Dr. Andrew Rawicz
School of Engineering Science
Simon Fraser University
Burnaby, BC
V5A 1S6

Re: ENSC 440 Functional Specification for uControl Solutions

Dear Dr. Rawicz,

Attached is a document describing the functional specification for uControl. We at Universal Control Solution aim to create a product which extends far beyond improving the luxury and comfort of the user. We aim to create a device which could potentially be used to control your entire home all the touch of your fingers. Our device aims to take a firm hold of the rapidly expanding tablet market and allow the users to control their lights, heating/cooling systems, and various multimedia systems all at the touch of your fingers from ONE place, your personal computer!

Our team consists of 3 highly talented electronics engineering student Stoyan Petrov, John Kenyon and Sajib Saha, and me, Ivan Petrov, a senior biomedical engineering student who will be responsible for integrating the user interface in a simple and "sexy" way that allows users to quickly access all of our product features. One other major component of our product is that we will attempt to integrate it with an environmental control system and could potentially replace the currently existing X10 systems. This plays a huge factor for assisting those with physical disabilities who have some form of access to a PC.

We believe that things should be made simple, effective and reliable. uControl is easy to use, inexpensive, portable and effective. Furthermore it is expandable and could be used by a wide demographic. We truly believe that once complete, this device will revolutionize the way users interact with their homes. If you have any questions or comments please contact me at ivp@sfu.ca , or by phone (604) 588-5429. I will convey your message to my fellow team members.

Thank you for attention.
Sincerely,

Ivan Petrov
Chief Executive Officer
Universal Control Solution
ivp@sfu.ca
604-588-5429

Enclosure: *uControl Solutions' functional specification is attached below*

uControl Solutions

uControl: Home Automation System

Project Team:	Ivan Petrov Stoyan Petrov Sajib Saha John Kenyon
Contact Person:	Ivan Petrov ivp@sfu.ca (604) 588-5429
Submitted To:	Dr. Andrew Rawicz Mike Sjoerdsma
Date Submitted:	February 16, 2011

Executive Summary

"Your home at your command"! This is the goal of uControl Solutions. What we are offering is the best solution for affordable home automation. Our product "uControl" will not only bring ease to the user in their everyday life but also greatly assist physically disabled people. Simple, Elegant, and Effective is the best way to describe uControl. uControl is not your typical 'universal' remote. In the Home Automation Industry, the term 'universal remote' usually only refers to controlling home entertainment systems.

At uControl Solutions our aim is to develop a truly universal remote control. One that is not overloaded with features but does everything you ask it to do. The uControl system will revolutionize the term 'universal remote'. People are no longer bounded to having to point at their TV to change a channel. People no longer have to disturb their quality TV time by standing up and turning off their lights. No more screaming across the room to ask someone to turn off the lights.

The development stage of the uControl is divided into 3 stages.

- **Stage 1**: Control modules
- **stage 2**: Central Unit and Remote Control
- **Stage 3**: User interface and setting up connection between central unit and control switches

In the first stage we will be making the wireless dimming switches for controlling lights and heaters, and send it for PCB production. In the second stage we will be implementing the TV remote control and also the central unit as a whole. In the final stage we will be implementing the GUI and set up the interconnection between the control switches and the central unit to be able to control the switches and entertainment system wirelessly. The duration of this project is estimated to take around 4 months to complete, starting from January 4, 2011 to April 4, 2011 which includes researching, designing and building prototypes, and debugging.

This document is meant to be framework for the engineers to work on with regards to the required features projected for our unit. However, this is not a final document and it will be continuously revised and updated after vigorous researching and numerous testing to provide a highly satisfactory end product.

Contents

1. Introduction

"Your home at your command"! This is the goal of uControl Solutions. What we are offering is the best solution for affordable home automation. Our product "uControl" will not only bring ease to the user in their everyday life but also greatly assist physically disabled people. Simple, Elegant, and Effective is the best way to describe uControl. uControl is not your typical 'universal' remote. In the Home Automation Industry, the term 'universal remote' usually only refers to controlling home entertainment systems.

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1.2 Intended Audience

This document is aimed at the design engineers and project managers. The purpose is to track and ensure all the required features are met. If a feature can't be physically met it shall be indicated on the final report.

