LUMO TECH
WRITE BRIGHT

February 20, 2017

Andrew H. Rawicz
School of Engineering Science
Simon Fraser University
V5A 1S6

Re: ENSC 405W/440 Functional Specifications for ***StyLight*** by ***LumoTech***

Dear Dr. Rawicz

The attached document, LumoTech's functional specifications for *StyLight*, provides a summary of our capstone project. Our goal is to design a cost effective and portable system to turn any cellphone to a notepad for taking electronic notes.

The purpose of this proposal is to outline the functionality of the *StyLight*. This includes system overview, overall device requirements, engineering standards, as well as sustainability and safety issues both at the prototype and product release phases of design. The specifications outlined in this document will serve as a guide throughout the design of the *StyLight*.

LumoTech consists of 6 determined, talented senior engineering students ranging in concentrations from Computer Engineering, Electronics Engineering, and Systems Engineering: Alexis Golding, Ahmadreza Edalat, Alex Kim, Fatemeh Darbehani, Hamed Mahdi, and Mohammad Shakoory. Complete profiles are available at the end of the proposal.

We appreciate your time in reviewing our functional specifications for *StyLight***.** If you have any questions or concerns regarding our proposal, please do not hesitate to contact our Chief Communication Officer, Hamed Mahdi, by phone at (778) 986-7601or by email at hmahdi@sfu.ca.

Sincerely,

Fatemeh Darbehani

Fatemeh Darbehani
Chief Executive Officer
LumoTech

Functional Specifications For *StyLight* by

LUMO TECH

WRITE BRIGHT

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Abstract

This document describes the functional specifications and outlines the requirements for the *StyLight* projector and pen. A detailed look at each specific engineering standards along with a complete analysis of the problem is also included. The goal is to give the reader an explanation of the product without the excessive design details.

The *StyLight* is system of two parts: a pen and a projector aimed at helping students and professionals to take notes digitally. Consisting of intuitive software controls along with an easy to use UI, while seamlessly integrating with the firmware and hardware, resulting in a product that creates the most efficient note taking experience possible. It's a product that couldn't exist without innovation across many engineering fields.

Overall, there are three main sections in this document:

- Requirement Specifications aimed at providing the reader with requirements of the system. This includes the general, electrical, software/firmware, safety, and mechanical requirements of the system along with justification for the chosen decisions. They are also distinguished between current project version and later stages of the project.
- Engineering Standards aimed at outlining the standards that apply to the system with references from outside sources
- Carefully analyzed sustainability and safety issues related to the device. "Cradle-to-cradle" cycle analysis has been covered in this document for the current version as well as outlines the major considerations for the system at the production stage.

This document also includes graphs and figures to represent specs as well as extensively detailed constraints considered for a marketed product. As well as providing the reader with a more comprehensive system overview of StyLight by using graphs and figures. Deliverables for up to the end of August 2017 can also be found in this document. Sustainability and Safety of the project have been integral parts of the design phase, and they will continue to play a large role at every phase moving forward. As here at LumoTech, we are determined to make great products that will benefit the people without harming the planet.

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1. Introduction

When you combine affordability, easy connectivity, mobility as well as versatility, you get *StyLight* by LumoTech. A device that allows the entire smartphone screen to be projected onto any surface, by enlarging the smartphone screen to a size that allows for easy note-taking and modification of those lecture notes. With *StyLight*, any notes taken can be written with a *StyLight* stylus directly on the projected image on the surface in front of you, and then save as a PDF document on the smartphone for future access.

With the ability to turn any flat surface into a notebook, *StyLight* is distinguished by its lightweight design and compact packaging. The user can interact with the projected screen in real time, saving any work digitally for later access across all devices.

1.1 Background

In today's ever advancing society, technology has been the catalyst behind improvements in accessibility and convenience, two things that have become increasingly important to students. In the face of notebooks and binders that never seem to have enough paper, pens with no ink and pencils with no lead, and the added weight of textbooks, students have eagerly transitioned to solutions that remove those hassles. With the help of smartphones, tablets, and laptops, students' lives in the classroom and at home have become easier. Of these products, tablets running mobile operating systems with large screened peripherals have, and continue to see, the largest segment growths. Although these devices have made it easier to be a student, buying a tablet and stylus while already paying for a personal mobile device is not always affordable.

While students can get away with accessing class materials solely on their smartphones, the screen is often too small, and does not allow for clear and convenient note-taking. This motivated us to look for a more robust way to make note-taking easier. Since smartphones are able to access lecture notes and textbooks online and download them as modifiable PDF documents, the *StyLight* allows the entire smartphone screen to be projected onto any surface in front of you, enlarging the smartphone screen to a size that allows for easy note-taking and modification of those lecture notes. The notes can be written directly onto the projected image with the *StyLight* stylus, and then saved as a PDF document on the smartphone for future access.

