Smart Tint – Hardware Design Document

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Gold Squadron

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-	Initial Release	4/19/2018	
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1 Scope

1.1 Summary of project

Project Summary:

Our project is to develop a system where a smart device running android OS (ideally an android smartphone) will communicate with a central hub (main arduino) to manage a series of windows. These windows will be covered with a film, which will either be off (letting all light through) or on (becoming non-transparent).

The application on the smart device will be able to see current windows/rooms available to modify and may select any of those options. Once selected the user can turn the items on/off. The main hub will identify the windows or room selected and communicate to additional arduino hubs (mini hubs) via nRF communication. The mini hubs control their respective windows and control by powering the film on or off.

This will allow the user to control which windows in their residence to let light pass through, which will be convenient for users who would wish to sleep-in past sunrise without being disturbed by natural sunlight.

1.2 Summary of hardware elements

The hardware elements integrated in this project all stem from our main arduino hub. The main arduino hub is a Arduino-Mega2560 which has a lot of room to operate all vectors of communication for our project. The main hub has a bluetooth module that communicates with a android smart device, an nRF module to communicate with mini hubs, and plenty of i/o ports operate a breadboard with LEDs to simulate multiple window systems.

The mini hub is a standard arduino uno device that has a nRF module that allows it to communicate with the main hub device. Additionally it connects with the window film via SSR chipset. For each window, there will need to be a mini hub system to control the window and communicate with the main hub. The film on the window is an Invisishade 4.0 film product.

The smart device requires android OS, and is mainly designed for a cellular device. The smart device's only requirements are bluetooth compatibility and run off of android OS. The smart device searches for the main hub device, connects, and the application may then select/send commands to the main system.

2 Reference Information

2.1 Product Reference Information

2.1.1 Specifications

[1] No Syllabus Provided.

Dates Required:

1) Final Design Documentation: May 4th, 2018
2) Final Oral Presentation: May 4th, 2018
3) Final Poster: May 4th, 2018
4) Final Peer Reviews: May 4th, 2018

2.1.2 Main Hub Drawing

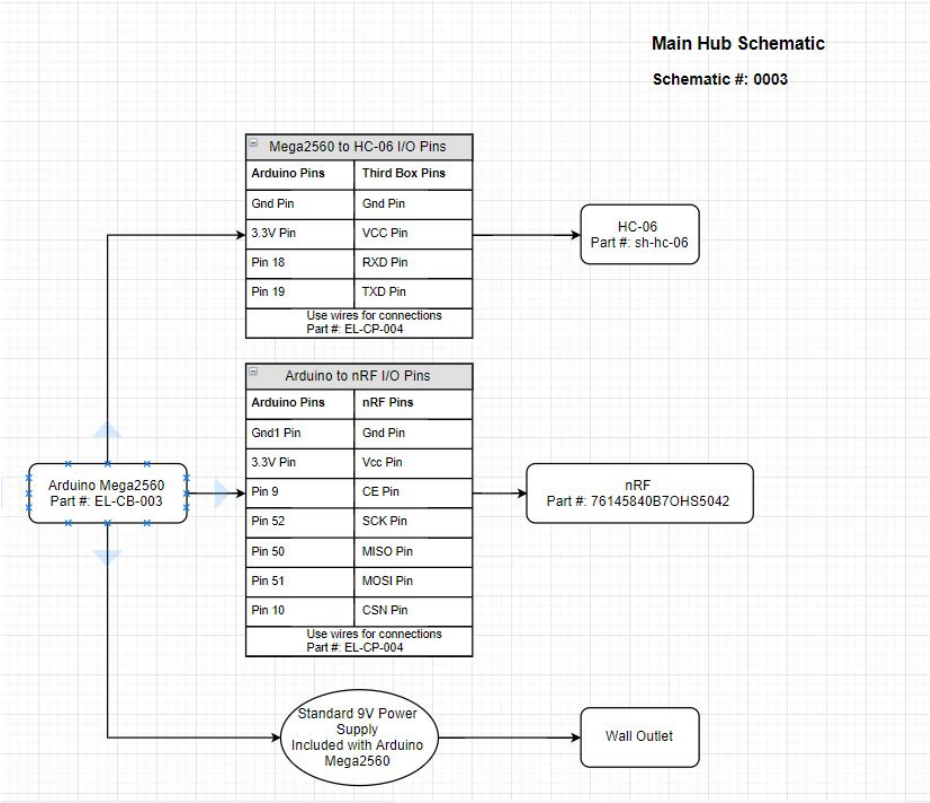

Figure 1: Main Hub drawing schematic, shows pin configurations between parts and their part number references.

