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NRF Transceiver based Saline Level, Health Monitoring & Control System

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Abstract - *A Great Impression has been built by the extensive growth in the wireless technology and communication services in this era, same has been the case of medical field. The main goal of this developed system is to provide health care to patient and prevent the patient from getting any harm. To deal with dehydration and to amend the health of patients, saline is provided to patients in hospitals. The patient demands from nurse that to continuously monitor the saline level, but at times due to remissness and heedlessness towards saline completion, their extravagant workload, a larger number of patients are being harmed in the hospitals. Hence to prevent the patient from getting harmed, this system has been developed which monitor the saline level continuously which is fed to the patient in addition to measure the health parameters of patients i.e. body temperature of patient, heart rate of patient and SPO2 level. When saline level will at critical stage & if any variations will occur in body parameters, doctors will be notified via LEDs, buzzer. Also, message will be display on LCD and SMS will send on mobile through GSM. This system can be utilized successfully in any hospital and it is necessary. The main purpose of this developed system is to provide reliable, convenient and automated saline and health monitoring system which can be easily implemented & easy for doctors as well as nurses to monitor from a distance. The accuracy of achieved system is 95%.*

Key Words: **Communication, NRF transceiver, temperature, wireless.**

1. INTRODUCTION

Population of India is analogous to 17% of the total rank in population. Due to changes in weather condition, human heath changes that means there is changes in the immunity power. Most of the time, immunity power decreases. When patient gets dehydrate then there is need to give saline to patient to prevent the patient. In present scenario, it is not possible and somewhat difficult to doctors, caretakers or nurses to stay besides the patients in the hospital all the time. In order to assists and monitor the patient's condition continuously and to help hospital staff about patient condition a biomedical application system has been developed that has saline level detection and monitoring unit along with body temperature and heart rate measuring devices are designed and developed.

Traditional systems for saline monitoring are to involve a nurse or a caretaker to continuous monitor the glucose status of patient. Also, it is not possible to the nurse to note down information of each patient and their status i.e. increases and decreases of body temperature and heart rate, also saline bottle at critical condition or emptying of saline bottle. Hence, to countermeasure, the above problems a saline monitoring with heart rate and body temperature monitoring system is being developed which could help patients, doctors and nurses in the hospital.

To overcome the drawbacks of conventional system, this NRF based saline and health monitoring system helps to satisfy following objectives:-

1. To provide effortless and cost effective system for monitoring saline level.
2. To measure and monitor the heart rates, body temperature and SPO2 level of patient's body.
3. To display results on LCD and send message on mobile through GSM.
4. To block the saline valve which helps to stop inversion of blood.

Related work is discussed in Section II, Methodology is described in the Section III and System Design of proposed system is described in Section IV. Results, experimental, measured parameters and analysis conducted are described in Section V and summary of system and future work is described in Section VI.

2. LITERATURE REVIEW

With the furtherance of technology, advancement is going to be takes place in each and every field of our life. This progress in the technology helps to reduce efforts of the human being in the form of automation. The utilization of technology is seen in many applications like household, commercial, industrial, biomedical and many others.

When patient gets dehydrate then there is need to give saline to patient to prevent the patient from this [1]. In this domain, monitoring saline level of patient, temperature sensor and heart rate sensor based on advanced wireless patient monitoring system concept is a new innovative idea in medical industry. Proper functioning of human body depends upon various parameters such as body temperature, heart rate etc.

Supplying the correct amount of vital nutrients at the correct time is the most fundamental and important requirement for the hospitalized patients [2]. Health status of an individual can be determined with the help of observing heart rate levels also. In order to avoid such cases of cardiac arrests, there needs to be a regular heart rate check-up [3], it can be measured either by the ECG waveform or by sensing the pulse - the rhythmic expansion, contraction of an artery as blood is forced through it by the regular contractions of the heart [5] and also by using lightweight wearable ECG sensors, textile electrodes and other ambient sensors collect data and send them in real time via a wireless protocol (ZigBee, Bluetooth, Wi-Fi) to a gateway [10][12].

