Development of a low-cost device to detect blood backflow in catheters

Sitipragyan Satapathy[1], Biswajeet Champaty[1], Kunal Pal[1]*, Sirsendu S Ray[1]
[1]Department of Biotechnology and Medical Engineering, NIT-Rourkela, Odisha, India- 769008
pal.kunal@yahoo.com*

D. N. Tibarewala[2]
[2]School of Bioscience & Engineering, Jadavpur University, Kolkata, West Bengal, India-700032

***Abstract*—The current study deals with the development of a blood backflow detector which can generate an alarm in the nursing station so that the health caregivers can attend the patient in the shortest possible time.**

***Keywords---* Blood Back flow, LabVIEW, Encoder, Decoder, saline/ IV medication**

I. Introduction

There is an acute shortage of health caregivers not only in the developing countries but also in various developed countries even though the medico-technical world has raised sky high. Due to this, it is not possible for the caregivers to monitor the patients 24x7. One of the common scenarios in the hospital environment is the administration of IV fluids. Once the caregivers have placed the catheters in place for the administration of IV fluids, they often have to leave to attend other patients [1]. After the IV fluid is emptied, there is a backflow of blood into the catheter due to the backpressure exerted by the circulatory system. If not attended early, the blood clots in the catheters and obstruct the flow of fluids, to be administered later [2] . This leads to the reinsertion of the catheter at a different site, which increases the agony of the patients. In the current study, we propose a low-cost device which can detect the backflow immediately and generates an alarm in the nursing station [3] . This device will help reducing the attending time by the caregivers.

II. Materials

MOC7811 (Slotted Opto Isolator Module), potentiometer (10K ± 0.15 %), butterfly catheter (Romsons Scintific & surgicals), IC 7805 (5V voltage regulator), ICOP07 Texas Instruments), USB4704 (Advantech), LabVIEW 2010, rhodamine B (RB; HiMedia) and ASK wireless transmission module (PROVOTECH WS-RX-TX-02) were used for this study.

III. Methodology

The designing of the module was carried out in 3 steps: (1) Determination of voltage variation using LED-LDR coupling, (2) MOC 7811 replacing the LED-LDR coupling to determine voltage variation and subsequent interfacing with LabVIEW, and lastly, (3) Blood-back flow alarm signal transmission using wireless communication protocol.

A. Determination of Voltage Variation using the simple Voltage Regulator coupled with LED and LDR

LED-LDR coupling forms the basis of optocouplers where the resistance of LDR varies inversely with the change in the intensity of light. A pipette carrying the RB solution mimicked the blood flow [4] detector assembly was setup using a simple voltage comparator circuit with an LED connected in parallel with the LDR around the pipette to monitor the voltage variation (Fig 1). In the presence of rhodamine B solution in the pipette, the intensity of light perceived by LDR is reduced with a corresponding change in the voltage. The signal was amplified to boost the signal and subsequently passed through a voltage comparator. The output signal of the comparator was acquired and monitored in PC by USB4704 using a LabVIEW program (Fig 2) to generate an audio-visual alarm in the presence of RB solution in the pipette. Preliminary study and verification was carried out using data acquisition system (DAQ; USB4704). The setup was realized using a LabVIEW program.

