Embedded Based Preemies Monitoring System With Jaundice Detection And Therapy

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Abstract: This paper describes the design of Embedded based preemies monitoring system with jaundice detection and therapy. It is a hybrid of the neonatal monitoring and photo radiation therapy system. It detects jaundice in newborns non-invasively by optical method and provides the required therapy by photo radiation. It provides an ideal environment for newborns needing special care and facilitates remote based temperature and respiration control. This system consists of two sections, a transmitter and a receiver section. ZigBee wireless protocol has been used. Transmitter part is used to set the room temperature and apnea values. Receiver part detects jaundice; provide single surface or double surface photo radiation treatment based on the level of jaundice. Monitors the room and baby temperature and controls the temperature by means of Heating and cooling mechanism and also monitors respiration rate. The system is inexpensive and reliable and can be used in hospitals, child care units etc

INDEX TERMS: Jaundice. Photo Therapy, Respiration, Hypothermia, Temperature, Exchangetransfusion, Operational Amplifier

1. INTRODUCTION

The term “Preemies” refers to the premature babies. Most frequently encountered problems in preemies are jaundice, problems related to hypothermia. This paper mainly focuses on the health care systems for preemies. This system is an up gradation of the conventional infant care systems [1], [2]. Health Care Systems form essential life supporting equipments for the premature babies in the hospitals. Unfortunately there is a lack of low cost health care systems in the developing world. Conventional infant care systems provide only temperature monitoring and control [1], [2]. Separate systems are used for jaundice detection and therapy. This leads to inappropriate usage of space and increased cost, as separate systems are used for assessing and controlling various abnormalities in the preemies [3], [4], [5], [6], [7]. Use of separate systems also leads to increased power demands for their operation. Health care systems in hospitals constitute devices such as baby incubators which provide an ideal temperature similar to that in the mother’s womb [1], photo radiation chamber used to treat jaundiced babies [6] and respiration monitors for monitoring respiration rates [7].This section gives its reader an insight into the general background of physiology of preemies and how the environment control can make a difference in the life of an infant.

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This investigation will be based on theoretical study on whose basis a prototype has been built. Advances in electronic techniques coupled with economical prices facilitate cost-effective, highly accurate and systems with stable performance. This system is an integration and enhancement of the various health care services provided by conventional health care systems for preemies. Jaundice detection is provided by sensing the yellow color on the preemies skin. Along with jaundice detection, it also provides photo radiation therapy for jaundice, respiration monitoring, detection of abnormal respiration conditions like apnea and tachypnea [7], [8], temperature monitoring and control using a wireless protocol. This system is advancement to the conventional health care systems in the field of pediatrics. Thus the developed system is accurate, economical, user friendly and provides an ideal environment for the normal growth of the preemies.

1.1 JAUNDICE

Jaundice is yellowing of the skin and other tissues of a newborn infant [9], [10, [11]. A common treatable condition of premature babies called jaundice, affects 80% of premature infants. Infants with jaundice have high levels of bilirubin, a compound that results from the natural breakdown of blood. This high level of bilirubin causes them to develop jaundice resulting in yellow discoloration of the skin. Jaundice typically results from the deposition of unconjugated bilirubin pigment in the skin and mucus membranes. Although mild jaundice is fairly common in full-term babies (about 60%), it is much more common in premature babies. Extremely high levels of bilirubin can cause brain damage, so premature infants are monitored for jaundice and treated quickly, before bilirubin reaches dangerous levels. Majority of Preemies develop jaundice on the second or third day of life. This then decreases gradually. This kind of jaundice in newborns usually does not need any treatment. But in some babies the jaundice can increase above safe limits requiring phototherapy (keeping the baby under blue tube lights).

1.2 TREATMENTS FOR JAUNDICE PHOTO THERAPY

Phototherapy is a treatment for jaundice where the baby is kept under blue tube lights. Blue light converts bilirubin (the substance that is responsible for yellow coloration of eyes and skin) into more soluble substances, which are easily excreted. Exposure of jaundiced skin to blue light photo-

isomerizes the bilirubin molecule into forms, which can be excreted directly into the bile, without having to be conjugated. The indications and use of phototherapy vary between units and are dependent not only on the level of the serum bilirubin but also on the gestation of the baby, rate of rise of bilirubin, likely underlying cause and well-being of the baby, The more premature the infant, the lower the levels of bilirubin that are tolerated. Phototherapy is now the preferred method of treatment for preemies jaundice by virtue of its noninvasive nature and its relative freedom from major complications. It is also convenient and easy to use.

