University of Idaho

Wireless Tower Lights

By: LEaD Design
Adrian Beehner, Andrew Butler, Kevin Dorscher, and Paul Martin

Team Members

- **Adrian Beehner:** “Adrian is a remote student, this can introduce unique challenges. He directs the budget for our project.”
- **Andrew Butler:** “Andrew is in charge of documentation for the project.”
- **Kevin Dorscher:** “Kevin is the client liaison and organizes team meetings”
- **Paul Martin:** “Paul is the team's Wiki-master and designer”

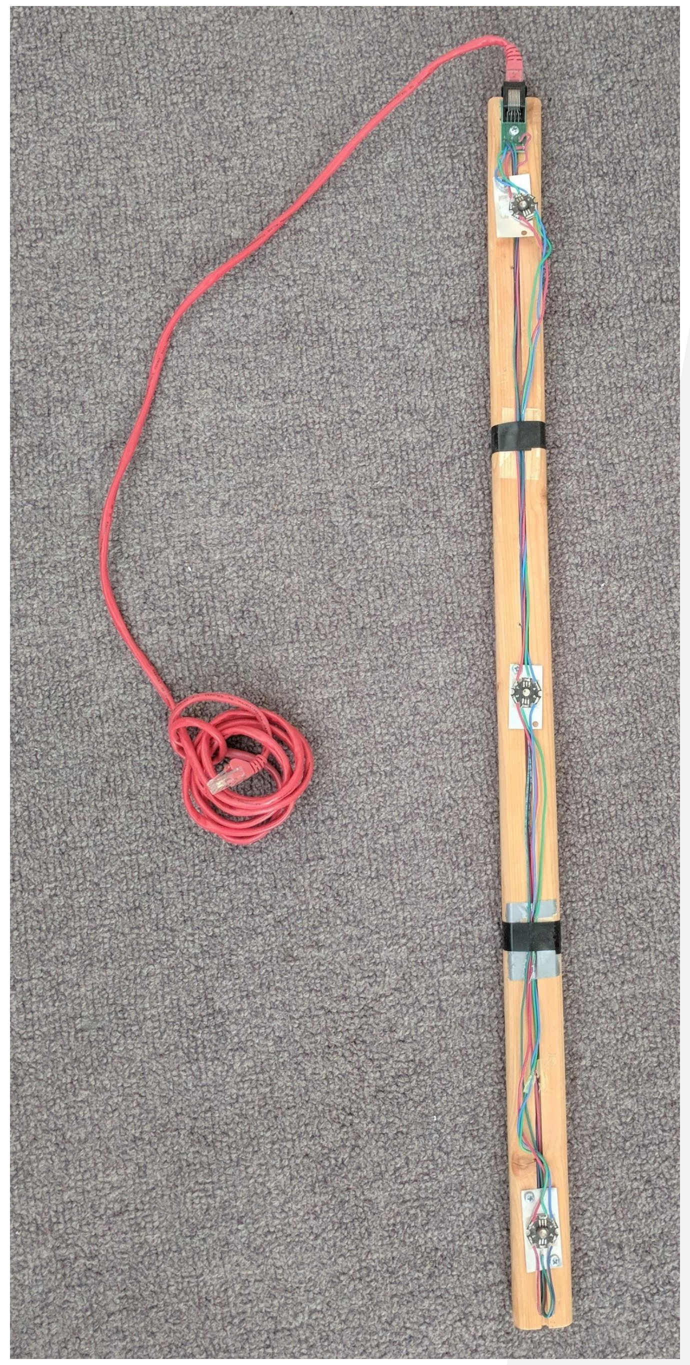
- Wiki: http://mindworks.shoutwiki.com/wiki/Wireless_Tower_of_Lights

Tower Lights Background

- Ongoing project to convert to a fully wireless system
- The Tower Lights show is displayed on the south side of Theophilus Tower
- Each window has LED lights which illuminate in sync to music

Project Information

Light Bar



Lit Up Tower

- The old system relies on CAT-5 wiring from basement up to every room
- New system will not rely on wires
- Thus Light show could be used in any building
- Interest in using the system in buildings in Coeur d'Alene, Idaho

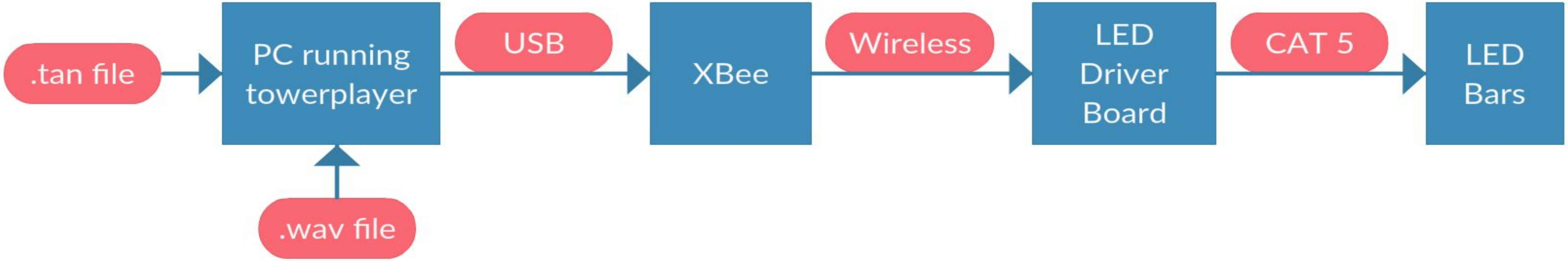
Problem Statement

- The University of Idaho’s Tower Lights system currently runs on old unused Ethernet wiring in the Theophilus Tower

