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Monitor of respiratory movement and caretaking system in baby cradle

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ABSTRACT

The paper introduces a helping hand for the busy professional parent. Parent of an infant is a responsible task. We are introducing an embedded system in the baby cradle that acts as a helping hand to nurture our next generation. With minimal effort, it creates a worriless and affectionate bond between the two while the parent is busy with professional work. The system pampers the baby and alerts the parent at the time baby cries. ARM7 microcontroller based system along with servomotor and MP3 module pampers the baby, the sound sensor detects when the baby cries, the pressure sensor detects the presence of a baby in the cradle, accelerometer sensor module takes a reading of cradle swing, the ultrasonic sensor senses the breathing movement during baby sleep time. All the collected data in CSV format get transferred to PC/laptop that can be stored to analyze baby sleep hours or how often the baby needs attention or can help to the pediatrician to diagnose some kind of disease.

Keywords— *Baby cradle, LPC2148 microcontroller*

1. INTRODUCTION

The baby needs a caretaker always present for basic comfort and pampering. Time to take out of our professional life for offspring is difficult, and that needs someone to take care of our babies during busy work hours. These days women empowerment is increased which brought a number of busy mothers (working women) in the society who could not give sufficient time to their loving babies. The need to relax the mind of working women from worries of their baby comforts and irregular wakeup time, the mother must get informed. And the baby will get the mother's response automatically (like cradle swing and mothers voice). This ability of the system gives a helping hand to those needy busy mothers and also helps in the growth of country's economy many folds. We designed the system in a way that it performs the activities as we desire and perform functions as its output.

2. BACKGROUND

The electronic baby cradle system is introduced in the market couple of decades ago and many of systems are being implemented and has sensor wiring needed to be attached to baby's body that could jumble up when baby try to move side by side. Also, the respiratory movement is generally monitored by Edi (electrical activity of the diaphragm) or by mechanical attachment to the ventilation system, which is not feasible in day-to-day life for its difficulty in mobility. Attachment needs a lot of mechanical equipment and wiring up of sensors. The necessity to measure respiratory movement has the advantage to diagnose the disease over time. The monitoring of the baby by a caretaker is also a vital factor to meet the comfort of the baby and take actions to be required further. This results in the need of contactless monitoring of respiratory movement and caretaking system in a baby cradle.

3. PROPOSED SYSTEM

The system is microcontroller based which runs on 5 volts and 1 ampere rated power supply. It senses the sound of baby cry and triggers the mp3 module to play an audio having mother's voice which is stored in the SD card in mp3 format and simultaneously the servomotor starts moving cradle with a gentle swing and all the sensed data is sent to the parent's mobile phone with the help of Bluetooth module or it is sent to the attached PC/Laptop through USB cable for continuous monitoring. The CSV file is generated for continuous monitoring of the baby that helps the pediatrician to diagnose any disease. The sensor's data collected in CSV file format that is displayed on MS Excel spreadsheets with help of add-in software PLX-DAQ (parallax data acquisition tool) macros and the graph is formed based on the monitored data along with the time stamp.

3.1 Hardware design for a proposed system

This paper has a purpose to represent an embedded system designed for wireless measurement of the respiratory movement of the baby. And it has the functionality of the caretaker system that helps the parent to get worriless mind while busy in their working hour. The block diagram represents the system components and their communication parts. It is based on ARM7 architecture microcontroller, which has low operating power consumption and high-speed processing factors. We used Development board as shown in fig to rig up and execute the hardware components.

