# ENSC 305W/440W Grading Rubric for Functional Specification

| Criteria | Details | Marks |
|---|---|---|
| **Introduction/Background** | Introduces basic purpose of the project. | **/05%** |
| **Content** | Document explains the functionality of the proposed product without excessive design content (i.e., outlines the "what" rather than the "how"). | **/10%** |
| **Technical Correctness** | Ideas presented represent valid functional specifications that must be considered for a marketed product. Specifications are presented using tables, graphs, and figures where possible (rather than over-reliance upon text). | **/15%** |
| **Process Details** | Complete analysis of problem. Justification for chosen functionalities. Sources of ideas referenced. Specification distinguishes between functions for present project version and later stages of project (i.e., proof-of-concept, prototype, and production versions). Comprehensively details current constraints. | **/20%** |
| **Engineering Standards** | Outlines specific engineering standards that apply to the device or system and lists them in the references. | **/10%** |
| **Sustainability/Safety** | Issues related to sustainability issues and safety of the device are carefully analyzed. This analysis must cover the "cradle-to-cradle" cycle for the current version of the device and should outline major considerations for a device at the production stage. | **/10%** |
| **Conclusion/References** | Summarizes functionality. Includes references for information from other sources. | **/05%** |
| **Presentation/Organization** | Document looks like a professional specification. Ideas follow in a logical manner. | **/05%** |
| **Format Issues** | Includes letter of transmittal, title page, executive summary, table of contents, list of figures and tables, glossary, and references. Pages are numbered, figures and tables are introduced, headings are numbered, etc. References and citations are properly formatted. | **/10%** |
| **Correctness/Style** | Correct spelling, grammar, and punctuation. Style is clear concise, and coherent. Uses passive voice judiciously. | **/10%** |
| **Comments** | | |

Simon Fraser University
8888 University Dr.
Burnaby, BC Canada

September 23, 2013

Dr. Lakhsman One
School of Engineering Science
Simon Fraser University
Burnaby, BC, V5A 1S6

**Re: ENSC 305/440 Functional Specifications for Smart Blinds System**

Dear Dr. One,

Enclosed is a functional specification from BikoTech describing the features and attributes of the Smart Blinds System. We are designing an improvement to conventional home and business window blinds by integrating a unique control system that offers users enhanced functionality and automation capabilities.

Our functional specification provides details to our high level performance and system functionality. This document will also be used by all members of our team throughout the build process as a guide to testing our components and integrated modules. By creating this document we specify targets for all members of our team to meet, and thus ensuring that our product prototype achieves an acceptable level of performance.

The BikoTech team consists of Jorden Bryer, Chaman Toor, Willy Wong, and Clark Zhao. As engineering students we believe we have the drive and the skills to make BikoTech a competitive and engaging company. If you have any questions, please contact me by email at jordenb@sfu.ca.

Sincerely,

Jorden Bryer
President and CEO
BikoTech Automated Systems

Enclosure: *Functional Specification for Smart Blinds System*

BikoTech
Automated Systems

Functional Specification for

# Smart Blinds System

**Project Team**
Jorden Bryer – Chief Executive Officer
Willy Wong – Chief Financial Officer
Chaman Toor – Chief Technology Officer
Clark Zhao – Chief Operating Officer

**Contact Person**
Jorden Bryer
jordenb@sfu.ca

**Submitted To**
Dr. Lakhsman One
School of Engineering Science
Simon Fraser University

BikoTech Automated Systems

# Executive Summary

Windows blinds are devices that can be found everywhere. From our homes to our places of business, they are an ever-present solution to the need to regulate natural light. We use them daily, but put little consideration into what they could be doing better. With our Smart Blinds System we hope to offer an automated solution that allows users to maximize or regulate levels of natural light.

The device itself is designed to blend in with conventional window blind systems. Its parts and control systems will be integrated into the structure of the blinds themselves and will utilize the housing for the blind's gears for connections to our motors. These motors will integrate with an Arduino Microcontroller that acts as the brain of our control system, receiving ambient light data as well as user inputs to achieve a fully functioning system.

