NEXASENSEE

EE40190 Senior Design II

Design Review 0

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System Block Diagram

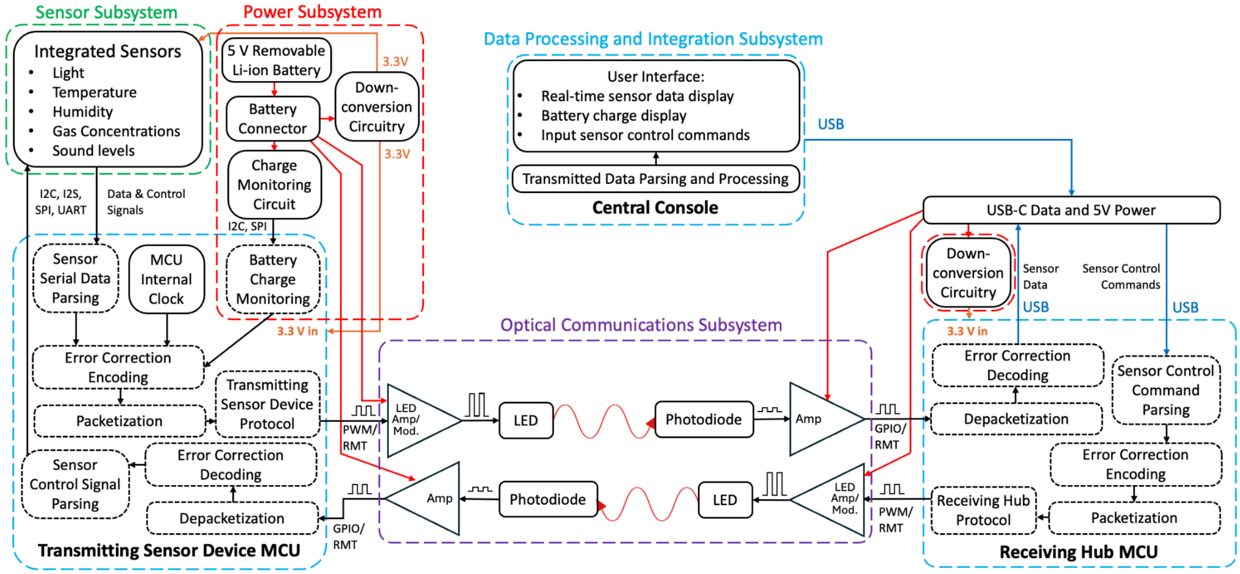

Figure 1. Full System Block Diagram

The following section specifies lower-level requirements for the different major subsystems of this project and provides a block diagram to visually represent the overall system architecture and the interfaces between subsystems. This project's major subsystems are:

1. Sensor subsystem
2. Optical communication subsystem
3. Power subsystem
4. Data Processing and Integration Subsystem

Sensor Subsystem Description and Interface Requirements

The sensor subsystem is responsible for collecting real-time environmental monitoring data, specifically light, temperature, humidity, gas, and sound levels. Data collected from individual sensors will be processed to extract desired parameters and time-stamped before transmission, to be performed by a central microcontroller. Central microcontroller software will manage to collect data from multiple sensors simultaneously.

To satisfy data sampling rate requirements (continuous sampling or interrupt-based sampling), standard serial communication interfaces, including SPI, I2C, and I2S, have transmission speeds of at least 100 kbits/s and are, therefore, satisfactory for this subsystem.

Optical Communication Subsystem Description and Interface Requirements

The optical communication subsystem will be responsible for reliable optical transmission and reception of data and control signals between the transmitting sensor devices and the receiving hub devices.

High-speed electrical signals to modulate the LED intensity can be outputted by I/O microcontrollers using pulse width modulation pins (PWM). Lower-level peripherals, such as ESP32's remote control transceiver (RMT) peripheral, will output and read out faster signals if needed. To ensure the received photodiode signal can be distinguished from noise, electrical amplification of the output microcontroller logic signals and received photodiode signals will be implemented. The amplified photodiode signals can be read out by high-speed digital GPIO pins. Power to electrical amplification circuitry is provided by the power subsystem.

To ensure reliable optical transmission, the central microcontrollers from the data processing and integration subsystem will also be used to encode and decode error-correcting codes. If needed, multiple receiving hub devices will also be implemented to introduce redundancy.

Communication protocols are required to manage multiple devices transmitting and receiving on the same optical link: With all communications occurring on the same wavelength, each device will have an assigned address to either be transmitted in a packet preamble or hard-coded for a specific time bin. Communication protocols will also be implemented on the central microcontrollers from the data processing and integration subsystem.

Power Subsystem Description and Interface Requirements

The power subsystem will provide stable power to all components. For the transmitting sensor devices, the internal power source will be a removable lithium-ion battery with downconversion circuitry for lower voltage devices. There must also be battery power monitoring circuitry controlled by the microcontrollers of the sensor subsystem. The receiving hub devices will be powered by its USB-C connection to the main console.

Data Processing and Integration Subsystem Description and Interface Requirements

The data processing and integration subsystem will be responsible for processing sensor data, implementing error-correcting codes, and managing communication protocols for the optical communication subsystem. This subsystem will also be responsible for gathering and storing data transmitted over the optical communication link and for providing a user interface for real-time display of environmental parameters and control of individual sensors. In each room, receiving hub devices receive environmental monitoring data from the sensor subsystem via the optical communications subsystem and transmit that data via a high-speed link (USB) to a central console. The receiving hub device also transmits control signals received from the central console to the sensor subsystem. The central console processes the transmitted data and provides the user interface.

NEXESENSEE's High-Level Design Document is linked here.

Timeline

- Week of 1/20 - Design Review 0
- Week of 1/27
  - Experiment with different optical components for communication system
    - Design associated amplification circuitry on breadboard
  - Develop a test plan for sensor calibration
  - Order and test sensors - ensure resolution, accuracy, and speed are satisfactory
  - Wired serial communication protocols to use (move to next week?)
- Week of 2/3 - Update Meeting
  - Interface sensors with dev board using wired serial communication protocols
    - Ensure MCU can timestamp collected data
  - Test battery management and monitoring circuitry with dev board
    - Estimate expected battery life
  - Determine and test optical communications protocol (move to next week?)
- Week of 2/10
  - Simulate communication link with associated signal processing (create data packets with error correction)
- Week of 2/17 - Design Review 1: subsystem designs, including major components and connections, as well as unsolved problems
  - Implementation of different subsystems with individual dev boards + breakout/breadboards
  - First iteration of board designs to be completed for review at update meeting
- Week of 2/24
  - Iterate board based on feedback
  - Begin creation of GUI for the central console (before DR 1?)
  - Design 3D housing for the receiver and transmitter modules
  - Assemble working prototype for each subsystem
- Week of 3/3 - Design Review 2: hardware demonstration of each subsystem, with initial board design
  - Demonstrate data acquisition, timestamping, and transmission over wired link to MCU
  - Show optical transmission and reception
  - Validate battery life estimates under operational conditions
  - Display real-time sensor data on GUI
  - Place board orders
  - Print housing