

## **ARDUINO BASED BLOOD LEAKAGE MONITORING SYSTEM IN HEMODIALYSIS THERAPY**

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### **ABSTRACT**

The purpose of this paper is to design, and characteristics of a bracelet monitoring device for blood leakage detection during hemodialysis treatment. The design includes a Photointerrupter, Bluetooth module, and alert components. The validation results show that it only needs a very small amount of blood and takes 1.6 sec to detect a blood leakage. As long as the patient wear this bracelet it gives monitoring signal to the health care unit. The absorbent material is placed at the Photointerrupter. Once the blood leakage occurs the absorbent material which is placed at the Photointerrupter absorbs the blood and the alarm will triggers. A warning light will also be activated, and a detecting signal is transmitted to the healthcare station. Immediately the health worker take action to prevent this risk. The proposed system continuously give out an alert for 18-h long and continuously monitor upto 41 hours. This system is more convenient to the patient and also healthcare workers

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## **INTRODUCTION**

### **Dialysis**

Dialysis is the artificial process of eliminating waste (diffusion) and unwanted water (ultrafiltration) from the blood. Our kidneys do this naturally. Some people, however, may have failed or damaged kidneys which cannot carry out the function properly-they may need dialysis.

### **Types of dialysis**

- Hemodialysis
- Peritoneal dialysis

### **Hemodialysis**

The blood circulates outside the body of the patient. It goes through a machine that has special filter. The blood comes out of the patient through a catheter that is inserted into the vein. The filter does what the kidneys do; they filter out the waste products from the blood. The filtered blood then returns to the patient via another catheter. The patient is in effect, connected to the kind of artificial kidney.

### **Peritoneal dialysis**

A sterile (dialysate) solution rich in minerals and glucose is run through a tube into the peritoneal cavity, the abdominal body cavity around the intestine, where the peritoneal membrane acts as a semi permeable membrane. The dialysate is left there for some times so that it can absorb waste

products. Then it is drained out through a tube and discarded. Peritoneal dialysis is not as efficient as hemodialysis. It is carried out for longer period.

Out of the above mentioned two methods Hemodialysis is the best treatment adopted by most countries for kidney renal failure.

### **Hemodialysis working**

- Hemodialysis machine has a dialyzer filter which cleans the blood.
- The doctor makes an access into our blood vessels. This is done with minor surgery, usually to our arm. Then blood is taken into the dialyzer.
- Dialyzer has two parts one part for our blood and the other part for a washing fluid called dialysate. A thin membrane separates these two sides.

Smaller waste products such as urea, creatinine and extra fluid pass through the membrane and are removed. Blood cells, protein and other important things remain in our blood because they are too big to pass through the membrane.

### **Why blood leakage detector?**

Blood loss to the environment during hemodialysis can occur due to the needle slipping from the vein. One or both needle may be completely or partially dislodged or removed from the access site during treatment. The needles slip out if the tape on a patient comes off due to excess skin moisture. It leads to coma or even death. To overcome this blood leakage detector is used during hemodialysis.

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## Need of the Study

Venous needle dislodgement has been reported to be a potentially serious complication during the hemodialysis therapy. In 2012, the American Nephrology Nurses' Association carried out an investigation on the venous needle dislodgement. The survey results revealed that 76.6% (n = 894) of the 1166 participants indicated about their observances of venous needle dislodgement in the past five years, and with 8.2% (n=96) of those having seen five events or more in this time period. Moreover, slightly more than half (57.9%) of the 1166 participants pointed out that venous needle dislodgement occurs very often or often. An additional 23.1% rated their concern as occasional. From the above reported data, it shows a high frequency of occurrence on venous needle dislodgement, and indicates that the venous needle dislodgement is indeed a potential problem during hemodialysis therapy.

