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Design and Implementation System for Serum Glucose Estimation

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Abstract:

Blood glucose monitoring is a way used for testing the concentration of glucose in the blood (glycemia). Practically important to measure the levels of blood glucose in the care of diabetes mellitus patients. A blood glucose test is performed by piercing the skin (typically on the finger) to draw blood, then applying the blood to a chemically active disposable "test stripe".

The main idea for the design of the circuit is by using a variable capacitor consist of two passive terminal or plates and by changing the density of the insulator between the two plates of the capacitor. The changing in capacitance results of the capacitor which is a part of a (frequency generator circuit) for that the output frequency of the circuit will be change, and if we used that frequency as an input to counter circuit we can read out the concentration of the glucose in the sample and then we display the result on a LCD monitor. The present study includes a comparison between the present system and the conventional glucose serums measurement systems, and the result approximately the same.

تصميم ووبناء نظام لحساب مستوى السكر في الدم

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الخلاصة:

مراقبة نسبة السكر في الدم هي طريقة لفحص تركيز الكلوكوز في الدم (كلايسيميا)، وبشكل خاص هذا الفحص ذا أهمية لقياس مستويات السكر في الدم لرعاية مرضى السكري.

يتم الفحص عن طريق غرز الجلد (عادة على الاصبع) لسحب الدم وبعد ذلك وضع الدم على شريط فحص يستخدم لمرة واحدة فقط لكل فحص. الفكرة الرئيسية لتصميم الدائرة هي باستخدام متسعة متغيرة السعة تتكون من لوحين معدنيين وبتغير كثافة العازل الموجود بين لوحي المتسعة سوف تتغير قيمة المتسعة التي هي جزء من (دائره توليد التردد)، لذلك فإن قيمة التردد الخارج من الدائرة سوف يتغير، ونستخدم هذا التردد كإشارة داخلة لعداد يقوم بقراءة تركيز السكر في العينة، وبعد ذلك نعرض النتيجة على شاشة LCD.

تضمن البحث على مقارنة بين النظام الحالي وأنظمة قياس السكر في مصل الدم الأعتيادية وكانت النتائج نفسها تقريبا.

Introduction:

Two major methods have been used to measure glucose. The first, is a chemical method exploiting the "nonspecific reducing" property of glucose in a reaction with an indicator substance that changes color when reduced. Since other blood compounds also have reducing properties (e.g., urea, which can be abnormally high in uremic patients), this technique can produce erroneous readings in some situations (5 to 15 mg/dl has been reported). The more recent technique, using enzymes specific to glucose, are less susceptible to this kind of error.

The two most common employed enzymes are glucose oxidase and hexokinase. In either case, the chemical system is commonly contained on a test strip, to which a blood sample is applied, and which is then inserted into the meter for reading [1]. This blood monitoring equipment contains software that allows the user to download meter results [2].

In last few years, "glucose sensing bio-implants" was produced: This kind of equipment is known to be the long term solution of continuous monitoring, used a long-lasting bio-implant, help in minimi-

Date of acceptance: 26 -2-2014

zing the burden of blood glucose monitoring for the people, and contained minor surgical implantation of the sensor that can last for one year to more than five years depending on efficiency of the product[3].

Materials and Methods:

Serum glucose, also known as blood sugar, is the amount of glucose or sugar present in the blood. Its measurement is often done to establish the diagnosis of diabetes mellitus as shown in Fig (1). Regular monitoring of serum glucose is also vital in the management and treatment of individuals with diabetes [4]. By using glucose meter (or glucometer) is a medical device for determining the approximate concentration of glucose in the blood. It is a key element of home blood glucose monitoring (HBGM) by people with diabetes or hypoglycemia [5].The present investigation includes design a prototype circuit for measuring serum glucose concentration in blood. The apparatus of the system are:

1- Circuit components:
   - A- (R, C)
   - B- Microcontrollers Fig (2)[6], arrangements for using microcontroller, to prepare:
     - * Suitable Hardware Platform (Start USB for PIC).
     - * Suitable Software (Flow Code programming).

