WIRELESS SENSOR ARRAY FOR FOREST FIRE DETECTION

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Introduction

1

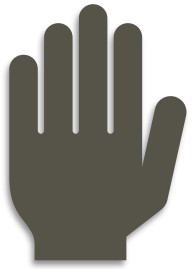
Forest Fire Detection system

2

A faster way to detect fires

3

Help stop fires before they get out of control



Prevent Single Node System Failure

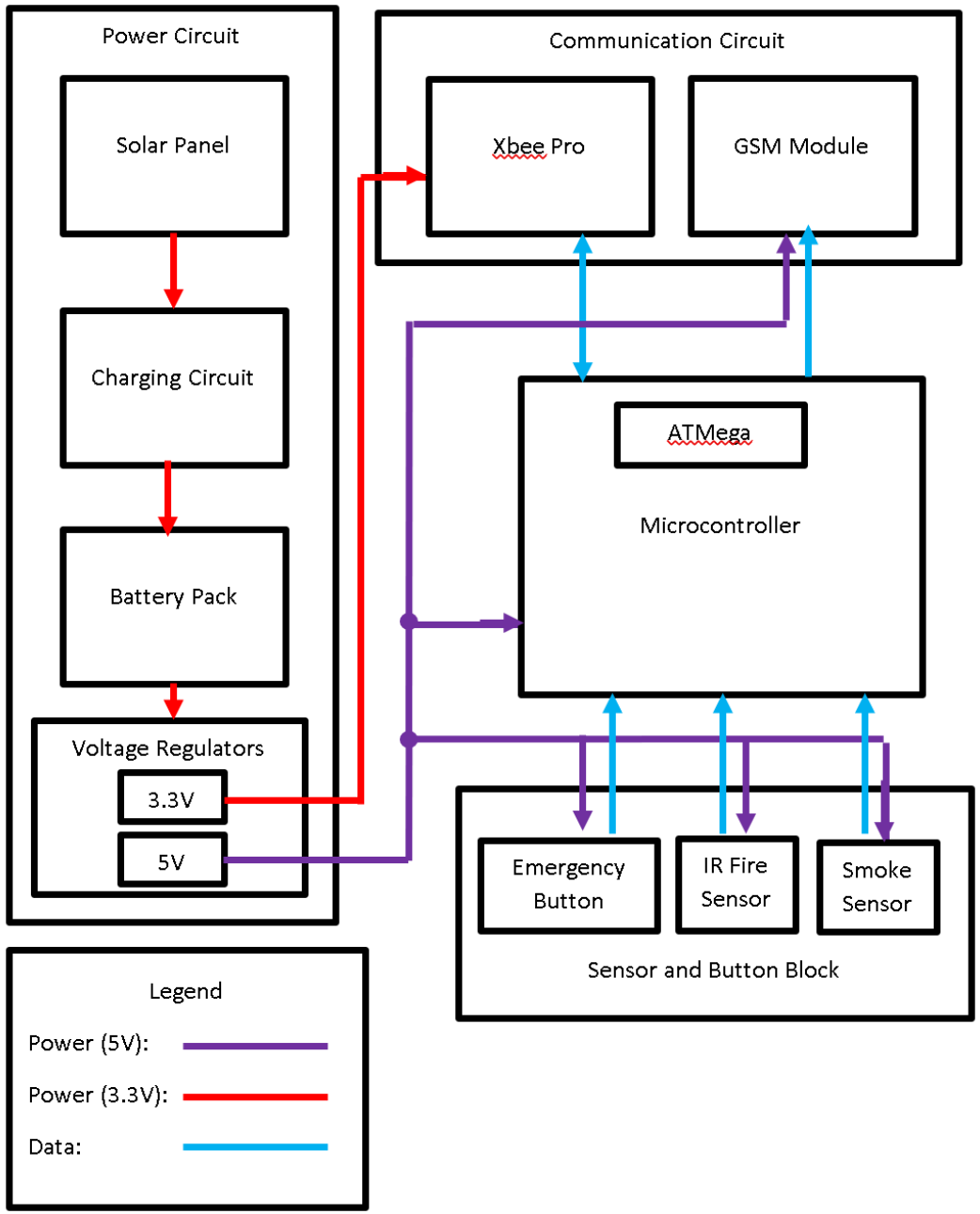
Provide a Low Maintenance Solution

Allow Real-Time Fire Detection

Objectives

Completed Design

- Three working, fully functional fire detecting units
  - 1 Gateway Unit
  - 1 Gateway/Router Unit
  - 1 Router Unit



BLOCK DIAGRAM

Create Mesh Network with Gateway and Router Nodes

Two Key Components

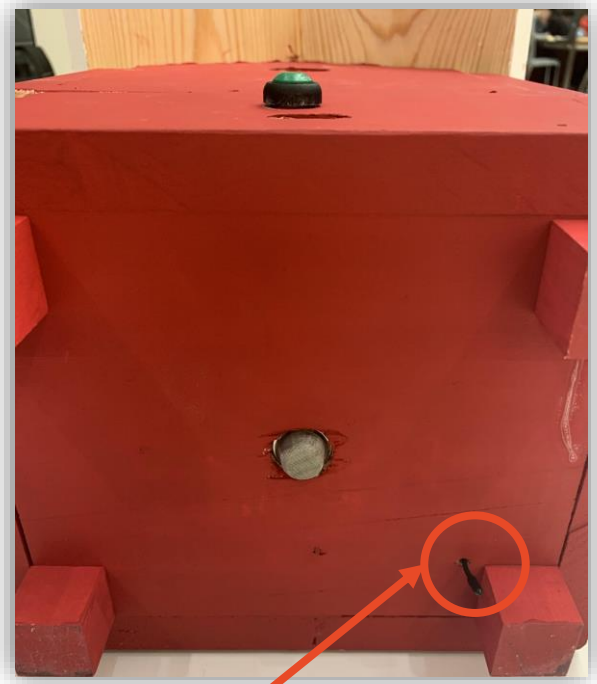
- GSM Module
  - Allows us to send text messages on 2G network
- XBee-PRO
  - Allows us to route messages
  - Allows us to send messages to multiple locations

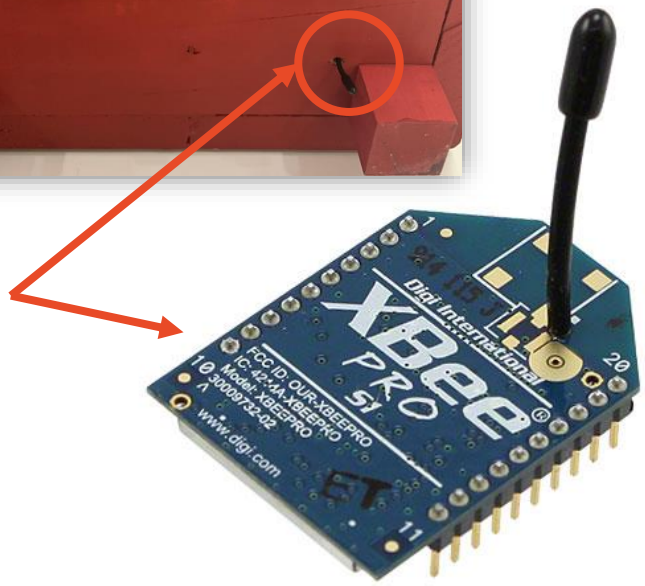
Prevent Single Node System Failure

Xbee-PRO

- Requirement:
  - Must be able to communicate with other XBees at distances up to 100m in forested areas

- Verification:
  - Went to the Arboretum (forested area)
  - Took two XBees began transmitting data
  - Moved XBees away from each other until the message was no longer being received





