characterized by various parameters like open loop gain, Bandwidth, Slew Rate, Noise and etc. The performance Measures are fixed Due to Design parameters such as Transistors size, Bias voltage and etc. In this paper we describe design of OTA amplifier and this design is done in 0.18µm technology.

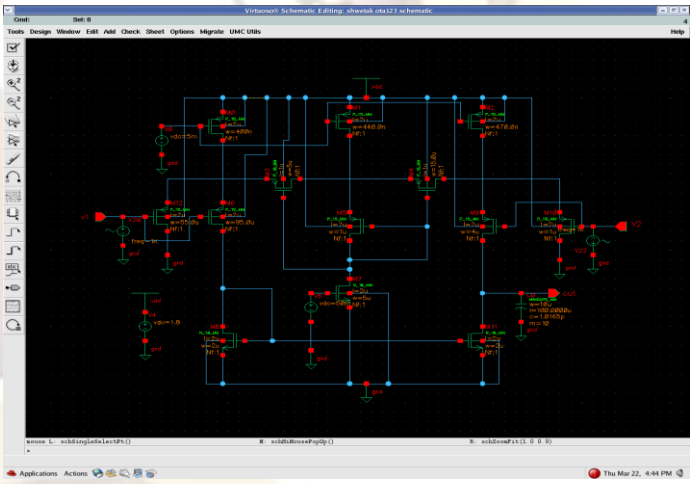


Figure 3.1 Schematic of CMOS OTA

TABLE I CMOS Transistor sizing for CMOS OTA design

Device	W/L(µm)
M1,M2,M3	40/0.6
M4,M5	20/0.6
M6,M7,M8,M9	42/0.6
M8,M9	50/0.6
M10,M11	60/0.6
M12,M13	0.8/0.6

4. Result of OTA

4.1 Gain and Phase of OTA

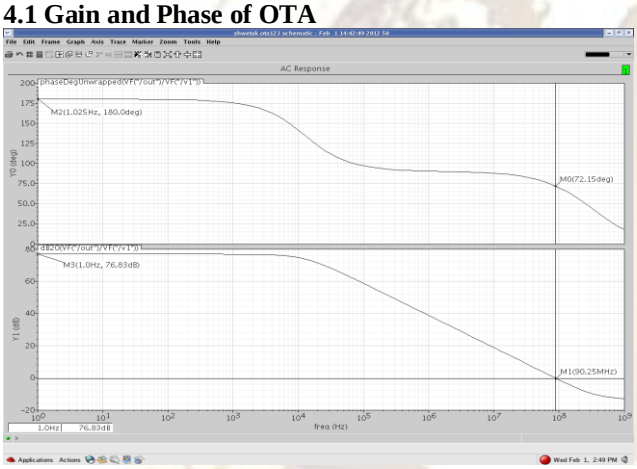
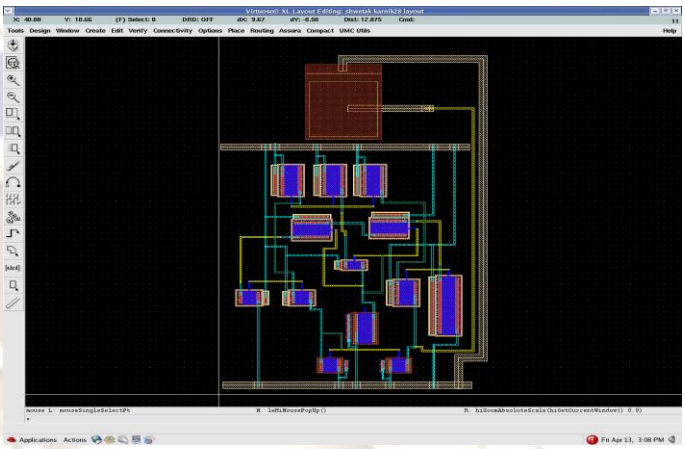


