Steam Heat Controller for Coover Hall

May11-19

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Overview

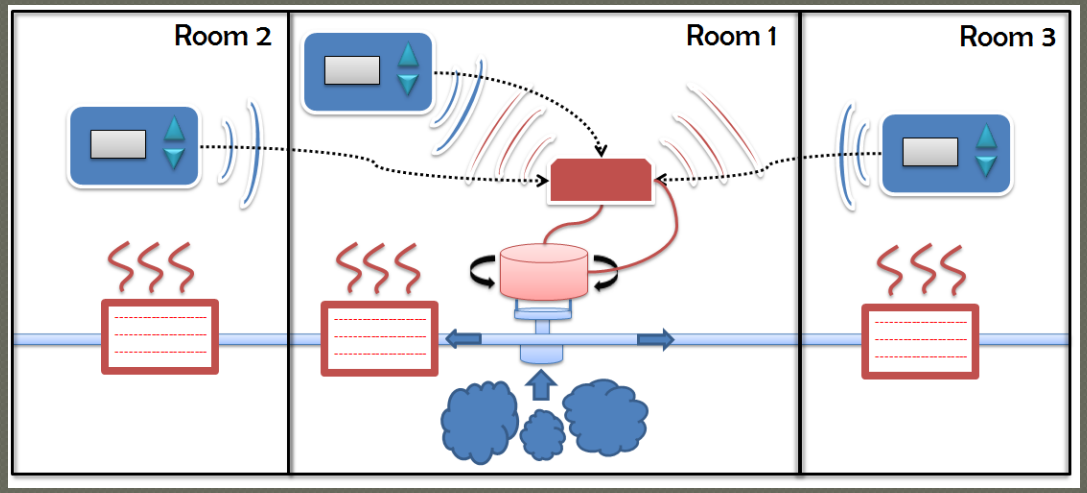
- Overview
- Requirements
- Design
- Implementation
- Testing
- Conclusion
- Questions

