Homework 4: Packaging Specifications and Design

Team Code Name: _Home Kinection__ **Group No.** __1____

Team Member Completing This Homework: _Brian Bowman_

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Evaluation:

SCORE	DESCRIPTION
10	***Excellent*** *– among the best papers submitted for this assignment. Very few corrections needed for version submitted in Final Report.*
9	***Very good*** *– all requirements aptly met. Minor additions/corrections needed for version submitted in Final Report.*
8	***Good*** *– all requirements considered and addressed. Several noteworthy additions/corrections needed for version submitted in Final Report.*
7	***Average*** *– all requirements basically met, but some revisions in content should be made for the version submitted in the Final Report.*
6	***Marginal*** *– all requirements met at a nominal level. Significant revisions in content should be made for the version submitted in the Final Report.*
*	***Below the passing threshold*** *– major revisions required to meet report requirements at a nominal level.* ***Revise and resubmit.***

** Resubmissions are due within **one week** of the date of return, and will be awarded a score of "6" provided all report requirements have been met at a nominal level.*

Comments:

Comments from the grader will be inserted here.

1.0 Introduction

The Home Kinection projects aims to build and develop a complete living room automation system centered around the Microsoft Kinect sensor. The team plans to build four separate module boxes each with a designated control type and a single main control box to communicate and interpret gestures and voice commands performed by the user. The four module boxes, dimmer, shade control, IR control, and USB virtual touchscreen, will all communicate with the control box wirelessly to relay commands and status. The module boxes should integrate with existing living room components such as lamps, DVD players, and electronic shades without hindering normal functionality.

Home Kinection requires several module boxes all with different purposes. However, a common packaging design should tie together the disparate boxes into a cohesive whole. Whenever possible, the module box should encompass at least as much functionality as its non "smart" counterpart. The dimmer module, for instance, must still allow a user to adjust a lamp's brightness and turn it on and off without interfacing with the Kinect. Moreover, whenever possible, the module boxes must integrate into the living room setting and not be a distraction during normal use due to size or appearance. The controller box should blend in with existing equipment in the AV cabinet and not distract the user due to noise or appearance. Because many boxes are being constructed, off the shelf components should be used when possible to minimize the cost of each module.

2.0 Commercial Product Packaging

Home automation products have become increasingly common over the past decade, ranging from simple module boxes like X10 controllers [1] to whole home controls like the Lutron RadioRa system [2]. Moreover, streaming boxes like the Roku [3] provide inspiration for the control box. An analysis of the packaging of both home automation controllers and streaming devices will assist the team in packaging its own components.

2.1 X10

Figure 2.1.1 X10 Lamp Module

The X10 module boxes represent extreme simplicity for module box packaging design. The basic lamp module box consists of little more than a "wall wart" and 2 selection knobs. The "wall wart" design enables a miniscule footprint and incredibly simple user interface. The user simply selects a channel for the module to listen on and then does not have to touch the module box again. Enclosed in cheap, white plastic the module boxes are garish but do cut down on price at only about 15 to 20 dollars.

Unfortunately, the "wall wart" design does come with drawbacks. The box provides no user control of the device plugged in. In the event that power line communication fails, the user has no option but to unplug the module which is probably hidden behind a couch thanks to its pasty appearance. Moreover, the module provides no mechanism to provide feedback to the user. The user must simply hope that the module can pick up messages and respond appropriately.

The team hopes emulate the X10 model in several important ways. Primarily, the team will use a similar wall wart design for the dimmer module except with a power cable so that the module need not be directly plugged into the wall. Moreover, the team hopes that the smaller module boxes like the HID controller and IR module can be housed as compactly as the X10 module.

2.2 Lutron RadioRa

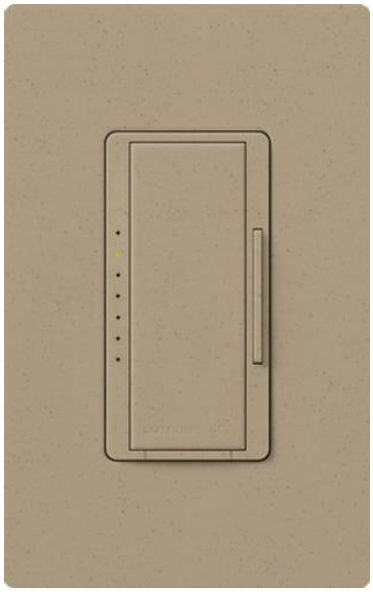


Figure 2.1.2 Lutron Dimmer

The Lutron RadioRa system allows total home lighting control by replacing standard wall box switches with a Lutron RadioRa dimmer. The dimmers consist of a large, momentary button, a rocker switch and a column of LEDs. The Lutron "wall box" design comes in a variety of colors to help the modules fully integrate into a space. Unfortunately, each dimmer module costs around $90.

