

Design of Low-Cost Remote Monitoring & Controlling System for Phototherapy Machine

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Abstract: Remote access and monitoring of data using the technology like Internet or LAN (Local Area Network) is one of the very fast growing application areas in various industries, hospitals, banking etc. This paper present design and implementation of phototherapy machine for the pediatric's hospital and attempt to provide remote monitoring facility, which is not present in existing low cost phototherapy machine. The control unit is designed based on an AVR microcontroller unit. Designed system basically measure the air & body temperatures and humidity. The control system is built for to control the air & body temperatures and humidity locally means where immature infants are kept and monitoring of all these vital parameters locally on to the LCD (Liquid Crystal Display) and from the remote place using LAN as well as Internet. The complete design consist of application software including, heating control system based on firing angle control of TRIAC, keypad for to set the required temperatures and humidity level, interactive GUI has been designed in Visual Studio for to display sensed and set point values and advices from the doctor, database which is stored previously measured parameters. The dedicated website is also designed for monitoring of all these parameters from the remote place.

Keywords: Remote monitoring, Temperature control, Serial to Ethernet converter, infants / newborn, Phototherapy machine / Baby incubator, GUI (Graphical User Interface).

I. INTRODUCTION

A phototherapy machine for pediatric's hospital is also known as baby incubator. An incubator or phototherapy machine is a very useful medical device which is used to maintain and regulate an appropriate environment for the newborns. There are millions of babies worldwide out of that either directly or indirectly at least 20% to 25% of babies deaths [1]. Near about 1.8 million babies die every year due to the low birth weight or lack of the heat unit for to maintain the body fat and metabolic rate to stay at the temperature which is required in newborns. Low birth weight (LBW) of the infants and if the organs of the newborn is not developed properly at the time of birth, it makes an infant more sensitive to the environmental temperature and humidity and other kind of infections. Soto maintain and control the temperatures and humidity level in the newborns, phototherapy machine or baby incubator is required. Generally an incubator is used for preterm babies which is born before 36 weeks to 37 weeks of gestation [1].

To maintain heat loss in infant phototherapy machine is needed, heat loss may occur in infant in following way [2];

1. **Conduction:** When a newborn's body comes in contact with the any solid body then the heat may transfer from newborn's body to the solid body and due to that newborn loss the heat it is known as conduction.
2. **Convection:** In convection newborn loss the heat to the air surrounding.
3. **Evaporation:** In evaporation heat of the newborn is loss due to heat transfer by water partials from the skin to the environment.
4. **Radiation:** In radiation loss of heat is occur due to external environment surfaces but there is no direct contact in between body and surface.

Currently available local products, low cost phototherapy machine does not consist of remote monitoring facility [3][4]. There are standard products are available in the market, which provides remote monitoring system but their cost is 3 to 4 times higher than the local products. So this design is an attempt to provide control system for phototherapy machine with remote monitoring features to the concern doctor as well as nurse with the limited cost.

Remote patient monitoring (RPM) is a technology which is used to monitoring of the patient from the remote place or outside the patient's room or conventional clinical setup.

Advantages of remote patient monitoring are;

1. Increase access to care
2. Monitoring many patients at a time.
3. Decrease health delivery costs etc.

Any biomedical controlling and remote monitoring system consists of bio-sensors, control system unit based on controller unit, communication gateway and central monitoring system with web server. The basic architecture of the biomedical system is shown in Fig. 1.

II. SYSTEM ARCHITECTURE

The system is mainly composed of various types of sensors which are used to measure vital parameters of newborn, control system for controlling and monitoring the sensed temperatures & humidity, RS232 to Ethernet converter, GUI based monitoring system & server, web server and web based remote monitoring system like PC, laptop or mobile phone which supports internet facility. The system architecture is shown in the Fig. 2.