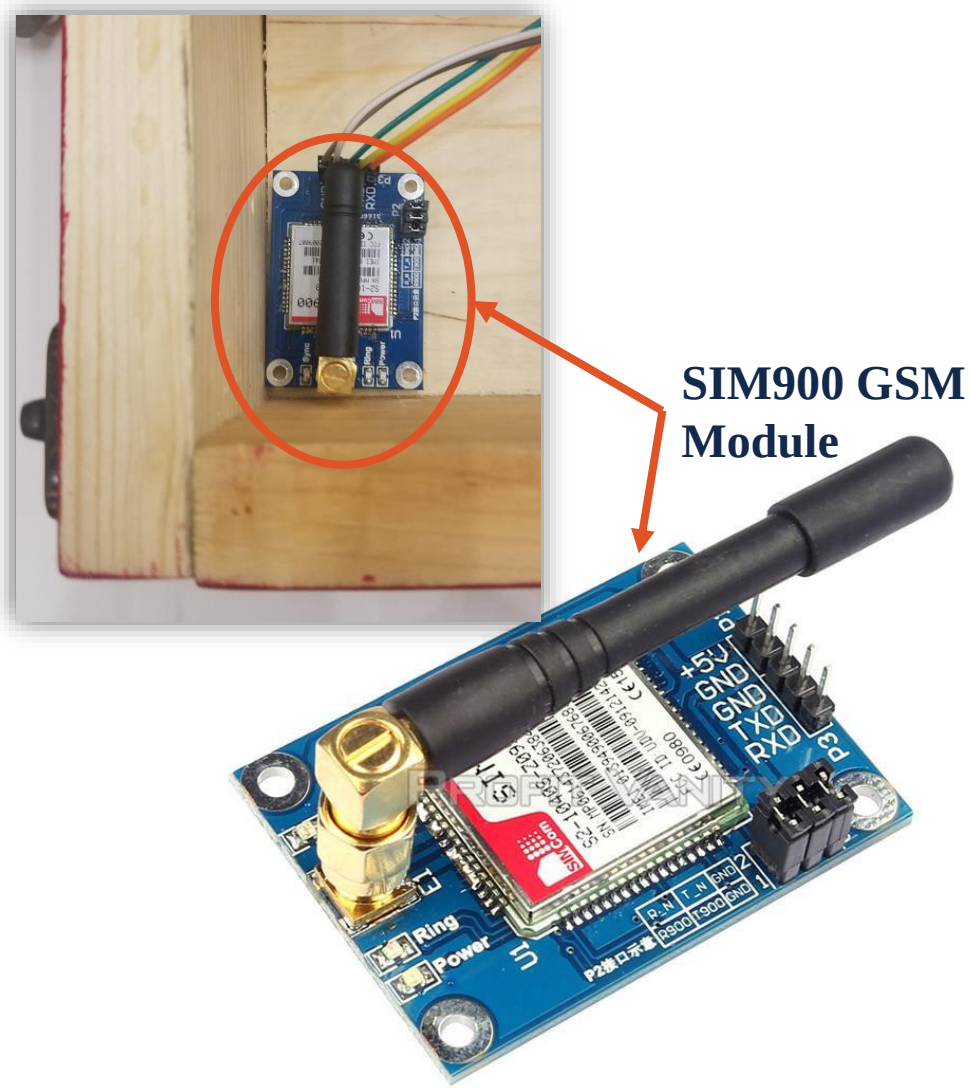
XBee-PRO Data

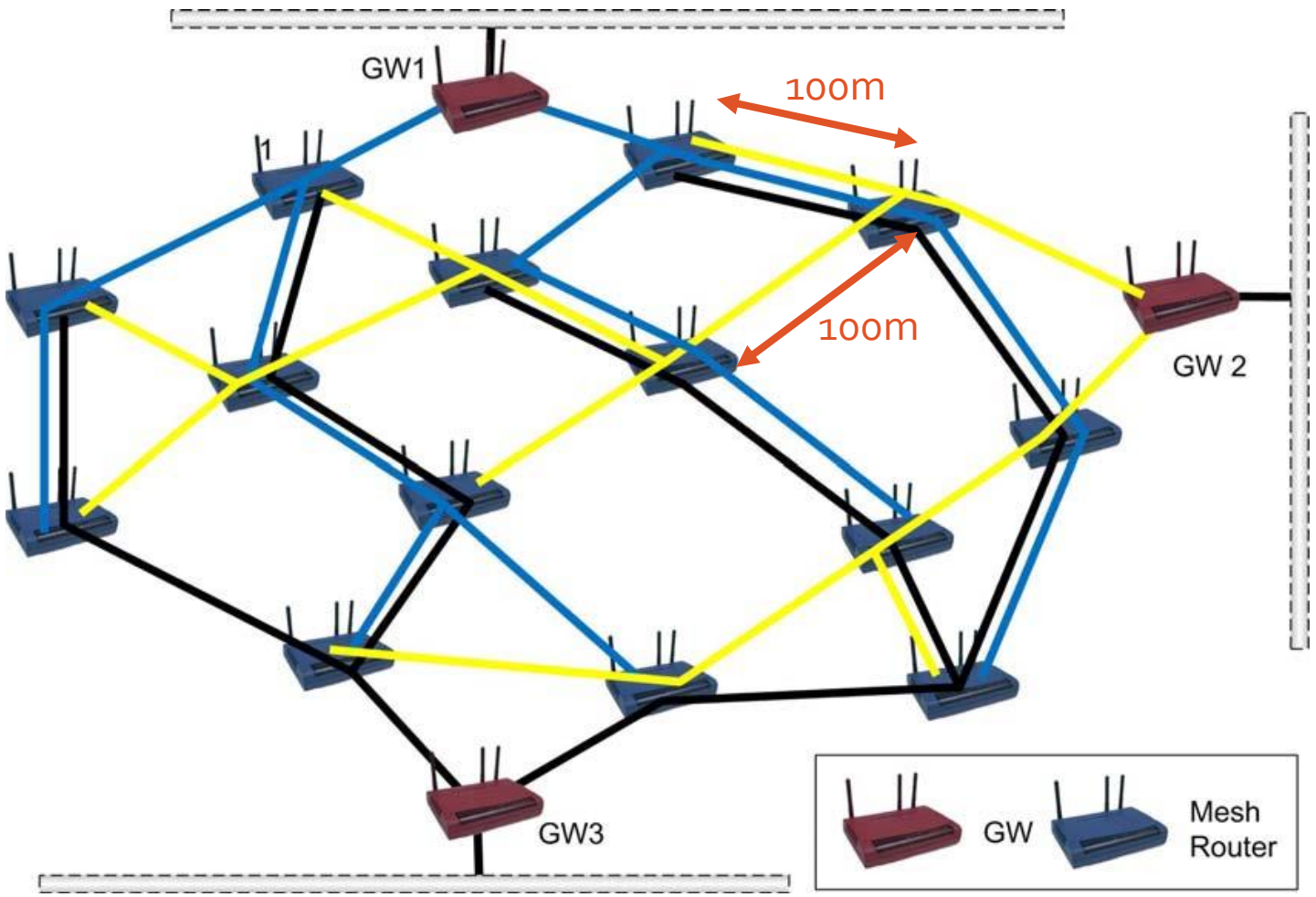
XBee-PRO Communication Distance	
Trial Number	Maximum Measured Communication Range (meters)
1	110
2	157
3	108
4	269
Average	**161**

GSM Module

- Requirement:
  - Must be able to connect to a 2G GSM network when the Gateway Node is in a remote location

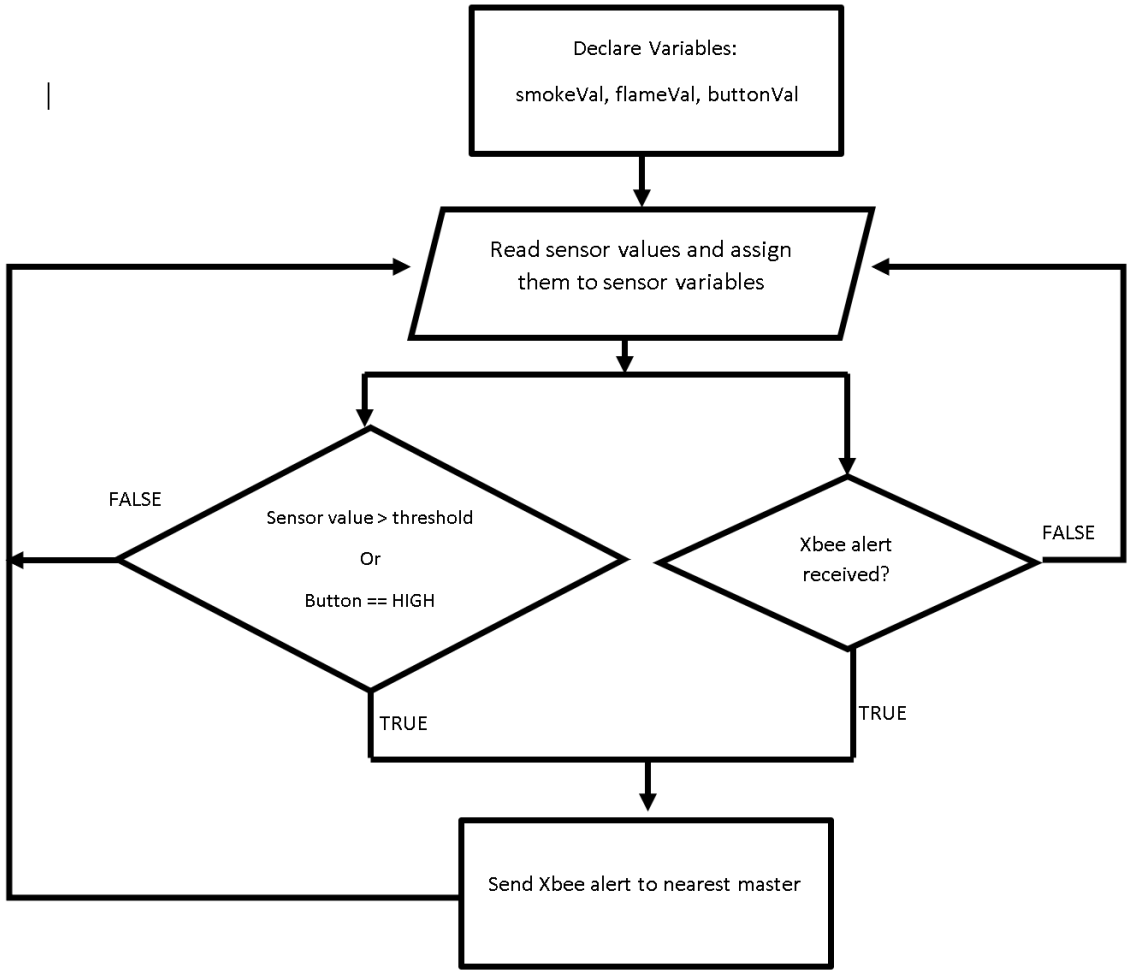
- Verification:
  - Used the ATmega to send a text message via the GSM Module while in a forested area

