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A High Gain Current Mode Instrumentation Amplifier

Vadlamudi Venkateswarlu
Dept. of Electronics and Communication Engineering,
BVC Engineering College, Odalarevu, Amalapuram,
Andhra Pradesh, India

Thoram Saran Kumar
Dept. of Electronics and Communication Engineering,
BVC Engineering College, Odalarevu, Amalapuram,
Andhra Pradesh, India

Abstract: A new current mode instrumentation amplifier is presented in this paper. It contains two current conveyors, one operational transconductance amplifier (OTA) and four resistors. It is designed for getting high gain and common mode rejection ratio. Results of the proposed circuit are tested through CADENCE simulation. Here we have applied a supply voltage ± 2.7 volts to the proposed instrumentation amplifier circuit using Cadence and the model parameters of a gpdk 180 nm CMOS technology.

Index Terms: Operational transconductance amplifier, current conveyer, Current Mode, instrumentation amplifier.

I. INTRODUCTION

An instrumentation amplifier (IA) plays a vital role in many areas such as data acquisition, medical instrumentation and signal processing applications. It needs wide bandwidth and high CMRR to suppress the unwanted common-mode signals[1-2].In instrumentation amplifiers the CMRR is usually considered to be one of most important parameters. The popular voltage mode three-operational amplifier-based topology has some drawbacks because it's CMRR and gain is very low because of resistor mismatching and the bandwidth of instrumentation amplifier is attenuated by the constant gain bandwidth product of the operational amplifiers [3-5]. To overcome these drawbacks we have gone through the current mode instrumentation amplifiers (CMIA). Similar supported current mode versions are Second Generation Current Controlled Current Conveyors (CCII) [20-23], Operational Transconductance Amplifier (OTA) [10-11], Operational Trans-resistance Amplifier (OTRA) [12-15], and Current Conveyors (CC) [16-19]. This proposed current mode instrumentation amplifier is designed by using two current conveyers and one operational trans conductance amplifier because of recent advancement in VLSI technology the size of transistors decreases and power supply additionally decreases. The current conveyer and operational transconductance amplifier are major building blocks in analog circuit design with linear input output characteristics. The instrumentation deals with low level signals .This proposed instrumentation amplifier is very good for rejecting the common mode noise signals and getting high gain compare to normal instrumentation amplifier. Practical application. Here we are using current subtraction mechanism[26] for getting high CMRR and that amplifier is redrawn in Fig. 1. But the use of operational amplifier limits the CMRR of this IA. In this paper, A further improved version of CMIA is reported in shown in Fig 1.

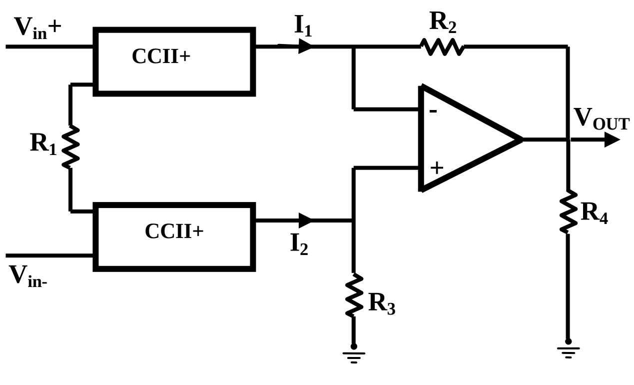

Figure 1: Current mode instrumentation amplifier

The present paper is constructed as follows: Section II gives the information about second generation current conveyers (CCII). Section III gives the information about the operational transconductance amplifier (OTA).Section IV

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presents the details of proposed current mode instrumentation amplifier. Section V gives the information about the simulated results and conclusions are drawn in section VI.

II. CMOS CURRENT CONVEYOR

It is an active building block for implementation of analog circuits and systems. Generally, current conveyers are 3 types:

First generation current conveyor (CCI), Second generation current conveyor (CCII), and Third generation current conveyer (CCIII).

In 1968 Sedra A and Smith, K C introduced the current conveyor [6]. In 1970 they had introduced second generation current conveyor[7]. It is nothing but reformulated the first generation current conveyor. A current conveyor is a major building block similar to an operational amplifier. By using current conveyers we can implement several useful analog subsystems such as amplifiers, integrators and rectifiers with the conjunction of other components such as resistors, capacitors and diodes. The CCII is a three terminal device, it can be represented by the black box fig .2 with the three ports denoted by X, Y, and Z. By using hybrid matrx we can represent the terminal characteristics by giving the outputs of the three ports in terms of their corresponding inputs [24]. The build block of current conveyor is shown in fig.2.

