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A Study of the Design of Non-Invasive Measurement of Blood Glucose and Blood Pressure Using a Wrist-Worn Unit

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ABSTRACT: Frequent measurements of Blood pressure and Blood glucose are required for a healthy living. When these are done Non-Invasively using a simple wrist watch , it allows for instantaneous and regular monitoring to take appropriate treatments thereby preventing future cardiovascular, kidney, liver related and neurological complications. This paper aims at designing a wrist worn unit that non-invasively measures blood pressure using Volume compensation technique and blood glucose using a microwave sensor. The blood pressure measuring unit comprises a C-shaped local cuff pressurizing unit and a servo controller used to measure the intra arterial pressure using Simulink based PID compensator. The blood glucose measuring unit consists of 2 VCO's 500-2000 Mhz frequency ,a monolithic logarithmic RF power detector (6Mw) that is capable of measuring RF signals over a wide dynamic range and a circular microwave sensor which can be interfaced using the RJ 45 cable to the display of the watch.

KEYWORDS: Blood Presuure, Blood Glucose, Non-invasive, PID compensator, microwave sensor.

I. INTRODUCTION

Approximately 18 million people suffer from diabetes mellitus, also known as diabetes. It is the seventh leading cause of death. By 2020, the cost associated with diabetic treatment is expected to rise as high as $192 billion. There is no cure for diabetic till date. Measuring glucose level in a diabetic patient on a regular interval and administering insulin are the key ways to keep him safe. Ideally it is suggested that glucose must be measured 1 to 4 times a day in a diabetic patient. In conventional technique, blood sample collected in an electrode strip glucose concentration is measured by making use of some chemical reactions – such as, reflectance photometry, absorbance photometry, and electrochemical methodology etc. These techniques are very painful for the patient as they involve pricking on the fingertip or some other areas of the body where a number of blood veins can be found. Moreover, the seemingly low cost electrode strips used in the glucose meters may become a significant expenditure over time for the patients requiring monitoring in frequent intervals. A viable option is to use microwave techniques that can measure glucose of a diabetic patient non-invasively for chronic diabetic patients.

BP monitoring is essential to reduce or prevent the risk of cardiovascular and kidney related complications. This method which uses volume compensation technique appears promising as a useful and helpful means for longer durations of instantaneous BP monitoring for BP patients.

II. PRINCIPLE AND WORKING OF VOLUME COMPENSATION METHOD FOR BLOOD PRESSURE

The method is to unload the arterial wall in order to linearize this phenomenon with a counter pressure as high as the pressure inside the artery. Blood volume is kept constant by applying this corresponding pressure from the outside. The continuously changing outside pressure that is needed to keep the arterial blood volume constant, directly corresponds to the arterial pressure. This is the basic principle called "Vascular Unloading Technique".

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For the realization, a cuff is placed over the wrist. Inside the cuff, the blood volume in the arteries is measured using a light source and a light detector. The resulting light signal is kept constant by controlling the alterable cuff pressure. During systole, when blood volume increases in the artery, the control system increases cuff pressure, too, until the excess blood volume is squeezed out. On the other hand, during diastole, the blood volume in the finger is decreased; as a result, cuff pressure is lowered and again the overall blood volume remains constant. As blood volume and, thus, the light signal is held constant over time, intra-arterial pressure is equal to the cuff pressure.

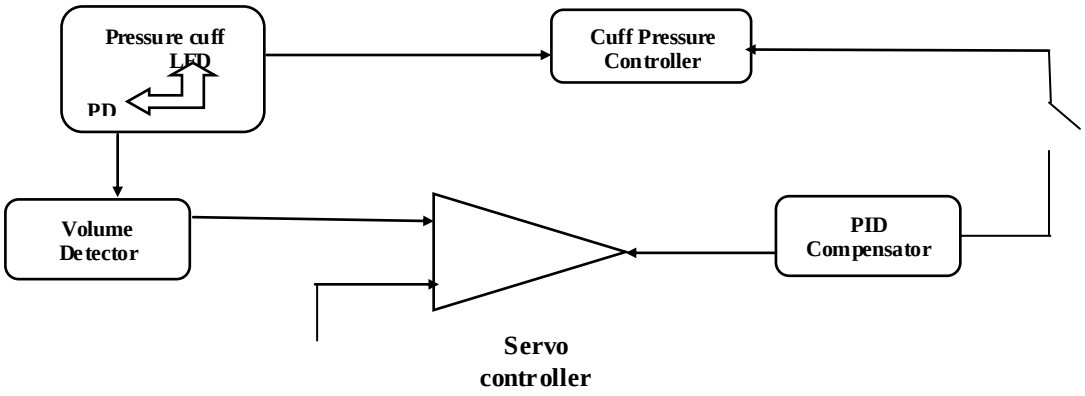

Fig. 1 Block Diagram of Blood Pressure measurement unit

When cuff pressure (Pc) is gradually increased, the unloaded vascular volume (V0) is determined from the mean level of the DC component of the photo plethysmographic (PG) signal (PGdc) at point of maximum amplitude of the pulsation signal of PG (PGac), based on the principle of the volume- Oscillometric method. A servo control error, produced by subtracting the instantaneously measured arterial volume from the reference value V0, is then fed to the compensator to clamp the vascular volume at the reference value. In this way, the intra-arterial pressure can be indirectly obtained.