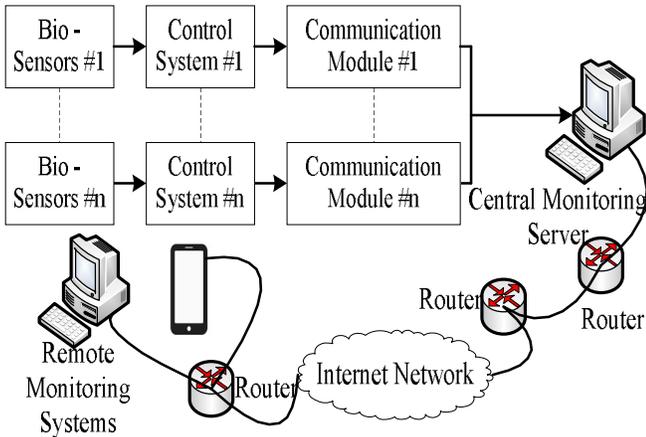


Fig. 1 Basic Architecture of Biomedical System

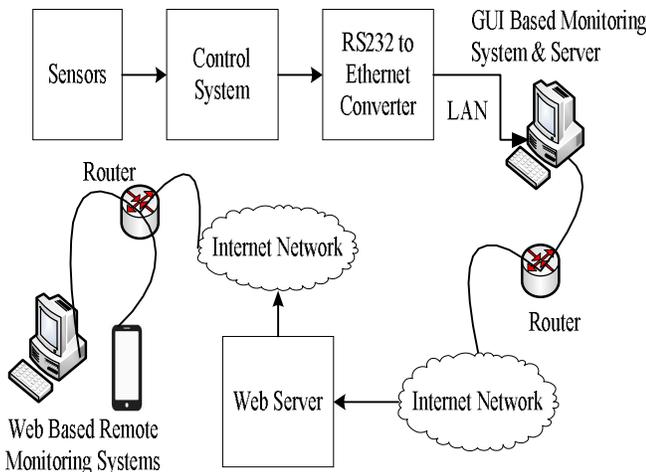


Fig. 2 System Architecture

The main functions of the system are;

1. to sense the temperatures and humidity of the infant continuously and display it on to the local display (LCD), as well as to set the temperatures and humidity as per requirement, by the control unit.
2. to transmit the sensed and set point values of temperatures and humidity over LAN by help of RS232 to Ethernet converter.
3. to display current value and set point value of temperatures and humidity on to the GUI using local area network.
4. to transmit current values and set point values of temperatures and humidity at the remote place via web server.
5. to monitor the current values and set point values of temperatures and humidity by help of specially designed website for this system using PC, laptop or mobile phone which support internet facility.

III. CONTROL SYSTEM HARDWARE & IT'S DESCRIPTION

The control system mainly consists of AVR ATmega32 microcontroller, sensors like air & body temperature sensors and humidity sensor. Present system also consist LCD for to display air & body temperature and humidity as well as to display set points of air & body temperature and humidity. Which is helpful to the doctor and nurse to monitor infant's air & body temperatures and humidity locally means where immature infants are kept. Present system also consist a buzzer as an Alarm system. It also have heater and heating control system, RS 232 to Ethernet converter and specially designed GUI / Web Page for remote monitoring purpose.

The designed control system block diagram is shown in the Fig. 3.

