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Telescopic Ota Based Cmos Design of High Gain, High Cmrr, Larger Bandwidth Instrumentation Amplifier

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Abstract: ***Instrumentation amplifiers (IA) play a crucial role wherever small differential voltages need to be amplified precisely in the occurrence of a any voltage at the input. It must therefore attribute high input-impedance, small input-referred noise and offset voltage, large differential-voltage gain without feedback and significantly cast-off deviations on power-supply and common mode voltages. In this paper efficient instrumentation amplifier with high gain, high CMRR and larger bandwidth is implemented. The proposed differential amplifier may be used for various control systems as well as small signal conditioning circuits; instrumentation amplifier having larger product of gain and bandwidth would encounter maximum application in these desires.***

Keywords: CMRR, Telescopic OTA, GBW.

I. INTRODUCTION

Instrumentation amplifiers, usually known as differential amplifier are significant blocks which are used for signal conditioning in many instrumentation systems. Instrumentation Amplifier van be design with Op-amp, differential difference amplifier (DDA), Constant Current draw amplifier (CCDA), operational transconductance amplifier (OTA) [3]. Basically instrumentation amplifier (IA) is a class of differential amplifier which is set with the input buffer amplifiers, which get rid of the require matching of I/P impedance and therefore design amplifier predominantly appropriate for application in measurement in the control system. Additional description consist of , reduced noise, large open-loop gain, small DC offset, low drift, high common-mode rejection ratio and large input impedances.[6

A. Instrumentation amplifier Vs Op-amp

In comparison with an op amp, an instrumentation amplifier is a closed-loop amplifier with single ended respect to the reference terminal and having differential I/P and O/P. Generally, impedances seen in 2 – terminals of the instrumentation amplifier are very high on average, $10^9\Omega$, or larger. Consequently, for high input impedance, the input biasing current must be very low and in the range of average 1 nA to 50 nA. The output impedance of op- amp is usually very low which is practically, in few milliohms if the frequencies are low. When comparison is done between the two, the op-amp require a an external resistance in its feedback path for the calculation of closed loop gain whereas in an instrumentation amplifier a network of internal feedback resistance is connected. [1]

B. Signal Amplification and Common-Mode Rejection

It is the virtue of an instrumentation amplifier that it amplifies the difference between the two signals given at its input and along with amplification it tries to nullify the common signal between them. The common signal between the two input terminals is rejected by the amplifier and it is very important characteristic of an IA. The instrumentation amplifiers can boost the weak signal coming from any transducer or any other sources. Common-mode rejection Ratio (CMRR), the quality of cancelling the common signal between the two differential input and it plays a crucial role while analyzing the response of the instrumentation amplifier. CMRR is quite important specification of IA for both DC & AC signals. A good quality instrumentation amplifier can shortened any error due to dc common mode voltage 80dB to 120dB. Today's IA have outstanding CMRR for both dc & ac input signals.

Mathematically, common-mode rejection of differential amplifier can be calculated as:

$$\mathbf{CMRR = 20\ Log\ \frac{A_d}{A_c}}$$

Where A_d is the differential gain; A_c is the common-mode gain of amplifier. [1]

II. CHARACTERISTICS OF HIGH QUALITY INSTRUMENTATION AMPLIFIER

For larger common mode rejection ratio, an instrumentation amplifier needs the following properties:

1. High AC as well as DC Common-Mode Rejection(CMRR)
2. Low Offset Voltage and Offset Voltage Drift
3. Low Noise
4. Low Nonlinearity
5. Adequate Bandwidth

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III. DESIGN OF OTA BASED INSTRUMENTATION AMPLIFIER

In this project work instrumentation amplifier is designed which is based on telescopic operational transconductance amplifier. As we know that amplifier is an essential building block in any system. The schematic of OTA based Instrumentation Amplifier is shown below:

