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MINIMIZING COMMON MODE INTERFERENCES IN THE MEASUREMENT OF BIO-SIGNALS

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Abstract

Bio-signals are signals that can be measured from a living being. Electrical bio-signals are the result of depolarization and repolarization of the cells in a specialized tissue, organ or cell system. Accurate reading and analysis of signals such as electrocardiogram (ECG or EKG), electroencephalogram (EEG), electromyogram (EMG) etc. is very important as they are used clinically in diagnosing diseases. Hum interference is caused by magnetic and electric fields from power lines and transformers cutting across the measuring electrodes and patients. This type of noise seems to be ever-present, although the modern noise reduction techniques are successful in minimizing this in signal recordings. We discuss a method to minimize such interference using a pre-amplifier design with a very high common mode rejection ratio of 131 dB at 60 Hz and high input impedance. A comparison of the design with the commercially available Instrumentation Amplifier is also done. We verify our results using computer simulation of an ECG signal via the software Multisim.

Introduction

1. Noises present during measurement

The main noises found during the measurement of the bio-signals are the common mode signals. The **common mode voltage (CMV)** in ECG is composed of two components –

(i) DC electrode offset potential, and
(ii) 50 or 60 Hz ac induced interference caused by magnetic and electric fields from power lines and transformers cutting across electrodes and patients.

Designing

An ECG preamplifier is a differential bioelectric amplifier. Amplifiers used to process bio potentials such as electrocardiogram (ECG), electroencephalogram (EEG), electromyogram (EMG) are known as bioelectric amplifiers.

1. Pre-amplifier Designing

The design has been divided into four parts – **(i) Input Differential Amplifier; (ii) Intermediate Differential Amplifier; (iii) Amplification stage (cascaded Common Emitter and Common Collector amplifiers); and (iv) Filter**.

