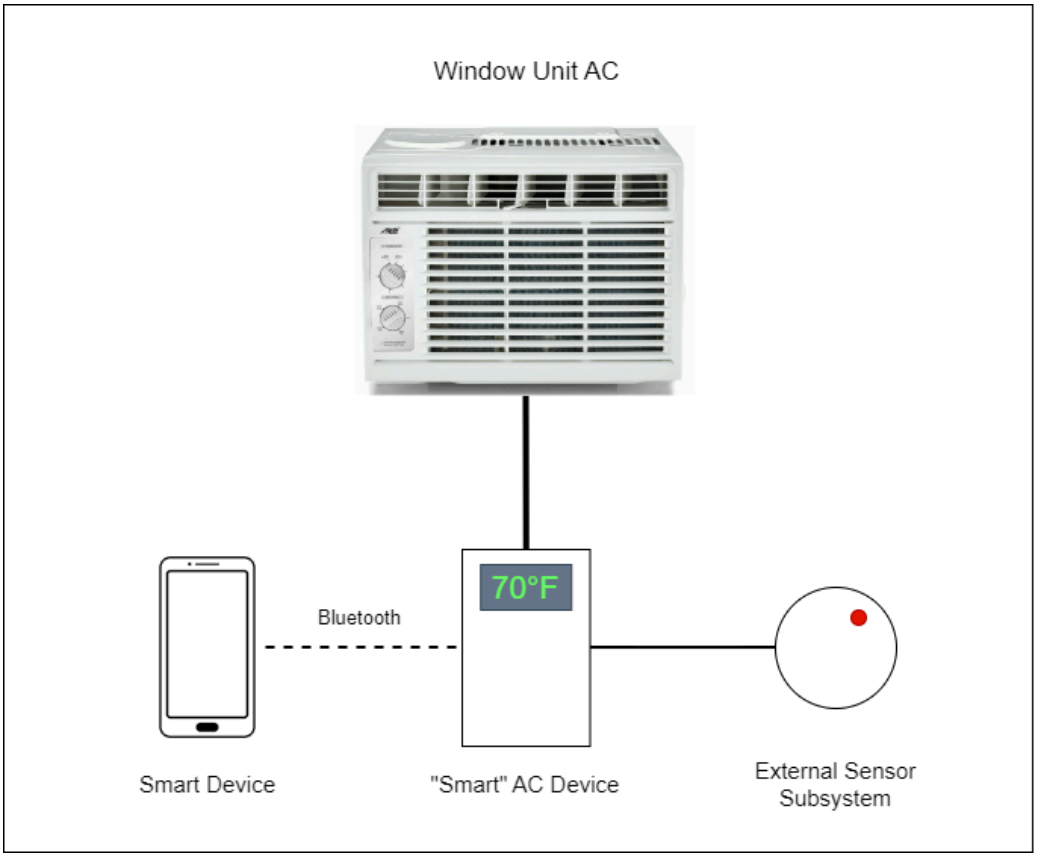
Smart AC Units

1. **Introduction**
    a. **Problem:**
        i. In the United States, about a third of homes lack a central air conditioning system. While some homes are in climates where they do not need a robust air conditioning solution, most other homes rely on window units for their air conditioning. This is especially true in communities with older homes, such as New York City and Boston. Many of these older homes use “dumb” wall-mounted AC units that are inefficient and manually set. We want to target these homes and make them more efficient through “smart” AC control units. These “smart” AC control units that make up most of the market are exclusively to be used with central air conditioning systems, many of which allow you to integrate voice assistants and other AI services. And although there exist “smart” wall-mounted units, these are often equipped with proprietary solutions that exclusively work with certain brands of expensive window units or are, themselves, expensive devices that simply modulate the voltage going inside the AC unit without changing the physical settings of the unit. With our Smart AC Unit system, we believe that we can accomplish a more efficient and equitable experience for those with window unit ACs and ensure optimal ease of access as well as a lower power bill. As the central air conditioning market advances in the technology available to make the air conditioning experience easier, such advances and improvements are lacking in homes that do not have central air conditioning.
    b. **Solution:**
        i. Our proposal is a multipart system combining temperature and humidity sensors, servo motors, and central control units to allow for window-mounted ACs to be automatically controlled through an application on one’s smart device. Our “smart” AC device will be able to latch on top of the knobs of a window unit AC and, with the help of the User Application available on their mobile device, be able to adjust the knobs remotely to the settings of the user’s choosing. The main system relies on sensor units, control units, and mobile devices. The prototype device will be tested on a 5000 BTU Arctic King window air conditioner.