1.3 Notation

The following notation will be used throughout this document:

[Rn-P] A functional Requirement

Where n is the requirement number and P is the product development phase. The development phase consists of three stages denoted by one of the three values

I Proof of Concept
II Proof of Concept and Final Production system
III Final Production only

1.4 Glossary

UI	User Interface
CU	Central Unit
LS	Light Switch
GUI	Graphical User Interface
ANSI	American National Standards Institute
CSA	Canadian Standards Association
RF	Radio Frequency
UL	Underwriters Laboratory
FCC	Federal Communications Commission
GFCI	Ground Fault Circuit Interrupt
IEC	International Electrotechnical Commission
IPC	Institute of Printed circuit
TRIAC	Bidirectional Triode Thyristor
IEEE	Institute of Electrical and Electronics Engineers

2. Systems Requirements

The uControl System is designed to be as simple as possible to the end user. This is achieved by minimizing the number of devices the user needs to directly interact with. The uControl System simplifies the universal remote by enabling the user to control their entire home using their own handheld device, installed with the appropriate uControl Solutions software and correct blue-tooth module. The system is composed of one user controlled device, one central unit, and then as many controllable modules as the user would like.

The central unit handles all commands sent to it by the user via blue-tooth and it keeps track of all current modules belonging to the system. The method the central unit employs to communicate and control these modules is to remain hidden to the user. The central unit will constantly be relaying information concerning the modules to the user's handheld device, which the user can then react to accordingly. The uControl System is designed in such a way that many different devices (computers, smart phones, tablets, etc.) will be usable to control the central unit.

An overview of this system is shown in the Figure 1 below.

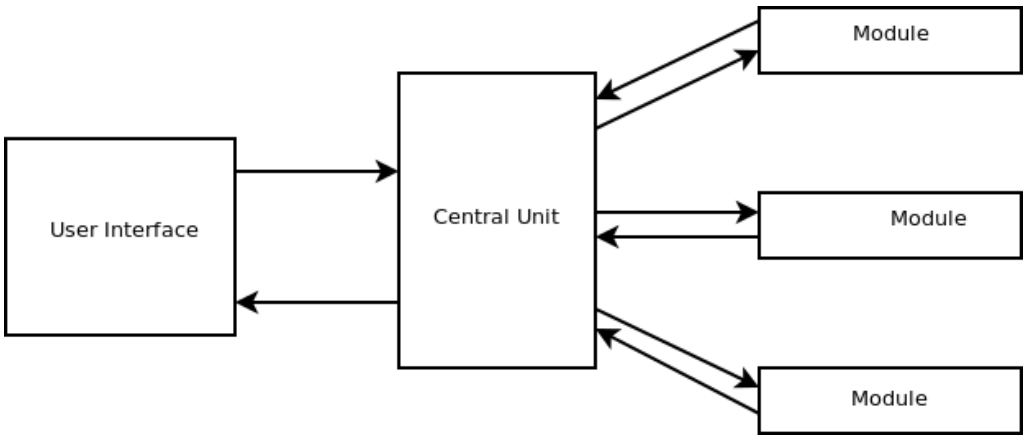

Figure 1: System Overview

Each module communicates with the Central Unit and the Central Unit sends messages to the User Interface containing the states of the modules. The only interaction from the user to the system must be done through the User Interface and therefore it is very important that the user receives real time states of the modules. Because of time restraints, we will only support Remote Controls and Lights.

