Review on Three stage Instrumentation Amplifier

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***Abstract*—The new design of three-stage instrumentation amplifier has been suggested in this paper. The new stage has been included into input of conventional instrumentation amplifier consisting of two op-amp and other associated circuit was utilized to remove DC offset voltages in the signal applied at the input of IA in this new design has been done by injecting external currents by employing constant voltage sources. This new configuration can be used to compensate large values of the offset voltage without affecting frequency response of IA. The instrumentation amplifier utilizing this configuration has been implemented and the obtained-out results were reported in the paper. The practical results prove that the proposed three-stage IA can be used to get rid of the unwanted DC offset voltages.**

I. Introduction

Instrumentation amplifier is widely employed for amplification of differential signals where large common mode signals are allowed to share. Hence, it is widely used in low level signal processing for various applications, such as biomedical instrumentation. AC coupling circuits are often used to eliminate any DC offset voltages that are unwanted in input signals. However, the values of compensating components R and C are finite in nature. Therefore, the common mode input is converted to differential signal and is amplified by high differential gain. This leads to the low CMRR and this indirectly reduces the dynamic range. Furthermore, the low frequency signal components are also reduced.

II. design of Three stage Instrumentation Amplifier

The proposed design of the new instrumentation amplifier is structured using five op-amps and three amplification stages, as opposed to the classic IA design of three op-amps and two stages. The first stage, with op-amps A1 and A2, Rg', Rf1', and Rf2' resistors, is used to counteract large DC offset voltages. The second stage, including op-amps A3 and A4, Rg, Rf1, and Rf2 resistors, is responsible for varying gain. Similarly, the third stage with the op-amp A5 and resistor R is also a common differential amplifier meant for output. This approach allows the new IA to be utilized in place of IAs optimized for execution reliant on a single large resistive cell.

III. THREE-STAGE INSTRUMENTATION AMPLIFIER WITH AUTOMATIC OFFSET VOLTAGE COMPENSATION

In that type of amplifier offset voltage is generated by feedback circuit using integrator, control logic,counter, DAC and inverter.Op-amp A6 integrates the DC offset voltage from the IA output. It adjusts a digital-to-analog converter (DAC) through control logic and a counter. By stabilizing the DAC's digital code post-compensation, only the DC offset voltage is corrected without impacting the frequency response. This operation utilizes the EN/Disable control of the counter, ensuring precise compensation while maintaining the integrity of the frequency response.

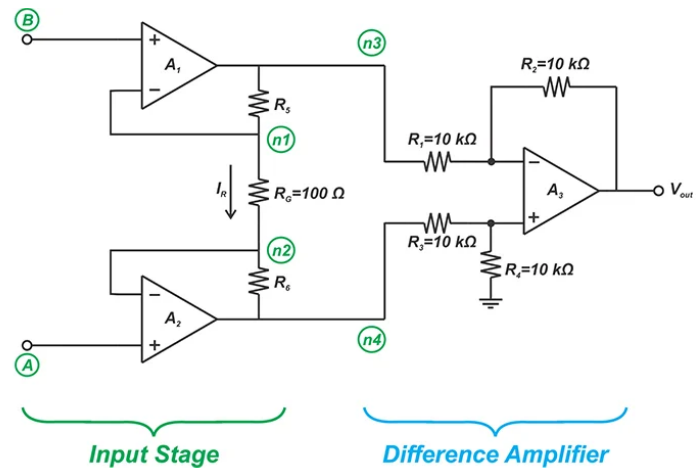

Fig. 1. three stage instrumentation amplifier

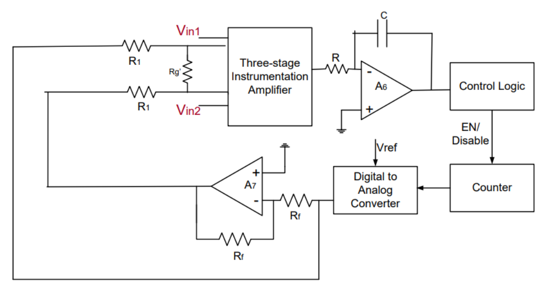

Fig. 2. three stage instrumentation amplifier

IV. Why Three Stage Amplifier

In systems powered by fixed voltage sources such as batteries, rapidly increasing the voltage is not practical. To address this limitation, it is recommended to substitute voltage sources V1 and V2 with voltage-controlled current sources, each featuring a high loop impedance of 1 megaohm or higher. This modification guarantees stability within the system.