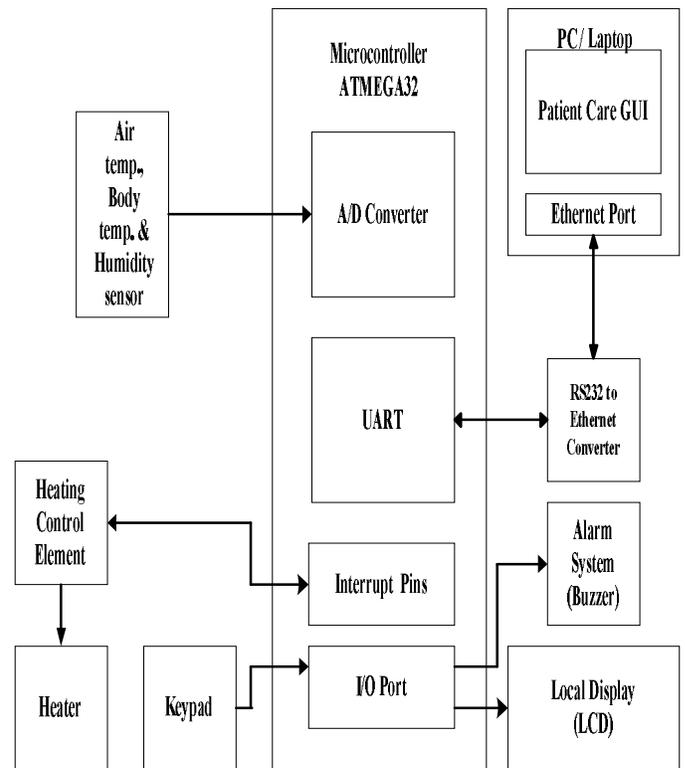


Fig. 3 Control System Block Diagram

The functionality of the each blocks of the control system is explain as below;

A. Sensors:

This designed system mainly consists of three kind of sensors; 1) Air temperature sensor 2) Body temperature sensor and 3) Humidity sensor.

1. Air temperature sensor:

For present work SEN-1853 is selected as an air temperature sensor with steel head, uses NTC thermistor (10K).

2. Body temperature sensor:

The driver in the circuit is the MOC3021. This is a random phase optically isolated TRIAC output driver. MOC3021 is used to fire TRIAC after interrupt is generated by microcontroller and interrupt generation is dependent on to the difference between measured temperatures and its set point values. PC817 (photocoupler) is used to provide isolation between AC source and microcontroller unit.

The complete circuit diagram of the control system is shown in Fig. 6.

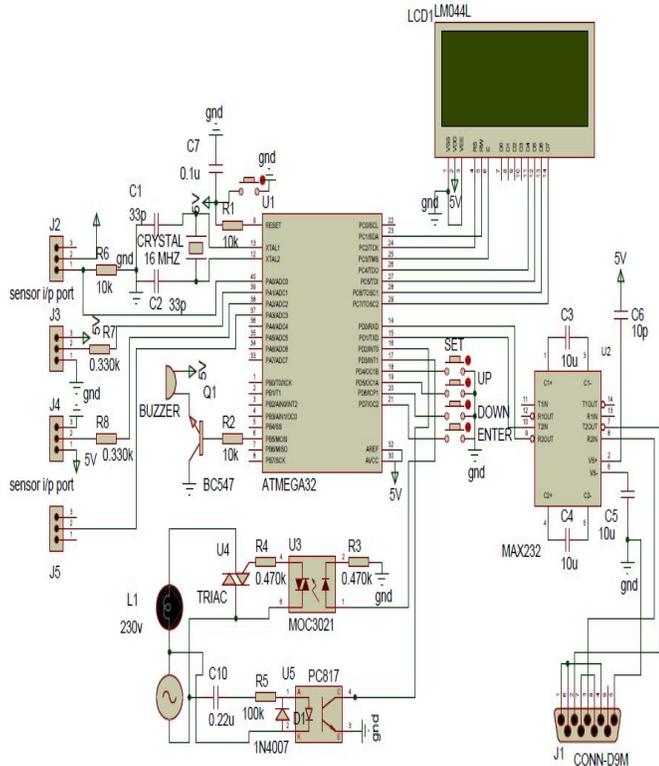


Fig. 6 Circuit Diagram of Control System

The complete setup of the designed control system for phototherapy machine is shown in Fig. 7.