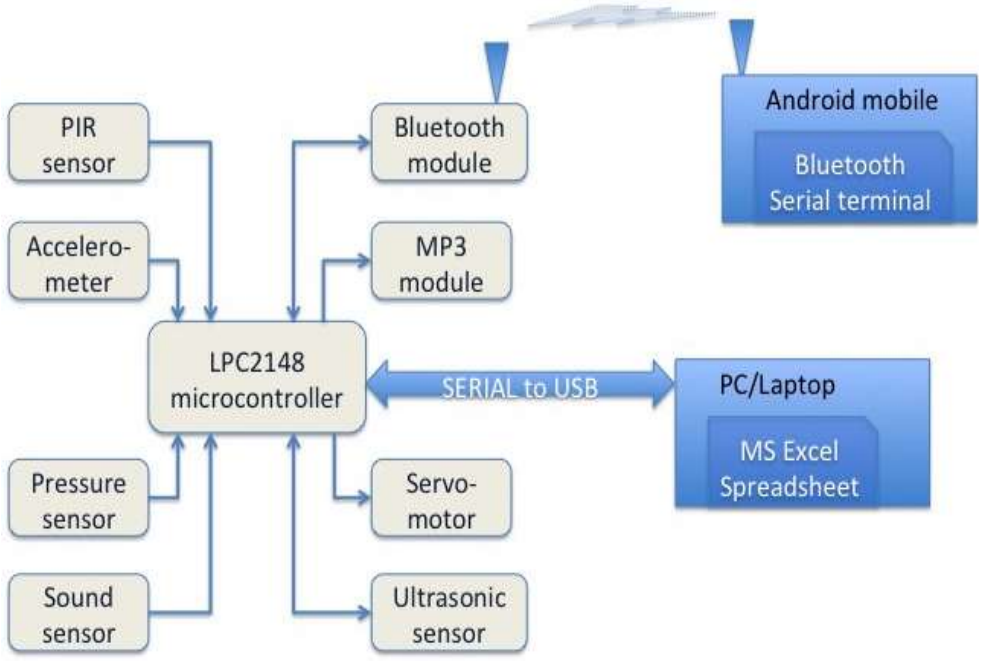

Fig.1: Hardware design for a proposed system

3.2 Components Requirement

3.2.1 Ultrasonic sensor module

It works on the principle of path measured based on half of the time taken to travel for 8 consecutive pulses from the transmitter to get back to the receiver element of the sensor module. It works on 40 KHz of ultrasonic frequency, which does not penetrate through the skin of the human body and does no harm to even babies. The sensor can identify the surface change of 3mm, which is optimum for chest movement monitoring when the baby breathes. This sensor only gets active when the cradle is at rest position and no cradle movement is identified.

Fig. 2: Ultrasonic sensor

3.2.2 Sound sensor

The sound sensor has to sense the baby cry. It has a microphone that captures any sound and converts the sound 0dB to the 120dB range to the analog voltage of 0 volt to 5-volt range this helps the ADC pins of the microcontroller to get readings in the range of o to 1023 integer values. The measured value for a baby cry is determined by measuring a number of babies in the locality that is nearly 20dB to the 24dB range, so the threshold for baby cry sound can be put to 22dB. Sometimes the baby giggles and tries to speak something by their own that sound comes for short interval and long interval sound made by baby has less pitch sound that comes below 19dB so the bifurcating of cry sound from the normal sound can be determined.

Fig. 3: Sound sensor

3.2.3 PIR sensor

This sensor is passive infrared receiver based sensor module, which captures the infrared pattern in terms of infrared energy received from the sensor's exposed angle. It has 120 degrees of exposing angle and has a Fresnel lens in the form of white plastic cover over the sensor element. The change in energy reading triggers the output pin of the sensor from low to high to indicate

any change in the infrared energy in the view field. The area under observation may differ in the range 20 feet. The output signal changes itself after 3 seconds to low and recalibrate the sensor element that ready to identify any change in received infrared energy. This module does not emit any infrared rays so it requires less power to operate.

Fig. 4: PIR sensor

3.2.4 Pressure sensor

The pressure sensor is in the shape of square flat and of type resistive sensor. It measures the pressure applied in the range of 0.2N to 20N, which is mapped into the resistance range of 10 M ohms to 0 ohms with the help of voltage divider in connection to ADC pins of the microcontroller. The sensed resistance can be digitized into 1 K resolution which can be read by the microcontroller and manipulate it to identify when the baby gets into the cradle. The sensor under the mattress changes its resistance when a baby's body weight applies force on the mattress and that indicates the presence of a baby in the cradle.