Project Overview

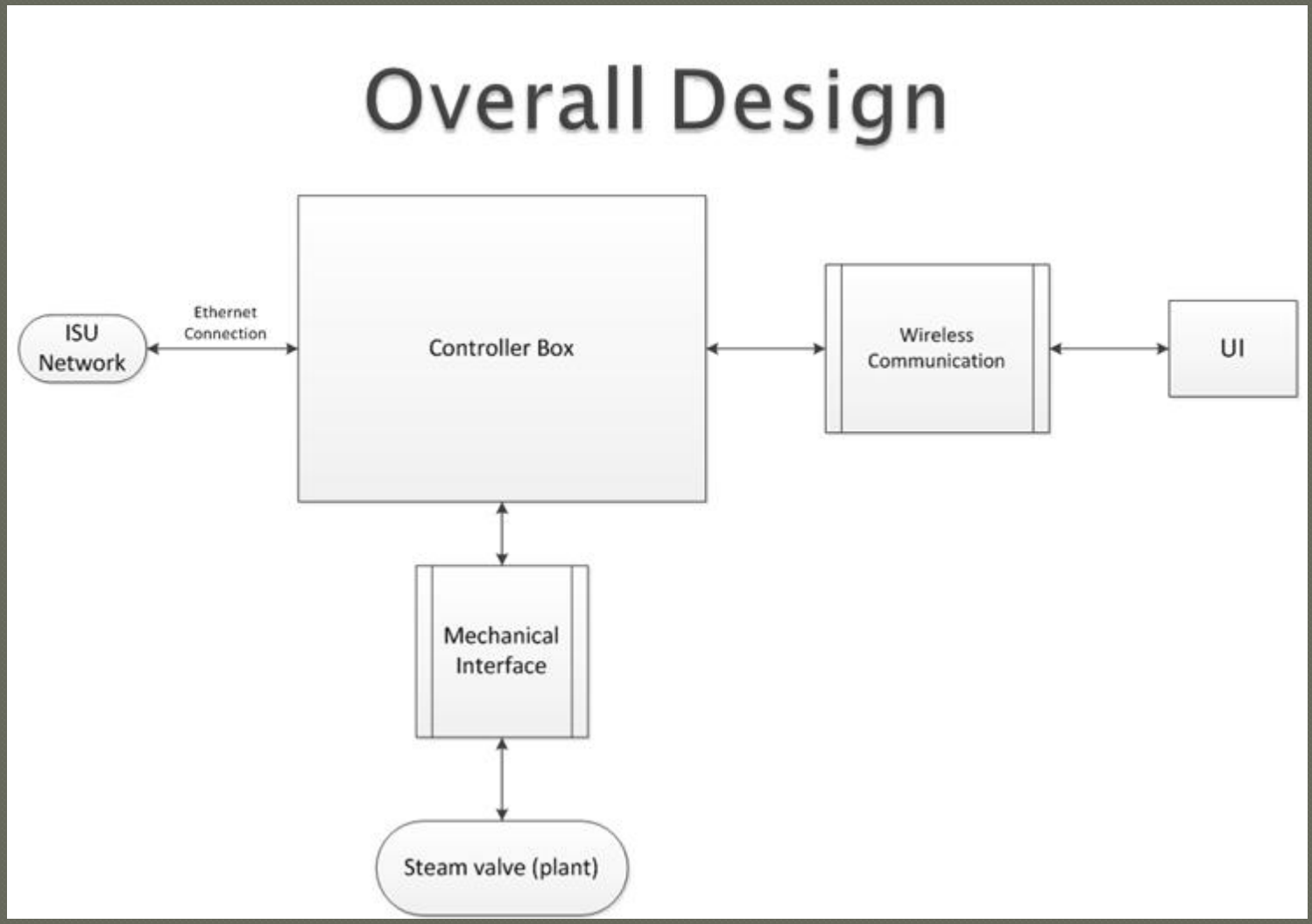
- Problem Background and Statement
  - The old section of Coover hall utilizes steam valves to heat adjacent rooms. A steam valve in one room can control the temperature of up to five rooms. This leads to **temperature offset in the rooms** and **continuous adjustment** of the valve in order to accommodate the individuals within each room.

Project Requirements

- Effective temperature control
- Removable mechanical Interface
- Wireless user interface
- Web interface
- Large graphic LCD
- Casing size
- Casing color
- Project budget