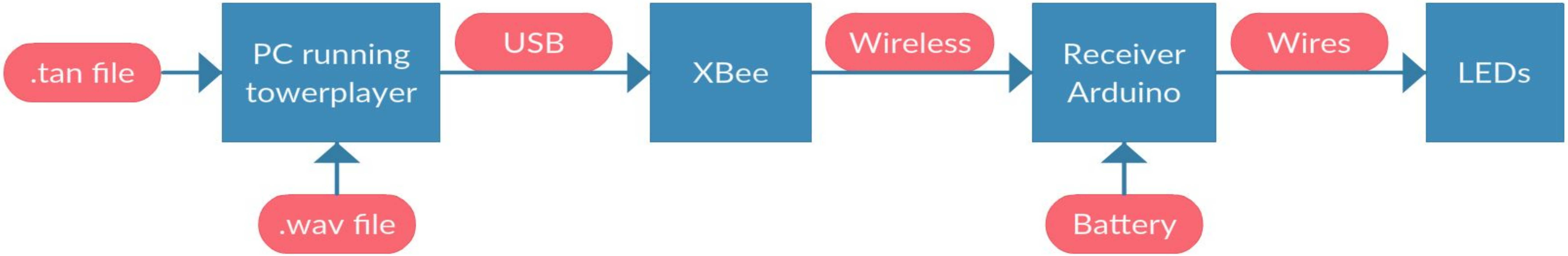
- Our team is faced with the problem of turning the current Tower Lights control system into a battery powered wireless system

Project Requirements Flow Chart

Current System



Projected System



Project Problems/Solutions

- **Problem:** Identify a wireless protocol to have an effective range of potentially up to 100 meters
  - Solution: Utilize the 802.15.4 protocol

- **Problem:** Frequency must be one that will work even in crowded venues, with lots of different cellphones, and Wi-Fi signals present
  - Solution: We are using channels 25 and 26, which are above Wi-Fi range.

Project Problems/Solutions

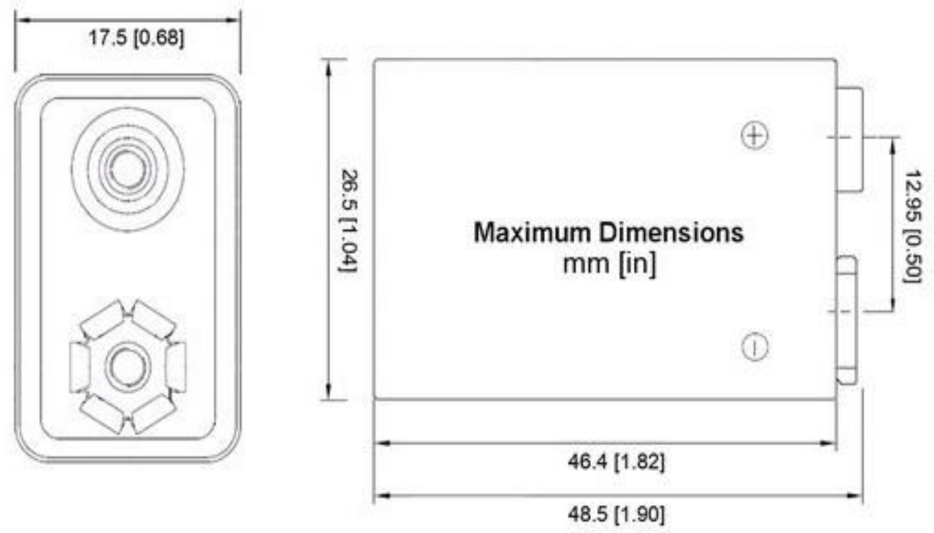
- **Problem:** Our wireless protocol can only send 250 kbits/s. If we have enough light bars in a large building, we may run out of bandwidth
    - **Solution:** Change quality of the RGB color send to each light bar, instead of sending 24bit Truecolor RGB with 16 million possible colors, send 12bit RGB and have 4,096 possible colors.

