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A low power and low noise chopper-stabilized amplifier with DC Servo Loop for EEG sensor

Erwin Habibzadeh, Adib Abrishamifar, Abdolreza Rahmati

1. M.Sc. student at school of electrical engineering in IUST, Habibzadeh.erwin@gmail.com
2. Associated professor at school of electrical engineering in IUST, Abrishamifar@iust.ac.ir
3. Associated professor at school of electrical engineering in IUST, Rahmati@iust.ac.ir

Abstract

In this paper, a low power and low noise chopper stabilized amplifier with DC servo loop (DSL) is presented. For reducing the complexity in designing and lower area consumption, the amplifier is designed with negative resistor. Furthermore, due to its special feature, this amplifier has suitable PSRR and CMRR without any additional circuit to boost them. This amplifier is designed with embedded low pass to evade vast resistor and capacitor as low pass filter. At the end, a DSL circuit is used to eliminate high DC offset of electrode. The chopper amplifier is designed and simulated in 0.18 µm CMOS technology. The proposed chopper amplifier has 47.3 mid-band gain. The bandwidth is from 0.5 to 8.5 kHz. The total input reffered noise in this bandwidth is 5.9 μV_{rms} when the amplifier including DSL consumes just 2.8 µw power. The noise efficiency factor (NEF) is 2.58. According to Monte Carlo simulation results,The PSRR and CMRR are respectively, more than 120 dB and 100 dB. Finally, the flicker noise corner is lower than 4 Hz.

Key words: Chopper amplifier, low power, low noise, instrumentation amplifier, biomedical sensor, DC servo loop

1. Introduction

In the last decades, there are increasingly demands for monitoring brain activities for clinical diagnoses and neuroscientific research [1-4]. Electroencephalograph (EEG) signals have very low frequency and amplitude that these qualities make them hard to record. The most important brain signals have a bandwidth from 0.5 to 200 Hz whose amplitude is from 2-200 µV [5]. Transistors always have flicker noise, also known as "1⁄f noise," with spectrum varying as 1⁄f and occurring at relatively low frequencies [6] which is much larger than amplitude of EEG signals. Accordingly, conventional amplifier is not suitable for amplifying them. Circuit designers utilize many techniques like chopping, Auto-Zero and bulk driven to accurately amplify these specific signals [7-9].

Chopping is an established technique to reduce the offset and 1/f noise and has been utilized widely in recent biomedical signal acquisition. Although this technique might reduce the input resistance, there are many other techniques to boost the input resistance of the