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Response of Cholesterol with Varying Glucose Concentration

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ABSTRACT: The paper discusses the response of Cholesterol in the presence of other blood constituents like Salt, Glucose, Urea and Alanine. The response is measured in the 10 - 500 MHz range with varying Glucose from below normal to above normal. The study is intended to ascertain the influence of Glucose on Cholesterol measurement. An RF spectroscopic technique is used in the study for recording the responses. The study is done with a low cost Spectrum Analyzer and has been found to give consistent results. A detailed cell design for attenuation measurement is given and various grounding techniques are explained, for minimising external EMI disturbance.

KEYWORDS: Cholesterol, Glucose, RF Spectroscopy, Tracking Generator, Spectrum Analyzer.

I. INTRODUCTION

Cholesterol is normally our friend as well as our foe. It is a useful substance for the functioning of the human body at the normal level, but it becomes dangerous and risky, should the levels of Cholesterol get too high. Cholesterol consumed by humans through food is poorly absorbed since it is esterified. Cholesterol synthesis is reduced when the body makes up for any retention of extra Cholesterol. It is normally reused in the body. The liver discharges it into the digestive tract in a non-esterified structure by means of bile. Around half of the Cholesterol is discharged by the small intestines and reabsorbed by the blood. Cholesterol is necessary to maintain and build membranes. It also functions in nerve conduction, cell signalling and intracellular transport inside the cell membranes.[1] The main cause of coronary heart diseases and other types of CVD, are correlated with atheroma formation in the arterial walls known as atherosclerosis, due to highly oxidized LDL Cholesterol particle concentrations.[2] This process over the years lead to strokes, heart attacks and peripheral vascular diseases.[3]

The amount of sugar present in the human blood is the blood Glucose level or blood sugar concentration.[4][5] Glucose is transported from the liver or intestines via the blood stream to body cells and is made accessible for cell absorption through the insulin produced in the pancreas. Glucose levels that fall above and below the normal range is a sign of a medical illness. A continual high level is known as hyperglycemia and a low level is known as hypoglycemia.[6] Diabetes mellitus is a cause of hyperglycemia and is the most conspicuous illness related to failure of Glucose regulation. Others related diseases include kidney, eye, nerve damage and coronary illnesses. The American Diabetes Association estimated that the total costs of diabetes have risen from $174 billion in 2007 to $245 billion in 2012. This figure signifies a 41% increase from 2007-2012.

The largest components of medical expenditures are:

- 43% - medical cost on hospital inpatient care
- 18% - treatment of complications of diabetes
- 12% - diabetic and anti-diabetic supplies
- 9% - office visits to a physician and
- 8% - residential/nursing care.

Individuals detected with diabetes, acquire a medical expenditure of around $13,700 every year, which is roughly 2.3 times higher than in the absence of diabetes.[7]

Indirect costs comprises of the following:

- $21.6 billion people having the disease related disability
- $20.8 billion for reduced productivity while at work and for the working population

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- $18.5 billion people having lost productivity due to early mortality and
- $2.7 billion reduced productivity for the unemployed.

II. PREPARATION OF SAMPLES

The Glucose in the human blood ranges from 70-110 mg/dL. The range of Urea is 10-20mg/dL, Salt is 9g/L, Cholesterol is 225mg/dL and Alanine is 10-20mg/dL. This experiment is conducted with 90mg/dL of Glucose, 12.5mg/dL of Alanine and 15mg/dL of Urea. Solution samples having concentrations in the range of 0.75 to 2.5 times the normal concentration of Cholesterol are prepared using double distilled water. Every sample comprises of 14mL of water and 1mL of Alcohol.[8] Alcohol is added to water in order to dissolve the Cholesterol, to a particular extent in water. Now 0.5 times the normal range of Glucose (6.8mg/dL) is dissolved in 0.75, 1, 1.25, 1.5, 2 and 2.5 times the concentration of Cholesterol i.e. 25.5mg/dL up to 85mg/dL and the results were noted. The experiments were conducted in 2 particular modes i.e. fast and slow sweep. The experiments were conducted and repeated after an hour and two hours so as to nullify the environmental effect. The above results were compared with the first results and were found to be precise. Next, the experiment was conducted with Glucose in the normal range with different concentrations of Cholesterol and the results were noted. Similarly Glucose having 2 times and 3 times the normal range i.e. 27mg/dL and 40.5mg/dL were mixed with different concentrations of Cholesterol and the results were noted again.