In this study, a Photointerrupter is used as a sensor for detecting the blood leakage and combined with a Bluetooth 4.0 for the function of wireless transmission. Furthermore, through our circuit design, the blood leakage detector can be integrated on a bracelet, which is a simple and inexpensive way to monitor the leakage of blood during the hemodialysis treatment. If the detector senses a leakage of blood, the alert system will be activated immediately, such as sound and a warning light. In addition, an alert signal will be transmitted to the healthcare station via the wireless transmission as well, so that healthcare workers can immediately take appropriate action to prevent any risks from happening.

## Existing Approach

The existing blood leakage detector have several disadvantages. The products outlined all need 1~2 ml of blood to trigger the blood leakage detector due to their sensor design. However, the amount of blood needed for sensing blood leakage can be improved. In addition, the price of such products is not affordable for general patients, and thus cannot be popularized. Although these products have an alarm, the loudness of the alert is limited by the distance, causing healthcare workers to give more attention to whether the alarm is warned or not, which is an inconvenience.

## Disadvantages

- It is cost effective and also it takes upto 2ml of blood to trigger the system
- The interfacing process with the microcontroller is comparatively difficult with the new technologies.
- These products have an alarm. The loudness of the alert is limited by the distance, causing healthcare workers to give more attention to whether the alarm is warned or not, which is an inconvenience

## Data Transmission Range

In this system the local receiver may stand alone or connected to a central monitoring station. In ancient systems most of the devices operate in the bands below 200 kHz and communicate at distances of less than one foot from the patient's body. But nowadays some of the devices are used to communicate data's which are Wi-Fi, Bluetooth. These devices operate in the range of 5725-5850 MHz bands at distances up to a few hundred feet.

## Proposed System Advantages

The blood leakage detector can be integrated on a bracelet, which is a simple and inexpensive way to monitor the leakage of blood during the hemodialysis treatment.

- If the detector senses a leakage of blood, the alert system will be activated immediately, such as sound and a warning light.
- Coding is somewhat easy with this system on comparing with the existing approach.
- The plot for the changes in the normal and leakage mode will be efficient to take more attention to the patient monitoring.
- In addition to that the voltage values and continuous alarm will be transmitted to the healthcare station via the wireless transmission as well, so that healthcare workers can immediately take appropriate action to prevent any risk from happening.
- Size is compact and it is economical.

## Embedded System

It is a combination of computer hardware and software design to perform a specific function. In contrast to desktop that performs a variety of task; an embedded system performs a single well defined task. The system has a processor, associated peripherals, and software for a specific purpose. Embedded software is present in almost every electronic device we use today. Cellular phone, automobile, industrial control equipment, scientific and medical equipment and defence services. Communication satellite, medical instruments and deep space probes would have been nearly impossible without these systems.

In general embedded system are divided into four categories

1. Autonomous
2. Real time
3. Network
4. Mobile

## Real Time

Real time embedded system are required to carry out specific task in a specified amount of time. These systems are extensively used to carry out time critical task in process control. For instance, a boiler plant must open valves if the pressure exceeds a particular threshold. If the job is not carried out in the stipulated time, a catastrophe may result.

## Embedded Development

The embedded system may not have a keyboard, a screen, a disk drive and other peripheral devices required for programming and development task. Therefore most of the programming for embedded system is done on a host, which we commonly refer as personal computer system with all the required programming tools. Only after the program has been written, compiled, assembled and linked it is moved to target or the system that is shipped to the customers.

## Sensor

A device which gives an output by detecting the changes in quantities or events can be defined as a sensor. Generally sensors produce an electrical signal or optical output signal corresponding to the changes in the input.

**Types of Sensors**

- Temperature sensor
- IR sensor
- Ultrasonic sensor
- Touch sensor
- Proximity sensor
- Pressure sensor
- Level sensor
- Smoke and gas sensors

**IR Sensors**

The small photo chip having a photo cell which are used to emit and detect the infrared lights are called as IR sensor. It is used for detecting obstacles. The proposed blood leakage detector system use IR sensors for detecting blood leakage.