Design Specifications Introduction

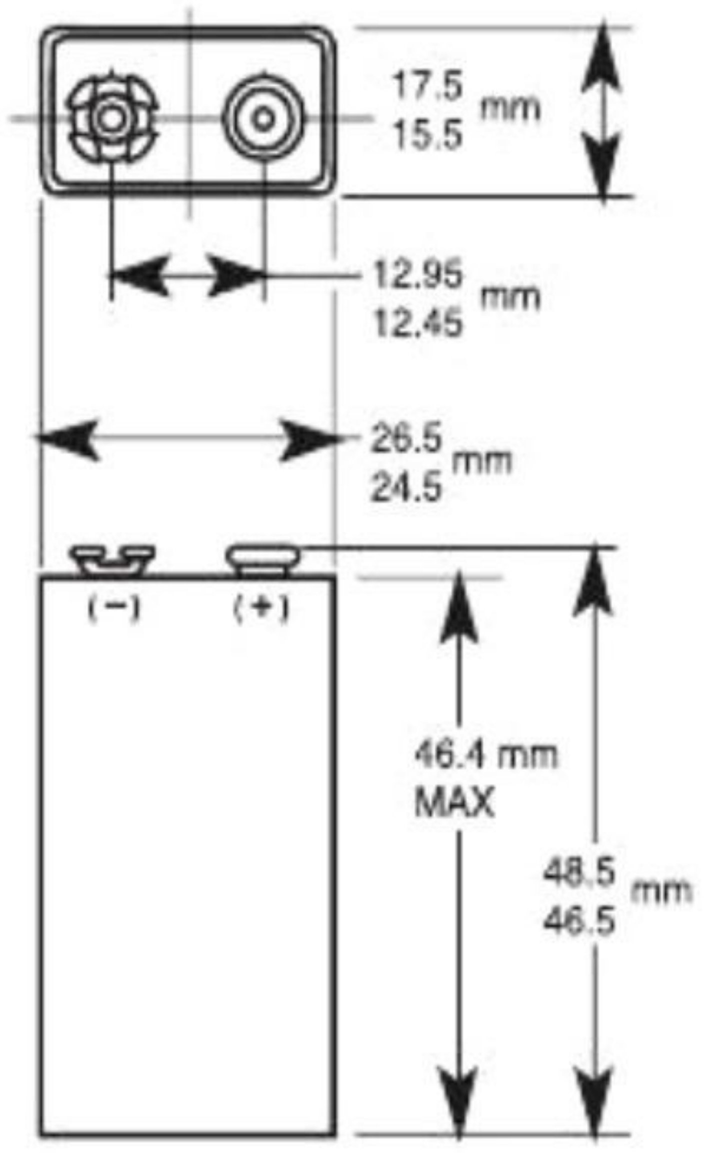
- Battery Specification
- LED Specification
- Arduino / Receiver Specification
- Wireless Specification