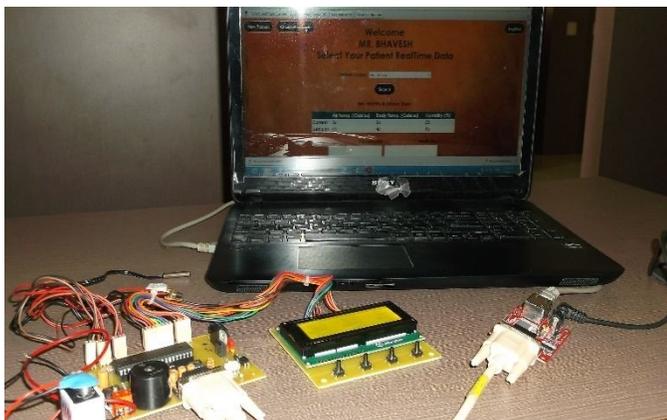


Fig. 7 Complete Setup for Control System of Phototherapy Machine
IV. SYSTEM SOFTWARE

Two kind of software are used, one is AVR studio which is used to do programming for control system of phototherapy machine and second one is visual studio 10 is used to do programming of GUI (Graphical User Interface).

The flow chart of the control system of phototherapy machine is shown in Fig. 8.

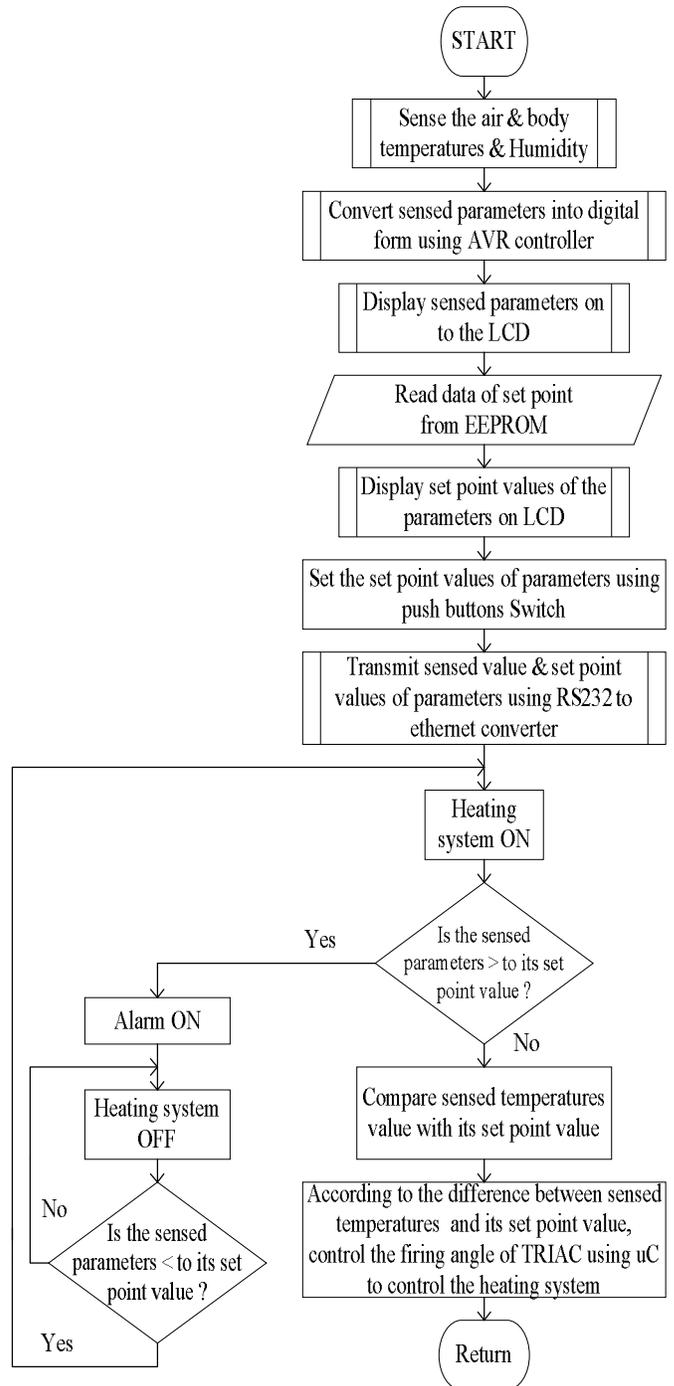


Fig. 8 Flow Chart of Control System