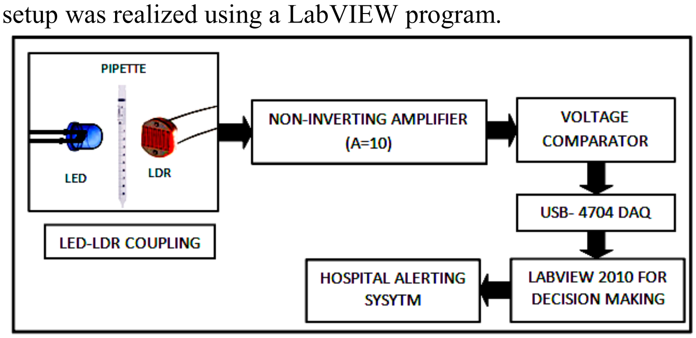

Fig. 1 Block diagram to detect blood back flow using LED-LDR coupling

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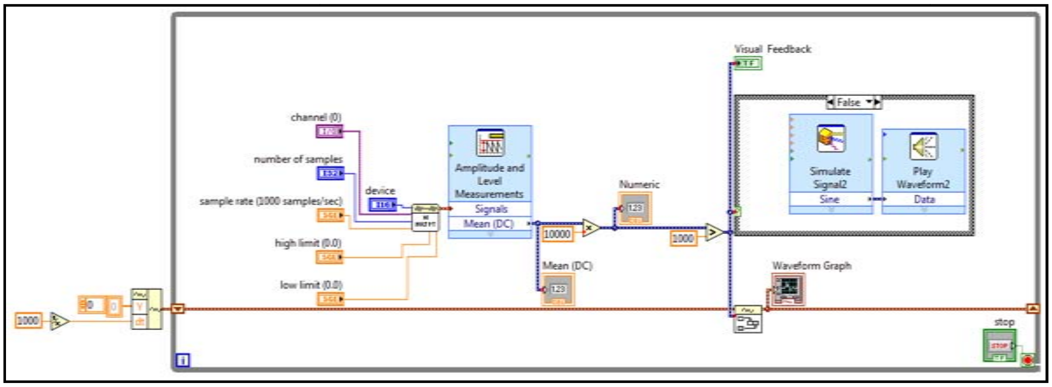


Fig 2 Lab view block diagram for blood back flow detection

B. MOC 7811 replacing the LED-LDR coupling to determine voltage variation and labVIEW interfacing

The LED-LDR pair was replaced with MOC7811, a slotted opto-isolator module with IR transmitter and a photodiode. It consists of an infrared emitting diode coupled with a photo-transistor in a molded plastic housing. Similar to the previous study, RB solution was used as an alternative for blood. A butterfly surgical catheter was placed in the slot of the MOC7811 [5] . Rest of the method was same as in the previous section. Detailed block diagram and circuit connection is illustrated in Fig.3 & 4 respectively.

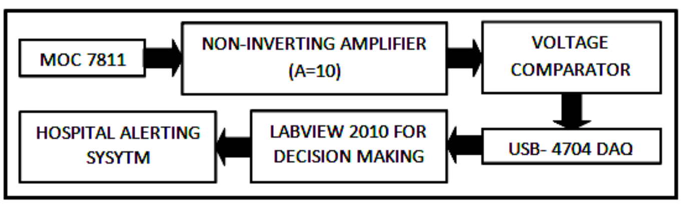


Fig. 3 Block diagram to detect blood back flow using MOC 7811

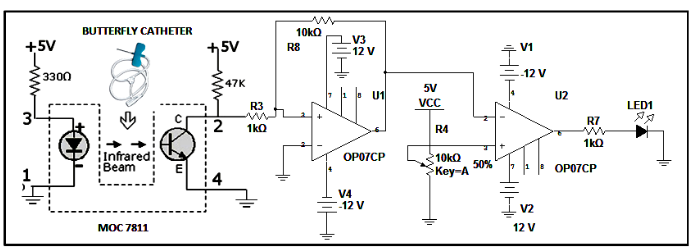


Fig 4 Circuit diagram to detect blood back flow using MOC 7811

C. Blood back flow detection through wireless communication

The output signal from the voltage comparator (digital/binary signal) was encoded and subsequently transmitted using a wireless transmission module [6] . The transmitted signal was received at the receiver end, decoded and acquired in PC by USB4704 using a LabVIEW program. A LabVIEW program was developed to activate an audiovisual alarm system (Fig.2). Fig.7 shows the absence and presence of RB solution with proper wireless transmission.

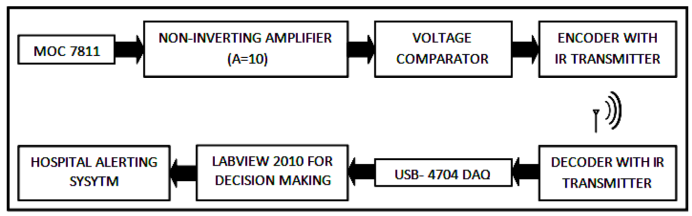


Fig 5 Block diagram of blood back flow detection module through wireless transmission