III. CELL DESIGN

In order to measure the RF response of Cholesterol with varying Glucose in the presence of other blood constituents, a cell was designed using plastic sheets with breadth of 1cm, length of 12.5cms and height of 2cms as shown in Fig. 1. A thin copper foil was used to cover the outside and a thin gold foil inside the cell. In order to avoid external radiation, the cell was put in an iron container which was grounded separately. 2 connectors were placed on both sides of the cell. A thin gold wire was connected along the center of the cell.

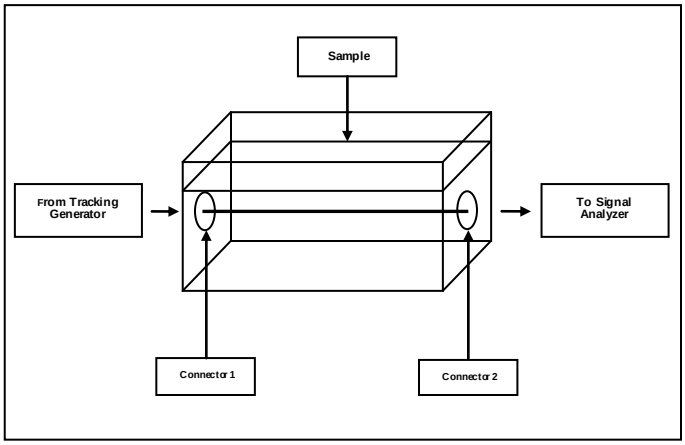

Fig. 1: Schematic of the Measurement Cell

IV. EXPERIMENTAL SETUP

In order to avoid any mechanical movements, the cell was screwed onto a wooden plank along with the signal analyzer and tracking generator. A signal was introduced into the cell from the Tracking Generator, through the gold wire and it was received by the signal analyzer at the other end of the cell.

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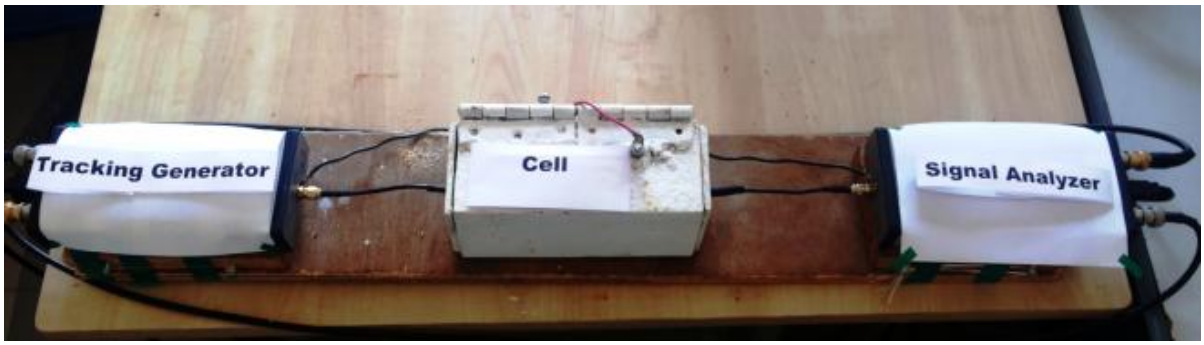

Fig. 2: Experimental Setup

The experimental Setup is shown above in Fig. 2 which uses a Tracking Generator USBTG44A and Signal Analyzer USB-SA44A. The instruments range between 10Hz and 4.4 GHz but the samples were analyzed up to 500MHz. The range can be modelled through curve fitting and multivariate applications in order to develop parameters to predict blood composition such as Cholesterol, Glucose, Urea, etc.