One of the important challenges related to the management of healthcare is to watch the saline level. Almost in all hospitals, a caretaker/nurse is responsible to keep an eye on the saline level and if they fail to monitor this, it is the patient who suffers [4] that means organisation requires manual caretakers which is time consuming method [11] so that centralised patient monitoring systems are in huge demand as they not only reduce the labour work and cost but also the time of the clinical hospitals [14]. Saline level is detected through IR sensors, An IR sensor might measure the high temperature from claiming an article and also detects the movement [6] along with that it emits in order to sense some aspects of the surroundings. When the IR sensor transmitter detects the droplet then it transmits the signal to the receiver so that the receiver can receive the droplet and sends it to the comparator [15] and IR sensor will be positioned at the critical level of the saline on the saline bottle to sense the critical level of saline as well as saline completion status [7]. Some systems can be used to check saline droplet of patients in each patient's bed. So, nurses can accurately check saline droplet status of their patients on a computer and remaining time [16].

Along with this, an intelligent patient monitoring system for monitoring the patients' health condition automatically through sensors based connected networks. Several sensors are used for gathering the biological behaviours of a patient [8] such as LCR temperature sensor is used to measure body temperature which is a wireless and passive (battery free) temperature sensor that can be embedded inside an orthopaedic implant [9] and a bipolar junction transistor (BJT) based temperature sensor is integrated to provide real-time temperature data [13][17]. Also a remote drip infusion monitoring system for use in hospitals which consists of several infusion monitoring devices and a central monitor used for sending data via Bluetooth module at nurses' station [18].

3. METHODOLOGY

The system comprehend two parts Transmitter section and Receiver section. Transmitter section contains patient side and receiver section contains reception side of nurses, doctors.

3.1 Transmission Section

Transmitter section means patients side part where number of patients' beds are present. Many patients are admitted in the hospital due to various reasons, sometimes patients need glucose and antibiotics at that time saline is fed to the patient. Transmitter at patient side contains in which saline monitoring unit, temperature measuring unit, heart rate monitoring unit.

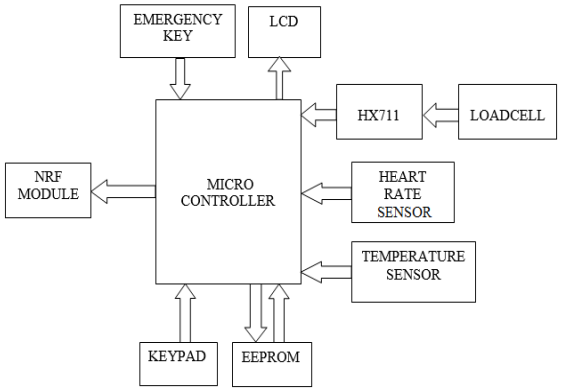


Fig -1: Transmission Section

3.1.1 Saline Monitoring Unit

The main purpose of this developed system is to prevent the patient from getting harm after emptying the saline bottle. Saline bottle is hanged to the load cell and other end of IV tube is attached to the patient's hand, here the load cell is used to measure weight of saline bottle. Then weight of the saline bottle is converted into output voltage. The sensed value is given to the HX711 chip which is used to amplify the given signal. When weight of the saline bottle changes according to that percentage will show on LCD. When weight of saline bottle reaches at or below critical point then respective LEDs will be blink and buzzer will starts sounding.

When saline level reaches below critical level then message will display on LCD. "Remove Saline Bottle" this message shows on the LCD. Sometimes due to lack of attention of nurses or nurses, caretakers & doctors are busy in their work or busy in treating the other patients. Then at that time there is a backflow of blood through IV tube in the bottle. This causes harm to the patient. Therefore, after emptying the saline bottle the servomotor blocks the IV tube which prevents the inversion of blood in

saline bottle and keeps the patient safe. Also with that, at patient side there is emergency key present which is helpful at the time of emergency like sometimes patients need drinking water, medicine, go to washroom and saline can be empty.

3.1.2 Temperature Measuring Unit

Health monitoring is very important for each and every person. In health monitoring body temperature, heart rate of patient is measured. Temperature monitoring unit measures the body temperature of the patient. For measuring the patient's body temperature, the proposed system uses LM35 IC. This IC has three pins i.e. VCC, GND, output voltage i.e. analog output voltage is proportional to the temperature. The measured output voltage from IC is in the Centigrade (Celsius). Using Celsius to Fahrenheit formula for temperature in Fahrenheit i.e.