The prototype of our product aims to achieve the following key features:

- Motorized blind lifting and tilting mechanisms to control light flowing into a room
- Ambient light sensing, allowing our microcontroller to obtain real time data on light conditions
- Power independence through battery power and a compact solar charging array positioned on the upper part of the blinds behind their housing and hidden from inside view
- Interactive software interface that allows users to program when or under what light conditions they want their blind system to open or close
- Aesthetically pleasing design with cords, motors, and other electrical components hidden from view

The BikoTech team is motivated to integrate these features successfully into our Smart Blinds System. We also realise that creating a safe device with robust software is a top priority. With this in mind we will follow the applicable ISO (International Standards Organization), CSA (Canadian Standards Association), and WCMA (Window Covering Manufacturers Association) standards to help make these requirements a reality.

# Table of Contents

BikoTech
Automated Systems

# List of Figures



# Glossary

| | |
|---|---|
| **ISO** | International Standards Association |
| **CSA** | Canadian Standards Association |
| **WCMA** | Window Covering Manufacturers Association |
| **LCD** | Liquid Crystal Display |
| **LED** | Light Emitting Diode |
| **UI** | User Interface |

# 1. Introduction

The Smart Blinds System is designed to be an automated blind control system. It will allow users to specify their own expectations for natural light entering their room, and to program specific times to open and close the blinds. It serves as an alternative to traditional blinds systems that are used daily but offer no other useful features. The requirements for the Smart Blinds System are detailed in the following specifications.

### 1.1 Scope

This document describes the functional specifications that BikoTech will follow when creating the Smart Blinds System. These requirements are written to describe our prototype device, and may need to be adapted or updated for a production device in the future. This document is not intended to describe the low-level implementation methods we will use to achieve the specifications listed.

### 1.2 Intended Audience

Our functional specifications are targeted towards all members of the BikoTech team. Each member will use this document as a guideline when developing each feature of our Smart Blinds System. This document will also be relied on during all stages in the testing procedure to ensure all outcomes adhere to our original specifications. Throughout the creation of our device our team members will use this document to assess the progress of our design and to eventually gauge the success of our project.

### 1.3 Document Conventions

The following convention will be used to indicate the type of function requirement:

[Rn-p] A Functional Requirement

where n is the requirement number and p is the priority of the requirement described as follows:

I – Must be included in the prototype.

II – Will be included if time permits.

III – Production only requirement.

# 2. System Requirements

The general requirements of BikoTech's Smart Blinds System are outlined in the following sections. Specific subsystems requirements can be found in the proceeding sections.

### 2.1 System Overview

BikoTech's Smart Blinds System is shown in the following conceptual drawing:

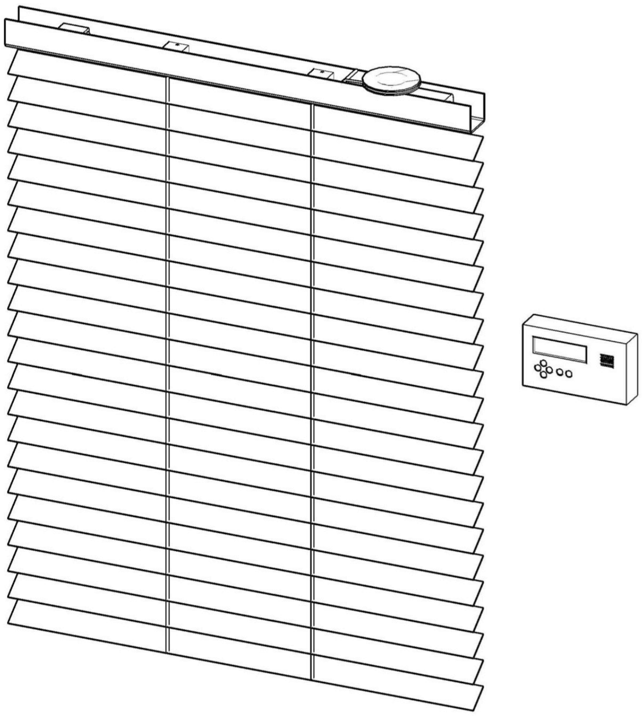

**Figure 1:** Smart Blinds Concept

The prototype of our Smart Blinds System will be a fully functional blind automation product. Our system is comprised of a handful of mechanical control and feedback systems. It features two control motors (one 180 degrees servo motor and one bidirectional DC motor) that allow for seamless control of our window blinds tilt and elevation. Powering these motors is the brain of our system, the Arduino Mega Microcontroller combined with a L298 motor controller circuit. These two components allow full control over our motors speed and direction.