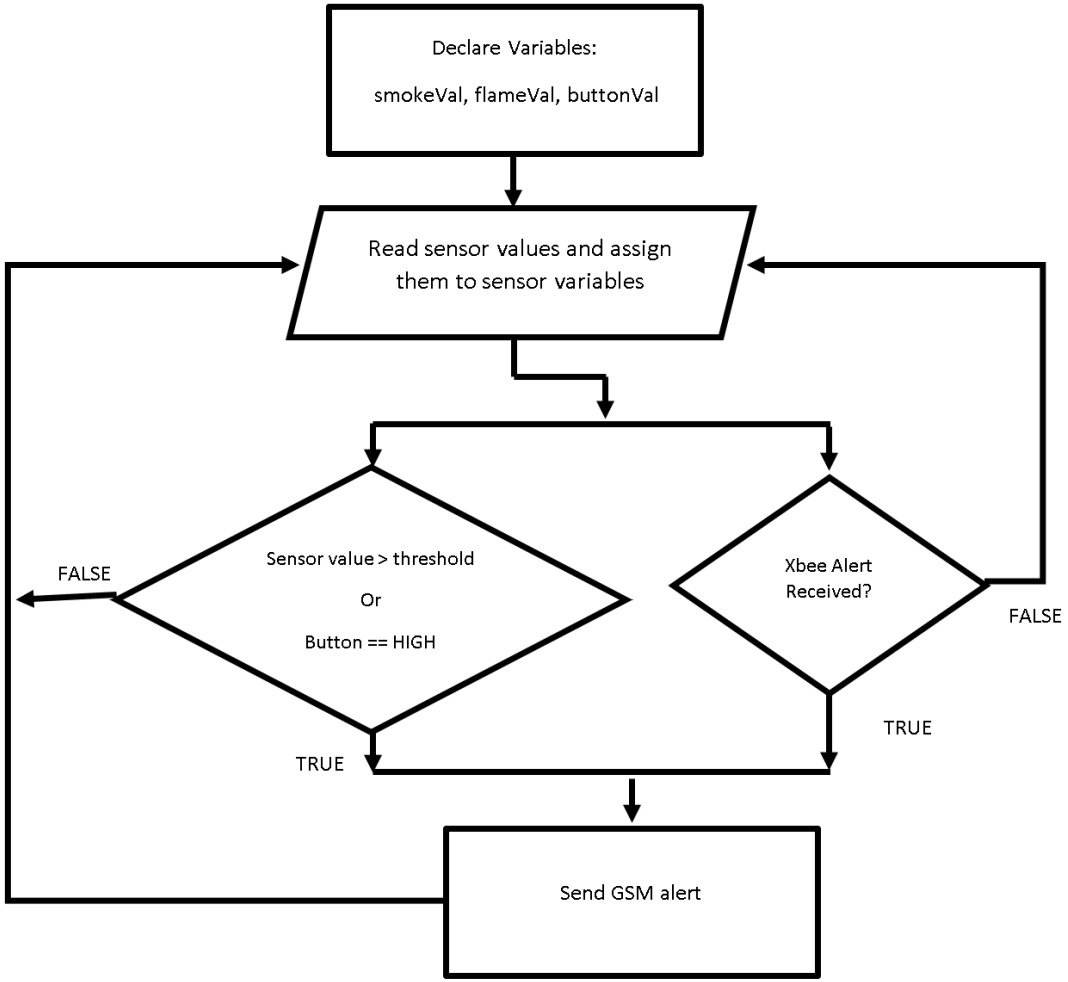




Mesh Network

- Gateway Nodes include GSM Module and Xbee-PRO
  - Located in position with 2G signal
- Router Nodes
  - Include only Xbee-PRO
  - Located in remote areas

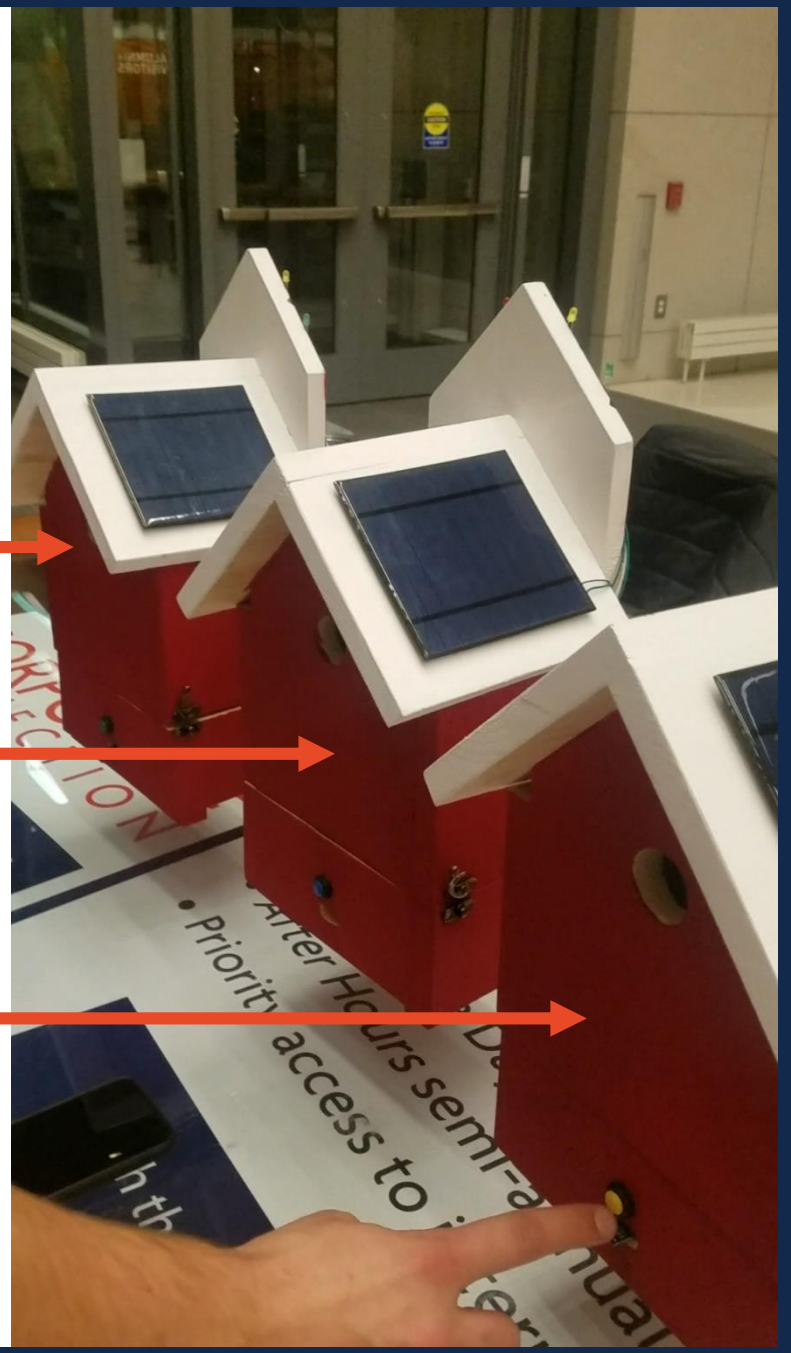

Declare Variables:
smokeVal, flameVal, buttonVal
Read sensor values and assign them to sensor variables
FALSE
Sensor value > threshold
Or
Button == HIGH
Xbee alert received?
FALSE
TRUE
TRUE
Send Xbee alert to nearest master