Temperature in Fahrenheit = (Vout * 1.8) + 32

The output voltage increases when increase in the temperature. This IC requires minimum 5.5 V supply. Sensitivity of LM35 is 10 mV/degree Celsius. Therefore,

T (°C) = measured voltage/10 mV

It refers to analog components integrated into a single piece of silicon. The material used by this sensor performs operation with respect to temperature which vary the resistance. The circuit senses this resistance and it measures body temperature. This sensor is connected to the microcontroller ATMega328. The measured temperature will be display on the LCD. The LM35 operates at -55°C to 150°C or 0°C to 32°C.

3.1.3 Heart rate Measuring Unit

The health monitoring system also contains the heart rate measuring unit. This measuring unit measures the heart rate of the patient. For measuring heart rates, this developed system uses MAX30100 which is an integrated pulse oximeter and heart rate monitor sensor. The operating voltage for the MAX30100 is in between 1.8V and 3.3V. To detect pulse and oximeter and heart rate signals, this heart rate sensor consists of two LEDs i.e. Red & Infrared Led, one photo detector, optimized optics and low noise analog signal processing unit. To measure oxygen in the blood both LEDs are used. There is always pumping of blood in the heart which increases oxygenated blood. The oxygenated blood decreases when the heart relaxes. The pulse rate is determined from the increase and decrease of oxygenated blood. By placing finger on top of the IC (the one with LED) and pulse will be displayed. The heart rates are measured in beats per minute (bpm). The range of heart rate measures by MAX30100 sensor is in between 60 to 250 bpm.

3.2 Receiver Section

Receiver Section part means receptionist side where doctors, nurses, ward boys/caretakers are present which is as shown in figure 2. The receiver section includes LCD, buzzer, LEDs mobile, servomotor and NRF module.

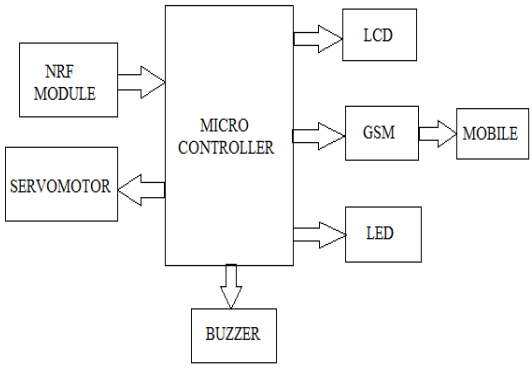


Fig -2: Receiver Section

NRF Module is nRF24L01 module, it's an abbreviation for Multiple Transmitters Single Receiver. nRF24L01 is a radio transceiver of single chip for the world-wide 2.4-2.5 GHz ISM band. It is basically a wireless transceiver and it is used to send and receive data or information by using radio frequency waves. Here, in this system all sensed & measured data are transmits and receives wirelessly.

Also in this implemented system, GSM works for allowing doctors or relatives of patient to check the status of patient's health and status of saline. If heart rate, body temperature and saline bottle level goes above or below certain limit then immediate informative alert message will be sent on the mobile along with that medicine timing of patient is sent on mobile on set timing as a message. The GSM operates at either 900 MHz or 1800 MHz frequency band. It supports voice calls and maximum data transfer speed up to 9.6 kbps, together with the transmission of SMS.

LCD continuously displays all sensed & measured data like after initializing, measured saline weight, remaining time of saline bottle to empty, patient's body temperature, heart rates, SPO2 level and "remove saline bottle" when saline level at or below critical level. If there will be variations in between measured value and actual value then alert notification will be given via LEDs and buzzer i.e. LEDs will ON and buzzer starts sound.

When saline level at or below set critical level or after emptying the saline, the servomotor turns ON and it blocks the saline valve which stops the backward flow of blood from body to saline bottle which prevents the patient from getting any harm.

4. SYSTEM DESIGN

When patient gets dehydrated saline is fed to the patient in the hospital. Also other heath parameters varies with the condition of the patient. Microcontroller ATMega328, temperature sensor LM35 & heart rate sensor max30100 will be power up. Initialization of LCD & EEPROM will be done. Saline bottle will attach to patient, it will hang up to load cell. After long pressing, the load cell will calibrate and check for EEPROM status flag. If EEPROM status flag will set the microcontroller then load will store loadcell value from EEPROM and start monitoring this loaded value and if EEPROM status flag will zero then current loadcell value will load and microcontroller will start monitoring this loaded loadcell value. The loaded value will send to HX711 which amplify the value and convert it into digital value. Through programming, threshold value of loadcell will set in the microcontroller.

