Study on the Design of an Optoelectronic Equipment Capable of Detecting Infusion Returns Blood

Maolin Zhu¹, Ya Wang², Liming Dong²
¹Changshu Institute of Technology, Changshu 215500, China
²Shanghai Urban Construction Vocational College, Shanghai 201415, China

Abstract: This topic uses photoelectric switch to monitor the characteristics of liquid in the infusion tube to transmit the resistance state. When the transmittance in the infusion tube changes, the signal is captured and fed back to MCU by means of the photoelectric switch to distinguish the return of blood to the infusion tube and the termination of transfusion process or other states. While MCU determines the occurrence of blood returning or the completion of medical transfusion, the alarm reminder function will be triggered. And stepper motor rotates to further clamps the infusion tube to stop the dripping of medicine to prevent the emergence of blood returning, air inflow, etc. The study of this system has a certain research and development value and market potential to alleviate the pain of patients and the burden on family members, greatly improving the work efficiency and fatigue of medical staff.

1. Introduction
The correct use of medical devices is closely related to the lives of patients. In medical treatment, a very small error will have serious consequences, ranging from disability to death. And the most general and commonly used medical treatment is intravenous infusion which plays an important role in clinical treatment and rescue. The principle is while the infusion bottle hang at a high place, utilize the distinction in atmospheric pressure and gravity difference to input the drug solution into the patient's blood vessels and entering the blood circulation. During intravenous injection, patient needs to pay attention to the liquid in the bottle, which imposes a certain burden on the patient or escort of the family. Domestic and overseas have done some more or less experiments and research for ordinary infusion alarm equipment, and succeeded with some new product exploitation up to now. So far, this technology has only been introduced by certain large hospital hospitals, although many positive results have been achieved. However, the function of blood reflux detection has not been reflected in this kind of products. And the phenomenon of blood reflux is very dangerous. At present, relying on artificial naked eye judgment to prevent such phenomena from emergence, often identification of the time has been the occurrence of blood reflux. Severe patients, children, the elderly and other groups of infusion often require that be accompanied by personnel, and the role of accompanying personnel is through continuous keeping a check on the allowance of the liquid in the infusion bottle to prevent unexpected situations. Consuming manpower and delaying work at the same time, results in a certain amount of manpower and time waste. Moreover, artificial error-prone, a trifling negligence will be due to not timely to cause re-infusing, returns blood, etc. which will cause unnecessary medical malpractice. Therefore, relying on manual judgment does not constitute an effective method.

2. Functional Objectives of Device Module Design
The design of the photoelectric module is shown in Figure 1. The system consists of two sets of...
photoelectric sensing equipment and a set of buzzer devices. It is used for different purposes according to the position of the photoelectric module clamping in the infusion tube:

When the photoelectric module is clamped above the dripper. When the infusion is complete, the transmittance in the infusion tube changes due to the exhaustion of the potion in the tube. When the liquid's surface in the infusion tube is lower than the photoelectric module, the buzzer is triggered and alarms. The stepper motor clamps the infusion tube and patients wait for the medical staff to replace the infusion bottle. This method is suitable for patients who still need to continue to have intravenous drip after the infusion.

When the photoelectric module is clamped at the bottom of the infusion tube and the liquid surface in infusion tube is lower than the photoelectric module. At this time from the liquid into the air and then into the blood, the transmittance of the medium in the infusion tube changes. The photoelectric module triggers the buzzer and alarms. The stepper motor clamps the infusion tube to reduce the waste of the drug solution. This method is suitable for patients have intravenous drip done.

When the photoelectric module was clamped on the infusion dripper. As the liquid in the dripper continues to drip, causing the changes of the liquid's transmittance. The infrared light of the luminescent diode is not enough to penetrate the infusion tube when no droplets drop fall in the dripper. Photosensitive transistor is in the cutoff state, and the output high level; When there are drug solutions in the dripper, through the droplets form a similar convex lens to gather light. Photosensitive transistor receives the optical signal. At this time in the conducting state, and output low level. Feedback to the LM393 comparator to form a round of level difference. The program of writing MCU in advance could accurately record the time difference of one round level change, and then performed the program to obtains the drip speed of the conveying liquid. Setting the range of drip speed in MCU. Buzzer automatically alarms and clamps the infusion tube when the actual drip speed exceeds this range. This method is suitable for the elderly and children, severe patients or other people with high demand for drip speed.