Currently, there is no product like this on the market, only similar ones in production which feature one functionality of our product. For example, a pen exists to take notes, but does not deliver any real time visual feedback [1]. This is where we differentiate ourselves from the competition. Our product will include a system that communicates with itself to provide fast and responsive feedback.

1.2 Scope

This document explains the functional specifications and requirements of the *StyLight*, which must be met by LumoTech. This document will give a thorough description of the proof of concept model and all of the different requirements necessary for production. It also seeks to clarify the high level functionality of the product, how it would work and how it would be used.

1.3 Intended Audience

This document in intended to be used by the members of LumoTech for development of StyLight as well as the TA's marking this document, and senior engineers who are interested in this project. It can be used throughout the research and product development stages as a reference to provide the overall view of the product. The hardware, software and design engineers can refer to the system requirements, hardware and software details contained in this document to aid in product development. Engineers performing quality assurance can focus on the sustainability and safety section of the report to ensure that safety concerns have been addressed and that the product meets all the goals and standards regarding its development and usage.

1.4 Classification

In order to make it easier to reference and prioritize the requirements, the following convention will be used through this document:

[Req A.B.C.D – XX] A functional requirement.

Req is an abbreviation for requirements. Letters **A**, **B**, **C,** and **D** correspond to integer values that symbolize the hierarchal order of the requirement. **A** references the root section, **B** represents the subsection of **A**, **C** corresponds to the subsection of **B** and **D** corresponds to the subsection of **C**. The **XX** specifies the priority of the requirement. There are three priority levels:

PC – The requirement refers to a proof-of-concept
PT – The requirement refers to a prototype
FP – The requirement refers to a final product

2. System Overview

2.1 Product Design

StyLight is a modern note-taking device that consists of a projector and a stylus to enable students to take notes on their cell phones. The design of the StyLight consists of two main parts: the design of the Projection Unit to display the screen of the smartphone, and the design of the Pen Tracking Unit to interact with the displayed screen, as can be seen in Figure 1.

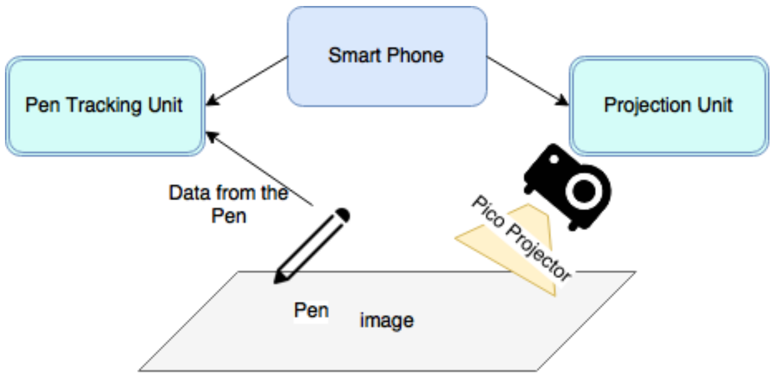

Figure 1- Overview of the system

Figure 2 is a rendered model of our device prototype to show some of its design aspects. As can be seen in this figure, user's phone will be placed in the front of the StyLight's case so the user is able to press the buttons of the phone and interact with it directly.

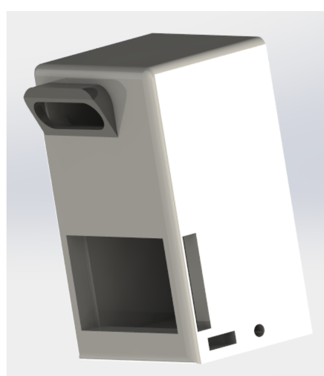

Figure 2-SolidWorks Design of the Prototype

Below are the main components of *StyLight*:

2.1.1 Large Projected Screen:

As shown in Figure 3, user's cellphone will be connected to the Pico projector through LumoTech's image processing system. The image processing system will set up HDMI connection with the cellphone and corrects any distortions in the image dimensions due to angle of projection. With the help of this system, the screen of the user's smartphone is projected onto any flat surface and an efficient keystone correction algorithm corrects the image distortion in real time so the user will not see a skewed image.