The gain of the instrumentation amplifier (IA) depends on the values of Rg, Rf1, and Rf2. Attaining a higher gain necessitates larger Rf1 and Rf2, while minimizing error requires relatively smaller values. Striking a balance between these conflicting requirements is a challenge, especially when compensating for a wide range of offset voltages. In order to solve this problem, I propose a novel three-stage IA design, which comprises of five op-amps rather than conventional three; this way, it allows for three amplification stages, rather than two. The first stage utilizes op-amps A1 and A2, resistors, and compensating voltage sources to counter DC offset voltages. This yields a completely undistorted wide dynamic range at the input of the following stages. In the present design, it is possible to set Rf1' and Rf2' to be as small as possible, as they do not influence the overall gain of the circuit, which is

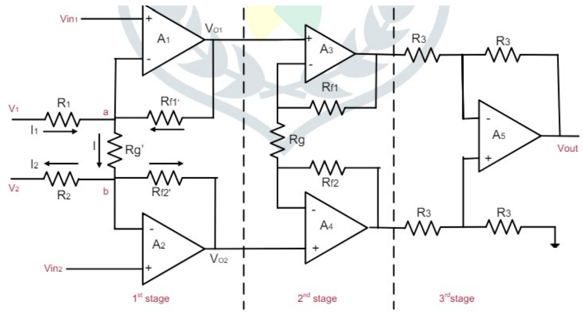

Fig. 3. three stage instrumentation amplifier

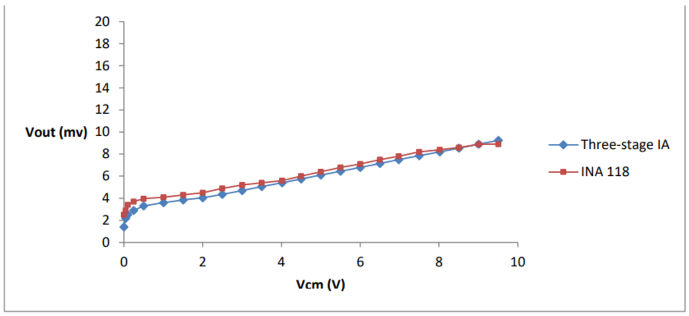

Fig. 4. Performance of three-stage of Instrumentation amplifier and INA 118 for common mode voltage

determined in the second stage using op-amps A3 and A4 and the corresponding resistors. As a result, adjusting Rg alone adjusts the gain, while Rf1 and Rf2 could be chosen in the usual way, as with traditional IA setups. Finally, the first stage of this novel IA design may be easily incorporated into conventional voltage or current mode IA setups, allowing for the kind of robust DC offset voltage compensation, even when its amplitudes is substantial.

V. Observations

VI. Advantages

(i)High Balanced Input Impedance
(ii)The Input Stage Can Provide High Differential Gain and CMRR
(iii)The Source Resistance Doesn't Appear in the Gain Equation.

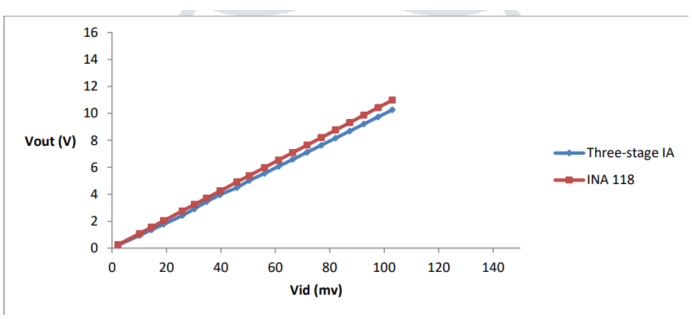

Fig. 5. : Performance of three-stage Instrumentation Amplifier and INA 118 for differential voltage

VII. Disadvantages

(1)Analog Nature and complex structure
(2)Symmetrical Power Supply
(3)Reduced Common-Mode Voltage Range
(4)Limitations in higher Frequency Response
(5)Medium and High Powers not favorable
(6)At High Voltages usage is not secure

VIII. Applications of Three Stage Instrumentation Amplifiers

(1)At the places where the accuracy of high differential gain is required, must get strength in noisy surroundings, also where huge common-mode signals are there.

(2)More precisely used in data acquisition from small output transducers like thermocouples, measurements of Wheatstone bridge, etc.

(3)Main part of making systems for navigation, medical, radar, etc.
(4)To enhance the S/N ratio (signal to noise) in applications when we have to deal with low amplitude audio signal.

(5)In the conditioning of high-speed signal and for uses like imaging sensors.

(6)For high-frequency signal they can be used in RF cable systems.

IX. Conclusions

In this new approach, we've enhanced the traditional instrumentation amplifier (IA) by adding a compensation stage at its input, creating a three-stage IA with five op-amps. This first stage, made up of two op-amps and a resistor network, tackles those pesky DC offset voltages, especially the ones with big amplitudes. It can be easily integrated into any existing IA without messing up its common-mode rejection ratio (CMRR) or frequency response. We can adjust the offset voltage manually or automatically using a DAC-controlled circuit. Through manual tweaking, we've shown that even high offset voltages can be handled, boosting the dynamic range without messing with the IA's performance. Unlike the traditional RC coupled IA, this setup doesn't need super precise components.

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