Consideration of conditions required for multi-channel simultaneous bioimpedance measurement

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Consideration of Conditions Required for Multi-Channel Simultaneous Bioimpedance Measurement

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Abstract *- Impedance techniques have been widely applied to biomedical engineering field. In order to obtain the definite results from bioimpedance, multi-channel measurement is effective. A linearity of biological tissue and fundamental technical parameters for the instrument must be confirmed. In this study, the fundamental conditions have been investigated for multi-channel bioimpedance measurement and the condition of measurement for biological tissue have been confirmed. The differences of every measurement frequency should be appropriate 1 kHz. And it has been cleared that the linearity of biological tissue is maintained. Based on these results, 2 channel bioimpedance measurement instrument has been constructed.*

I . INTRODUCTION

Impedance techniques have the following advantages; it is non-restrictive about measuring item and measuring part, it is non-invasive, measuring system is easy handling and low cost. Therefore, it has been widely applied to biomedical engineering field, for example, movement analysis of respiratory system, cardiovascular system and human limb. However, the meaning of their results are originally not analytical but composite, because biological tissue is organized by many kinds of organs. We think that multi-channel impedance measurement is effective in order to obtain the define results from bioimpedance. Before, execution of multi-channel impedance measurement, a linearity of biological tissue and fundamental technical parameters for the instrument must be confirmed. In this study, in order to realize multi-channel bioimpedance measurement at 50 kHz high frequency range which is normally used for human limb and human body, we have investigated the fundamental conditions of measuring system and biological tissue.

II . MEASURING SYSTEM

In this study, we have adapted the four electrode technique based on sinusoidal constant current (50 kHz, 0.5 mA) [1]. Fig.1 shows the block diagram of impedance meter to measure bioimpedance (one-channel measurement) [2][3]. In this system, the equivalent series resistance of the evaluated part is measured as voltage.

Fig.2 shows the block diagram of 2 channel bioimpedance measurement instrument using two impedance meters. In order to avoid interference of each impedance meter, we have separated each ground by using different power supply, and used different measuring frequency. Next, we have confirmed about difference between measuring frequencies. According to the results, more than 0.5 kHz is needed as the difference to avoid interference of each impedance meter. Then, we have selected 1 kHz. Therefore, measuring frequency of the other impedance meter has been made 49 kHz.

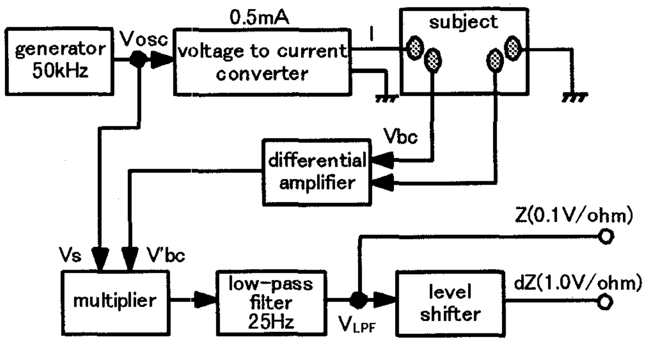

Fig.1 Block diagram of impedance meter.

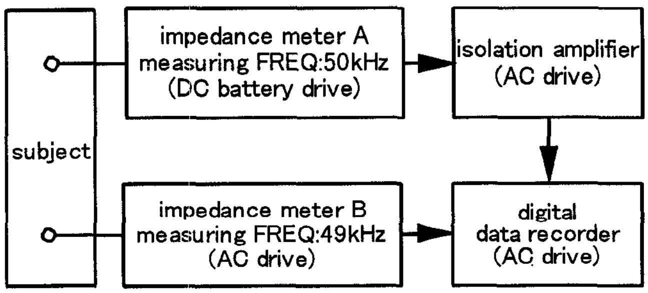

Fig.2 2 channel bioimpedance measurement instrument.

Fig.3 shows output characteristic of this measuring system on resistance element having linear characteristic. According to the results, we can confirm measuring errors in the range of 1 %. Therefore, by confirming linear characteristic of bioimpedance, we can expect it of the measuring system when it is applied to measuring bioimpedance, i.e. measuring of neck electrical impedance which we normally measure and standard range is about 20-50 ohm.

III. MEASURING METHOD

It is difficult to confirm linear characteristic of bioimpedance because we cannot define true value of bioimpedance differ from measuring resistance element. Thus in the study, we have experimented with the definition which linear characteristic of bioimpedance is achieved by corresponding both measured values by single measurement and simultaneous measurement.