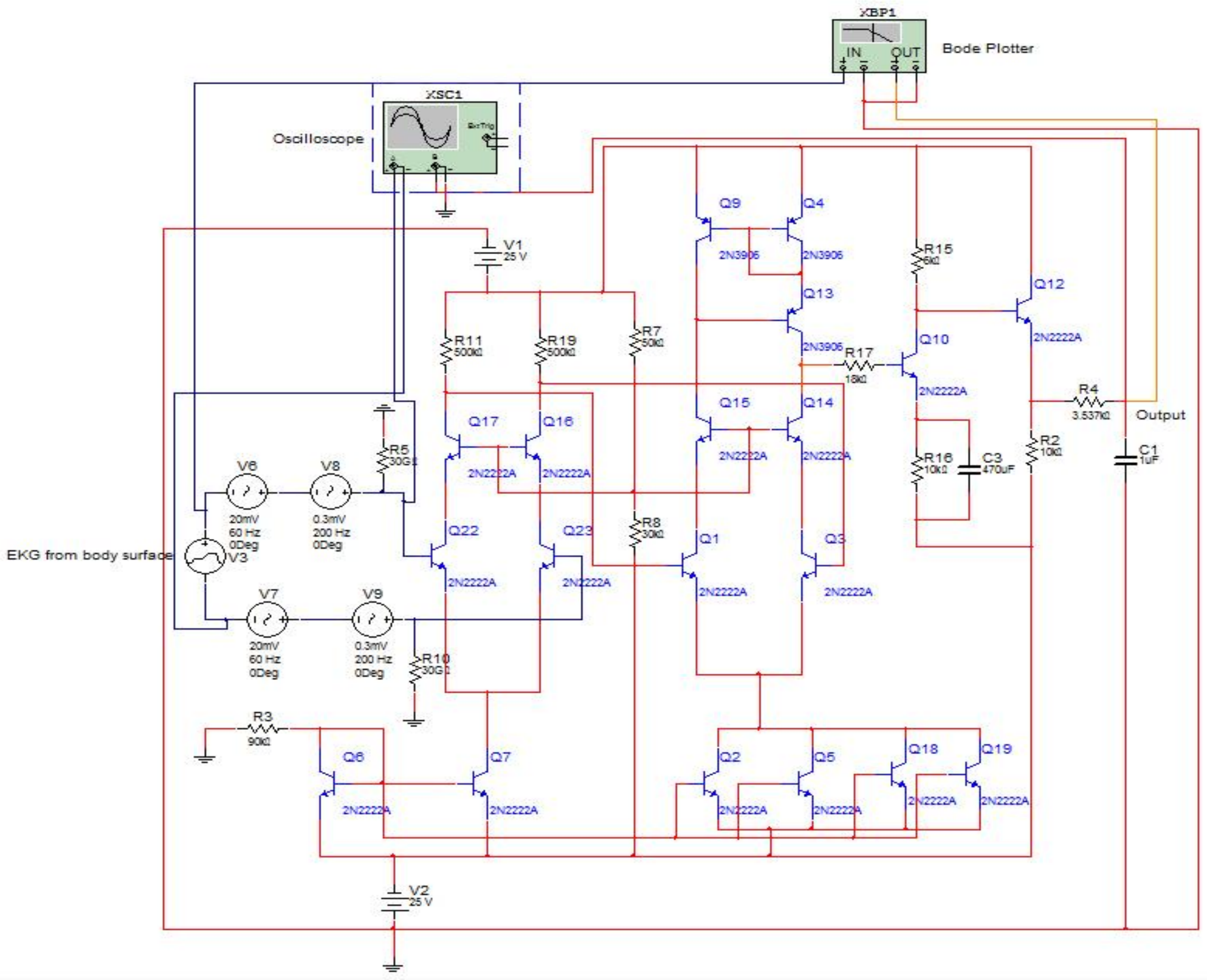

Figure 1. Designed Pre-Amplifier

Parameter	Value
Voltage rails	± 25 V
Gain	8.883
Input resistance (differential)	33.23 GΩ
Frequency range	96.5967 mHz – 48.0512 Hz
CMRR (at 60 Hz)	131 dB
CMRR (at 50 Hz)	135.275 dB
CMRR (at 70 Hz)	129.9 dB

Table 1. Specifications of the proposed Pre-Amplifier

Results

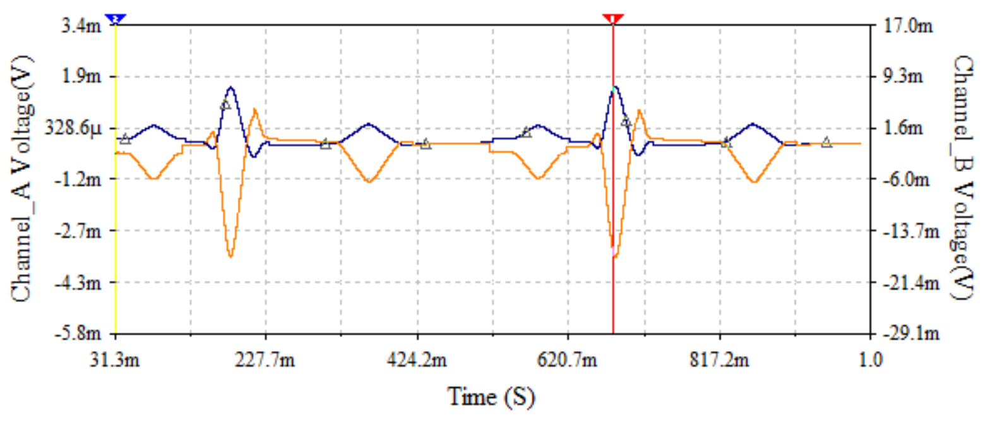

Figure 2(a). Output of the second stage when a differential EKG is used as the input. Blue plot (Channel A) shows the input and orange plot (Channel B) shows the output. Comparing the R wave peaks, we get the differential gain A_d= (15.480 mV/1.532 mV) =10.1

