Implementation of wireless ECG measurement system in ubiquitous health-care environment

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Abstract: - In this study, the measurement system was developed to measure ECG conveniently in an ubiquitous health care environment. The new-developed system consisted of hardware and software. The hardware system eliminated the inconvenience like connecting and disconnecting electrodes and extended the life span of these electrodes. According to Lead I ECG measurement, the metal mesh electrodes were attached on the both armrests of a chair. The result of the mesh mental electrodes was investigated as compared with the measured result of common disposable electrodes, Ag/AgCl. The ECG signal was detected by using high-input-impedance bio-amplifier, and then pass the filter. The measured continuous time signal was converted into digital signal using the microprocessor, and transmitted to PC by bluetooth wireless communication The digitalized ECG signal was displayed, compressed and recorded on the PC. In order to demonstrate the reliability of the system, the result was compared with Ag/AgCl electrode, skin-electrode impedance and measured signals, and then, the 10 subjects' ECG signals of this research were measured each position, and compact experiment was able to be performed.

Key-Words: - ECG, electrode, ubiquitous, Bluetooth, wireless, LZW

1 Introduction

A short lifetime and the skin irritation of the one-time-use Ag / Agcl electrode which we use in the general ECG measurement were excluded. By using the metal mesh, the electrode which attachable to the armrest of a chair was made to secure the convenience of a reuse and measurement.

Bio-amplifier in which the input impedance is high was comprised to extract the ECG signal from the metal mesh electrode. And the circuit for the filtering of a signal and amplification were implemented with a design. By using the bluetooth communication module for the wireless transmission of the measured signal, data were transmitted with the pc and a system was organized so that the monitoring of the real-time ECG signal could be possible.

In order to perform compression of data of the ECG signal which is measured by applying the LZW compression algorism for the remote monitering of the ECG signal, the program was organized. Moreover, in the implemented variation, the function of reproducing a measurement and stored data was added. And the LabView7.1 (National Instrument Co., U.S.A.) was used for the embodiment of PC monitoring program.

2 Method

The ECG signal measured in the skin surface shows a difference according to the subject but mostly is the weak signal of about 1 p-p. In the signal, the noise component which there are many with not only the ECG signal but also the signal, the connection through the stray capacitance of the surrounding environment, and the traffic signal it doesn't desire it occurs in the equipment inside generated in the organism excitable tissue including a muscle except a heart, and etc. pure is flowed in.

Therefore, the system is needed process of signal including an amplifier and filtering. The system is comprised by using the amplifiers for measurement of the field effect transistor type (INA121) detected by the metal mesh. The system was used of notch filter after bio amplifier. The amplification of the manufactured ECG signal and configuration diagram of the filter section were shown in figure 1.

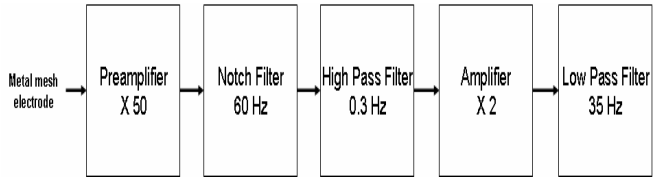

Fig1. Block diagram of electronic circuit for ECG measurement

Front end is removed 60 common signal that flowed in due to the differential amplifier characteristic of having the high input impedance along the line of induction. The system used 0.3 high pass filter to reduce the change of a baseline. Moreover, by using 35 lowpass filter, an influence removed the high frequency noise, it removed the noise except the range of concern frequency of the ECG waveform. The system comprised the A/D converter to convert into the digital signal that analysis was possible measured analog ecg signal in a computer. The system used the AVR (Atmega128) to convert the analog ECG signal into the digital signal.

The data acquisition system comprised of the sensor unit, the A/D converter and wireless communication unit. A/D convert sampled with 1,000 samples/sec signal that obtains in the angular magnification and filter. It quantizes with 10bit. The measurement range did by ±2.5V. 3byte Hex code transmitted to 19,200 bps speed with the asynchronous method.

The communication unit comprised by using the blue tooth wireless communication module for PC and the smooth interface. figure 2 showed the system configuration diagram of A/D converter and Bluetooth communication part.

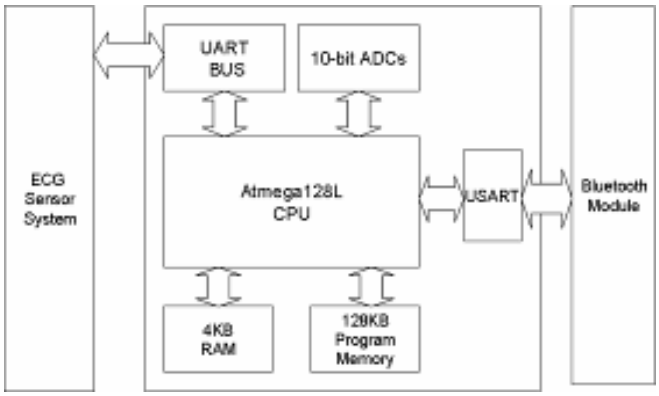

Fig.2. The implemented hardware converter.

