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Original Research Paper

Tele Alert System Based on ECG Signal Using Virtual Instruments Environment

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Abstract: This manuscript addresses the design and implementation of a portable PC-based ECG device. Three electrodes are often employed for ECG recording, with two of them being connected to the patient's chest via the ECG amplifiers' differential inputs. Therefore, every stage of the design takes into account factors like low cost, low power consumption, portability, and simplicity of usage. In this system, the ATMEL Company's ATMEGA 328 low-power microcontroller is investigated for signal processing and delivering digital format to a PC through a serial connection, where it is then displayed utilizing LabVIEWTM SP1 software (released version in Feb. 2022). A portable tool that can capture, amplify, filter, and analyze biological signals is this one ECG. The intended device's target beneficiary was the intensive care unit.

Keywords: AD624CDZ, Electrocardiogram, LabVIEWTM SP1 Software.

1. Introduction

An ECG consists of three primary components: the P wave, which represents the depolarization of the atria; the QRS complex, which represents the depolarization of the ventricles; and the T wave, which represents the repolarization of the ventricles. Conventionally, the range of the typical ECG is 0.05 to 150 Hz, although the ECG signal also contains higher frequencies. These higher frequencies can be recorded and analyzed utilizing high-resolution technologies. Table 1 shows the class distribution of the samples for each feature in the training and test data set.

Table 1. Class Distribution of the Samples for Each Feature in the Training and Test Data Set

Frequency	Decomposition	Frequency Bands
0.03–0.06	D14	Low Frequency Bands
0.06–0.12	D13	
0.12–0.24	D12	High Frequency Bands
0.24–0.488	D11	
0.488–0.9766	D10	Unutilized Frequency Bands
0.9766–1.953	D9	
1.953–3.90625	D8	
3.90625–	D7	
7.8125–15.625	D6	
15.625–31.25	D5	
31.25–62.5	D4	
62.5–125	D3	
125–250	D2	

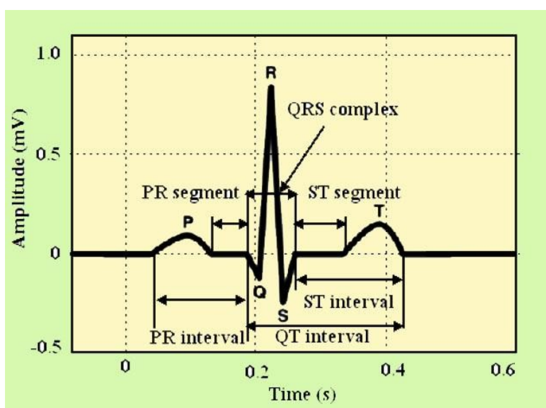

Figure 1. Normal ECG Waveform Shown Schematically

This article offers some suggestions for implementing an ECG monitor on a budget. Its configuration is intended to be utilized with a personal computer (PC). Despite the fact that this article was developed with patient safety in mind, any concepts offered are not always consistent in conforming to all system safety standards; whoever applies these concepts must ensure that the final design satisfies the relevant safety standards . Fig.1, shows the normal ECG signal.

Designing and implementing a PC-Based patient monitoring system is the aim of this project. The system is capable of signal acquisition and PC screen presentation of ECG data. Additionally, it features a function that determines the number of sample rates per minute based on the acquired ECG signals.

2. Literature Review

To identify any cardiovascular disease patient, the PC-based patient monitoring system delivers crucial information about the person's heart. The majority of commercial ECG monitoring systems, however, include intricate functions [1]. Therefore, the issue that has to be researched is how to build and execute a time-saving, appealing, and user- friendly system. Two other problems are the patient's vital signal measurement and the ECG data collection module. In addition, the configuration for interfacing an ECG circuit to a computer by utilizing certain software is a topic that has to be investigated. In addition, it is necessary to create the coding from which the sampling rate may be computed [2]. The patient monitoring system was created specifically for utilize in hospitals, thus it must feature an ECG signal database to protect patient confidentiality [3].