The drawback of the "wall box" design comes in form of installation. Because the modules replace a standard wall switch, the user must have some electrical knowledge to install the device or hire a contractor to do so for him. Moreover, the modules involve a complex and unintuitive process of discovery and assignment to enable wireless control. In order to avoid the confusion with configuring a wireless system, the team is developing a GUI interface for discovery and assignment of modules. Because the modules communicate via a proprietary wireless protocol, expansion and compatibility with other devices is severely limited. The Zigbee protocol used by the team's modules allows for comparatively easy expansion.

The team does hope to emulate several features of the Lutron wall dimmer. Most importantly, the Lutron dimmer allows for manual user operation along with status indication. In a similar fashion, the team's module boxes will provide LED feedback and manual operation on all boxes which allow for it. Moreover, the team hopes to emulate the size, about the size of an index card, of the Lutron modules for its dimmer and shade modules.

2.3 Roku XD

Figure 2.1.3 Roku

Because the Kinect control box has no true equivalent in the home automation world, the closest point of comparison is a streaming box like the Roku XD. The Roku XD represents the typical packaging for a small home theater pc like device. The box measures about 5" by 5" and weighs only 2 pounds. At those dimensions, the Roku has no problem fitting in the typical AV rack or TV stand configuration. The roku provides minimal information to the user, a single LED besides any GUI interface. While some may consider this a design flaw, the minimalistic interface also diminishes the distractions and annoyances a user may experience, an important aspect in the home theater setting. Moreover, the Roku operates silently thanks to its well ventilated exterior.

Though not an equivalent product, the team's control box hopes to emulate many features of the Roku XD. The team hopes to retain a small footprint, although a 5" x 5" enclosure will not be feasible thanks to the size of the motherboard. The team will need to actively cool the full power processor; however, the ventilation of the Roku XD will be emulated.

3.0 Project Packaging Specifications

Drawing inspiration from the X10 module, Lutron RadioRa dimmer, and Roku XD, the team has designed packaging for its module boxes and control boxes. The module boxes will bridge the gaps between the X10 module and Lutron dimmer while the control box will attempt to emulate the roku as much as possible.

Each module box will be a variation on a plastic housing fitted with manual control interfaces and status LEDs. The plastic housing has the double advantage of requiring little tooling and cutting down on RF interference.

The dimmer module, because of larger components like the SSR and transformer, will have a relatively large enclosure, around 4" by 6" by 2.5". In order to manually control a connect light, a rotary pulse generator will be added to the top. Two power connectors will be placed at each end for module power and the attached lamp. The module power will use a monitor or printer type connector to ensure correct wiring.

The shade module will have roughly the same dimensions as the dimmer module due to the size of the mechanical relays. To comply with existing shade drives and enable easy expansion to other CCI devices, a standard female 4-pin terminal block connector will supply power to the box and a male connector supplies power and CCI inputs out to a shade drive. Two pushbuttons on the top of the module will allow for manual operation of the drive unit.

The IR module includes no large components and thus the team hopes to shrink the enclosure down to a 3" by 3" box. The module will have a DC power input from a wall wart to help minimize box thickness and cable size required. The current design includes an IR led and detector on opposite sides of the box for learning and transmitting commands. IR "blaster" jacks, likely a typical 3.5mm jack, are also being considered to allow additional flexibility in the placement of the unit. A "learn" pushbutton is placed on the top of the device to simplify the learning procedure.

The HID controller will have the same physical dimensions as the IR module but will remove the pushbutton and IR components. Instead, a single female USB port will adorn the module along with the typical status LED.

The controller box will utilize an off the shelf mini-ITX case to reduce cost and tooling. A small, 3" x 3" or smaller, PCB will house the wireless chip and serial interface.