The design level diagram for the uControl System is described in **Figure 2**

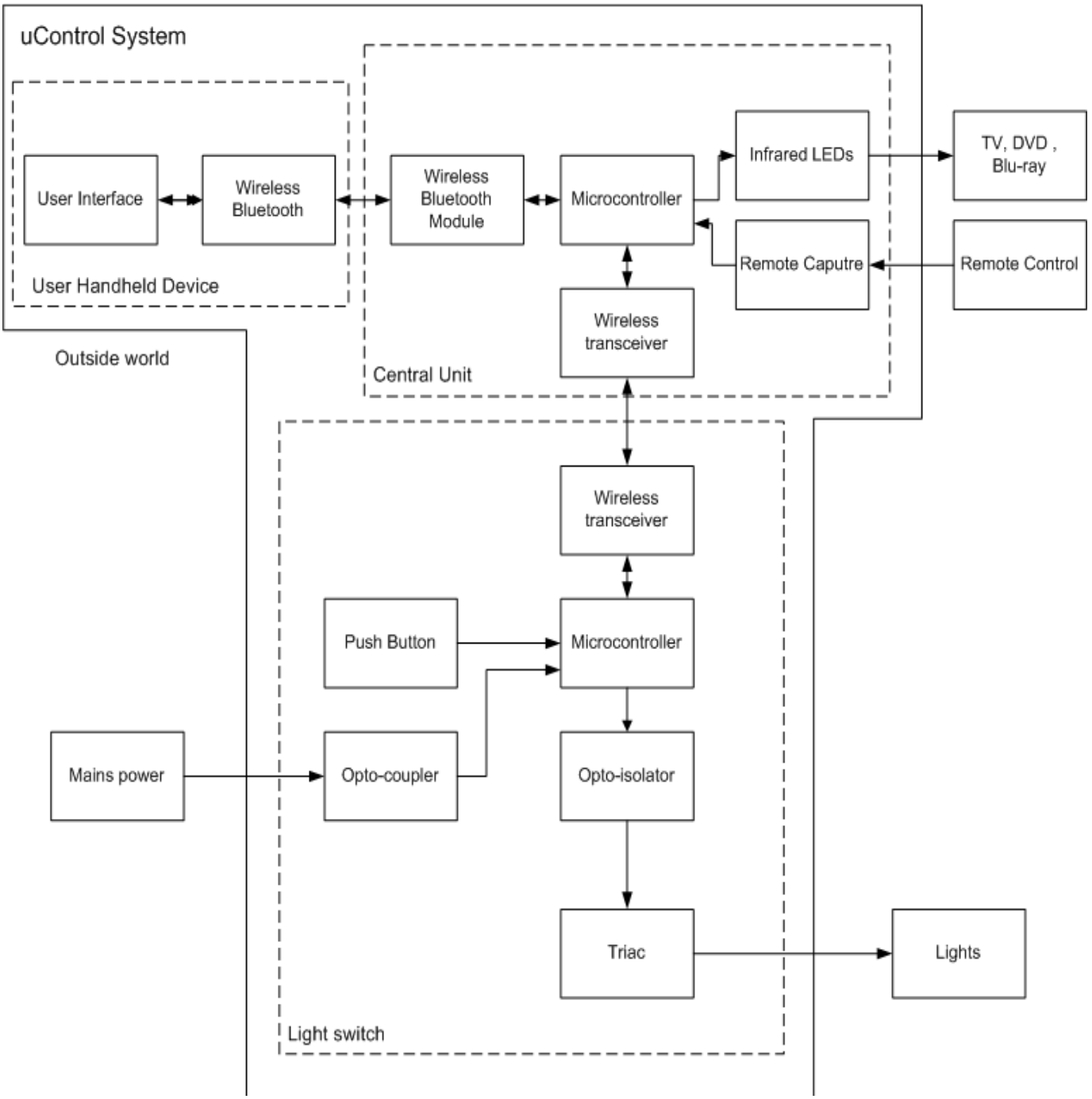

Figure 2: Design Level Functional Block Digram

Figure 2 highlights an important feature of the central unit with it's on board infrared capability. Rather than building individual infrared modules, the central unit will directly handle the communication between the user and their home entertainment systems (TV, DVD Player, etc.) using the built in infrared LED's. Observing **Figure 2**, it's easy to see that the central unit will act as a hub between the modules and the user. This allows the central unit to take note of malfunctioning devices that no longer receive inputs and then inform the user on their handheld device immediately.

However the best parts about this design methodology is the fact that the system could be expanded simply by installing more uControl modules with each module being relatively inexpensive and easy to install. Later on, more and more modules can be added as the user desires.

2.1 General Requirements

The uControl system will,

[R1-II]	turn lights on and off
[R2-II]	dim lights
[R3-II]	control entertainment systems
[R4-II]	support manual on and off toggling of lights
[R5-II]	have a simple and easily understood User Interface.
[R6-II]	allow for auto turning lights on or off.
[R7-II]	have a response less than 100ms.
[R8-III]	allow recording of remote control codes for various entertainment systems.
[R9-III]	measure and display power usage.
[R10-III]	be able to control various home appliances, heaters and ventilation systems.
[R11-III]	indicate problems with light bulbs, heaters and other uControl devices
[R12-III]	will cost less than 650 dollars which will include the central unit along with four light control switches

2.2 Electrical Requirements

[R13-II] The uControl light switch shall consume less than 500milliWats.