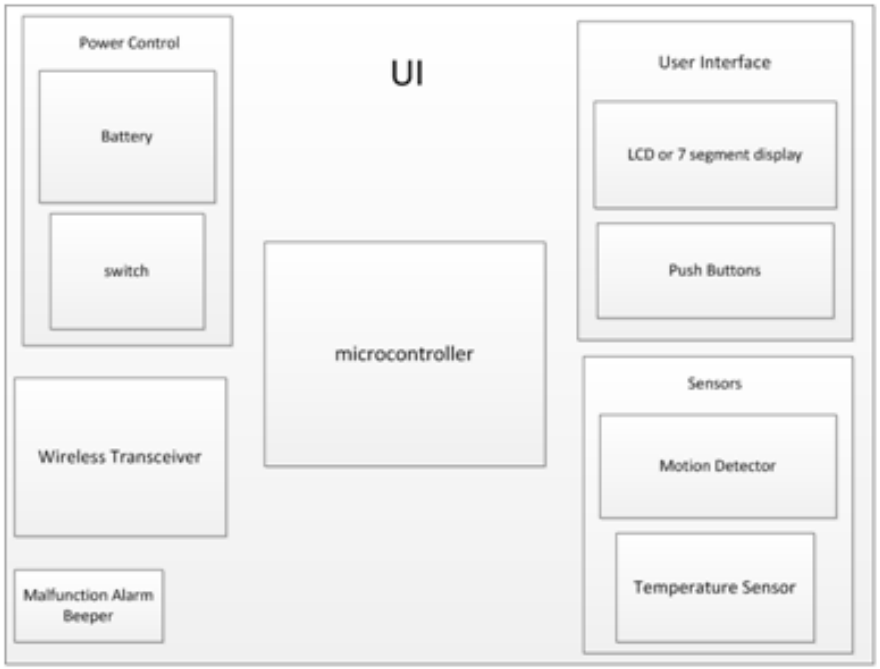


Project Design

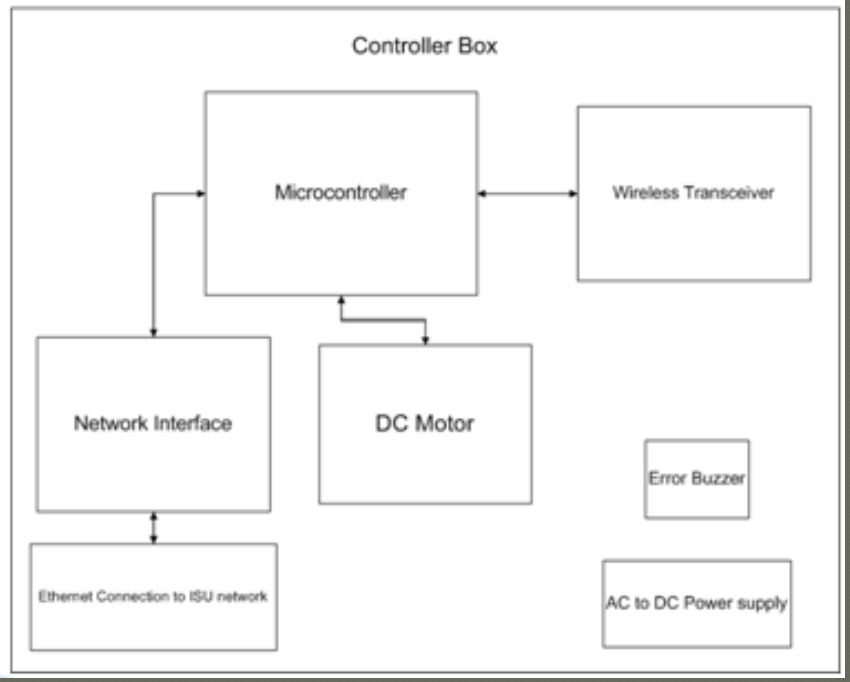


Project Design

User Interface



Controller Box



Project Implementation

- AVR STK600 Development Kit

Project Implementation

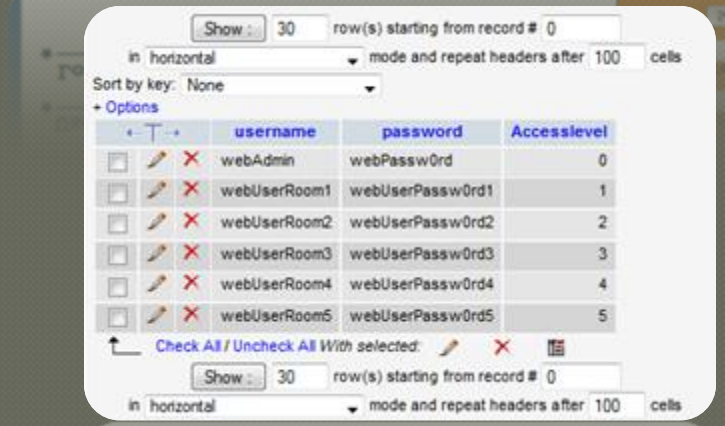
- Controller Box
  - Microcontroller
  - Wireless Transceiver
  - Ethernet Module
  - Buzzer
  - Power Supply
  - Motor Driver Circuit

Project Implementation

- Control Panel
  - Microcontroller
  - Wireless Transceiver
  - LCD Display
  - Power Supply
  - Buzzer
  - Push Button
  - Temp Sensor
  - Recharging Circuitry

Website Implementation

- Website Interface
  - Login Authentication
  - Access Levels
  - Displays Current Temp
  - Remotely Set Temp