c. Visual Aid:

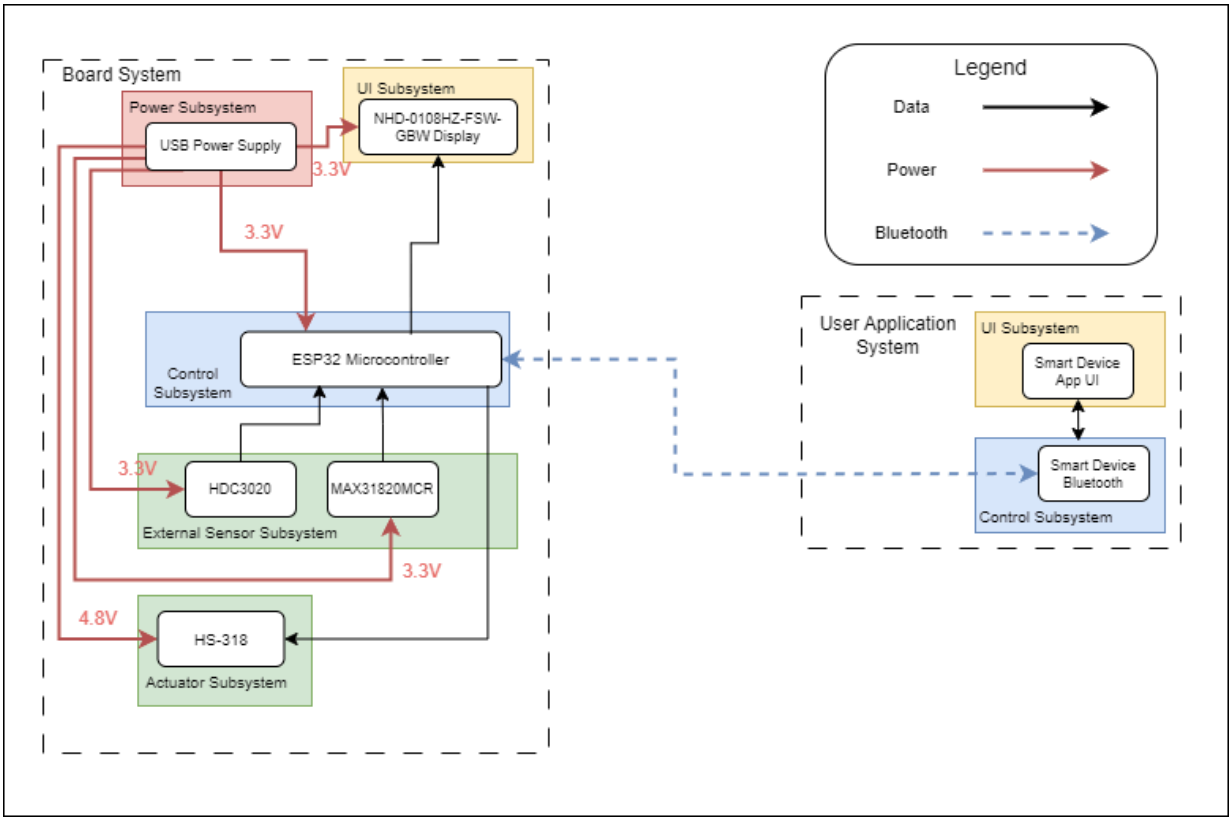


d. High-Level Requirements List:

i. The AC Unit can be controlled and changed following signals from the temperature sensors
ii. The sensor unit can accurately read the current room temperature
iii. Mobile Devices able to communicate with the AC System
iv. Change AC temperature whenever and wherever via one's smart device
v. Automatically set time ranges for AC use to increase the efficiency of the unit

2. Design

a. Block Diagram:



b. Subsystem Overview:

i. Air Conditioner System (Smart AC device)

