Embedded Based Driprate Measurement Using Magnetic Sensor

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Abstract
Drug administration and accurate fluid infusion are extremely important for optimum management of critically ill neonates. It requires continuous and controlled administration of drugs. This method is preferred for therapy of acute care. The drug is continuously sent to the human body intravenously. The aim is to design an Intravenous Drip Sensor, with the help of a magnetic sensor to measure infusion rate, and to display the number of drops passing through the drip chamber per minute i.e. the drip rate. The signal thus obtained is conditioned by a F563x microcontroller for further measurement of drips rate. When a drop passes through the drip chamber, the sensor output voltage is changed. In this projectthe drip rate is measured by sensing the change in voltage.

Keywords
Magnetic sensor, Infusion Drip rate, Neonate.

I. Introduction

The drip rate counter device is usedin automated instruments for monitoring of infusion rate in intravenous therapy. These devices are more helpful to the diabetic patients to simplify their routine that relies on manual control of blood glucose levels. This device can adapt to different lifestyles and various infusion pumps.3 mL of fluid is given to adultsin the form of subcutaneous or intramuscular injections because a higher dose will cause problems in the tissue surrounding the injection site. Since an intravenous injection goes directly into a patient's vein, the only limit in the amount of fluid that can be administered via an intravenous is the amount a fluid a person's body can consume without receiving more liquid than the body can absorb or excrete.The safe range of daily fluid intake will vary based on the patient's condition, size and age, as several diseases such as heart failure, kidney failure, and diabetes.Limits on a patient's fluid intake should be indicated by a doctor based on the patient's condition, but for a normal healthy adult, the normal range of total fluid intake(coming from IV fluids and fluids that they drink) should be 35-50 mL/kg body weight/day. For example, a 100 kg healthy adult, should get 3500-5000mL per day of fluid, or 3.5 to 5 L.This is a lot of fluid compared to the amount that can be given using other parenteral routes of administration.

IV administration is faster than any other method of administration because it goes directly into the blood, so it may be used when rapid action of the drug is necessary.

Based on a field research conducted in the initial stages of research, observing different types of drops counter devices from the market, it was noticed that the drip rate counter devices follow a pattern of operation, which can be described as an optical model of the drops counter device. In early days, the dripping detection devices used to work in an optical method or capacitance method. The generic model consists of a user interface using input and output devices to communicate with the patients, such asLCD's, buttons, sound alerts; a battery that powers the whole system; a unit responsible for all data processing, where the unit is the entire circuit composed mainly by a microcontroller or microprocessor, and it is responsible for all drops counting calculations as well as monitoring the flow. The drips counter device works combined with the syringe pump or infusion pump. It is not a separate device. According to the American Diabetes Association, currently the infusion pump cost from $ 4,000 to $ 8,000, with just few manufacturers ruling the market around the world. The advantages of the separate drips counter device, is that it is useful for the normal patients who are being treated by intravenous therapy. For example the intensive care patients, accident cases, low blood pressure patients taking infusion fluids, blood and liquid food via the intravenous therapy. Those patients do not needan infusion pump, but need a drops counter device for regulating and monitoring fluid flow rate.

II. Prototype

A. Requirements

In the following subsections, the results from requirements engineering performed on the proposed prototype are presented. The requirements were divided into hardware, software and safety requirements.

1) Hardware

The device must have a power supply, which is a non-rechargeable battery easy to change. The drips counter device is found in the regular market, and the whole type of the prototype was designed to fit in an intravenous chamber. A SM353LT magnetic sensor is connected to a microcontroller. To get an accurate counting value a shielded magnet is required. The communication between the system and user is done via a Liquid Crystal Display (LCD) and a buzzer. All functionality of the system are controlled by a low power consumption microcontroller from the AT-mega family.

2) Functional Requirements

The main functional requirements for the prototype are described as follows:

Information display: the device must display the approximate battery levels, drops rate, time, malfunction alarm.

Enable Alarm Profiles: User can setup a manual profile for alarm function at different volume rate.

Critical alerts: For each problem, such as lack of battery or lack of insulin, the device must have audible and visible alerts.