1.3EXCHANGETRANSFUSION

1.4RESPIRATORY PROBLEMS IN PREEMIES

An important part of lung development in babies is the production of surfactant [7], [8]. This is a substance made by the cells in the small airways and consists of phospholipids and protein. It begins to be produced in the fetus at about 24 to 28 weeks of pregnancy. Surfactant is found in amniotic fluid between 28 and 32 weeks. By about 35 week's gestation, most babies have developed adequate amounts of surfactant. Surfactant is normally released into the lung tissues where it helps lower surface tension in the airways. This helps keep the lung alveoli (air sacs) open. Premature babies may not have enough surfactant in their lungs and may have difficulty breathing. Babies breathe much faster than older children and adults. A newborn's normal breathing rate is about 40 times each minute. This may slow to 20 to 40 times per minute when the baby is sleeping. The pattern of breathing in a baby may also be different. A baby may breathe fast several times, and then have a brief rest for less than 10 seconds, than breathe again. This is often called periodic breathing and is a normal occurrence. Babies normally use their diaphragm (the large muscle below the lungs) for breathing. Changes in a baby's breathing rate or pattern, using other muscles and parts of the chest to breathe, or changes in color may mean the baby is having respiratory distress and needs immediate medical attention.

1.5 HYPOTHERMIA

Hypothermia is a condition in which the body temperature is abnormally low. Maintaining a neutral thermal environment is one of the key physiologic challenges a newborn infant faces after delivery. The infant's body temperature drops immediately after birth in response to the extra uterine environment. His internal organs are poorly insulated and his skin is very thin and does not contain much subcutaneous fat. The infant's heat regulating mechanism has not fully developed. His temperature rapidly reflects that of his environment. The flexed position that the infant assumes is a safeguard against heat loss because it substantially diminishes the amount of body surface exposed. Once babies are born they only have a limited ability to regulate their own body temperature. Newborns can become hypothermic (subnormal body temperature) very soon after birth. A newborn is more prone to develop hypothermia because of large surface area per unit of body weight. Premature infants have a thin, underdeveloped stratum corneum, or the rough, outer layer of the epidermis which protects the skin from external agents, that enables excess of water to diffuse out. Evaporative heat losses make up a significant fraction of the total heat loss of a premature infant .A low birth weight baby has decreased thermal insulation due to less subcutaneous fat and reduced amount of brown fat. Brown fat is the site of heat production. It is localized around the adrenal glands, kidneys, nape of neck; inter scapular area and auxiliary region. Metabolism of brown fat results in heat production. Blood flowing through the brown fat becomes warm and through circulation transfers heat to other parts of the body. This mechanism of heat production is called **non-shivering thermo genesis [9], [10], [11].**

1.6 MECHANISMS OF PREVENTING HEAT LOSS

One of the most commonly used mechanisms to create a neutral thermal environment is the incubator. It tries to stimulate the conditions as inside the womb. Perhaps no other piece of medical equipment is more closely associated with neonatal care than the incubator.

1.7 BLOCK DIAGRAM

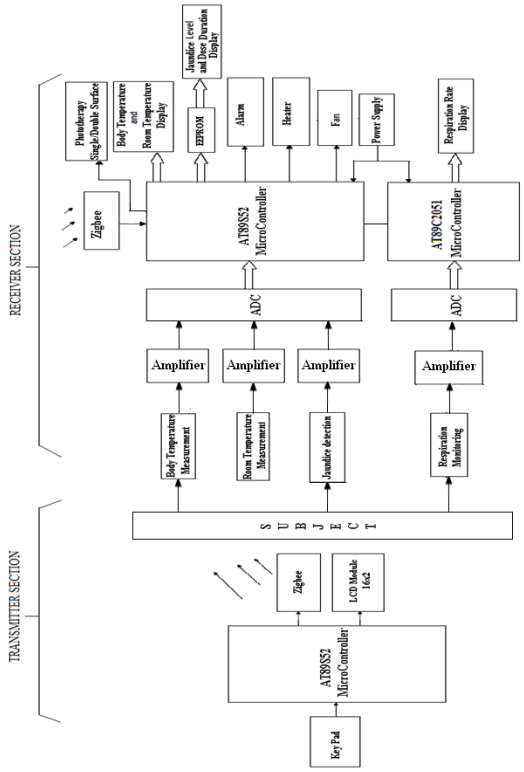

Fig1: The block diagram of Embedded based preemies monitoring system with jaundice detection and therapy consists of two sections. Both the Transmitter and the Receiver sections are shown in the diagram.

