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An Integrated Monitoring System for ICU Patient

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Abstract: *A new integrated device using a single-chip microcontroller (ATmega328) device for measuring heart rate (BPM), body/room temperature, dimension or appearance of humidity, alcohol detection and detection of carbon-di-oxide (CO2) as well as measurement of saline level of ICU patient, is designed and developed. A security system has also been used in this proposed device as if the patient can easily understand when someone entered into ICU room. In our proposed device, pulse sensor, saline level sensor, MQ-3 alcohol sensor has been used as coupling to determine heart rate, dimension of saline level of ICU patient and to detect the alcohol consumption by the smell of the breath of ICU patient respectively in the ICU room which showing the output at the LCD display simultaneously as well as DHT22 sensor and MQ-135 gas sensor has been used as combinative to determine humidity, temperature and* CO_2 *gas of the ICU room which showing the output at the LCD display simultaneously with those outputs that provides high accuracy measurements with very low power consumption. Our proposed device can also be used at any hospital ICU rooms to determine aforementioned concepts. As a result, the amount of cost will be less for ICU patients. The results of our proposed integrated device have been compared with the existing conventional machines and the outcomes of our aforementioned concepts showed that the error rate of our combining device is negligible. In a word, our proposed combining device is cost-effective, user friendly, reliable, convenient and uses a viable technology to measure and monitoring the disorders of ICU patients as well as the condition of ICU room.*

Key words: **Intensive Care Unit (ICU), Saline Level Sensor, Humidity, DHT22 sensor, LCD display, MQ-3 Alcohol sensor, MQ-135 gas sensor**.

I. Introduction

In the intensive care unit (ICU), continuous patient monitoring is essential to detect critical changes in patients' health statuses and to guide therapy. The implementation of digital health technologies for patient monitoring may further improve patient safety. However, most monitoring devices today are still based on technologies from the 1970s [1]. Patient monitoring can be rigorously defined as "repeated or continuous observations or measurements of the patient, his or her physiological function and the function of life support equipment, for the purpose of guiding management decisions, including when to make therapeutic interventions and assessment of those interventions". Basically, continuous measurement of patient parameters such as heart rate dimensions of saline level of patients and ICU room surrounding condition for patient's safety and many other parameters have become a common feature of the care of critically ill patients[2]. Because of expanding work cost, medical institutions would constrain to decrease nursing staff for patients. Our project aims to develop new innovations for the use of basic nursing care. In this paper, we introduce a secure a single-chip microcontroller (ATmega328) based ICU patient care monitoring system within six concepts. In our proposed system, the work progress depends on sensor based system work in which the first step is data collection and then monitoring output as digital way. However, the death rate of 55.3 million people dying each year or 1,51,600 people dying each day or 6316 people dying each hour is a big issue for all over the world [3]. As our country is developing country, so it is not possible for our government to appoint doctors for everyone. Although, the finance minister has proposed Taka 257.32 billion for the two wings of the health ministry - health services division and the health education and family welfare division – for the next fiscal and the allocation for this purpose in FY 2019-20 is Tk. 29,464 crore (294.64 billion), which is 1.02 percent of GDP and 5.63 percent of total budget allocations [4]. As observed from the statistics, individuals over 65 years of age have higher health care costs and a significant portion of these costs are a consequence of the services provided by the physicians. If everyone maintains some rules then health care costs will be decreased at the ICU patient room. So, a cost-effective combining device is needed for patient to measure and monitoring aforementioned concepts at the ICU room. This device will be used generally for measuring heart rate (BPM), Body/room temperature, dimension or appearance of humidity, alcohol detection and detection of carbon-di-oxide (CO_2) at the ICU room as well as measurement of saline level of ICU patient that are cost-effective. In generally, a heart rate measurement device is a simple device that takes a sample of the heartbeat signal and computes the BPM so that the information can easily be used to track heart conditions [5].Basically; heart rate indicates the soundness of our heart and helps assessing the condition of cardiovascular system [6].Heart beat and body/room temperature or humidity monitoring of ICU room using Arduino will detect the heart beat using the Pulse Sensor and body temperature or humidity using DHT22 sensor respectively. Pulse sensor will show the readings in BPM (Beat per Minute) on the LCD connected to it [7]. In this work, we will go over how to build an alcohol sensor with an Arduino and the alcohol sensor we will use is the MQ-3 sensor. This is a sensor that is not only sensitive to alcohol, particularly ethanol, which is the type of alcohol which is found in wine, beer, and liquor [8].This project proposes a low cost saline level measurement system using a single-chip microcontroller (ATmega328) device [9]. An alarming system has been also being used in this project working as if the patient can easily understand when someone entered into ICU room and this alarming system will be helpful for ICU patient to get doctor's appearance in the ICU room. In our proposed device, an MQ-135 sensor is being used which is sensitive to CO2. The change in CO_2 levels changes the resistance of sensor which results in the change in the output of the sensor [10].

