Design Low Noise Voltage Amplifier for Hand-Held Electronic Reader

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Abstract. There are limited number of electrical based two type electrode electronic readers for biosensors are commercial available because of the noise issues and amplification at nano to pico ampere current range. This research is mainly focused on designing an active low pass filter circuit of electronic reader for biosensors. The entire circuits are comprised of a voltage converter circuit, active low pass filter circuit, voltage amplifier, microcontroller and display unit. The circuit capture, filter and amplify nano and pico ampere current convert it to detectable voltage range as an output signal to the processing circuit. NodeMCU was act as the process and control circuit to read the output voltage from the amplifier circuit. The signal generator will act as a replacement for the biosensor input current and oscilloscope will display the input and output signal. The Design Spark PCB software was used to design the voltage amplifier circuit. Arduino software was used to create a programming code to upload in NodeMCU microcontroller.

1. INTRODUCTION
Nowadays, very few electronic readers used two electrode type for electrical biosensors and capability to detect low current until nano and pico ampere range in the commercial [1-3]. Normally biosensors give extra small electrical output and most of them are amperometric, impedometric and potentiometric [4-8]. The development of simple and portable electronic readers have elevated potential for automation of sensor-based applications [9-12]. To measure this small electrical outputs, bench type source measurement units and impedance analyzers were widely used. Requirement of portable electronic readers enhance the convenience to retrieve results much more easily and rapidly [13-15]. Thus, using electronic readers can be saved time, handle out field and save money [16-18]. Direct current (DC) voltage, DC current and resistance were measured most frequently using present electronic reader and other equipment [19-21]. Moreover, most industries are still based on the desktop computer and user need to complete the appropriate actions in the laboratory. Furthermore, the equipment that used to measure low current was so expensive and inefficient because of the limitation of the detectable range. [22-24]

Controlling noise in a measurement system is vital because it can become a major problem even in the best instrument and data acquisition hardware. Most industrial and laboratories environments contain abundant electrical-noise sources. Simple devices and techniques such as using a filters, signal averaging
methods, and differential input voltage amplifiers, can control the noise in most measurements [25-27]. Some techniques prevent noise from entering the system, while others remove extraneous noise from the signal. Active filters are cost effective as a wide variety of economical op-amps are available. Active filters are mainly used in communication and signal processing circuits. The advantages of active filters are active filters can be designed to provide required gain, and hence no attenuation as in the case of passive filters [28-31]. No loading problem, because of high input resistance and low output resistance of op-amp. They are also employed in a wide range of applications such as entertainment and medical electronics. The use of biosensors and electronic readers in the medical industry and the food industry could make detection more efficient and less expensive.

In this paper, we designed and developed hand held electronic reader which included voltage converter circuit, active low pass filter circuit, voltage amplifier circuit, NodeMCU microcontroller and OLED display unit. The current input as nano and pico current were flown through shunt resistor to convert current input to micro voltage. An active low pass filter to block any frequency that falls outside the required range before the voltage amplifier amplify the microvoltage into mili voltage. The mili output voltage through to analog input port of NodeMCU. NodeMCU convert analog signal to digital and display the result to OLED display.

2. MATERIAL AND METHODS

2.1 Apparatus, Equipment and Software
The MAX 4238 was used as active low pass filter and voltage amplifier to filter and amplify micro voltage to mili voltage. All ICs and resistors were used in this prototype are from Texas instruments. The signal generator will act as a replacement for the biosensor input current and oscilloscope will display the input and output signal. The LTspice software was used to design and simulate the circuit. The Arduino Uno software was used to write program code and uploaded it into microcontroller NodeMCU. The Design Spark PCB software was used to design the circuit.

2.2 The Circuit Design

![Figure 1. Detail block diagram for the hand held electronic reader](image)

Figure 1 shows the detail block diagram for the hand held electronic reader. Various current biosensor inputs in the nano and picoampere range were through shunt resistor to convert the current input to microvoltage. The active low pass filter to make sure the input voltage from voltage converter, falls within a band of specified frequency while rejecting or blocking signals of frequencies outside this band. The voltage amplifier amplifies input microvoltage into milivoltage. The amplified voltage output can be detected as a input signal for a processing circuit and display the result on OLED display unit.

Figure 2 shows the active low pass filter circuit analysis using LTspice software. The used of active low pass filter, Sallen-Key filter in the electronic reader was to make sure the output voltage from the voltage follower, falls within a band of specified frequency while rejecting or blocking signals of
frequencies outside this band. Each RC set of filter components represents a pole and greater roll-off rates can be achieved with more poles. The type of active low pass filter used in this research, is second order or two pole filters which consist of two RC filter sections connected together to provide a -40dB/decade roll-off rate and the filter start to roll-off at -6dB.

3. RESULT AND DISCUSSION
The signal generator will act as a replacement for the biosensor input current and oscilloscope will display the input and output signal. Figure 3 shows the measurement set-up for testing the performance of the active low pass filter on the electronic reader. Figure 4 shows the input signal given with input voltage 1 V and input signal type sine wave by using input signal generator.

Figure 2. Active Low Pass Filter Circuit Analysis using LTspice Software

Figure 3. Active Low Pass Filter Circuit Analysis using LTspice Software
Figure 4. Input signal for Testing the Performance of active low pass filter on Electronic Reader

Based on the voltage to dB converter and common gains table, when the input voltage given is 1 V and the output voltage 0.5 V then, the gain loss value or roll off value is equal to -6 dB. Therefore, it reduces and filter voltage output by half of the input voltage value. Figure 5 shows the peak-to-peak for the input signal and output signal. It shows that the output signal peak-to-peak reduce half from the input signal peak-to-peak value when the cut-off frequency equal to 90 Hz. Although the ideal cut-off frequency value was 79.65 Hz and the hardware test for electronic reader value was 90 Hz, the performance of active low pass filter circuit on electronic reader is to reduce and blocking signal frequency are performed well, smooth and accurate. The difference was due to the tolerance value of the components.

Figure 5. Peak-to-Peak for Input Signal and Output Signal

4. CONCLUSION
Active low pass filter circuit for electrical biosensors has been designed and simulated using LTspice and designed Spark PCB software. The active low pass filter blocks any signal frequency that falls
outside the required range before the voltage amplifier amplify the micro voltage into mili voltage. The result shows the cut-off frequency is equal to 79.57 Hz and the filter starts to roll off at -6 dB. If high frequency noise occurs, it can degrade the quality of the signal coming from the sensor. Finally, in this experiment shows that the system can successfully capture, filter and amplify different current ranges and produce an output voltage in mV for biosensor applications.

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