Fig.4 shows locations of electrodes connected to the above mentioned measuring system. In the case, measured object is bioimpedance of forearm which is as stable. Arrangement of potential electrodes have been set up so that measured impedance is about 40 ohm which nearly equals to value of neck electrical impedance. By changing connection of electrodes, both values measured by single measurement

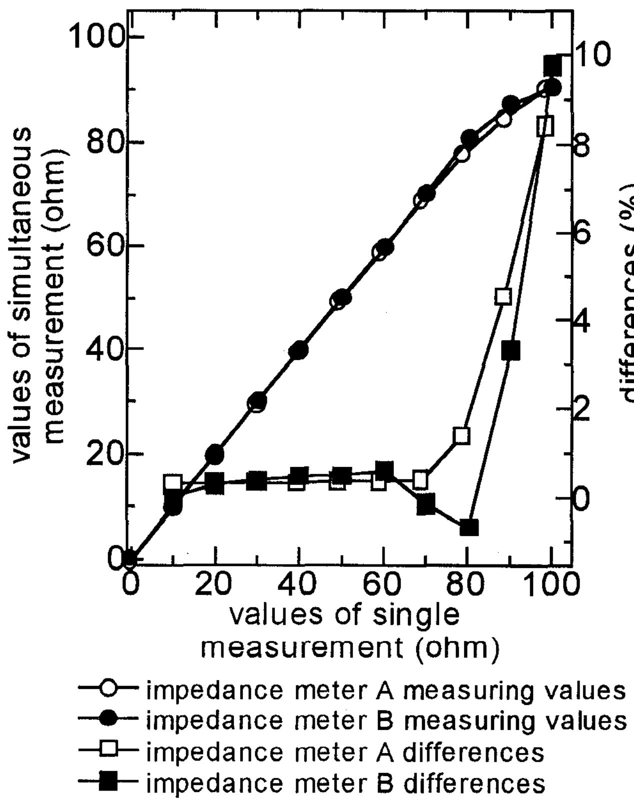

Fig.3 Results of simultaneous measurement on resistance element.

and simultaneous measurement have been recorded. Because bioimpedance always change slightly, measurement has been done about ten times in each case. The average and the standard deviation of the results have been calculated.

IV. RESULTS AND CONSIDERATIONS

Table I shows results of the measurement. According to it, we compare both average values from single measurements, with impedance meter A and B, and simultaneous measurement. The differences are 0.96 % in impedance meter A, and 0.23 % in impedance meter B. In other measured part, the differences which is less than 1 % are constantly observed. Therefore in the strict sense of the world, bioimpedance has nonlinear characteristic. However in this study, because we evaluate impedance with measuring errors in the range of 1 %, this is not serious problem to evaluate bioimpedance which is regarded as having linear characteristic on condition that differences are in the degree.

V. AN EXAMPLE OF APPLYING TO BIOIMPEDANCE MEASUREMENT

We are analyzing swallowing using IPG (Impedance Pharyngography) which is obtained by measuring neck electrical impedance [4]. Since multi-channel simultaneous bioimpedance measurement become possible, it is very convenience to compare EGG (Electroglottography) which uses neck electrical impedance as well as IPG.

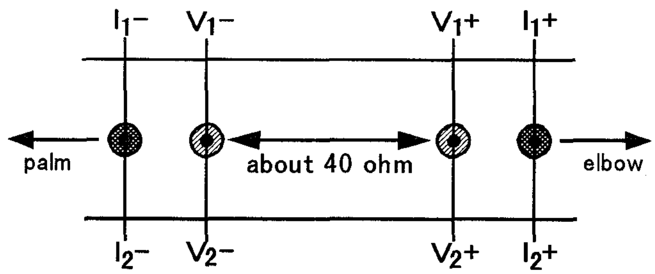

Fig.4 Locations of electrodes on forearm.

TABLE I

RESULT OF SIMULTANEOUS MEASUREMENT ON FOREARM.

	impedance meter A (measuring FREQ:50 kHz)	impedance meter B (measuring FREQ:49 kHz)
single measurement	42.60±0.12 (ohm)	42.58±0.05 (ohm)
simultaneous measurement	42.19±0.13 (ohm)	42.48±0.11 (ohm)
difference	0.96 (%)	0.23 (%)

Fig.5 shows locations of eight electrodes on subject's neck for IPG and EGG simultaneous measurement. Above four electrodes are standard locations for IPG measurement, and below four electrodes are ones for EGG measurement. Fig.6 shows result of this experiment. By comparing IPG and EGG, we can confirm that changes of both waveforms are opposition each other, and there is difference between the time of maximum value of EGG and one of minimum value of IPG.