4.0 PCB Footprint Layout

In order to help keep the PCB footprint as small as possible, any available surface mount components available were selected. A full listing of components can be found in Appendix B.

The ZigBit [4] wireless module is the biggest component that is found on each PCB at roughly 13.5mm x 24mm. Unfortunately, the dimmer box has many large components. The transformer necessary to generate a lower voltage secondary is 41.3mm x 33.5mm. Also, the solid state relay used to switch the AC power to the lamp measures 43mm x 7.6mm and is 25.4mm tall. Because of the component sizes and a desire to leave sufficient separation between the wireless module and power circuitry, the dimmer pcb will be large, around 4" by 6".

5.0 Summary

The team decided on its packaging design based around several commercial products. The X10 “wall wart” module gave the team inspiration on size and simplicity. The Lutron dimmer provided ideas on user control and feedback. The Roku XD helped the team have a basis for its control box design. In all, the packaging for each module is pretty simple, a plastic box with interface ports and manual control interfaces. Unfortunately, the number of different PCBs and interfaces complicates the project.

List of References

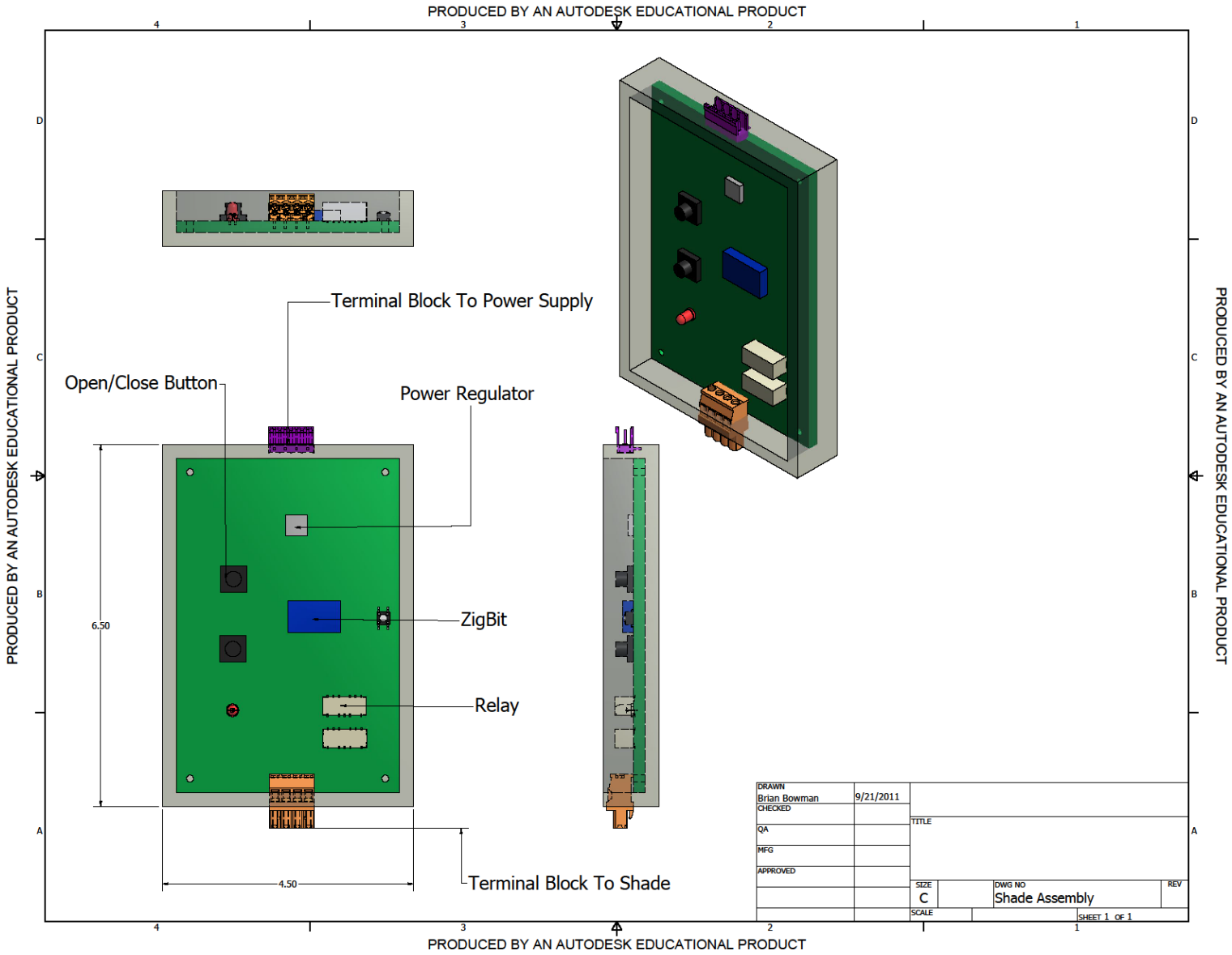
[1] X10. "X10 Lamp Module." Internet: http://www.x10.com/promotions/lm465_cat_hm.html?TWENTY11 [September 22, 2011].

