

RDCONT – A system for diabetes blood glucose data management

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Abstract

Diabetes is a very common disease in the European and North American countries. About 5-8 percent of the inhabitants do have diabetes in these countries, including Hungary too. The modern treatment methods of diabetes include the so called “Self Monitoring of Blood Glucose” (SMBG). SMBG means, that the patient measures his blood glucose value regularly (many times in a day), and logs the results into his diabetes diary. Then, the diabetes specialist doctor can analyze the diary and can make decisions for the further treatments. In this paper we would like to describe the RDCONT system, which can be used to produce diabetes diary automatically by reading the measured blood glucose data from the memory of the glucose meter and transferring it to an electronic diabetes diary. The hardware and software components of the RDCONT system was developed at the University of Debrecen in Hungary, and it can be used by everybody as a free software tool for SMBG. As a result of the RDCONT usage we got a completely error-free electronic diary (as no human data typing is necessary), and it can be electronically transferred to the diabetes specialist doctor (e.g. by e-mail), so opening the possibility of the “Remote Diabetes Control”.

Keywords: Blood glucose monitoring, Blood glucose meter, Diabetes diary, Data management.

1. Introduction

Diabetes is a worldwide disease. In the West-European and North-American countries about 5-8 percent of the inhabitants are estimated to be affected by diabetes. Different forecasts tell us, that this ratio is increasing.

The basic problem of the diabetes is, that the patient’s body does not produce enough insulin to keep the blood glucose value at the normal level (below 7 mmol/l), so the blood glucose value of the patient increases, and special treatments are necessary.

One of the modern, currently used diabetes control methods is the so called “Self Monitoring of Blood Glucose” (SMBG) (see [1, 2]). SMBG means, that the patient do have a blood glucose value meter, and he measures his blood glucose value many times in a day. The patient logs the measurement results into his diabetes diary. The diabetes specialist doctor will check the diary, and (using other laboratory investigations too) decides the necessary treatment steps. The

Date	Before Breakfast	After Breakfast	Before Lunch	After Lunch	Before Dinner	After Dinner
15/11	6.3		8.7		3.8	13.6
16/11	9.6		5.3		4.8	
17/11	6.8	9.8	8.3	12.7	7.1	10.6
18/11	4.9		7.5		8.2	

Figure 1: Diabetes diary

diabetes diary is a simple table (see Figure 1), containing one day measurement data in one row. The standard technical solution is that the patient performs blood glucose measurements before the main meals and after the main meals. The table is usually managed by hand, and the empty cell means, that there was no measurement at that time.

Most of the diabetes patient do not log the measurement values into the diary immediately after the measurement process: The currently available blood glucose meters do have memory, which can store 100-500 measurement data (depending on the type of meter). The memory will contain the exact date, time and measurement value, so giving the possibility of logging the data into the diary later.

In this paper we would like to introduce the RDCONT system, which can be used to read the data from the memory of the blood glucose value meter and transforming them into the form of diabetes diary automatically.

Reading the memory data of the blood glucose meter is meter specific, usually needs special communication hardware and software. The RDCONT system was developed to the “Dcont Personal Blood Glucose meter” (see Figure 2), which is a very popular blood glucose meter in the Eastern-European countries: It was introduced about five years ago, and it gives high precision measurement for the cheapest price on the market. The meter can store 150 measurement data in the memory, and it is able to transfer the data from the memory to the computer using a special infrared communication hardware and software.



Figure 2: Dcont Personal BG meter

2. The RDCONT System

The user manual of the Dcont Personal BG meter writes (see [3]): “It is able to transfer the measurements’ data to the computer using a special optical interface, which is currently not available.” The purpose of the RDCONT development is to make an implementation of this special infrared communication, and so offering the automatic diabetes diary creation for the patients.

The development of the RDCONT system contained three different parts:

1./ Infrared receiver circuit development. Unfortunately, the standard infrared receivers of the computer market (as built into the computers or available as external devices) are not able to communicate with the Dcont Personal meter. A special infrared receiver is necessary. The most important guidelines of the infrared receiver development were, that it should be precise (giving error-free, or almost error-free communication to the meter), and it should be simple, giving the possibility of “making at home” by the patients.

2./ Communication protocol discovery. The infrared communication protocol of the Dcont Personal glucose meter is not published. We had to develop special hardware and software components, which could be used to discover the communication protocol. The protocol discovery means, that we had to sense the infrared signals, we had to specify the frame format of the communication, and last but not least the application data structure must have been discovered.