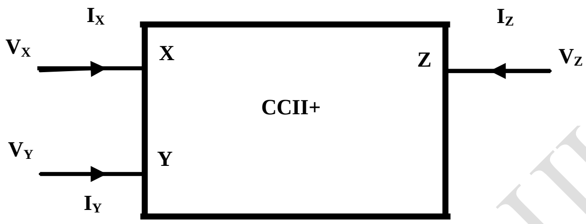

Figure 2: Symbol for CCII+

The port relations of CCII+ can be

$$\begin{bmatrix} I_y \\ V_x \\ I_z \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 \\ 1 & 0 & 0 \\ 0 & \pm 1 & 0 \end{bmatrix} \begin{bmatrix} V_y \\ I_x \\ V_z \end{bmatrix}$$

In circuit design impedence is considering as the finite value. Here a voltage is applied at node Y, that voltage is same at node X, just like virtual short on an operational amplifier. Also, when a current is injected into node X, that same current gets copied into node Z. The notation CCII+ denotes a positive Z output current conveyor, similarly CCII- denotes a negative Z output current conveyor.

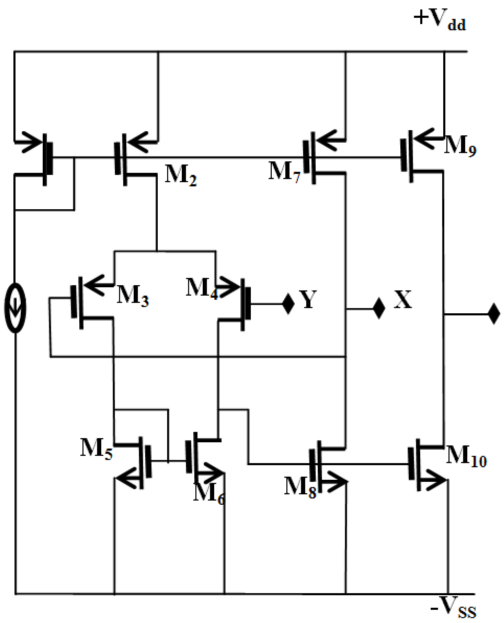

Figure 3: Device level presentation of the CCII+

III. CMOS OPERATIONAL TRANSCONDUCTANCE AMPLIFIER

In analog design the operational transconductance amplifier (OTA) is one of the major building block. The OTA contains differential input pair and current mirrors. In OTA the differential input voltage produces an output current, so we can called it as a voltage controlled current source (VCCS). In OTA there is an additional input for a current to control the amplifier's Trans conductance. The OTA is same as standard op amp in that it has a high impendence differential input stage and it can be used with negative feedback [8-9]. In OTA the transconductance can be controlled by changing the external dc bias voltage or current. It can work at high frequencies. Present OTA based high frequency integrated circuits, filters and systems have been widely used. The output equation is:

$I_{out} = g_m(V_{1+} - V_{1-})$

where, V_{1+} is Non inverting input, V_{1-} is Inverting input, I_{out} is output current. The above equation can be rewrite as

$$I_{out} = g_m V_{in}$$

Here, the trans conductance g_m as the proportionality factor between the two inputs and it is also a function of the input differential voltage. The fig 4 shows the equivalent diagram of OTA.

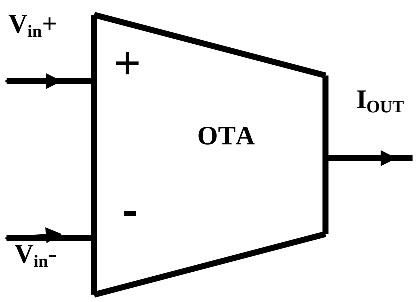

Figure 4: Symbol for OTA.