[R14-II] Central unit of the uControl system shall operate on 9volts with power consumption less than 100milliwatts

[R15-III] The uControl system shall run on 220V, Europe and Asia, or 110V-120V , North America

2.3 Environmental Requirements

[R16-II] Shall operate in 10 degrees to 40 degrees Celsius

2.4 Safety Standards Requirements

[R17-III] UL safety standards

[R18-III] CSA, FCC, IEC60364

[R19-III] ANSI / IPC-2221/IPC-2221A PCB trace width standards

3. Central Unit Requirements

The uControl Central Unit is the main hub through which all data between the user and the modules passes through. It incorporates several wireless communication techniques to achieve this. The communication between the handheld device and the Central Unit is handled by Bluetooth. Bluetooth was chosen for its wide availability on consumer electronics, its reliability, and its security. To communicate with the modules Radio Frequency (RF) technology is employed. RF was chosen for its simplicity, ruggedness, and affordability. Infrared technology is included in the central unit to allow it to broadcast information to control home entertainment systems, including Televisions, Blu-ray players, and audio receivers. The central unit will be elegant and sized specifically so it can be stored within line of sight of infrared devices while remaining pleasing on the eyes.

3.1 General Requirements

[R20-II]	Dimensions – 10cm x 10cm x 10cm
[R21-II]	Runs on 9 Volts and consume less than 100 milliwatts
[R22-II]	Placement distant from home entertainment system can be from 10cm to 2 meters
[R23-III]	Allow for recording of new IR protocols through ‘remote capture’
[R34-III]	Interface to other devices, Flash memory, wireless modules , etc.

3.2 Infrared Standards Requirements

[R24-II]	Philips RC-5
[R25-III]	Philips RECS80
[R26-III]	Sharp Protocol
[R27-III]	JVC Protocol
[R28-III]	SONY SIRC
[R29-III]	Nokia NRC17
[R30-III]	Philips RC-6
[R31-III]	Philips RC-MM
[R32-III]	Ability to record any infrared protocol.

3.3 Wireless Requirements

[R33-II] IEEE 802.15.4 wireless standards utilizing a Star Network protocol

[R34-II] IEEE 802.15 Bluetooth protocol

4. Light Switch Requirements

Our goal for the light switch is to make it easily installable and compact. We are planning to use double layer PCBs for the final product to optimize space usage of the circuit. We are using the atmega168 microcontroller for the switches interfaced with the microchip MRF24J40 wireless module to control it wirelessly. The key to the circuit design is to convert the 110v ac supply from the main power line to 3.3v dc in order to power the microcontroller and the wireless module. For this reason several components such as rectifiers, zener diode, diodes, capacitors, etc. in our circuit design are used to control the voltage. TRIACs and opto-isolators will also be employed in order to enable the dimming capabilities of the switches.

4.1 General Requirements

[R35-II]	Easily installed
[R36-II]	Self pair up with central unit upon instalment
[R37-II]	Smooth dimming functionality
[R38-III]	Current and power monitoring circuitry
[R39-III]	Reports power consumption
[R40-III]	Indicates a faulty light bulb
[R41-II]	Manual toggling of lights

4.2 Safety Standards Requirements

[R42-III]	Comply with UL safety standards [1]
[R43-III]	Comply with CSA's Canadian Electrical (CE) Code
[R44-III]	IEC 60364 Electrical Installations for Buildings [2]
[R45-III]	ANSI / IPC-2221/IPC-2221A PCB trace width standards [3]

4.3 Electrical Requirements

[R46-III]	Power consumption less than 1 watt
[R47-II]	Protection for low voltage components from the Mains line

4.4 Wireless Requirements

[R48-II]	IEEE 802.15.4 wireless standards utilizing a Star Network protocol
[R49-III]	Wireless Connection monitoring with auto pair up in case of a disconnection

5. User Interface

The user interface must be simple, easy to use, and reliable. The UI is aimed to be used on tablets and other touchscreen devices. What this means is that we need to limit embedded menus and have all our features presented in an easily accessible manner. To achieve this, we have decided to design the user interfaces in a tabbed manner where each component resides in its own tab.

The **Figure 3** below shows a sample overview of the user interface.