2.1.3 Secondary Hub Drawing

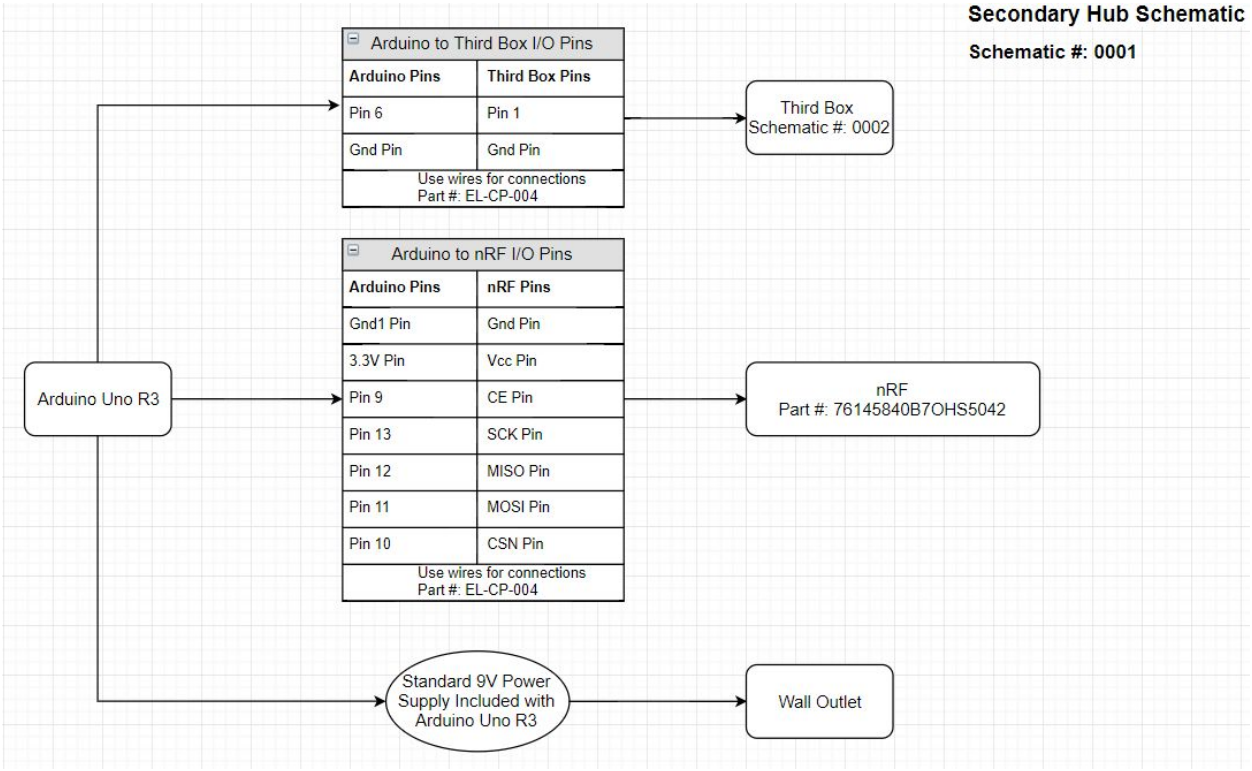

Figure 2: *Secondary Hub drawing schematic, shows pin configurations between parts and their part number references.*