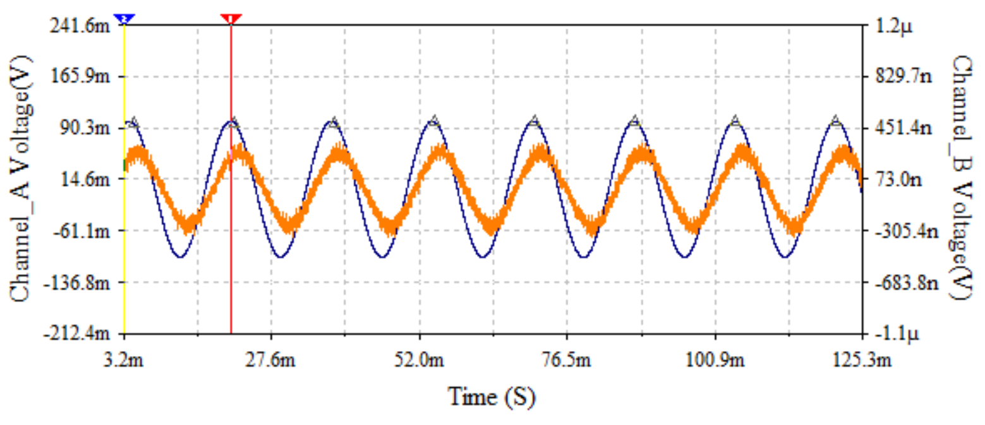

Figure 2(b). Output of the second stage when a common mode signal of 100mV peak and 60 Hz is used as input. Blue plot (Channel A) shows the input and orange plot (Channel B) shows the output. Comparing the amplitudes, we get the common mode gain A_{cm}= (282.5 nV/99.975 mV) = 2.83e-6

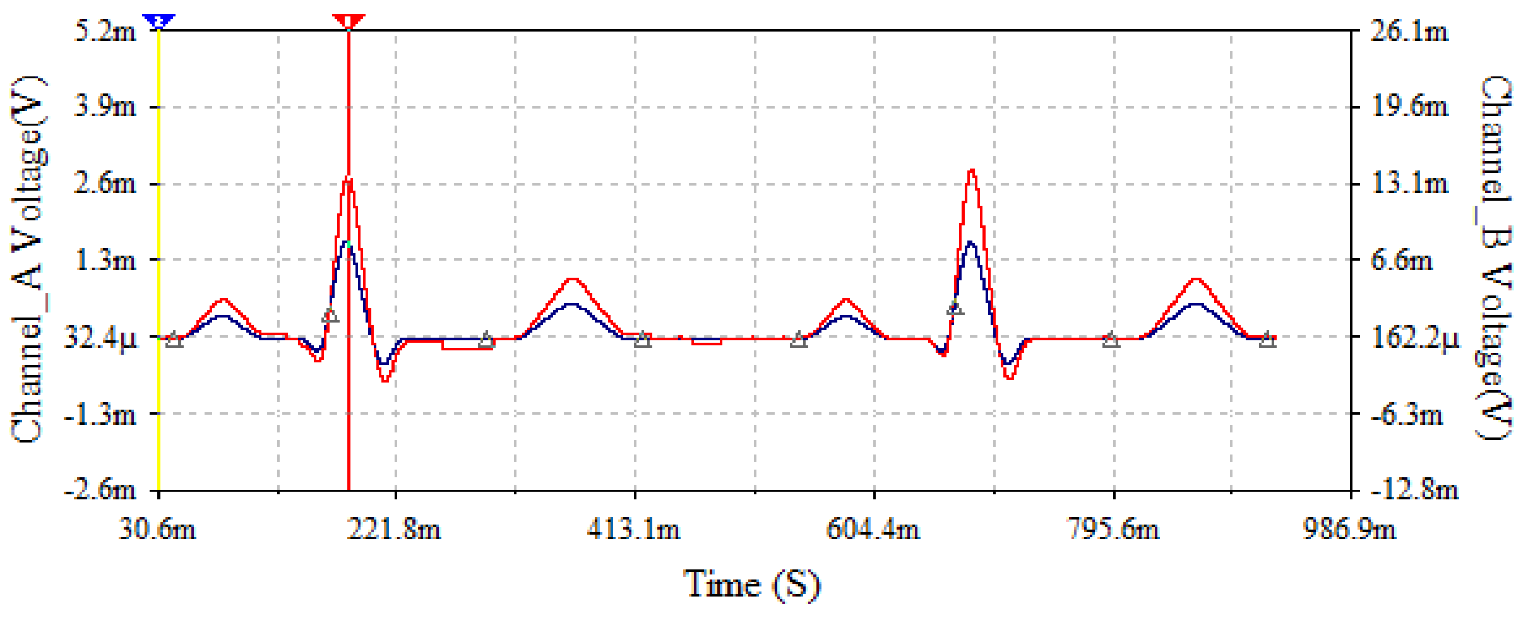

Figure 3. Final output of the designed pre-amplifier when a normal ECG signal is used as input. Blue plot (Channel A) shows the input and red plot (Channel B) shows the output. Comparing the R wave peaks, we get the overall gain A = (14.275 mV/1.607 mV) = 8.883