3. Operational principle
•Schematic diagram of this design as follows

![Schematic diagram of this design](image-url)
Among them, D1 and D2 are infrared light source transmitter, D3 and D4 are infrared signal receiving end. The pair of sensors D1 and D3 are used to detect the interface of the pharmaceutical/air. The detection principle is as follows:

The sensor D1 emits a signal, which is received by the phototransistor after being refracted by the infusion tube. When there is liquid medicine in the infusion tube, the cross section of the infusion tube is two convex lenses, which can focus the light and allow the light to be absorbed by the transistor D3, at which point the output low level. When there is no liquid in the infusion tube, the intensity of the light signal emitted by the LED cannot penetrate the infusion tube, photosensitive transistor can’t receive the signal, in the cutoff state, at this time the output high level. Buzzer alarm and stepper motor clamps the infusion tube.

The circuit diagram of the photoelectric system is as follows (Figure 2)

![Circuit Diagram](image)

**Fig. 2 Schematic diagram of photoelectric detection system**

As shown in Figure 2, the core module of this design is the LM393 chip. While the photoelectric detection module uses the infrared signal whether it can be absorbed by the phototransistor emitted by the infrared emission tube to form the state of the guide. This system uses the adjustable potentiometer in the adjustment diagram to change the infrared frequency of the infrared light emitting diode, which makes it possible to control the amount of infrared light overflow through different media to determine the state of the phototransistor. According to the different transmittance of medium light, the detection is realized.

Install the photodetection system on infusion tube. As shown in the figure, when the infusion tube solution drops normally, adjust the potentiometer, change the resistance, and change the intensity of the light signal of the infrared emitter, so that the light frequency can be through the infusion tube exactly when there is liquid medicine. The light emitted by the light-emitting diode D1 is condensed by the cross-sectional lens, and the photo-transistor D3 receives the optical signal, and is in a conducting state. Comparator LM393’s (negative) inverting output terminal voltage is higher than the (positive) non-inverting input terminal. At this time the output low level, detecting that the infusion tube is in normal
working condition and the liquid is liquid medicine. When the infusion is complete, a returns blood is produced. The infrared and blood belong to the red spectrum, the emitted infrared is absorbed by the red blood, and the phototransistor D4 does not receive the signal in the cut-off state; Comparator LM393’s (negative) inverting output terminal voltage is lower than the (positive) non-inverting input terminal. At this time the output high level, buzzer alarm. When the liquid in the infusion tube is run out and enters the air, the light intensity emitted by the LED cannot be received by photo-transistor D3 through the infusion tube, at which point D3 is in the cut-off state. Comparator LM393’s (negative) inverting output terminal voltage is lower than the (positive) non-inverting input terminal. At this time the output high level, buzzer alarm. After such a round of low and high level staggered forms different rules of the waveform, and then the waveform fed back to the MCU to calculate the cycle time to obtain the droplet speed of the liquid.

In Figure 2, D1, D2 simulate infrared transmitter, are used to emit optical signals. D3, D4 simulate phototransistor for receiving the optical signal that infrared transmission tube D1,D2 emitted. Whether phototransistors D3, D4 could receive D1 and D2’s optical signals is related to the liquid in the infusion tube. By changing the resistance of the rheostat to adjust the frequency of the infrared emitter, to change the emission distance of the LED. Experiments prove that when the resistance of rheostat is adjusted to 2.1K-7.6K, the blood in air, liquid and liquid can be distinguished at the same time.

4. Other function module configurations
Connected alarm circuit in MCU. When have intravenous drip with the optoelectronic switch clamp on the infusion set. If there's no liquid or blood reflux in perfusion tube, then the photoelectric tube, i.e. phototransistor cannot receive the light signal from the LED at this time. The triode is positioned in the cut-off state, outputs high level and MCU triggers buzzer and alarms. At the same time, this design alarm pulse can trigger the stepper motor to screw into a certain angle, for clamping or relaxing the infusion tube, thereby achieving the role of regulation. At the same time, when the liquid drip speed exceed the adjustment range, it will also trigger the motor to clamp the infusion tube.

5. Summary
This paper describes a method for detecting the interface of infusion liquid/blood/air by using photoelectric sensing technology, which plays different detection functions according to the different clamping position of the sensor. When the infusion tube is in a liquid-free or returns blood state, the photosensitive transistor outputs a high level, the system alarms and terminates the infusion. The design structure is simple, the cost is low, and it has certain technical application value.

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