2.1.4 Third Box Drawing

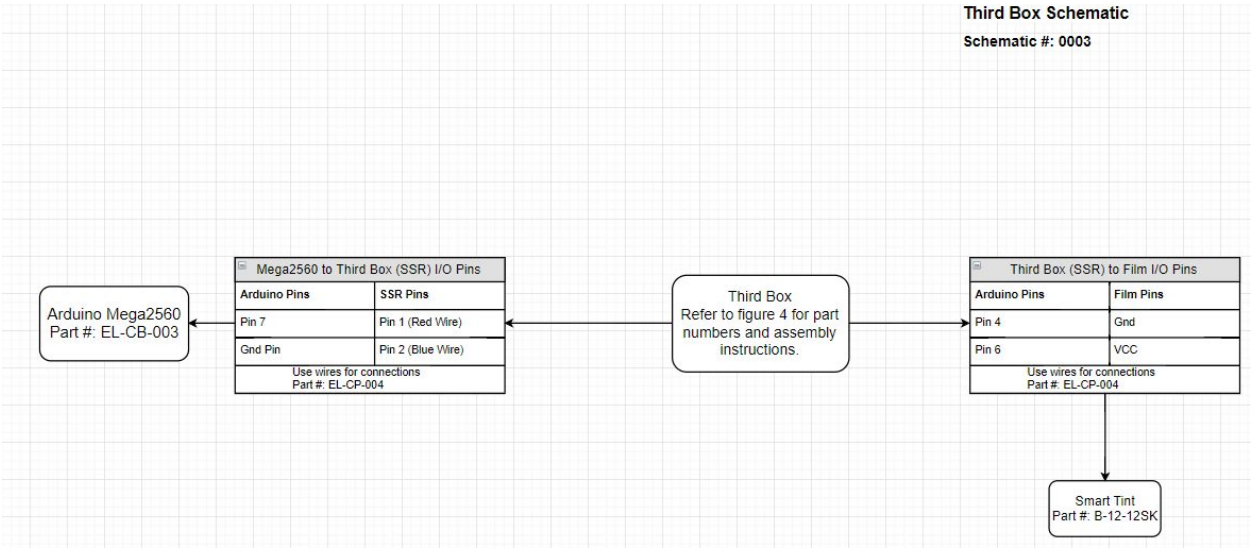

Figure 3: Third Box drawing schematic, shows pin configurations between parts as well as part number references. This image also provides instructions on third box assembly. Refer to Figure 4 for Third Box Assembly.

2.1.4.1 Third Box Assembly Instructions

1. Drill 1/4" holes in opposite sides of the junction box (Part #: a17031600ux1142)
   Note: one side must have two 1/4" holes.
2. Place bread board (Part #: 4330125372) inside of the junction box and glue in the center.
3. Place 1.5K resistor on to the bread board.
4. Solder a wire (Part #: EL-CP-004) to pin 1 and pin 2 of the SSR (Part #: LH1546AABTR).
5. Use red for pin 1 and blue for pin 2.
6. Connect pin 2 (blue wire) to the 1.5K resistor.
7. Connect another blue wire to the opposite side of the 1.5K resistor.
8. Run the red and blue pins out the same drilled hole.
9. Cut and strip 1/2" from both sides of both alligator clip cables (Part #: B072C8G3XJ).
10. Solder the black alligator cable to pin 4 on the SSR. Then solder the red alligator cable to pin 6.
11. Run the cables through the 1/4" hole on the side with only one 1/4" hole.
12. Cut the red wire on the smart tint (Part #: B-12-12SK) between the film and the built in switch.
13. Strip 1/2" on both sides of the film.
14. Solder the black alligator wire coming from the junction box to the stripped switch side of the stripped wires from step 12 and the red to the opposite.

Abbreviations

The following abbreviations are used within this document (this includes everything that even seems obvious to you. Do not count on your audience to see an acronym the same way you do):

Table 1: Abbreviations Table

Term	Definition
LCD	Liquid Crystal Display
LED	Light Emitting Diode
LSB	Least Significant Byte
Max	Maximum
Min	Minimum
SSR	Solid State Relay
Main Hub	Arduino Mega 2560
Secondary Hub	Arduino Uno R3
Film	Smart tint
HC-06	Arduino bluetooth module
nRF	Arduino radio module nRF24l01
BOM	Bill of materials
Third Box	Film solid state relay component box
I/O Pin	Input output pin

2.2 Test Conditions and Special Procedures

There are no security requirements associated with the testing of this assembly.