**Hardware**

**Block diagram**

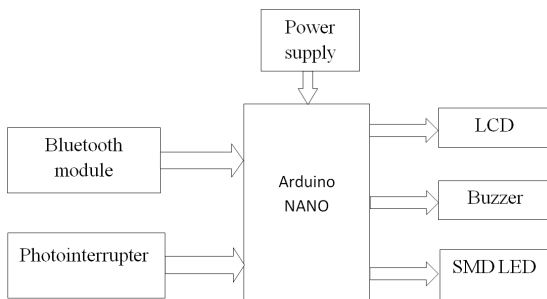


Fig 1 Block diagram of blood leakage detector

**Hardware Components**

**Photointerrupter**

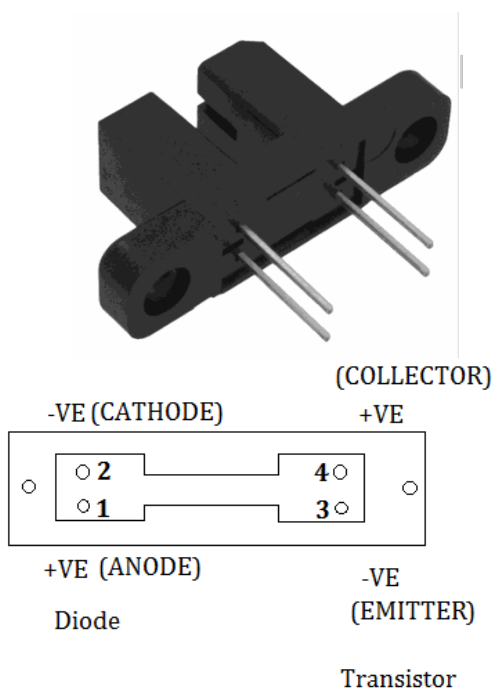


Fig 2 Structure of photointerrupter

Photointerrupter is an optical coupling (OC) element which is electrically insulated and optically coupled to each other in the light emitting and receiving parts. The principle is to convert the input electrical signals into light, meaning the light-emitting unit (emitter) emits an infrared light. The light

receiving unit (collector) receives the infrared light and converts it into electrical signals so that the light emitting portion and light receiving portion of the photo interrupter becomes conducted. A model of MOC7811 photo interrupter is used in this study for sensing the blood leakage. When the emitted infrared light is blocked by the absorbent material, the emitter on the photo interrupter does not conduct to the collector (i.e., open circuit). At this point, the received voltage on the collector becomes Low and changes to High while the absorbent material being removed which conducts the light emitting and receiving parts. Thus, the conduction between the emitter and collector can be detected by examining the signal, High or Low.

**Bluetooth Module**

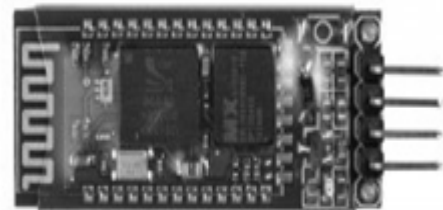


Fig 3 Bluetooth module

**Features**

- Mainstream CSR chip
- Bluetooth v4.0 Protocol
- Wave band : 2.4GHz-2.8GHz, ISM Band
- 6dBm Power Class
- -85dBm Reception Sensitivity
- Operating Voltage : 3.3
- Operating Current: Paring 35mA, Connected 8mA

**Audio Visual Signs**

The alert components used in the blood leakage detector include the light and sound devices, providing both visual and auditory warning signs. The descriptions of the alert components are as follows.