Declare Variables:
smokeVal, flameVal, buttonVal
Read sensor values and assign them to sensor variables
FALSE
Sensor value > threshold
Or
Button == HIGH
Xbee Alert Received?
FALSE
TRUE
TRUE
Send GSM alert

SOFTWARE

Mesh Network Verification

- Two Tests Performed
  - Routing Test
    - Take two nodes and walk away from each other
    - Send signals until not received
    - Place third node in middle
  - Multiple Gateway Test
    - Send alert to both gateway node
    - Receive two text messages



Create an efficient high capacity rechargeable Power Circuit

Two Key Components

- Solar Panels 2.5W
  - Recharge batteries in an efficient manner
- Lithium Ion 18650 Batteries
  - Rechargeable and provide a high capacity

Low Maintenance Solution

Battery Pack

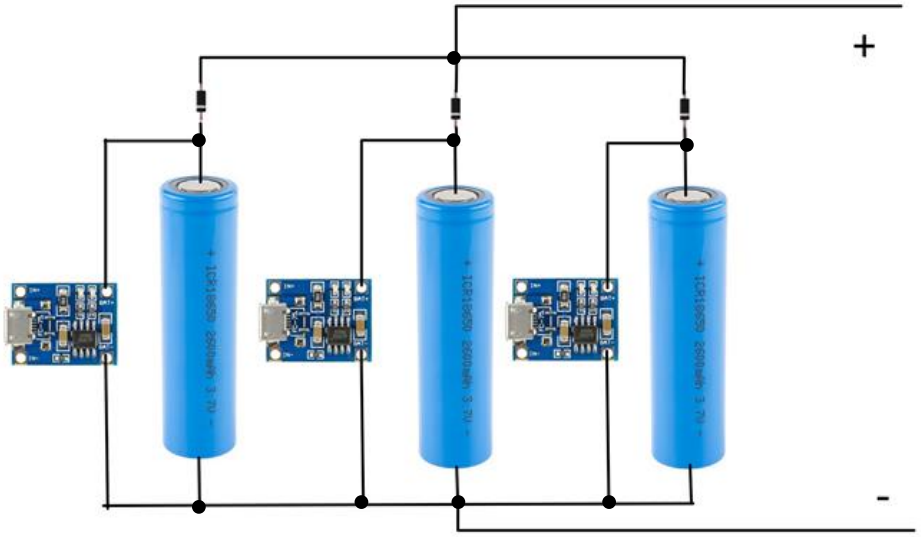
- Requirement:
  - The Battery Pack design must have a total capacity greater than 5196mAh
  - The individual batteries must be able to be charged to 3.7V using the output from the solar panel

- Verification:
  - Test individual capacity of batteries
  - Once battery is drained, recharge the battery using solar panel back to 3.7V

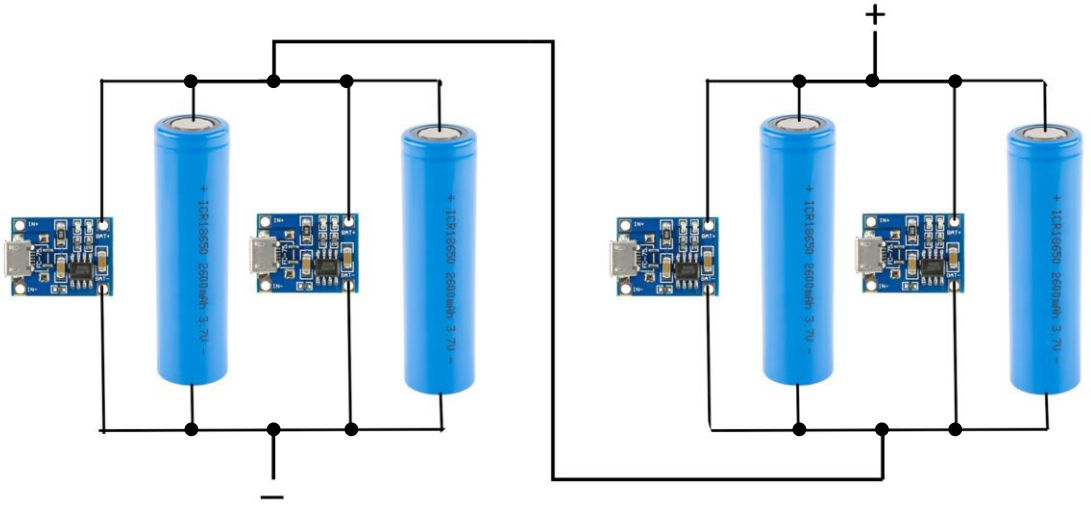
18650 Lithium-Ion Battery (2500mAh)

Battery Pack

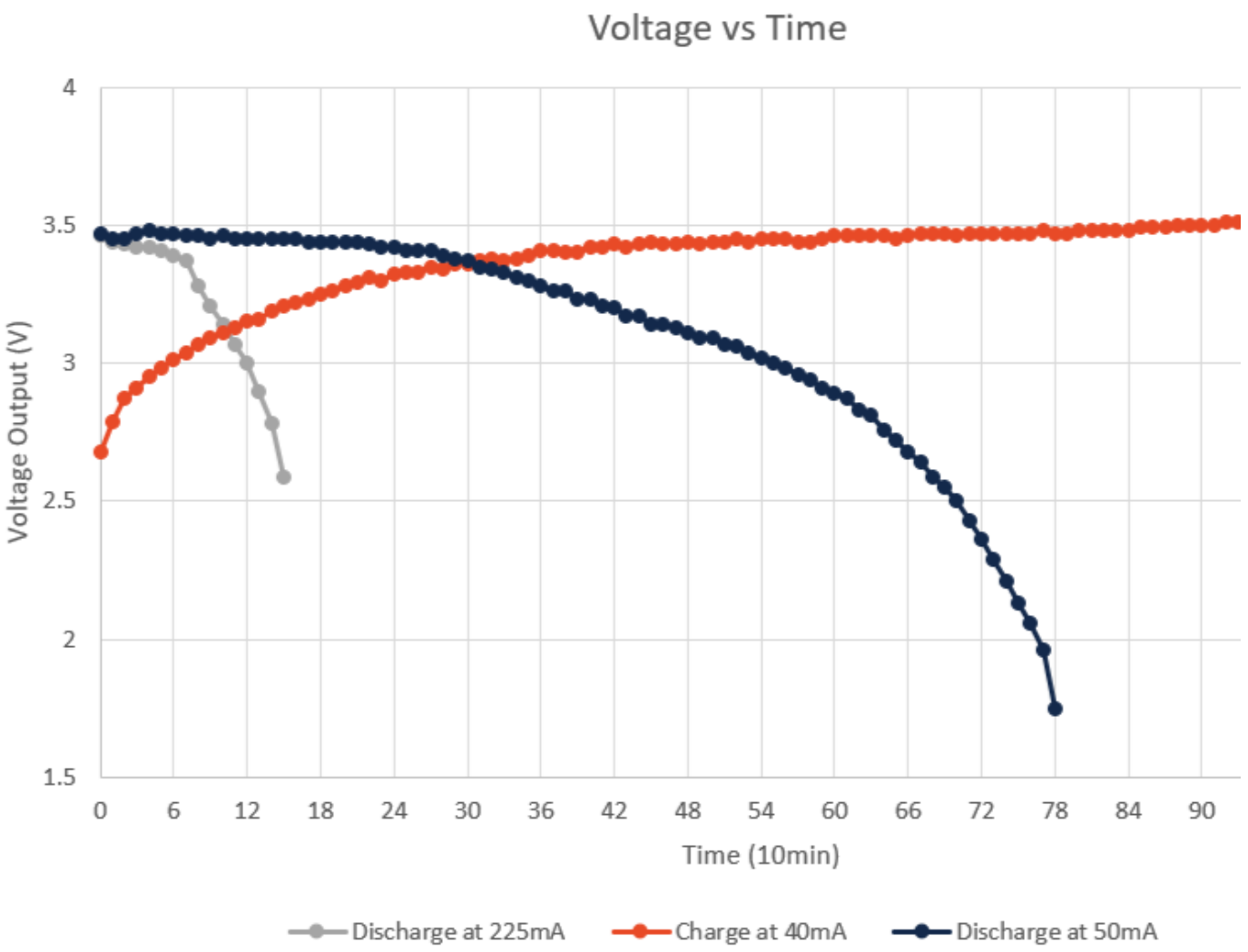
Original setup
Capacity: 7500mAh
Voltage: 3.5V