Unless otherwise stated, all usages of this product shall be performed under the following conditions:

2.2.1 Environmental

The product is recommended only for indoor use.

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2.2.2 Power Requirements

The product requires the following input voltages and currents (make a table that includes each module):

Table 2: Power Requirements

Description	Voltage Range, Max Current
Main Hub	7 - 12 V, 0 - 200 mA
Secondary Hub	7 - 12 V, 0 - 200 mA
Third Box	35 - 75 VAC, 3 - 4w/M^2 (Note: Power consumption depends on size of film strip).

2.2.3 Grounding Requirements

nRF module is grounded to either the Arduino Uno R3 or the Arduino Mega 2560.

HC-06 module is grounded to the Arduino Mega 2560.

Third Box is grounded on both sides, one side is grounded to the Arduino Uno R3 the other through the connection to the power supply of the smart tint.

The Arduino Uno R3 is grounded using the provided power supply, through its connection to the wall.

The Arduino Mega 2560 is grounded using the provided power supply, through its connection to the wall.

Note: If construction steps and pin configurations are followed every item will be properly grounded.

2.2.4 Warm-up Period

This product doesn't require any warm-up period before use. It is recommended to allow the software 5-10 seconds to start before user begins initiating any commands to the device.

2.2.5 Recommended Power-Up Procedure

1. Plug in main hub
2. Plug in secondary hub
3. Plug in third box
4. Start Android application
5. Allow 5 - 10 seconds for software to properly start

2.2.6 Recommended Power-Down Procedure

There is no recommended power-down procedure. Any combination of unplugging the main hub, secondary hubs or third box are acceptable.

2.3 Communication Hub Block Diagram

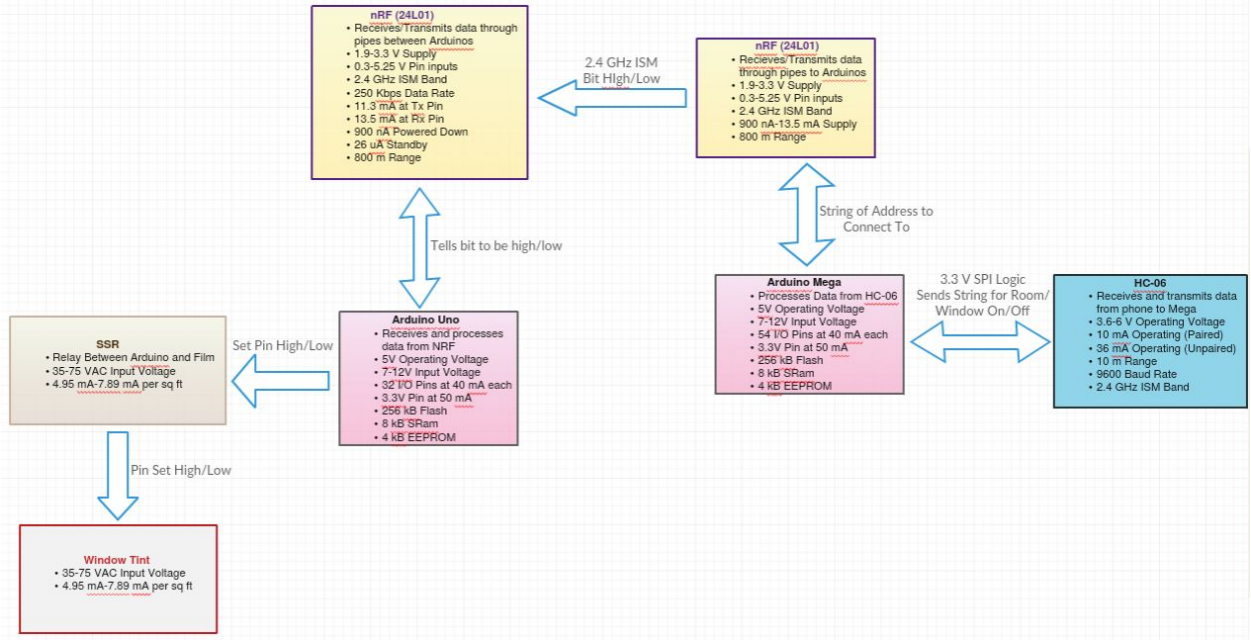

Figure 4: Hub block diagram, shows communication and information on individual parts.