3) Safety Precaution

Considering that a drip counter device is a safety critical system, additional care should be taken to ensure safety requirements, which were organized into the following hazard categories: hardware and software hazards. The hazard categories are described as follows:

i) Potential Hazards

Failures related to hardware hazards can be caused by defects from the sensor circuit designing, or handling of the device by the user. There are many failures identified in this category Fault in microcontroller is one of the biggest problem as the microcontroller is the "heart" of the device it is mandatory to ensure a good protection of the chip against external environment. Then comes the misalignment because the sensor and magnet alignment is mandatory for a good results. A buzzer with unusual behavior is another difficult problem to be avoided, the most conventional way is by shielding physical shocks, only allowing the passage of sound. There is also chance for failure of the battery sensor so a battery sensor is included in the microcontroller, if not, it can be implemented on programming based on the empirical cases, providing life timesafety. The other minor issues include real time clock (RTC) which can be late or early. Lastly,failure in the circuit components.To avoid this defect, a refined circuit design should be made and tested in different environments.

ii) Software Hazards

Failures related to software hazards can be caused by defects introduced in embedded software development. The main failures in the categories are: displaying incorrect results to the user; incorrect step calculation for the drip rate counting; infinite looping; threshold of ill-defined sensors; incorrect conversion of the sensor values; incorrect command to the buzzer. In order to increase the system safety, all these hazardous situations must be avoided and they should betaken into account during the prototype development.

B) Design

The whole structure was designed from a marketable drips counting device, which is an important problem in the development of drips counting device using magnetic sensor. The sm353lt magnetic sensor has very low power consumption, consuming 310nA in active mode. The prototype graphical user interface is based on a custom LCD 21mm in height and the 40mm in width. The design of the LCD has to be compatible with the hardware requirements of the microcontroller used, which was the ATmega16A.

This microcontroller with an 8-bit advanced RISC architecture has a low power consumption, consuming 1.1mA in active mode, 0.35mA in idle mode, less than 1µA in power down mode. It has several features (see datasheet supplied by Texas instruments), including an integrated LCD driver. The magnet strength is typically 14 gauss. The clip type holder is used to fix the alignment of the magnet and sensor. Its shape is designed by depending on the intravenous chamber and it was in low weight.

C) Software (Architecture)

The software of the drops counting device is structured modularly, allowing functions to be easily modified and improved. Basically the software architecture is divided into 4 modules: main, timer, display and mode check.

1. Main module

The main module is responsible for initializing all the required parameters, preparing the device to start its normal operation. This module sets the ports that will be used, active LCD, initialize the variables and start the first state of the drips counting device.

2. Time module

The timer module is designed to count the time interval between the two drops passing in the chamber. The timer is started when the function "configure_timerA" is called by the main module and uses the TimerA interruption to fire every ½ second.

3. Display module

The display module is a library designed to control the LCD. It creates the functions to hide the complexity of controlling the display. The functions that control the display are explained as follows:

1) Upper_number_float(float num): this function receives a float number to display in the upper segment.
2) Hours(bool mode): enables symbol "H",
3) Percent(bool mode): enables symbol "%",
4) Lower_count(char strin[]): this function writes a string on the text display.
5) Clock(bool mode): enables "clock" symbol,
6) Battery display(int amount): this function displays battery level.
7) Stop(bool mode): enable "stop" symbol.