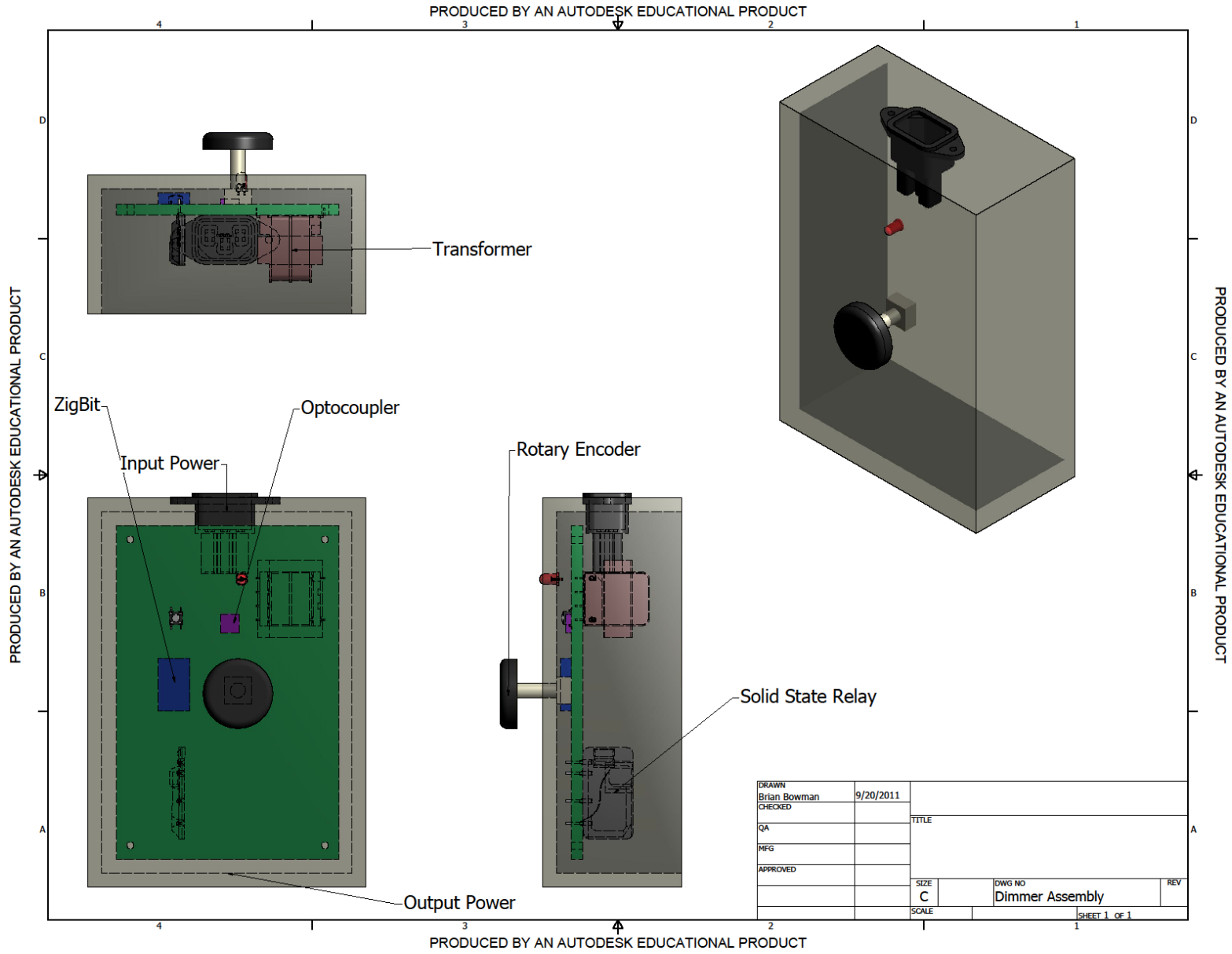
[2] Lutron, Inc. "Lutron Store- Dimmers" Internet: http://www.lutronstore.com/systems/p-142-dimmers.aspx [September 22, 2011].