At the same time temperature sensor LM35 will give measured temperature to microcontroller. Heart rate sensor Max30100 will give measured heart rate to the microcontroller. Microcontroller will receive all these data through the NRF module. This module will send the signal wirelessly. This wireless signal will receive by NRF module. Microcontroller will compare all these received values with the threshold values. All transmission & reception of signal will be done through NRF module. After comparing all values, it will check all possible conditions i.e. below or above threshold value using programming.

If the loadcell value will fall below than threshold value then microcontroller will actuate the solenoid. This solenoid will operate such as to control the saline liquid flow. Also body temperature & heart rate increases than threshold value then SMS will send on mobile as temperature is high & heart rate is high so put LED & buzzer ON. NRF receiver module will receive this wireless signal and send it to receiver side microcontroller, upon receiving this signal microcontroller will set the alarm buzzer and put on LED corresponding to that bed. In case of receiving emergency signal microcontroller will set emergency alarm through emergency key. All these signal levels, LED indications, alarms are monitored by nurse's control room. Upon receiving signals nurse will take appropriate action. When saline level will reach at critical point then message will display on LCD that "remove saline bottle".

Along with that buzzer makes sound on set timing that shows medicine timings of patient. At 12 pm if there will be medicine for patient it will make sound and display on LCD and SMS will send on registered number on set timings. For this, timers are used which are already present in the microcontroller.

5. RESULTS

Saline Weight (gm)	PWM Values
50	17
250	85
500	170
1000	250

Table -1: PWM value generated from weight of saline bottle

Above Table-1 Shows the PWM values generated for the saline weight. HX711 chip generated the digital signal i.e. this PWM values. According to weight PWM values are generated.

Age of Patient (Years)	Heart Beats of Patient (Beats Per Minute)
7	110
11	104
16	86
25	78
33	72
55	87
70	65
80	104

Table -2: Measured heart rate values

Table-II Shows heart beats of patients of different ages in Beats Per Minute (BPM) which are measured from pulse oximeter.

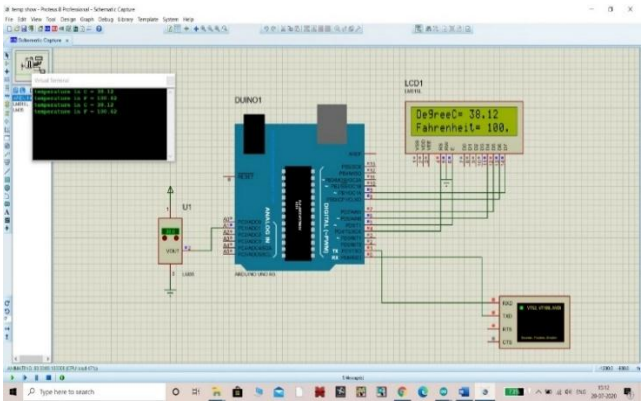


Fig - 4: Simulation of temperature using LM35 sensor

LM35 temperature sensor gives temperature in degree Celsius. Fig. 4. Shows temperature simulation where 38.12 °C shows on LCD which is measured. In Fahrenheit, it is,

Temperature in Fahrenheit = (Vout * 1.8) + 32

Temperature = (38.12 * 1.8) +32

Temperature = 100.616 Fahrenheit

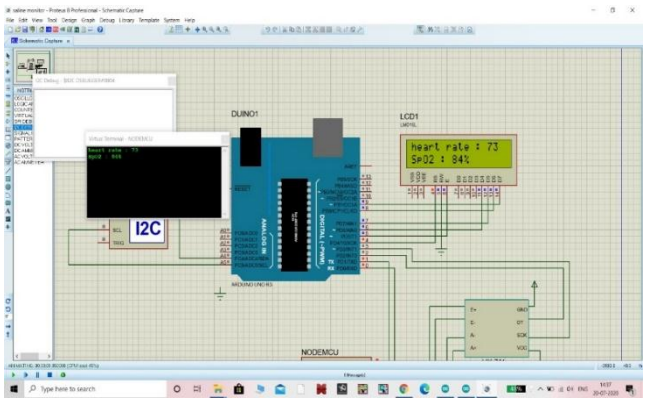


Fig -5: Simulation of Heart Rate Sensor using Pulse Oximeter MAX30100

Pulse oximeter measures heart rate as well as SPO2 level as shown in Fig. 5. Sensor measured heart rate 73 BPM and SPO2 level 84%.