Another function of our microcontroller is to receive both user and environmental inputs. Our user inputs are driven to our device from our Arduino LCD and button shield. With this shield our product's user can interact with our device, setting the times they would like their blinds to change position, or the amount of sun they would like the blinds to let into the room at any given time. To fulfill that later requirement, our system's digital intensity lux sensor will be able to provide real time data on the amount of ambient light entering through our blinds.

Powering our system is a 9V rechargeable battery that is connected to a 300 mA trickle charge circuit. This circuit utilizes a small solar array facing outwards from our devices upper housing to allow our product to sustain a long lifetime without the need for a replacement battery. When working together effectively these systems generate a seamless experience for its user. The following figure displays our system's flow chart, which outlines the highest level operation of our Smart Blinds System:

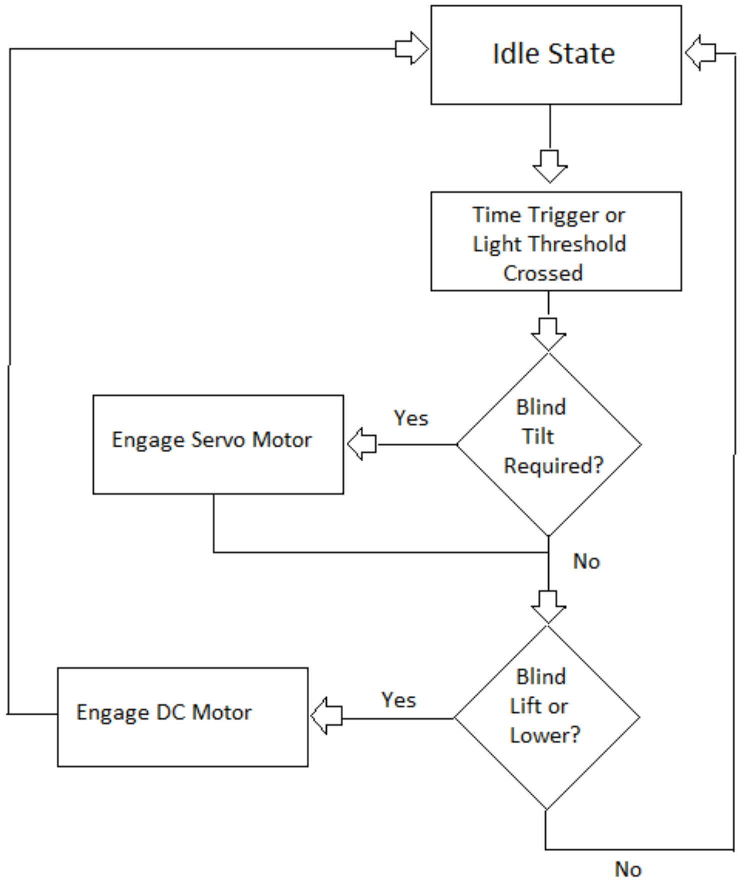


**Figure 2:** System Flow Chart

### 2.2 General Requirements

[Rn-I] The system shall have an idle state where only the microcontroller and light sensors are operating

[Rn-I] The blind control system shall be able to fit conventional lightweight aluminum blinds

[Rn-II] The system shall have an off state at which all components are inactive and power is fully disconnected

[Rn-II] The entire blind system shall be easy to install for most home owners

[Rn-III] The retail price of our system shall not be more than $150

### 2.3 Physical Requirements

[Rn-I] The weight of our system including blinds shall not exceed 12 kg

[Rn-II] The entirety of the control systems shall be of small enough size to not require an external housing outside of the blind cover

[Rn-II] Noise generated by our system's motors shall not exceed 65 decibels

### 2.4 Electrical Requirements

[Rn-I] The entire current drawn from our microcontroller shall not be more than 500 mA at any given moment

