# Final Project: Baby Monitor utilizing integrated microphone and CC3200 Launchpad

Marcos Alvear and Donggeon Kim
*College of Engineering*
*University of California, Davis*
Davis, USA
maalvear@ucdavis.edu, dgkkim@ucdavis.edu

## I. Description

This project aims to prototype a device that utilizes a simple microphone that will be integrated with an external circuit that will be mounted in a corner of a room to analyze and notify the user of a loud noise/cry. The system leverages the CC3200 Launchpad for processing and is the center of communication between all the parts of the system like the OLED screen, the TV remote User input, and the email push notifications. Utilizing the CC3200's onboard WiFi module we will communicate with AWS IoT for email notifications that will contain the machine states and volume detected level. This information will also be displayed on an OLED screen using SPI communication and will be the GUI for the User to interact with the system. The user will interact with the device using a Universal TV remote that will interact with the system via an IR signal receiving circuit, making the system an easy to use and set up system that can be utilized in a family home.

## II. Design

### A. Functional Specification

The high-level behavior of the product is represented through a state machine. The system transitions through states based on the sound signals detected by the microphones, processing these signals to determine the sound's location.

- **Idle State**: The system waits for the User sent TV remote start signal to begin monitoring.
- **Monitoring State**:Upon activation with the ST command, the system continuously monitors sound levels through the integrated microphone
- **Detection State**:When a loud noise is detected, the system will send an email notification containing the state and volume information.
- **Notification State**: The system updates the OLED display with the "baby is crying" screen and triggers the Leds to flash.
- **Reset State**: After input from the User, the system resets and returns to the Monitoring State for further detections.

### B. System Architecture

The architectural block diagram (refer to the provided diagram) outlines the main components of the system:

- **CC3200 Launchpad**: The core processing unit, handling sound signal processing and communication.
- **Microphone**: Integrated microphone placed in the room to capture sound.
- **OLED Display**: Displays the state of the machine in the program and is the GUI for users.
- **WiFi Module**: Onboard the CC3200 Launchpad, used for sending email notifications via AWS IoT.
- **IR signal Module**: The Universal TV remote sends signals to the IR receiver, used for sending start and stop commands to the device.

Each component interacts as follows:

- The **CC3200 Launchpad** acts as the head of the system as all information between parts passes through various communication methods.
- The **OLED display** acts as the GUI terminal for the User to interact with the system and to understand which state the machine is in.
- The **IR signal Module** captures signals sent by the universal TV remote controller to receive input from the User for the system.
- The **microphone** captures sound levels and send the data to the CC3200 Launchpad through the ADC input pins.
- The **WiFi module** that is embedded on the board communicates with AWS IoT to send an email notification with the state and volume information.

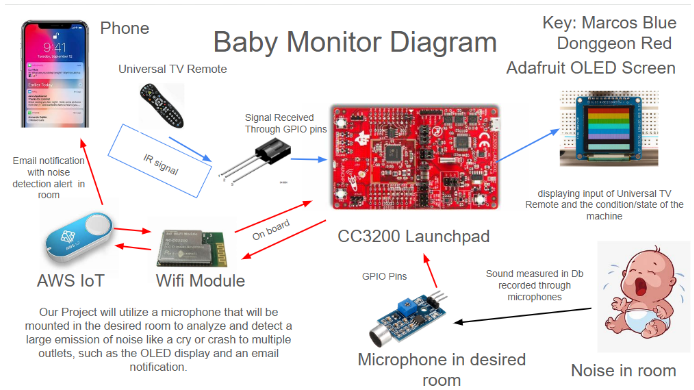



Fig. 1. A High level block diagram showing how each of the parts of the system interact with one another