New setup
Capacity: 5000mAh
Voltage: 7V



Requirement: 5196mAh



Discharge at 225mA: ~600mAh capacity per battery

Charge at 40mA: ~653mAh capacity per battery

Discharge at 5omA: ~667mAh capacity per battery

TESTING BATTERIES

Solar Panel Charging

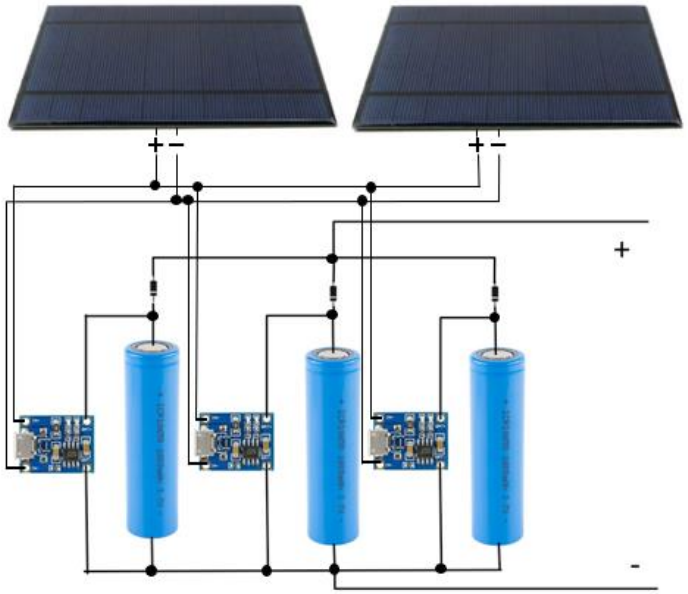
- Requirement:
  - Supply an average of 519.6mA at 5±1V to the charging circuit

- Verification:
  - Measure the current and voltage output of the two solar panels in parallel in various conditions

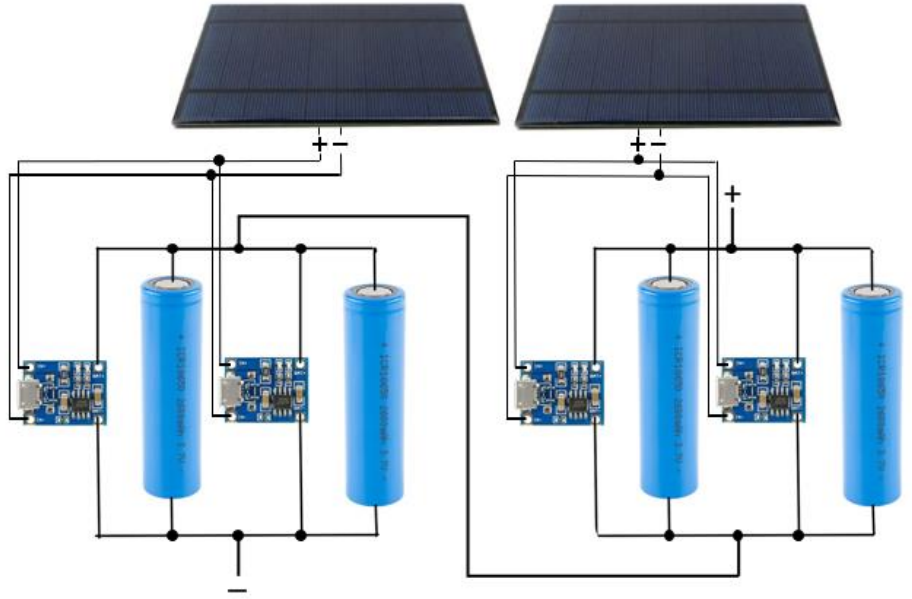
Two 2.5 Watt Solar Panels

Solar Panel Charging

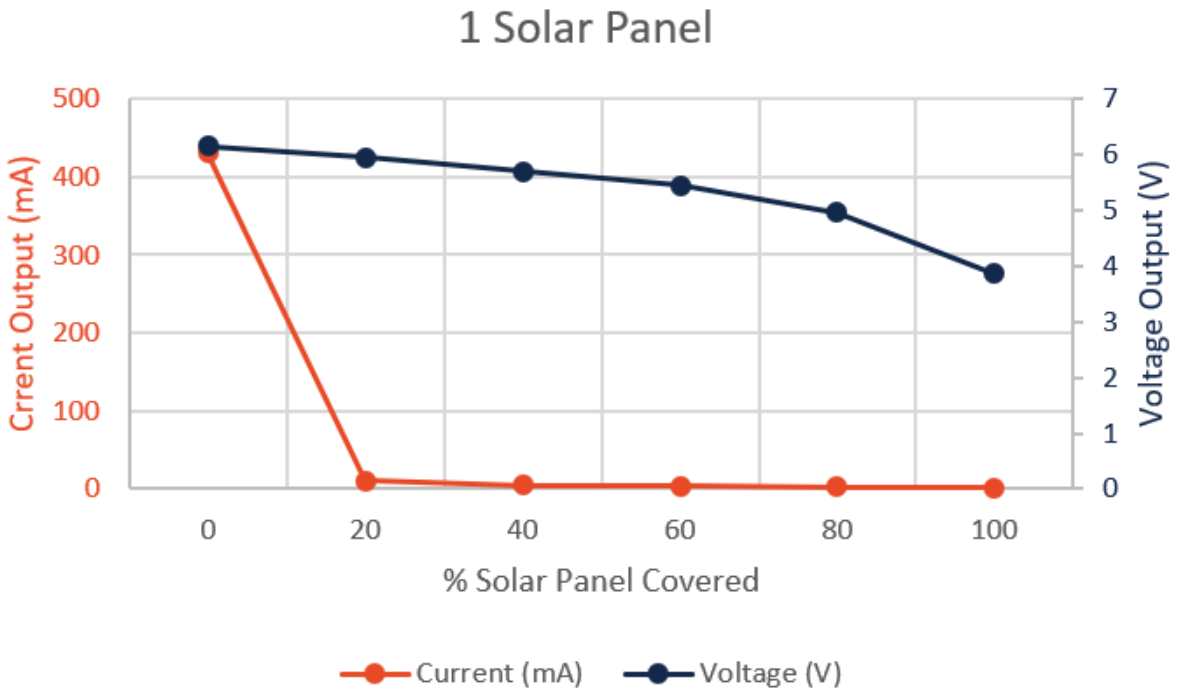
Original setup
Ampacity: 1000mA
Voltage: 5±1V