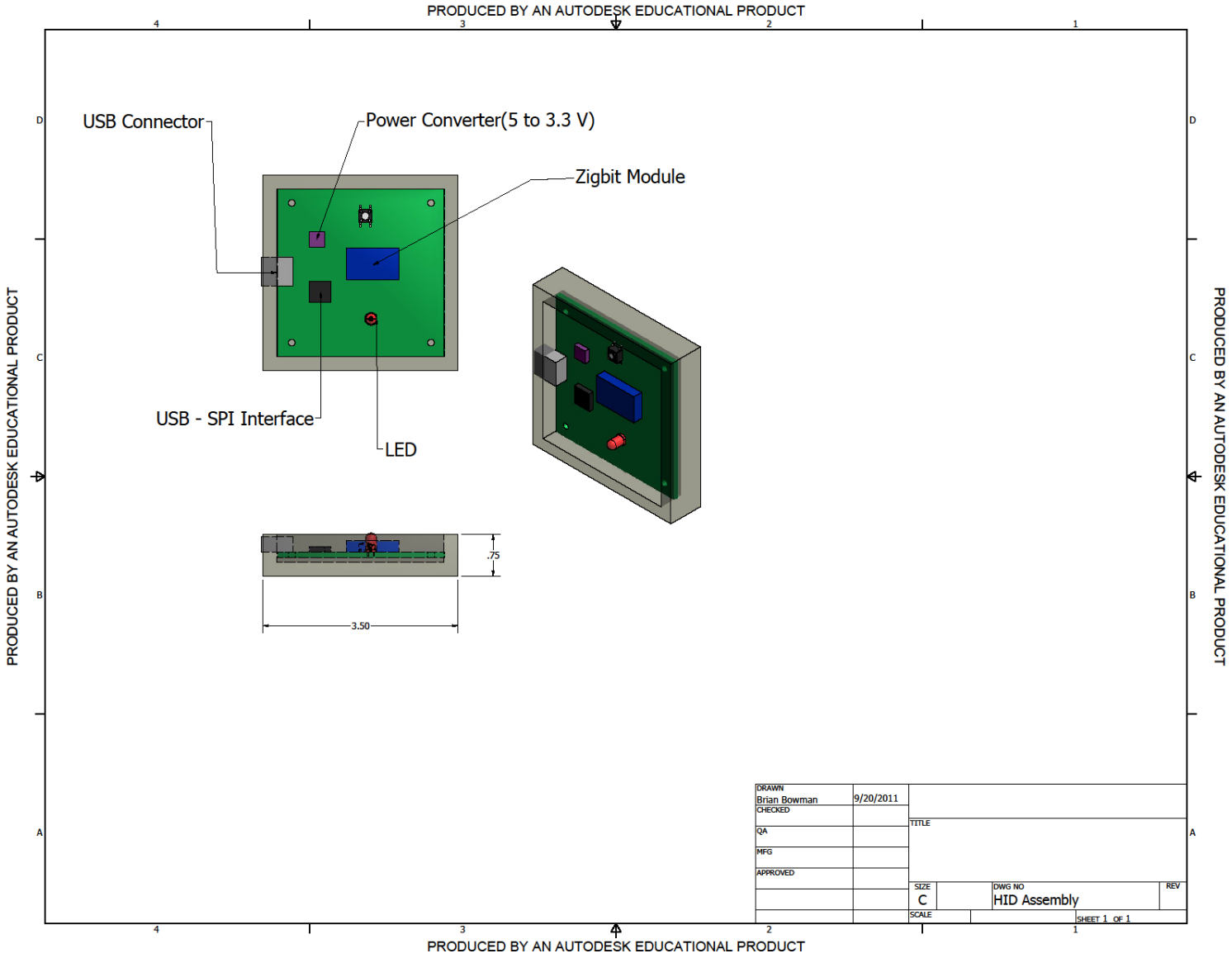
[3] Roku. "Roku Streaming Player". Internet: http://www.roku.com/ [September 22, 2011]

[4] Atmel. "ZigBit 2.4 GHz Wireless Modules" PDF: http://www.atmel.com/dyn/resources/prod_documents/doc8226.pdf [September 22, 2011].

