Development of Blood Leakage Detection In Fistula During Haemodialysis Therapy And Transmission Through Ipv6/Ipv4

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***Abstract- Haemodialysis is a clinical treatment that requires puncturing of the body surface. However, needle dislodgement can cause a high risk of blood leakage and can be fatal to the patients. This paper is to design a monitoring device which can be tied in the wrist of patients for the detection of blood leakage during haemodialysis. This device includes a photo interrupter, power source and IPV6/IPV4 internet protocol with an alarm system. Thermal energy harvesters are used to assist the device with uninterrupted power supply. The Photo interrupter helps to detect even a very small amount of blood of about 0.01ml. When the device detects the blood leakage, it sends this signal to alarm components and to the computer via IPV6/IPV4 Internet protocol. IPV6 is a two way communication/transmission which favours for faster transmission. It is a handheld and time efficient device. The proposed blood leakage monitoring system can improve the current medical approach for the haemodialysis therapy*.

Keywords: Haemodialysis, Photo Interrupter, IPV4/IPV6, Thermal energy Harvestors

I. INTRODUCTION

Haemodialysis is a process to cleanse the blood consisting of toxins, salt and waste substances using a dialysis machine. It helps to maintain proper chemical balance such as potassium, sodium and chloride and keeps blood pressure under control [1]. This is the treatment done to the patients having chronic kidney failure or patients waiting for kidney transplant. To perform haemodialysis it is necessary to have easy access to the blood vessels. An alternative and more permanent means of access to the circulation is by means of a fistula. The fistula is usually placed at the wrist or inner part of the elbow depending on the size of the blood vessels in the non-dominant arm [2]. Haemodialysis fistulas are surgically created communications between the native artery and vein in an extremity. But, Less than 15% of dialysis fistulas remain patient and can function without problems during the entire period of a patient's dependence on haemodialysis [3]. A developed Arteriovenous Fistulas can cause reduced blood flow distal to the arteriovenous anastomosis, which leads to hypoxia, ischemia and necrosis [4].The most important complications of fistula for Haemodialysis are lymphedema, infection, aneurysm, stenosis, congestive heart failure, steal syndrome, ischemic neuropathy and thrombosis. The most common cause of vascular access failure is neointimal hyperplasia [5]. It also has surgical complications. In order to ensure that no blood leakage occurs in the fistula, a monitoring device can be used. Several monitoring devices are available in the market for the continuous monitoring of blood leakage in fistula.

II. EXISTING SYSTEM

Venous needle dislodgement is a serious complication during haemodialysis therapy so, the blood leakage detector, HEMOdialert products [6] was invented. It is capable of sensing less than 1ml of blood and the blood leaking condition should be detected within 1-2 s. The sensing method is based on changes of the voltage signal in the sensor. The other device for the detection of blood leakage is obtained from Redsense [7] having a sensing sensitivity of 1ml of blood. It can be detected by change in the electrical conduction across the circuit. It contains two metal wires which is separated by slit and it creates electrical connection between two wires when the blood flows into the slit [8]. Ramesh Wariar *et al* [9] invented other device for needle dislodgement detection. The blood leakage can be detected by using the capacitive sensor based on capacitive changes in the circuit. Lay-Ekuakille *et al* [10], [11] states that the pressure variation formed by the blood flow is analogous to those made by the leakage in pipeline, so the vibration caused by the blood pressure within the artery or vein can be used for blood leakage detection.Later, a photo interrupter is used as a sensor the detection of blood leakage and it gives more attention to the healthcare workers when it combined with Bluetooth 4.0 [12] for the purpose of wireless transmission. The detector can be worn as a bracelet at the fistula and the alert system will be activated when it detects a blood leakage by producing sound or light signal and also the signal will be transmitted to the computer via a wireless transmission Bluetooth module.

III. PROPOSED METHODOLOGY

The Proposed model consists of

- Hardware setup
- Software setup

HARDWARE SETUP

The hardware model is composed of the following parts which will help in the detection of blood leakage in the fistula during haemodialysis. The Main Components in this include OPB610 Photo interrupter, a microcontroller ATMEGA 2560, TEC1-12706 (Thermoelectric generator), ENC28J60 Ethernet module, LED. The following Block representation helps in better understanding of the process.

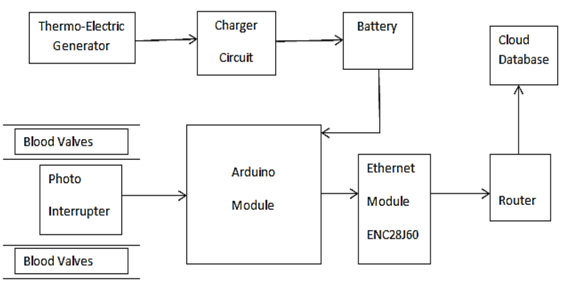

Fig. 3.1 Block diagram of the hardware

OPB610 PHOTO INTERRUPTER

Photo interrupter 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, which means, 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 [13]. A model of OPB610 photo interrupter is used in this study for sensing the blood leakage. It consists of an infrared emitting diode and an NPN silicon phototransistor with an enhanced low current roll-off to improve contrast ratio and immunity to background irradiance. The sensitivity to ambient radiation is minimized [14]. 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.