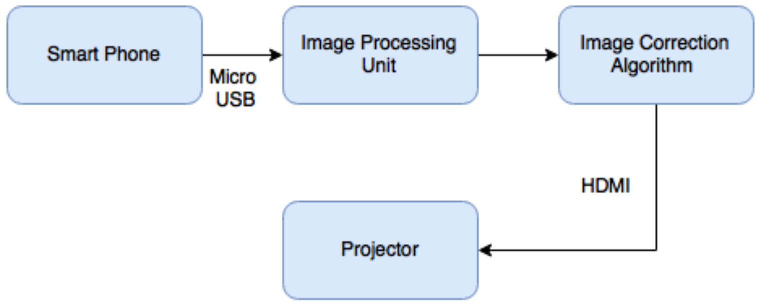

Figure 3- Conceptual Diagram of the Projection Unit

2.1.2 Remote Stylus:

User can take notes with the use of the *StyLight* engineered remote stylus in conjunction with any note-taking application. The remote stylus resembles a typical pen, aside from an LED that turns on when the stylus tip is pressed onto the surface during writing. As shown in Figure 4, the remote stylus consists of an electromagnetic coil that creates a constant magnetic field around it. The magnitude of this electromagnetic flux is sensed by a pair of magnetometers inside the StyLight box. The data then is sent to an Arduino board through IC2 bus connection for further processing.

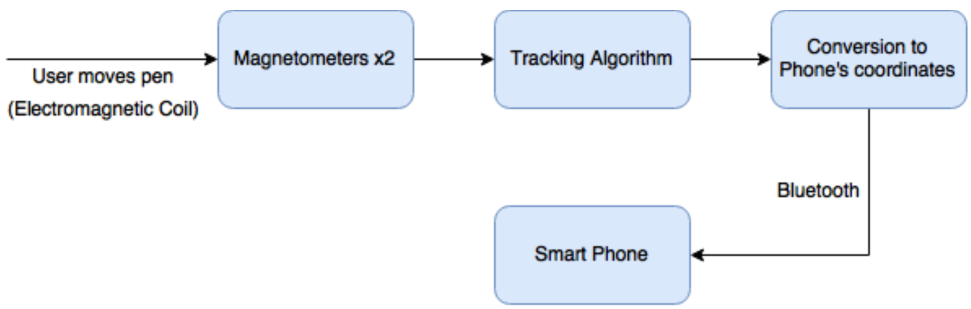

Figure 4- Conceptual Diagram of the Pen Tracking Unit

The advantage of using electromagnetic sensors over optical methods is the elimination of the need for line-of-sight. Regardless of the position of the pen, or the magnet being covered by user's hand and even in low-light conditions, the movement of the remote stylus should be tracked by the two magnetic sensors. Data is then converted into coordinates that correlate to those on the user's smartphone's screen to reconstruct the writing onto the PDF document. The processor will send data to the smartphone via Bluetooth.

2.2 Deliverables

2.2.1 Deliverables for Alpha Production (ENSC405):

- The image correction system makes a connection from cell phone to the Pico projector and enables the user to project their cellphone's screen on a flat surface.
- Luminosity of the projector is set to work in darker classrooms.
- Pen movement is tracked when the tip of the pen is pressed on a surface.
- Pen's position (x and y coordinates) on a 2D surface is determined using magnetic sensors

2.2.2 Deliverables for Beta Production (ENSC440):

- The image correction system fixes any distortion of the image dimensions due to angle of projection.
- Luminosity of the projector can be adjusted by the user
- Pen's position is converted into correlated coordinates of the smartphone's screen.
- Pen's movement is sent to the smartphone as touch events using android libraries and are inputted by the note-taking application.
- A battery bank is added to the system that can last for minimum of 4 hours' powers StyLight.
- At least one popular PDF note-taking application works with the StyLight.

3. System Requirements

This section will describe the requirements of the pen and project system designed by LumoTech. The requirements will be split up into five sections: General, Physical and Operational, Electrical, Software/Firmware, and Safety Requirements.

3.1 General Requirements

[Req 3.1.1 - PC] The system will only be intended for indoor use

[Req 3.1.2 - PC] The operating temperature of the system should be from -30° to 85° C

[Req 3.1.3 - PC] The operating relative humidity of the system should be from 5% to 95% noncondensing

[Req 3.1.4 - PC] The maximum operating altitude of the system should be 10,000 feet (3000 m)

[Req 3.1.5 - PC] Strong documentation practices and software version control management systems will be implemented.

[Req 3.1.6 - PC] The device shall be easy to assemble and disassemble.

[Req 3.1.7 - PT] Subsystems of the *Stylight* product will be designed modular where possible for improved delivery and maintenance.

[Req 3.1.8 - PT] Device should turn off automatically if not connected to a phone.

