Modeling of Heart Phantom using the Multidipole Current Source

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Abstract: In order to design the phantom of heart, we have developed the multi-dipole current source system. Such a one be clue to the various motion of heart. The magnetocardiograph (MCG) system for diagnosing the disease of the heart due to an analysis of the heart signal. The multidipole current source system be built by microprocessor. We use the shield room to obtain a good experimental result. Then the signal acquired is mixed with a background noise, through a filtering extracts a pure signal. The pure signal such a heart phantom is analyzed by an electromagnetic map.

Keyword: heart phantom, multidipole, magnetocardiograph, electromagnetic map.

I. Introduction.

Recently, the disease diagnosis using an organism signal have variously studied in the areas such a electroencephalogram(EEG)[1,2]. The diagnosis methods using this system are two. The one is the invasive method of measuring a hiving body signal by sticking an electrode to the skin[3]. The other is the vasive method of measuring a having body signal by putting extremely signal electrode in brain. An invasive diagnosis can divide the signal reflecting an activity of the central nerve like a brain wave and the signal reflecting the change of the autonomic nervous system like GSR(Galvanic skin resistance)[4].

In the other side, have been constantly progressed in areas of the EMG(electromygram), The EOG(electrocculogram) and the ECG (electrocardiogram) relating to the sensitivity[5].

A general cardiac excitement begin from the SA(sinoatrial) node, shrinking an atrium, and transmits an electric current into the AV (atrioventricular) node. After the his bundle and bundle branch, an excitation is transmitted to the purkinje fiber.

Such a course make transfer the blood to the whole body. The SA node and AV node is excited by an increase of Ca current, the current movement be made by an increase of Na current[7].

In this paper, we discuss the heart organization to know an excitation path of the heart, a current an a power distribution. After these doing, the current flow and an analysis of the heart be able to design the heart’s phantom model.

II. The normal cardiac structure

Figure 1 show the cardiac structure and a circulation of a blood. The heart be composed of two atrium and two ventricle, they are arrayed at a left and right in a regular line.

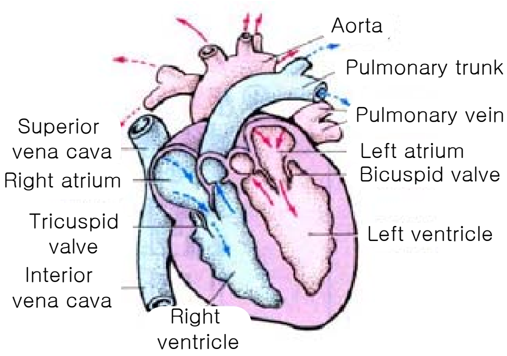

Fig. 1 An organization of the heart and the blood circulation.

The pulmonary artery go out at a right ventricle and the aorta go out at left ventricle. The between two atrium and two ventricle is completely closed. There is tricuspid between right atrium and right ventricle. There is the pulmonary artery plate between the right ventricle and the pulmonary artery, and this fill in a blood topsy-turvy. Also, there is the bicuspid value between left atrium and left ventricle, and the aorta valve between the left ventricle and the aorta.[1,2]

The blood of the right atrium is flow into the right ventricle through the tricuspid valve. The pushed blood by the contractile force of the right ventricle is flow into the lugs.

The blood flowing into the pulmonary artery be supplied to an oxygen. The blood of the pulmonary supplied by an oxygen flow into the left atrium, and then flow into the left ventricle followed the tricuspid vale.

An aortic blood pumped by an activity of the left ventricle is transmitted to the body, and then conveys the oxygen and nutrition.

III. The multidipole current source

An active voltage of the heart has the differential shape and property in the parts. Therefore, there is a series of current pattern and consume an electric power.

The estimation of a power distribution independent of an electric conductivity of a medium, but must see a criterion to estimate an activity of a heart. On the other hand, the estimation of the power distribution is related to the electrical deminsion of a heart as the static voltage source or the static current source. In the view point, we have assume the simulation model that the voltage is constant and a resistance is different.

In this simulation model, the part of presenting a high power is to have the highly electric resistor[8]. Also, we consider that the static voltage and the current occur in the regular hexahedron areas including an excited transmission path.

The boundary of a regular hexahedron and the other parts assume the boundary condition of establishing the Newman boundary condition. Actually, this boundary condition could not always established. But if we can estimate the power distribution of a heart from the localized electromagnetic distribution, we can consider it the proper model.