The complete GUI has been developed using visual studio 10. Visual studio is specialized software for designing graphical user interface as per requirement. The designed GUI is also able to create database of the previous sensed and set point values of temperatures and humidity. Developed GUI is access to monitor real time data over LAN on to the PC or laptop. The SQL web server and website is also created so that it is possible to access real time data from the remote place also.

The features chart of the designed GUI is shown in Fig. 9.

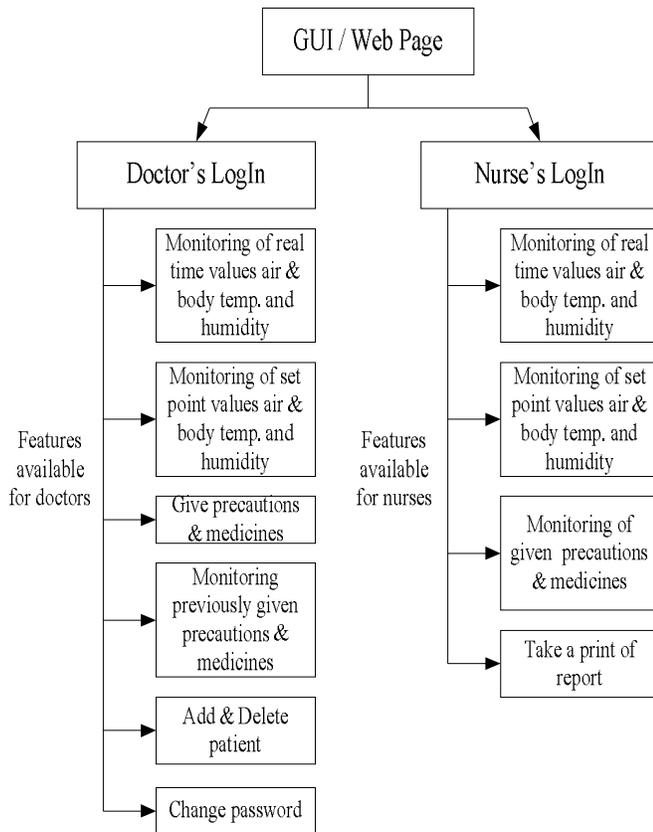
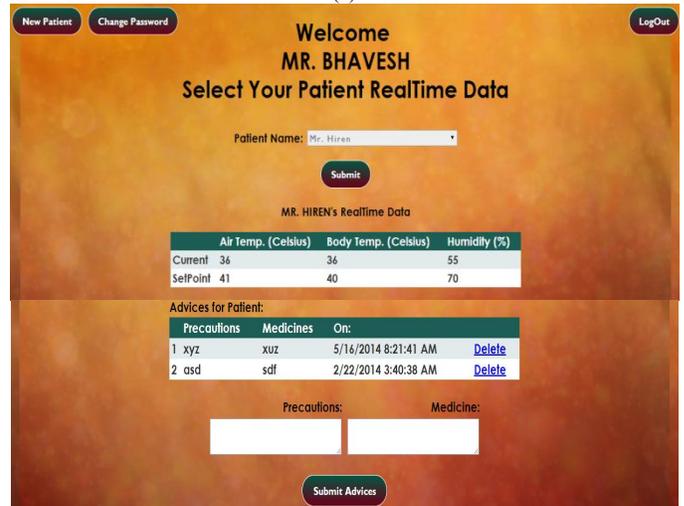