2.1. Heart Computer Interfaces

The challenge of mapping the human heart connectivity for the benefit of society is of greater importance. Various studies have been conducted to correlate ECG data and heart failure in connection to human safety. Heart computer interfaces (HCI) are utilized to acquire the ECG signal to analyze heart activity [4] [5] [6]. ECG-based approach to detect the heart failure state of the driver for minimizing false alarms and having the capability of giving multiple alarms. ECG data provides a noninvasive means of reliably monitoring brain activity. ECG signal may be one of the most predictable and reliable physiological indicators to measure the level of early arrhythmias detection [7].

There are several reviews on patient Monitoring systems, and some of them have an Importance of Tele medicine. Such as Lamonaca et al [8] provided an IoT approach to Health observation and Management systems which consists of detecting physiological parameters such as Blood pressure, Hemoglobin, Blood sugar, and abnormal cellular growth in any part of the body. The major part of the paper is it is based on the RFID system. The IOT-based RIFD system is utilized to determine and manage the objects via the WEB.

This paper amplifies the forward technique in how it saves energy which is achieved at a low threshold. The disadvantage in this paper is the requirement of authentication and authorization which is required for IoT systems. Abdulbaqi et al [9] provided a reconfigurable device network for the observation of structural health. This paper is based on the monitoring of the patient’s vitals utilizing NFC technology. The NFC technology fetches the patient’s data and provides the information utilizing the web to the doctors [10]. This is a low-cost and much more effective health sensing device. The disadvantages of this paper are the NFC technology which is not secure and the utilize of the web which provides information lately due to the web-based monitoring [11].

2.3. Microcontroller ATMEGA Features

AVR microcontrollers come in a variety of families, including the ATMEGA 8, ATMEGA 16, and ATMEGA 328. We utilized the ATMEGA 328 microcontroller in this tutorial. The ATMEGA 328 is functionally identical to other ICs in terms of pin compatibility and features a 32kB flash memory, additional SRAM and EEPROM, pin change interrupts, and timers [12] [13]. Some of the features of ATMEGA 328 are: 28-pin AVR microcontroller with 32 Kbytes of Flash program memory, 1 Kbytes of EEPROM data memory, 2 Kbytes of SRAM data memory, 23 I/O pins, two 8-bit timers, an A/D converter, six channels of PWM, an embedded USART, and an external oscillator with a 20 MHz operating frequency are among the features of the ATMEGA 328 [14] [15].

3. Methodology

The goal of designing and implementing a portable PC-based ECG was achieved utilizing the following method: ECG signal amplifying, ECG signal extraction (filtering), ECG signal preprocessing, ECG signal displaying, storages, and power supply are the system's six primary steps. Pre amplifier AD624CDZ is part of the ECG signal amplifying step. The “Low Pass Filter” (LPF) and the “High Pass Filter” (HPF) in the filtering stage were created by LM324 to measure the biological signal's measurement and processing capabilities. The output's signal to noise ratio will be raised by utilizing this technique. The ATMEGA 328L microcontroller is the component that processes signals to produce digital values and deliver them in a serial fashion to a PC in under a second. As a display unit, LabVIEWTM created a GUI. The proposed power supply unit required two voltages of 5, 12, and 12 as well as an inexpensive, small adapter. It planned, simulated, constructed, tested, and integrated every prior suggested ECG system. Functional and compatibility tests were performed on the integrated modules. The embedded code was created utilizing mikroC for AVR, and the suggested architecture was simulated utilizing Proteus ISIS. Real components were constructed on a breadboard

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for the prototype's implementation, and a digital AVO meter was utilized to measure the voltage. Figure 2 displays the suggested PC-Based ECG.