Table.4.1 SUMMARY OF EXPERIMENTAL RESULTS

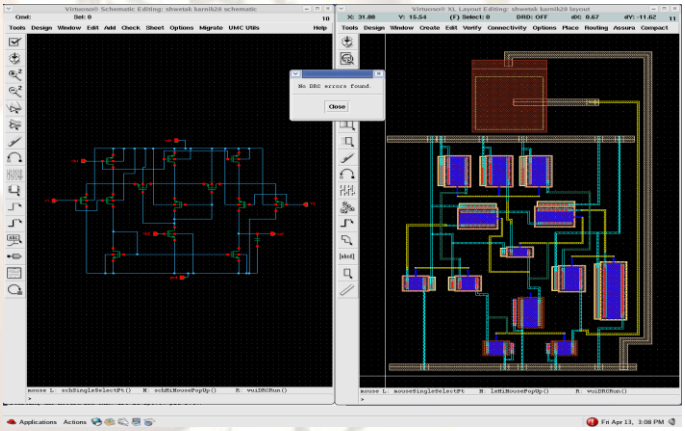
TABLE II
SIMULATED CHARACTERSTICS OF OTA

S.NO.	Experimental	Results Value
1	Open Loop Gain	76.83dB
2	3dB Frequency	31.41kHz
3	Unity Gain Frequency	90.25MHz
4	Slew Rate	2.344V/usec
5	Power Dissipation	0.74mW
6	Load Capacitance	0.1pF
7	PSRR	80dB
8	CMRR	91dB

4.2 Layout of OTA:



4.3 DRC (Design Rule Check) of OTA:



5. Architecture Instrumentation Amplifier

Figure 5.1 shows the schematic of instrumentation amplifier for biomedical applications. This instrumentation amplifier based on OTA , which actually could accomplish the desired features of high common mode rejection .The Instrumentation Amplifier is based on a current-balancing technique . The differential inputs voltage, Vin1 and Vin2, are converted into a Differential Currents, I_g, flowing across resistor R_g in Tran conductance stage. By the current mirror composed of M5-M16, I_g is mirrored to be is in Tran impedance stage. Then, the mirror current, Is, is converted into a voltage by flowing across resistor Rs. The design works with a 1.8 V power supply, to ensure optimum working point. Its function produces output voltages that are difference

between the two input terminals, multiplied by the gain. For our purpose , the Biomedical application will be represented by the gain of the device , thereby applying a signal at the non-inverting input of the amplifier.

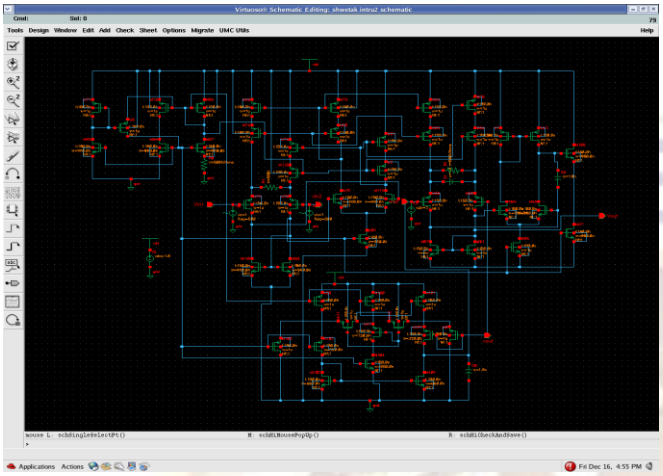


Figure 5.1 Schematic of Instrumentation Amplifier

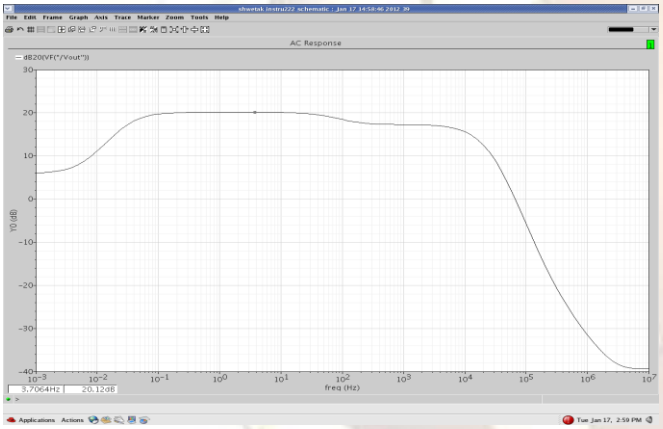


Figure 5.2 AC response of IA for the measurement of open loop gain and 3-dB Bandwidth