First, let us consider now the implications of the change of both waveforms are reverse each other. We can see from Fig.7 that in IPG measurement, increasing of equivalent cross sectional area, which is brought about by swallowing organs nearly epiglottis ascending have been measured. On the other hand, in EGG measurement decreasing equivalent cross sectional area bring about swallowing organs nearly thyroid cartilage.

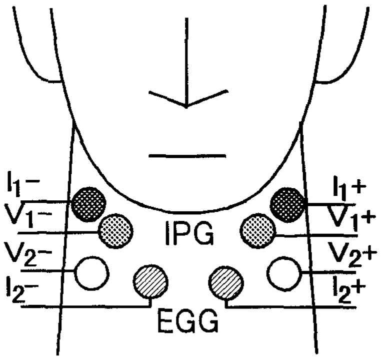

Fig.5 Locations of electrodes on front of neck.

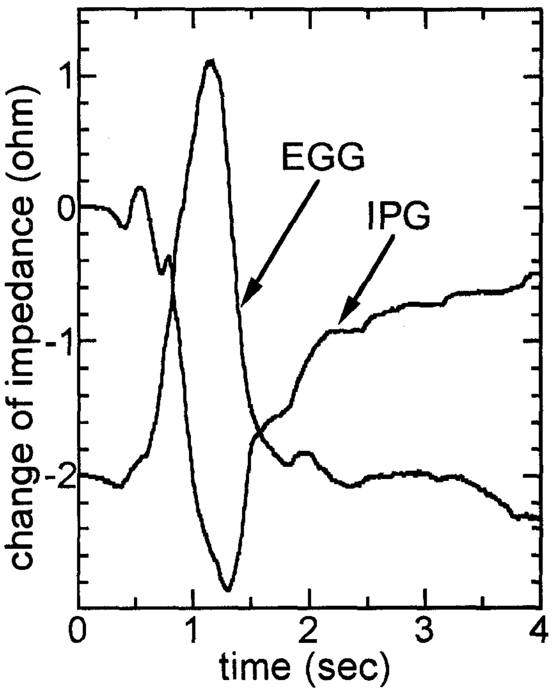

Fig.6 Result of IPG and EGG simultaneous measurement.

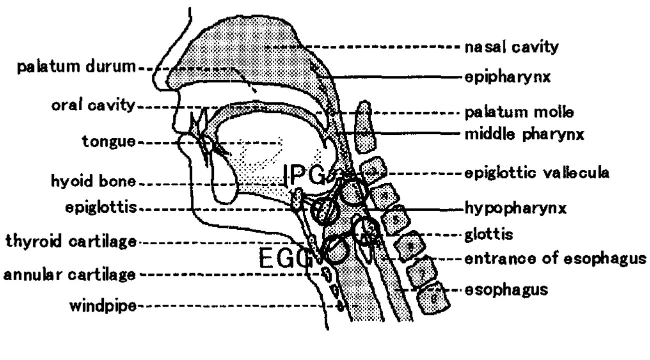

Fig.7 Organs concerning swallowing

Second, consider now the implications of the difference between the time of maximum value of EGG and one of minimum value of IPG. In oral cavity phase and the first half of pharyngeal phase, larynx (hyoid bone, thyroid cartilage and annular cartilage) ascend and epiglottis cover vestibule of larynx. In the second half of pharyngeal phase, larynx descend. However, we must pay attention to this phenomenon. First, thyroid cartilage and annular cartilage descend. Second, hyoid bone descend and epiglottis go back former conditions. Therefore, it is reasonable to suppose that this phenomenon affect timelag.

VI. CONCLUSIONS

In this study, in order to realize multi-channel bioimpedance measurement at 50 kHz high frequency range using normally for human limb and human body, we have investigated the fundamental conditions of measuring system and characteristic of biological tissue.

We have been able to confirm that under the circumference of 50 Hz of maximum frequency spectrum in biological signal and the apply of phase sensitive detection in 2 channels, the differences of every measurement frequency should be appropriate 1 kHz. Further, it has been cleared that the linearity of biological tissue is maintained with the extent of about 1 mA effective value of multi-frequency current at around 50 kHz. Based on these results, 2 channel bioimpedance measurement instrument has been designed and constructed. Next, by measuring IPG and EGG simultaneously, we have been able to reveal effectiveness of multi-channel bioimpedance measurement from obtaining information which are difference of measuring object and waveforming of both waves.

There is impedance CT which is one of bioimpedance measurements. This is a kind of multi-channel measurement. However, it has problems that measuring system is intricately and measuring time is restricted. We expect that our method will be useful for development of handy and specified part, by establishing multi-channel measurement such as our method.

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