3./ Software tool development. The last phase of the RDCONT system development is the software tool development. The RDCONT software tool implements the discovered communication protocol and uses the mentioned infrared receiver circuit to read the measurement data from the blood glucose meter and transform them into an electronic diabetes diary automatically.

2.1. The infrared receiver circuit

The Dcont Personal BG meter contains a 3 mm infrared LED on the top side, which can transfer the data from the memory of the equipment to the computer. Unfortunately, the meter does not use the Irda communication protocol, so the infrared receivers available on the computer-market are not applicable (this statement is valid to the built-in IR ports, and to the external IR ports too).

We have developed and investigated three different types of infrared receiver circuits (the development run parallel to the communication protocol discovery). The first two was very complicated, and unfortunately they produced relatively many errors (about 5-10 percent of the transferred data contained errors). The third version of the circuits (see Figure 3) is a very simple and reliable circuit: the error rate is under 1 percent, which means, that the data transfer usually runs without error. The circuit contains only a phototransistor, a diode and 3 resistors,

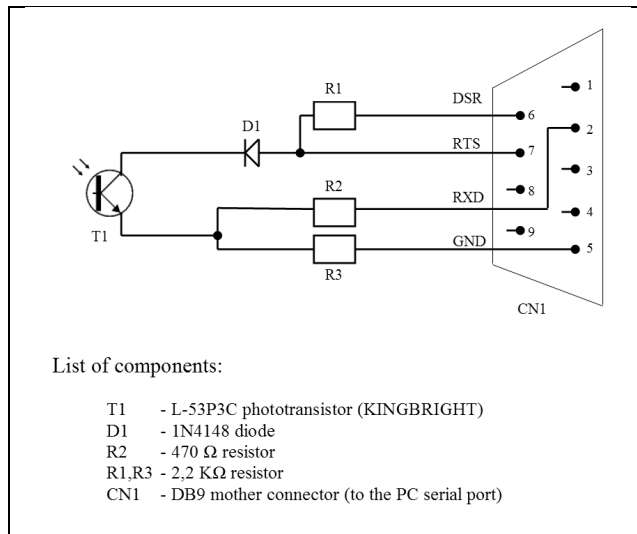
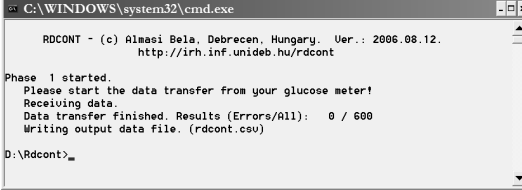


Figure 3: RDCONT Infrared receiver circuit schema

which means, that the circuit is very cheap: the total sum price of the components is about 2-3 Euros.

The resistors and the diode can be attached directly to the DB9 mother connector (there is enough space in the plastic box of the connector), and the phototransistor can be connected with a simple two-wire cable (the length of the cable is about 1-1.5 meter). The most important component of the circuit is the Kingbright L-53P3C phototransistor (or the newer type of Kingbright WP7113P3C phototransistor can be used too). It is a very sensitive phototransistor, tuned exactly to the infrared signal wavelength transmitted from the Dcont Personal blood glucose meter.

A screenshot of a Windows command prompt window titled "C:\WINDOWS\system32\cmd.exe". The window shows the execution of the "rdcont" program. The output text is as follows:

```
RDCONT - (c) Almasi Bela, Debrecen, Hungary. Ver.: 2006.08.12.  
http://irh.inf.unideb.hu/rdcont  
  
Phase 1 started.  
Please start the data transfer from your glucose meter!  
Receiving data.  
Data transfer finished. Results (Errors/All): 0 / 600  
Writing output data file. (rdcont.csv)  
  
D:\Rdcont>
```

Figure 4: The screen of the rdcont.exe software

The working mechanism of the circuit is very simple: the infrared phototransistor must be placed in front of the blood glucose meter’s LED (about 10-15 mm far away from the LED), so the coming infrared signals are transformed to electronic pulses by the phototransistor, and these pulses are transmitted to the serial port (COM port) of the pc.

The circuit was tested on hundreds of pc-s and using many-many pieces of Dcont Personal blood glucose meters: In all cases we have seen a stabile and reliable data transfer.

