Low cost drip count device for IV gravity sets

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Abstract - The use of IV gravity sets for infusion is outspread around the world. This paper presents a method of drip count measurement based on an infrared LED and phototransistors receptors as well as signal analysis of the waveform produced by a passing drop by such receptors. Furthermore, this article also presents the steps taken for the development of a physical apparatus which can be connected to any IV gravity set.

Keywords - iv drip count; drip problem; embedded system; infusion rate meter

I. Introduction

The use of electronic devices in the health industry is not a new trend. Ranging from the use of computers to store patient data to the use of complex machines in surgeries, the use of technology has proved to be fundamental to a quick and reliable health service.

Research regarding new technologies in the health industry has increased in the last few years and many new devices to assist in the control and monitoring of hospitalized patients are in use nowadays. An area which grew quickly in the last decade was the one related to monitoring infusion IV gravity sets. These systems work on the following premise: the gravity force applied to the liquid within a bottle associated with the pressure inside an infusion chamber help in the administration of a substance intravenously at a certain adjustable speed. The whole set does not consume energy, therefore it is the means of substance administration most used nowadays.

Following the improvement of life quality, the Brazilian population has experienced in the last few years a significant rise in life expectancy. The Brazilian people have been living more [1] and due to this, the need for hospitals specialized in the care of the elderly also grew. An alternative that has become more prominent is the Home Care services. Many families also choose to care for their elderly at home.

The Home Care services offer all the equipment necessary for the well-being of their patients, nonetheless some devices that could give the family more comfort and make them more involved in the care of the patients aren't always available. Sometimes, this happens due to the high cost associated with this equipment, and other times because the service won't provide them.

An activity very common in these homes is the administration of intravenous substances. Some equipment in the market nowadays are responsible for monitoring the administration of these substances, even the adjustment of dripping speed[3][4] Unfortunately, these devices are used mainly in large hospitals as they're equipment of considerable size and cost, additionally they consume a large amount of energy.

As solution for this problem, this paper proposes the development of a low cost and size device that is capable of counting drip rates at a variety of IV gravity set types. The main purpose of the device is to allow a mean of monitoring these sets which can be used by most people.

The development of the device was divided into two phases: design and assembling of the hardware and development of the firmware. The device is composed by an infrared transmitter, a receptor, a microcontroller and an LCD display. Low cost measures were also put in practice as to enable the device to consume a lower quantity of energy, in owing to its portable nature and the need for the use of small batteries.

II. Device Characteristics

The physical characteristics of the device can be summed up in three parts:

- Outside box, needed for keeping the batteries and auxiliary boards in place.
- Main board, containing the power supply circuit, the LCD display and the microcontroller.
- Auxiliary boards, one board containing the receptors and another containing the infrared transmitter.

The device can be coupled with an IV gravity set and will monitor the drops passing through the sensors. An infrared LED (transmitter) sends luminous pulses to the receptors that are placed in the opposite side of the infusion chamber.

The transmitter is controlled by the microcontroller and has its luminosity adjusted depending on the ambient luminosity. Two phototransistors are used in series as receptors, one sits over the other as two help in the drip detection when the equipment is out of its vertical axis. The voltage level presented by the receptors is connected to one of the ADC inputs of the microcontroller which will process the signal presented. The drip rate is presented in a LCD display.

A red LED is used to give warnings to the user. In the case of no drop passing through the sensor in a period of one minute the LED will start blinking. Two buttons are fitted in the main board, one of them enables the device reset and the other is a wake up button for when the device enters the Deep Sleep mode. The device uses a PIC18F microcontroller [5] to control the device and process the drip counting.

III. Drop Characteristics

The waveform presented by a passing drop through the sensors is shown in Figure 1 and it is typically not uniform[6]. It depends on factors such as: current ambient luminosity, chamber alignment with the vertical axis and dripping speed

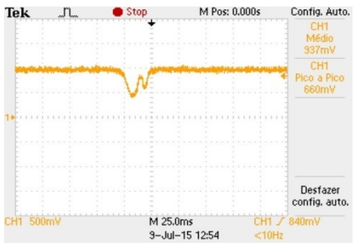

Fig. 1 – Waveform presented by a passing drop through the sensors.

