A Low Power, High Gain Miller Compensated Operational Transconductance Amplifier

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Abstract— This paper proposes a 72dB-gain operational transconductance amplifier (OTA) with an enhanced bandwidth and a reduced compensation-capacitor. The proposed OTA expands the bandwidth and decreases the compensation-capacitor in the low-voltage bulk-driven Miller OTAs [1]-[2] by using the indirect feedback compensation method [3]. The proposed OTA was implemented using a 32nm CMOS process. In the simulation, it has a 72dB-gain and consumes 1.94nW at 250mV supply-voltage. The unit-gain frequency is 14kHz. The compensation-capacitor is 0.6pF.

Keywords: Bandwidth, CMOS, Compensation-Capacitor, Low-Voltage, OTA

I. INTRODUCTION

Brain computer interface (BCI) is the technology that decodes the biomedical signals into general human commands. Previously, BCI was studied to provide augmentative communication options for patients with severe motor disabilities such as amyotrophic lateral sclerosis (ALS) [4].

However, at present, BCI applications have been expanded to a category of user interface (UI) that includes not only entertainment but also general equipment. Especially, auditory steady-state response (ASSR), where the electroencephalography (EEG) response to the sound stimulus shows the same frequency on the EEG spectrum as that of stimulus , can be used for the additional modality for UI. Depending on the user's attention to sound stimuli, the signal amplitude of ASSR shows 60% average variation. Due to this characteristic, ASSR can be applied to many of UI fields including smart devices based on the EEG spectrum analysis.

For the ASSR-based UI applications, ear-EEG is considered as superior approach compared to the conventional on-scalp EEG. The OTA(operational transconductance apmlifier) integrated i this BCI interface consuming more power as whole OTA require 4.3 uA of bias current. The supply used is 0.8 V.

So another alternative OTA is shown in this paper with supply of 0.25V and the whole OTA is working at current of 130nA. This OTA is producing gain of 72db with UGB of 14kHz and bandwidth of 11 Hz.

II. PROPOSED OTA

Fig. 1 shows the conventional Miller compensation bulkdriven input OTA [2]. It consists of two stage amplifiers. All transistors in the OTA operate in the weak inversion. all transistors in Fig. 1 are implemented with a self-cascode transistor in Fig. 2 to increase the DC-gain of the OTA. The self-cascode transistor is very effective method to increase the transistor output resistance by reducing the channel length modulation [5], [6].

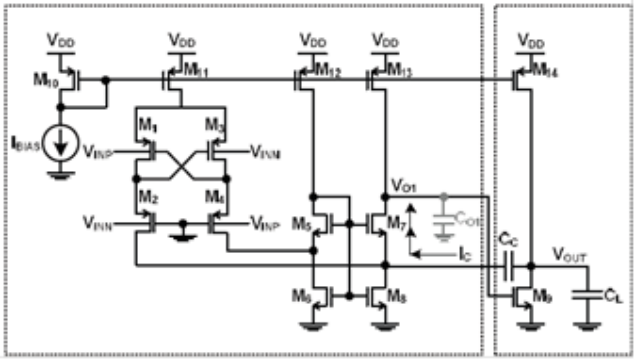

Fig. 1: Circuit Diagram of Proposed OTA

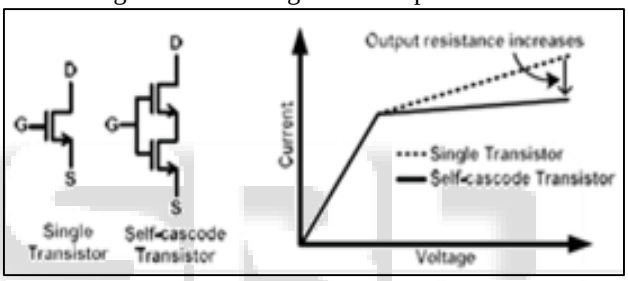

Fig. 2: Self cascade Transistor

To avoid the direct connection, the proposed OTA in Fig. 1 uses the indirect feedback compensation method [3]. This method has no direct connection between the first and second stage outputs.

Therefore, it changes the right-half-plane zero (RHZ) to the left-half-plane zero (LHZ), but it still has the Miller effect to increase CC for the frequency compensation.

III. SIMULATION RESULT

The proposed OTA was implemented in a 32nm CMOS process. The transistor sizes in the OTA are given in Table I. All transistors are implemented with the self-cascode transistor having two same transistors as shown in Fig. 2. The biasing currents are 10nA in M_1~M_8 in the first stage, the bias current is 100nA in M_9 in the second stage. All simulations are performed at 250mV supply-voltage (V_{DD}) and the load capacitor (C_L) is 50pF.

Transistor	Size	Transistor	Size
M_1-M_4	64um/0.2um	M_5,M_7	6.1um/63nm
M_6,M_8	15um/0.2um	M_{10},M_{12}-M_{13}	40um/0.2um,15um/0.2um
M_{11}	80um/0.2um	M_{14},M_9	130um/100nm,16um/100nm

Table 1: Transistor Sizes

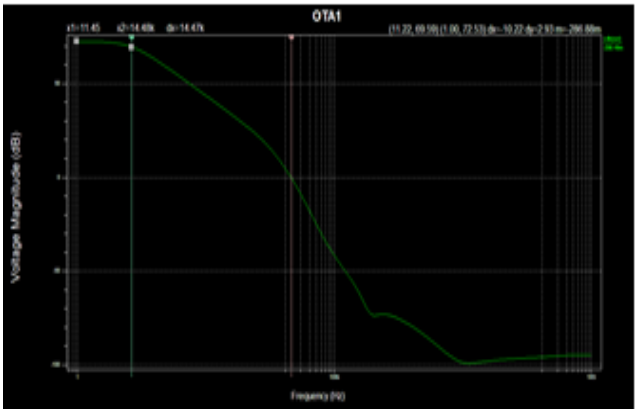

Fig. 3: Frequency response

Fig. 3 shows the simulation results of the proposed OTA with C_C=0.6pF. Table II shows the comparison results of the bulk-driven input OTAs. They have 72dB gain. They consume 1.94 nW at 250mV supply-voltage. The proposed OTA expends the bandwidth from 10Hz to 11.45Hz and the unit-gain frequency from 13kHz to 14.47kHz.

	Previous OTA[4]	Proposed OTA
Process	65nm	32nm
Supply-Voltage	0.8V	0.25 V
DC gain	65db	72db
Power	34nW	1.94nW
Bandwidth	-	11.45Hz
Unit gain frequency	-	14.47 kHz

Table 2: Comparison table

IV. CONCLUSION

This paper proposes the 250mV supply-voltage 72dB-gain OTA with an enhanced bandwidth and a reduced compensation -capacitor. The proposed OTA expands the bandwidth in the low-voltage bulk-driven Miller OTAs by using the indirect feedback compensation method. The proposed OTA was implemented using a 32nm CMOS process. It has a 72dB-gain and consumes 1.94nW at 250mV supply-voltage. Its unit-gain frequency is 14.47kHz, it reduces the compensation-capacitor from 5pF to 0.6pF.

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