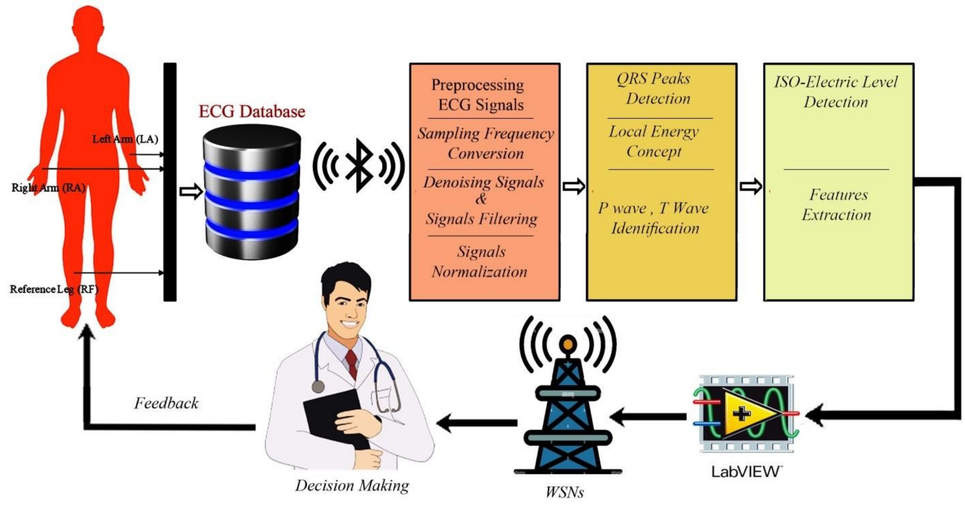

Figure 2. PC-Based ECG Proposed

4. Finding and Discussion

ECG signal collection and filtering unit, ECG preprocessing unit, ECG signal displaying and indication unit, and power supply unit are all parts of the system. The components of the PC-based ECG were created, simulated, put into practice, and integrated. The suggested ECG system shown in Fig. 2 was simulated utilizing a proteus ISIS environment simulator, and the implemented meter was made utilizing a breadboard.

In this manuscript, a Holter machine for ECG Signals collecting, as illustrated in Fig. 2, is chosen to record the patient's ECG signals at 512 Hz sample rates. The individual connects with the electrodes sensor tip secured on the wrist and the leg.

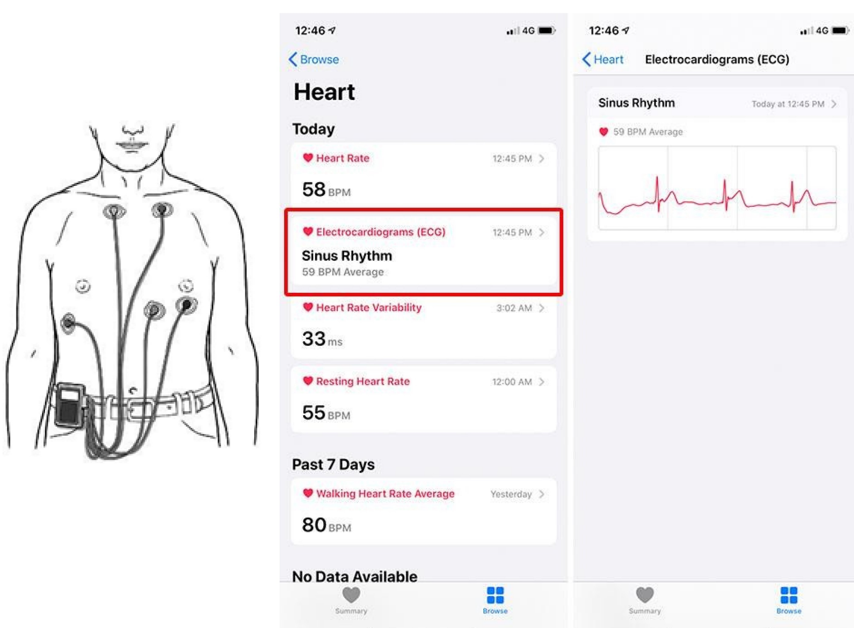

Figure 3. Mobile App for ECG ID

The Holter machine enters Bluetooth pairing mode as soon as it is switched on. After collecting cardiac signals in a database dedicated to these purposes (Holter device, as an example), these signals are transmitted through pairing with the server device to start the chain of operations for initial processing via Bluetooth, the Bluetooth device (smartphone/laptop) is opened to start the ECG ID program For data collection and recording. Here, the ECG amplifier's collected data are first uploaded to a drop box before being transferred to LabVIEWTM.