V. RESULTS

It can be observed from the graphs shown in Fig. 3 to Fig. 6 that as the concentration of Cholesterol increases from 0.75 to 2.5, the absorption increases in the range of 60MHz to 100MHz.

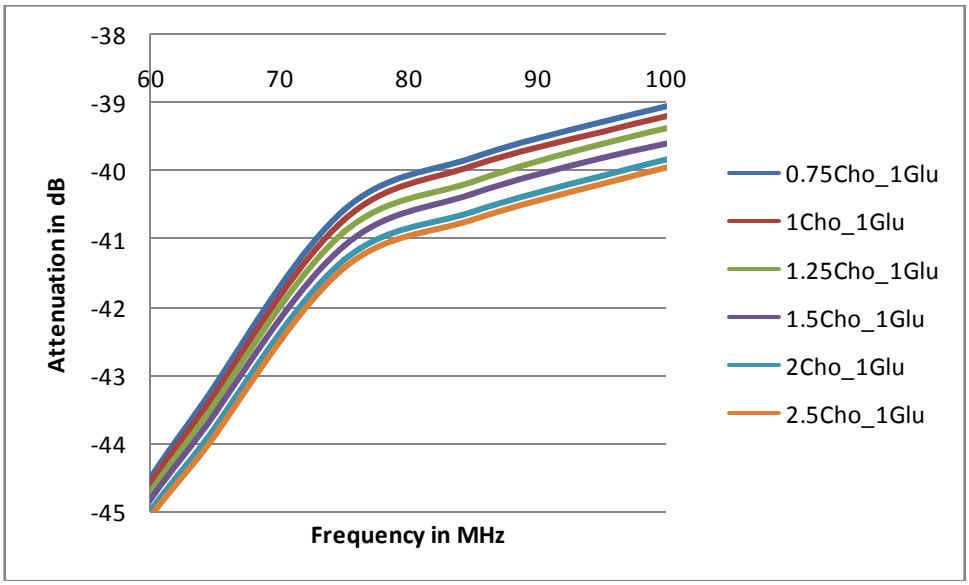

Fig. 3: Graph of 60MHz - 100MHz with normal Glucose concentration

A typical graph is shown in Fig. 3 which gives the variation in the signal attenuation for varying concentration of Cholesterol where Glucose is maintained at the normal level i.e. 1 and the other constituents are also maintained at normal levels. It may be observed that between 80MHz - 100MHz, attenuation due to Cholesterol is significant.

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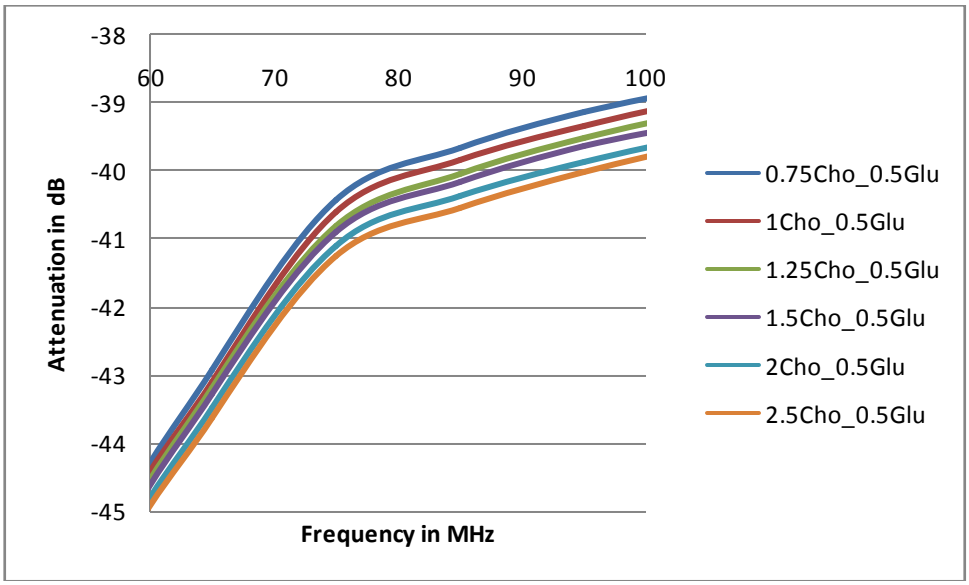

Fig 4: Graph of 60MHz – 100MHz with half the normal Glucose concentration

Similarly, Fig. 4 gives the variation in the signal attenuation for varying concentration of Cholesterol where Glucose is maintained at a low level i.e. 0.5 and the other constituents are maintained at the normal level.