1. Power Unit
    a. The Smart AC itself will need to be powered with enough voltage to be able to power the two motors responsible for turning the knobs on a 5,000 BTU Arctic King window air conditioner as well the temperature and air quality sensors.
    b. The goal is to have the entire control and sensor units powered by USB power through a wall outlet. This necessitates a voltage regulator to ensure the correct voltage to the microcontroller and the Servomotors, which will both operate at 4.8-5V. We will likely use a USB based power.
2. Sensor Unit
    a. The Smart AC device will be equipped with a temperature sensor to read the temperature of the room, and thus, regulate the temperature to the temperature selected by the User Application. The Smart AC device will also be equipped with an air quality sensor which enables the air

quality of the room to be read and communicated to the user through the User Application.

b. We will use the MAX31820MCR digital temperature sensor made by Analog. Has +- 2F temperature accuracy. If more accurate sensors are necessary we may use the MCP9808 with a +-.0625C temperature accuracy. Our humidity detector will use an HDC3020 IC made by Texas Instruments. These temperature sensors will be held by thin cables that connect them to the main AC unit such that they can be spaced far enough away from the Main AC unit to avoid regional cold spots near the AC unit.

3. Control Unit
    a. The control unit of the Smart AC device system will be capable of changing the settings of both the temperature and cooling knobs of the Arctic King window air conditioner. If the temperature set by the User Application is higher or lower than that measured by the Sensor Unit, the Control Unit is responsible for adjusting the air conditioner settings to ensure that the room temperature stays constant. These will interface with an ESP32 microcontroller to calculate the heat index. The Control Unit should also be able to be Bluetooth interfaced with the mobile device and the user application.
    b. The heat index calculation is well known: https://www.wpc.ncep.noaa.gov/html/heatindex_equation.shtml. However, if we are unable to get enough precision we can always load a look-up table into the microcontroller. This should be well enough given the 16MB of flash memory the ESP32 has.
4. Knob Actuation
    a. The knobs of the smart device should be able to toggle the settings of the AC unit. This will be accomplished by two HS-318 actuators which will manipulate the knobs on the AC unit. If the HS-318 does not have enough torque to turn the knobs we will gear the output down.
5. Display
    a. Simple display to be able to display the desired temperature. Will use NHD-0108HZ-FSW-GBW from Newhaven Technologies to display the status and current set temperature of the room.

ii. Mobile Device System (User Application)

1. UI Unit
    a. The user applications contain all the necessary features to read the current room temperature, turn on/off the AC

system, change and schedule temperatures, change fan speeds, etc.

2. Control Unit
    a. The user application will be able to communicate with the Smart AC device via Bluetooth and/or Wi-Fi.

c. Subsystem Requirements:

i. Power Unit
    1. Must have a supply voltage that can consistently power the entire system through the USB connector.

ii. Sensor Unit
    1. Successfully measure humidity within ±1% of the room's Real Humidity.

iii. Control Unit
    1. Efficiently collect data from sensors and control the actuators accordingly by the settings inputted by the user. As well as that, communicate with the user's smart device via bluetooth.

iv. Knob Actuation
    1. Manipulate the knobs of an Arctic King window unit to change its cooling settings.

v. Display
    1. Visibly display the data received from the microcontroller.

vi. UI Unit
    1. Allow the user to seamlessly input their desired settings for a room's temperature.

vii. Mobile Control Unit
    1. Successfully relay user input to the "smart" AC Unit device via bluetooth.

3. Ethics and Safety

a. While developing the Smart AC Unit, the safety and ethical considerations are very important factors to keep in mind while proceeding. Regarding safety, we plan to stick to the strict protocols and regulations laid out and follow the correct procedures as we learned in our lab safety training. We plan on always having sufficient lab members present and carefully following all instructions and rules for safety. Moreover, our project shouldn't require anything that would require additional training to complete. In terms of ethics, we plan to uphold all standards in the 7.8 IEEE Code of Ethics sections laid out to ensure a safe and healthy professional working environment that would allow for a respectful, comfortable, and supportive working environment for the members of this team and towards other groups. Moreover, according to the ACM Code of Ethics, we plan on complying with all general ethical principles, professional responsibilities, and professional leadership principles. One specific code that we hold dearly is 7.8 IEEE Code of Ethics Section II where we respect and support our colleagues and fellow group members. Moreover, section 2.9 in the ACM Code of Ethics is also very important, as to protect all future user's information and ensure that there is

no potential misuse of our product. We can avoid these breaches by ensuring a safe and helpful workplace and ensuring proper testing, monitoring, and patching to avoid any potential safety concerns within our product.