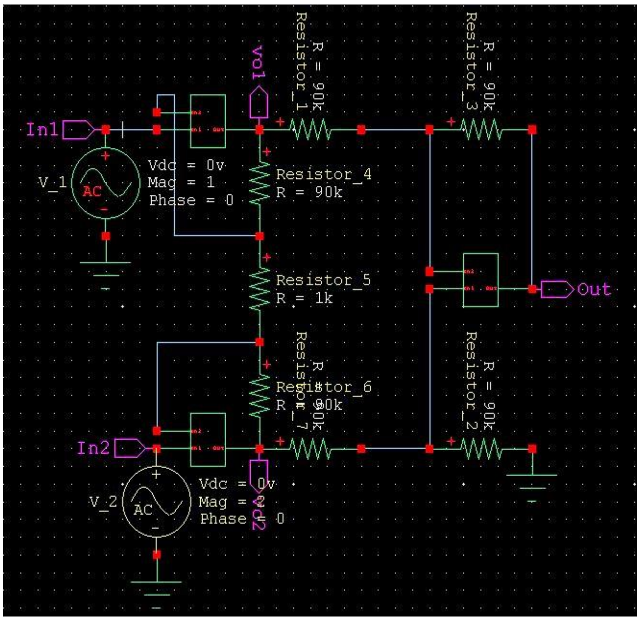

Fig.1 Schematic of OTA based Instrumentation Amplifier

A. Gain and CMRR calculations of designed Instrumentation Amplifier

Taking,

$R_1 = R_3 = R_4 = R_5 = R_6 = R_7 = 90\ K\Omega$, $R2 = 1\ K\Omega$

From Equation (2.19) output voltage of first Non-inverting OTA can be calculated as:

$$V_{O1} = \frac{g_m(R_1+R_2)}{1+g_mR_2}.Vi \qquad (1)$$

Where $g_m = 7.505$ mS

Putting the values of R_1, R_3, R_4, R_5, R_6, R_7, R_2 & g_m in equation (4.1)

$$V_{O1} = 89.80\ V$$

Similarly,

$$V_{O2} = 179.60\ V$$

Now,

$$V_O = \frac{(1-g_mR_6)}{(1+g_mR_4)}.\ V_{O1} + \frac{V_{O2}.R_7}{R_5+R_7}.\frac{g_m(R_4+R_6)}{1+g_mR_4} \qquad (2)$$

Putting the values we get:

$$V_O = 89.8\ V$$

$$\text{Gain (dB)} = 20\ \text{Log}\ \frac{Vo}{V_i} \qquad (3)$$

Common Mode Rejection ratio:

Common Mode rejection Ratio is the capability of Differential amplifier to nullify the output when both the inputs are equal. In designed instrumentation Amplifier CMRR can be calculated as follows:

$$\text{CMRR} = 20\ \text{Log}\ \frac{A_d}{A_c} \qquad (4)$$

IV. SIMULATION RESULTS

On simulating the circuit designed above on Tanner Spice following response is obtained:

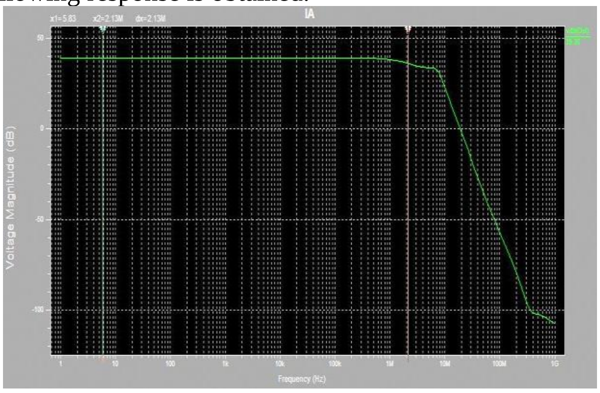

Fig.2 Response of OTA based Instrumentation Amplifier designed in fig.1

V. ANALYSIS OF SIMULATION RESULTS

It can clearly be observed from response shown in fig no.2 that differential gain of Instrumentation Amplifier designed in fig. no. 1, is 39.30dB which is almost equals to as calculated mathematically by equation (3)

Gain= 39.30

And CMRR of designed amplifier is observed as 97 dB which is almost equals to as calculated mathematically by equation (4).

Since;

A_d= differential gain =92.30;

A_c = common mode gain= 0.00131

Putting these values in Equation (4) we get

CMRR = 96.72 dB

Bandwidth of designed Instrumentation Amplifier is observed as **2.13MHz**

VI. CONCLUSION

For any instrumentation amplifier it is necessary that it has lowest offset. Regardless of offset voltages, the specific concern of this paper is to improve gain, bandwidth, CMRR and gain bandwidth product.

For schematic design of instrumentation amplifier 13.0 version of Tanner EDA is used and all the values are verified mathematically.

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