The receiver section uses AT89S52 microcontroller which controls every action of its related peripheral circuits [16], [17]. The output signals from temperature and color sensors are given to the ADC through the amplifiers of variable gain [13], [14], [15]. The amplifier used in this project is OP07. The ADC 0809 converts the electrical voltages into proportional binary values. The output data from the ADC is in 8 bit form which is provided to the microcontroller through the 8 data lines. After receiving the 8-bit data from the ADC the microcontroller performs various operations such as

- Displaying the baby, room temperatures, jaundice level, duration and kind of phototherapy on the LCDs [6], [9],[13], [14].
- Controlling the fan and heater in order to maintain the room temperature within preset limits.
- Receives information from the transmitter section through ZigBee wireless protocol.
- The microcontroller is responsible for controlling the relays through ULN2003 line driver.

The Max 232 serves the purpose of serial communication between the microcontroller and the ZigBee wireless protocol. The transmitter section also uses the same AT89S52 microcontroller. The transmitter section consists of 3 toggle switches and 2 push buttons which form the keypad. Here the microcontroller controls the room temperature and apnea settings at the receiver section by transmitting the information through ZigBee. Thus it enables for adequate controlling of temperature and apnea settings at the receiver section from a distance of 100 meters [7], [8].

2. PRINCIPLE OF OPERATION

2.1 JAUNDICE DETECTION

Jaundice detection is based on the fact that premature babies are prone to visible jaundice. Thus detection of jaundice employs a color sensor which senses the yellow color of the baby and decides if the baby is infected by jaundice. The color sensor is based on reflectance of light when an object is illuminated

2.1.1COLOR SENSOR

In this system, different shades corresponding to different wavelengths of yellow color need to be determined. Color sensor is used to perform this operation. It consists of a LDR, 4 LEDs and a series of four 1K ohm resistors. LEDs provide for constant illumination of the object to be sensed and are enclosed in a case which blocks the external light from entering into the case. In this project 4 different yellow shades are used for testing Jaundice, which will be detected by the color sensor, range of yellow color starts from lightest shade to the darkest shade. Intensity of each yellow color increases in ascending order and is labeled as 0,1,2,3. The table below shows the jaundice levels, therapy, and its duration for the range of yellow colors.

Yellow shade	Jaundice level	Therapy	Time(Seconds) (Experimental Purpose)
0	10 – 12 mg/dl	SS	10
1	12 – 14mg/dl	SS	20
2	14 – 20mg/dl	DS	40
3	>20mg/dl	ET	NILL

TABLE 1: Jaundice level and therapy

Abbreviations used:
SS – Single Surface

DS – Double Surface

ET – Exchange Transfusion

NT – No Treatment

2.1.2 OPERATIONAL AMPLIFIER (OP07)

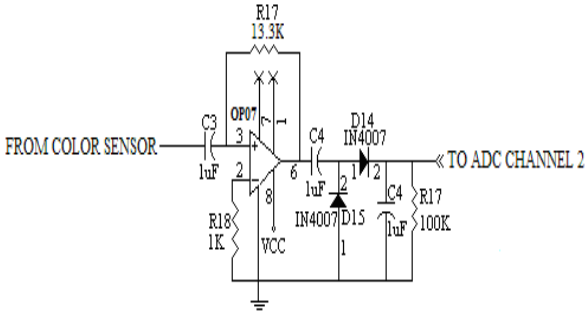

Fig 2: Amplification circuit for color sensor

The operational amplifier used for jaundice detection and therapy section is OP07, details of which are discussed in temperature monitoring section. The output from color sensor is applied to the non-inverting terminal of the amplifier through 1k ohm resistor and 13.3k pot, which serve as a feedback resistor. Gain of the amplifier is calculated as follows,

DESIGN

Rf=13.3K

Rin=Rs=1K

Gain =1+ (Rf/Rin)

Gain =1+ (13.3K/1K)

Gain =14.3

Minimum output 0.17V and maximum output 0.34Vof the color sensor

2.2 PHOTOTHERAPY

Phototherapy units are developed to provide a easy but effective method of treating new born babies with Jaundice. High intensity light-emitting diodes (LEDs) are being studied as possible light sources for the phototherapy of jaundiced preemies. These power-efficient, low heat-producing light sources have the potential to deliver high intensity light of narrow wavelength band in the blue-green portion of the visible light spectrum, which overlaps the absorption spectrum of bilirubin (BR). Light from blue LEDs is considered a more effective treatment for jaundiced preemies.