     To Achieve:
     - * Control Counter Readings and Display the results on LCD Display
     - * Develop programs supported by Flow Code programming using Boot loader technique
   - C- Start USB for PIC (Peripheral Interface Controller). It is a miniature development system that enables to experiment with the PIC18F2550 microcontroller.
   - D- Counter IC 4040.
   - E- Schmitt triggers inverter IC 40106.
   - F- IC 7400, and
   - G- IC74244.

2- Bread board.

3- Power supply.

4- Connection wires.

5- Suitable Software (Flow Code programming).

6- A variable capacitor (Sensing unit) it is designed and implemented in the present research as a Test strip, we used a variable capacitor (originally known as **condenser**) is a passive two-terminal electrical component made of copper. Most capacitors are designed to maintain a fixed physical structure as in Fig.(3). However, various factors can change the structure of the capacitor, and the resulting change in capacitance can be used to sense those factors.

7- Oscillator.

Circuit Block Diagram:

The main idea for the design of the circuit is by changing the capacity which is consist of passive two-terminal electrical component by changing the density of the insulator between the two plates of the capacitor. If the density of the insulator is changed according to the concentration of the glucose that will result in changing the capacitor which is a part of a (frequency generator circuit) as shown in Fig (4). For that the output frequency of the circuit will be change, and if we used that frequency as an input to counter circuit we can read out the concentration of the glucose in the sample and then we display the result on a LCD monitor as shown in Fig. (5). The serum glucose electrical circuit diagram is shown in Fig.(6).

The procedure of the measurement is as follow:

- * Connected the microcontroller to a PC by USB for programming using software language.
- * put the sample on the test strip (the variable capacitor).
- * Connected the test strip to the circuit.
- * Connected the frequency generator circuit to the oscilloscope to display the output of the frequency generator circuit in both time domain and frequency domain.
- * display the result on LCD.

Date of acceptance: 26 -2-2014

Figure-1: Blood Glucose Levels [4]

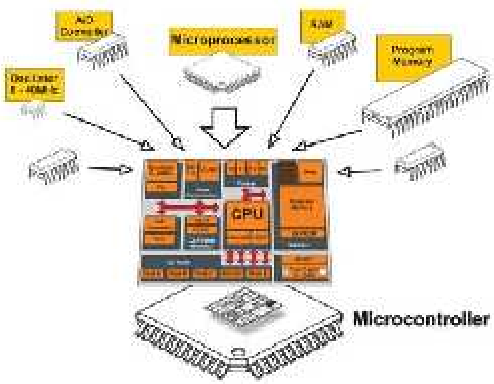

Figure-2: Microcontroller [6]

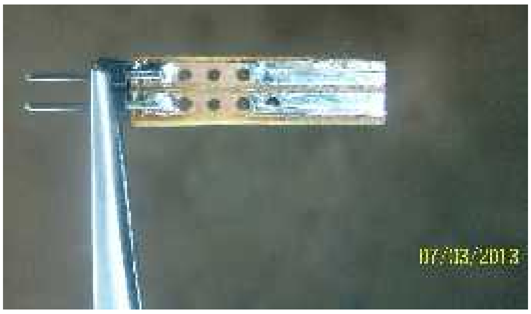

Figure-3: The Sensing Capacitor.

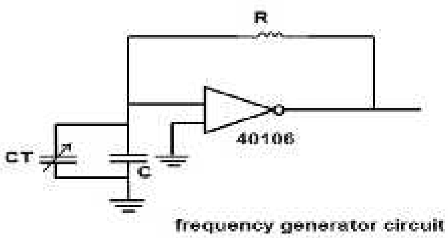

Figure-4: The Frequency Generator Circuit.