**SMD LED**



Fig 4 SMD LED

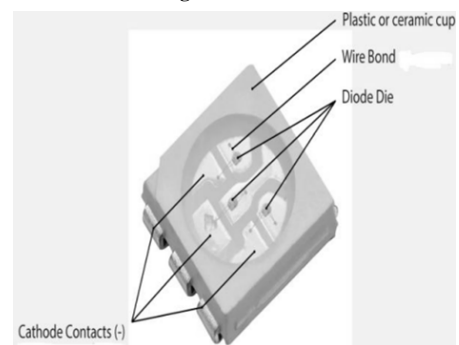


Fig 5 Structure of SMD LED

## Features

- Dimension of SMD LED : 5.7mm x 3.0mm
- Thickness : 0.8 mm
- Working current : 100-150 mA
- Longer service and less luminosity, 50000 hours
- Different emitting colors are available
- With or without heat sink are both available

## Applications

- Commercial lighting
- Decorative lighting
- Residential lighting

In this study, a Surface Mount Device Light-Emitting Diode (SMD LED) is used in the blood leakage detector to provide the visual warning signal. SMD LED has advantages, such as the power saving and the small volume, which saves the overall circuit space for our detector.

In addition, its high specification features are more effective, long life, not easily damaged, fast response and high reliability, which is not available on the conventional light sources.

## Buzzer

A buzzer or beeper is a signaling device, usually electronics, typically used in automobiles, household appliances such as a microwave oven, or game shows.

It most commonly consist of a number of switches or sensors connected to a control unit that determines if and which button was pushed or preset time has lapsed, and usually illuminates a light on the appropriate button or control panel, and sounds a warning in the form of a continuous or intermittent buzzing or beeping sound. Initially this device was based on an electromechanical system which was identical to an electric bell without the metal gong (which makes the ringing noise). Often these units were anchored to a wall or ceiling and used the ceiling or wall as a sounding board. Another implementation with some AC-connected devices was to implement a circuit to make the AC current into a noise loud enough to a drive loudspeaker and hook this circuit up to a cheap 8-ohm speaker. Nowadays, it is more popular to use a ceramic-based piezoelectric sounder like a son alert which makes a high-pitched tone. Usually these were hooked up to “driver” circuit which varied the pitch of the sound or pulsed the sound on and off.



Fig 6 Buzzer

## Structure of Piezo Electric Buzzer

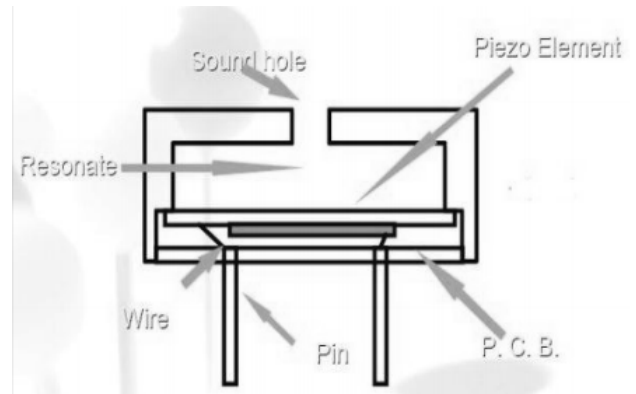


Fig 7 Structure of buzzer

## Specifications

- Operating frequency :  $3.1 \pm 0.5$  KHz
- Operating voltage : 3~20 V dc
- Current consumption : 14 mA
- Sound pressure level : 73 db
- Rated voltage : 12 V dc
- Tone : continuous
- Dimensions : 23.8x 14.55 mm
- Material : ABS UL-94 1/16" high heat (black)
- Weight : 4.5g

An electrical buzzer generally comprises of an electromagnetic or a piezoelectric element and is widely used as an audible electronic component in many electronic products. Whereas the piezoelectric buzzer is mainly assembled by a multivibrator, a piezo ceramic element, an impedance matching device, a resonance box, and a shell. In addition, it has a smaller volume compared to the electromagnetic one and the sound is created via a vibrating metal film due to the piezoelectric effect. Thus, in this study a piezoelectric buzzer was chosen to be installed on the blood leakage detector as an auditory alert.