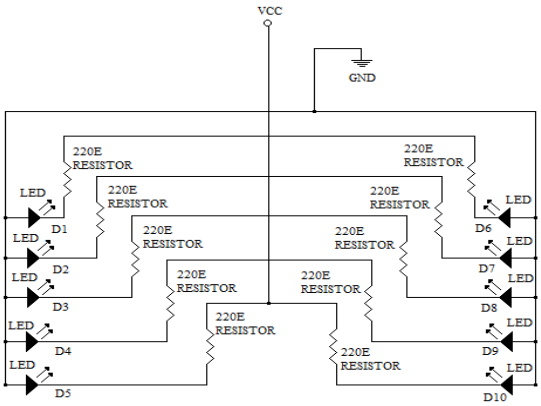

Fig. 3: Phototherapy tube construction

In this system we are employing LEDs of wavelength 410nm which comes under the UV spectrum and thus is suitable for treatment of jaundice in the preemies. Here we are providing treatment in two forms

- Single Surface
- Double Surface

Thus according to the level of jaundice detected the microcontroller decides what kind of treatment is to be given: Single surface and/or double surface. Both single surface and double surface consist of 5 phototubes. Each phototube is provided with 2 blue LEDs thus allowing for large surface illumination of the preemies body. The phototherapy is provided for a particular duration as prescribed by the microcontroller.

2.3 RESPIRATION MONITORING

Disorders of the lungs and the respiratory tract are among the most important and serious conditions that can affect the Preemies. It is therefore important to monitor conitinuously the respiration of Preemies. To achieve these criteria, piezoelectric sensor is used in our project to monitor the respiration rates of the preemies continuously. The details of respiration monitoring are discussed as follows. In this project we are making use of piezoelectric sensor for obtaining the respiration rate in terms of breathes/min and for detecting abnormalities like apnea and tachypnea in preemies

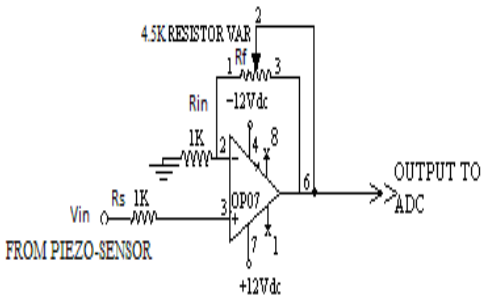

Fig 4: Amplification circuit for respiration

The operational amplifier used for respiration monitoring is OP07. The output from piezoelectric sensor is applied to the non-inverting terminal of the amplifier through 1k ohm resistor and 4.5k pot, which serve as a feed back resistor. Gain of the amplifier is calculated as follows,

DESIGN

Rf=4.5K

Rin=Rs=1K

Gain =1+ (Rf/Rin)

Gain =1+ (4.5K/1K)

Gain =5.5

Amplifier O/P = I/P voltage of Piezo sensor x Gain

Amplifier O/P = (0.7) * 5.5 = 3.85V (since 0.7 is standard)

2.4 TEMPERATURE MONITORING

Operational amplifier OP07 is used to amplify the signal from LM35 sensor. Two op-amps are used in the temperature monitoring section, one for amplifying the room temperature and another for amplifying baby temperature. IC Operational amplifier provides improved performance and temperature stabilization.