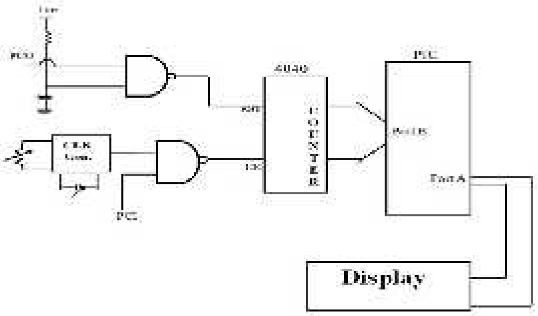

Figure-5: Circuit Block Diagram

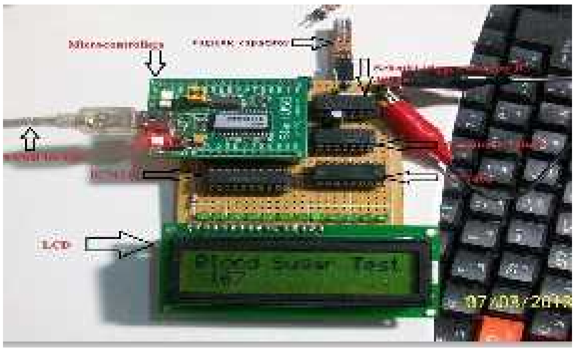

Figure-6: The Serum Glucose Electrical Circuit.

Results:

We used three different samples in our testing and the samples were: Water, Water and sugar, Blood. The result of water sample as shown in Fig.(7) and (8) which are illustrated frequency and time domain respectively for water sample. While the result of water and sugar is shown in Fig.(9) and (10) which are illustrated frequency and time domain respectively for water and sugar sample. In blood sample frequency and time domain is shown in Fig. (11) and (12) respectively.

Another result after some calibration tests was as shown in Fig. (13) and (14) which is include comparison between the result for each blood sample by using ACCU CHECK device (conventional glucose meter) with the one result from our prototype circuit and the result was almost matched, and this is what we aim to in this project by getting the best result close to the real one.