Therefore, the body/room temperature or humidity, CO_2 gas as well as alcohol detection and dimension or appearance of saline level of patient at the ICU room shall be displayed on the LCD monitor along with BPM readings. If we can measure both those aforementioned concepts with an integrated device through combining, it will be remarkable progress in Biomedical Engineering sector and we are optimistic.

In our work, we introduced an integrated device which can measure the major concepts of ICU patient and ICU room that can be measured and monitoring cost effectively and we are optimistic in the sense that, our proposed device gives good accuracy (error rate less than 5%) that can be measured easily at the ICU room.

II. Objectives

There are many systems for measuring heart rate (BPM), body/room temperature, dimension or appearance of humidity, alcohol detection and detection of carbon-di-oxide (CO_2) as well as measurement of saline level of ICU patient room. But, all systems do not give good accuracy and all systems are not cost-effective and reliable. For many years heart rate, body/room temperature, dimension or appearance of humidity, alcohol detection and detection of carbon-di-oxide (CO_2) as well as measurement of saline level of ICU patient room monitoring system remains an interesting field of research and many works have been done for introducing measurement device for ICU patient and ICU room that will give maximum accuracy and will be reliable and cost effective. In our work, we will introduce an integrated device to measure heart rate (BPM), body/room temperature, dimension or appearance of humidity, alcohol detection and detection of carbon-di-oxide (CO_2) as well as measurement of saline level of ICU patient room. In the ICU room a doctor or a nurse can be easily measured and monitored heart rate (BPM), saline level, alcohol detection, body temperature of any patient and on the other hand, room temperature, dimension or appearance of humidity and detection of carbon-di-oxide (CO_2) of ICU room can be easily measured and monitored by using our proposed integrated device which will show the output simultaneously at the LCD display that will be cost effective device.

In our work, we will try our best to introduce a cost-effective integrated device for measuring heart rate (BPM), body/room temperature, dimension or appearance of humidity, alcohol detection and detection of carbon-di-oxide (CO_2) as well as measurement of saline level of ICU patient room digitally. We will try to keep the cost less than 50$ (about 4000 Taka). Besides this, we will try to keep minimum error rate.

III. Methodology

The circuit of our proposed device consists of a single-chip microcontroller (ATmega328) Arduino, a step down transformer, a rectifier, a capacitor, a DC-DC Buck and Boost converter and an LCD display for displaying output as digitally and a security system has been also being used in this proposed device as if the patient can easily understand when someone entered into ICU room. Moreover, in our proposed circuit we have been used pulse sensor for heart beat measurement in BPM, DHT22 sensor for body/room temperature and humidity of ICU room. Similarly, MQ-135 CO_2 gas sensor, MQ-3 alcohol sensor are being used for CO_2 gas detection at the ICU room and also to detect dimension of alcohol level of ICU patient respectively. First of all, we have converted high input voltage (220V) to low input voltage (12 x 2V) through using a step down transformer and this AC output voltage is converted to DC output voltage through using D25xB60 rectifier. In our proposed circuit, a capacitor is being used to store energy in the form of an electrical charge that produces potential difference across its plates much like a small rechargeable battery. Then, a DC-DC Buck converter (LM2596S) is being used that can change 3.5-75V power supply to 1.23-30V power supply. Finally, all type of remarkable sensors are being connected with a single-chip microcontroller (ATmega328) Arduino by maintaining both pin configuration of sensor and Arduino

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and then this Arduino is being connected to LCD (20 X 4) display to show output . In case of detection of level of saline of ICU patients, when the saline level is below 20% the LED will blink and as a result, nurses will get about the critical point of saline level. When the saline level is below the critical point i.e. 20% then the LED will blink and when LED blinks, the nurse or doctor will get and as a result, they will discard the saline tube from the patient's body.