2.4.1OPERATIONAL AMPLIFIER (OP07)

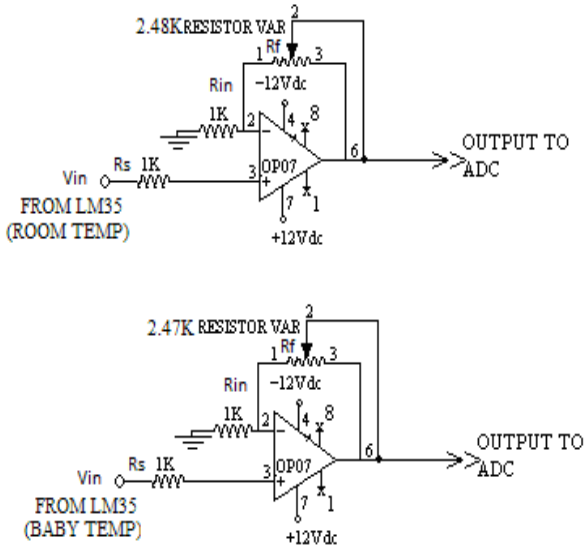

Fig 5: Amplification circuit for room temperature and baby temperature

Op-amp acts like a voltage amplifier. A voltage amplifier increases the voltage level of the input signal so; it is designed to produce the largest possible voltage gain with only the little power being ground from the output by the load. The output from the temperature sensor LM35 is given to Op-amp OP07 which will act as voltage amplifier i.e. it will amplify mV into Volts, and then from the amplifier the signal is given to ADC0809. The output from LM35 is applied to the non-inverting terminal of the amplifier through 1k ohm resistor and 2.48k pot for amplifying room temperature, 1k ohm resistor and 2.47k pot for amplifying baby temperature which serve as a feedback resistor. Gain of the two amplifiers are calculated as follows,

DESIGN:

(a)Room temperature
Rf=2.48K

Rin=Rs=1K

Gain =1+ (Rf/Rin)

Gain =1+ (2.48K/1K)

Gain =3.48

(b) Baby temperature

RF=2.47K

Rin=Rs=1K

Gain =1+ (Rf/Rin)

Gain =1+ (2.47K/1K)

Gain =3.47

After amplification the input voltage given to the ADC will be **Amplifier O/P = O/P voltage of LM35 x Gain**

Amplifier O/P (Room temperature) = 250mV * 3.48 = 0.87V.
Amplifier O/P (Baby temperature) = 250mV * 3.47 = 0.8675V.

3. EXPERIMENTAL RESULTS

The following results were obtained from the experimental analysis of the module

3.1Jaundice

1. Initially the receiver side LCD displays "Please Update colors"
2. Now all the colors starting from the lightest i.e., color 0 to the darkest color i.e., color3 is updated into the EEPROM memory by placing the color sensor on each color starting from color 0 to color4.
3. The color 0 corresponds to the bilirubin level 10-12mg/dl for which a single sided (SS) phototherapy is required.
4. The color 1 corresponds to the bilirubin level 12-14mg/dl for which a single sided (SS) phototherapy is required.
5. The color 2 corresponds to the bilirubin level 14-20mg/dl for which a double sided (DS) phototherapy is required.
6. The color 3 corresponds to the bilirubin level greater the 20mg/dl for which the system provides no treatment. The blood has to be taken for Exchange Transfusion.

3.2 Photo radiation therapy

1. Color sensor is randomly placed on any color. The color sensor now senses this color and decides jaundice levels and provides photo radiation therapy.
2. If the color sensor detects color in the range of 10-12mg/dl then the LCD display "Jdlvl=10-12mg/dl" "SS=10sec 'time in sec'" ie. For jaundice level of 10-12mg/dl single surface(SS) of photo radiation therapy is provided
3. If the color sensor detects color in the range of 12-14mg/dl then the LCD displays "Jdlvl=12-14mg/dl" "SS=20sec 'time in sec'" ie. For jaundice level of 12-14mg/dl Single surface(SS) of photo radiation therapy is provided
4. If the color sensor detects color in the range of 14-20mg/dl then the LCD displays "Jdlvl=14-20mg/dl" "DS=40sec 'time in sec'" ie. For jaundice level of 14-20mg/dl Double surface(DS) of photo radiation therapy is provided
5. If the color sensor detects the color has exceeded 20mg/dl then the LCD displays "Jdlvl=>20mg/dl" "Xchng Trnsfusion" ie. For jaundice level greater than 20mg/dl NO photo radiation therapy is provided. The treatment is exchange transfusion
6. If the color sensor detects that the detected range is below 10mg/dl then the LCD displays "Jldvl=___mg" not detected" ie. For jaundice level less than 10mg/dl NO photo radiation therapy is provided