External (skin) electrodes may be utilized to measure the electrical activity that the heart is producing. The ECG registers these activities through electrodes that are attached to various body parts. Ten electrodes are utilized to compute a total of twelve leads.

The ten electrodes are the four extremity electrodes and the six chest electrodes. The four extremity electrodes are:

- LA - left arm
- RA - right arm
- N - neutral, on the right leg (= electrical earth, or point zero, to which the electrical current is measured)
- F - foot, on the left leg

It makes no difference whether the electrodes are attached proximal or distal on the extremities. However, it is best to be uniform in this (eg. do not attach an electrode on the left shoulder and one on the right wrist).

The six chest electrodes:

- V1 - placed in the 4th intercostal space, right of the sternum
- V2 - placed in the 4th intercostal space, left of the sternum
- V3 - placed between V2 and V4
- V4 - placed 5th intercostal space in the nipple line. Official recommendations are to place V4 under the breast in women.[1][10]
- V5 - placed between V4 and V6
- V6 - placed in the midaxillary line on the same height as V4 (horizontal line from V4, so not necessarily in the 5th intercostal space)

The voltage V in Figure 3 (which corresponds to the R-peak of the ECG waveform) normally peaks at 1 mV. As a result, amplification is necessary to boost the signal's amplitude for later processing and display (typically on either a chart recorder or a screen of some sort). A fundamental challenge in the design of a system like this is acquiring and identifying very small electrical signals in the presence of much larger noise components.

The most popular method for diagnosing different ailments is an ECG or EKG, particularly when the condition is heart-related. Medical personnel apply the leads to the patient's skin in order to perform an ECG. The leads create a graph by continuously tracking the electrical activity of the heart throughout one heartbeat cycle on paper. For a heart rate between 60 and 100 beats per minute, the amplitude value is typically in the 0.5 mV to 1 mV range.

Medical equipment designers want a flexible, dependable, and accurate means to seamlessly produce ECG signal patterns to check their designs since there is a large variety of cardiac equipment that displays and interprets ECG signal patterns.

The operational amplifier, which uses a common-mode rejection function to reduce common-mode interferences at the two electrodes while amplifying the slight difference between the signals, is the most important part of the ECG circuit. It must have a high gain to magnify the weak ECG signal and be immune to noise (common mode signal) and other electromagnetic signals. The ECG amplifier is represented by a differential potential between the electrodes and the two input terminals of the instrumentation amplifier. The interference signal appears as a common-mode potential on the electrodes. An instrumentation amplifier's primary job is to isolate background noise from the target signal so that it may be amplified with a very high CMRR. Strong common-mode signal rejection is one of a good biopotential amplifier's most important properties.

With low-level transducers like pressure, strain, and load cells, the AD624CDZ instrumentation amplifier usually has good accuracy and low noise. Due to the AD624CDZ's low noise, high gain accuracy, low gain temperature coefficient, and outstanding linearity, it is ideal for utilize in high-resolution data acquisition systems [11] [12] [27] [28]. The maximum nonlinearity of the AD624CDZ is 0.001% at G = 1, input offset voltage drift is less than 0.25 V/°C, output offset voltage drift is less than 10 V/°C, CMRR is more than 80 dB at unity gain, and CMRR is greater than 130 dB at G

= 500. The AD624CDZ performs pretty well in terms of ac performance in addition to these great dc specifications. The AD624CDZ's 25 MHz gain bandwidth product, 5 V/s slew rate, and 15 s settling time make it suitable for high-speed data acquisition applications. The AD624CDZ, as seen in Fig. 1, may be utilized for trimmed gains of 1, 100, 200, 500, and 1000. 4 does not need any additional parts. Other increases like 250 and 333 may be set with a 1% accuracy with the utilize of external jumpers. By utilizing a single external resistor, the gain of the 624 may also be adjusted to any value between 1 and 10,000.