2.4 Memory Maps

2.4.1 Hub Memory Map

Arduino IDE cannot guarantee the location of programs loaded onto their developmental boards.

3 Hardware System

3.1 HC-06 Connected to Arduino Mega 2560

HC-06 is connected to the Arduino Mega using RX and TX pins. These pins allow for information to be sent from the Arduino Mega to the HC-06 serially. The data received from the Arduino Mega to the HC-06 can then be transferred using UART packets to connected bluetooth enabled devices.

Note: For technical specifications for the HC-06 (Part #: sh-hc-06) refer to the document *HC-06 Datasheet*.

3.2 Arduino Mega 2560

The Arduino Mega is a programmable development board that runs on 5V logic. The Arduino Mega acts as the the Main Hub and central computer that interprets commands from a user using their connected smart device.

Note: For technical specifications for the Arduino Mega 2560 (Part #: EL-CB-003) refer to the document *Arduino Mega 2560 Datasheet*.

3.3 nRF Module Connected to Arduino Mega 2560

The connected nRF module uses an SPI connection to receive and send data between itself and the Arduino Mega. The nRF uses standard commercialised 2.4GHz radio frequencies to send data to addressed nRF modules. The nRF modules are used to communicate between the Main Hub and the Secondary Hubs.

Note: For technical specifications for the nRF Module (Part #: 4328612760) refer to the document *nRF 24L01 Datasheet*.

3.4 nRF Module Connected to Arduino Uno R3

The nRF module connected to the Arduino Uno uses an SPI connection to communicate between itself and the Arduino Uno.

Note: For technical specifications for the nRF Module (Part #: 4328612760) refer to the document *nRF 24L01 Datasheet*.

3.5 Arduino Uno R3

The Arduino Uno is a programmable development board that runs on 5V logic. The Arduino Uno is used as a Secondary Hub to receive and pass on commands from a user to control an SSR.

Note: For technical specifications for the Arduino Uno R3 (Part #: EL-CB-001) refer to the document *Arduino Uno R3 Datasheet*.

3.6 SSR Connected to Arduino Uno R3

The SSR connected to the Arduino Uno allows the Arduino Uno, with a simple I/O pin to control the state of the film through completing the circuit in the SSR.

Note: For technical specifications for the SSR (Part #: LH1546AABTR) refer to the document *SSR LH1546AABTR Datasheet*.

3.7 Smart Tint Connected to SSR

The SSR bridges a connection between the Arduino Uno and the Smart Tint. When the Arduino Uno sets the connected I/O pin high or low that either turns on or off the film connected to the opposite side of the SSR. The Smart Tint is

Note: For technical specifications for the SSR (Part #: B-12-12SK) refer to the document *Smart Tint Datasheet 1* and *Smart Tint Datasheet 2*.