[Rn-II] A 9V battery will be sufficient to power the entirety of our system excluding the DC motor controller that may use a separate battery pack

[Rn-II] Key test points shall be made available for testing and debugging purposes

### 2.5 Mechanical Requirements

[Rn-I] The components used by the user (buttons, LCD panel) must be installed in an easy to reach, visible area

[Rn-I] The system prototype and its components shall be installed securely to a conventional window frame with a similar structural integrity

### 2.6 Environmental Requirements

[Rn-I] The system will be constructed from re-usable parts and components

[Rn-I] The system will not generate exhaust or other waste products

### 2.7 Standards

[Rn-II] The system shall comply with standard CSA C22.2 NO 68 [1] regarding household and commercial motor operated appliances

[Rn-II] The system shall comply with standard ANSI/WCMA A100.1-2012 [2] regarding the safety of corded window covering products

### 2.8 Reliability and Durability

[Rn-I] The system shall be easy to disassemble and repair

[Rn-II] The system shall be resistant to fluctuations in temperature, and able to operate from 5 degrees to 40 degrees

[Rn-II] An LED must alert the user when battery power nearly drained

[Rn-III] The system shall be able to perform blind operations up to 5 times a day for no less than 4 months without needing a replacement battery

### 2.9 Safety Requirements

[Rn-I] All functions of the system shall not exceed 85 decibels [3]

[Rn-I] There will be no uncovered copper wires or poorly soldered joints in our device

[Rn-I] The device shall not overheat or catch fire or otherwise constitute a fire hazard

[Rn-II] A limit switch between the motors and the blinds shall prevent movements that may damage the blind system

[Rn-III] The device shall be able to detect overheating conditions and power itself down

### 2.10 Performance Requirements

[Rn-I] The systems motors shall take no longer than 2 seconds to tilt the blinds completely from open to close, and take no longer than 5 seconds to raise or lower them fully

[Rn-I] The system shall not exert an excess amount of force on the blinds during operation

[Rn-II] The system shall lower the blinds to within half an inch of the bottom of the window

[Rn-II] The system shall not leave more than half an inch between the top of the system and the fully pulled up blinds

[Rn-II] The system shall not take longer than 2 seconds to respond when a button is pressed

[Rn-III] The system must be able to detect changes to surrounding light and respond to them in no less than 5 seconds

### 2.11 Usability Requirements

[Rn-I] The system shall enter idle mode 10 seconds after a button is last pressed

[Rn-II] The user shall be able to fully understand the systems interface within 10 minutes of instruction or use

[Rn-II] The user shall be able to set at least 2 different times a day for the blinds to change position

[Rn-III] The systems firmware shall be upgradable by a technician

# 3. Blind Lift Mechanism

The lifting mechanism is used to raise and lower the blinds of the Smart Blinds System. This will allow the window to be completely exposed or completely covered, therefore dictating the amount of light able to enter a room.

