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Baby Incubator using RF-Zigbee Telemetry system and Detection of Hypothermia

Patel Mitali R [#1], Raksha K Patel[*2], Palak Parikh[#3]

[1-3]Biomedical Engineering M.tech, (U. V. Patel college of Engineering, Ganpat University, Mehsana, Gujarat-(384012)

***Abstract*—** Critically preterm infants before 37 weeks of the gestation period needs Continuous monitoring at the neonatal intensive care unit (NICU) of a hospital and there is crucial for early detection of in adverted events and possible complications, and consequently increases the survival rate. New born has more chances to suffering from hypothermia. A newborn is normothermic when its body temperature is between 36.5C and37.5°C with hypothermia considered to be any temperature below this identified spectrum. Neonatal hypothermia is a potentially common and dangerous occurrence related to a number of risk factors categorised as environmental, physiological, behavioural and socioeconomic. Preterm baby requires surrounding exactly similar as in the womb to cope with the external environment, also Vital organs or enzymes of premature babies grow to the very lesser extent and thus requires special attention to cope with external physical condition like temperature, humidity, light and oxygen level. As well the disturbance, interruption of sleep, and lack of natural communication with nurse and doctor all interfere with the babies' normal growth and development.This paper presents an infant incubator system that provide stable level of temperature, relative humidity and light condition to an extent in which the preterm have some condition as in the womb. Air temperature, relative humidity and light condition has to be maintained as it requires to preterm baby. This system monitor vital parameters such as body and air temperature, pulse rate and Oxygen saturation (spo2) and, humidity level of an infant and using RF Wireless system this information is continuously communicated to the concerns authorities so as to take immediate action and proper care. And whenever the temperature goes below the 35 C then the alarm buzz n display it on lcd.The system also implement a closed loop control to regulate the temperature, relative humidity and light intensity by using LED'S lamp and air fan to avoid jaundice condition to inside incubator. The system uses hardware, ATmega328 microcontroller, RF 433Mh serial communication module and LCD display to monitor system parameters. It uses various sensors, Max30100 pulse oximeter, LM35 temperature and DHT11 Humidity and temperature sensors and led light and air fan regulated through a relay driver.

***Keywords*— Infant Incubator, Hypothermia, Microcontroller, RF Communication, Pulse Oximeter, Heart Rate, Temperature Sensor, Humidity Sensor**

1 Introduction

Newborn baby needs time to adjust their condition with the outside world. This is critical time to new baby born especially premature babies. There are various infant incubator system are developed to take proper care of premature babies, the period premature babies in the incubator according to soundness, durability and system of organs of them. The infant incubator is help to premature babies to adjust with the outside world, because condition in the womb is very different with outside world, especially condition of temperature. Temperature in the womb is approximately 36 - 37 0 C but in outside world is approximately 27.0 C – 28. 0 C. Temperature in the incubator is maintained according to age and weight of premature baby, as on average the temperature in the incubator is maintained of 35 ˚**C** and relative humidity is maintained of 50% RH - 75% RH. Using the incubator the premature babies hope will be adjusting their condition with outside world and the babies can survive. The vital body parameters are also critical at the premature baby born time hence it needs to keep watch continuously for taking proper care in adverse parameters. For this, Comfortable textile based electrodes monitor ECG, Respiration Rate .Pulse Oximetry would be integrated with the baby's hoodie and would measure the oxygen saturation in blood in the earlobe .Hypoxemia and apnea can be detected early using Respiration and Blood Oxygenation data to trigger alerts .The wearable would also provide peace of mind to a parents who in many preterm cases are extremely stressed.

In this study, we design an infant incubator system using wireless RF (Radio Frequency) communication system that transferred all the monitor parameters of system to remote personnel computer terminal where it can continuous monitor by the concern care taker doctor/nurse and parents and they can take any immediate action in any adverse condition of any parameters. This incubator system also consists of LCD display for local monitoring. The various sensors such as DHT11 sensor for relative Humidity and air temperature measure, LM35 sensor for body temperature, MAX301000 Pulse

oximeter to measure Heart rate and Oxygen saturation (spo2) are used. These sensors are interfaced to an advance series of microcontroller ATmega328P with operating clock frequency of 16 MH, in real time communication a RF 433Mh Serial communication is established worth any remote PC terminal, hence one 433MHz RF Transmitter module is serially interfaced to the microcontroller and one 433MHz RF receiver module is connected to the remote PC through a serial USB to TTL convertor.