The stop band is the range of frequencies when the output is considerably muted. The frequency range with low attenuation is known as a pass-band. The frequency that marks the transition from one pass-band to the next stop-band is known as the cut-off frequency. According to the most common definition, the cut-off frequency is the frequency at which the gain has decreased by a factor of 1/2=0.707 from its maximum value in the pass-band. The passband of a gain characteristic's frequency range is referred to as its bandwidth.

In order to reduce certain ECG signal frequencies, a filter is utilized. The attenuation level is influenced by the kind of filter being utilized. In this circuit, two active RC filters are utilized. Between the pre-amplification and a high pass filter with a 0.5 Hz cut-off frequency is the low pass filter. The purpose of this filter is to prevent the ECG signal from being enhanced simultaneously with amplifier saturation and DC offset. A low pass filter was added to the output of the high pass filter to reduce high frequency noise over 130Hz. Actually we employ dc offset, as shown in Fig. 5. If we want to convert our signal to digital form, we may utilize a bi-polar analog to digital converter or a dc offset. DC offset circuit is shown in Figure 5.

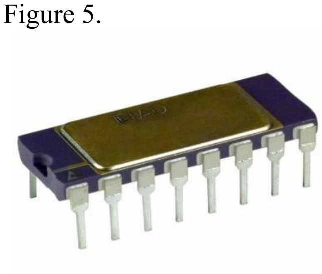

Figure 5. DC offset circuit

The suggested system's primary power supply is seen in Figure 6. With an output voltage of 12 VDC, -12 VDC for analog components, and 5 VDC for digital components, it is a straightforward design. A voltage regulator might be utilized to supply the necessary voltage to the microcontroller and other peripherals and components. For the majority of the units in the planned ECG, the power supply unit employs integrated circuit regulators (LM8705, LM7812, and LM7912) to maintain the necessary voltage level.

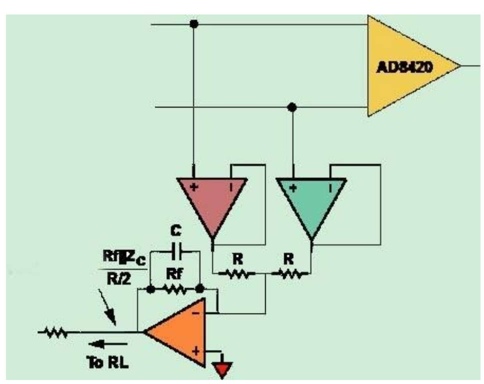

Figure 6. Schematic of a power supply unit

Among the many benefits microcontrollers provide in our everyday lives, improving energy efficiency is one of them. The use of microcontrollers in certain applications, such as central heating and cooling systems, greatly enhances the quality of the control, the user interface on thermostats, and the efficiency of motors [13]. In addition to its tiny size and low power consumption, microcontroller-based thermostats are designed to be reliable at an affordable cost, and to be easy to manufacture. It is possible to achieve this goal using a microcontroller that is highly integrated and suitable for developing thermostats. A digital to analog converter is already built into the ATMEL ATMEGA 328 microcontroller in this project. An analog-to-digital converter circuit does not seem to be required. There is a wide range of discrete values that can be produced by an analog converter. Electronically stored values are frequently expressed in bits due to the fact that they are usually stored in binary form. Thus, some discrete numbers have two powers of two, or "levels." For example, an ADC with an 8-bit resolution would be able to encode analog inputs into one of 256 values. If a signed integer is required (e.g., a range of 0 to 255), the value may be in the range of -128 to 127. A voltage unit can also be used to measure resolution electrically. In an ADC, the voltage resolution is determined by dividing the number of discrete intervals by the whole voltage measurement range.

Logic is used to communicate between digital devices. There have been groups set up for this binary information. In these sets, each binary digit is called a bit. Increasing the size of the group results in more data being given. Because 64 bits can carry more information than 32 bits, 64 bit game systems provide better graphics than 32 bit game systems. Providing an accurate image is made easier by this method. In serial communication, 8-bit units called bytes are often used. Through a single wire and a ground, serial transmission sends one byte at a time. Various devices, including IBM PCs, support this format. As an example, TTL is normally operated by a voltage between +5 and 0VDC, whereas RS-232 is normally operated by a voltage between +10 and -10VDC. A RS232 connection differs from a regular serial connection in this sense. It converts serial data from the CPU to RS-232 by utilizing the MAX232 chip.