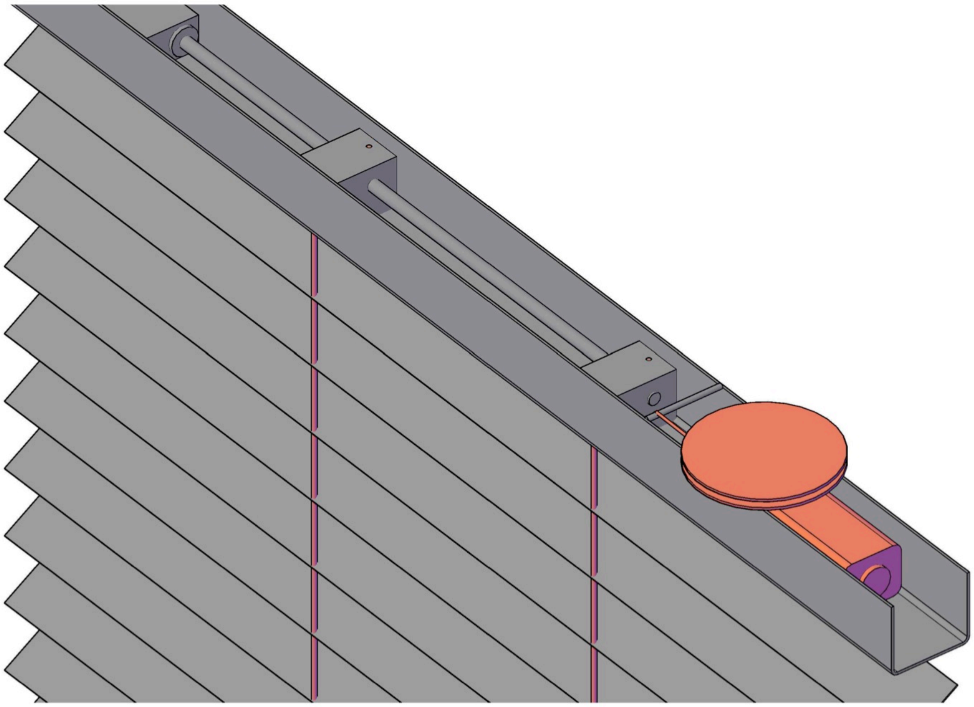

**Figure 3:** Blind Lift Mechanism (Shown In Red)

### 3.1 General Requirements

[Rn-I] This mechanism will pull the blinds up to reveal the entire window
[Rn-I] The mechanism ensures that the maximum amount of light enters the room

### 3.2 Physical Requirements

[Rn-I] The mechanism shall fit inside the dedicated housing
[Rn-I] The mechanism shall not interfere with other parts of the system such as the tilt mechanism, or any of the wiring

**3.3 Mechanical Requirements**

[Rn-I] The lift mechanism shall be capable of lifting all the blinds without halting or stopping
[Rn-I] This mechanism will lift the blinds at a constant speed
[Rn-II] The mechanism shall be durable and resistant to wear during everyday use
[Rn-II] The mechanism will not drain the battery when not in use
[Rn-III] The shall not cause excess vibration of the system enclosure

# 4. Blind Tilt Mechanism

The tilt mechanism will provide the user with the ability to let light into a room. However, unlike the lifting mechanism, the tilt mechanism will not expose the entire window to ensure some amount of privacy. This mechanism allows the user to change the angle of the tilt on the blinds thereby allowing various amount of light to enter a room.