Fig. 9 Features Chart of the Designed GUI / Web Page

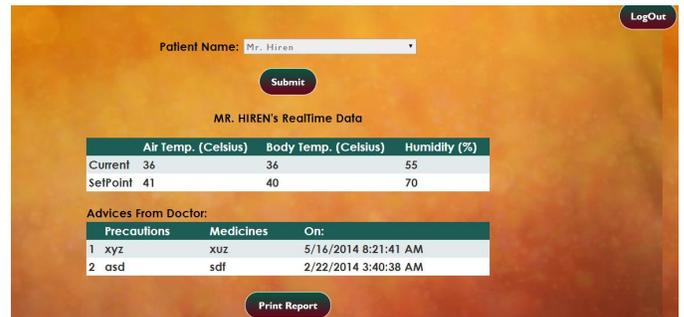
The Different windows of the designed GUI / Web Page are shown in Fig. 10.



(a)



(b)



(c)

Fig. 10 (a) Main Window of Designed GUI (b) Doctor's Window of Designed GUI (c) Nurse's Window of Designed GUI

V. EXPERIMENTAL RESULTS

As a result of experiment, it can be said that concern doctors and nurses are able to monitor the real time data of the infant. The data of measured and set point values of an air temperature, a body temperature and humidity are update continuously and it can be monitor from the remote place. The databases of measured parameters are shown in Fig. 11.

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VIII. REFERENCES

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| ID | pat_id | air_temp | body_temp | humidity | datee |
|----|--------|----------|-----------|----------|----------------------|
| 1 | 1 | 123 | 12 | 12 | 22-Feb-14 |
| 2 | 1 | 343 | 34 | 123 | 21-Feb-14 |
| 3 | 1 | 334 | 32 | 32 | |
| 4 | 1 | 35 | 36 | 58 | 05-May-14 8:45:38 AM |
| 5 | 1 | 35 | 36 | 58 | 05-May-14 8:45:45 AM |
| 6 | 1 | 35 | 36 | 58 | 05-May-14 8:45:47 AM |
| 7 | 1 | 35 | 37 | 58 | 05-May-14 8:45:54 AM |
| 8 | 1 | 35 | 37 | 58 | 05-May-14 8:45:56 AM |
| 9 | 1 | 35 | 37 | 58 | 05-May-14 8:46:03 AM |
| 10 | 1 | 35 | 37 | 59 | 05-May-14 8:46:05 AM |

(a)

| ID | pat_id | air_temp | body_temp | humidity | datee |
|----|--------|----------|-----------|----------|----------------------|
| 4 | 1 | 234 | 23 | 324 | 26-Apr-14 |
| 5 | 1 | 41 | 40 | 70 | 05-May-14 8:45:38 AM |
| 6 | 1 | 41 | 40 | 70 | 05-May-14 8:45:45 AM |
| 7 | 1 | 41 | 40 | 70 | 05-May-14 8:45:47 AM |
| 8 | 1 | 41 | 40 | 70 | 05-May-14 8:45:54 AM |
| 9 | 1 | 41 | 40 | 70 | 05-May-14 8:45:56 AM |
| 10 | 1 | 41 | 40 | 70 | 05-May-14 8:46:03 AM |

(b)

Fig.11 (a) Database of Measured Temperatures and Humidity (b) Database for Set Point Values of Temperatures and Humidity

VI. CONCLUSION

In this work design and implementation of phototherapy machine for infant has been discussed also different hardware and software unit of the system is described. Heating control method used in this work is quit better than simple ON-OFF control method. The main purpose of the whole development is to reduce the cost of control unit for phototherapy machine and to provide remote monitoring facility to the doctors and nurses using LAN as well as internet network so that it would increase access to care and doctor can monitor many infant at a time. The result are presented which are quite satisfactory.

The main advantage of the web based remote monitoring system is, it vanish the requirement of the android based remote monitoring application because android based application can only run on to the phone which support android applications, windows phone cannot support android applications, but web based remote monitoring system can run any phone which support internet facility.

VII. ACKNOWLEDGEMENTS

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