## Package and Wearable Devices

A commercially available multifunctional bandage is utilized as the bracelet where the straps can be adjusted to the proper fixture size. Finally, after processing of the bracelet, it can be bonded on the case of the blood leakage detector.

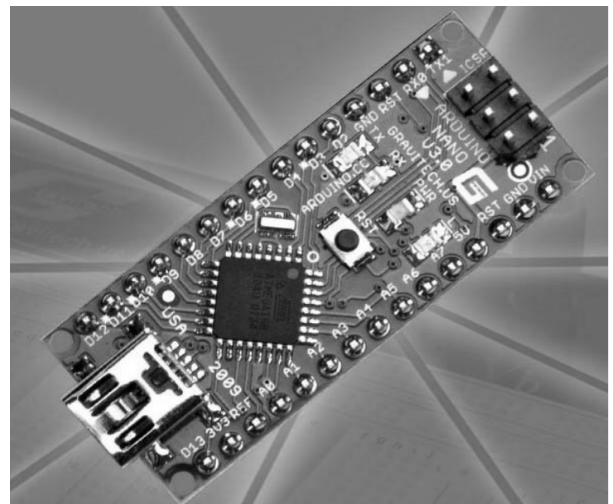


Fig 8 Arduino nano board

### Arduino Nano Board

The Arduino Nano is a small, complete, and bread board friendly board based on the ATmega 328. It has more or less the same functionality of the Arduino but in a different package. It lacks only a DC power jack and works with a mini-B USB cable instead of a standard one.

#### Features

- 10MHz Serial Interface
- Individual LED Segment Control
- Decode/No-Decode Digit Selection
- 150µA Low-Power Shutdown (Data Retained)
- Digital and Analog Brightness Control
- Display Blanked on Power-Up
- Drive Common-Cathode LED Display
- Slew-Rate Limited Segment Drivers for Lower EMI (MAX7221)
- SPI, QSPI, MICROWIRE Serial Interface (MAX7221)
- 24-Pin DIP and SO Packages

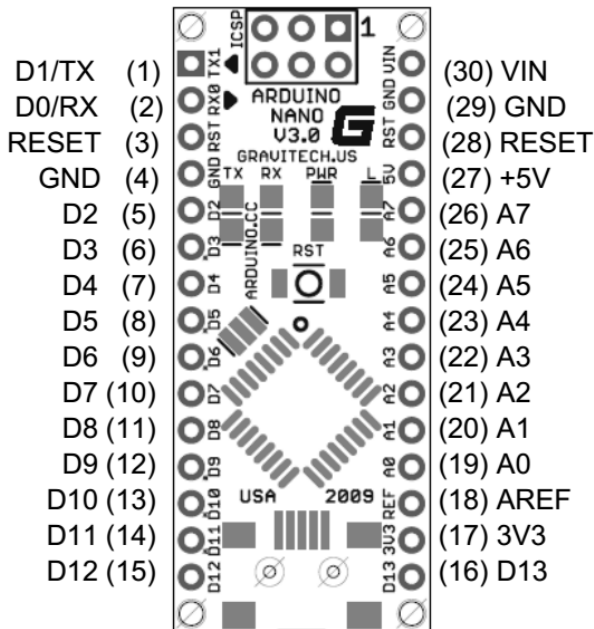


Fig 9 Pin configuration of Arduino nano board

#### Pin Configuration

Table I Pin Description of Arduino Nano Board

Pin Number	Name	Type	Description
1-2, 5-16	D0 – D13	I/O	Digital input/output port 0 to 13
3,28	RESET	Input	Reset (active low)
4,29	GND	PWR	Supply ground
17	3V3	Output	+3.3V output (from FTDI)
18	AREF	Input	ADC reference
19-26	A0-A7	Input	Analog input channel 0 to 7
27	+5V	Output or Input	+5V output (from on-board regulator) or +5V input (from external power supply)
30	VIN	PWR	Supply Voltage

#### Software

##### Introduction

Arduino nano is an open source platform used for building electronic projects. Arduino nano consists of both a physical programmable circuit board (often referred to as a

microcontroller) and a piece of software, or IDE that runs on the computer, used to write and upload computer code to the physical board.