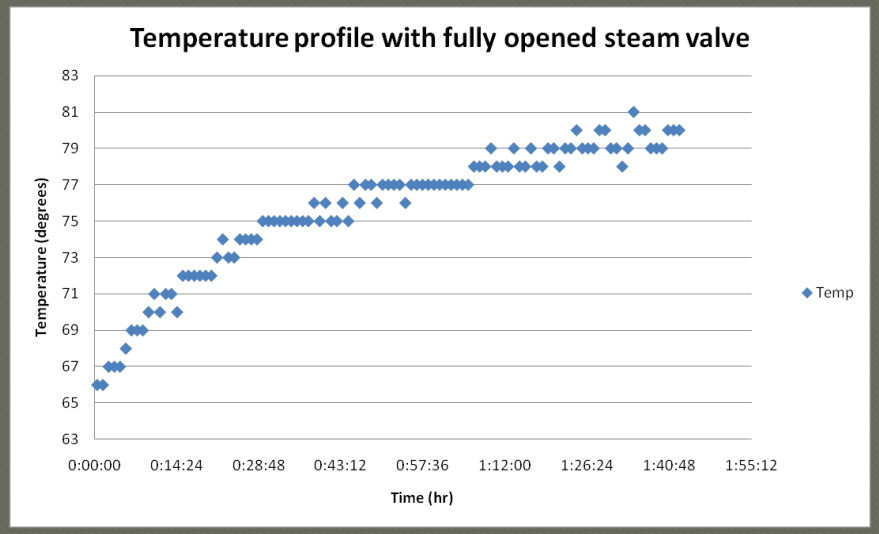


Integration Testing

- AVR STK600 Development Kit
  - Microcontroller
  - Push Button
  - Motor System
  - Temperature Sensor
  - LCD
  - Wireless Transceiver