4 Hardware Design

4.1 Main Hub Design

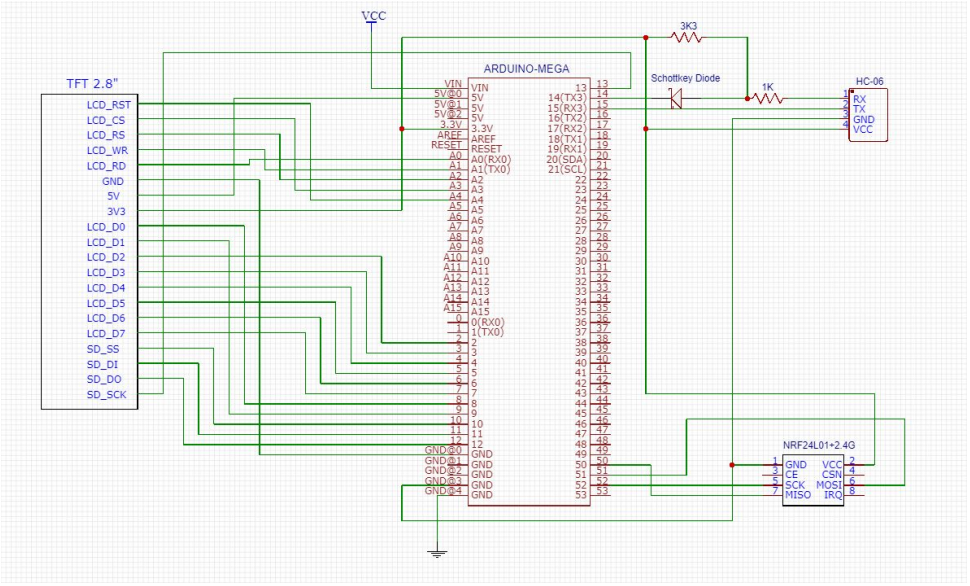

Figure 5: Main Hub wiring schematic with attached modules.

4.1.1 Arduino Mega2560: Chosen for the extra I/O pins and higher SRAM for use with the TFT screen.

4.1.2 HC-06: This was chosen as a means to establish a connection between the Main Hub and the Android Application installed on a smart device.

4.1.3 nRF: This was chosen as a way to communicate between individual Secondary Hubs and the Main Hub. This directly influences the modular design specification, it allows up to 125 devices to communicate with distinct addresses. This works perfectly with our design as it allows our Main Hub design to theoretically communicate with up to 124 other distinct Secondary Hubs.

4.1.4 TFT: This was chosen as a good way for a user to interface with the Main Hub if they wished to control the Main Hub manually rather than wirelessly.

4.2 Secondary Hub

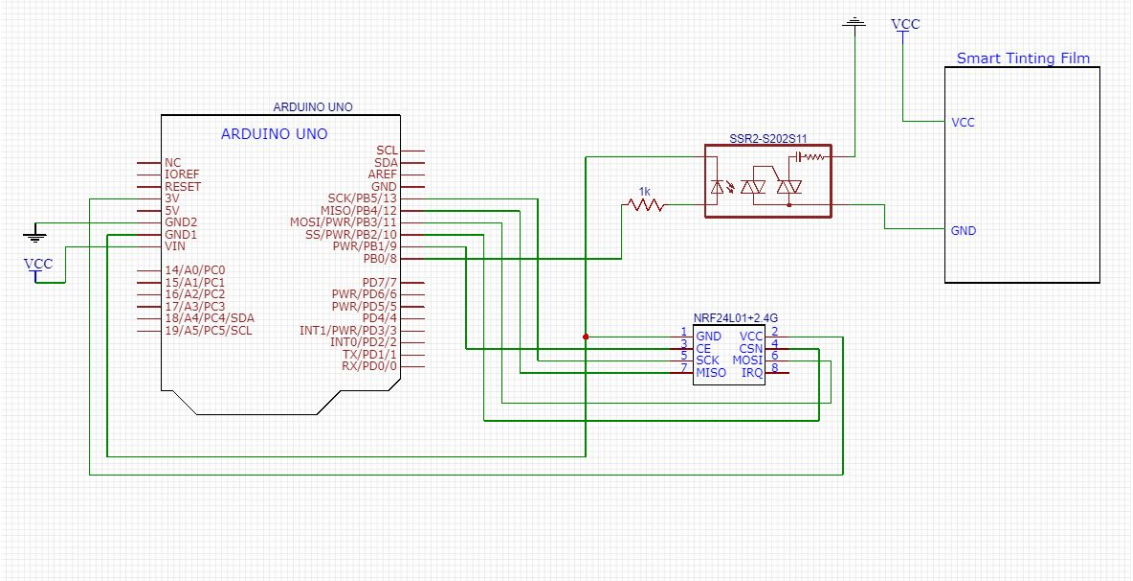

Figure 6: Secondary Hub wiring schematic with attached modules.

4.2.1 Arduino Uno R3: This was chosen due to its relative cost effectiveness in comparison to its power. Choosing this device was ideal to keep similar code structure and interfacing between nRF modules similar between both the Main Hub and Secondary Hub.

4.2.2 nRF: This was chosen as a way to communicate between individual Secondary Hubs and the Main Hub. This directly influences the modular design specification, it allows up to 125 devices to communicate with distinct addresses. This works perfectly with our design as it allows our Main Hub design to theoretically communicate with up to 124 other distinct Secondary Hubs.

