Dhaka Univ. J. Sci. 56(2): 221-224 2008 (July)

Variation in Sensitivity within the Focused Zone of the New Four-electrode Focused Impedance Measurement (FIM) System

K S Rabbani and M A S Karal

Department of Physics, Dhaka University, Dhaka- 1000, Bangladesh

Received on 08.08.2007. Accepted for Publication on 16.01.2008

Abstract

This paper presents an empirical study of the variation in sensitivity caused by small changes in position of an object in and around the central focused zone of the new 4-electrode FIM technique developed by us. Experimental measurements were made using a 2D phantom and a circular object whose diameter was about 73% of the sides of the defined square shaped focused zone. Raw data initially suggested a relatively large variation, of the order of 60% from the centre of the focused zone to its sides, however, a qualitative analysis revealed that this large variation was due to part of the object falling outside the focused zone in most of these measurements, and the true variation in sensitivity for small objects would be much less. This result also indicated that for measurement of time variation of physiological parameters of organs like stomach, heart, lungs, etc., where the electrode positions remain fixed during the measurement, a much higher degree of accuracy and resolution may be expected.

I. Introduction

Electrical impedance measurement has the potential of physiological study and diagnosis of certain disorders of the human body in which the electrical properties of specific tissues change over time or with the frequency of measurement[1,2,3]. Stomach emptying after food intake, bladder emptying during urination, lungs ventilation and perfusion during breathing, and blood volume change through the heart cycles are some of the physiological parameters that may be amenable to such impedance measurements. However, focusing the measurement to a physically localised region is necessary for this technique to be useful and a new method named as Focused Impedance Measurements (FIM) was conceived of and developed earlier in the Biomedical Physics Laboratory of the University of Dhaka[4,5] for this purpose. This uses six electrodes to localize a zone of interest. In order to reduce the number of electrodes of this earlier FIM system a new four electrode FIM technique has been conceived of and developed recently by us[6]. The basic measurement method for this new 4-electrode measurement is as follows. In fig 1, four electrodes A, B, C & D are shown placed at the corners of a square region which is the zone of interest. Suppose A&B are the current drive electrodes and C & D are the potential measuring electrodes for a measurement set. The drive current has a constant amplitude I, while the resulting potential amplitude V_{34} is measured and recorded. Next B&C are chosen as the current drive electrodes passing the same current I while the potential V_{41} is measured across electrodes D&A. E_1F_1 and G_1H_1 are the appropriate equipotential lines passing through the measuring electrodes C & D respectively for the first measurement while E_2F_2 and G_2H_2 are the appropriate equipotential lines passing through the measuring electrodes D&A respectively for the second measurement. From the above measurements we can obtain the respective impedances $Z_1=V_{34}/I$ and $Z_2 = V_{41}/I$. Here Z_1 is the effective impedance of the zone surrounded by E_1F_1 and G_1H_1 with the sensitivity falling off away from the centre. Similarly the impedance Z_2 is the effective impedance of the zone surrounded by E_2F_2 and G_2H_2 with similar sensitivity reduction away from the centre. The sum of the two impedances, Z_1 and Z_2 has a dominant contribution from the central zone defined by the electrodes A, B, C & D, and this is the basis of this FIM method.

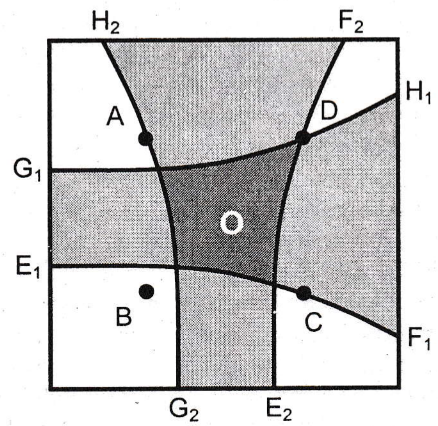

Fig. 1. Electrodes and equipotential lines defining a focused zone in a 2D four-electrode FIM system

In order to increase the utility of this measurement, focused measurements around a zone of interest are usually carried out in a background situation and then in another where the impedance changed locally in the focused region only. The difference of these two measurements gives a figure of sensitivity of the focused region. To study the degree of focusing obtained, sensitivity of other neighbouring regions were also measured in a similar way by placing the same object at the centres of these zones. An ideal focusing would be where sensitivity is high in the focused zone and zero elsewhere. Practically it would not be so and some sensitivity will also be obtained in the neighbouring zones, but these should be as small as possible. In the 4-electrode FIM, the sensitivity dropped to about 5% of the central value in the immediate neighbouring zones, and became negligible further out.

For the focused impedance measurement to be useful, the target object should be located at the centre of the square region. In practical measurement situation, a target organ inside the human body may not be placed accurately in the centre of the specified matrix position, or it may change position slightly during essential body functioning. Ideally, for an object whose dimensions are less than that of the focused zone, variation of sensitivity within the centrally defined focused zone should be zero, so that the same