Study of Single-Arm Electrode for ECG Measurement Using Flexible Print Circuit

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Abstract—The purpose of this letter is to study a new ECG measurement by an annular FPC (flexible print circuit) electrode to the arm of the subject. This study attempts to use one FPC patch to measure ECG signals from a single-arm. The measurement system for the ECG circuit and analysis software was built to be able to measure and interpret the very weak and noisy ECG signals from the electrode. To compare with traditional three-point electrode measurement, this study will improve the patient uncomfortable and security. The results showed that the new ECG measurement system have the same capability compared to the traditional measurements for subjects at rest.

Keywords: ECG, flexible print circuit

INTRODUCTION

Today, the hospital has been widely used many medical instruments, the electrodes of the traditional electrocardiogram instrument have to paste on the body that make patient feel uncomfortable. In previous study [1], it has designed a measurement system for measuring ECG signals from the arm of subject with two electrodes. But the distance of two electrodes pasted on the arm was too long; therefore it is not convenient for measuring ECG signals. From [2,3], we have found that it is possible to measure some essential features of the ECG signal with electrodes attached to the left arm of the subject only. Those studies concentrated mainly on electrode placement and comparison of different electrode materials. However, it is difficult to measure ECG signals when the electrodes close each other from a single-arm. This study we attempt to design an ECG belt sensor that can attach to the upper or lower single-arm only.

EXPERIMENTAL

The structure of FPC electrode is shown in Figure 1. There are three foils (25 x 2.7 mm²) on the FPC act as traditional three-point electrode, and the interval of each electrode is 30 mm. Traditionally, ECG signal measurement systems should have reference electrode and measure ECG signal between reference level, positive and negative electrodes. This design prevents signal drifting which is a typical problem in noisy environments, caused by EMG artifact or other electromagnetic interferences. The ECG circuit as shown in Figure 2 includes pre-amplifier, high-pass filter, low-pass filter, Output stage amplifier and clamping circuit. To retain perfect ECG signals, the frequency band of this circuit is designed between 0.5 ~ 40 Hz. The position of FPC electrode attached on the left upper arm is shown in Figure 3.

RESULTS AND DISCUSSION

The subject is a male 23 years old who sat on the chair calmly and relaxed. First, the FPC electrode was attached on the upper left arm, the signals from ECG circuit is shown in Figure 4. Because of the three electrodes are close each other, the ECG signal is very weak and noises or interferences e.g. EMG exist obviously (Figure 4(a)). So MATLAB has to be used for signal processing. From Figure 4(b) shows that the ECG signal exhibits very clear especially Q, R, S waves. Similarly, measuring right upper arm was able to fetch the same results (Figure 5(a, b)). However, when FPC electrode was attached on the elbow, the ECG signals are getting weaker. But Q, R, S waves still are discriminated (Figure 6, 7). Finally, if the FPC electrode was attached on the lower arm, the signals are indistinct (Figure 8, 9).

CONCLUSION

We have studied a new ECG measurement by an annular FPC (flexible print circuit) electrode to the arm
of the subject. The structure of FPC electrode is very simple and fabrication easy. This electrode has the advantage of well flexible that it can tight attach on skin. When the electrode measures on the upper arm, it has good performance. But measures on the lower arm, it cannot work well. Because of the ECG from the lower arm is very weak, the signals are easy interfered by noises or interferences e.g. EMG.

REFERENCES


Figure 1. The FPC of electrode

Figure 2. ECG circuit

Figure 3. Electrode’s position on left upper arm

Figure 4. ECG signal on left upper arm
(a) from ECG circuit, (b) signal process by MATLAB

Figure 5. ECG measure on right upper arm
(a) from ECG circuit, (b) signal process by MATLAB

Figure 6. ECG measure on left elbow
(a) from ECG circuit, (b) signal process by MATLAB
Figure 7. ECG measure on right elbow
(a) from ECG circuit, (b) signal process by MATLAB

Figure 8. ECG measure on left lower arm
(a) from ECG circuit, (b) signal process by MATLAB

Figure 9. ECG measure on right lower arm
(a) from ECG circuit, (b) signal process by MATLAB