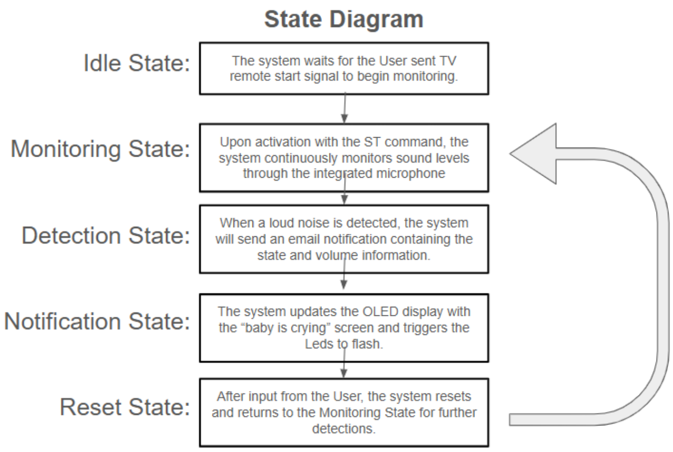



Fig. 2. A State Diagram showing how the system will flow through it's high-level behavior

## III. Implementation

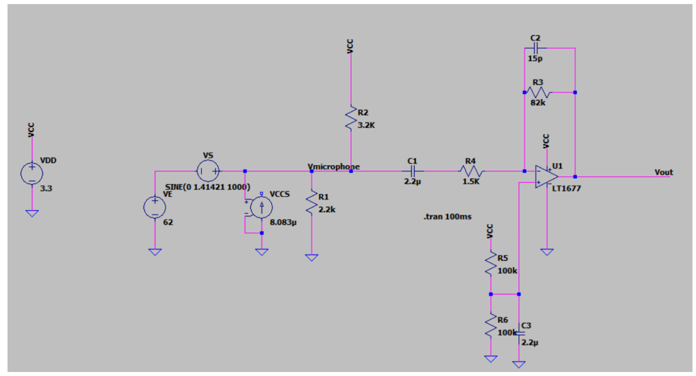
The implementation of the baby monitor system involved both hardware setup and software development. Each component played a crucial role in achieving the overall functionality of the system.

### A. Hardware Implementation

The hardware setup required connecting all necessary components to the CC3200 Launchpad. The key steps were as follows:

- **IR Module Connection**: The IR receiver module from lab 3 for the TV remote controller was connected to one of the GPIO pins on the CC3200 Launchpad. This allowed the system to receive and decode signals sent from the remote.
- **OLED Display Connection**: The OLED display was connected to the SPI pins of the CC3200 Launchpad just like in lab 2. Since the communication was unidirectional (from the Launchpad to the OLED), the MISO pin was not used. This setup enabled the display to show real-time status updates and user interactions.
- **Microphone Connection**: The microphone was connected to one of the ADC pins on the CC3200 Launchpad. Due to the microphone's output voltage potentially exceeding the ADC pin's maximum voltage of 1.8V, we implemented a voltage limiter circuit using an operational amplifier (opamp), resistors, and capacitors to ensure safe voltage levels.
- **WiFi Module**: The CC3200 Launchpad's onboard WiFi module was used to connect to AWS IoT for sending email notifications like in lab 4. This module is integrated into the CC3200 hardware and did not require additional connections.

**Circuit Diagram for Microphone:**




### B. Software Implementation

The software implementation involved programming the various modules to interact with the hardware components and AWS IoT. The primary tasks included:

- **IR Module Programming**: The software for the IR module captured all signal data from the remote controller when a button was pressed. It decoded these signals to identify which button was pressed and used a GPIO handler to trigger interrupts accordingly. This allowed the system to respond to user inputs via the remote controller.
- **OLED Display Programming**: The OLED display was controlled through the SPI protocol. We configured the necessary pins and programmed the communication sequence to send messages to the OLED. This included initializing the display, setting cursor positions, and updating the screen with text and graphics to show system status and user interactions.
- **Microphone Programming**: The microphone's analog signals were converted to digital values using the ADC pin. The software monitored the voltage levels to detect loud noises. When a loud sound was detected, the system triggered an event to send a message to AWS IoT.
- **AWS IoT Integration**: We set up an Internet of Things (IoT) configuration on AWS and downloaded the necessary keys to allow the CC3200 Launchpad to access the IoT services. The software was programmed to send HTTP POST requests to AWS IoT whenever a loud sound was detected. AWS IoT then processed these requests and sent email notifications with the detected sound information.