A slave node on-board program handles data reception and signals display, while PC software handles analog-to-digital conversion and data transmission. A sampling frequency of 200Hz is the absolute minimum needed to sample an ECG signal with a bandwidth of 100Hz. The computer program is sampling at 250Hz, which is a frequency high enough to pick up the ECG signal. ECG's embedded software was developed using the ATMEL AVR family of microcontrollers' mikroC PRO for AVR IDE (Integrated Development Environment). Data is sent to the PC through the USART of the ATMEGA 328 microcontroller for visual display after the 10-bit A/D converter digitizes the ECG signals.

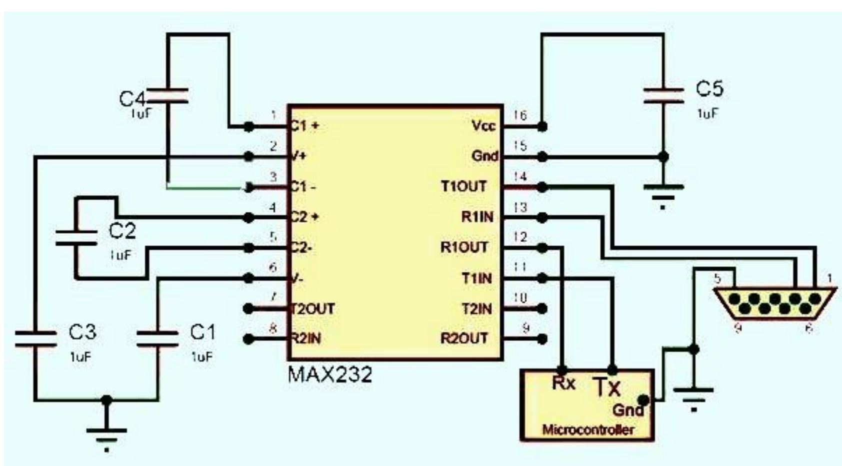

Figure 7. Schematic of MAX232 with Female Serial Connector

A Graphical User Interface (GUI) is used to link the proposed ECG circuit and the standard PC/laptop to store the ECG signal values in an MS database file on the PC, as shown in Figure 8.

An application called LabVIEWTM (Laboratory Virtual Instrument Engineering Workbench) allows users to design programs using icons instead of unending blocks of coding. Technicians, scientists, and engineers are familiar with the symbols, terminology, and forms used in it. Interfaces such as LabVIEWTM enable hardware parts to communicate with each other. A LabVIEWTM program also includes built-in libraries that allow users to work with various operating systems, computer languages, and Internet environments. In order to simulate the brain's signal, an ECG simulator was created, as shown in Figure 8.