Battery Specifications

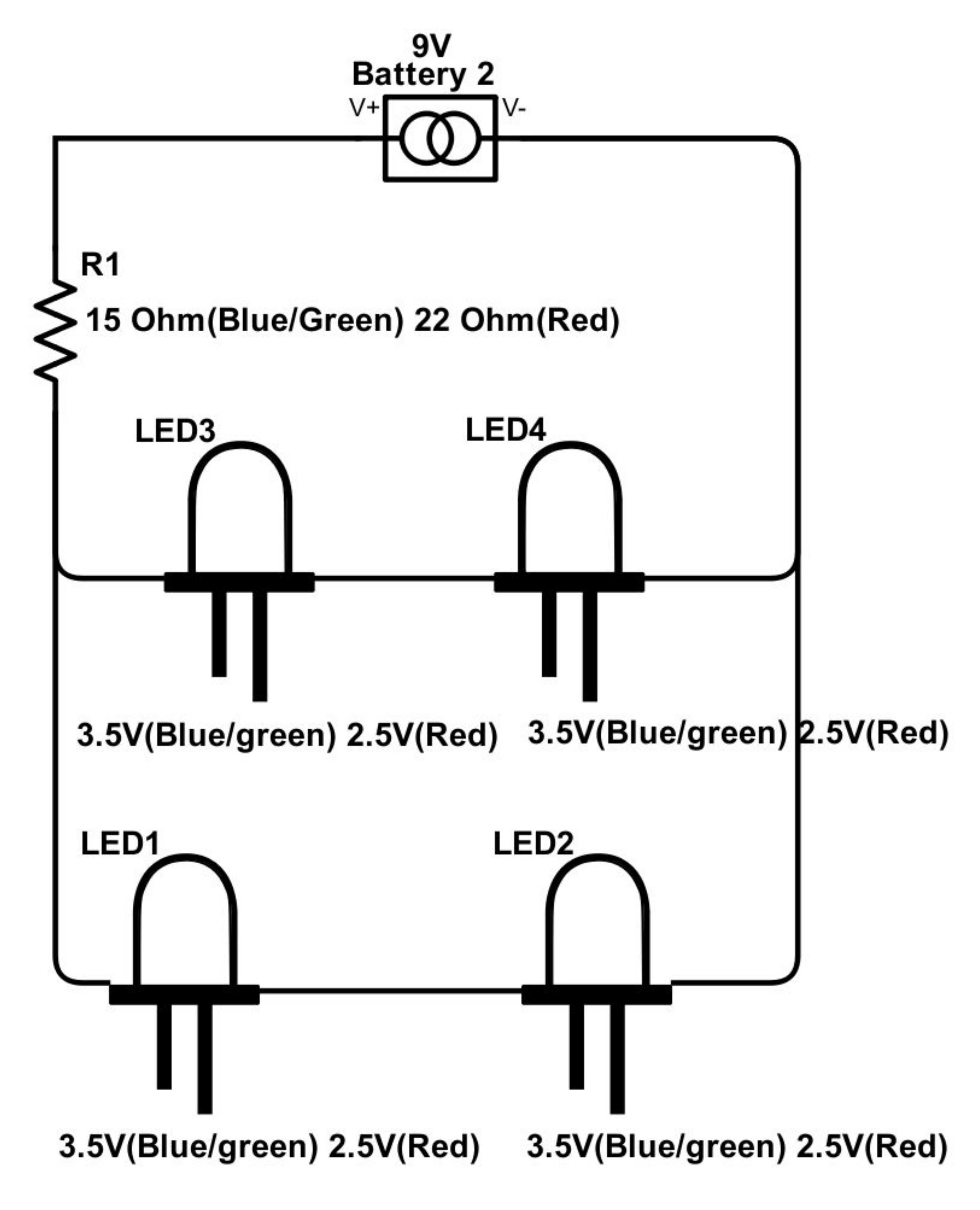
9V Battery



Voltage	8.6 - 9.3 V
Capacity	400 - 700 mAh
Power	> 3.44 Wh
Charge Current	< 250 mAh
Approximate Charge Time	> 1 hr
Weight	34 - 45 g
Battery Chemistry/Type	Lithium Ion
Operating & Storage Temp	Around 21 °C (70 °F)



LED Specifications



Wireless Specification

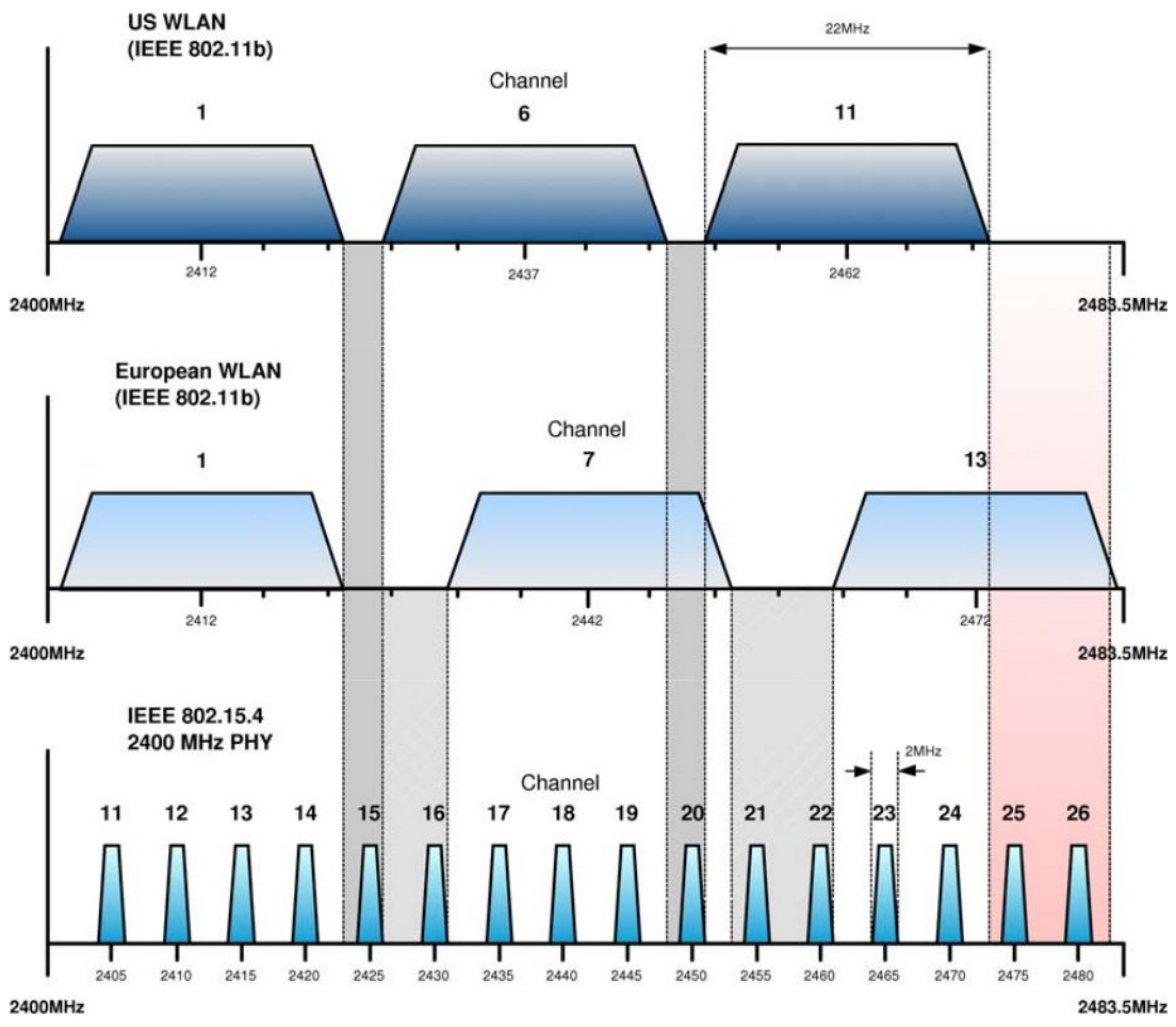


Figure 4: LR-WPAN vs Non-Overlapping WLAN Channel Allocations

Deliverables

- LEaD Design Wiki Page
- LEaD Design Team Portfolio
- Wireless Light Bars

Project Learning

- Battery Component
- LED Component
- Arduino / Receiver Component
- Wireless Component
- Code Additions
  - Sleep / Wake Mode
  - 40+ Channel Support

