International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064, Impact Factor (2013): 4.438
www.ijsr.net

Microcontroller Based Instrument for Semi-Invasive Blood Glucose Measurement

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Abstract: ***Diabetes is considered to be one of the major health care epidemics of modern era. Generally diabetic patients are advised to check their blood glucose level 5 to 7 times per day. The determination of blood glucose concentration using the self monitoring blood glucose devices involves the chemical analysis of blood samples taken by pricking the finger or extracting blood from forearm. The pain, discomfort and inconvenience in the current invasive method have led to the feasibility study of non invasive measurement techniques. In this paper, an optical method using Infra red is used which shows that it can be possible to measure glucose concentration in blood non-invasively. This sensor consists of two IR wave generators that can generate IR waves in the wave length of 640 nm and 900 nm. Initially the sensor has to be calibrated by measuring the known blood glucose level of various patients having glucose level in the range of 80-500 mg. Thus two set of records for measurement at two different wavelengths are created. Then the sensor is used to measure the unknown blood glucose level, by comparison with recorded data.***

Keywords: Glucose monitoring, IR sensors, non-invasive, Light Absorption

1. Introduction

Diabetes is a condition in the human body wherein the human body does not produce the quantity of insulin adequately required to maintain normal circulating blood glucose. Insulin is a hormone that enables glucose to enter the body's cells to be used for energy. As a result diabetics must regulate their own blood sugar levels through diet and insulin injections. Currently, blood glucose can only be monitored through a small pinprick and placing a drop on a test strip. These measurements must be taken several times, generally around half a dozen, a day by those with diabetes. The risk of infection and measurement in accuracy are present with all invasive techniques. But the methods existing today are efficient and reliable providing accurate reading. The past two decades has attracted tremendous attention in the diagnosis and monitoring of diabetes by non invasive methods. A truly non-invasive glucose–sensing device could revolutionize diabetes treatment by leading to improved compliance with recommended glucose levels. Non invasive methods offer the main advantage of relief from pain and discomfort due to frequent finger pricks needed for the invasive analysis. Non invasive determination of the glucose also promotes frequent testing, adequate control, reduce the complications and consequently reducing the health care costs.

2. Non-Invasive Techniques

Non-invasive techniques include infrared, Raman spectroscopy, polarimetry, light scattering, photo acoustic spectroscopy, polarization technique etc. In infrared spectroscopy absorption or emission data in the region of spectrum are compared to known data for glucose. In Raman spectroscopy, laser light is used to stimulate emission from transitions close to the level excited. Photo acoustic spectroscopy deals with the laser excitation of fluids to generate an acoustic response and a spectrum as the laser is tuned. In scatter technique, the scattering of light can be used to indicate a change in the material being examined. For polarization technique, the presence of glucose in a fluid is known to cause a polarization preference in the light transmitted. In this paper, the technical analysis of non-invasive blood glucose measurement using infrared at the present time is been discussed. The main aim is the blood glucose determination and the concept of measuring system.

3. Major Issues of the Design

The recognition of the signal induced by the glucose is quite complex because the background signal is dynamic and difficult. Absorbance spectra that are measured from skin tissue are influenced not only by water, albumin, globulin, hemoglobin, and triglyceride but also by environmental factors such as temperature and vapor levels. Another major design issue related to NI blood glucose measurement is calibration due to varying amounts of protein, fats and water in different people. The actual measurement of blood glucose through absorption in the visible to low infra red region has the problems of interference through protein and fat absorption and water. Although, satisfactory prediction results have been obtained by most groups in their published papers, problems remain to be unanswered in order to achieve reliable and precise results. There are several critical obstacles preventing from the success of measuring glucose noninvasively. There are many potential sources of interference in the present measurement technique. The stability relies on a constant optical coupling to skin, which is difficult to maintain unless the patient is lying still. Besides profound methodological problems with the calibration methods necessary for the analysis of absorption measurements, any spectrometric estimation glucose in skin faces a number of problems mainly significant scattering of light, heterogeneous distribution of light absorbing and light scattering structures which additionally are variable over time (in part due to changes in blood supply and blood oxygenation), unknown path length of light in skin, heterogeneous glucose distribution in skin, presence of many other interfering light absorbers (like water) in much higher

concentrations, very similar absorption spectra of water and glucose, temperature dependence of light absorption.