In our proposed circuit, since we have interfaced both the sensor with the Arduino simultaneously so, in this case we shall be capable of showing the output in the LCD display of any patient at the ICU room simultaneously.

IV. Proposed Model

In this section, the concept of our system is given and the concept of our system is explained with using a block diagram. In our system, different sensors have been connected such as heart rate sensor, temperature sensor, MQ-3 sensor, MQ-135 sensor and saline level sensor, IR obstacle sensor and also connected humidity-temperature sensor in the Arduino board. Then the received signal from above sensor and the received signal goes to microcontroller .Then we can obtain the output of heart rate, alcohol, CO2 gas, saline level and humidity as well as temperature in the LCD display. A security system has also been used in this proposed device as if the patient can easily understand when someone entered into ICU room and the alarm is also obtained from the buzzer. The circuit operation of our proposed device is divided into four units. Four units' are- power unit, sensor unit, signal conditioning unit, microcontroller and display unit. First of all, the AC supply power is converted to DC power through using rectifier and by using buck converter the fixed DC voltage has been supplied to the Arduino.

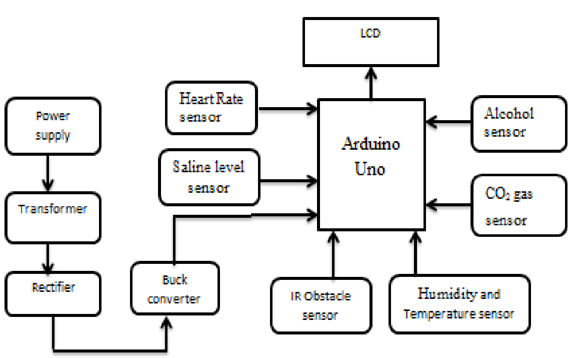

Figure 1: Block diagram

The flowchart of the system is shown in Fig. 2 and this flowchart has been used as diagrammatic representation of our proposed device that provides a complete solution in analyzing, designing, and working process or program. This system is started by initializing the LCD and input/output ports of the Arduino. Then, the system waits for the signal, which is to be received from the sensors. When the system receives a data, it shows the output in the LCD display as our remarkable concepts.

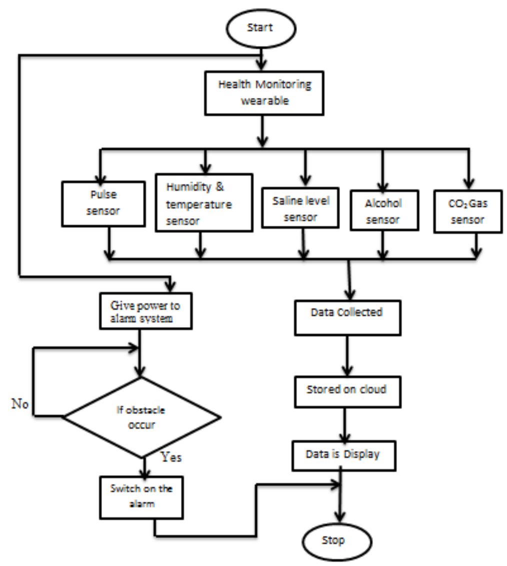

Figure 2: Flow chart

The complete circuit diagram and the real view of our designed system are shown in fig-3 and fig-4 respectively through which our proposed model has been performed.