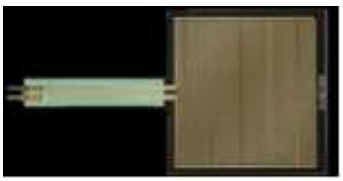

Fig. 5: Pressure sensor

3.2.5 Accelerometer sensor

The ADXL335 is used to measure the y-axis swing motion of the cradle. That is also attached to one of the ADC pins of the microcontroller to input the digitized reading in 1K resolutions to the microcontroller. It is capable of taking readings on three different axis. Here we are observing only y-axis movement that indicates the swing of the baby cradle.

Fig. 6: Accelerometer sensor

3.2.6 MP3 module

The module is used to play mp3 audio that is stored in fat32 formatted SD card. The inbuilt DAC chip is used to convert 24bit-sampled digital bits to analog audio output. The MP3 module operates at the 5-volt power supply, the audio output is then amplified with the help of PAM8403 amplifier chip that runs on 5-volt 1-ampere power rating to run a 4 ohms 3-watt speaker enough to produce high-quality sound.

Fig. 7: MP3module

3.2.7 Servomotor

A servomotor works on PWM input signal that has 0 to 180-degree movement angle and has the high torque to produce 1 to 1.5 Kg of force with the intake power rated at 5 volts and 1 ampere. The high torque notch attached with an arm/horn that pulls the thread attached to cradle to swing the cradle up to 15 degrees from the horizontal plane.

Fig. 8: Servomotor

3.2.8 Bluetooth module

The Bluetooth module (HC-05) has low power communication strategy to send and receive the data between the microcontroller and Bluetooth enabled android mobile phone. The sensed data are captured by the microcontroller and send to the Bluetooth module through serial communication at the baud rate of 9600. The received data from the microcontroller is then sending by a wireless communication channel to the Android mobile in real time. The received data in a mobile phone is in integer format that displays the status of baby sound and the intruder or unwanted movement around baby cradle.

Fig. 9: Bluetooth module

3.2.9 LPC2148 Microcontroller

It is based on ARM7 architecture design of microcontrollers, which have low operating power consumption and high-speed processing factors. We used Development board as shown in fig to rig up and execute the hardware components.

Fig. 10: LPC2148 Microcontroller

4. SOFTWARE USED TO DESIGN THE PROPOSED SYSTEM

4.1 Keil uVision 4

The software is used to develop an embedded system program in Embedded C or Assembly programming language. This IDE (integrated development environment) has many features (Editor, Built, Debugger, Run-time environment and Project management) widely used to design source code for embedded systems. And the hex file can be generated that is required for flashing the desired source code in the LPC2148 microcontroller.

4.2 Flash Magic

The software is used to burn the hex file to the microcontroller programmable memory, and the LPC2148 microcontroller has flash type programmable memory. By selecting the appropriate COM Port, Baud rate, Device Name, interface and Oscillator frequency in the communication block the connection is established between the PC and the microcontroller. The selected hex file can be burned to the microcontroller after selecting the start command button. With the help of USB to TTL converter, the hex file gets transferred to the programmable memory and the automatic Reset sequence will get executed after completion of flashing process. The software has other options like serial monitor and that helps to provide a console for the serial communication.

4.3 MS Excel

Microsoft developed a spreadsheet that can be used for analyzing and a decision-making tool for explicitly monitored data. The measuring instruments and devices that require data analyzer and report make take advantage of functionalities of the MS Excel spreadsheet. The monitored data will be stored for the future reference or can be sent to the pediatrician in real-time to diagnose the baby health.

4.4 MIT App Inventor

MIT app inventor has interactive programming and design tools, having features of visual and intuitive programming development environment. Easy to the built android mobile app in less time and effort. This is an online browser-based software where we can design the Android mobile app and the app can be executed in the virtual emulator, or on the mobile phone by scanning the generated QR code for the designed app or can be downloaded to transfer to other android mobiles

5. RESULTS AND DISCUSSION

The execution of the system designed is provided below:

Fig. 11: Hardware connection of the complete system with an uncovered pressure sensor in the cradle