The purpose of this study is to design a system that can communicate and monitor the all parameters of infant incubator system to remote place. This system is also implemented the closed loop control of environment inside baby incubator. Hence when the temperature in the incubator is goes below/ above 35˚ C and relative humidity are below 50% RH and above 75% RH. This system can automatically improve the condition of these parameters for that a LEDs lamp and Air Fan is place in infant incubator which operates automatically through a relay driver interfaced to the microcontroller and keep maintain the above range of these parameters inside the incubator. Thus this security of the system to errors on baby infant incubator, so as to avoid the occurrence of death in infants due to temperature and humidity are not appropriate in an incubator, so as to create a sense of security and comfort for babies, parents of infants and hospital personnel on when the baby is put into an incubator.

1.1Hypothermia

Neonatal hypothermia is a pathological condition where the temperature of the newborn drops below the recommended normal temperature ranges. However, no agreement exists within the literature as to a standard accepted normal temperature range with different values identified in different studies. The lack of an agreed normal temperature value results in range of temperatures being accepted as 'normal' by various authors with neonatal norms ranging between 36˚C, depending on the geographical location of the study as well as the environmental conditions. WHO guidelines are used to describe the 'normal' ranges of neonatal normothermia and hypothermia.

WHO (1997) considers a newborn to be normothermic when temperature is between 36.5˚C and 37.5˚C and hypothermic, When temperature is below the spectrum mentioned above. In order to facilitate the diagnosis and management of hypothermia, WHO has divided this classification into three well defined Categories.

These categories are (WHO, 1997):

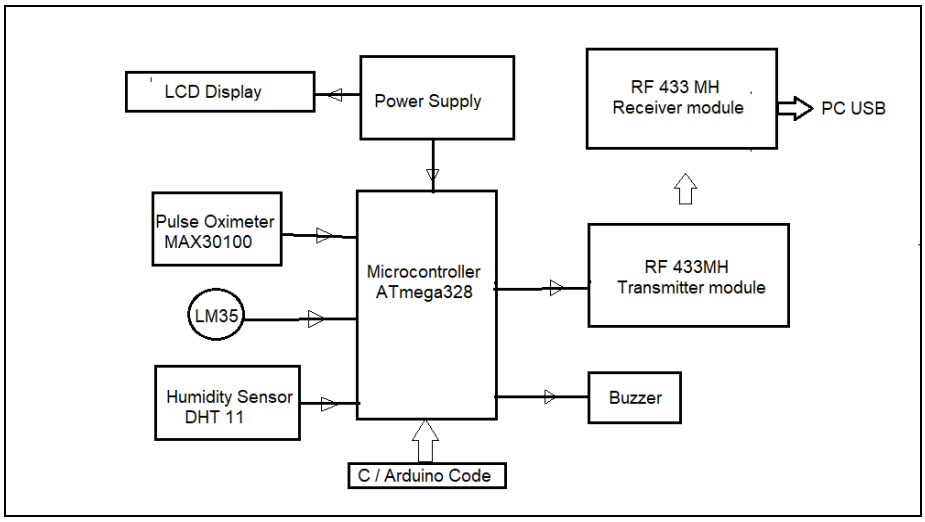
- **Mild hypothermia**: with ranges between 36 and 36.4°C
- **Moderate hypothermia**: ranging between 32 and 35.9°C
- **Severe hypothermia**: with any temperature below 32°C.

While the WHO categorise are useful, It does not identify the body site associated with each temperature category and this present further challenges with the potential to result in a degree of confusion for both researchers and health professionals. Rectal temperature is approximately 0.5˚C-1˚C higher than oral and/or axillar temperature and is generally considered more presentative of the temperature. However, given the risks associated with the measurement of rectal temperature in new born babies (i.e. rectal performation and nosocomial infections), it is not recommended for newborn infants. WHO recommended that neonatal temperature is measured at the axilla and recommended that rectal temperatures are only measured in the event of diagnosed neonatal hypothermia. While the above classification is used by some maternity hospital internationally, its use is still narrowly spread .identified that of 20 studies reviewed, only seven used the WHO classification system. This inconsistency of classifying neonatal neonatal hypothermia may lead to under-recognition as well as inadequate management newborn hypothermia. It is essential, therefore that guidelines are developed for the classification, prevention and management strategies for neonatal hypothermia, and that they are implemented by all medical and nursing.

2. Proposed Methodology

2.1 Block Diagram

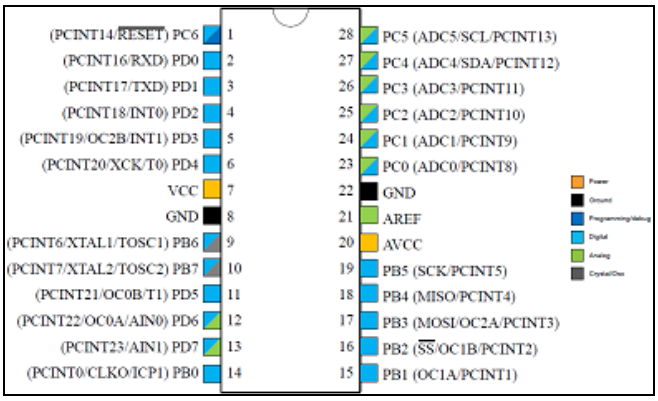
The figure shows the block diagram of proposed incubator system.