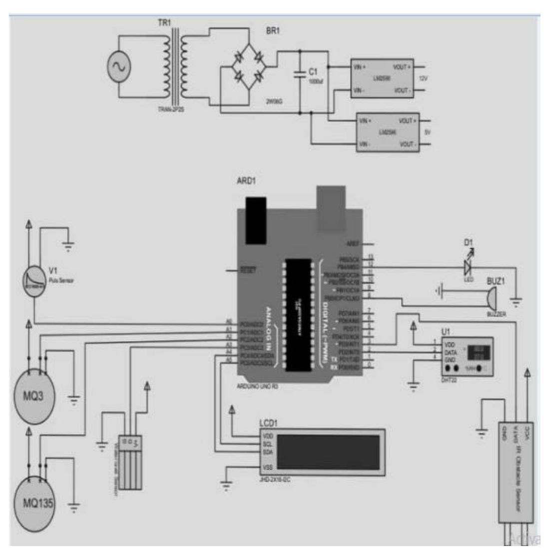

Fig-3: Complete circuit diagram.

The operation of signal conditioning unit is described in the methodology section as well as the sensor unit.

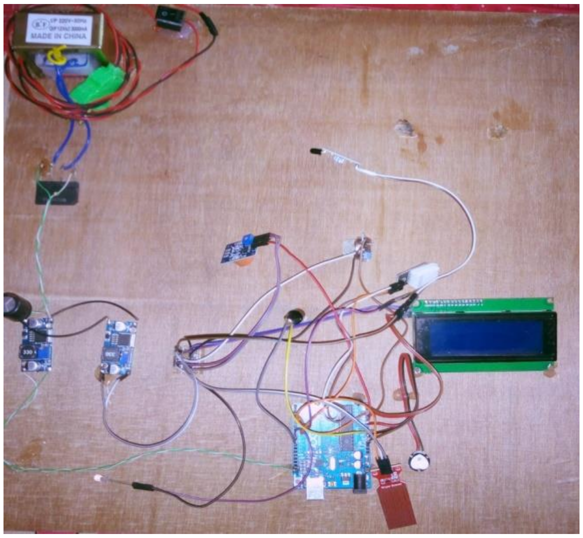

Fig-4: Real view of our designed system.

V. Background

The measurement of heart rate (BPM), body/room temperature, dimension or appearance of humidity, alcohol detection and detection of carbon-di-oxide (CO_2) as well as measurement of saline level of ICU patient room is used by medical professionals to assist in the diagnosis and tracking of medical conditions. It is also used by individuals, such as athletes, who are interested in monitoring their heart rate to acquire maximum efficiency. Heart rate, body temperature and appearance of saline level monitoring systems are very important parameters of human body at the ICU patient room. Moreover, doctors use various kinds of medical apparatus like thermometer for checking fever or body temperature, other various apparatus for measurement of dimension of saline level and heart rate monitor for heart rate measurement at the ICU room. In this project, we have built an Arduino based heartbeat monitor which counts the number of heartbeats in a minute. Here we have used a heartbeat sensor module which senses the heartbeat upon putting a finger on the sensor. The MQ-135 gas sensor is sensitive to CO_2 and to the following flammable gases: LPG, methane, alcohol as well as hydrogen. The resistance of the sensor is different depending on the type of the gas. The MQ-135 gas sensor has a built-in potentiometer that allows us to adjust the sensor sensitivity according to how accurate we want to detect gas. In this Arduino based device, we have been used a MQ-3 sensor to detect present alcohol level in the breath of any patient at the ICU room if the patient took any alcohol. A (20 x 4) LCD is being used for displaying the PPM (parts per million) value of alcohol [11].Therefore, the output of our proposed concepts will be showed in the LCD display simultaneously one by one that will be helpful for doctors or nurse for displaying the result at the ICU room.

VI. Result and Performance

Hardware implementation of our proposed device has been done. Heart rate of 5 patients has been measured and this outcome has also been compared between our proposed device outcomes and conventional device outcomes. To get maximum accuracy, our best try is done. At last, error rate is obtained in case of measuring heart rate (BPM), body/room temperature, dimension or appearance of humidity, alcohol detection and detection of carbon-di-oxide (CO_2) as well as measurement of saline level of ICU patient that is less than 5% after comparing between our proposed device and conventional device. The data table for 5 patients and overall outcomes of our designed device is shown in table-1 and fig-5 respectively.