Design Choices Introduction

- Resistors for Voltage Adjustment
- Two Sets of Two LED’s in Series
- Single 9v Lithium Ion Battery

Resistors Instead of Specialized Circuitry

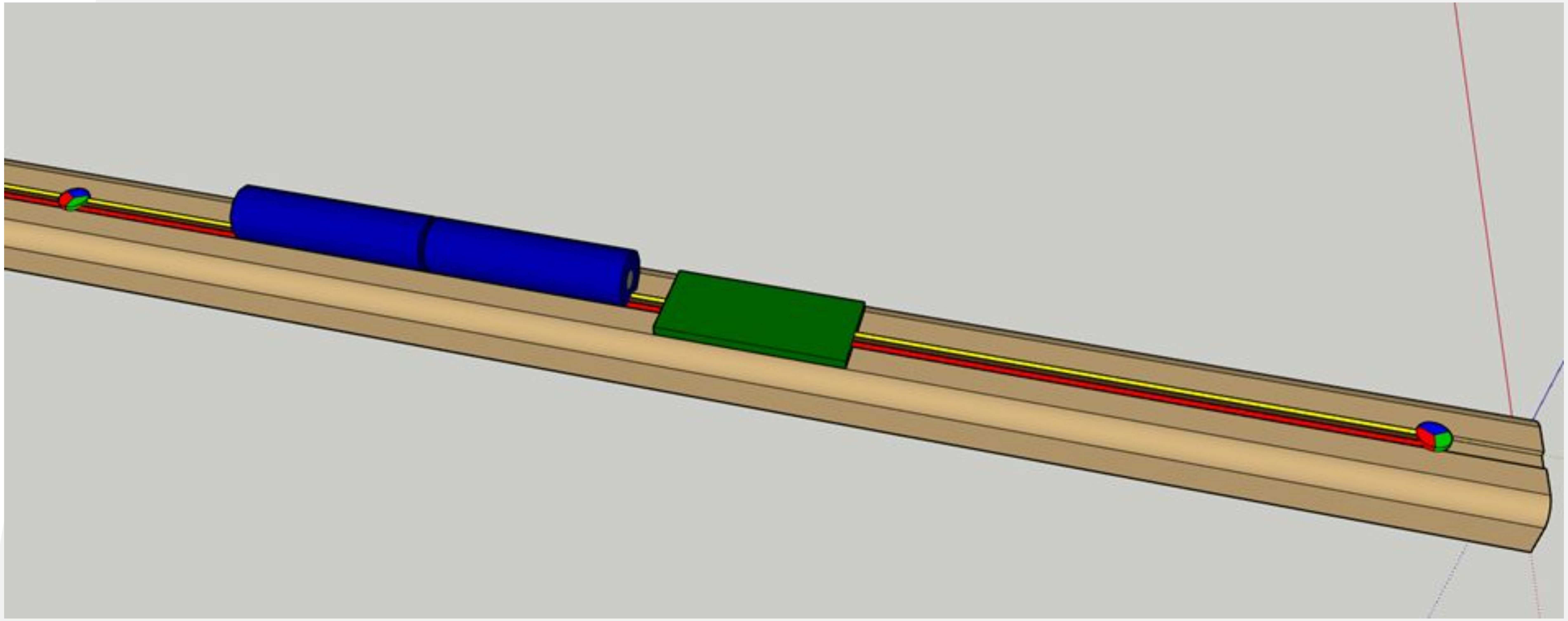
- Decreased Cost Short-Term
- Integrated Into a Single Circuit
- Smaller Time Investment Short-Term
- Optimal Solution