Functional Testing

- Simulate operating environment
- System performance test



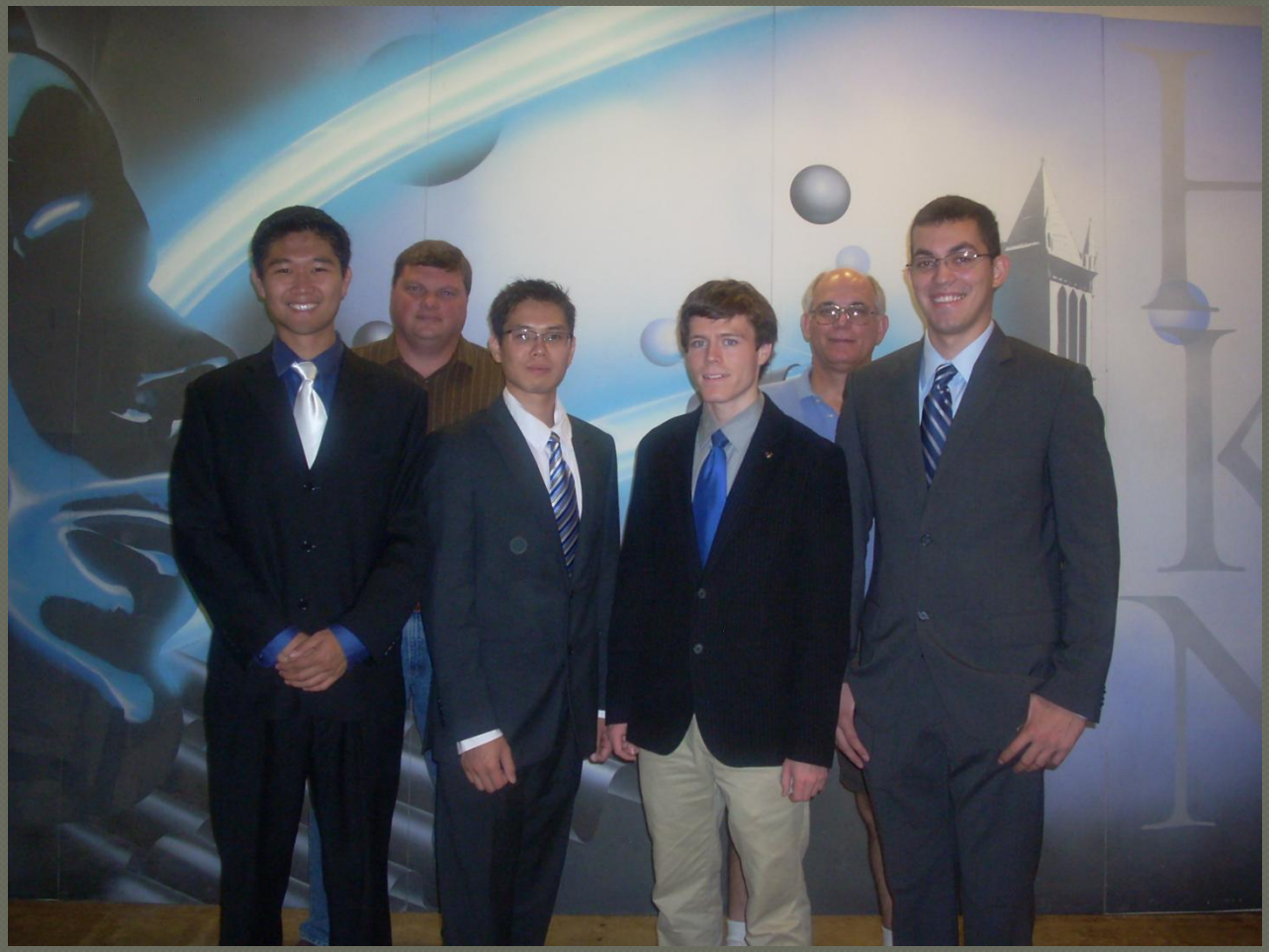
Lessons Learned

- **PCB Board**
  - **Floating pins**
  - **Power line routing**
  - **Inductor selection**
- **Microcontroller**
  - **Integrated Ethernet**
  - **Less functionalities**
  - **Provide external clock**
- **Motor**
  - **Filtering current sense**
  - **Encoder with index channel**