Serial No.	Patient's name	Heart rate from proposed device	Heart rate from conventional device	Error Rate for Heart rate	Age
1	Hamid	88	86	2.27 %	16
2	Kamran	90	88	2.22 %	14
3	Mamun	85	82	3.53 %	25
4	Hafsa Begum	77	80	3.20 %	42
5	Shakil	72	70	4.77 %	18

Table 1: Data table for 5 patients.

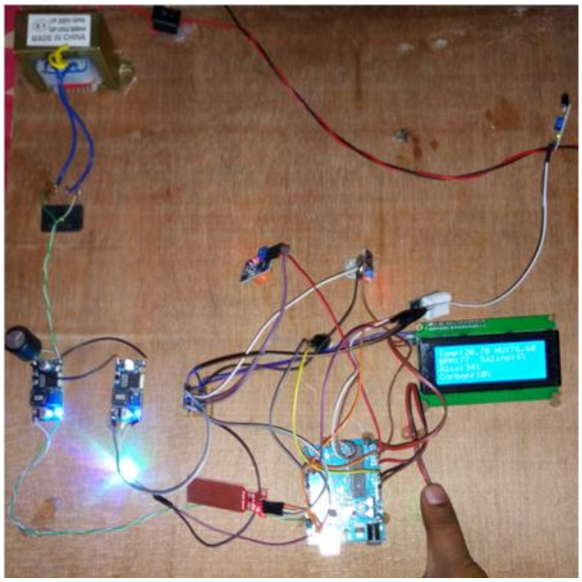

Fig-5: Result of our proposed device

VII. PROBLEMS & TROUBLESHOOTING

While performing the task, we have faced some troubles about the functioning of the circuit. We have performed the troubleshooting processes step by step from the very beginning of the circuit formation. Finally, we solved the troubles, the circuit is working fine. It is noted that, it is difficult to get fixed 5V for measuring the detection of CO_2 gas at ICU room and the appearance of alcohol level of any ICU patient through using MQ-135 gas sensor and a MQ-3 alcohol sensor. The harder part is that it is difficult to work with the ADC values of the sensors. It is difficult to work smoothly depending upon only the ADC values of the sensors. Sometimes, the soldering connections create problems. So, it is recommended that all of complexities should be handled carefully.

VIII. Future Work

This project work has a lot of scope for further implementation and to upgrade this work, we can use graphical LCD to display the heartbeat signal. In our proposed system we monitor the patient condition especially for the ICU or cardiac patients but in the future we will upgrade our hardware part. This study also evaluated the staff's expectations for future technological developments to explore clinical requirements and barriers to the implementation of a novel monitoring system. We aimed to explore desires, concerns and perceived challenges of ICU staff on patient monitoring that may stimulate rapid and sustainable technological adaption in the ICU. Moreover, in our proposed device we will try to combine the six more concepts in a single-chip microcontroller (ATmega328) Arduino that can perform the desirable concepts simultaneously. Despite these advances and the apparent impact made on patients' outcome, there are still a lot of progress to be made to bring monitoring to the level of safety and reliability achieved by industries. The design can be extended to implement noise detection in future. Therefore, we will try to make IOT based our proposed device for ICU patient and ICU room as if the doctor and the nurse cab be observed easily from his/her room.

IX. Conclusion

The most important point is that our device will work as the best friend of poor population, because they cannot bear the health expenditure at the ICU room. Our device is cost-effective and it is less than 50$ (about 4000 Taka) as well as it is simple to use. This qualitative study on patient monitoring involves core statements from ICU staff. To promote a rapid and sustainable implementation of digital health solutions in the ICU, all health care stakeholders must focus more on user-derived findings. For digital transformation in health care, increasing the trust and awareness of ICU staff in digital health technology may be an essential prerequisite. This paper also compared the early aged medical system between present time health monitoring. The present time represents the time reducing; reduce health care cost especially for rural area people in the ICU room. So, using our cost-effective device everyone can measure heart rate and other disorders of ICU patient and the surrounding condition of ICU room easily. Since, our proposed device is economical, user friendly, reliable so it claims right to consider itself as a popular device. Besides this, our device provides maximum accuracy (about 95%). The error rate of our device is negligible (less than 5%). We had issued almost correct results that we desired.

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