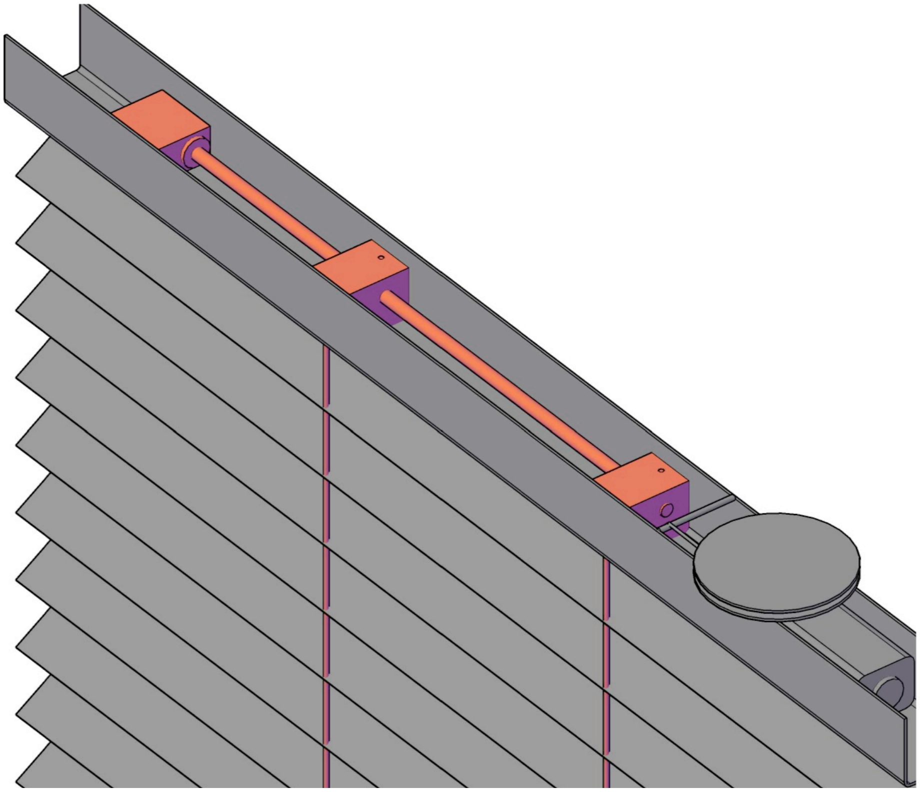

**Figure 4:** Blind Tilt Mechanism (Shown In Red)

### 4.1 General Requirements

[Rn-I] The mechanism will provide the user with finer control of the amount of light that enters a room

[Rn-I] This mechanism will allow for a higher level of privacy than the lift mechanism

### 4.2 Mechanical Requirements

[Rn-I] The mechanism will be capable of turning the blinds so that they are positioned at an angle that optimally blocks or allows natural light to enter a room

[Rn-I] This mechanism will turn the blinds slowly in order to prevent damage to the mechanism

[Rn-II] This mechanism shall be durable and resistant to wear during everyday usage

[Rn-III] The servo motor shall not cause excess vibration of the enclosure

### 4.3 Physical Requirements

[Rn-I] The mechanism will fit inside the dedicated housing

[Rn-I] The tilt mechanism shall not interfere with other parts of the system

# 5. Electronic Hardware

The function of electronic hardware, mainly Arduino Mega 2560 microcontroller, is to process user and light sensor inputs to control the speed and direction of the control motors.

### 5.1 General Requirement

[Rn-I] All the electronic components shall be able to perform in a room temperature environment

[Rn-I] All electronic hardware will be enclosed inside the blind housing

[Rn-I] Any heat generated shall be minimal and will be dissipated efficiently

### 5.2 Light Sensor Requirements

[Rn-I] The light sensor shall provide real time data to our microcontroller

[Rn-I] The light sensor shall be able to perform under temperature from 5 to 40 degree Celsius

[Rn-I] The light sensor shall be able to tolerate continuously direct sunlight

### 5.3 Power Source Requirements

[Rn-I] The Arduino Mega 2560 microcontroller requires a DC input range between 7-12V [4]

[Rn-II] The Arduino Mega 2560 microcontroller will be powered by 9V DC rechargeable batteries

[Rn-II] The 9V DC rechargeable batteries shall be charged by a small 7.3V solar array

# 6. User Interface

The user interface of our system is designed to allow the user adequate control over their blind system. By interfacing with the LCD and pushbutton Arduino shield, our microcontroller gives its user numerous control options that dictate the Smart Blinds System's use.

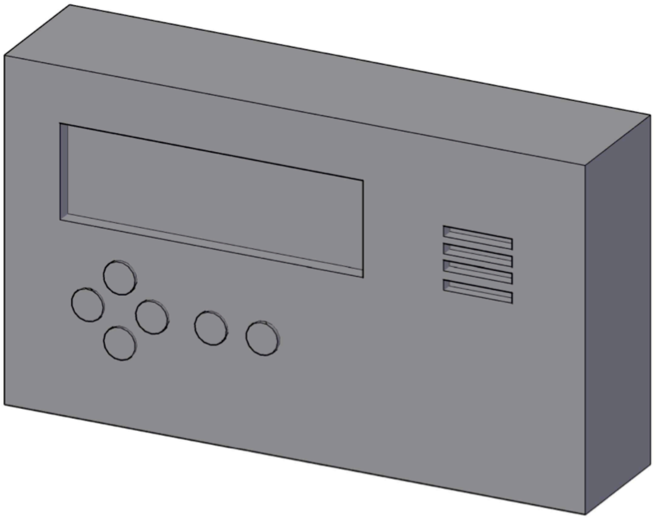

**Figure 5:** Control Panel

### 6.1 General Requirements

[Rn-I] The systems LCD panel shall display the current state and control options of open, close, and tilt for the blinds

[Rn-II] The systems LCD panel shall display the time settings for the alarm

[Rn-II] The systems LCD panel shall display the amount of energy remaining in the batteries