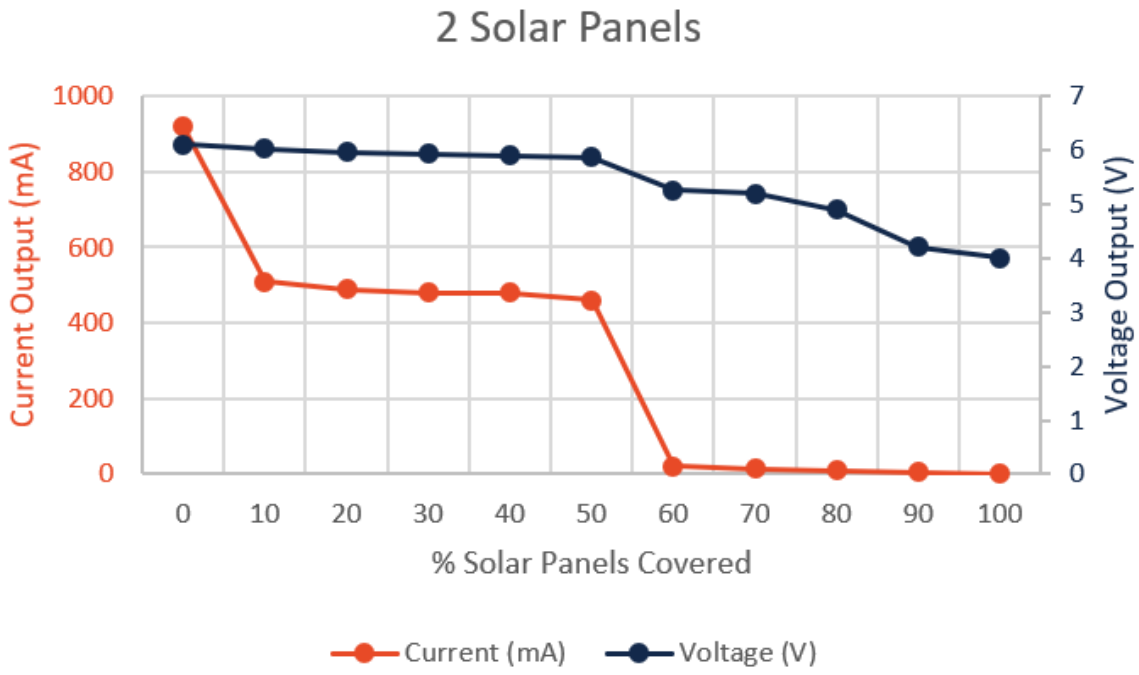


New setup
Ampacity: 1000mA
Voltage: 5±1V



Requirement: 519.6mA





TESTING SOLAR PANELS

Create fast responding fire detection system

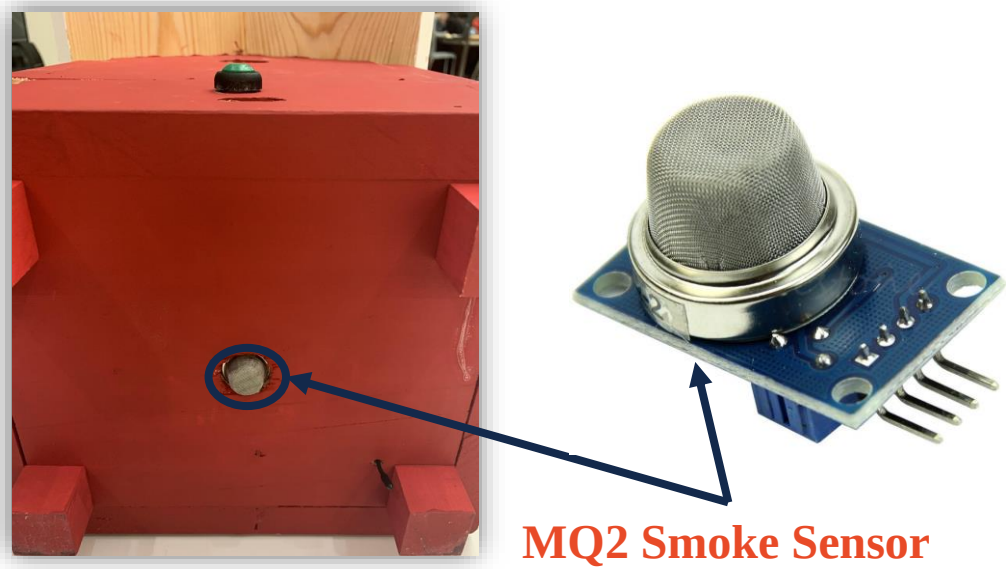
Two Key Components

- ATmega328P
  - Provides us an efficient way to process and transmit data
- Smoke Sensor and IR Flame Sensor
  - Allow us to detect forest fires first hand

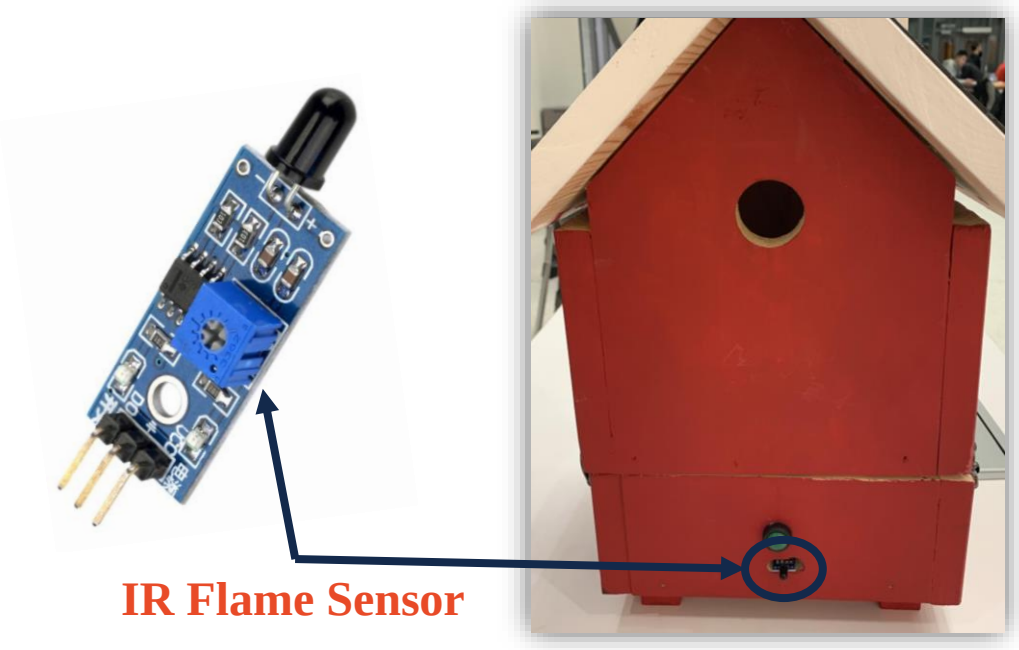
Allow Real-Time Fire Detection

Smoke Sensor

- Requirement:
  - Must be able to accurately detect smoke at concentrations of 0.5±0.25% ppm
- Verification:
  - Create different smoke concentrations
  - Detect smoke with sensor