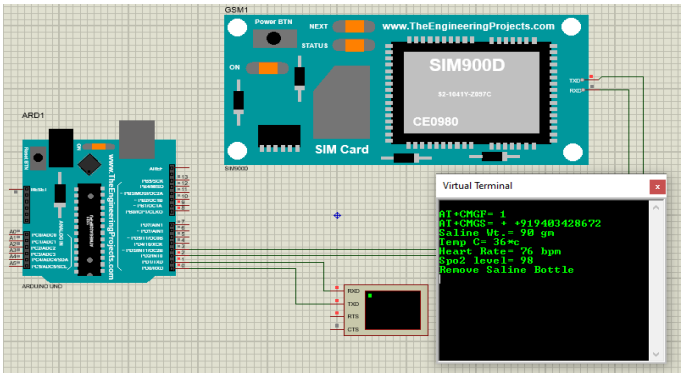


Fig -6: Simulation of measured & sensed data sent via GSM

All sensed & measured data displayed on virtual terminal screen using GSM i.e. saline weight, temperature, heart rate & SPO2 level in above Fig. 6.

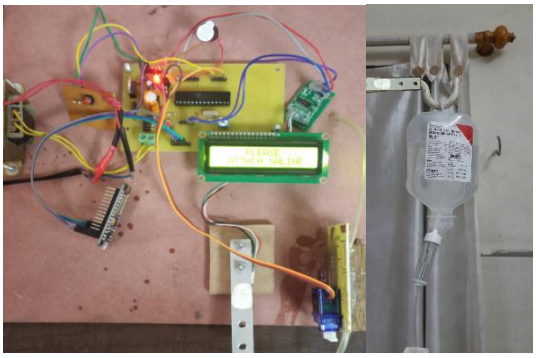
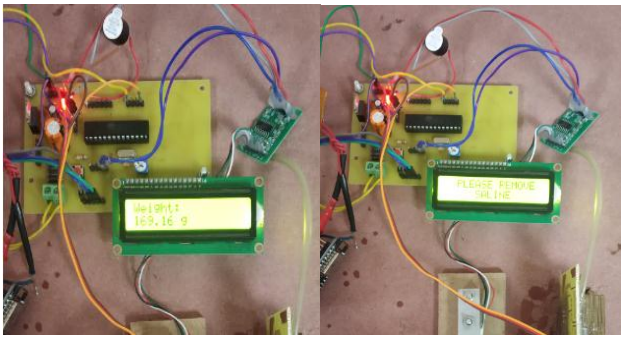


Fig -7: Initializing the system Hardware

Fig -8: Saline bottle hanging to Load cell

Fig.7 Shows the Initialization of system where "Attach Saline Bottle" displays on LCD and saline bottle hanged to load cell displays in above Fig. 8.



(a) (b)

Fig -9: Measured saline weight & remove saline bottle display

Above Fig. 9(a). After hanging saline weight displayed on LCD. For 1000 gm saline bottle critical level is at 20% i.e. at 200 gm and weight displayed 169.16 gm means below 200 gm so that "Remove Saline Bottle" displays on LCD in Fig. 9(b). The saline valve was blocked and stop inversion of blood as shown in below Fig. 10.

Fig -10: Saline valve blocked

Fig -11: Data sent on Mobile via SMS

Fig.11. Shows the measured and sensed data on mobile through SMS. In first SMS, data sent when weight was 400gm & in second SMS, weight was below 100gm i.e. 20% of 500gm saline bottle, so remove saline bottle message sent.

6. CONCLUSIONS

This paper proposes a saline and health monitoring system based on NRF transceiver and GSM which automatically monitors saline level through weight, remaining time, patient's body temperature, heart rates, SPO2 level. Also saline level reaches below critical layer then remove saline bottle message displays on LCD and servomotor stops inversion of blood in body that means saline valve is blocked. Besides, the system gives alert through buzzer, LEDs if any variations occurred in between measured and actual values. It transmits and receives all data wirelessly and also displays result on LCD and sends message, alert notification on mobile which reduces nurses and doctors work. It can be used in a hospital, home.

Pulse oximeter gives **SPO2 level** which measures concentration of oxygen in the blood and this is very important & helpful at present stage of "**CORONA**" because in hospital, doctors check firstly the SPO2 level of patient, if SPO2 level of patient is low then there is chances that patient can suffer from virus.

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