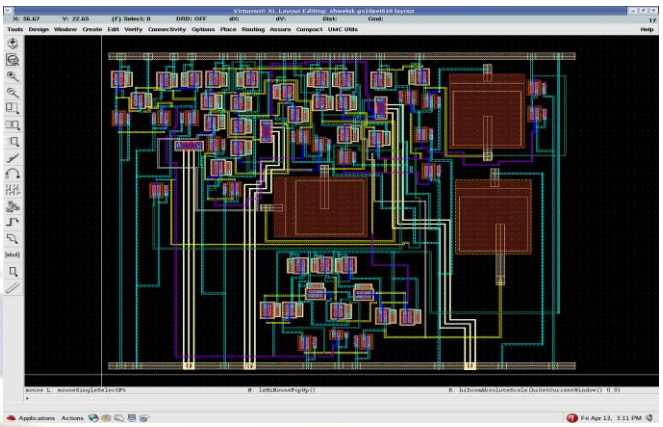


Figure 5.3 Layout of Instrumentation Amplifier

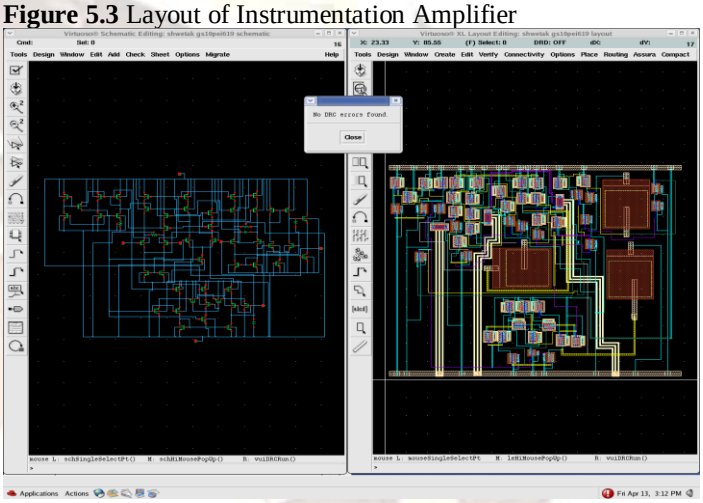


Figure 5.4 DRC (Design Rule Check) of Instrumentation amplifier

TABLE III
SIMULATED CHARACTERSTICS OF IA

S.NO.	Experimental	Results Value
1	Open Loop Gain	20.12dB
2	Input referred noise	160 nV/√Hz
3	Power Dissipation	0.52mW
4	PSRR	65dB
5	CMRR	124dB

Figure 5.1. Schematic on instrumentation amplifier based on OTA .We know that this Gain factor is:

$V_{out} / (V2-V1) = [(1+2R1)/Rgain]* [R3/R2]$

Where R_i is the resistance to the amplifier feeds one and two. Therefore, the differential gain of instrumentation amplifier is determined by the ratio of R_s to R_g.

Ad = [Vout – Vref] / [Vin2 –Vin1]

= is. Rs /ig .Rg = Rs /Rg

6. Conclusion

In this paper we present a Instrumentation Amplifier (IA) topology for low voltage and low power, and ECG Monitoring System applications. This IA can be used in low power, low voltage. High CMRR and PSRR applications such Biomedical instrument and small battery operated devices. It is the schematic of CMOS Instrumentation amplifier using OTA. It has Open Loop Gain 76.83dB.A unity gain frequency is obtained 90.25MHz. . The phase margin is obtained 72.15 degree. . There is the plot of power supply rejection ratio. It recognized that the change in output with power supply is 65dB of instrumentation amplifier. The common mode rejection ratio was found to be 124dB and bandwidth 0.23 KHz, Power Dissipation is 0.52mW. Then, finally Layout of CMOS Instrumentation amplifier for ECG Monitoring System. Therefore, we can finally say that the application of our read-out circuit has high viability to be using in biomedical application.

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