In the analysis of magnetocardiogram signal, the main information is an electric activity of the heart, the homogeneity of an electric activity, the progress direction of an excitation front, the intensity of an electric activity in a heart, the waveform of the magnetocardiogram and the pattern of a space waveform[9]. P-wave be made by the polarization of an artrium, the height is 2.5mm and the width is about 0.12sec. Ta-wave is made by the repolarization of an atrium, PR-wave is made by an excited transmittion time from an atrium to the ventricle. The width of QRS-wave is 0.04~0.11sec and the height is 0.5mm. ST is segmentation, T and U-wave is made by the repolatization of the ventricle and a QT interval is the duration time between polarizations[10].

Fig. 3 The current source model of the dipole

Figure 3 shows the current source model. It is made of a cylindrical polyethylene resin rolled with the Cu-line, and covered by the polyethylene resin. Then, the twisted Cu-line cancel an electromagnetic field, and do not effect on the any operation. In order to minimize an electromagnetic field, we have covered the twisted line with an aluminium coil and insulated tape. Finally, the shielded line of a terminal become grounded to cancel an inner noise.

An experimental results Figure 4 shows the multidipole current source using the microprocessor. The used microprocessor is 8 bits microcontroller (AT89C51) of ATMEL co. We have used the photo-coupler to separate the power supply.

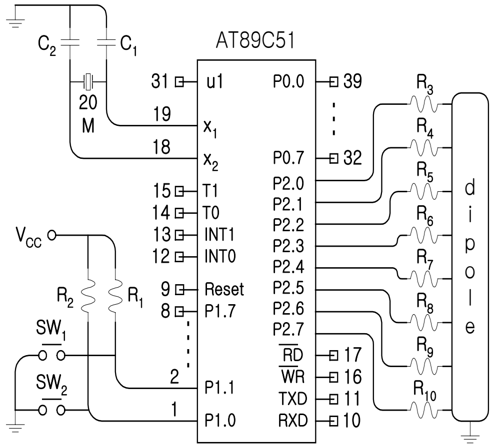

Fig. 4 The circuit diagram.

The AT89C51 have programmable hash memory of 4Kbytes, the speed of 24Mhz, a program memory lock function of three-level, an inner RAM of 128*8bit, a programmable input/output of thirty-two, two 16bit timer/counter, six interrupt and serial channel. And we have used components of the R1=R2=10KΩ, R3=k10=330Ω, and C1=C2=30pF.

In order to derive the precise operation of an experiment, we must carefully measure an electric operation. Actually, the SQUID(superconducting quantum interference device) sensor is very sensitive and can effect on the system by an outer change. So, in order to remove an outer noise, we use the magnetic shield room.

In an experiment, the 15mA be supplied to the dipole 1 and 10mA to the dipole 2 during a 60sec with the period of 15sec. Then we have measured the change of an electromagnetic field. Figure 5 shows the microcontroller for measuring an electromagnetic field.

Figure 5 shows the phantom of the heart attached with the multidipole current source.

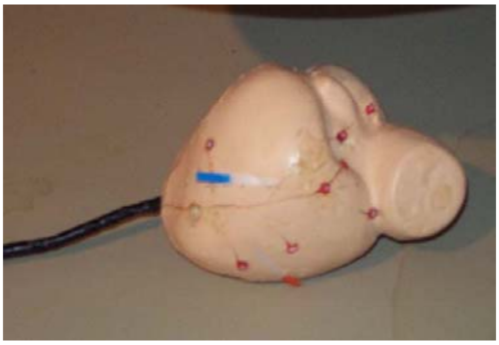

Fig 5. Phantom of the heart.

The research for the heart based on the brain must be going first an electric modeling of the heart. And then, it is necessary for analyzing the structure of the heart to know an excited path and the power distribution of the heart. We have applied an invented system to the MCG system.

In experimental results, the precision of the system go down, but the prototype invention has an important means to research the heart. The various test about the model must be worked more and more for the future. Table 1 explain the time interval and the location of current source in a channel analysis.