9v Li Battery

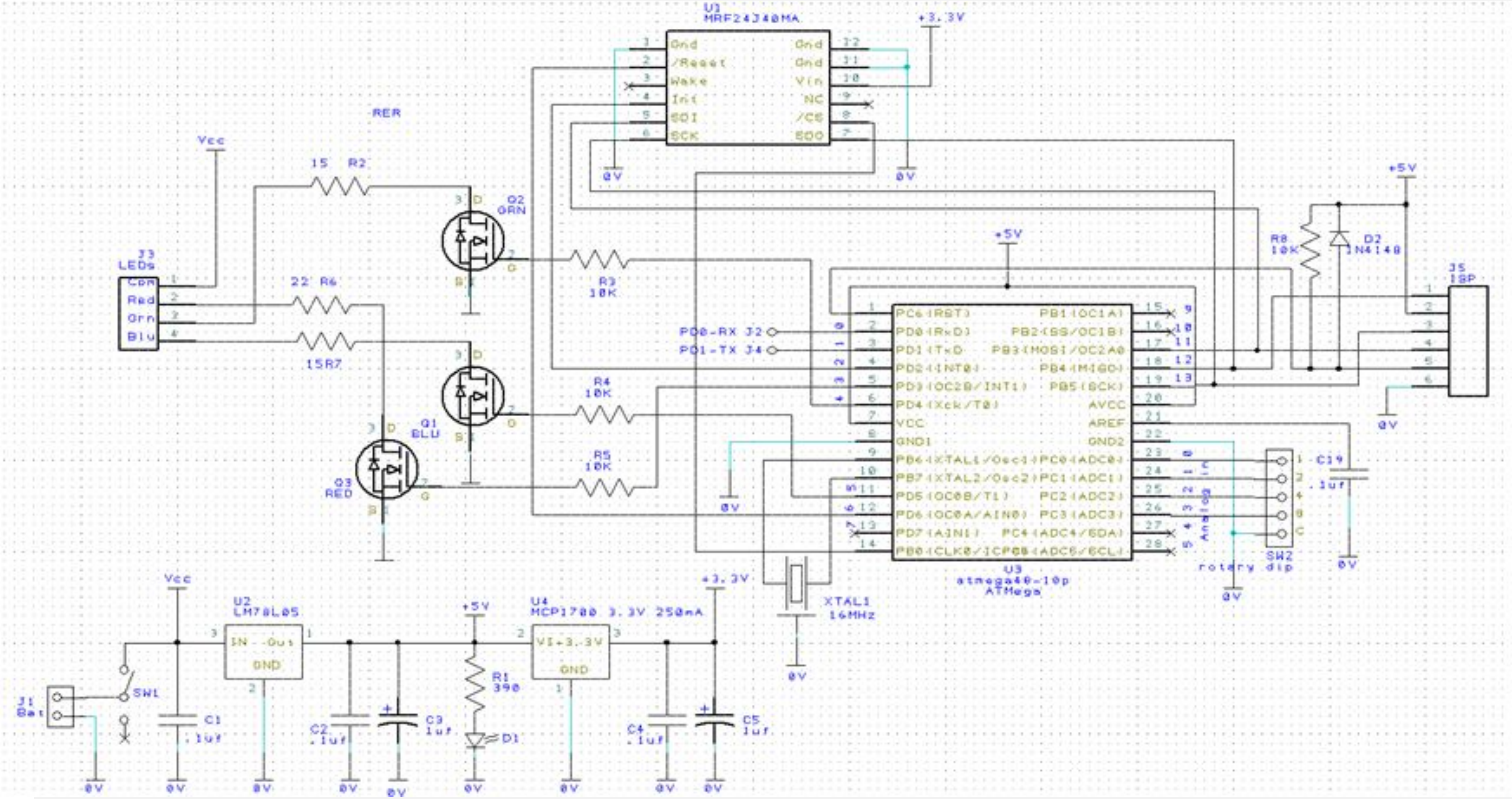
- Readily Available
- Increased Reliability
- Rechargeable
- Decreased Cost Short-Term
- Capacity Fits Needs

LightBar CAD Prototype Model

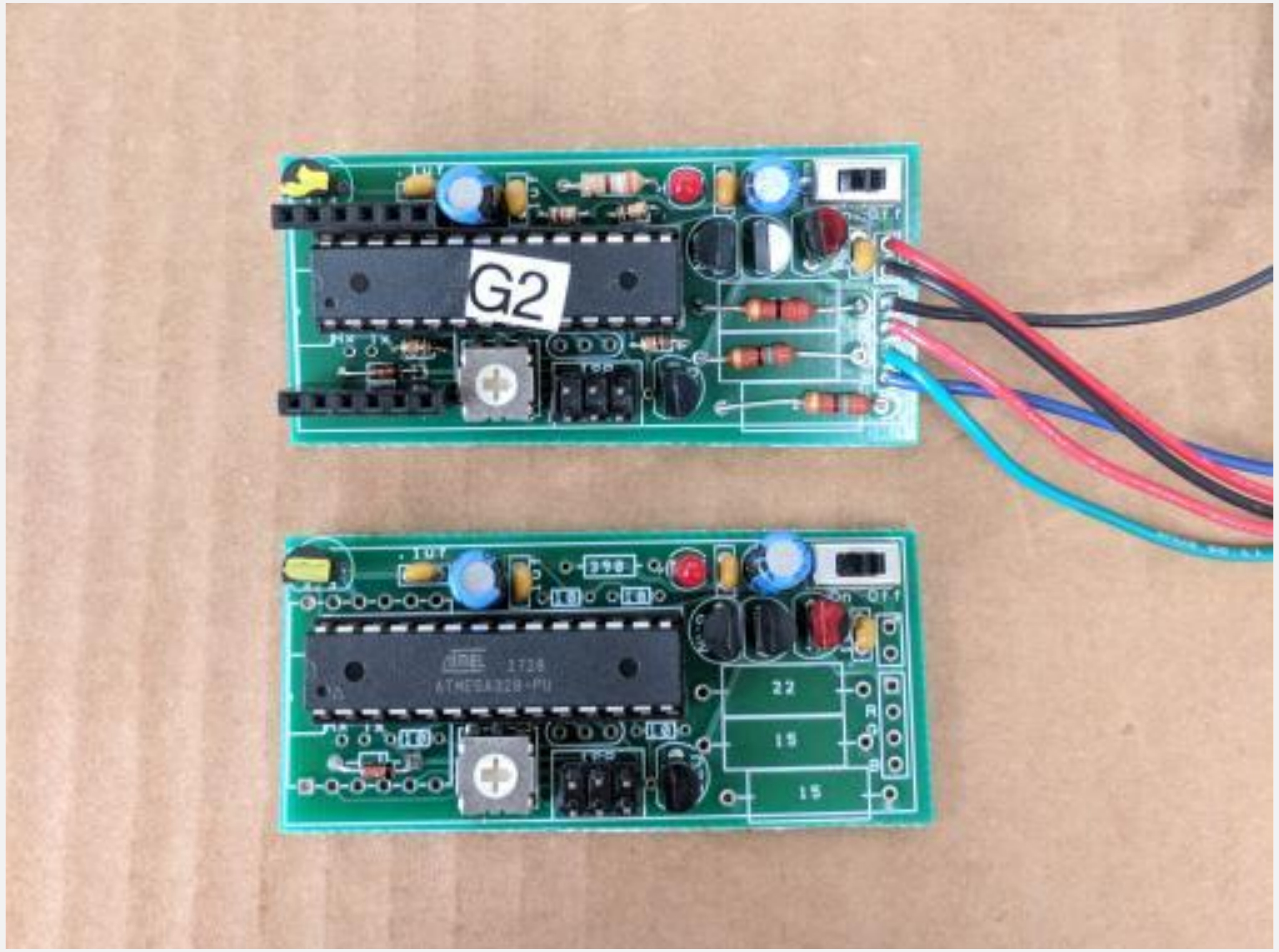
- Rendering of Light Bar, batteries and wireless receiver mounted on top