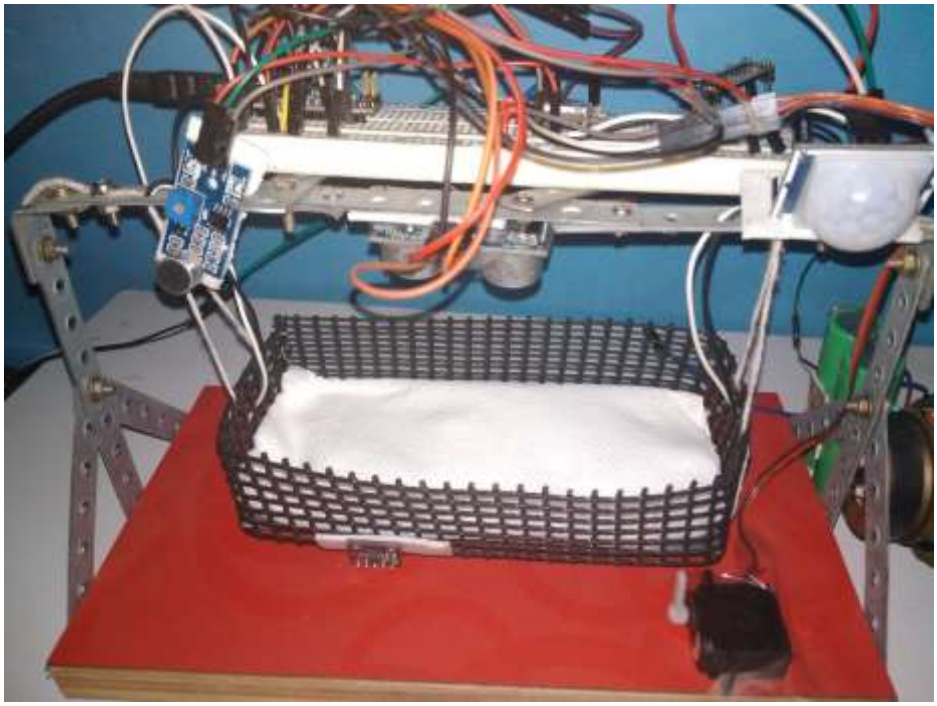

Fig. 12: Hardware connection of the complete system with mattress

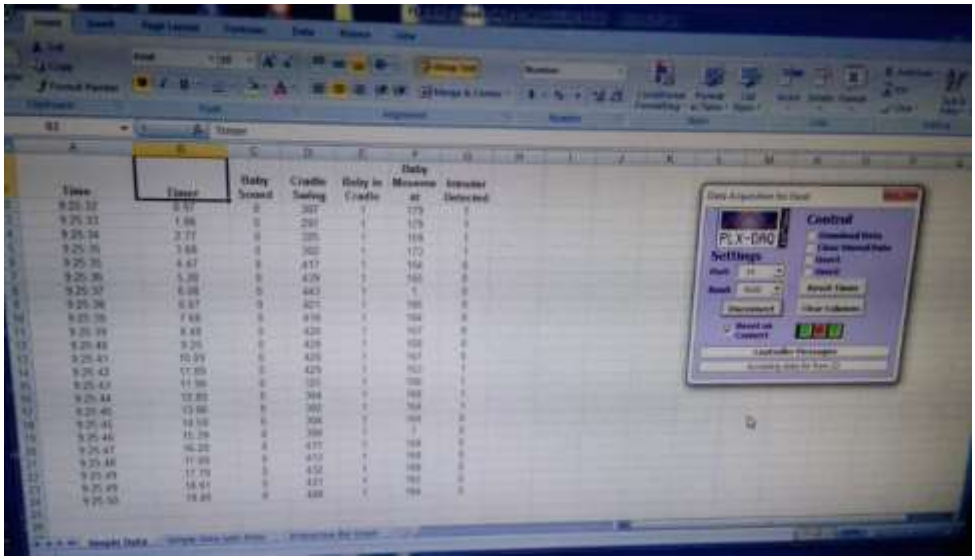

Fig. 13: MS Excel spreadsheet observing sensor data on PC

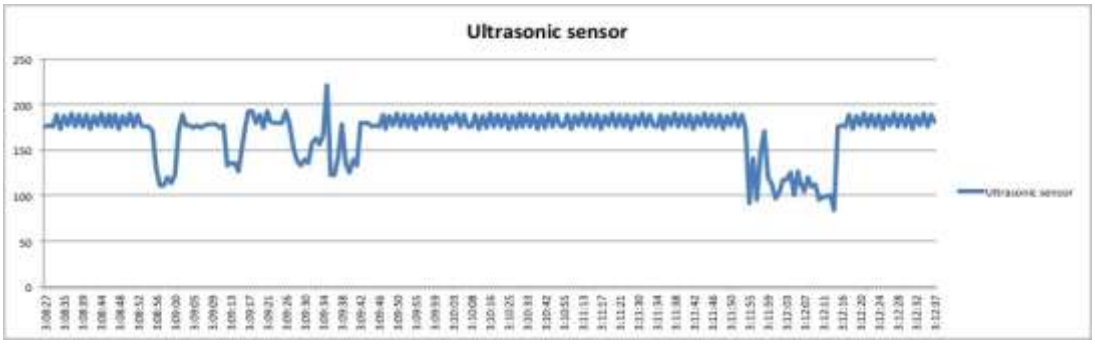

Fig. 14: The ultrasonic sensor shows respiratory movement during sleep time and unwanted body movement during wakeup time