4. Working Principle

The proposed system is based on the principle of absorbance transmittance photometry. The value of absorption of light energy is dependent on the number of molecules present in absorbing material. Thus, intensity of light energy leaving the absorbing substance is used as a sign of concentration of that particular substance Qualitatively, the absorbance is expressed by Beer Lambert Law as follows:

$$T=I/I \qquad \text{----- (1)}$$

Transmittance of the sample can be measured directly by taking the strength of the wavelength measured and dividing it by initial strength. The absorbance can then be calculated as in the following:

$$A=-\log(T) \qquad \text{------- (2)}$$

Absorbance is also equal to abc, which is the absorptive coefficient (a) multiplied by the path length (b) multiplied by the concentration (c). The actual glucose level will be measured against a baseline wavelength which changes little with glucose levels. The actual concentration will be

$$A_{(\lambda_1)} - A(\lambda_2) = bc(a_1 - a_2) \qquad (3)$$

with a known glucose level (say 400 mg/dl), a1 - a2 can be premeditated from the equation (3). Once this is known, all other concentrations measured can be calculated as a ratio of the initial concentration, where a1- a2 and b are both constants. The concentration ratio is then checked against the known concentrations of the glucose solutions to determine the characteristic equation of the ratio to the actual concentration. This method is based on the direct effect of glucose on the scattering properties of the organ. Glucose decreases the mismatch in refractive index between scatters and their surrounding media, leading to a smaller scattering coefficient and consequently, a shorter optical path. As a result with the growing concentration of glucose, fewer photons are absorbed and the light intensity increases.

5. Methodology

Several techniques have been proposed for non-invasive in vivo monitoring of blood and tissue glucose in recent years. NIR spectroscopy for determining the blood glucose concentration non-invasively has been demonstrated by many groups and much progress has been made in past few years. An IR transmitter and IR receiver can be used for the noninvasive measurement of blood glucose. The proposed system has been equipped with the light source, ie IR transmitter and IR receiver and PIN photodiode. The light returned from the tissue has been received and collected by the photodiode. Then an ADC is used to convert the analog signal to digital. A microcontroller based circuitry converts the values into corresponding blood glucose value, which is then displayed on PC through GSM. The probe contains light sources and detectors operating in the red/near-infrared (R/NIR) spectral region and pneumatic to occlude blood flow has a special adaptive mechanism for easy positioning and a suitable grip for a wide range of palm sizes, thus assuring user convenience and compliance.

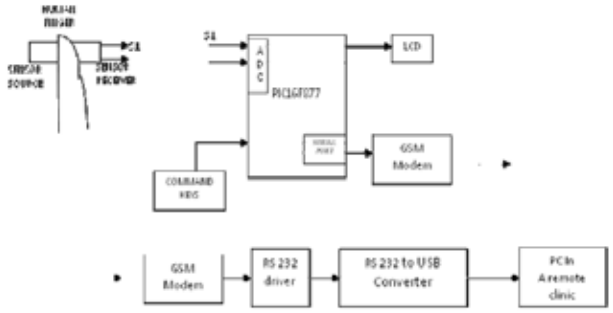

Figure 1: Block diagram for microcontroller section of the glucose monitoring.

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This GSM Modem can accept any GSM network operator SIM card and act just like a mobile phone with its own unique phone number. Advantage of using this modem will be that you can use its RS232 port to communicate and develop embedded applications. Applications like SMS Control, data transfer, remote control and logging can be developed easily. The modem can either be connected to PC serial port directly or to any microcontroller. It can be used to send and receive SMS or make/receive voice calls. It can also be used in GPRS mode to connect to internet and do many applications for data logging and control. In GPRS mode you can also connect to any remote FTP server and upload files for data logging. This GSM modem is a highly flexible plug and play quad band GSM modem for direct and easy integration to RS232 applications. Supports features like Voice, SMS, Data/Fax, GPRS and integrated TCP/IP stack. Connect MCU TXD/RXD through MAX232 so your MCU can communicate with GSM Modem.