3.3 Respiration

1. The respiration counts are taken by placing the peizo sensor on baby's diaphragm.
2. The respiration counts are picked from the respiration sensor. To alert the personnel of an abnormal situation we first need to set the abnormal apnea range for the baby which differs for each baby based on their breathing rates.
3. To enter into the apnea settings mode we make use of toggle switch 4. The LCD displays "Mode 2 Apnea Set".
4. The desired apnea values are set by pressing the increment and decrement push buttons 5 and 6 respectively. The LCD displays "Mode 2 inc apnea 'value'".
5. This apnea value is set or locked by bringing down the toggle switch to bottom position.
6. While we set this value in the transmitter section the receiver section LCD for respiration also displays this set value as "Mode 2 inc apnea 'Value'" momentarily.
7. The receiver LCD keeps displaying the Breathes/min of baby picked from the peizo sensor and the LCD displays "breathes/min 'value' Apnea /tachypnea detected" and gives an alarm if apnea or tachypnea is detected.
8. The tachypnea is detected when breathes exceeds the normal breathing range per minute.
9. The apnea condition is indicated when there is no breathing for the set time or the set apnea value.

3.4 Temperature control

1. The temperature is detected by placing one temperature sensor in baby's hand and the other is kept in the incubator.
2. The LCD displays the current temperature of the room on the LCD of the transmitter section by receiving it from the 1st microcontroller in the receiver section
3. The room temperature and the baby temperature is also displayed on the receiver section LCD.
4. By looking into the temperature values of baby and room in the receiver section the user/ the concerned professional can adjust the room temperature by using the toggle switches and push buttons in the transmitter section as shown below

5. The system enters into the temperature control/setting mode by pushing the toggle switch 1 to top position. The LCD displays “Mode 1 Temperature set”.
6. To set the temperature in the required range we need to define a temperature range i.e. we need to set the maximum temperature value and a minimum temperature value for the room so that if the room temperature falls below the minimum temperature value set, the heater is turned on and the heater continues heating the room till it reaches the maximum temperature value set.
7. Once the temperature crosses the maximum value the fan is turned on and heater is switched off and then when the temperature starts dropping below the minimum set value the fan is turned off and heater is again turned on.
8. In this way the temperature is maintained within the set range. To set the maximum temperature value toggle switch 2 is pushed to the top most position At this point the LCD displays “Mode 1 .a(max) temperature set”.
9. The value is set by pressing the increment and decrement pushbuttons 1 and 2 respectively. Now the LCD displays “Mode 1 .a ‘max inc ‘value’”.
10. Then the toggle switch 2 is moved back to the bottom position to lock the max temperature value.
11. Similarly to set the minimum temperature value toggle switch 3 is pushed to the top most position At this point the LCD displays “Mode 1 .b(min) temperature set”.
12. The value is set by pressing the increment and decrement pushbuttons 3 and 4 respectively. Now the LCD displays “Mode 1 .b min inc‘value’”.
13. Then the toggle switch 2 is moved back to the bottom position to lock the max temperature value.
14. The toggle switch 1 is then brought down to log out of the temperature control/setting mode.

3.5. Result Analysis

3.5.1 Snapshots of Jaundice detection

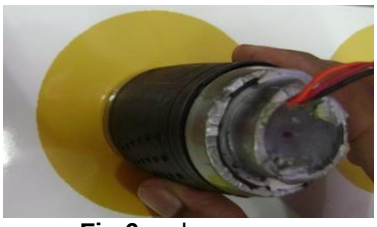

Fig 6: color sensor

Color sensor is used to detect the jaundice level as shown in Figure 6. It is randomly placed on any color. This color is sensed by the sensor and the system decides if the baby is infected by jaundice based on a preset range of jaundice levels.

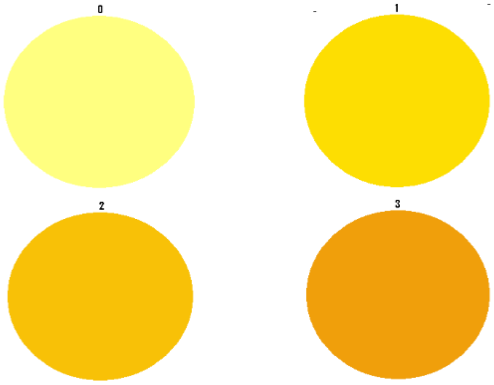

Fig 7: Sample colors used in the project to indicate different levels of jaundice.