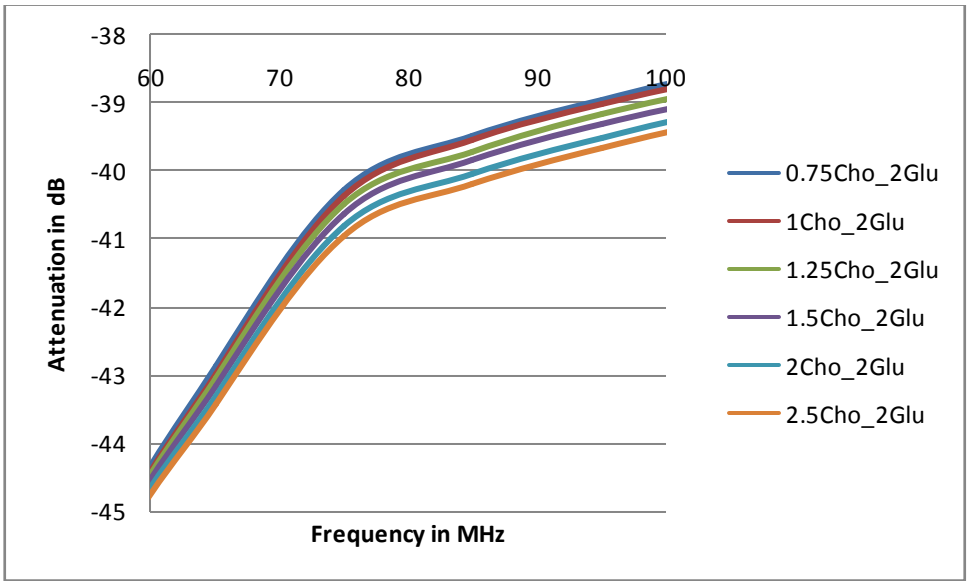

Fig. 5: Graph of 60MHz – 100MHz with twice the normal Glucose concentration

As shown above, Fig. 5 shows the variation in the signal attenuation for varying Cholesterol concentration wherein Glucose is maintained at twice the normal level i.e. 2 and the other constituents are maintained at the normal level. As the concentration of Cholesterol increases from 0.75 to 2.5, the absorption also increases.

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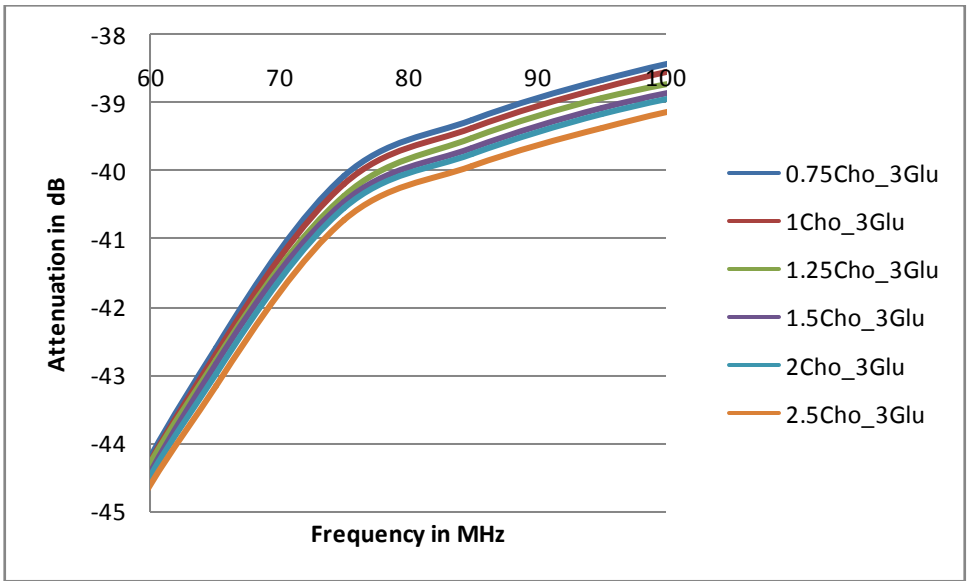

