

Baby Breathing Monitoring System

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Introduction



Main goals:

1. Real-time monitoring of breaths per minute (BPM)
2. Immediate apnea detection & alert
3. Safe, low-cost, and easy for parents and caregivers to use

How it is achieved :

1. Use an accelerometer to detect chest movement and compute breaths per minute.
2. Alerts via LED and buzzer when breathing is irregular or absent.

What is Baby Breathing Monitoring System?

Baby breathing monitoring refers to the continuous tracking of an infant's breathing patterns to detect normal respiration as well as dangerous pauses, known as apnea.

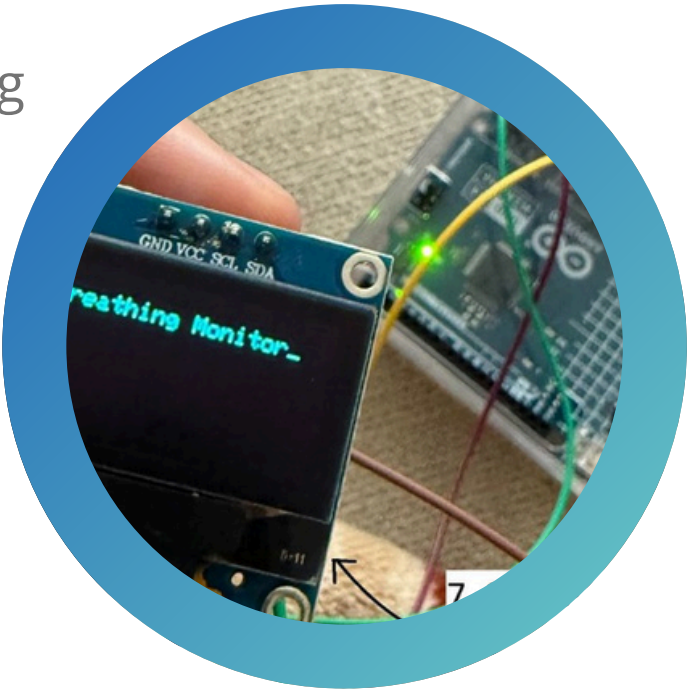
Since SIDS is a leading cause of infant death and traditional baby monitors cannot identify breathing anomalies, a specialized monitoring system is needed. Such a system observes the rise and fall of the infant's chest in real time and immediately triggers alerts if breathing becomes irregular or stops for 10 seconds or more, allowing caregivers to respond before a critical situation occurs.



System Features

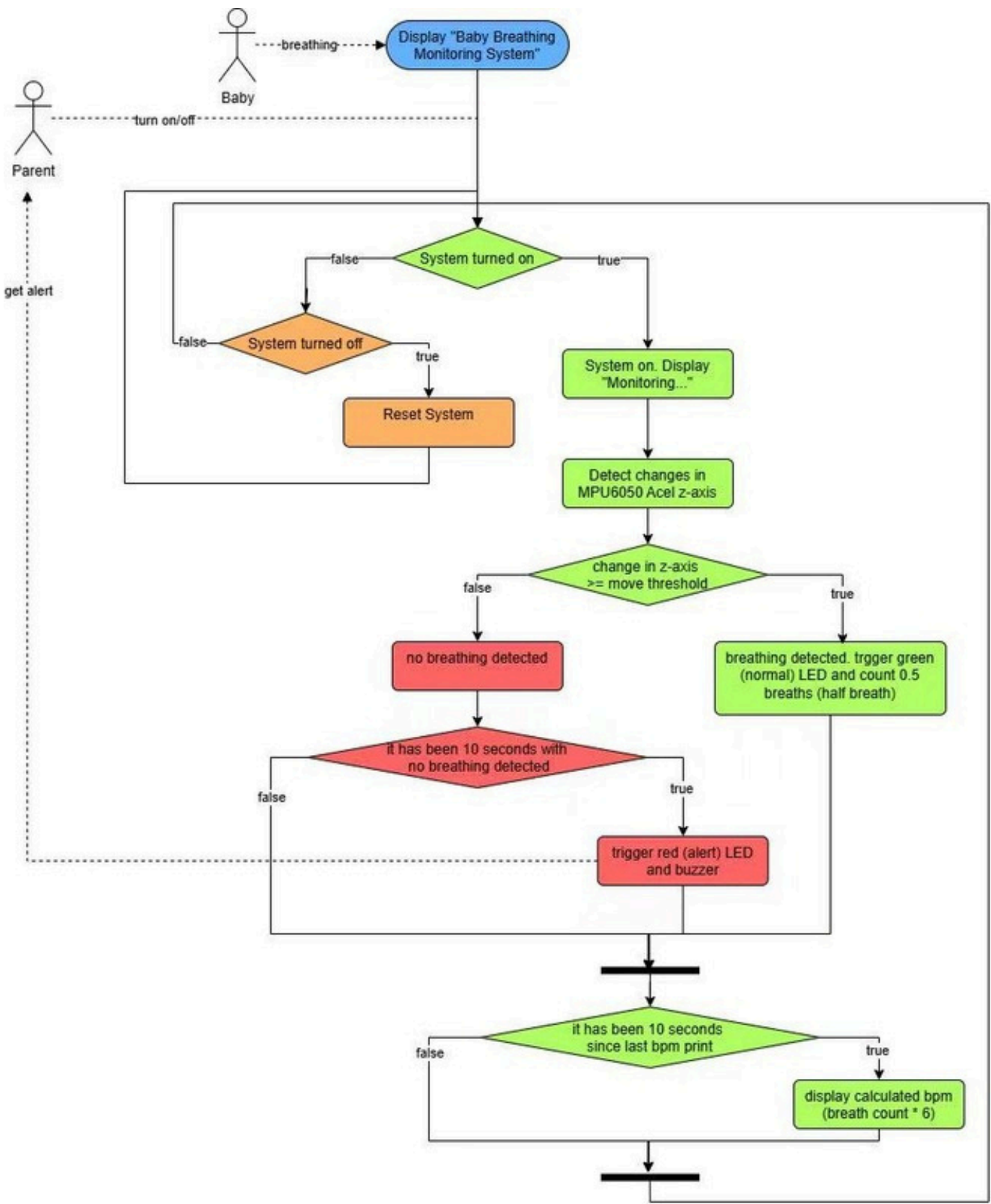
Hardware Features:

- **MPU6050 accelerometer:** Detects rise/fall of chest (Z-axis).
- **SSD1306 OLED display:** Shows BPM every 10 seconds.
- **Alert system:** Red LED + Buzzer for apnea
Green LED for normal breathing
- **Start/Stop push buttons:** User control.
- **Arduino Uno-based real-time execution.**



Software Features:

- **Calculates BPM:** breath count over 10 seconds $\times 6$.
- Detects apnea **after 10 seconds of no movement.**
- **Hard real-time constraint:** Button presses recognized <100 ms.
- Debouncing of **accelerometer.**



Challenges Encountered and Overcame

| | Challenges | Solutions |
|---|--|--|
| 1 | <p>Hardware Availability & Assembly</p> <p>Early testing was delayed due to missing jumper wires and the need to solder the MPU6050, during which our first sensor was accidentally damaged—likely from incorrect soldering.</p> | <ul style="list-style-type: none">• Ensured correct soldering + stable wiring (we appreciate the help from TA Nick and Austin).• Completed individual testing of every component (except resistors tested with LEDs). |
| 2 | <p>Incorrect Voltage Supply Caused MPU6050 Malfunction</p> <p>The MPU6050 was mistakenly powered at 5V instead of 3.3V, leading to sensor malfunction and interference with the SSD1306 during physical testing.</p> | <ul style="list-style-type: none">• Corrected MPU6050 supply voltage to 3.3V.• Rechecked I²C operation—no address conflict found.• Updated initialization sequence for stable MPU6050 + OLED operation. |
| 3 | <p>Breathing Detection Accuracy</p> <p>To ensuring accuracy, fine-tuning the Z-axis sensitivity is required, improving the BPM calculation so each rise and fall was counted correctly, and setting an apnea timeout that accommodates normal 5–10 second breathing pauses without triggering false alarms.</p> | <ul style="list-style-type: none">• Created a stable breath-count algorithm:<ol style="list-style-type: none">1. Detect change ≥ 0.01 g2. Enforced minTimeBetweenBreaths (667 ms)3. Implemented 10-second BPM update cycle• Added debouncing to ensure reliable start/stop button behavior. |

Future Enhancement

● Non-Invasive System

The current prototype must attach the accelerometer directly to the infant's chest, which is not ideal. Our planned improvement is to adopt a contactless approach using TinyML and an infrared sensor (MLX90614) to detect warm airflow from the nostrils, allowing the system to evolve into a fully "contactless smart baby monitor."

● Improve Reliability & Scalability

We hope to introduce a central controller for timing, sensor fusion, and system self-checks, provide a simple UI for configurable thresholds and settings, and incorporate Bluetooth/WiFi connectivity to deliver real-time alerts directly to parents' phones.





THANK YOU



Our Reflection

This project allowed us to experience how real-time embedded systems can have a meaningful impact in real life. Designing a device that monitors infant breathing highlighted the potential of real-time technology to improve safety and support caregivers in critical situations. Even with a simple prototype, we saw how strict timing constraints, reliable sensing, and immediate alerts can make a real difference.

Conclusion

This project deepened our appreciation for key concepts from Real-Time and Embedded Systems—deterministic behavior, hardware & software integration, and designing for correctness under time constraints. These ideas will continue to shape how we approach embedded devices in future work, reminding us of the responsibility behind building systems people can depend on.