ARDUINO MEGA 2560

It is a microcontroller board based on the ATmega2560. The microcontroller board has 54 digital I/O pins (of which 14 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button [15]. The ATMEGA 2560 features a 10-bit successive approximation ADC. The ADC is connected to an 8/16-channel Analog Multiplexer which allows eight/sixteen single-ended voltage inputs constructed from the pins of Port F and Port K. Four of the differential inputs (ADC1 & ADC0, ADC3 & ADC2, ADC9 & ADC8 and ADC11 & ADC10) are equipped with a programmable gain stage, providing amplification steps of 0 dB (1×), 20 dB (10×) or 46 dB (200×) on the differential input voltage before the ADC conversion. The 16 channels are split in two sections of 8 channels where in each section seven differential analog input channels share a common negative terminal (ADC1/ADC9), while any other ADC input in that section can be selected as the positive input terminal. If 1× or 10× gain is used, 8 bit resolution can be expected. If 200× gain is used, 7 bit resolution can be expected. The ADC contains a Sample and Hold circuit which ensures that the input voltage to the ADC is held at a constant level during conversion.

TEC1-12706 THERMO ELECTRIC PELTIER COOLER/GENERATOR

A thermoelectric generator (TEG), also called a Seebeck generator, is a solid state device that converts heat flux (temperature differences) directly into electrical energy through a phenomenon called the Seebeck effect (a form of thermoelectric effect) [16]. TEC creates a temperature differential on each side. One side gets hot and the other side gets cool. Therefore, they can be used to either warm something up or cool something down, depending on which side of usage [17]. When there is a temperature difference between the two materials, a direct electric current will flow in the circuit.

SOFTWARE SETUP

The Arduino is interfaced with the photo interrupter with the help of C programming. C is a basic powerful programming language which is fast, reliable in all platforms. IPV6 is implemented in Ethernet module using Arduino IDE. It is also accomplished using C programming.

ENC28J60 ETHERNET MODULE

The ENC28J60 is an Ethernet controller with industry standard SPI. It is designed to serve as an Ethernet network interface for any controller equipped with SPI [18]. Microchip's ENC28J60 is a 28-pin, 10BASE-T stand-alone Ethernet Controller with on board MAC & PHY, 8 Kbytes of Buffer RAM and an SPI serial interface. With a small foot print package size the ENC28J60 minimizes complexity, board space and cost [18].IPV6/IPV4 is supported via Ethernet module. IPV6/IPV4 is an advanced internet protocol which is a two way communication or transmission, favours for faster transmission. IPV6 automatically takes IP address of the device, meanwhile, in IPV4, it should be loaded manually.

IV. EXPERIMENTAL RESULTS

Previous models allow the blood leakage detection using patches and Bluetooth module transmission. This model includes a wearable device with photo interrupter and IPV6/IPV4 module transmission. At atmospheric medium, the photo interrupter will have an uninterrupted communication between the transmitting and receiving parts. Whenever the medium contains blood, the transmitting part of the photo interrupter fails to communicate with the receiving part. Hence, the alarm device gets activated and a warning signal is received in the computer via IPV6/IPV4.

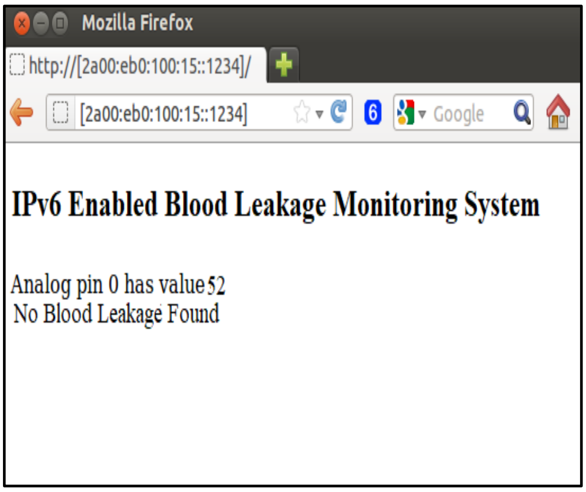

Fig. 4.1 Output when no blood leakage is detected

Fig. 4.2 Output when blood leakage is detected

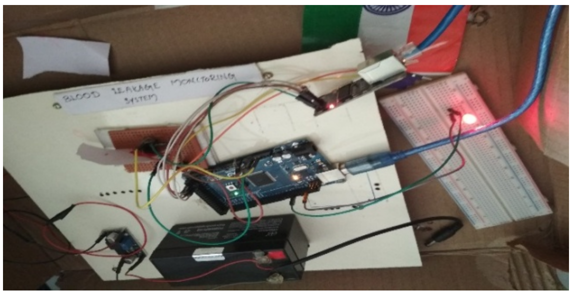

Fig. 4.3 LED output when blood leakage occurs

V. CONCLUSION

In this paper, we designed and developed a monitoring system to detect the blood leakage at the fistula during haemodialysis therapy and it could be used along with the haemodialysis equipment. Once the blood leakage is detected, the LED light will be activated and the alert signal will be sent to the monitoring computer via an IPV6/IPV4 wireless router where the program is encoded at the interface.

Here, a tissue paper with red ink is used as an absorbent material for the capillary action. The test result shows that the detector needs only a little amount of red ink (0.01 ml) and takes fraction of seconds to detect the blood leakage condition.

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