Fig. 6: Graph of 60MHz – 100MHz with 3 times the normal Glucose concentration

Fig. 6 shows the variation in the signal attenuation for varying Cholesterol concentration wherein Glucose is maintained at a high level of 3 i.e. 3 times the normal Glucose level and the other constituents are maintained at the normal level. It is observed that attenuation due to Cholesterol is significant between 80-100MHz.

The results bring out the conclusion, that the RF response of Cholesterol is independent of Glucose and therefore no normalization needs to be done if Glucose is found varying from person to person.

VI. CONCLUSION

The manuscript reports the results of study done on samples of solutions prepared, using various constituents such as Cholesterol, Glucose, Urea, Alanine and Salt. The study shows that Cholesterol is showing a significant change in the attenuation, in the range of 80MHz - 100MHz, inspite of large variation of Glucose concentration. This indicates Glucose has no effect on the RF of Cholesterol in this range. The study is significant for the development of monitoring Cholesterol wherein Glucose need not be taken into account, as its influence is almost negligible in this range. It may be noted that in the present lifestyle of people, Glucose is a commonly varying factor and if had to influence Cholesterol, the instrumentation development could be more complicated. The results shown above can be used in regression analysis to quantify the concentration of Cholesterol.

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BIOGRAPHY

Ingrid Anne P. Nazareth is currently a Ph.D. Scholar in the Department of Electronics, Goa University, Goa (India). She completed her Masters in Electronics having secured the 1st place and is an awardee of the 'IV SERC School in Physics Gold Medal'. She is also a visiting faculty at the Goa University. She has attended a number of National Symposiums and Conferences where she has presented her research work. Her research interest is in the field of Biomedical Electronics.

Sulaxana R. Vernekar is currently pursuing her Ph.D in Electronics at Goa University. She is Assistant Professor in the Department of Computer Science at GGPR College of Commerce, Ponda - Goa and has 18 years of teaching experience. She has participated in number of symposium / workshops and presented her research work. Her areas of interest are agricultural electronics, micro electronics and digital signal processing.

Dr. Rajendra S. Gad completed Ph.D. Electronics and is an Associate Professor in the Department of Electronics, Goa University, Goa, India. He has worked on the ICMR and UGC, New Delhi, funded research project in the area of noninvasive glucometer. Also closely associated with the Million Book Project of Carnegie Mellon University, USA and related digital repository projects of Indian Navy associated with ALTERA Inc. USA under the MOU with ALTERA University program. Dr. Gad is Sponsored and Administered "Leading Engineer of the World 2008" & 2000 Outstanding Intellectuals of the 21st century 2009/2010, by International Biographical Center, Cambridge, England. Dr. Gad, was a winner in Mentor Graphics Design contest 'Design and verification of LC3 processor' for year 2010 in India. He is also a recipient of the Indian National Science Academy Fellowship for the year 2012-13.

Prof. Gourish M. Naik obtained his Ph.D from Indian Institute of Science, Bangalore (1987) and served the institute as research associate in the areas of Optoelectronics and Communication till 1993. For the last 20 years, he is associated with Goa University Electronics Program. He is the founding head of USIC and established Fiber optic LAN & Wireless Communication Network at Goa University. He is also coordinator of DEITI (an educational broadcast studio supported by Indian Space Research). He has to his credit around 50 odd research papers published in National and International Journals and has presented research works at various National and International Forums. He has authored a book on Embedded Systems published by Springer (Holland). Presently he is head of dept. of Electronics at Goa University.