Appendix A: Project Packaging Illustrations




PRODUCED BY AN AUTODESK EDUCATIONAL PRODUCT
PRODUCED BY AN AUTODESK EDUCATIONAL PRODUCT
PRODUCED BY AN AUTODESK EDUCATIONAL PRODUCT
Transformer
ZigBit
Optocoupler
Input Power
Rotary Encoder
Solid State Relay
Output Power
DRAWN
Brian Bowman
9/20/2011
CHECKED
QA
MFG
APPROVED
TITLE
SIZE
C
DWG NO
Dimmer Assembly
REV
SCALE
SHEET 1 OF 1


PRODUCED BY AN AUTODESK EDUCATIONAL PRODUCT
USB Connector
Power Converter(5 to 3.3 V)
Zigbit Module
USB - SPI Interface
LED
.75
3.50
DRAWN
Brian Bowman
9/20/2011
CHECKED
QA
MFG
APPROVED
TITLE
SIZE
C
DWG NO
HID Assembly
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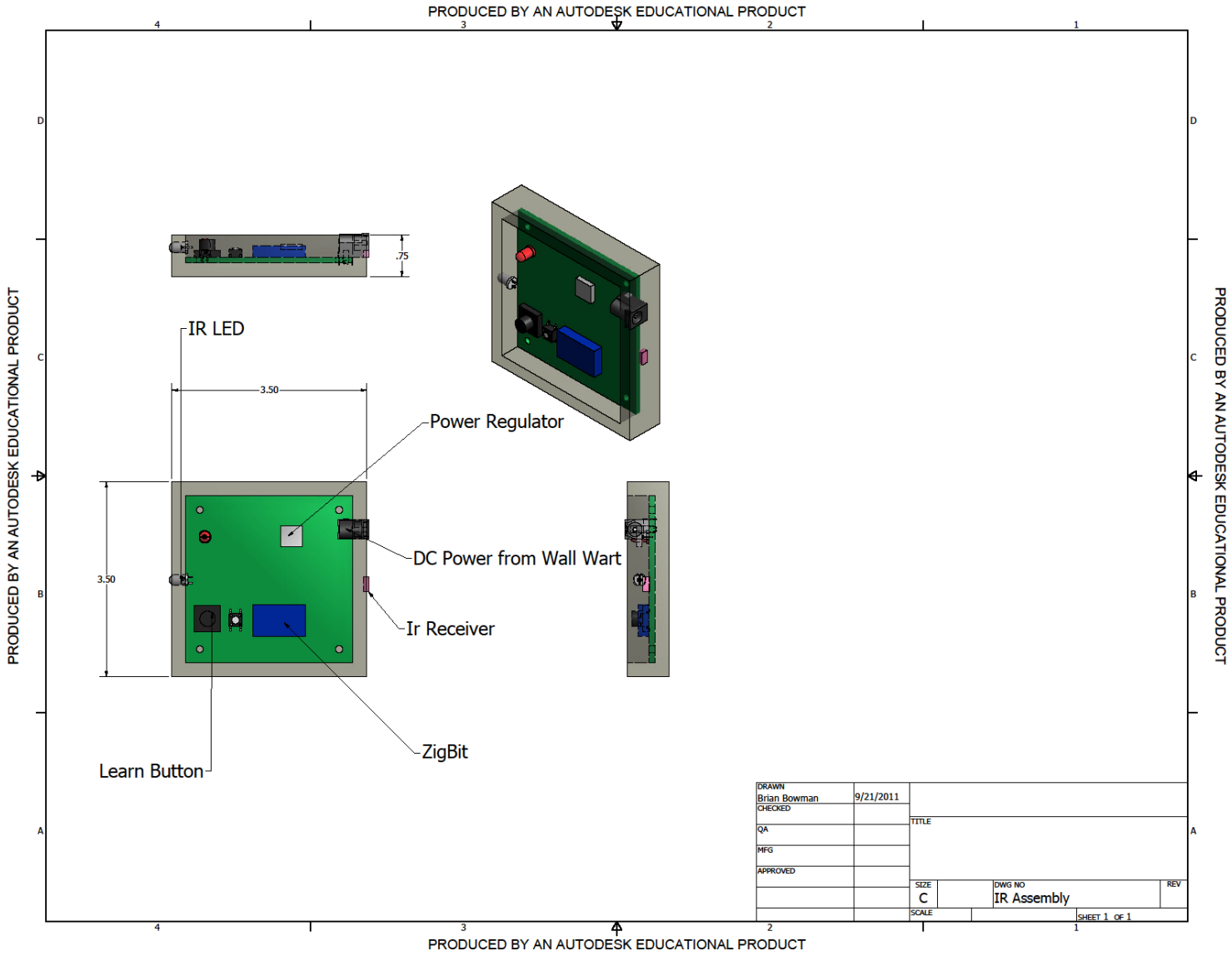
SHEET 1 OF 1