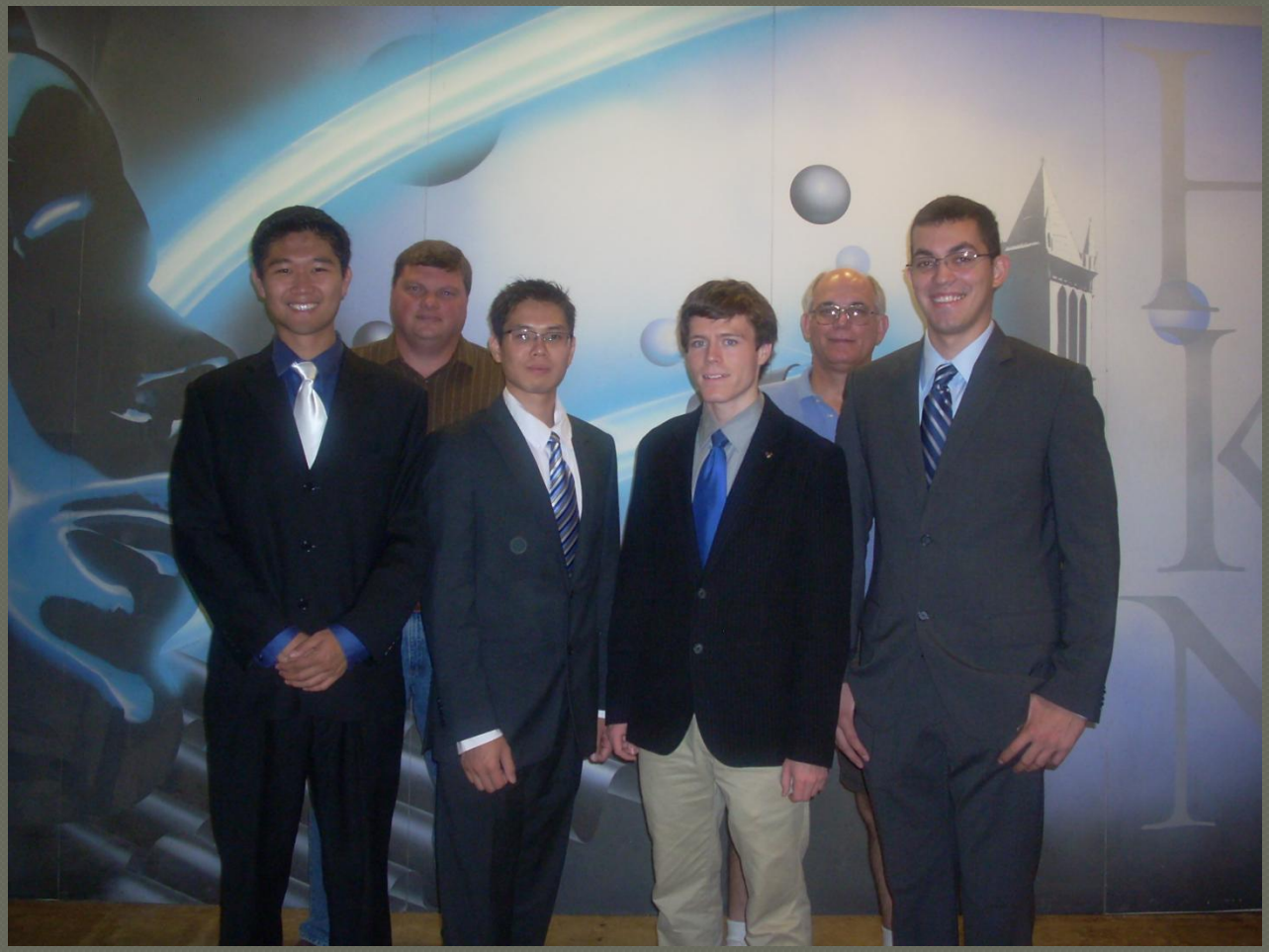
Conclusion

- 3 Control panels
- 1 Controller box
- Website
- Successful implementation
- Possible improvements:
  - Completion of the recharging circuitry
  - Ethernet connection
  - Additional testing
    - various seasonal and environmental conditions

Questions



Thank You

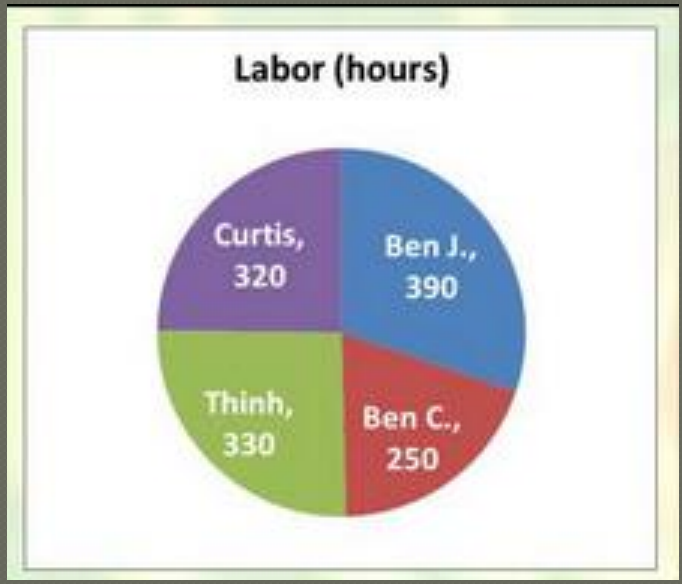


Appendix

Final Budget

Controller Box	
Module	**Cost**
Microcontroller	$ 10.00
Power Supply	$ 19.99
Xbee	$ 30.00
PCB	$ 8.00
Ethernet	$ 2.28
Motor System	$ 79.77
Other	$ 35.00
Total	**$ 185.04**

Control Panel	
Module	**Cost**
Microcontroller	$ 10.00
Power Supply	$ 9.13
Xbee	$ 30.00
PCB	$ 8.00
LCD	$ 22.00
Other	$ 20.00
Total	**$ 99.13**



