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Glucose Monitor Reader for Visually Impaired Diabetics Patients

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This paper describes the project in which visually impaired diabetics can operate a blood glucose monitor. This can be done with the help of a device reading aloud all the messages (including glucose levels), displayed on a LCD screen. The reader contains a microprocessor, a EPROM memory, a D/A converter and a loudspeaker with an amplifier. Most of the messages are recorded as a whole, and is played directly from the memory, while the rest are synthesised — spelled letter by letter. All the numeric values are read correctly up to 999. At present the device connects to OneTouch® and reads Polish messages. Thanks to the software, the process of creating/updating a memory image is quick and easy. Very little work is required to change it to other languages. The product is adapted to OneTouch® glucose monitor, which was chosen as the best device for this purpose. In the future, by co-operating with manufacturers, other reader interfaces can be developed.

Keywords: glucose monitor, talking device, OneTouch, PIC microcontroller.

Introduction

Diabetes is one of civilisation illness, which affects a few per cent of adult population. The treatment involves diet, insulin injections and frequent blood glucose monitoring. For the time being, the latter is done by taking blood and measuring its glucose levels, most often by putting a drop of the blood on a test stripe. With recent advances of technology, the changes in the colour of the stripe can be measured by a handheld electronic monitor. Not only does it give satisfactory accuracy, but is fast and reliable.

Some units incorporate a serial interface, which allows stored data to be transmitted to the PC. Since some diabetics may be visually impaired, they are unable to read LCD displays on their own and need help to use glucose monitors effectively. The proposed solution is to equip the glucose monitor with an external electronic device reading displayed messages aloud. For this purpose, the unit must be capable of transmitting displayed messages through a serial interface. Out of several products available on the market fulfilling these requirements, OneTouch® has been chosen. The reader's operation is described below.

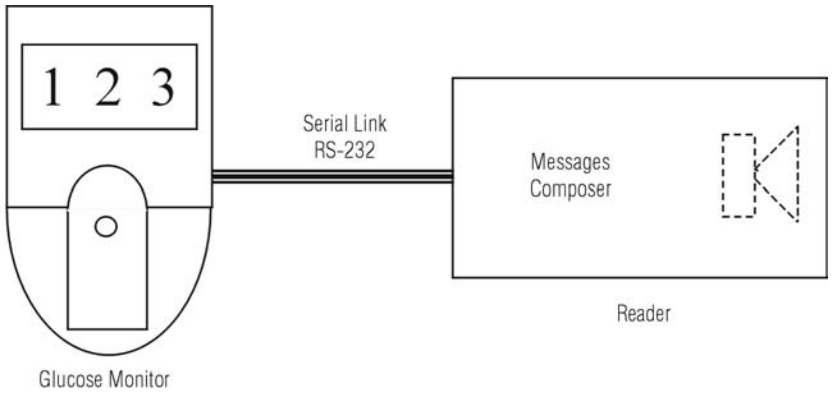

Figure 1. The connection of player to reader

The reader connects to the unit via a built-in serial interface, receives and interprets data. If the whole frame has been collected the reader plays or synthesises the recorded messages.

Approaches

There can be several possible approaches to reading messages:

a. using algorithms to synthesise messages from single sounds,
b. synthesising messages from recorded letters, and
c. analysing messages as a whole and playing relevant message (previously recorded).

Each of these approaches has advantages and disadvantages as stated below.

Approach	Advantages	Disadvantages
a.	• Very good quality of reading • Can read any message (even unknown at the time of designing)	• Very much language specific • Complex algorithms (often inefficient)
b.	• Can read any message (even unknown at the time of designing) • Not language specific • Does not take much memory	• Very easy reading algorithm • Poor quality of reading (spelling, rather than reading)
c.	• Excellent reading quality • Can be programmed in any language	• Very easy algorithm • Limited number of messages (must be known at the time of programming) • May take much memory (depending on number of messages)

The solution adopted in our reader is a mixture of the last two approaches. All the known messages are recorded as a whole, and therefore can be easily played with reasonable quality. Other messages are spelled using single letters. In addition, all the numbers, which are crucial in glucose measurements, are synthesised and read correctly. This approach provides reasonable quality and is easy to implement with very limited hardware.

Design and Operation

The reader is quite simple and consists of the following parts:
– a processor (Microchip PIC16C64),
– a EPROM memory,
– a register,
– a D/A converter,
– an analogue amplifier and loudspeaker.

Data are received via a built-in serial interface and whole frames are detected. When this is done, the memory is searched for a matching sequence, which can be played. If the sequence cannot be found, the screen if synthesised from single letters, however all the numbers are synthesised according to the rules. The design is shown below.

In both cases, a single message (or letter) is played in the same way. The processor addresses the memory and latches output, which goes to a D/A converter. This process is

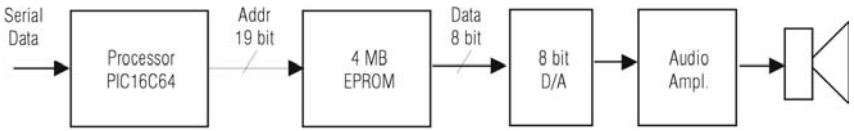

Figure 2. Block diagram of messages player

repeated until the last sample address has been found. If the message is spelled, consecutive letters are translated and played, otherwise the process is finished. It is worth noticing that the processor does not have an access to the data in the memory — it only has to know what it contains to be able to output a correct address. Thanks to this, the processor does not have to do any data processing — any word length and encoding can be used. Although messages can be recorded (and saved to the disk) in any format, they are stored in the memory as 8bit unsigned, no headers, sampled at 6 kHz. There is a tool, which generates a memory image file, and PIC includes files (contains offsets of all the messages) from given sound files. Alternatively, another approach may be used (Bogusz 1999). There is a ready-to-use integrated circuit (e.g. ISD2560) for recording and playing messages. Playing is triggered by an appropriate address set on address lines. However, there are several factors which make this circuit unsuitable for our purposes:

– messages have to be recorded individually,
– automated recording is therefore impossible, and
– one cannot have many variable length messages.

Performance considerations

Since the quality of the recorded sound and size of the memory are pulling in different directions a compromise has to be reached. The messages are sampled with the frequency of 6 kHz and encoded as 8-bit unsigned (with offset) data. For better performance for speech coding non-linear (eg. μ-Law) encoding should be used (at the cost of additional circuitry). 4Mbit EPROM has been found sufficient to store all the messages. Depending on the message length, higher sampling (such as 8 kHz) may be used. This would decrease recording time by 20 seconds (from 87 sec to 67 sec).

Conclusions and future work

The design of a reader proved to be successful. The prototype version has been tested at the Outpatients Clinic for Diabetics in Zabrze. The whole device fits into a standard computer loudspeaker case, and as such has a very smart design. However, there are still several problems to be solved, before the product can be produced in greater numbers:

– using non-linear sound encoding (gives much better quality with the same parameters), which would involve replacing D/A with μ-Law decoder,
– professional recording of all the messages,
– special filtering of recorded messages to give the best performance with low sampling and resolution,
– replacing a standard loudspeaker case with a dedicated case — possible miniaturisation, and
– replacing a power supply adapter with rechargeable batteries — power consumption may be reconsidered.

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