III. PRINCIPLE AND WORKING OF BLOOD GLUCOSE MEASUREMENT

When an electric field passes through a dielectric medium, its transmission is governed by a phenomenon called permittivity (ε). The relative permittivity (ε_r) of a material is also called the dielectric constant. The relative permittivity of a material is a ratio of its permittivity to the permittivity of free space

$$\varepsilon_r = \varepsilon / \varepsilon_0$$

An equation for complex permittivity has to be used when an electric field is applied across a conducting medium

$$\varepsilon = \varepsilon' - j\varepsilon''$$

From the different studies, it is established that an inverse relationship exists between dielectric constant of blood and glucose concentration in mg/dL for glucose concentration.

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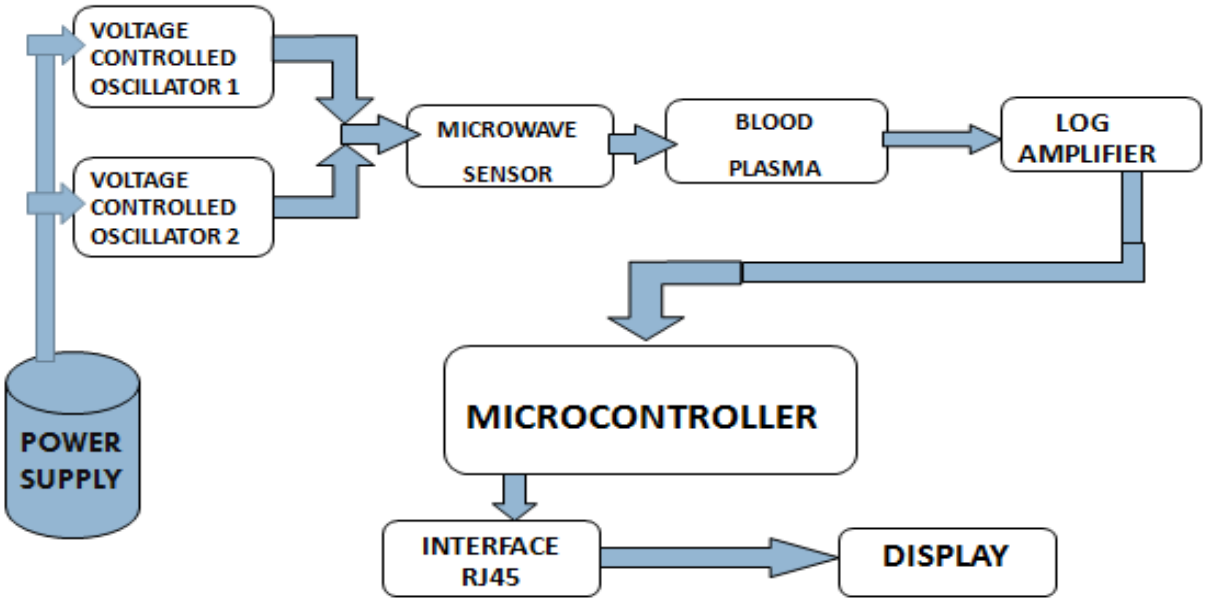

Fig 2. Block diagram of the Blood Glucose measurement unit

The Voltage Controlled Oscillators give a large frequency output range of the microwave (500MHz-2000MHz).
The Microwave sensor emits Microwave radiations in that frequency range. This falls on the blood plasma. The dielectric property of blood gives rise to electrostatic charges. The storage of the emitted energy is more when the blood glucose concentration is high. Hence the frequency reflected will be low. The Log Amp compresses the large data output of the Microwave sensor. The microcontroller finds the difference:
(Standard Reference Reflected Frequency – Instantaneous Reflected Frequency)

A. If reflected frequency is low, difference is high → High Blood glucose concentration
B. If reflected frequency is high, difference is low → Low Blood glucose concentration

RJ 45 cable is used to interface the output of microcontroller to the LCD Display of the watch.

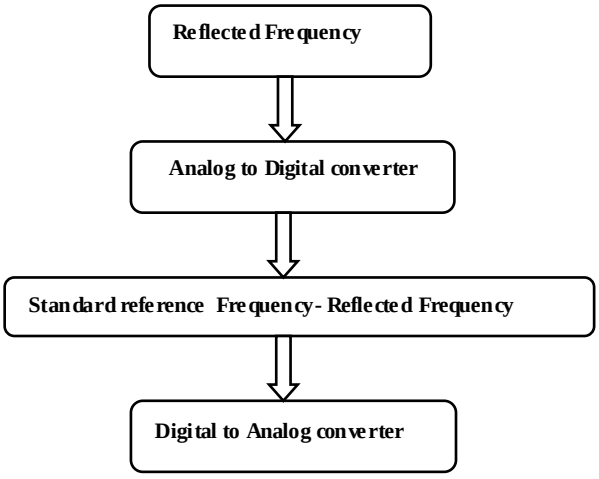

Fig 3. Flow Chart of the method for Blood Glucose measurement

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V. RESULT AND DISCUSSION

A wrist worn unit that non-invasively measures Blood Glucose and Blood pressure is designed. This paper shows that the techniques used to measure blood glucose and blood pressure provides a non-invasive method to get easy results. This device in the form of a wrist watch makes it compact, portable, easy to use without causing discomfort and is an effective means to regulate dietary habits for chronic BP and sugar patients.

VI.CONCLUSION

Based on a survey conducted on the existing similar products, it was observed that this product will have very good market potential as it measures both the parameters blood glucose and blood measure cost effectively and non-invasively. The watch being a wearable monitoring device can enable elderly patients to monitor blood glucose and BP conveniently.

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