Functional Testing

Basic Functionality		
Test	Success (P/F)	Criteria
temperature set pt. is higher than the current temp	Y	valve opens more
temperature set pt. is lower than the current temp	Y	valve closes more
set temperature preference and then check to see if set pt. is reached	F	valve is close (within 20% of turn range) to being closed
Set all preferences to 68°	Y	temperature is set to within 2° c after
Stand 3 ft. away from the LCD and read the temperature	Y	LCD is visible, can be read from 3 feet away
Attempt go below the lower temperature limit of 60°f	Y	UI should stay at 60°f
Attempt go above the upper temperature limit of 80°f	Y	UI should stay at 80°f

Valve Calibration		
Test	Success (P/F)	Criteria
Increment temperature preference by one °F starting from 60 to 80.	Y	valve should open slightly more each time the temperature preference goes up
Decrement temperature preference by one °F starting from 80 to 60.	Y	valve should close slightly more each time the temperature preference goes down

Range Tests		
Test	Success (P/F)	Criteria
Send one message to the transceiver at each range between 0 walls to 4 walls	Y	Range of up to 300 ft. with up to 4 walls between the UI and the control box
Send 100 messages to farthest range (300 ft., 4 walls)	Y	Have 95% of sent messages received successfully

Response Test		
Test	Success (P/F)	Criteria
User sets temperature to 78°F from 72°F	F	The room should reach approximately 78°F in two hours
User sets temperature to 72°F from 78°F	F	The room should reach approximately 72°F in two hours

Equalization and weighting Test		
Test	Success (P/F)	Criteria
Start from temperature set point of Room1: 75, Room2: 78, Room3: 83	F	The room should reach approximately 78°F depending on states
Start from temperature set point of Room1: 60, Room2: 75, Room3: 85	F	The room should reach approximately 75°F depending on states

Environmental and extreme Tests		
Test	Success (P/F)	Criteria
Put the steam valve control system in the oven at 100° F	F	Controller box functions after running for 10 hrs. in 100° F
Put the steam valve control system in the fridge at 100° F	F	Controller box functions after running for 10 hrs. in 10°F Temperature
Set all preferences to maximum	F	The temperature is set to within 2° F
Set all preferences to minimum	F	The temperature is set to within 2° F

Power and Charging		
Test	Success (P/F)	Criteria
Plug the controller into the USB when the battery level is at 50%	F	The unit indicates charging state
Drain the controller battery level to less than 10%	F	The buzzer sounds indicating low battery state
Plug the controller into the USB when the battery level is at 100%	F	The unit will indicate charging complete state

Monitored extended use testing		
Test	Success (P/F)	Criteria
Run system for 1 week, monitoring the temperature	F	The temperature is set within one time constant
Run system for 1 week, monitoring the LCD quality	F	The contrast of the LCD should remain the same, the LED backlighting should be at medium brightness
Press push buttons over 300 times	F	The incrementing and decrementing of the temperature should be functional