[Rn-II] The systems LCD panel shall display a warning when the electrical failure condition occurs

### 6.2 Usability Requirements

[Rn-I] The user interface control shall be easily understandable and controllable
[Rn-II] The user interface control shall be able to remotely control the blinds
[Rn-II] The user interface shall be visually aesthetic and physically comfortable

### 6.3 Software Requirements

[Rn-I] The software shall not produce erroneous outputs to the hardware system
[Rn-II] Software development will use standard ISO/IEC 12207 [5] regarding life cycle processes and overall software maintenance
[Rn-II] Software development will use standard ISO/IEC 15504 [6] regarding software process improvement and capability determination
[Rn-II] The software could be updated by user
[Rn-III] The software could be installed on any modern PC

# 7. User Documentation

[Rn-I] User documentation shall be available online on ENSC 305/440 website
[Rn-II] The online documentation will be easily readable and understandable
[Rn-III] A demonstration video will be recorded and uploaded onto YouTube

# 8. Test Plan

It is important to let the Smart Blinds System undergo extensive testing before releasing the finalized product for production. Not only to guarantee that there are no faults in our design, but also to ensure that it continues to perform as desired over a long period of time. Our test plan will therefore be divided into 3 main steps: First testing the systems individual components before they are added to the design, next testing the combined modules and how they interact together, and finally testing the entire prototype system.

**8.1 Component Test**

The Smart Blinds System is made up of many individual components that must work together seamlessly in order to perform their designated function. We will test each of these components individually to ensure they are operating correctly before we integrate them into our design. These components and how they will be tested are listed below:

- The Arduino Microcontroller: This device needs to be tested to ensure it can supply adequate current through its 5V output to power our devices. We also need to confirm that it can load and store software on its memory, and properly execute that software.
- DC Motor Controller and DC motor: The motor controller and DC motor will undergo multiple tests to ensure it can maintain a constant speed, and that it can operate in both directions. We will also perform stress tests on the motor to determine the maximum weight it can lift while still maintaining a nominal speed.
- 180 Degree Servo Motor: This motor will be connected directly to our microcontrollers power and control pins. We will test to ensure it can rotate a full 180 degrees and that it maintains enough torque to rotate our blinds tilting mechanism.
- Light Sensor: This device will be tested through a connection with our microcontroller. We will utilize a short software script to ensure our light sensor is pulling accurate data from its environment. This includes being able to detect changes in ambient light in real time within a specific (10% target) threshold.
- LCD and Button Shield: This device will be connected to our microcontroller. We will run a script that all pixels are able to light up and go dark as required. We will also run some speed tests to make sure our screen can update and display text in a quick manner. We will also determine if they need to be debounced in software by tying the button presses to a visual indicator on the LCD screen.
- Solar Array and Batteries: These devices will be tested to ensure that they supply 9V at maximum capacity. We will also test the solar array with different light levels to see how much power they supply in all conditions.
- Blinds: We will perform basic usage stress tests on our blinds. We will also confirm that the upper casing of the blinds can hold the weight of our system. It is also important to weigh the blinds to confirm that our motors will be able to move them efficiently.

**8.2 Integrated Module Test**

The test plan for integrated modules is written with function in mind. Each of these components needs to be able to communicate with each other and be able to interact with the blinds in a way that does not damage or alter their function. The test plan itself is broken up into 3 separate parts, each that focuses on the primary goals of our design.

- Kinematics: This section will be specific to the motors, motor controller, microcontroller, and blinds themselves. We must first confirm that we can establish a connection between the blinds two control mechanisms and our motors. The radial tilt mechanism will be connected to our servo motor, and the blinds string pulley system will connect to our DC bidirectional motor. We must confirm that our motors can fit securely in the upper housing of our blinds, and they have adequate access to the blinds movement systems. Once these connections are established we will use two Arduino scripts, one for each motor, to test the variables that dictate how our blinds will function. Specifically these are the amount of time the bidirectional motor needs to lift the blinds fully open and to lower them completely. And also the amount of degrees the servo motor needs to open and close the blinds fully. Once these two variables are found we will be able to move onto the next stage of our product.