To design this RF wireless communication based Infant incubator, we have developed a single layer PCB board which include microcontroller(ATmega328P) and its crystal oscillator and reset circuit, +5 volt regulated power supply and placed a LCD display circuit and two channel relay driver circuit in same board. We use sensors, DHT11 sensor, LM35 sensor and MAX301000 Pulse oximeter module which are interfaced to the microcontroller. The RF 433 MHz transmitter and receiver module are serially interfaced for remote PC monitor. The hardware for our experimental set up of our system is shown as below.

2.2Description of Components

[A] Microcontroller - ATmega328P



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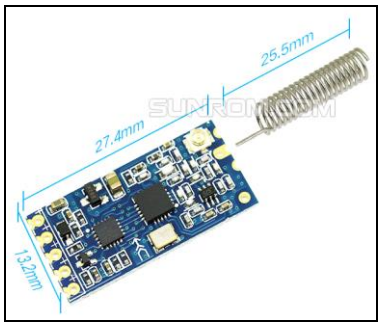
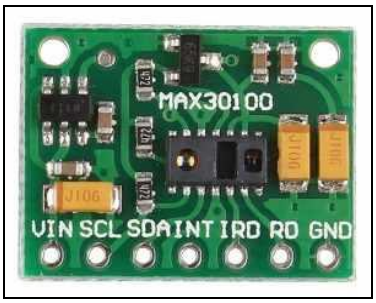
• In-System Programming by On-chip Boot Program
• True Read-While-Write Operation – Programming Lock for Software Security

[B] RF 433MH Serial Transmitter and Receiver



The serial RF module is a low cost, high performance transparent FSK transceiver with operating at 433 MHz. It features small size, high output power, high sensitivity, long transmission distance and high communication data rate with auto set up for communication change and data receiving and transmission control. With the UART interface to the microcontroller at transmitter side and USB to TTL convertor interfaced at receiver side, Its wireless working frequency band is 433.4-473.0MHz, multiple channels can be set, with the stepping of 400 KHz, and there are totally 100 channels. The maximum transmitting power of module is 100mW (20dBm), the receiving sensitivity is -117dBm at baud rate of 5,000bps in the air, and the communication distance is 1,000m(1 Km) in open space (600 meters indoor).

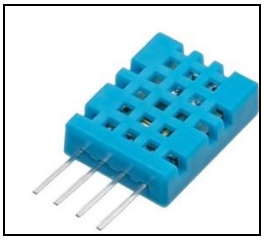
[C] MAX30100 Pulse Oximeter



MAX30100 is an integrated pulse oximetry and heart-rate monitor sensor solution. It integrates two LEDs (IR and Red), a photo detector (Red), optimized optics, and low-noise analog signal processing to detect pulse oximetry and heart-rate signals. It is fully configurable through software registers and the digital output data is stored in a 16-deep FIFO within the device. It has an I2C digital interface to communicate with a host microcontroller.

The pulse oximetry subsystem in MAX30100 consists of ambient light cancellation (ALC), 16-bit sigma delta ADC, and proprietary discrete time filter. It has an ultra-low-power operation which makes it ideal for battery operated systems.MAX30100 operates on a supply in the range of 1.8 to 3.3V.It can be used in wearable devices, fitness assistant devices, medical monitoring devices, etc.The MAX30100 operates from 1.8V and 3.3V power supplies and can be powered down through software with negligible standby current, permitting the power supply to remain connected at all times.

[D] Humidity Sensor DHT11

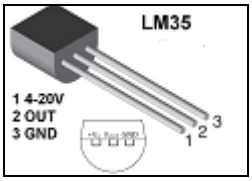


DHT11 is a low-cost digital sensor for sensing temperature and humidity. This sensor can be easily interfaced with any micro-controller such as Arduino, Raspberry Pi etc... to measure humidity and temperature instantaneously.

The DHT11 is a basic, ultra low-cost digital temperature and humidity sensor. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air, and spits out a digital signal on the data pin (no analog input pins needed). Its fairly simple to use, but requires careful timing to grab data. The only real downside of this sensor is we

can only get new data from it once every 2 seconds, so when using our library, sensor readings can be up to 2 seconds old.