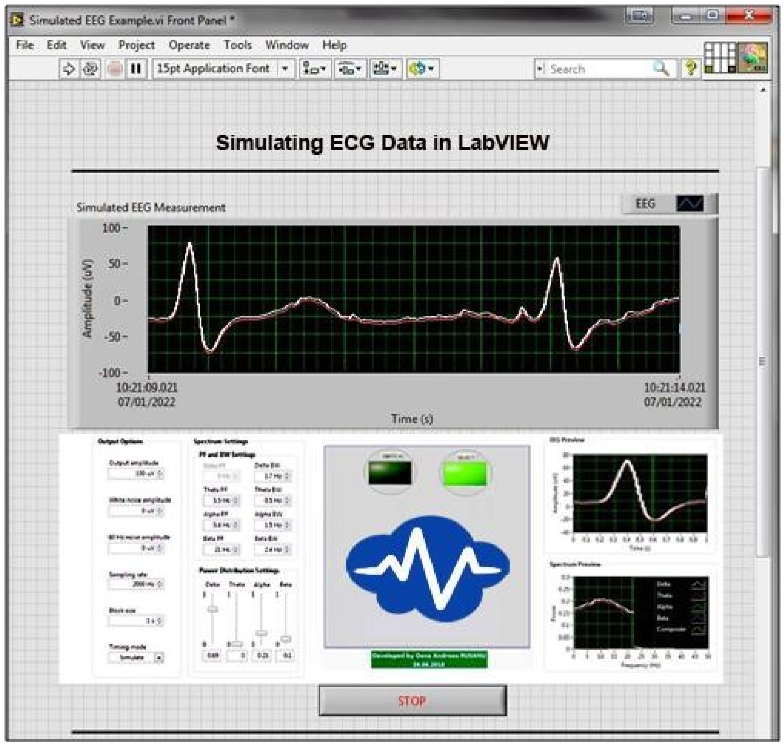

Figure 8. Designed of LabVIEWTM GUI of an EEG Signal Simulator

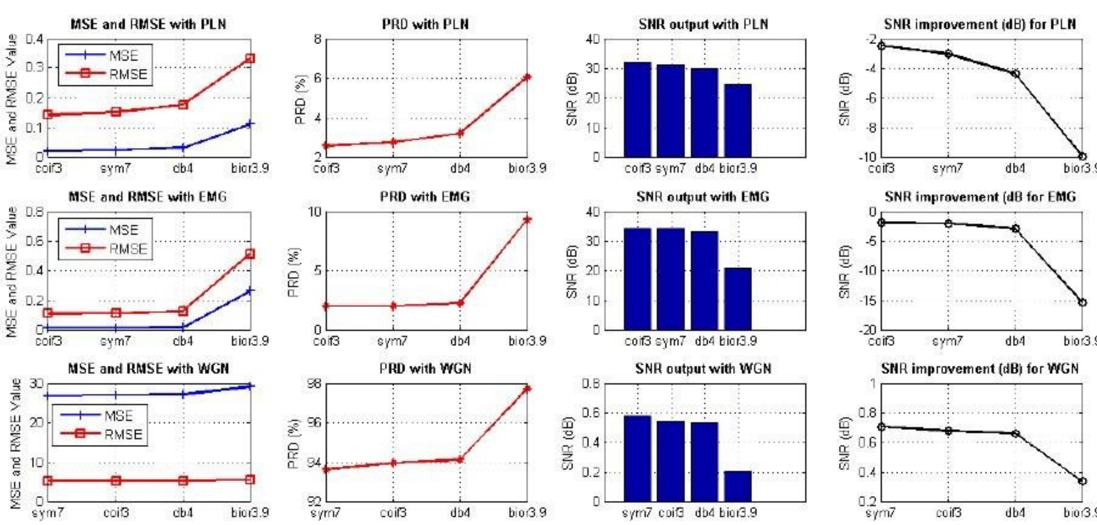

Figure 9. Output EEG Signals with various Types of Artifacts.

The total results demonstrate that the hardware needed to get an EEG signal with a right leg driver was successfully developed. A clean EEG signal is received and shown on PC Provider by LabVIEWTM in these results. This project includes the interaction with biological signals, which often entails a real-world human link for data acquisition. Simulated bio-signals were required for the tests in order to examine the system and swiftly and effectively ascertain its performance. Utilize of a ground plane helped to minimize noise. By utilizing a filtering approach, extraneous noise was reduced to emphasize the EEG signal. The output frequency of the high-pass filter is shown in the table (4.1) below as the outcome of the test filter.

The running result of the suggested PC-based EEG and the EEG graph of the recorded screen are those of a healthy individual when the EEG gear is operational and linked to the serial port, as shown in Figure 9.

5. Conclusion

As a result, the project's primary goal has been satisfactorily completed. This project's objective is to create a PC-Based EEG that accurately reads the EEG signal from a patent and displays it on a computer utilizing LABVIEWTM VI. Despite the usage of basic electrical circuitry, good results are obtained. The project's present status should not be seen as the finished result but rather as a promising foundation for future design improvements. The intended final product is quite feasible and reachable with a continuance of the existing design. There are several design restrictions, such as excessive power consumption that results from utilize of poor-quality components, which may be mitigated, and the absence of a notch filter to minimize power line noise.

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