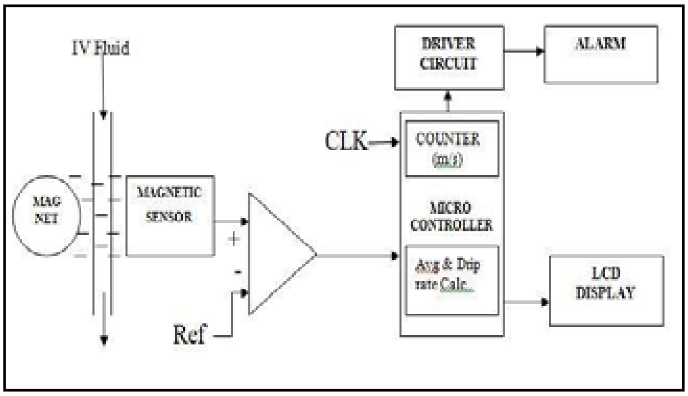

Fig. 1: Block diagram

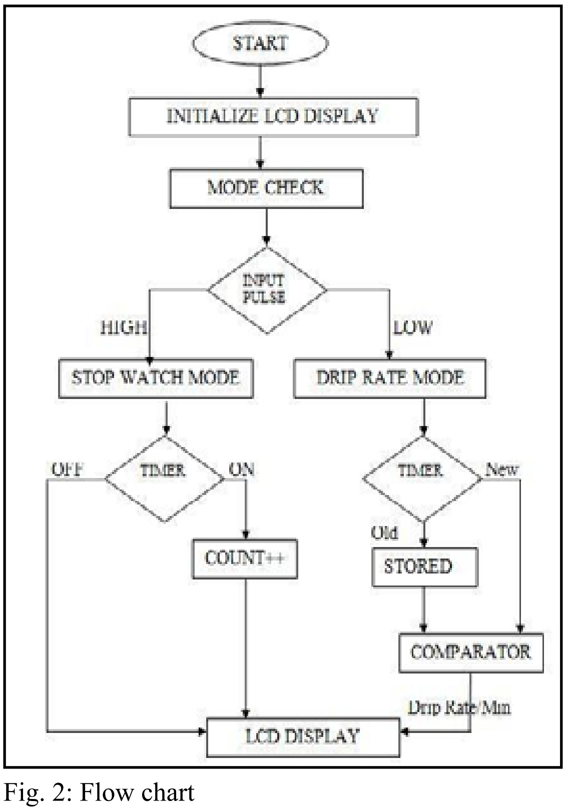

Fig. 2: Flow chart

Sensor

Magneto resistive Sensor ICs:

Honeywell's Nanopower Series Magneto resistive (MR) Sensor ICs are ultra-sensitive devices designed to accommodate a wide range of applications. It has large air gaps, small magnetic fields and low power requirements. The sensor ICs respond to either a North or South Pole applied in a direction parallel to the sensor. They do not require the magnet polarity to be identified, simplifying installation and potentially reducing system cost. These sensor ICs use a very low average current consumption and a push-pull output which does not require a pull-up resistor. The sensor ICs can operate from a supply voltage as low as 1.65 V, promoting energy efficiency.

Fig. 4: SM353LT

These magneto resistive sensor ICs may have an initial output in either the ON or OFF state if powered up with an applied magnetic field in the differential zone (applied magnetic field >Brp and <Bop).

Honeywell recommends allowing 10 µs for output voltage to stabilize after supply voltage has reached its final rated value. The sensor will turn LOW when the magnetic field is present and switch to HIGH when the field is removed.

The sensor will latch and hold the state during the sleep "mode".

III. Result

When the 5V supply is passing to the sensor, the sensor gives the 5V in the output terminal, if there are any magnetic fluxes the sensor output reduces to below 3V. The output is displayed on the CRO, Figure. In this figure we see the continuous waveform. In this waveform chart, the two peaks are displayed. So it explains that the two drops are crossing the magnetic field.

IV. Conclusion

Drips rate counter can help in monitoring drips rate and volume of the intravenous fluid which may cause diabetes in patients, and can also be used to detect. In the future we can still modify and construct the sensor circuit for better results. Generally the theoretical voltage of sensor output variation is constant at a level of voltage but we get various range of voltage. This shows that we are detecting those voltages with by focusing of magnetic flux lines at a straight line. Moreover it can also implement an alarm system that can detect overflow of the drug. The alarm system should be designed in such a way that it can detect when the fluid in the intravenous bottle is over. We can also implement an alarm system for the sensor being unable to receive the signal in case there is improper displacement of intravenous chamber. Then adopt new type of overall design so that it's easy to fix the intravenous chamber.

Using this system the intra venous fluid drops are countered and also determine the fluid flow volume. This system is more helpful to the diabetic patients, because of their continuous infusion fluid process. This system is more important to reduce the routine checking of fluid level by the nurse.

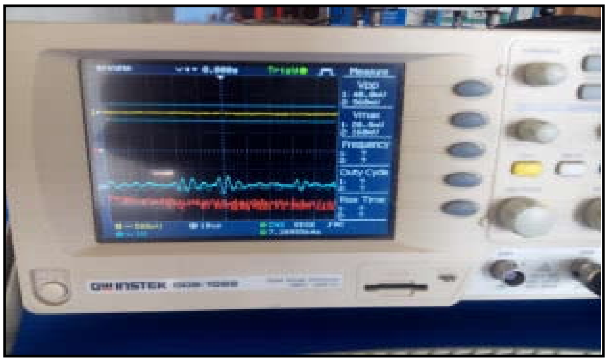

Fig. 5: CRO Output

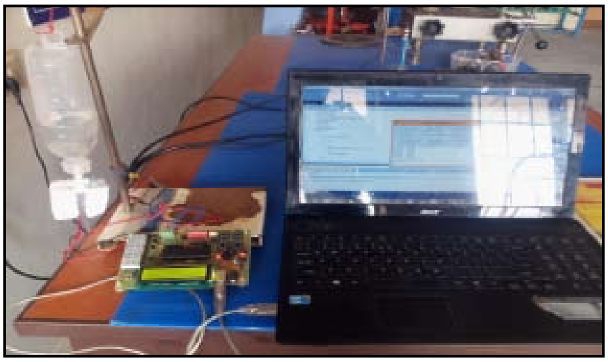

Fig. 6: Experimental Setup

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