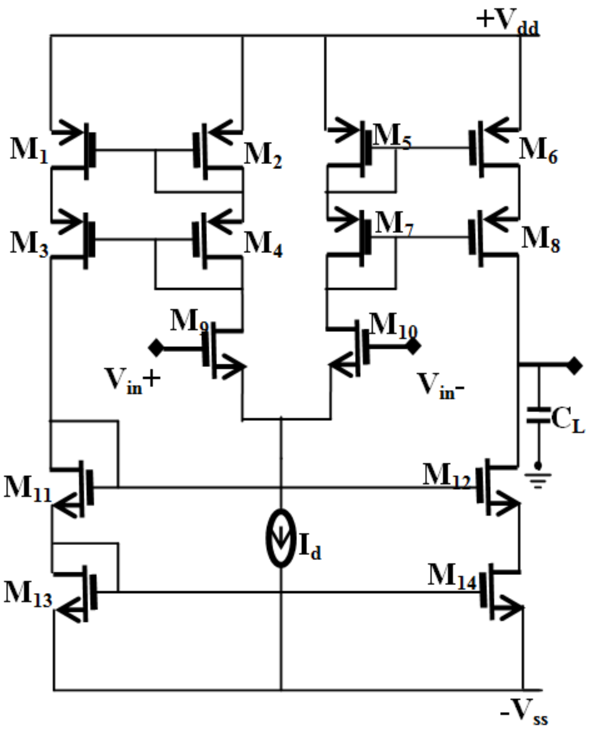

Figure 5: Device level presentation of the OTA

IV. PROPOSED INSTRUMENTATIONAL AMPLIFIER

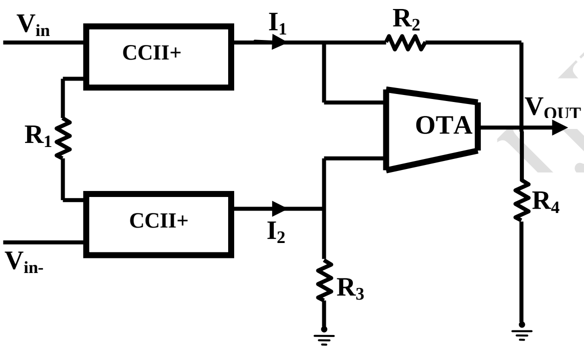

Figure 6:Proposed instrumentation amplifier

In this proposed current mode instrumentation amplifier we are using two current conveyers and one OTA. Where we have applied input to the two current conveyers high input impedance terminals and taken the output from OTA. Here OTA acts as a voltage amplifier by connecting R_L. So output also can be measured in terms of voltage .By using two conveyers topology we will get only a small gain. When we have used OTA cascading to the CCII topology, then only we can get the high gain and CMRR.

Gain =V_{out}/V_{in}

Here,$V_{in}=V_{in+}-V_{in-}$

CMRR=20 log(A_d/A_c)

In this circuit different sinusoidal voltages applied to two current conveyers high input terminals, then we would get higher gain in terms of sinusoidal voltage .This process is known as differential mode of operation(Ad).

Both input terminals of the instrumentation amplifier are connected together, then we will calculate common mode gain(Ac) .

V. SIMULATION RESULTS

For getting simulation results we are applying sinusoidal input wave forms with a frequency of 1 KHz and amplitudes 5mv, 6mv. The supply rail voltages are +2.7 V for $+V_{dd}$ and -2.7 V for-$V_{SS.}$ The circuit is suitable for high gain and high CMRR applications. To design such type of circuits by selecting above supply voltages.

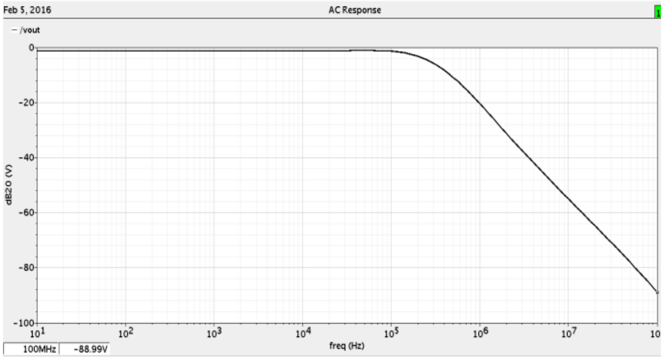

Figure 7: Differential voltage gain of proposed instrumentation amplifier

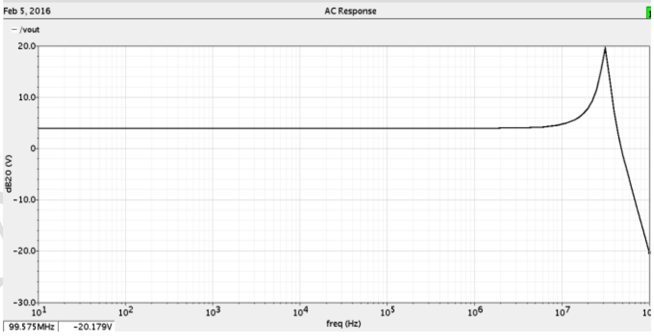

Figure 8: Common mode voltage gain of proposed instrumentation amplifier

Simulated parameter	Fig 1	Fig 6
Voltage Gain	70dB	88dB
CMRR	116dB	128dB
V_{DD}=-V_{SS}	2.7 V	2.7 V

Table 1: Comparision between the proposed instrumentation amplifier (fig 6) and current mode instrumentation amplifier (fig 1)

VI. CONCLUSION

Current mode circuits are most widely used operational devices in continuous time and current mode signal processing. By using single OTA and two current conveyor we have designed new current mode based CMOS instrumentation amplifier. The circuit is designed in 180 nm CMOS technology at a supply voltage of ± 2.7 V. The amplitude of the proposed circuit inputs are very low but we could get high output voltage because of current mode circuit. The main features of our proposed design includes high CMRR and high gain.

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