Each of these steps involved detailed coding and configuration to ensure that the components interacted seamlessly. The integration with AWS IoT provided a reliable method for sending notifications, enhancing the system's utility for real-world applications.

## IV. Challenges

During the implementation of the baby monitor system, we faced several challenges that required thoughtful analysis and problem-solving strategies. This section discusses these challenges, the observations made, the thought processes involved, and the steps taken to address them.

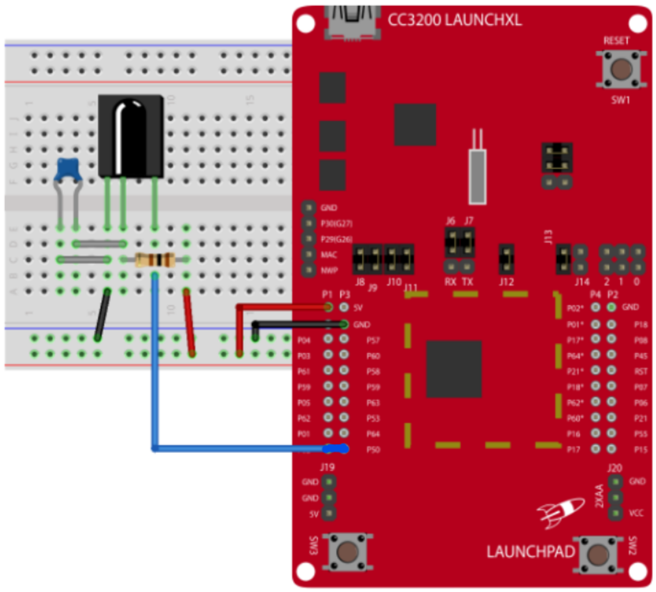



Fig. 3. State Diagram

### A. Microphone Voltage Compatibility

One of the initial challenges we encountered was the voltage compatibility between the microphone module and the ADC pins on the CC3200 Launchpad. The microphone module we intended to use operated at a maximum voltage of 5V, whereas the ADC pins on the CC3200 Launchpad could only handle a maximum voltage of 1.8V. Connecting the microphone directly to the ADC pins risked damaging the Launchpad.

**Solution:** To address this issue, we decided to use a voltage limiter circuit to cap the voltage at 1.8V before feeding the signal into the ADC pins. This involved using ——— to ensure the voltage remained within safe limits. After implementing the voltage limiter, we successfully interfaced the microphone with the CC3200 without exceeding the ADC pin voltage threshold.

### B. ADC Pin Functionality

Another significant challenge was the inconsistent functionality of the ADC pins. Some ADC pins did not appear to work correctly, leading to unreliable sound level readings from the microphone. This inconsistency hindered our ability to obtain accurate sound data.

**Solution:** We conducted a systematic troubleshooting process to identify functional ADC pins. This involved testing each ADC pin individually with a known voltage input and observing the output. Pins that did not provide accurate readings or any readings at all, were ruled out. We eventually identified a set of functional ADC pins that would work for the individual microphone but no other microphones could be Incorporated. We then adjusted our circuit design to use only the verified ADC pins, which improved the reliability and functionality of our sound detection.

### C. Flashing the Program to the CC3200 Board

Flashing the program to the CC3200 board presented another major challenge. Initially, the program would only run correctly when executed directly from the laptop. Attempts to flash the program to the board for standalone operation were unsuccessful, which limited the system's usability.

**Solution:** After numerous troubleshooting attempts, including verifying connections, updating firmware, and re-flashing the program, we concluded that the issue might lie with the hardware itself. We decided to use a new CC3200 board, which resolved the issue. The program flashed correctly and ran independently of the laptop. We hypothesized that the initial board might have had hardware defects, such as faulty flash memory or corrupted bootloader firmware, which prevented successful flashing.

### D. General Debugging and Integration Issues

Throughout the project, we encountered various debugging and integration issues, such as synchronization problems between the microphone input and the OLED display updates, and occasional failures in sending notifications through AWS IoT through network errors.