2.2. The communication protocol

To discover the communication protocol we have built a special infrared detector, which could give us time values about the detected infrared signals. The time values described the “on” and “off” states of the transmitter’s infrared LED. The precision of the detector was about 30 microseconds (which was much better than needed). The real problem came from the errors in the detection (i.e. sometimes the detector showed “on” state but the LED was really “off”, or sometimes the detector showed “off” state but the LED was really “on”).

We have repeated the data transfer many times, and using simple calculation of relative frequencies it was possible to decide, that the communication protocol of the Dcont Personal blood glucose meter is RS-232 (see [4]).

2.3. The RDCONT software tool

The RDCONT software tool has two different logical functionality: The first step is the data transfer from the memory of the blood glucose meter to the computer, the second step is the automatic creation of the electronic diabetes diary (by transforming the data into the form of diabetes diary).

According to these functionalities the RDCONT software tool contains two executables: the rdcont.exe can be used for the data transfer and the rday.exe can be used to produce the electronic diabetes diary. The detailed description of the RDCONT software tool can be found on the web: <http://irh.inf.unideb.hu/rdcont>.

2.3.1. The rdcont.exe software

The rdcont.exe software can be started in a command line window by issuing the rdcont.exe command (see Figure 4). The rdcont.exe software reads the data from the memory of the blood glucose meter (by using the infrared receiver), checks the data transfer errors, and puts the results into a CSV (Comma Separated Values) output file (named rdcont.csv). The output file contains a spreadsheet table, and can be loaded directly into Microsoft Excel, or into other kind of spreadsheet calculator programs. The rdcont.csv file contains one measurement's data in one row: date, time, and blood glucose value (see Figure 5). The last column (named as "Error") indicates the data transfer errors (zero means: no error).

	A	B	C	D	E	F	G	H
	Month	Day	Hour	Minute	Glucose	Error		
1	4	16	8	45	6,8	0		
2	4	16	11	59	7,4	0		
3	4	16	19	1	7,3	0		
4	4	16	23	31	4,1	0		
5	4	16	23	32	9,1	0		
6	4	17	0	33	12,1	0		
7	4	17	7	8	3,5	0		
8	4	17	13	1	6,8	0		
9	4	17	15	38	6,5	0		
10	4	17	18	17	10,2	0		
11	4	17	20	51	5,8	0		
12	4	17	22	57	9,6	0		
13	4	18	7	52	7,8	0		
14	4	18	9	34	9,7	0		
15	4	18	12	59	5,7	0		
16	4	18	17	7	6,8	0		
17	4	18	18	29	5,9	0		
18	4	18	20	1	2,8	0		
19	4	18	20	1	2,8	0		

Figure 5: The rdcont.csv output file.

2.3.2. The rday.exe software

The rday.exe software can be started in a command line window by issuing the rday.exe command. The software reads the rdcont.csv file (produced by the rdcont.exe software) and transforms the data into the form of diabetes diary. The rday.exe software can be personalized for each user by writing the daily blood glucose measurement time specifications into a simple ASCII text file. The output of the rday.exe program is a spreadsheet table file containing the diabetes diary (see Figure 6). As the rday.exe software works with data files only, no user interaction is necessary for the usage.

The reason of building this functionality into a different executable is, that we would like to open the possibility of using the system with other kind of blood glucose meters. Only the rdcont.exe is blood glucose meter specific, and only this executable must be changed if we want to use different types of BG meters.

	A	B	C	D	E	F	G
1	Month	Day	Before Breakfast	After Breakfast	Before Lunch	Before Dinner	After Dinner
2	4	16	6,8		7,4		
3	4	17	3,5		6,6	10,2	
4	4	18	7,8	9,7	5,7	6,8	5,9
5	4	19	6,7				
6	4	20	7,6			8,3	
7	4	21	5		3,7		
8	4	22	9,7		4,6		

Figure 6: The diabetes diary, produced by the RDCONT system

3. Summary

In this paper we introduced the RDCONT system, which can be helpful for the diabetes patients to create their diabetes diary automatically. The automatic creation of the diabetes diary is based on reading the blood glucose measurement data from the memory of the “Dcont Personal Blood Glucose Meter” and transforming them into the form of diabetes diary. The RDCONT system contains a special infrared receiver circuit and a software tool. The system is available as a free software (including the infrared receiver circuit diagram too), and can be downloaded from the internet: <http://irh.inf.unideb.hu/rdcont>

References

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