ECG signal cannot record as the hand. because it is continuous signal like the blood pressure's numerical value and blood sugar's numerical value. Therefore, it has to store with the display of the measurement signal. In the stored conclusion, added function to confirm the ECG waveform again. Software used the LabView 7.1 (National Instrument Co., USA). Speed is set as 19,200 bps. The program realized actually was shown to figure 3 and figure 4.

Fig. 3. ECG acqusition and data save, display parts implemented by PC program

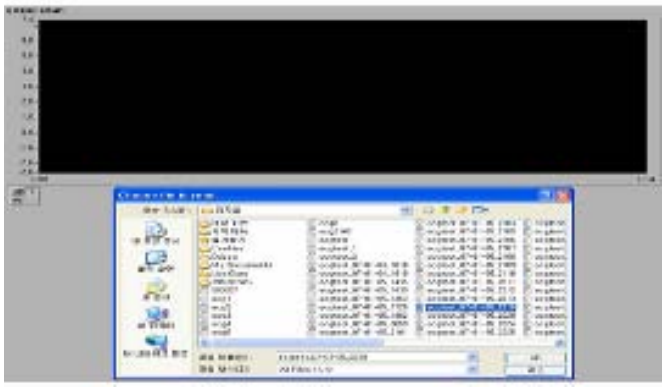

Fig. 4. File loading and reviewing parts implemented by PC program.

ECG is continuous signal. Therefore, the obtained data slot of the ECG increases as the measurement time. But the space of PC is limited. Therefore, data are compressed and it needs to store. In this study, the LZW algorism was used on the PC program for compression of data. fig. 7 is shown the algorithm block diagram.

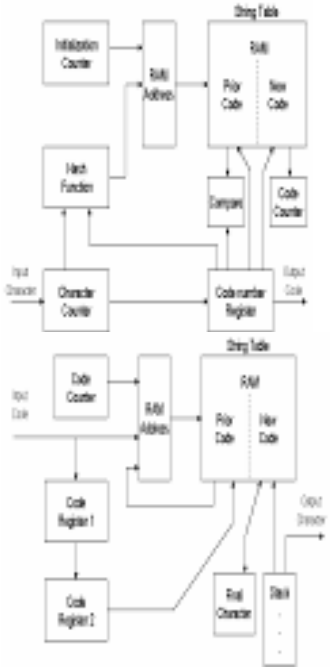

Fig. 5. the compression and the decompression program using LZW algorithm.

2.1 Data Acqusition

In order to measure the ECG signal in the armrest of a chair by using the lead I method in the chair attachment style sensor unit among the ECG induction method, it made the electrode of the metal mesh shape and attached to a chair.

It compared and evaluate the commercial Ag/AgCl electrode and impedance and the electrode of the metal mesh shape tried to make the optimum the metal mesh ECG electrode.

Fig. 6. A photography of ECG eletrode attached on a sofa.

Software part is composed of display and save the data. An experiment was performed against healthy 20 graduate student 5 people and it was evaluated based on the result of being measured in order to evaluate the performance of the implemented system. We could confirm to accurately can each waveform of an ECG classify from the signal measured from the experiment result sticking chair type ECG measurement system and we could confirm that the application of HR through R peak detection and the various electrocardiogram analysis algorithms were possible. The screenshot of the implemented monitoring program was shown to figure 7.

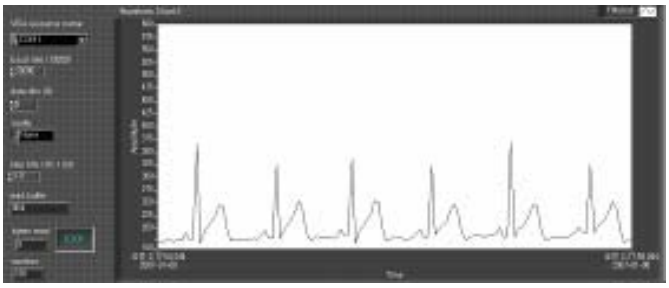

Fig. 7. The computer screen of measured ECG signal.

2.2 Metal mesh electrode reliability test

The electrode system is the most core in the ECG measurement. but there is the disadvantage that the most of electrode systems has to make the electrode system according to each individual body.

The research is coming to be continued until now about ECG electrode system.[1]~[6]

In this study, We used the metal mesh which makes of the stainless material of about diameter 0.1mm as measuring ECG use electrode to solve the disadvantage. And the size of an electrode is 4 mm.

Fig. 8. The metal mesh electrode.

The skin - electrode contact impedance was measured to evaluate the feasibility about the use availability the metal mesh electrode as the ECG electrode. The metal mesh and the size $1cm^2$, $4cm^2$ compared the skin-electrode contact impedance of the Ag/Cl electrode. the skin-electrode contact impedance measured by using the lock-in amplifier.