PRODUCED BY AN AUTODESK EDUCATIONAL PRODUCT
PRODUCED BY AN AUTODESK EDUCATIONAL PRODUCT
PRODUCED BY AN AUTODESK EDUCATIONAL PRODUCT
.75
IR LED
3.50
Power Regulator
3.50
DC Power from Wall Wart
Ir Receiver
ZigBit
Learn Button
DRAWN
Brian Bowman
9/21/2011
CHECKED
QA
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APPROVED
TITLE
SIZE
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DWG NO
IR Assembly
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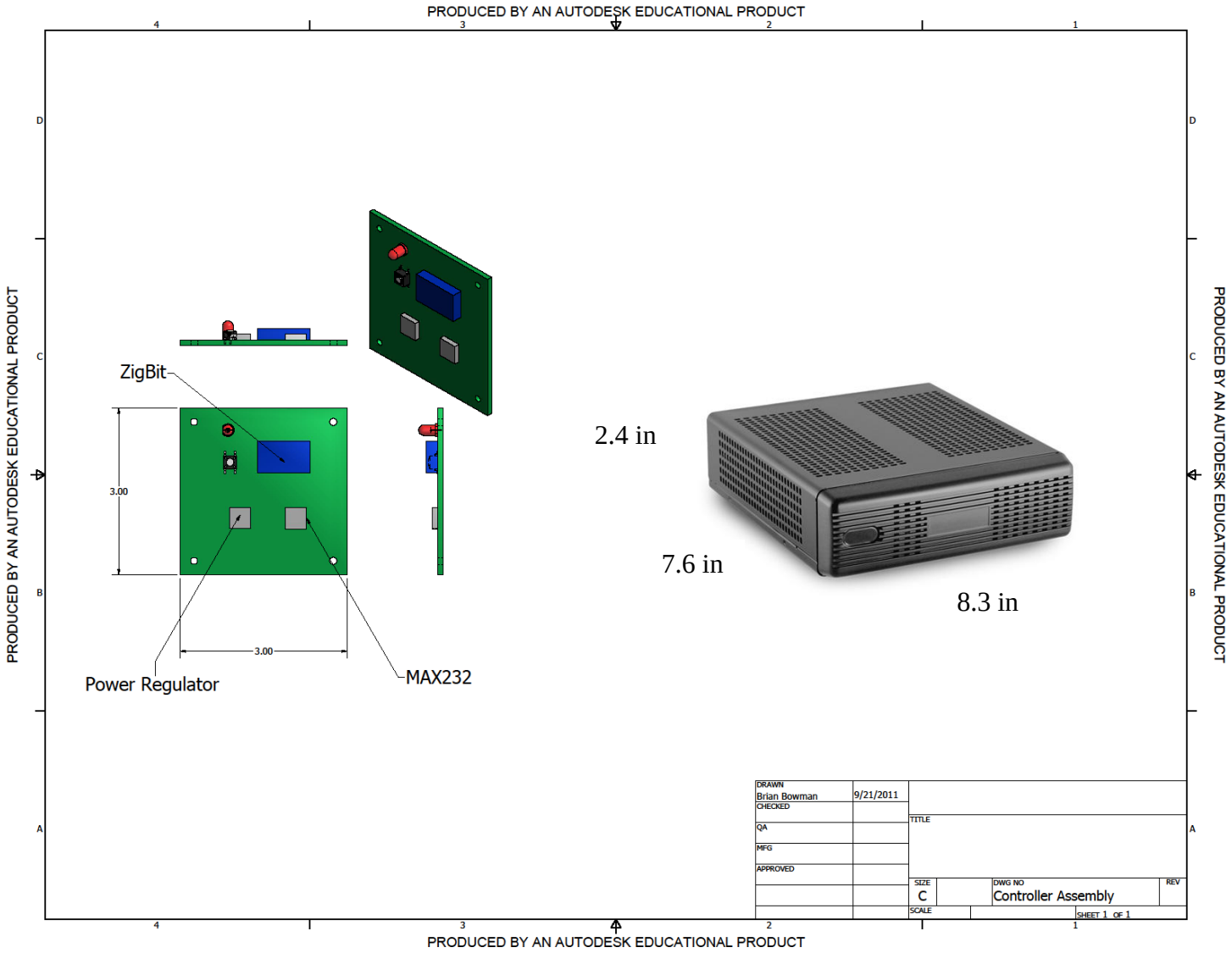
SHEET 1 OF 1