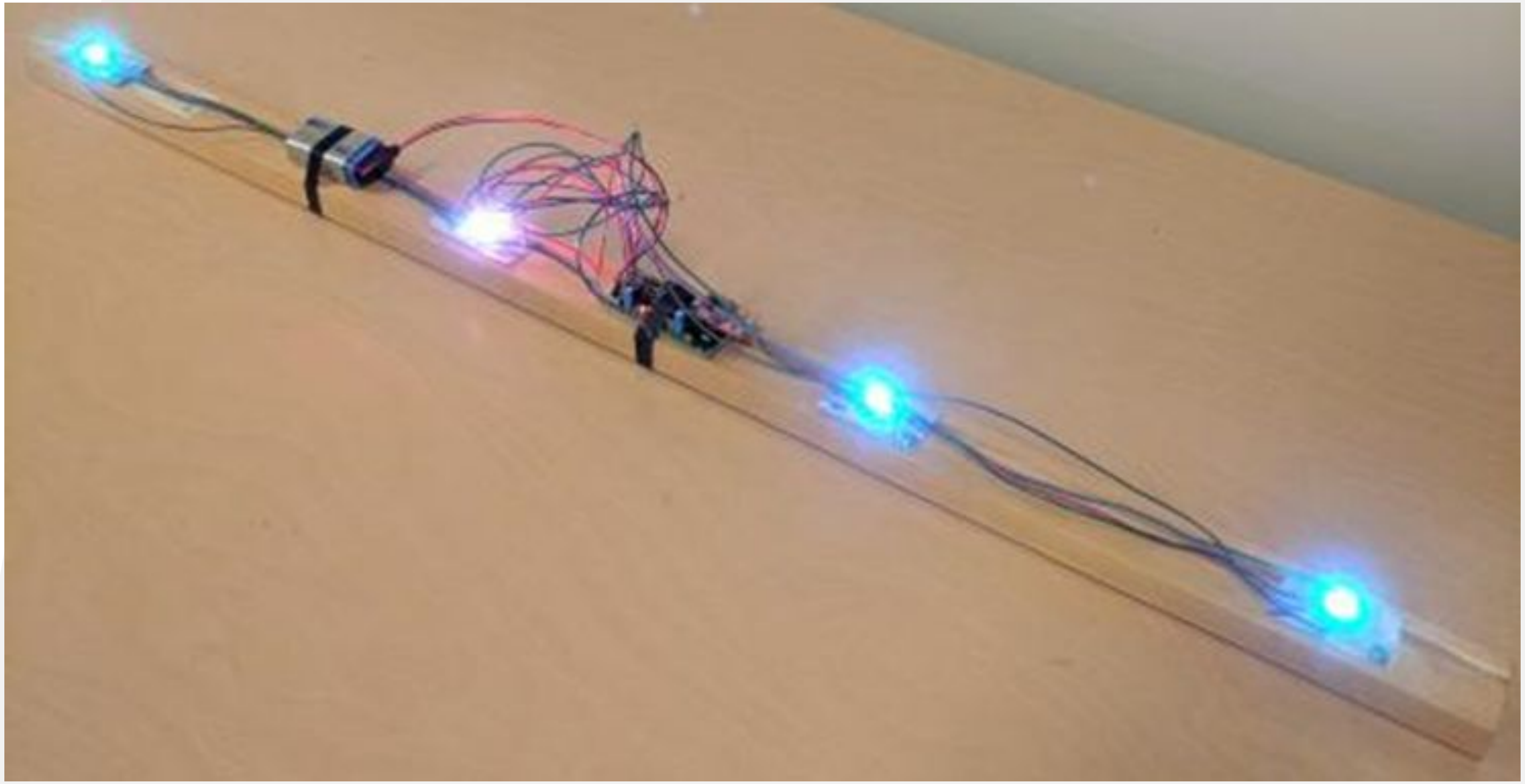
Schematic for Circuit Board



Circuit Board



Final Prototype



Budget / Cost

Budget

- Approx. $30 per light bar
- Approx. $3000 total budget
- 4 prototypes created

Cost

- Atmega 328P Chip - $2.00~$6.00
- MRF Receiver Chip - $6.00~$9.00
- 9V Battery - $7.00~$12.00
- RGB LED - $2.00
- LED Driver Circuits - $33.00 60 in^2 board
- 1 in x 2 in Board - $1.00~$10.00

Budget / Cost

For Each LightBar

Component	Package	Value	Unit Cost	Manuf	Manuf Part No	Distrib	Distrib Part No	Ref Name	Qty
1N4148 Logic Diode	USER		$0.06	Parts Express	1N4148	Parts Express	1N4148	D2	1
2-pin to 9V Adapter	DIL	Battery	$1.19	Philmore	48-9000	intertex Electronics	PH-48-9000	J1	1
4-pin header	USER	LEDs		TE Connectivity	640456-4	Mouser Electronics	571-6404564	J3	1
6-pin header	USER	ISP	$0.60	Gravitech	6fx1L-254mm	Mouser Electronics	992-6FX1L-254MM	J5	1
atmega48-10p	DIL	ATMega	$1.87	Microchip	ATMEGA48V-10PU	Microchip Direct	ATMEGA48V-10PU	U3	1
BoardPadSmall	USER			Rx				J2	1
	USER			Tx				J4	1
CAP5mm (Cermaic Capacitor)	USER	1uf	$0.28	TDK	FA28C0G2A101JNU00	Mouser Electronics	810-FA28C0G2A10100	C3 C5	2
disccap	USER	.1uf	$0.30	KEMET	C320C104M5U5TA	Digi-Key	399-4266-ND	C1 C2 C4 C19	4
FET NChan - TN0604	USER	BLU	$0.98	Microchip	TN0604N3-G	Microchip Direct	TN0604N3-G	Q1	1
	USER	GRN						Q2	1
	USER	RED						Q3	1
LED-T1 (Through Hole Red Diffuse)	USER		$0.37	Broadcom Limited	HLMP-1301	Mouser Electronics	630-HLMP-1301	D1	1
LM78L05	USER	5v	$0.67	Texas Instruments	LM78L05ACZ/NOPB	Mouser Electronics	926-LM78L05ACZ/NOPB	U2	1