IV. RESULTS

TABLE 1
RECORDING OF VOLTAGE VARIATION IN VARIOUS CONDITIONS

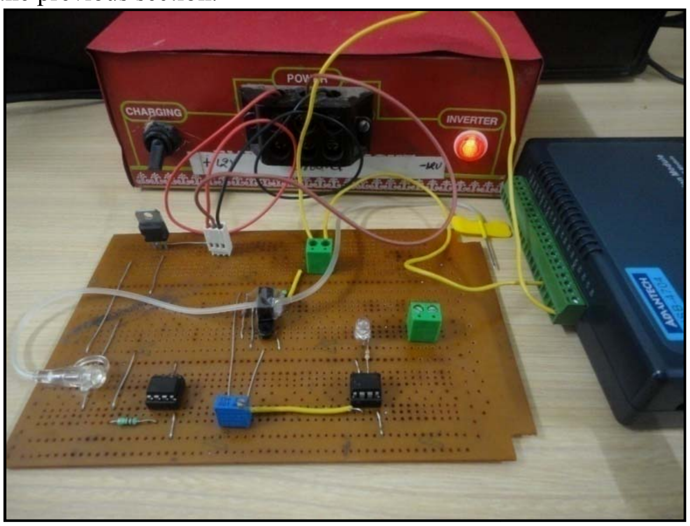
Steps during testing	Output Voltage (V) With RB solution	Output Voltage (V) Without RB solution
A	8.0743	4.930
B	0.8420	1.134
C	0.8430	1.142

A. *LED-LDR coupled setup*

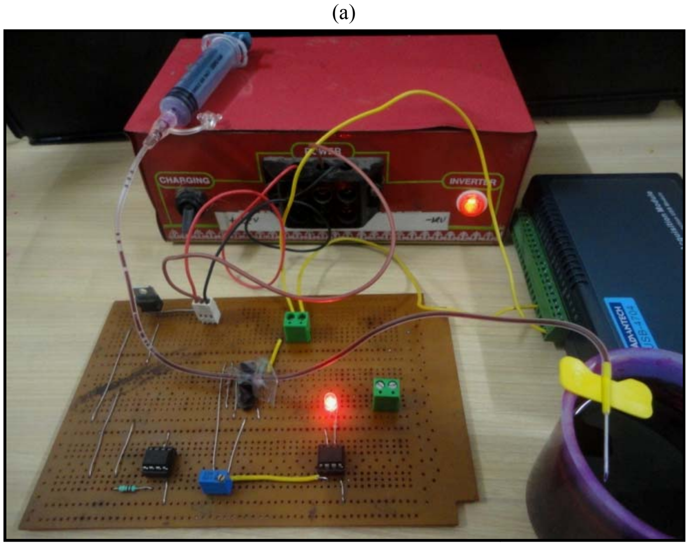
The LED-LDR coupled setup was initially developed to detect the flow of the RB solution in pipette and have an understanding about the ability of the setup to be made functional. The results suggested a significant change in the output (Table-1) when the RB solution was passed through the pipette. The output signal from the LDR was an input to the voltage comparator having a reference voltage of 6.5 V so as to distinguish the presence or absence of RB solution [7] . The output of the voltage comparator was acquired in PC and processed to activate an audio-visual alarm. A visual feedback system implemented to power-on a LED, in the presence of the RB solution while the audio feedback was implemented by generating audio alarm in the PC.

B. *Setup using MOC 7811*

With the successful implementation of LED-LDR coupling/ pipette setup, the principle of the backflow detection was implemented using MOC7811 as the opto-coupler. MOC7811 provided a relative easy and firm support to the solution carrier (butterfly catheter) [8] . Like in the previous technique, the voltage variation was noted under similar conditions (Table-1). A threshold (1.0V) was set and the LabVIEW program was used to produce an audiovisual alarm, similar to the one discussed in the previous section.



(a)



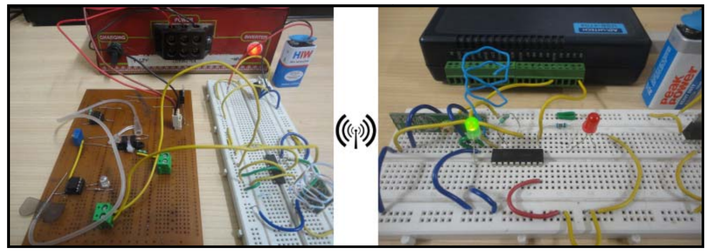
(b)

Fig.6 Experimental setup to detect blood back flow using MOC 7811
(a) Without RB solution (b) with RB solution