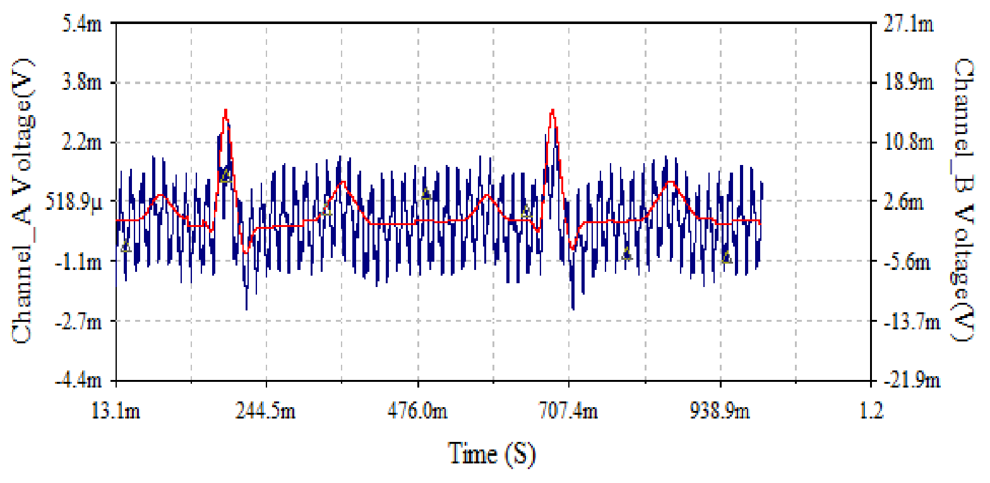

Figure 4. Testing the amplifier with noisy EKG. Blue plot (Channel A)shows the input (ECG + [1 mV peak 60 Hz sine wave + 0.5 mV 200 Hz sine wave] -common mode noise) and red plot (Channel B) shows the noise free output (pure EKG)

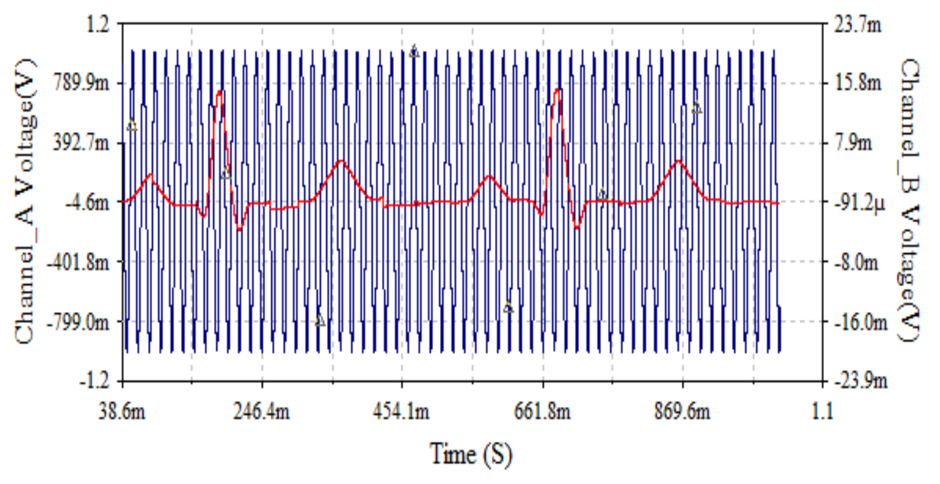

Figure 5. . Testing the amplifier with noisy EKG. Blue plot (Channel A)shows the input (ECG + [1 V peak 60 Hz sine wave + 0.5 mV 20 Hz sine wave] -common mode noise) and red plot (Channel B) shows the noise free output (pure EKG))

Figs. 4 and 5 show that the amplifier is able to smoothen out the noisy EKG to a very high extent.