IV. Drip Count Algorithm

The drip counting existing methods vary from fuzzy logic[7], the use of interruptions[6] to the use of digital filters[8]. The algorithm used by the device is based on the constant reading of the receptors voltage values. Each reading is converted by the ADC and contributes to the analysis of the presence of a drop. The algorithm is divided into three parts:

- Average voltage levels detection.
- Detection of a fall in the voltage levels
- Detection of a rise in the voltage levels.

Figure 2 sums up the behaviour presented by the algorithm:

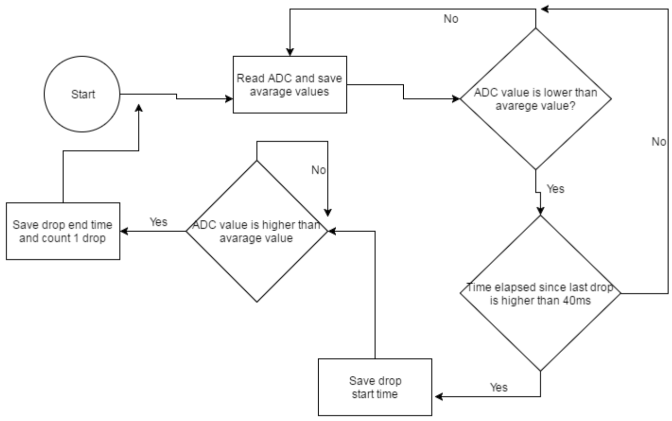

Fig. 2 – Algorithm flow chart

The waveform presented by the receptors has a constant value during most of the time. When reading these values, if the current reading is constant compared to the last four readings, this value is stored in a statistical buffer. The average voltage level buffer stores the last ten constant ADC readings. The arithmetical rounded average associated with the variance of the values stored in this buffer is used to calculate the average voltage level representing the constant value of the waveform.

If the voltage value read from the ADC is lower than the average level, this indicates a possible drop. Hence, the initial drop time is registered and the existence of a possible drop is flagged. Note that this signalling will only happen if the time registered between the beginning of a previous drop and the current drop is above 20ms. This is necessary because in a drop will always present two peaks in its waveform. As the time of a passing drop is no higher than 20ms it is guaranteed that a double peak won't be registered as two drops. Finally, when the voltage level registered by the ADC is back to the average level the existence of a drop is confirmed.

V. RESULTADOS E CONCLUSÕES

A prototype has been assembled with the aim of testing and validating the firmware developed. Figure 3 shows an overview of the prototype.

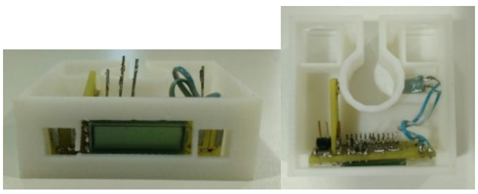

Fig. 3 – Photography of the prototype

Drip counting

The tests were conducted in normal luminosity levels using an IV gravity set model EQL with a bottle of 350ml containing water. The liquid was released at different dripping rates and the counting was registered using oscilloscopes and the display. The results can be seen in Table I. Note that at certain rates (216 and 412) there was a small variation in the drip counting of 0.9%. This is due to the fact that at high speeds the waveform presented by the receptors can become deformed or blended.

TABLE I – DRIPPING COUNT RESULTS.

Rate Drops/min	4	12	24	150	216	412
Manual counting	4	12	24	150	216*	412*
Device counting	4	12	24	150	214	408

Tests concerning the influence of ambient luminosity were also conducted. Two luminosity conditions were simulated as to analyse the device reaction to these conditions: low ambient luminosity where the device was put in a dark room; and high ambient luminosity where the device was put in a totally bright room. In both cases the device worked as expected not altering the results presented on the display.

Cost and energy saving

The device cost will be defined only but the price of the microcontroller and the box fabrication. The other components involved have a very low price compared to these parts.

The energy saving policy was implemented to save the maximum amount of power from the two AAA batteries that will feed the device. Firstly the ADC reading is done at periodic intervals of 5ms, during the rest of the time the microcontroller will be sleeping. If no drop is registered within a period of 2 minutes the device will be set to Deep Sleep mode, the user will be able to wake the microcontroller up using one of the two buttons provided. Lastly, the infrared LED is set to work at a switched-mode.

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