- Communication: In this section the attributes of the LCD and pushbutton shield will be tested with our system and our digital light sensor. It is of the utmost importance that once the desired user interface is programed for the LCD panel that we confirm it is working correctly. The user needs to be able to use the buttons to select through a simple menu of options that control the blinds. This includes being able to set a time for the blinds to open or close, and to be able to program a specific amount of light the user wants to enter their room at all times. We will first use separate scripts to test each of these individual options on a short time frame. Next we will test the inputs of our digital light sensor with our microcontroller. We must ensure that it responds quickly to changes in light. We will do this by having our microcontroller display the light readings it receives onto our LCD panel. We will test the integrity and speed of these readings by using flashlights or variations in natural light to ensure it works correctly. We will next alter this script and combine it to the above script (in this section) to allow the programing of desired light to enter a room. This will be tested with flashlights and natural light sources to establish how specific light levels can be described in the software that interacts with the user.

- Power: In this section the maximum power draw of our system will be tested. We will connect all components to our microcontroller and operate them individually and then together to test that our microcontroller can supply adequate power. We will next connect our 9V battery and its solar charging circuit to test that the microcontroller and its components can be powered from this cell, or if more cells need to be added. More batteries or a more efficient charging circuit may need to be designed if we find that the battery depletes too quickly under normal conditions, or that the circuit simply charges too slowly for extended use. Extensive stress tests will be undertaken by constantly engaging the motors to open and close the blinds, and after a period of time testing the battery with a multimeter to read how much energy was drained. This information, paired with the speed at which our battery recharges, should give us a good idea of how long our system can operate without the need of a new battery.

**8.3 System and User Acceptance Test**

Once the above tests have achieved satisfactory results we will move onto overall system tests. These tests are designed with the user in mind, to allow ourselves and others not associated with our project to get hands on experience with our system. This will be useful in providing us with feedback. Most of these tests will follow what we expect to be the typical usages of our system. These include setting a time to open or close the blinds, setting the amount of light you desire and being able to understand how much light that will be, and powering down or turning on the blinds. More tests will be constructed to ensure the overall safety of our design. These include excess heat tests that will sample the amount of heat radiating from our device and its components under extreme use conditions.

We believe that if these test procedures are followed that we will achieve a successful end to our prototype design.

# 9. Conclusion

This functional specification defines the fundamental requirements of BikoTech's Smart Blinds System. The project development will be divided into two stages. The first stage is the prototype stage where we attempt to include all "I" and most "II" level requirements. The success of this stage will be dependent on the final prototype of our system. If we meet enough requirements outlined in this document we will design a second stage in which we will investigate further development of this product. The first stage is planned to be complete by December 12, 2013. Further development may include enhancements to the user interface of the design, and changes to the control system itself to ensure a more marketable and affordable product.

# 10. References

[1] CSA C22.2 NO 68-2009, Canadian Standards Association, [Online], Available: http://shop.csa.ca/en/canada/appliances/c222-no-68-09/invt/27002302009 [Accessed Oct 11, 2013]

[2] ANSI/WCMA A100.1-2012, Window Covering Manufacturers Association, [Online], Available: http://shop.csa.ca/en/canada/appliances/c222-no-68-09/invt/27002302009 [Accessed Oct 11, 2013]

[3] City of Saskatoon, "Sound Attenuation", [Online], Available: http://www.saskatoon.ca/DEPARTMENTS/INFRASTRUCTURE%20SERVICES/TRANSPORTATION/ATTENUATION/Pages/SoundAttenuation.aspx [Accessed: Oct. 11, 2013]

[4] Arduino Mega 2560 User Documentation. [online] http://arduino.cc/en/Main/ArduinoBoardMega2560?action=print [Accessed Oct. 10, 2013]

[5] ISO/IEC 15504-1:2004, International Standard, [Online], Available: http://webstore.iec.ch/preview/info_isoiec12207%7Bed2.0%Den.pdf [Accessed: Oct 14, 2013]

[6] ISO/IEC 12207:2008, International Standard, [Online], Available: http://webstore.iec.ch/preview/info_isoiec12207%7Bed2.0%7Den.pdf [Accessed: Oct 14, 2013]