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Preface

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Arindrajit Pal All Authors

Abstract:
It is with great pleasure that I present the proceedings of the 2024 4th International Conference on Computer, Communication, Control, and Information Technology (C3IT). This conference, technically co-sponsored by the IEEE Kolkata Section, CSI, IETE, and the Computer Society, IEEE Kolkata Section Chapter, serves as a global forum for the exchange of cutting-edge research in computer science, communication systems, control technologies, and information technology.

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Design and Analysis of Low-Noise Instrumentation Amplifier for Biomedical Signal Acquisition Systems

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***Abstract*—Biomedical signals are essentially required to be monitored in the diagnosis and treatment of many human illnesses and health problems. Biomedical instrumentation, consisting of instrumentation amplifiers, various filters, digitizers, and data acquisition systems, is essential for building efficient physiological signal acquisition systems to sense, monitor, and acquire low-amplitude biomedical signals. This article describes a thorough simulation research work conducted to analyze the noise levels in several biomedical instrument amplifier circuits. The research aimed to develop an instrumentation amplifier (INA) with high gain and low noise while keeping the cost reasonable. Three distinct biopotential amplifier circuits have been designed and developed using NI-Multisim software, and a thorough examination of noise was conducted to determine the optimal biomedical measuring method. The simulation results demonstrate that the instrumentation amplifier, constructed using a combination of a voltage feedback instrumentation amplifier (VF-INA), exhibits the highest gain (98.22 dB), a high signal-to-noise ratio (SNR) of 70.93 dB, and a high common mode rejection ratio (CMRR) of 102 dB. These characteristics are achieved while maintaining a low noise level within the biomedical signal bandwidth of the voltage feedback amplifier. This study offers a comprehensive framework for developing biomedical signal acquisition system (BSAS) circuits that exhibit great amplification with lower noise interference. These circuits are specifically designed to capture the low-amplitude physiological signals for biomedical research.**

Keywords*—*Biomedical instrumentation, Instrumentation Amplifier (INA), voltage feedback Instrumentation Amplifier (VF-INA), biomedical signal acquisition system (BSAS).

I. INTRODUCTION

Human health information is found embedded within the physiological signals available from the body's surface. Physiological signals are essentially required to be acquired for extracting health information for noninvasive biomedical diagnostic procedures. Biomedical instrumentation [1-5] and biomedical devices [6-10] along with biomedical sensors [11] are employed for acquiring the physiological signals from the subject under test. Physiological signals or the signals generated by some external excitation with X-rays, electrical, optical, and magnetic, are found available on the body surface in different forms which are generally converted into the electrical voltage signals. The electrocardiography (ECG) signal [12-14], electroencephalography (EEG) signal [15], and other signals are available on the body surface without any external excitation. Bioelectrical impedance analysis (BIA) [12,16], electrical impedance plethysmography (IPG) [12, 17], electrical impedance cardiography (ICG) [12,18], electrical impedance spectroscopy (EIS) [12,19-20], electrical impedance tomography (EIT) [12, 21-23] injects electrical signal and measures the system response to find the properties of the material under test. The biomedical instrumentation is developed with different circuit blocks such as electrical signal generator (voltage control oscillator, etc.) [24-26], electrical signal converter (voltage to current converter, current to voltage converter, etc.) [24-26], electrical signal processor (amplifiers, filters, etc.), data acquisition system [27-28], graphical user interface (GUI) [29-30] and controller or PC. Each of these components must be designed very carefully and tested individually and collectively to assess their individual and collective performances during the practical applications. The overall performance is crucial as the noise level and other parameters may be individually under the specified limit. Still, the performance of the entire circuit made by connecting all may be associated, sometimes, with a larger noise level.

There is an increasing need for smaller and lighter portable medical equipment in the healthcare industry. Medical and biomedical equipment equipped with biomedical sensors are widely used in healthcare settings, such as hospitals, clinics, and other medical facilities. Biomedical sensors gather physiological signals to get crucial health information, which is necessary for monitoring health issues, diseases, and other medical situations [31-33]. Biomedical instruments play a vital role in a wide range of healthcare applications. Additionally, it can observe and regulate a wide range of physiological processes and anatomical features [34].

Studying biomedical and physiological signals is crucial for extracting vital health information in the diagnosis and treatment of diseases. Utilizing wearable devices for processing biological signals is advantageous for the healthcare system. Biological signal sensing poses a significant scientific challenge. The biological signals, exhibit amplitudes that span from microvolts (μV) to millivolts (mV) and frequencies that range from direct current (DC) to a few kilohertz (kHz), as illustrated in Figure 1. [35]. The portable biomedical signal collection systems offer several benefits due to their rapid, small, low volume, user-friendly design, and low power consumption during operation.

A prime illustration of a portable electronic system for collecting physiological data would be a compact solution consisting of a single integrated circuit with just essential peripherals and excluding any unnecessary features seen in other designs [36]. The instrumentation amplifier is a crucial component in the readout circuit of any system that handles low-level data. An instrumentation amplifier, unlike a