MQ2 Smoke Sensor



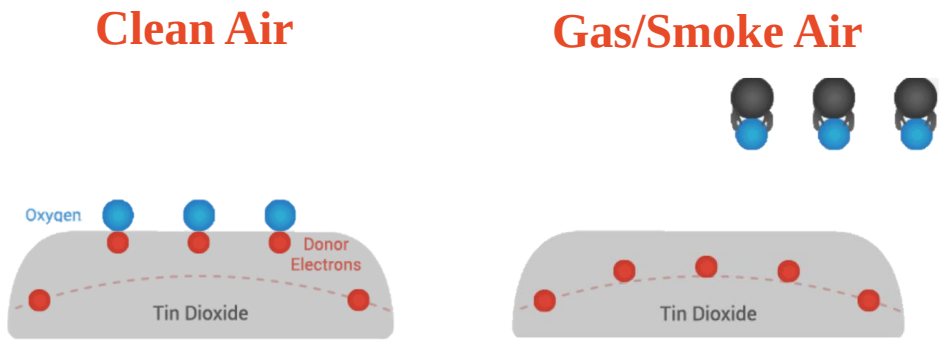
IR Flame Sensor

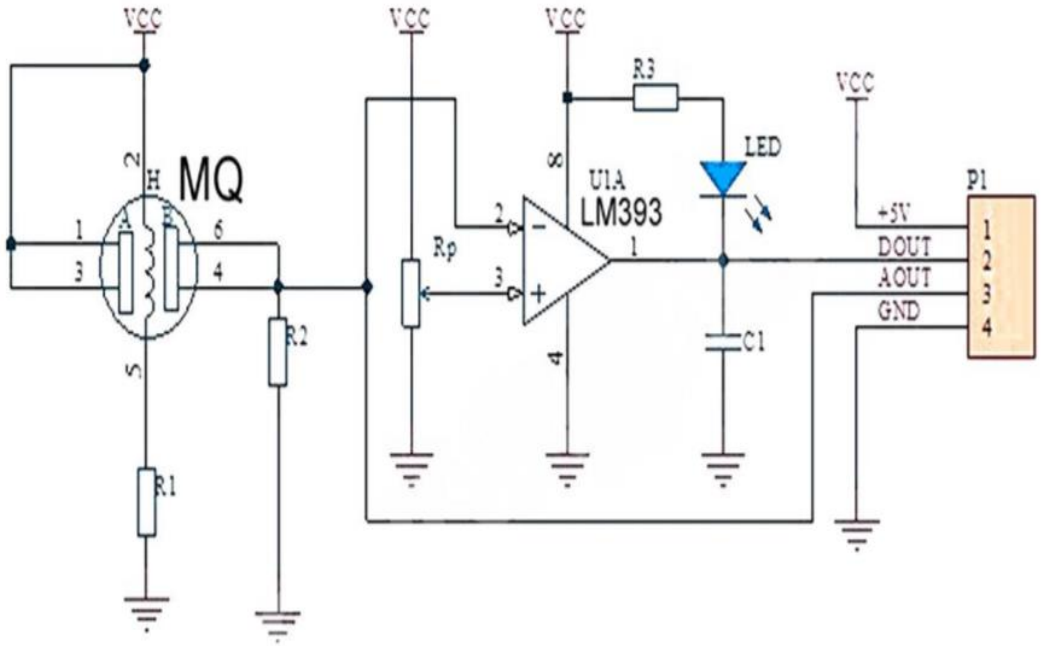
IR Flame Sensor

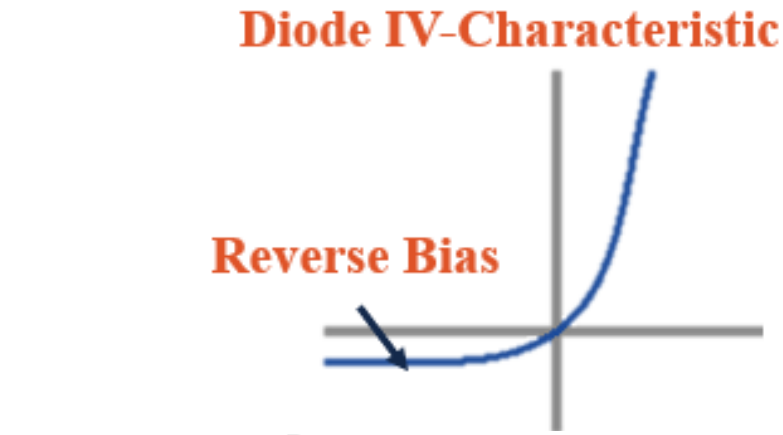
- Requirement:
  - Must be able to accurately detect flame at 10 meters
- Verification:
  - Create different size fires
  - Measure maximum detection distance

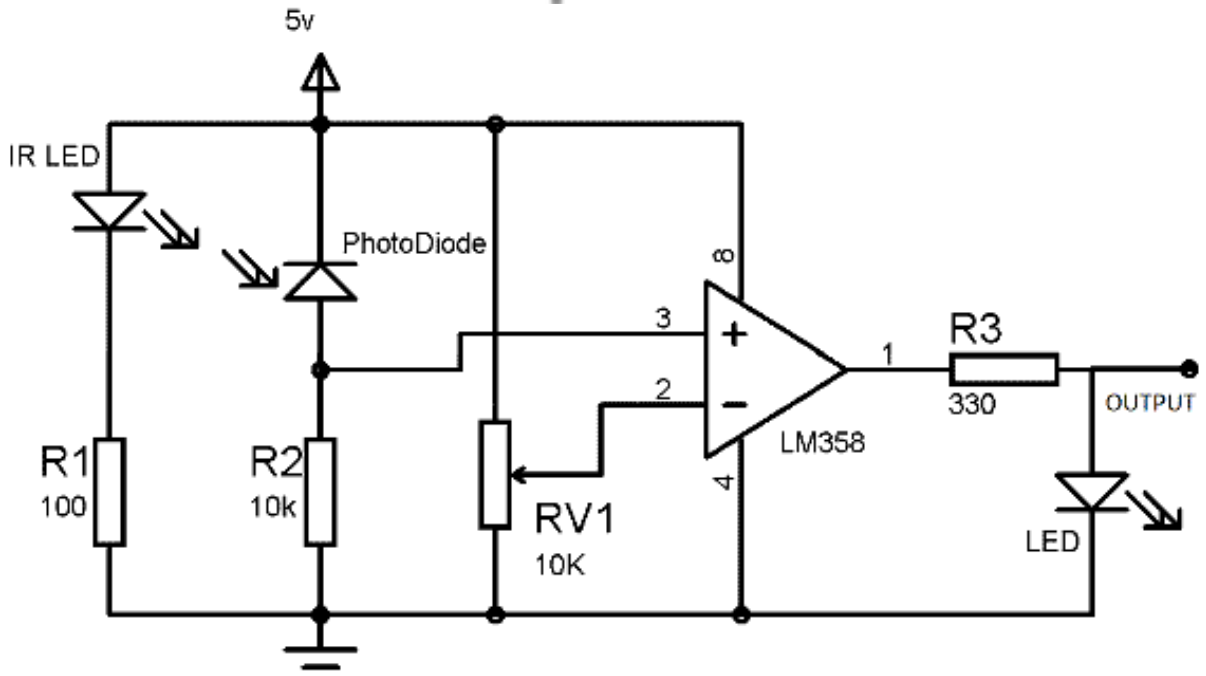
Physics of Smoke Sensor

- Heats up SnO_2 so Oxygen will absorb on the surface
  - In clean air, donor electrons in SnO_2 are attracted to Oxygen making SnO_2 highly resistive
  - In gas/smoke filled air, the amount of absorbed Oxygen decreases as it reacts with gases releasing electrons back to SnO_2 making it more conductive
- The LM393 voltage comparator chip selects higher voltage of two inputs







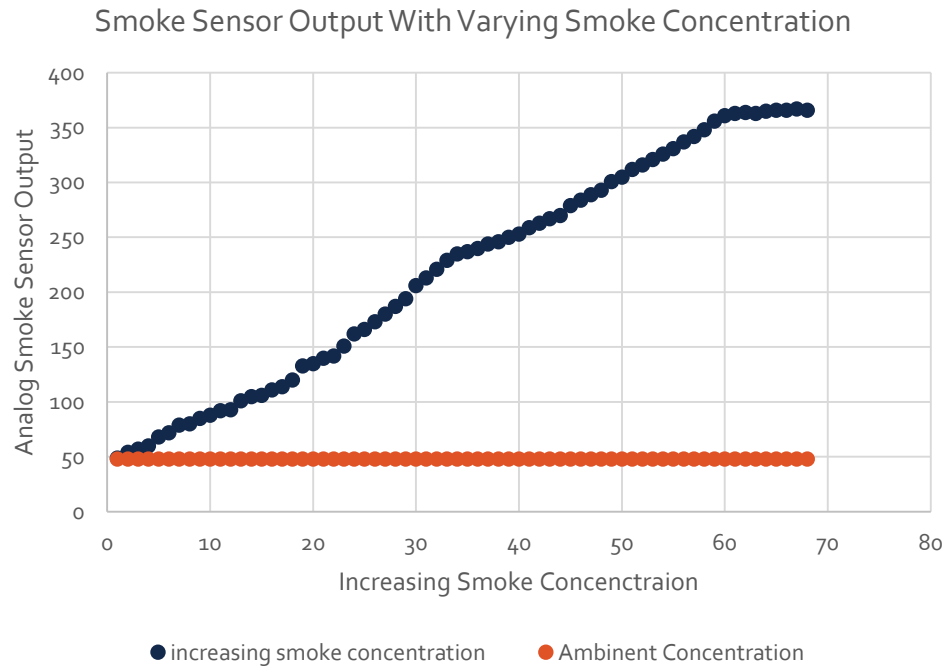


Physics of IR Flame Sensor

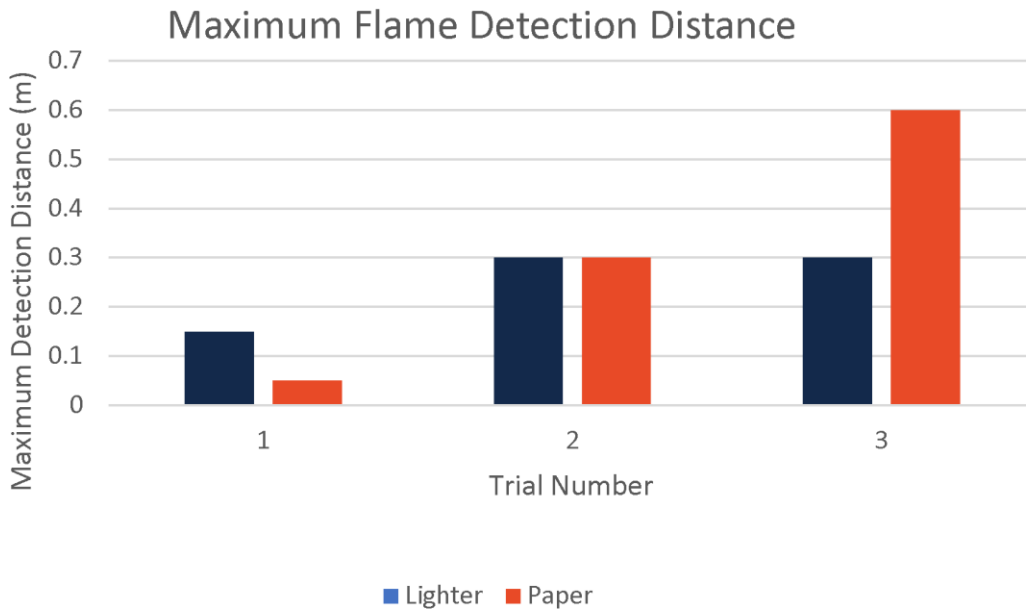
- Photodiode (photodetector)
  - Reverse Bias
    - Operates in the third quadrant of I-V characteristic
    - Responds only to Photon Absorption
  - As light intensity increases, resistance decreases
  - The LM393 voltage comparator chip selects higher voltage of two inputs