Table 1. 8 position of channel

dipole \ position	position	Time(sec)
First	SA node	0. – 0.02
Second	Left atrium	0.16-0.26
Third	AV node	0.18-0.29
Fourth	His bundle	0.30-0.32
Fifth	Bundle branch	0.34-0.36
Sixth	Right Purkinje	0.40-0.45
Seventh	Left Purkinje	0.40-0.47
Eight	Left ventricle	0.62-0.73

Figure 6 show the signal properties of an electromagnetic field during 50 sec. The periodic signal of 5 sec and the strength are presented.

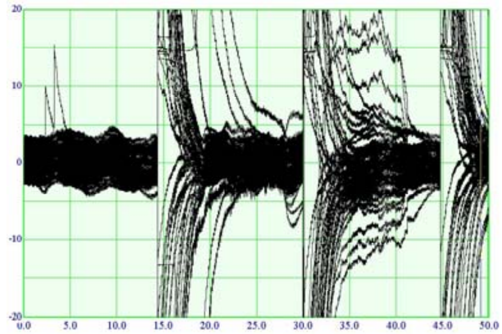

Fig 6. Signal property of an electromagnetic field

Figure 7 shows that the magnitude of an electromagnetic field from 15 sec to 20 sec be presented at a map.

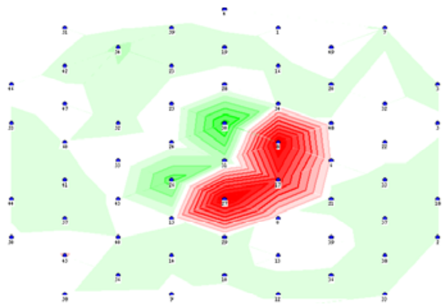

Fig. 7 Mapping of an electromagnetic field in the current source

In Figure 8, the strength about the current source of channel-8 and channel-27 is presented. We have used the MCG(Magneto cardiograph) of 64-channel, the operated current and voltage are about 5 ㎃ and 2.5V, respectively.

Figure 8 shows the detected signal from 4 channels. Where the vertical line is signal strength and the horizontal line presents the time.

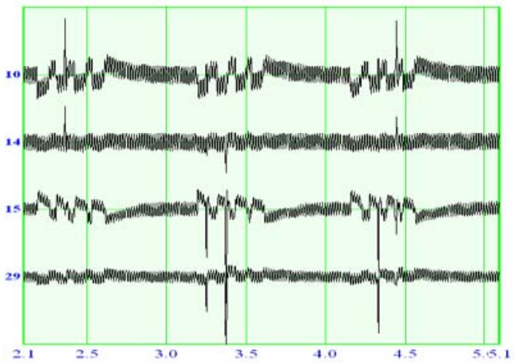

Fig 8 The measured signal from 8 channels.

In Figure 8, the number of the noise buried in background signal. In order to cancel such a noise, we must use a filter technique like LMS, NLMS, so on

Figure 9 shows 4 channels signal after lowpass filtering the Figure 8.

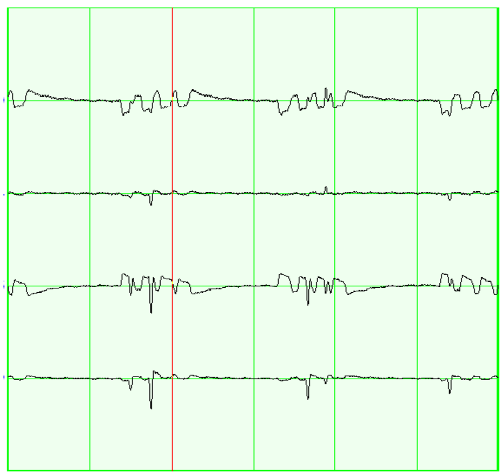

Fig. 9 Signal property after lowpass filtering 4 channel signals

Ⅴ. Conclusion

A lot of the research to diagnose the heart disease has progressed at the noninvasive method. Such a noninvasive method can diagnose the patient without paining. An electric model in the heart research is necessary and an excited path of the heart must be analyzed. The multidipole current source have developed in these purpose attach to the real heart phantom. Then the generated signal by the microcontroler can make the signal similar to a real heart. An acquired signal is transmitted to the MCG system and analyzed by PC.

The signal generated in the dipole role in the channel and presented in an electromagnetic field. Then the mapping of an electromagnetic signal explains the syndrome generated in special location of the heart phantom. Also, the pulse wave of this signal is displayed to the 1-dimension type of each channel and then in channel signal that cancel the background noise.

Conference

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