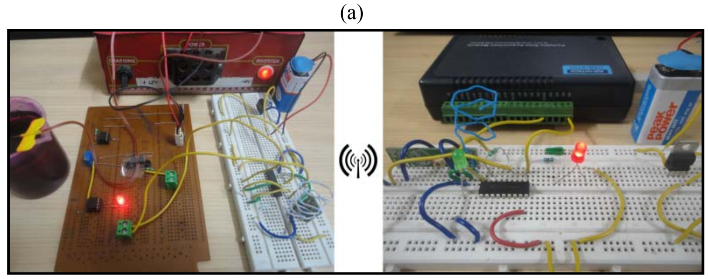
Fig.6 shows the experimental setup for two different conditions like without RB solution and with RB solution. The presence of RB solution can be ensured visually with the glowing of an LED.

C. *Wireless transmission*

The setup developed in the previous section was used for transmitting the audio-visual commands to a remote location using ASK wireless module [9] . In the presence of RB solution (simulated blood backflow), an audiovisual alarm was initiated at the remote receiving station [10] .

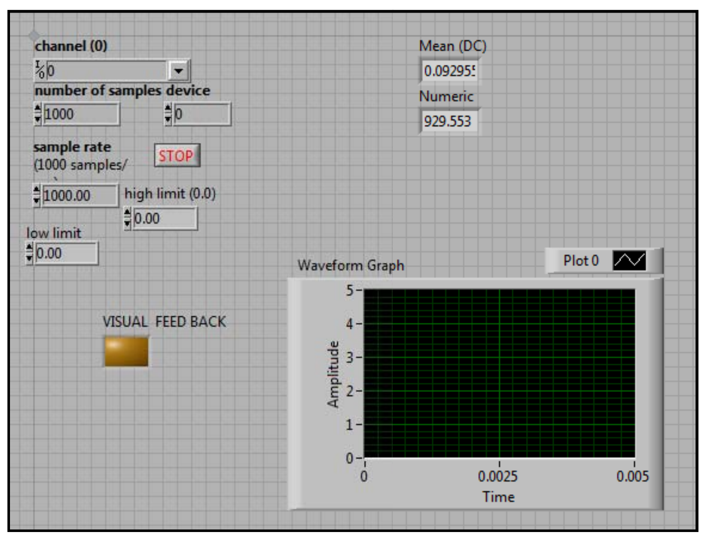


(a)

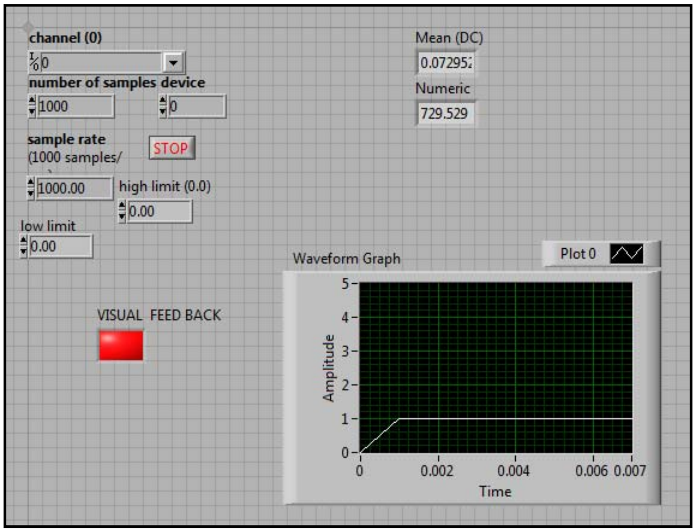


(b)

Fig. 7 Circuit set-up to detect blood back flow through wireless transmission
(a) Without RB solution (flashing green LED at receiver end) (b) with RB solution (flashing red LED at receiver end)



(a)



(b)

Fig. 8 LabVIEW front panel detecting the blood back flow (a) without RB solution (b) with RB solution

V. Conclusion

As per Indian Nursing Council (INC) norms, the nurse: patient ratio should be 1:1 in critical care unit, 1:3 in the intermediate care unit and 1:6 in the ambulatory (general) ward. Unfortunately, the currently ratio of nurse: patient is 1:60. Due to this reason, there is an increase in the workload of the nurses. The current system was developed to alert the nurses in the nursing station (remote location) as soon as there is backflow of blood in the catheter [11] . The designed gadget may be made into a low cost, efficient, user friendly and portable and hence may be used as a supportive asset for the caregivers.

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