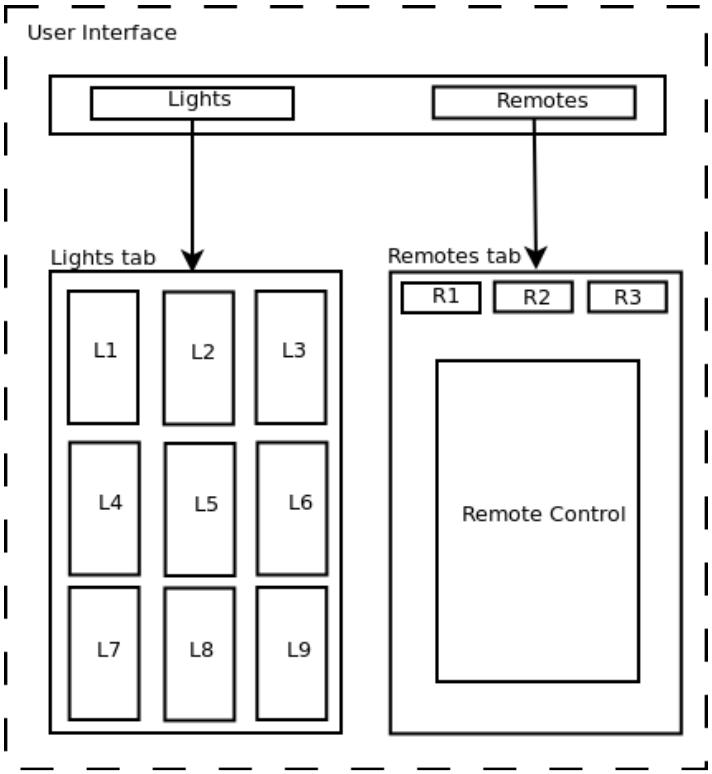

Figure 3: Sample Anticipated User Interface

Each light module will be present within the Lights tab. Consequently, each remote control will reside within the Remotes tab. If additional components are later added to the system, it is the Central Unit's duty to alert the User Interface that a new component has been added. The user interface must then add the component within the appropriate tab. An example of a light component is shown in the **Figure 4** below where Light Name represents the name of the component. This name will be user customizable.

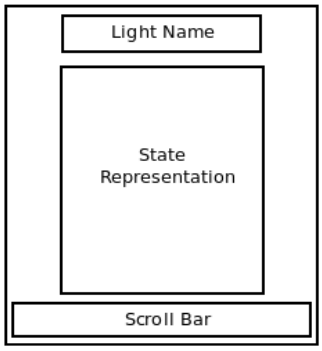

Figure 4: Example of a Light Component from User Interface

5.1 General Requirements

[R50-II]	A new component added to the system shall be recognized by the UI and automatically placed within its appropriate section
[R51-II]	The UI shall provide real time module information
[R52-III]	The UI shall provide minimization to system tray capability
[R53-II]	The UI shall provide the user with the ability to customize components names
[R54-III]	Upon program exit, the UI shall save all customized changes to a data file
[R55-III]	Upon start up, the UI shall load all saved changes from the previous running session
[R56-II]	Upon start up, the UI shall retrieve all available module information from the Central Unit and display it accordingly
[R57-II]	The UI shall provide tabbed display at a minimum of 640x480 resolution
[R58-II]	The main window of the UI shall consist of 2 panels (tabs) containing Light switch components and Remote controls respectively
[R59-III]	The UI shall be displayed identically on Windows, Mac and Linux

[R60-III] A UI shall be available over the local area network

[R61-II] Light and Remote Control components shall be grouped within a tab

5.2 Requirements for the Light Components

[R62-II] The light panel shall be automatically populated with the number of light modules present. This information will be obtained from the Central Unit

[R63-II] The name of each light component will be user customizable by double clicking the top of each object

[R64-II] Each light component shall provide an adjustable slider (analog control) to control the brightness of each light

[R65-II] A light component shall provide a visible display of the current state (brightness) of the light

[R66-II] A light component shall provide a digital state control (on or off) by directly clicking on the light object

5.3 Requirements for the Remote Control

[R67-III] The remote controls panel shall provide the ability to add at most 6 remotes

[R68-III] Each remote control name shall be user customizable

[R69-II] A read button will be present within the remote control panel to read a button code from the user

[R70-II] A readout display shall be present showing which buttons the user has pressed

5.4 Communication Requirements

[R71-II] The User Interface (UI) shall communication with the Central Unit (CU) via Bluetooth protocol