For this, electrode system approve the standard voltage 0.5V and it measured the output current according to the frequency shift of 0.1~100Hz. An electrode adhered to the both arms according to the Lead I induction method. it measured per the frequency with five times and it found each average. The measurement result metal mesh electrode's area $1cm^2$ is About 2 ~ 26MΩ. It was measured by 7M Ω ~ 450k Ω in case of being a $4cm^2$. A commercial Ag/AgCl electrode indicated the variation of 13M Ω ~ 530k Ω. Therefore, the impedance was lower measured in the measurement frequency band of 0.1~100Hz than Ag/AgCl electrode when the size of the metal mesh was $4cm^2$.

Figure 9 compares each electrode impedance at 0~35Hz gap that is the longitudinal wave of the conduction, T-wave, and the frequency band of the QRS party.

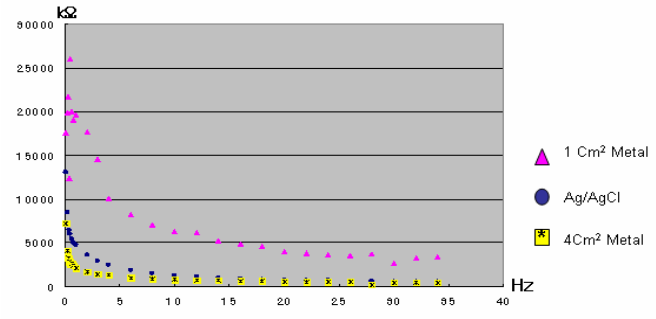

Fig. 9. The skin impedance of metal mesh and Ag/AgCl electrode in 0 35 Hz frequency bandwidth.

The table II shows that the impedance is lower than the Ag/Agcl electrode and the size $4cm^2$ metal mesh can reduce the distortion of the ECG signal between 0~20Hz.

TABLE II. The Comparsion of Measured Contact Impedance between Skin-Electrode of Metal Mesh and Ag/AgCl Electrode.

Frequency(Hz)	Impedance(kΩ)		
	$1cm^2$ Metal Mesh	$4cm^2$ Metal Mesh	Ag/AgCl
0.1	17,593.24	7,217.09	13,100.44
0.2	19,888.62	4,034.86	8,469.14
0.5	26,068.82	2,561.21	6,021.67
1	19,561.82	2,142.24	4,784.68
5	8,188.66	985.10	1,856.65
10	6,242.19	815.66	1,267.42
15	4,844.96	657.23	893.01
20	4,012.19	552.60	701.09
25	3,497.48	496.48	632.03
30	2,686.72	476.48	525.28
35	3,310.82	471.62	554.36

Figure 10. shows The measured ECG signal by $4cm^2$ metal mesh electrode and Ag/AgCl electrode.

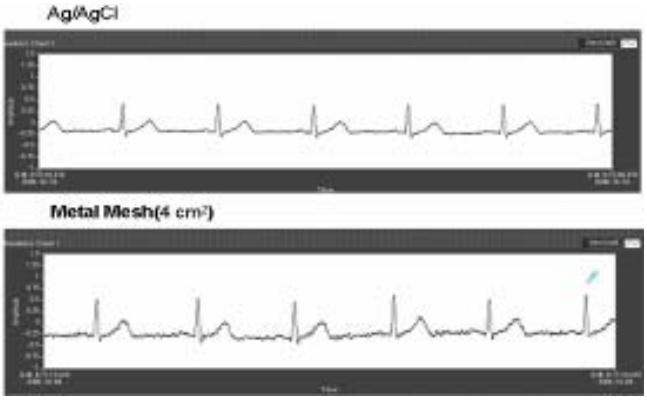

Fig. 10. The measured ECG signal by 4 cm^2 metal mesh and Ag/AgCl electrode

2.3 The performance evaluation of the LZW compression algorithm

To perform compression of data of the ECG signal which is measured by applying the LZW compression algorism for the remote monitering of the ECG signal, it comprised the program. And it performed the performance evaluation of the implemented compression algorithm.

The experimental result compression ratio showed up with the table III. And it showed the compression performance of about 50%.

TABLE III. The Compression Rate of ECG Data Using LZW Algorithm

File capacity befor compression	File capacity after compression	Compression rate
130k byte	67 kbyte	51.53%
206k byte	113 kbyte	54.85%
324k byte	185 kbyte	54.85%
1,106 kbyte	600 kbyte	54.24%
1,590 kbyte	785 kbyte	49.37%
5,136 kbyte	2,674 kbyte	52.06%
Average compression rate		53.19%

TABLE III. The Compression Rate of ECG Data Using LZW Algorithm

3 Conclusion

The ECG instrumentation system for the chair attachment style health care was proposed to measure the ECG signal and monitor the condition of one's health. For this, it classified from the electrode manufacture department for the ECG signal detection and the hardware part and software part and conducted a research. Health condition, the system continuously performs the wireless transmission technique of the techniques for measuring not only an ECG but also the various bio-signals through the perform of the continued research and the measured signal, and the research about the signal processing and analysis algorithm based upon the result of this research. If it is the case, it is considered that the development of the ubiquitous healthcare monitoring system which can monitor the condition of one's health to be actually useful at the ubiquitous environment is possible.

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