

Synovial Fluid Density Measurement for Diagnosis of Arthritis

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ABSTRACT

Synovial fluid generally present in the joint region for the purpose of lubricant as a major task. During arthritis disease affected condition the density of synovial fluid varies as a function of time in case of osteoarthritis and as a function of disease condition in case of rheumatoid arthritis. By measuring the variation in density of synovial fluid arthritis diseases can be diagnosed. In this paper an non invasive method has been adopted for measurement of synovial fluid density change using electrical bio-impedance concept. Electrical Bio-Impedance is the measure of opposition given by the tissue for applied electrical signal. The Bio-impedance values are measured in terms of voltage drop across the joint tissue region as tissue can be represented as resistance and capacitive reactance. These resistance and reactance varies from normal person to Arthritis patient for a fixed frequency and voltage. Hardware section made using signal generator circuit with variable frequency and variable voltage provision. To measure the voltage drop using non invasive method four electrodes has been utilized for given electrical signal and acquiring the response.

Key words: Synovial fluid density, Arthritis, Electrical bio-impedance, Non invasive diagnosis, Electrodes.

INTRODUCTION

Arthritis, human joint disorder was analysed generally by invasive methods, blood test, Pathology, X-ray, MRI, Ultrasound, CT and Synovial fluid test. Based on the sign and symptoms obtained during initial diagnosis the doctor advices to go for any one of the above test^{2,3}. The diagnosis ends with basic blood test and x-ray for initial stage patients. For advance stage diagnosis the patient needs to go for MRI, Synovial Fluid test or ultrasound test. During these conventional methods either blood has to be taken out or body fluid has to be collected from region of interest by undergoing minor surgery^{4,5}. From the advancement in medical diagnosis technology as optical sensing and bio-impedance makes the possibility of non invasive diagnosis. The Bio-impedance spectroscopy has been used to monitor

body fluid volume, Water content in body, Cardiac output etc., with non invasive system. The potential problems of the affected tissue can be identified by measuring impedance of a set of tissues using invasive method^{1,6}.

Bio-impedance spectroscopy diagnosis system design was made of constant current source as an essential part. Current source are widely obtained from voltage to current converter and Howland current source⁹. Bio-impedance analysis uses mathematical analogues and complex equations to find the resistance of body fluid. The resistance measurement varies as input frequency varies from zero to infinity¹⁰. During implementation of bio-impedance based non invasive method for diagnosis of arthritis the diagnosed output value obtained on the skin surface near the joint region

varies as the function of input voltage and frequency. This paper analyse the effect of input frequency and input voltage variations on output reading.

EXPERIMENTAL

The non invasive system for diagnosis of arthritis was designed using signal generator with the provision of varying the frequency ranging from 10 KHz to 500 KHz and varying the voltage ranging from 0 Volts to 8 Volts. To have non invasive contact with joint region four electrodes have been used. The purpose of four electrodes is to give electrical signal in to the tissue region and also to collect the response of the tissue to the applied electrical signals^{7,8}. The passage of electrical signal through tissue was opposed by the electrical property of the tissues called electrical bio-impedance. This opposition given by the tissue to the applied signal has been measured in terms of voltage drop. The obtain voltage signal was processed using data acquisition unit and display using voltage display unit as shown in figure 1. These resistance and reactance varies from normal person to Arthritis patient for a fixed frequency and voltage. If input voltage or frequency was varied the measured voltage drop in terms of bio-impedance varies.

The readings which were obtained from the joint region using non invasive electrodes were

Table 1: Voltage values obtained in terms of bio-impedance for fixed frequency and variable input voltage

Output voltage in Volts variation for Constant Frequency = 200 KHz			
V ₁ = 1 Volts	V ₂ = 3 Volts	V ₃ = 6 Volts	V ₄ = 8 Volts
0.14	0.25	1.00	1.80
0.14	0.27	1.28	2.17
0.19	0.29	1.34	2.32
0.21	0.33	1.39	2.45
0.25	0.38	1.48	2.75
0.30	0.42	1.62	2.98
0.34	0.47	1.79	3.08
0.38	0.51	1.89	3.28
0.41	0.56	2.18	3.46
0.45	0.60	2.50	3.70

separated in to two tabulations. The first tabulation contains output voltage values for constant input frequency of 200 KHz as shown in table 1. Similarly second tabulation contains voltage values for constant input voltage of 8 Volts as shown in table 2. From table 1 we observe that for the fixed input frequency 200 KHz the output voltage varies as a function of input voltages. By varying input voltage from 1 Volts to 8 Volts we observed that output voltage varies from 0.08 Volts to 3.70 Volts.

In the tabulation the output voltage readings were arranged in age order so we observe that the older the age higher was the voltage drop for same value of input voltage. Similarly from table 2 we observe that for the fixed input voltage of 8 V the output voltage varies as a function of input frequency. By varying input frequency from 50 KHz to 200 KHz we observed that output voltage varies from 0.14 Volts to 3.70 Volts.