4.2.3 Third Box: This was chosen as an effective way to prevent injury due to high current electricity moving through circuits that were not completely sealed without the use of the Third Box or junction box.

4.3 Third Box

4.3.1 SSR: This particular SSR was chosen due to its specifications. The SSR allows a lower current and voltage circuit to interact with a higher current and voltage circuit. Due to the Arduino Uno R3 running on a lower current and voltage this allows a single I/O pin from the Arduino Uno R3 to control the state of the film wired into the SSR.

4.3.2 Film: This film was chosen due to the companies close proximity to where development began. The company the manufactures this item also had high recommendations. The tinting film was chosen to help the meet the specifications of controlling the amount of light let into a room through adjusting the dimming on the film from opaque to transparent.

5 Bill of Materials

Table 3: This is the BOM, holds the part numbers, descriptions as well as costs at time of purchase.

Part Name	Part Number/Model	Units	Cost	Part Description	Supplier
Smart Film	Smart Tint B-12-12SK	x1	$99.99	This will attach to the window hub and through commands provided will adjust the amount of light shown through.	Smart Tint
Elegoo Mega 2560 R3	EL-CB-003	x1	$13.99	This will be used as the processor for the main hub.	Amazon
Elegoo Uno R3	EL-CB-001	x1	$10.90	This will be used as the processor for the window hubs.	Amazon
DSD Tech HC-06	sh-hc-06	x1	$8.99	This will be part of the main hub and will allow for a user to control the main hub from the application on their smart device.	Amazon
SSR LH1546AABTR	LH1546AABTR	x1	$2.04	This part will be used to switch the higher voltage circuit on and off using the lower voltage circuit on the Arduino Uno	Mouser
Sumnacon Dual Alligator Clips	B072C8G3XJ	x1	$9.99	Used to test with third box to with film.	Amazon
MakerFocus NRF24L01	4328612760	x2	$12.99	This will connect between the window hub and the smart tint to allow the window hub to adjust the film depending on commands provided by the main hub.	Amazon
Foxnovo NRF24L01	76145840B7OHS5042	x10	$11.99	This will be part of the window hub and main hub. These items will allow communication to be established between the various window hubs and the main hub. Ordered more due to the original nRF modules breaking.	Amazon
Uxcell 4.5" x 3.4" x 1.4" ABS Junction Box	a17031600ux1144	x1	$8.85	Used as the third box enclosure for saftey.	Amazon
Uxcell 3.3K Resistors	a11102400ux0138	x1	$3.88	This will be used for a voltage divider to protect the HC-06 on the main hub.	Amazon
E-Projects 1K Resistors	25EP5141K00	x1	$5.78	This will be used for a voltage divider to protect the HC-06 on the main hub.	Amazon
MclgIcM Schottkey Diode	1N5822	x1	$7.99	This will be used for to ensure the HC-06 will not be shorted by the Arduino Mega 2560.	Amazon
eBoot Prototype Bread Board and Assorted Wire Kit	4330125372	x1	$9.99	These wires and breadboard will be used to connect the various modules to either the main hub or the window hubs.	Amazon
Elegoo EL	EL-CP-004	x120	$7.86	Wires used to connect various modules together.	Amazon
		Total:	$215.23		

6 Traceability Matrix

Table 4: Traceability matrix, holds all the constraints, assigns them names and provides a brief description.

CR#	Name	Description	Component	RML(TP#)
1	Film Control	Develop device (Arduino) that will control amount of light coming through a window.	Hardware	003-TP5
2	Hub Communication	Have the device communicate to a main hub via nRF configuration.	Firmware	003-TP4
3	Data Storage	Have a main hub that stores information of all window controllers and controls the windows.	Firmware	003-TP8
4	Device-System Communication	Have the main hub communicate with smart device via bluetooth communication.	Firmware	003-TP3
5	Window/Room Selection	Have the smart device be able to select a window/room and control the tint on selected window(s).	Software	003-TP5
6	Software Application	Create Android OS smart device application to communicate with main hub and serve as a user interface.	Software	003-TP4
7	System Modualization	The system must be able to add/delete a window or a room. Effectively making the system expandable.	Software	003-TP7