Optimized Instrumentation Amplifier for Biomedical Applications

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June 30, 2021

Abstract

The design process in biomedical sensing operations is dominated by the instrumentation amplifier design which determines the amplification of weak signals without adding any significant amount of noise. In this design, it is aimed to achieve a lower input-referred offset voltage using a current feedback based instrumentation amplifier. Another problem addressed by the design is the dependence of the traditional IA's on matching resistors and that the input and output common-mode voltages are exactly the same. This design involves voltage to current converters and current to voltage converters in various stages of the IA does processing the signals in current mode. This design also ensures a good CMRR value.

1 Circuit Details

The circuit uses a current feedback based Instrumentation amplifier (IA). In my e-Sim implementation transistors are used in the outputs of the op-amps of the first stage IA to decrease the current loading from the op-amps. The extra current is no longer the additional current but the current required by the resistor in the later stage. This design reduces the input-referred offset largely. This arrangement of the opamp and a transistor in its output will act as a voltage to current converter and thus produce a current proportional to the input voltage. In this process, the voltage swings which occur at the output of the first stage of the instrumentation amplifier drops down. To convert the current back to voltage after this stage, a mirror of MOSFET in the first stage is connected to the op-amp in the second stage of the IA and thus a trans-impedance amplifier is formed to get back the voltage from the current in the second stage. This stage acts as a voltage to current converter. A bias circuit is used to provide an appropriate common-mode voltage to the third op-amp. This design makes the output common-mode voltage of this circuit independent of the input common-mode voltage.

The op-amp specifications are not optimized for this circuit but promise a high future scope in this area. The design is implemented in the eSim electronic design automation software which provides all the capabilities to implement this design.

2 Implemented Circuit

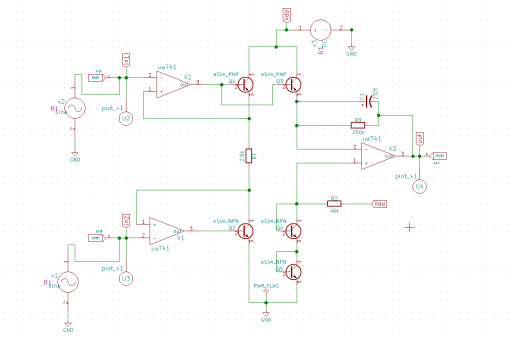

Figure 1: Implemented circuit diagram.

3 Implemented Waveforms

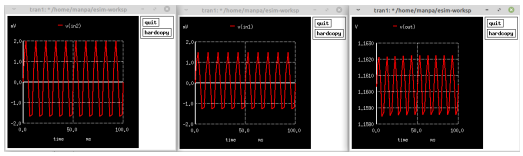

Figure 2: Implemented waveform.

References

[1] A. V. Rajasekhar Nagulapalli, Sumathi Raparthy. A low offset instrumentation amplifier for biomedical applications. https://ieeexplore.ieee.org/document/8394168.

[2] S. B. S. Z. N. Y. S. R. . A. T. Rajasekhar Nagulapalli, Khaled Hayatleh. A novel high cmrr trans-impedance instrumentation amplifier for biomedical applications. https://link.springer.com/article/10.1007/s10470-018-1256-8.