RESULTS AND DISCUSSION

Using the values in tabulations two graphs was plotted. The voltage variation based on age for different input voltage variations has been shown in figure 2. Output voltage varies as a function on age as well as input voltage variation has been clearly observed from the four different curves. For constant frequency of 200 KHz the out voltage oscillates from

Table 2: Voltage values obtained in terms of bio-impedance for fixed voltage and variable input frequency

Output voltage in Volts variation for Constant Input voltage = 8 volts			
50 KHz	100 KHz	150 KHz	200 KHz
0.08	0.13	0.98	1.82
0.11	0.19	1.06	2.16
0.13	0.21	1.12	2.3
0.14	0.23	1.21	2.42
0.15	0.25	1.26	2.75
0.19	0.27	1.32	2.98
0.22	0.31	1.37	3.08
0.25	0.33	1.43	3.26
0.31	0.4	1.54	3.46
0.26	0.43	1.6	3.73

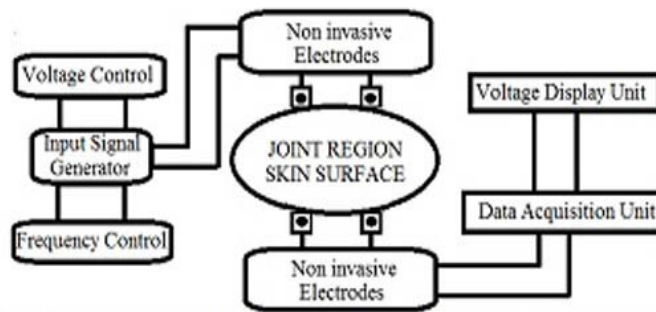


Fig. 1: Basic block diagram for variable voltage and variable frequency non invasive bio-impedance diagnosis

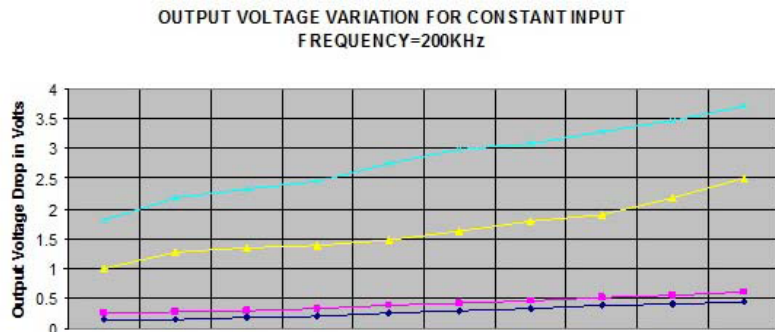


Fig. 2: Graph showing the Voltage variation for fixed frequency and variable input voltages

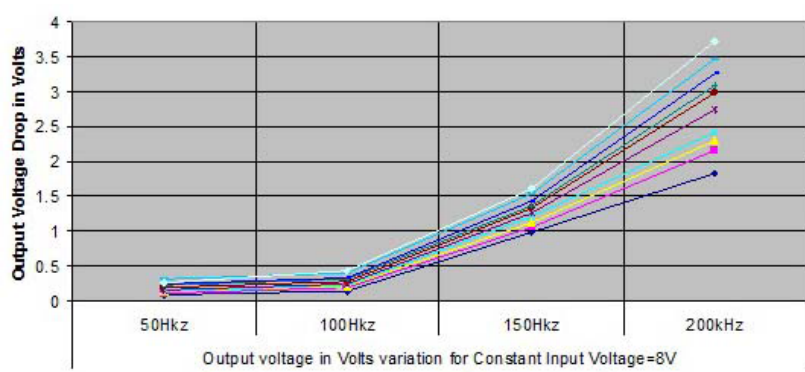


Fig. 3: Graph showing the Voltage variation for fixed voltage and variable input frequencies

0.14 Volts to 3.7 Volts. The voltage variation based on age for different input frequency changes has been shown in figure 3.

Output voltage varies as a function on age as well as input frequency variation has been clearly observed from the plotted curves. For constant

voltage of 8 Volts the out voltage oscillates from 0.08 Volts to 3.73 Volts. From the two graphs we can observe that the output voltage varies as age varies. High voltage drop for persons with older age and low voltage drop for person with young age irrespective of the input voltage and frequency variation.

CONCLUSION

The synovial fluid density changes have been observed in terms of voltage drop. Also the voltage drop variation for variation in input frequency and input voltage has been observed. The current study implements analyses of the impact of input voltage and frequency variation during bio-impedance based diagnosis. These resistance and

reactance varies from normal person to Arthritis patient for a fixed frequency and voltage. If input voltage or frequency was varied the measured voltage drop in terms of bio-impedance varies. In this paper the effect of input frequency and voltage on output measurement has been analysed with circuit made using signal generator circuit with variable frequency and variable voltage provision.

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