Fig 8: Receiver side LCD display “Please Update colors”The LCD displays “Please Update colors” as shown in Figure 8 when the key is pressed.

Fig 9: Jaundice level and duration display for color 0 at the Receiver Section

If the detected color is in the range of 10-12mg/dl then the system provides a single sided phototherapy for 10 seconds. The LCD displays “Jdlvl=10-12mg/dl” “SS=10sec ‘time in sec’” as shown in Figure 9.

Fig 10: Jaundice level and duration display for color 1 at the Receiver Section

If the detected color is in the range of 12-14mg/dl then the system provides a single sided phototherapy for 20 seconds then the LCD displays “Jdlvl=12-14mg/dl” “SS=20sec ‘time in sec’” as shown in Figure 10.

Fig 11: Jaundice level and duration display for color 2 at the Receiver Section

The LCD displays "Jdlvl=14-20mg/dl" "DS=40sec 'time in sec'" as shown in Figure 11, if the color sensor detects that the detected color is in the range of 14-20mg/dl then the system provides a double sided phototherapy for 40 seconds as explained in .

Fig 12: Jaundice level and duration display for color 3 at the Receiver Section

If the detected color has exceeded 20mg/dl then the system does not provide any treatment. The LCD displays "Jdlvl=>20mg/dl" "Xchng Transfusion" as shown in Figure 12. The baby has to undergo Exchange transfusion

Fig 13: Jaundice level and duration display's in Receiver Section

If the color sensor detects that the detected range is below 10mg/dl then the LCD displays "Jldvl=___mg/dl" "not detected" as shown in Figure 13.

3.5.2Snapshots of Photo radiation therapy

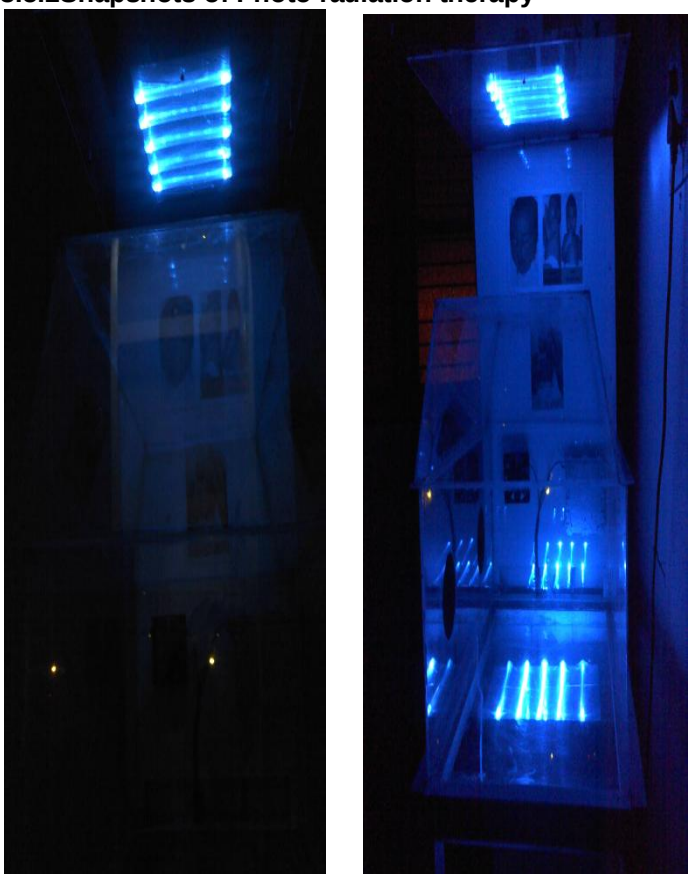

Fig 14: Single and double layer photo radiation therapy.

Figure 14: shows the module used to give Single and double surface photo radiation therapy

3.5.3 Snapshots of temperature detection and control

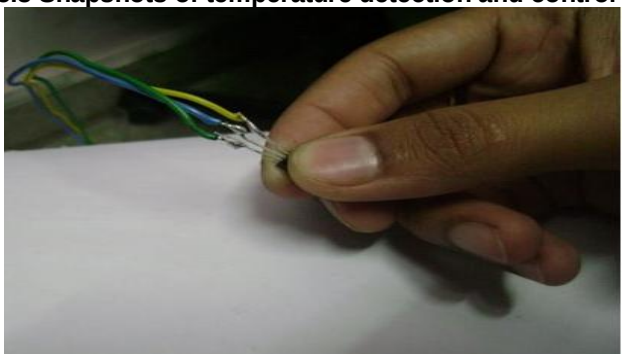

Fig 15: Temperature sensor

Figure 15 shows the temperature sensor that is used in the project. The temperature detection is done by placing one temperature sensor in baby's hand and the other is kept in the incubator.