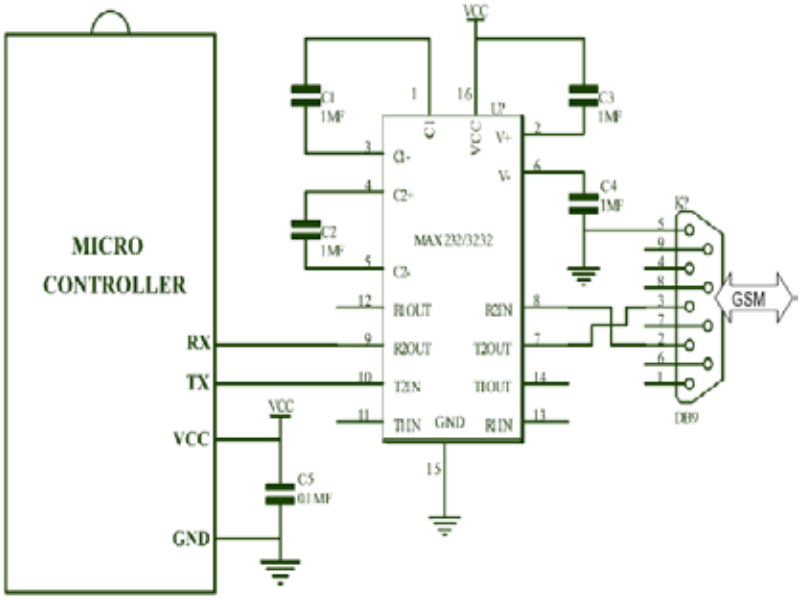

Figure 2: Communicating with GSM modem and microcontroller through MAX 232.

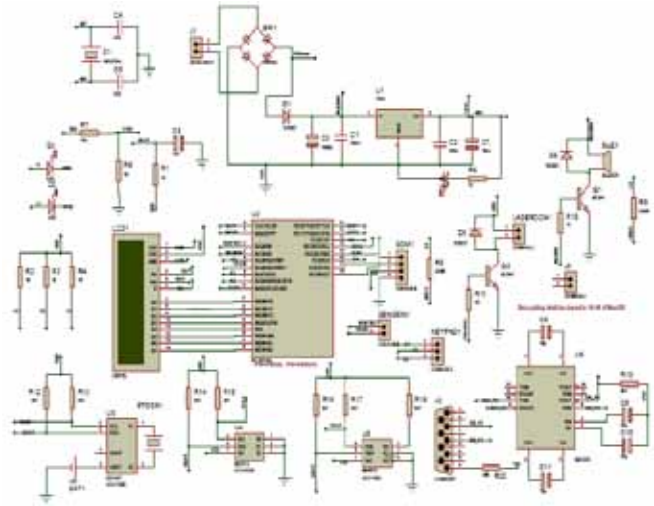

Figure 4.31: Working circuit for non-invasive blood sugar measurement

6. Conclusion

The glucose monitoring provides additional temporal information, such as trends, magnitude, duration and frequency of glucose level fluctuations. This information can aid in the detection and avoidance of unwanted hypo and hyperglycemic episodes. Furthermore, it can activate alarm signals for extreme glucose levels; CGM can also adjust therapy trials, monitor conditions where tight control without hypoglycemic is sought (Intensive Care Units, gestational diabetes, pediatric diabetes). This study demonstrates the feasibility study and design issues to monitor blood glucose concentration noninvasively in human subjects. The overall investigation into non-invasive measurement techniques for blood glucose indicates that it is a non-trivial problem. Despite the problems, it is a viable technique for the measurement of glucose concentrations in the blood and requires further investigation.

References

[1] Z. Ali , A. Caduff, Y. Feldman ,E. Hirt, , and L. Heinemann, Biosensors and Bioelectronics, 2003,19, 209.
[2] “Non invasive Glucose Monitoring: A Novel Approach”, Journal of Diabetes Science and Technology, 2009, 3, 2.
[3] Yamakoshi, K. Y. Yamakoshi: Pulse Glucometry, Journal of Biomedical Optics 2006, 11(5), 1.
[4] Caduff, A., Talary, M., Mueller, F., Klisic, J., Donath, M.Heinemann, L., Stahel, W., Biosensors and Bioelectronics 2009, 24, 2778.
[5] Jin Zhang, William Hodge, Cindy Hutnick, and Xianbin Wang, Journal of Diabetes Science and Technology 2011, 5, 1.
[6] Rosenthal et al, U.S.Pat.No.5, 086, 229.
[7] H.M. Heise, H.W. Siesler, Y. Ozaki, S. Kawata and H.M. Heise Near-Infrared Spectroscopy, 2002, 289
[8] D.C.Klonoff, *Diabetes. Technol. Ther*. 2005 7, 770.
[9] K. Maruo, M. Tsurugi, M. Tamura and Y. Ozaki. *Appl.Spectrosc.* 2003, 57, 1236.
[10] M.A. Arnold and G.W. Small. Anal. Chem. 2005, 77, 5429.