Sensor Data

Smoke Sensor

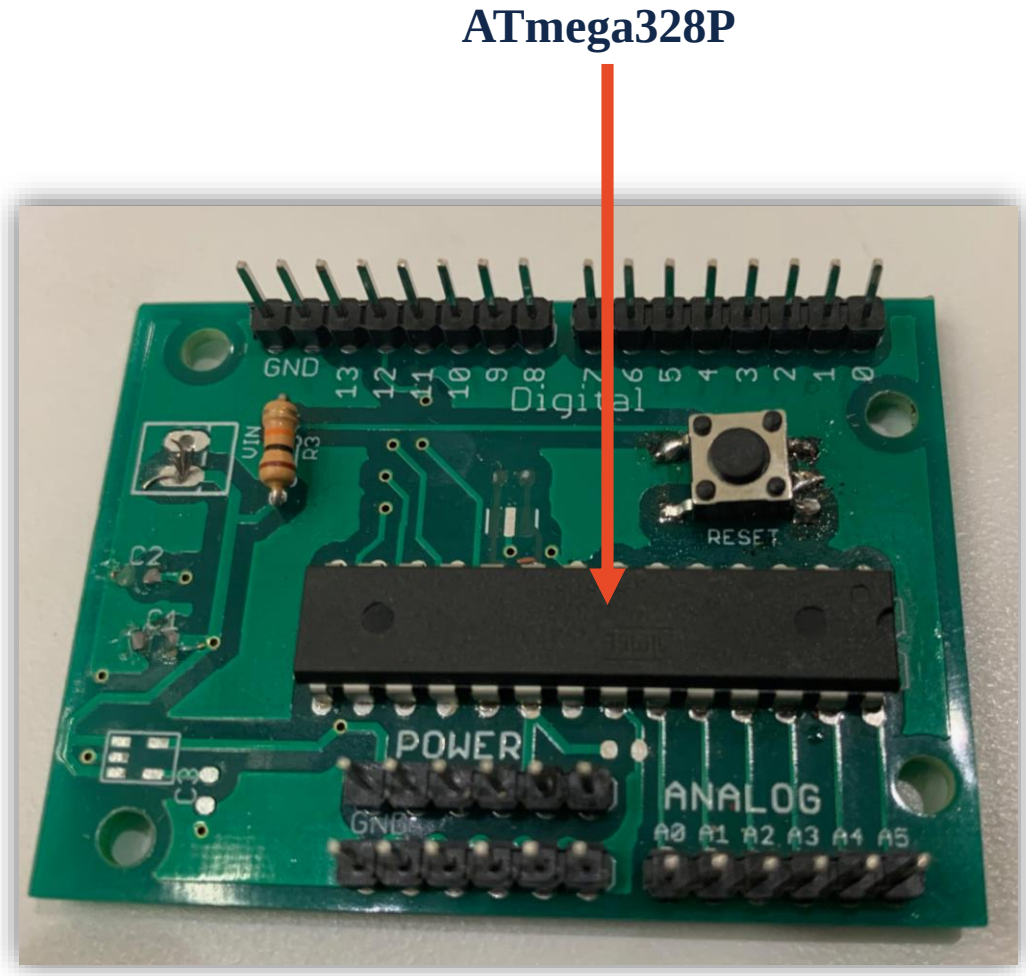


IR Flame Sensor



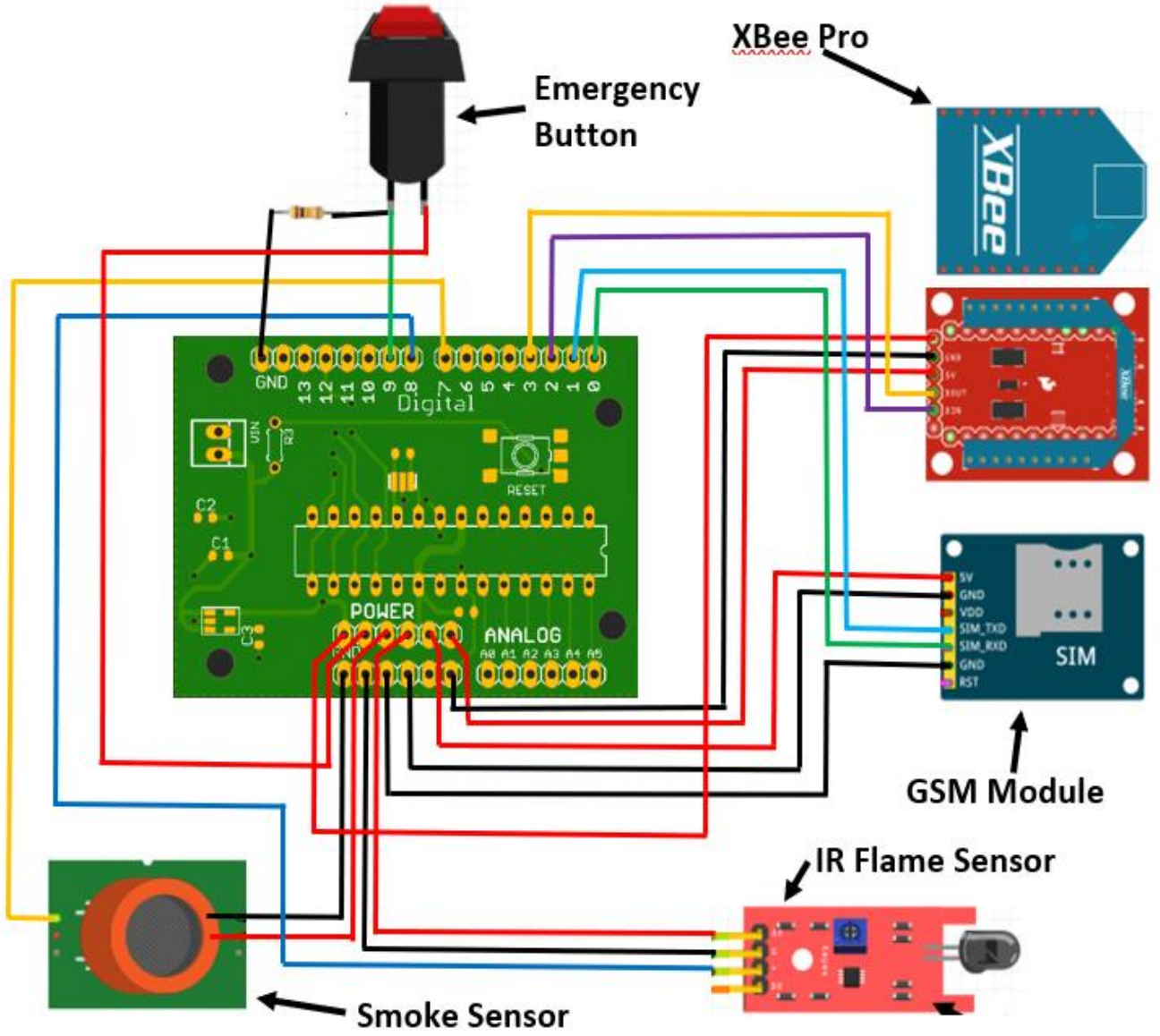
ATmega328P

- Requirement:
  - Must be able to continuously process data from at least four input pins
  - Must have the ability to communicate through the GSM module and XBee-PRO via serial communication port



ATmega328P

- Verification:
  - Transmit data through ATmega to XBee Pro and process data received through ATmega from XBee-PRO
  - Transmit data through ATmega to GSM Module and receive a text message
  - Connect XBee-PRO and all three sensors to ATmega and ensure chip has enough computing power to process all the information



Conclusions and Further Work

- Current Progress:
  - Core functionality working properly
- Future work:
  - Research alternative battery options with higher capacity
  - Find an ethical way to test and verify max detection distance of flame sensors
  - Find a better way of calculating smoke detector threshold values

QUESTIONS?