The temperature of both the baby and the room is sensed and displayed in the receiver section LCDs as shown in Figure.

Fig 16: Temperature display of room and baby at the Receiver Section

Fig17: Temperature display of room at the Transmitter Section

The room temperature in receiver section is transmitted back to the transmitter section as shown in Figure 17

Fig 18: Temperature setting mode display of the room at the Transmitter Section

By looking into the room temperature the user can set the desired temperature range from the transmitter section. The system enters into the temperature control/setting mode by pushing the toggle switch 1 to top position and the LCD display is as shown in Figure 18.

Fig 19: Maximum temperature setting mode display of the room at the Transmitter Section

To set the max temperature value toggle switch 2 is pushed to the top most position At this point the LCD displays "Mode 1 .a(max) temperature set" as shown in Figure 19.

Fig 20: Display of Maximum temperature of the room set by the user at the Transmitter Section

The value is set by pressing the increment and decrement pushbuttons 1 and 2 respectively. Now the LCD displays "Mode 1 .a max inc 'value'" as shown in Figure 20.

Fig 21: Minimum temperature setting mode display of the room at the Transmitter Section

To set the minimum temperature value toggle switch 3 is pushed to the top most position. The LCD displays "Mode 1 .b (min) Temperature set" as shown in the above Figure 21.

Fig 22: Display of Minimum temperature of the room set by the user at the Transmitter Section

The value is set by pressing the increment and decrement pushbuttons 3 and 4 respectively. Now the LCD displays "Mode 1 .b min inc 'value' as shown in the Figure 22.

3.5.4 Snapshots of respiration detection

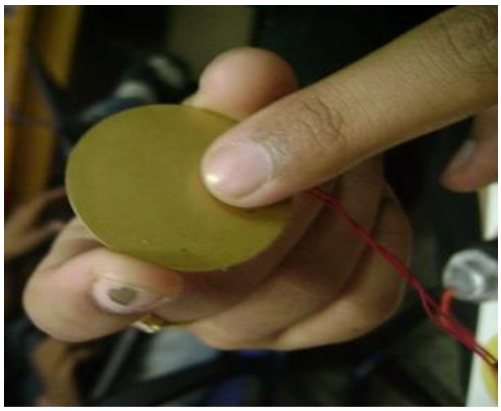

Figure 23: Peizo electric sensor

The respiration counts are taken by placing the peizo sensor on baby's diaphragm. Here we give pulses manually as shown in the Figure 23.

Fig 24: Display of respiration count per minute and detected tachypnea at the Receiver Section

The receiver LCD keeps displaying the Breathes/min of baby picked from the peizo sensor and the LCD displays "breathes/min 'value'" and Apnea /tachypnea detected" as shown in the Figure 24 .The tachypnea is detected when the respiration count per minute exceeds the normal breathing range.

Fig 25: Apnea setting mode display at the Transmitter Section

In the transmitter section to enter into the apnea settings mode toggle switch 4 is used. The LCD displays "Mode 2 Apnea Set" as shown in Figure 25.

Fig26: Display of Apnea limit set by the user at the Transmitter Section

In the transmitter section the desired apnea values are set by pressing the increment and decrement push buttons 5 and 6 respectively. The LCD displays "Mode 2 inc apnea' value'" as shown in Figure 26

Fig 27: LCD display when the peizo sensor is disconnected from the baby.

When the peizo sensor is disconnected from the baby, the LCD displays Breath/min as 000 and a disconnected message as shown in the Figure 27.

4. CONCLUSION

The system developed here is a cost-effective instrument which is designed to help diagnose jaundice and hypothermia. It is a very vital and a life supporting unit for the premature babies. It focuses on monitoring multi-parameter of the Preemies. The system detects jaundice and provides therapy as per the requirements. In addition, it monitors respiration rate, detects tachypnea and gives alarm at the occurrence of abnormal situations like apnea and also monitors and controls temperature wirelessly. This system can be used in hospitals, Child Care Units, etc.

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