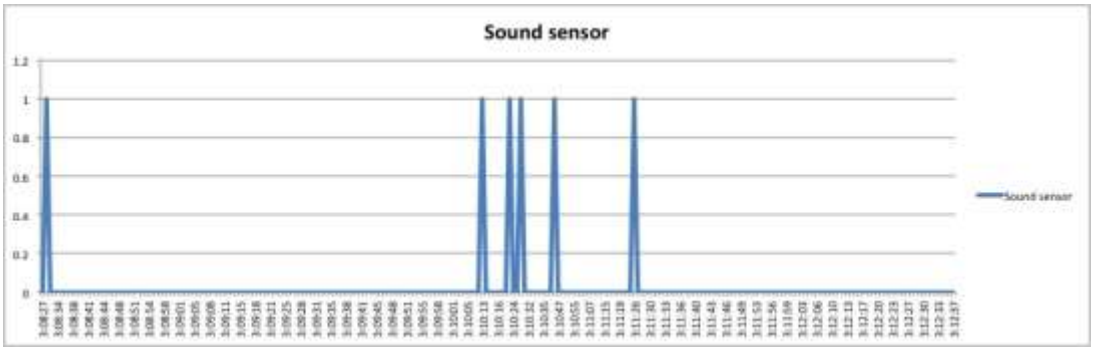

Fig. 15: Sound sensor reading to show when the baby cried

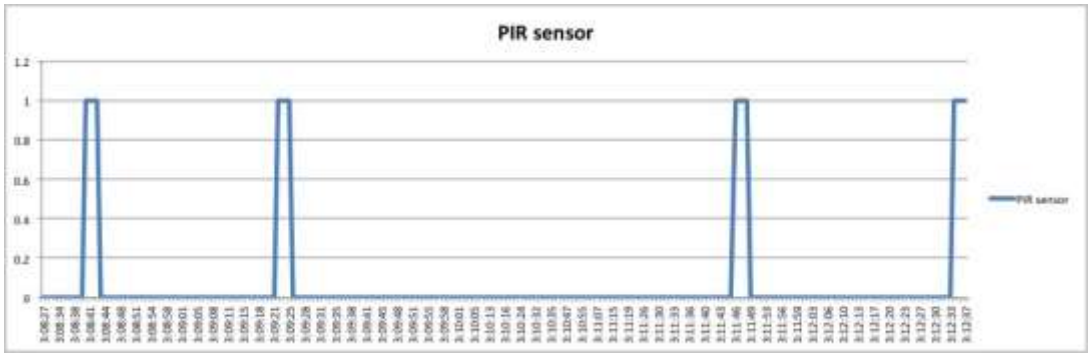

Fig. 16: PIR sensor reading to find unwanted movement near the baby cradle

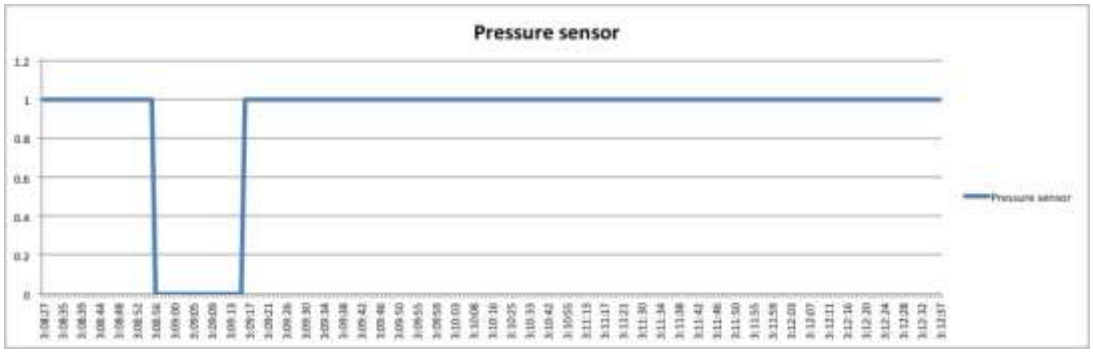

Fig. 17: Pressure sensor indicates the presence of a baby in the cradle

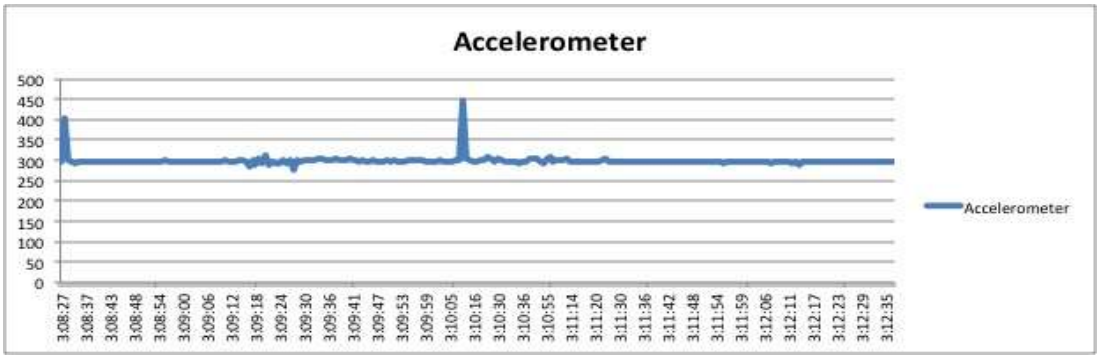

Fig.18: Accelerometer shows the cradle swing movement

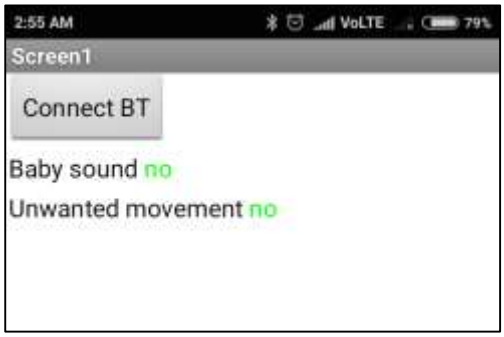

Fig. 19: The mobile app after connected with the Bluetooth module shows no unwanted movement around baby cradle and baby is not making a sound.

Fig. 20: The mobile app after connected with Bluetooth module shows unwanted movement around baby cradle found and baby is not making a sound.

Fig. 21: The mobile app after connected with the Bluetooth module shows unwanted movement around baby cradle found and the baby is making a sound (crying).

Finally, the system as designed worked properly and all the sensor readings are considered for the analysis of baby behavior (like sleeping hours and how frequently baby need attention).

6. CONCLUSION

The Implementation of smart baby monitoring cradle system is executed in real-time. And the system monitors baby's respiratory movements without any hurdle during baby sleep time. The activity of audio play and cradle swing performed by the system as described. The system is implemented for private purpose in the home as well as for the maternity and neonatal centers.

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