Power:			
Test voltage levels, voltage ripple, voltage stability, and voltage behavior due to transients of all power supplies over their full loads	Y	3.3 V booster circuit needs re-route in order to test Used 3.3 V	Max voltage ripple is 50 mV. All voltages within 5% of target value
Test the limits on inputs to all switchers and LDOs	Y	3.3 V booster circuit needs re-route in order to test Used 3.3 V	LDO limit: 10 V. 5 V Switcher Limit: 20 V
Test typ. current draw for all major power rails	Y		Controller Box 3.3 V: 90 mA max 5.0 V: 30 mA max 12.0 V: 2.64 A max Control Panel: 3.3 V: 200 mA max
Test typ. noise levels on all major IC power rails	Y		Typical voltage ripple on IC power pins is approximately 25 mV.
Test the limits of current limiter circuit	Y		Current Limit: 2.64 A
Test reverse protection circuitry	Y		Reverse protection tested up to 30 V.
Ensure proper power supply sequencing	N/A	3.3 V booster circuit needs re-route in order to test Used 3.3 V	Controller Box: 12 V sequenced prior to 5V sequenced prior to 3.3 V Control Panel: N/A
Microprocessor:			
Test high speed signal lines for signal integrity:			
SPI signal integrity CD lines	Y		Typical rise time < 30 ns
USART signal integrity on transceiver lines	Y		Typical rise time < 30 ns
Ethernet signal integrity on the transceiver lines	Y		N/A
PWM lines on motor driver lines	Y		Typical rise time < 30 ns
Test system reset functionality	N/A		Reset functionality only resets the mP clocks and not the system
Test microprocessor can be JTAGed and programmed as needed	Y		JTAG and programming fully functional
Test microprocessor can communicate to LCD, Xbee transceiver, Ethernet Transceiver, and motor driver circuit - proper handshake	Y		Proper handshakes between mP and peripherals. 100 % communication.
Test RJ-45 and USB port lines for proper level conversion	N/A	Need to add 12 MHz external	Using the current PCB, we could not test without an external crystal.
Test LED systems to determine if operating in safe current limits	Y		LED circuitry has appropriate current draw an operating limits.
Ensure proper clock start up sequence	Y		mP clock starts up accordingly. Only one cloc used currently.

Push Buttons:			
Test for noise, bounce, and transient levels during switching for slider switches and momentary push buttons	Y		No switch bounce due to filtering design.
Test for proper signal rise/fall times during switching for slider switches and momentary push buttons	Y		Maximum rise/fall time 3 ms due to rc time constant.
Unit casings:			
ESD testing to determine the quality of design	Y		ESD does not seem to penetrate the casing. Does not affect performance due to ESD protection circuitry.
Temperature sensitive testing in order to determine endurance	Y		Does not deform in the operating temperature range of 40 to 140 degrees
LCD:			
Test under temperature limits to determine quality dynamics and mitigate adverse effects	Y		Tested from 20 to 100 degrees Fahrenheit. Contrast and quality stay high.
Test under various lighting conditions to determine proper backlight strength	Y		Decided to use medium strength to save energy. Sufficient in dark room conditions.
Temperature sensor:			
Test accuracy of the temperature sensor in various environmental conditions	Y		Tested in hot, cold, humid, and dusty conditions. Always achieve +/- 1 degree Fahrenheit
Test limits of operational temperature	Y		Tested between 40 to 100 Fahrenheit. Achieved +/_ 1 degree resolution.
DC Motor:			
Test operation under extensive temperature range	Y		Tested in hot, cold, humid, and dusty conditions. Temperature range is 40 to 120 degrees Fahrenheit. Performance remains
Test output torque and make certain that it meets required specification	Y		Tested typical torque of steam valves around Coover and set the motor torque output to 30% percent higher than maximum measured
Test quality of performance using different driver circuits	Y		Tested three driver circuits, obtained similar performance and used the least expensive solution

Software Testing Results

LCD, Temperature, and Microcontroller				
	Test Case	Pass	Fail	Comments
1.	Display all characters supported by the LCD	Pass		
2.	Verify correct display results for all components	Pass		
	c. Correctly displays current temperature readings	Pass		
	d. Warning for low battery	N/A		Was not tested
3.	LCD display updates accordingly after user input	Pass		
4.	LCD displays desired output after system reboot	Pass		

Website Interface				
	Test Case	Pass	Fail	Comments
	1. Password authentication for average user	Pass		
2.	Password authentication for admin	Pass		
3.	Administrator's ability to add, remove, or modify user	N/A		Was not tested
4.	Administrator's ability to overwrite temperature preferences	N/A		Was not tested
5.	Verify that JDBC correctly communicates with database	Pass		
6.	The status of the overall system is displayed correctly	Pass		
7.	The user feedback is archived displayed for the admin	Pass		
8.	The web interface correctly retrieves data after system failure	Pass		
9.	The web interface displays appropriate message after invalid user requests	Pass		

Simulink set up