[R72-II] The user is responsible to pair the bluetooth device prior to starting the User Interface

[R73-II] If an invalid message is received from the CU, the UI must retry for 10 attempts

[R74-I] Maximum waiting for a success full message shall be 60 seconds

[R75-III] If a timeout occurs, the user will be notified as to the reasons

[R76-II] The user shall be visually notified regarding bluetooth connection failure

[R77-II] If a connection the CU fails to be established, the UI shall provide indications

[R78-II] All communication between the UI and CU must contain a message of at least 20 bytes

[R79-II] Upon an event triggered by the user, the UI must wait until it receives an acknowledge message from the UI

[R80-II] If an acknowledge message is received, the UI's component state will be updated. Otherwise, no changes to component state will be made

6. User Documental

[R81-III] The user manual shall be written for an audience with minimal knowledge

[R82-III] A detailed installation guide for the light switches and the UI shall be created

7. Test Plan

The proof of concept presentation will be conducted on a test panel consisting of four light switches and four light builds. All the required wires will be isolated and routed behind the panel and away from possible human contact. For safety reason the power plug will be a Ground Fault Circuit interrupt (GFCI) plug. The test will demonstrate how easy it is to install light switches and the operation of the devices. Addition demonstrations will be performed on a small TV or a DVD connected to a monitor to show the home entrainment features of the uControl System. A 'test subject' who is unfamiliar with the User Interface may be asked to perform certain task to ensure the User Interface requires no learning curve. The test will accomplish the following

- Prove the functionality of the dimming switches
- Prove the wireless communication between the systems.
- Show the ability to control home entertainment systems
- Demonstrate manual toggling and that it updates the UI to indicate a light is on/ off

Here are several sample test cases that will be performed

LS01 - Light Switch Modules – Power Supply

Description:
The power module must be able to provide 3.3V and 50mA DC to the light controlling circuit without harming any users or electronic devices connected to the circuit.

Test Equipment:
110V power supply
Pre-built power supply circuit with light switch and light
Industrial Grade High Power Rated Oscilloscope

Procedure:
Connect the oscilloscope probe to the 8th pin on the Atmega168 microcontroller on the PCB
Turn on the oscilloscope
Connect the pre-built circuit to the power supply
Press AUTO SET on the oscilloscope
Ensure the oscilloscope reads 3.3V and 50µA DC at the input to the microcontroller
Turn off the power supply
Turn off the oscilloscope

PASS/FAIL

Other comments:
Safety is of the utmost priority. Do not touch the circuit while it is connected to the AC power supply under any circumstances. Another note, the TRIAC will be set to off at first so the light should not power on.

Automatable through software: YES
Automated: NO

LS02 - Light Switch Modules - Wireless Activation

Description:
The light switch modules must be able to receive radio signals from a control device and should react accordingly

Test Equipment:
110V power supply
Control device with built in radio frequency
Pre-built power supply circuit with light switch and light

Procedure:
Connect the pre-built circuit to the power supply
Turn on the power supply to 110V and .75A AC
From the control device, send data via radio frequency to turn the light on (no dim)
Ensure the light turns on
From the control device, send data via radio frequency to turn the light off
Ensure the light turns off
Turn off the power supply

PASS/FAIL

Other comments:
Safety is of the utmost priority. Do not touch the circuit while it is connected to the AC power supply under any circumstances. Another note, the TRIAC will be set to off at first so the light should not power on. For sake of simplicity, both the on and off test cases are included in the one test case

Automatable through software: YES
Automated: NO

8. Conclusion

Simple, Elegant, and Effective is the best way to describe uControl. The ability and freedom it provides in controlling your environment ALL from one place at the touch of your fingertips is unprecedented. With our product, you can enjoy your favourite TV shows, set the mood by playing music and dimming your lights and most importantly is you who control all this and much more. Our device is expandable, portable and usable by anyone with access to a computer. Furthermore it can also be used for individuals with physical disabilities to interact with their environment. This is one of the major factors in developing this product. Every existing system falls short behind uControl. The features we offer all in ONE place are unprecedented. uControl is all that and more!

This document is meant to be framework for the engineers to work on with regards to the required features projected for our unit. However, this is not a final document and it will be continuously revised and updated after vigorous researching and numerous testing to provide a highly satisfactory end product. The development is divided into 3 stages and the first build is already in progress which will prove the concepts that of being able to create a working affordable universal home remote.