PRODUCED BY AN AUTODESK EDUCATIONAL PRODUCT
ZigBit
3.00
3.00
Power Regulator
MAX232
2.4 in
7.6 in
8.3 in
DRAWN
Brian Bowman
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CHECKED
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Controller Assembly
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SHEET 1 OF 1

Appendix B: Project Packaging Specifications

Vendor	*Part No.*	*Description*	*Unit Cost*	*Tooling*	*Qty*	*Total Cost*
Mouser	ATZB-24-A2R	ZigBit Module (Radio transceiver, antenna, Microcontroller)	30.08	Solder Iron	5	$150.4
Mouser	CX240D5R	Solid State Relay	13.41	Solder Iron	1	$13.41
Mouser	TSOP75236WTR	IR receiver	1.35	Solder Iron	1	$1.35
Mouser	MAX3420EECJ	USB Interface	8.94	Solder Iron	1	$8.94
Mouser	653-G6K-2F-Y-DC3	Mechanical Relay	2.68	Solder Iron	2	$5.36
Mouser	H11A1	Optocoupler	0.49	Solder Iron	1	$0.49
Microsoft	Kinect	Kinect sensor	144.48	Solder Iron	1	$144.48
Newegg	BOXDQ45EK	Mini-ITX Motherboard	74.99	None	1	$74.99
Mouser	EVE-GA1F1724B	Rotary Pulse Generator	1.08	Cordless Drill	1	$1.08
Mouser	SMLW56RGB1W1	RGB SMD LED	2.75	Cordless Drill	5	13.75
Mouser	PTS525SM10SMTR LFS	Pushbutton	0.48	Dremel/ Cordless Drill	10	4.80
Newegg	BX80571E3500	2.7 GHz Dual Core Processor	59.99	None	1	$59.99
Newegg	WD500AAKX	Hard Drive	44.99	None	1	$44.99
Newegg	KVR800D2K2	RAM	42.99	None	1	$42.99
Logic Supply	M350	Mini-ITX case	39.95	None	1	$39.95
Mouser	10104111-0001LF	USB connector	0.46	Dremel	1	0.46
Mouser	20ESRMC2	Power Connector	2.80	Dremel	2	5.60
Mouser	39503-2003	Terminal Block	0.89	Dremel	2	1.78
Mouser	KLDHCX-0202-A	DC Barrel Plug	0.89	Cordless drill	1	0.89
Mouser	4900-8020RC62	Transformer	8.40	Solder iron	1	8.40
Mouser	MAX3232IPWE4	Serial Interface	2.76	Solder Iron	1	2.76
Mouser	STX-35398A-5N-TR	3.5mm Jack	1.24	Dremel	1	1.24
Mouser		Passive Component Estimate				80
				TOTAL		**$668.01**

Appendix C: PCB Footprint Layout

The above CAD drawings also show PCB footprints and component locations to scale. The two PCB sizes are 4” x 6” and 3” x 3”.