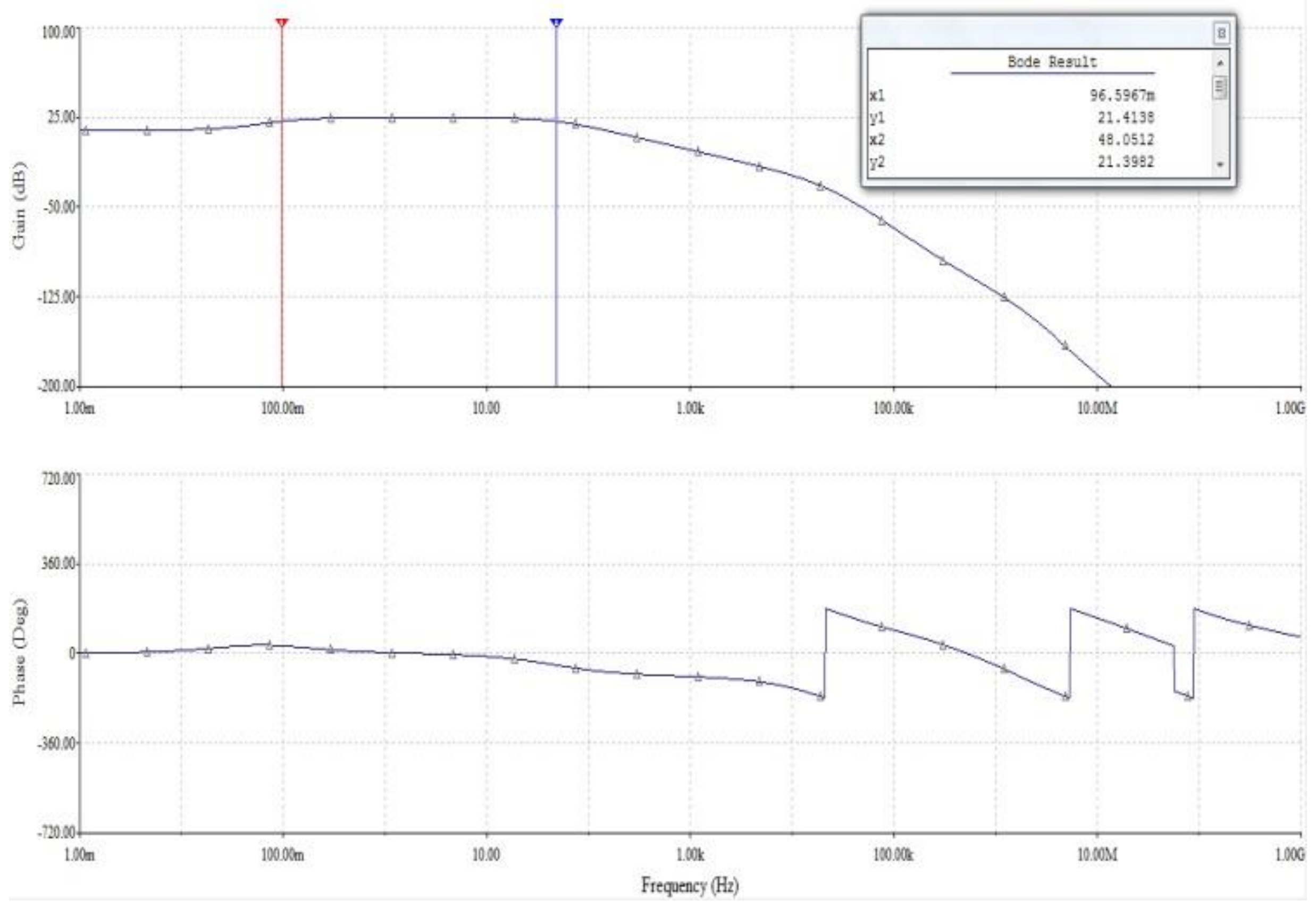

Figure 6. Frequency response of the amplifier

Conclusion

➢The presence of much larger external high frequency noise plus 50/60 Hz interference common mode voltages (hum noise) caused by magnetic and electric fields from power lines and transformers cutting across the measuring electrodes and patients makes it hard to record the bio-potentials with a high accuracy.

➢The poster presents a method to minimize such interference using a pre-amplifier design with high common mode rejection ratio of 131 dB at 60 Hz and high input impedance. The CMRR seen is higher compared to the most of the commercially available Instrumentation Amplifiers