Date of acceptance: 26 -2-2014

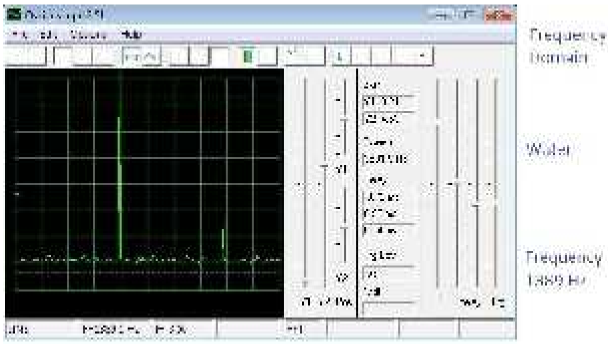

Figure-7: Frequency Domain for Water Sample

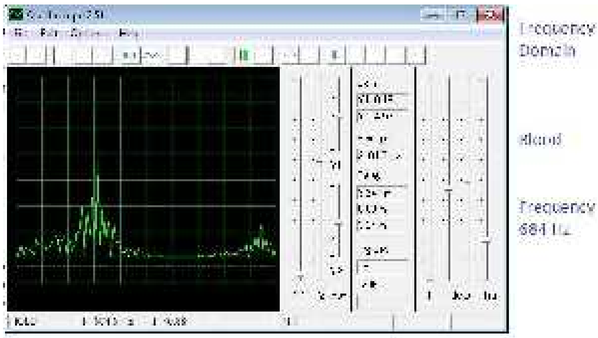

Figure-11: Frequency Domain for Blood Sample

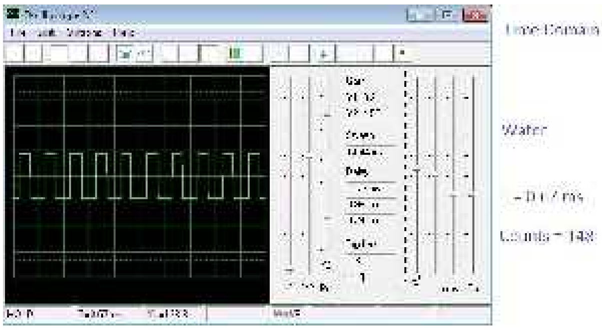

Figure-8: Time Domain for Water Sample

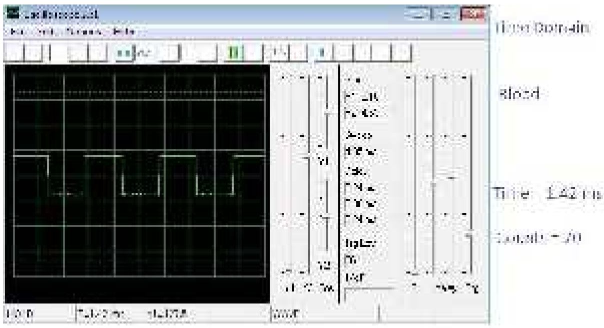

Figure-12: Time Domain for Blood Sample

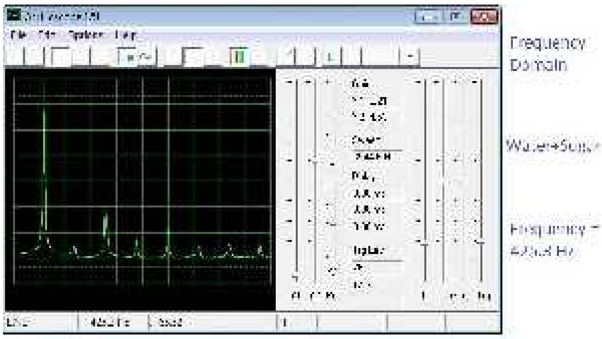

Figure-9: Frequency Domain for Water and Sugar Sample

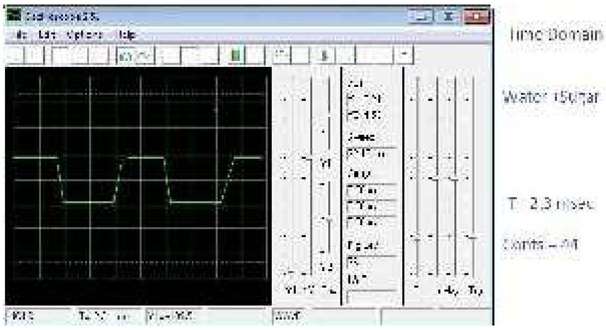

Figure-10: Time Domain for Water and Sugar Sample

Figure-13: The Result for the First Blood Sample by Using Accu-Check

Figure-14: The Result for the First Blood Sample by Using the Prototype Circuit

Date of acceptance: 26 -2-2014

Discussion:

The present design considers the most important glucose meter devices in our medical and engineering laboratories based on educational approaches especially in electrical, electronical, and biomedical engineering departments. The previous studies in this field include design a glucose meter system based on spectrometric instrument for example. The basic idea for this research is designing a system to measure glucose concentration in different samples includes water, water and sugar and blood.

The most difficult part in designing the circuit was the sensing part because in most commercial devices they use a test strip which is a consumable element containing chemicals that react with glucose in the drop of blood is used for each measurement. For some models this element is a plastic test strip with a small spot impregnated with glucose oxides, in this design instead of using the chemical reaction for sensing the concentration of the glucose we manufactured the sensing part which is a variable capacitor (the density of the insulator is changing according to the concentration of the glucose in the sample that will result in changing the capacitor) which is connecting to a clock or frequency generator circuit. The result we got it for the three samples were different slightly from each other according to the glucose concentration in each sample because each sample will change the frequency of the clock generator circuit and result in changing the input to the counter .

References:

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