MCP1700 3.3V 250mA	DSC	3.3v	$0.45	Microchip	MCP1700-3302E/TO	Mouser Electronics	579-MCP1700-3302E/TO	U4	1
MRF24J40MA	DIL		$9.12	Microchip	MRF24J40MA-I/RM	Microchip Direct	MRF24J40MA-I/RM	U1	1
R0.25W (Carbon Film Resistor)	R035	390K	$0.05	Multicomp	MCF 0.25W 390K	Newark	38K0372	R1	1
R0.125W (Carbon Film Resistor)	R035	10K	$0.10	RadioShack	2710006	RadioShack	2710006	R3 R4 R5 R8	4
R1W (Metal Film Resistors)	USER	15 ohms	$0.70	Vishay	CPF115R000FKB14	Mouser Electronics	71-CPF1-15R0FT1	R2 R7	2
R1W (Metal Film Resistors)	USER	22 ohms	$0.36	Vishay	MBE04140C2209FC100	Mouser Electronics	594-MBE04140C2209FC1	R6	1
Rotary Dip (Coded Rotary Switch)	DIL	7.4mm	$2.17	CTS	220AMC04R	Mouser Electronics	774-220AMC04R	SW2	1
Switch - mini slide PCB	USER		$0.58	E-Switch	EG1201A	Mouser Electronics	612-EG1201A	SW1	1
XTAL/Resonator (Ceramic)	DSC	16MHz	$0.95	adafruit	1873	adafruit	1873	XTAL1	1
9V Li Ion Battery		600 mAh	$6.99	EBL	LN-8161	newegg	9SIABFB5250166		2
1 in. x 2 in. x 8 ft. Furring Strip Board			$1.05	Home Depo	100009348	Home Depo	100009348		1
Total			**$28.84**						**34**

Schedule

Month	Goal
September	Finalize Program Flow
October	Hardware Decisions
November	Initial Prototyping
December	Unit Testing
January	Finalize Hardware Decisions
February	Production of Final Hardware
March	Scale Testing
April	Final Testing
May	Deliver Final Product

Client Needs

- Wireless / Portable
- Low Power Consumption
- Visibility of LED’s
- 40+ Light Bars Supported by Code Base

Conclusion

- We are interested in any questions, confusions, or input you may have!

Thank You for Listening!

University of Idaho
College of Engineering