The Arduino platform has become quite popular with people just starting out with electronics, and for good reason. Unlike most previous programmable circuit boards, the Arduino does not need a separate piece of a hardware (called a programmer) in order to load new code on to the board. Additionally, the Arduino IDE uses a simplified version of C++, making it easier to learn to program. Finally Arduino provides a standard form factor that breaks out the function of the microcontroller into a more accessible packets.

#### Arduino – Bluetooth Interface

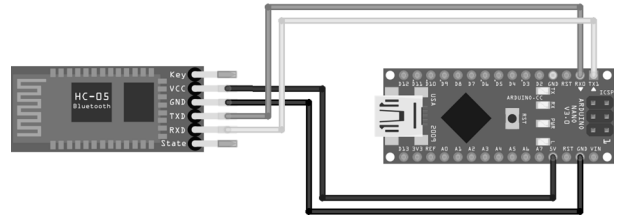


Fig 10 Interfacing of Bluetooth and Arduino Nanoboard

The power supply (VCC) and the ground (GND) pin of both the Bluetooth module and the arduino Nano board are interconnected. The transmitter (TX) pin of the Bluetooth module is connected to the receiver (RX) pin of the arduino. The transmitter (TX) pin of the arduino is connected to the receiver (RX) pin of the Bluetooth module. A photo interrupter is connected to the VCC and the GND pin of the arduino board and also connecting the potential divider circuit with this system for the voltage level conversion to the photo interrupter and the Arduino board. The output pin of the photo interrupter is given to the analog pin A2 of the Arduino. A normally closed (NC) push button is connected between the Bluetooth module and the arduino board for avoiding the system jamming. Buzzer is connected to the digital pin D8 and the SMD LED is connected to the digital pin D7 of the arduino.

```

main_code | Ardu
File Edit Sketch Tools Help
main_code
//Declaring pin connections as integers
int photoIntPin = A2; //Photo Interrupter is connected to the analog pin A2
int ledPin = 7; //smd led is connected to the digital pin 7
int buzzerPin = 8; //piezoelectric buzzer is connected to the digital pin 8
int val, i, count, first_value[100], diff;

void setup() {
//Declaring pin connections as either input or output
pinMode(photoIntPin, INPUT);
pinMode(ledPin, OUTPUT);
pinMode(buzzerPin, OUTPUT);

//Initialising serial communication
Serial.begin(9600); //Default communication rate of the bluetooth module

wait();
}

void loop() {
//Declaring integer variables
for(i=0; i<100; i++)
{
val = analogRead(photoIntPin); //Reading values from the analog pin A2
//Printing serially the results
Serial.println(val);
delay(20);
first_value[i] = val;
}
}
    
```

## RESULT AND DISCUSSION

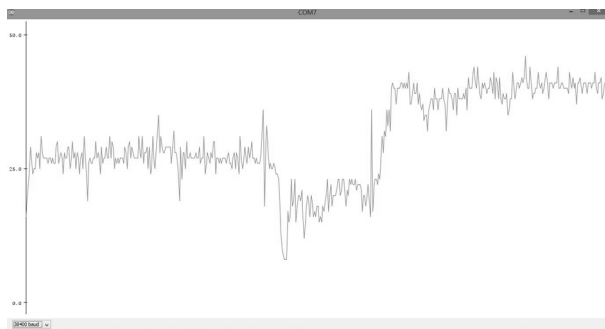


Fig 11 Resultant graph



Fig 12 Resultant output

## CONCLUSION

The goal our project is to design the blood leakage monitoring system which would be simply used along with the current hemodialysis equipment. In addition it is a non-invasive monitoring device which enables an easy installation of the detector on the human arm.

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