These challenges provided valuable learning experiences and highlighted the importance of thorough testing, systematic troubleshooting, and adaptability in project development. Despite the difficulties, we successfully developed a functional baby monitor system that met the project requirements.

## V. Future Work

While the current implementation of the baby monitor system successfully detects loud noises and sends notifications, several additional features and improvements can enhance its efficiency and performance.

### A. Additional Microphones

Integrating more microphones into the system can significantly improve the accuracy of sound detection and location. With a greater number of microphones, the system can better triangulate the sound source, providing more precise information about the location of the noise within the room. This enhancement would require additional ADC channels on the CC3200 Launchpad and more sophisticated signal processing algorithms to analyze the inputs from multiple microphones.

### B. 3D-Printed Casing

A custom 3D-printed casing to house the electronics can provide better protection and organization for the components. The casing can be designed to include proper ventilation for the microphone and IR receiver, as well as secure mounting points for the CC3200 Launchpad and OLED display. Additionally, a well-designed casing can improve the aesthetic appeal of the device, making it more suitable for use in a family home environment.

### C. Displaying Volume Levels on OLED

Adding functionality to display real-time volume levels on the OLED screen can provide users with immediate visual feedback on the noise detected by the system. This feature would involve updating the OLED display code to include a graphical representation of the volume levels, such as a bar graph or numerical readout. This enhancement can help users quickly assess the noise environment in the room and understand the severity of the detected sounds.

### D. Advanced Sound Filtering

Implementing advanced sound filtering algorithms can improve the system's ability to distinguish between background noise and significant sounds, such as a baby's cry. Techniques such as noise reduction, adaptive filtering, and machine learning-based sound classification can be explored to enhance the reliability of sound detection. This improvement would require additional computational resources and potentially more advanced processing capabilities on the CC3200 Launchpad or an auxiliary processing unit.

### E. Integration with Smart Home Systems

Future work could also explore the integration of the baby monitor system with existing smart home ecosystems, such as Amazon Alexa or Google Home. This integration can enable voice commands to control the system and allow notifications to be sent through smart home devices. Additionally, the system could be configured to trigger other smart home actions, such as turning on lights or playing a lullaby when a loud noise is detected.

By incorporating these additional features and improvements, the baby monitor system can become a more robust, user-friendly, and efficient solution for monitoring a baby's environment and providing timely notifications to caregivers.

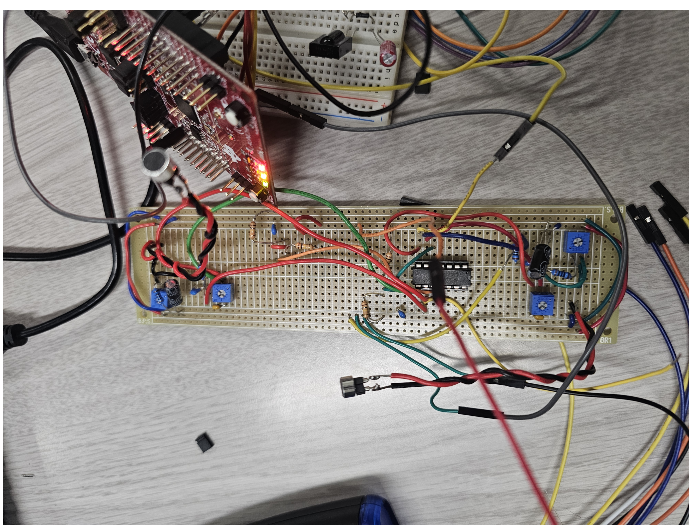


Fig. 4. The microphone module of the project

## VI. Bill of Materials

The anticipated materials and their costs are listed below:

TABLE I
BILL OF MATERIALS

| Component | Cost | Source |
|---|---|---|
| CC3200 Launchpad | \$0.00 | Class Provided |
| OLED Display | \$0.00 | Class Provided |
| IR Circuit and Remote Control | \$0.00 | Class Provided |
| Microphone | \$1.25 | Amazon |
| Miscellaneous (Wires, Breadboard, etc.) | \$10.00 | Amazon |