[E] LM35 Temperature Sensor

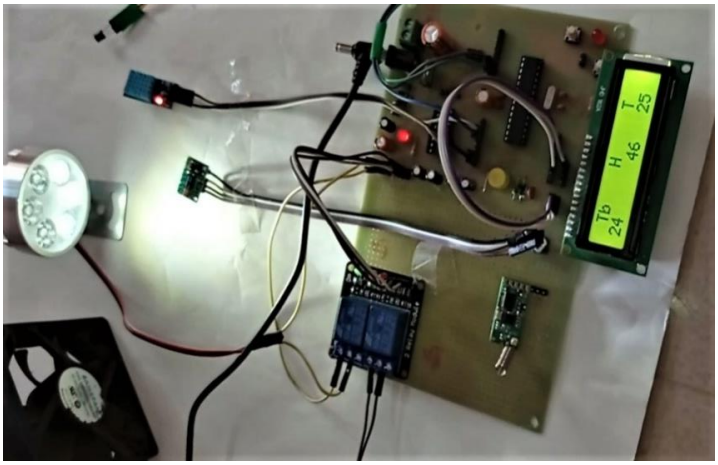


LM35 is a linear Monolithic sensor, which is calibrated directly in Celsius (centigrade), this is its advantage over linear temperature sensors calibrated in Kelvin. For every 0.01V increase in voltage 1°C with a 0.5°C Ensured Accuracy at 25°C. The LM35 does not require any external calibration or trimming to provide typical accuracies of ±¼°C at room temperature and ±¾°C over a full -55 to +150°C temperature range. The pin diagram is shown in figure. Its output is connected to analog pin of microcontroller and its ADC circuit convert the analog value into digital. This sensor is compact in size and it is easily attached to human body to measure body temperature.

[F] LEDs Light &Fan

There are LEDs light and air fan is placed at incubator to provide required temperature and humidity, hence these are operated on 12 volt dc power through a 2 chanel dc relay driver interfaced to the microcontroller. The controller programme decides to operate condition of this light and fan as to maintain the desire humidity and temperature inside the baby incubator.

3 Experimental Hardware Setup



System Working

This proposed incubator system can fulfil all the need in proper taking care of new baby born. This incubator system consistshardware components i.e. Pulse Oximeter, DHT11 and LM35 humidity and temperature sensor, LEDs light bulb, fan, RF communication module and LCD display and microcontroller ATmega328P. The proposed software programming can be done in C Programming language or using Arduino Open source Programming platform.

The monitoring part of proposed system has involved a RF based wireless communication to monitor all the parameters from multiple remote place and also send a warning/alert in case of emergency in any abnormalities from incubator so to take immediate action by care taker authorities.Hence one RF 433 MH transmitter module is interfaced to serial UART pin of microcontroller ATmega328 and one RF 433MH Receiver module is connected to USB port of remote PC terminal through a USB to TTL convertor. For monitoring the body parameters, there are heart beat and spo2 blood oxygen measure combine sensor MAX30100 is attached to baby, which is interfaced to the microcontroller through I2C serial communication to measure HB pulse and spo2 % and DHT11 sensor is interfaced to the microcontroller, which measure the relative humidity and ambient air temperature, there is also a LM35 sensor is interfaced to the analog pin of microcontroller and it is attached to the baby to measure the body temperature. These all sensor's parameters value are shown on LCD display, also these data are transferred to the remote PC terminal through wireless RF communication.The programming algorithymis set as to control and maintain temperature and humidity level, when the temperature in the incubator is goes below/ above 35 C and relative humidity are below 50% RH and above 75% RH, the corresponding dc

relay is operated by microcontroller to switched on/off the connected LEDs lamp and air fan which are operating on 12 volt dc supply.

Result Analysis

Our system uses two temperature sensors are used for the premature infant and for the Incubator. The body temperature sensor we are using here is LM35 and DHT11 sensor is for incubator. The specifications of temperature and humidity sensors are coded such that in our experimental setup that when DHT11 detect temperature more then 34 Celsius, so cooling fan will be switched on automatically and LEDs bulb is switch off. In case temperature is decrease to the 34 Celsius so bulb is automatically switch on. Temperature sensor maintains the 34 to 35.50 Celsius temperature in baby incubator. Moreover when the body temperature goes below 35˚C then it detect as a hypothermia and we can see it on Lcd.

CONCLUSION

This RF communication based incubator system is useful for the premature infants care taking in hospitals. It can be life saving machine for low birth weight infants. It controls the temperature, humidity and measures the critical vital body parameters such as heart rate, Blood Oxygen Saturation and body temperature. Especially this research is leveraged the advantages of RF - Zigbee to health field.

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