[Req 3.1.9 - FP] Retail price should not exceed $400

[Req 3.1.10 - FP] Physical user manual should be printed and shipped with the product. Languages used in the manual will be appropriate for their destination.

[Req 3.1.11 - FP] Technical support should be provided to assist customers having troubles with the device.

[Req 3.1.12 - FP] All completed *Stylight* systems should be thoroughly and consistently tested according to established procedures prior to shipping

[Req 3.1.13 - FP] The device can be operated and initialized by a single person without a need for prior technical knowledge.

[Req 3.1.14 - FP] The *Stylight* will be compatible with Android and Apple smartphones

3.2 Physical and Operational Requirements

[Req 3.2.1 - PC] The device should consist of the main body of *StyLight*, projection, note taking application for android and the stylus pen.

[Req 3.2.2 - PC] The main body of *StyLight* should have a start button that upon press will start the projector and projects the content of your phone screen on the surface in front of you.

[Req 3.2.3 - PC] The main body should include a holding dock for android phones that is equipped with a micro USB cable to connect the user's cellphone to *StyLight*. The user will still be able to see the screen of the phone.

[Req 3.2.4 - PC] Turning on *StyLight* should result in the projection of phone screen on the surface in front of the user.

[Req 3.2.5 - PC] Using *StyLight* pen's movement should be tracked by the device using a microcontroller and a motion-tracking algorithm.
[Req 3.2.6 - PC] The system should be able to track the location of the tip of the pen within 5mm.
[Req 3.2.7 - PC] The material of the box will be hard plastic.
[Req 3.2.8 - PC] The pen will be plastic with a metal magnetic tip.
[Req 3.2.9 - PC] It should have a stable surface with either a clamp or suction cups at the bottom of the box.
[Req 3.2.10 - PC] The system is powered using wall plug

[Req 3.2.11 - PT] *StyLight's* shape consists of a 10cm x 10cm x 15cm rectangular cube.
[Req 3.2.12 - PT] Dimensions of virtual screen should be a minimum of 20cm by 13.4cm and a maximum of 30cm by 22cm
[Req 3.2.13 - PT] Product must be light and weigh less than 10 pounds (4536 grams)
The boot up speed of the projector upon turning on must be less than two seconds.
[Req 3.2.14- PT] The virtual screen will be in focus, interactive and produce at least 200 ANSI lumens so the projected screen resolution is consistent in various lighting conditions.
[Req 3.2.15 - PT] The *StyLight* shall be powered using a rechargeable battery and last for at least 4 hours' standby.
[Req 3.2.16 - PT] Interactions with the virtual screen will be limited (Using only our pen)
[Req 3.2.17 - PT] The system must be able to be turned on and off with a press of a button.
[Req 3.2.18 - PT] System should be cooled down by a fan, with the noise not exceeding 50 decibels (dBA)

[Req 3.2.19 - FP] Device should have appealing user interaction. It should feel like the user is using a pen and notebook.
[Req 3.2.20 - FP] All of the main components will be easily accessible in order for the user to be able replace any broken parts.
[Req 3.2.21 - FP] The internal hardware of the product must consist of custom PCB assemblies and ASIC chip(s)
[Req 3.2.22 - FP] Accuracy of pen should not exceed an average of 1.5 mm (1.33 mm was the reported Finexus accuracy)
[Req 3.2.23 - FP] Throughput of the system should be less than 0.5 second.
[Req 3.2.24 - FP] All the interaction with the system is done in real time (less than 0.5 second).

3.3 Hardware Requirements

3.3.1 Electrical Requirements

[Req 3.3.1.1 - PC] Circuit components will be resistant to external sources of heat or noise.
[Req 3.3.1.2 - PC] System will be powered by a 12 V adapter.

[Req 3.3.1.3 - PT] Battery in pen will consist of two 1.5 V coin batteries in series, with 150 mAh each.

[Req 3.3.1.4 - FP] Battery will last for approximately 2036 days, assuming powered circuitry draws 3 μA.
[Req 3.3.1.5 - FP] The electromagnet in the pen, due to the strength of field it will emit, will be

detectable up to 28 cm.
[Req 3.3.1.6 - FP] Sudden loss of power will not result in loss of information or performance.
[Req 3.3.1.7 - FP] Circuit components will be chosen from companies that have a reduced likelihood of rendering part obsolete and therefore irreplaceable
[Req 3.3.1.8 - FP] Product PCB in pen will be designed to minimize transmission losses
[Req 3.3.1.9 - FP] Product will be powered by a 5 V rechargeable battery.

The hardware systems diagram is shown in Figure 5.

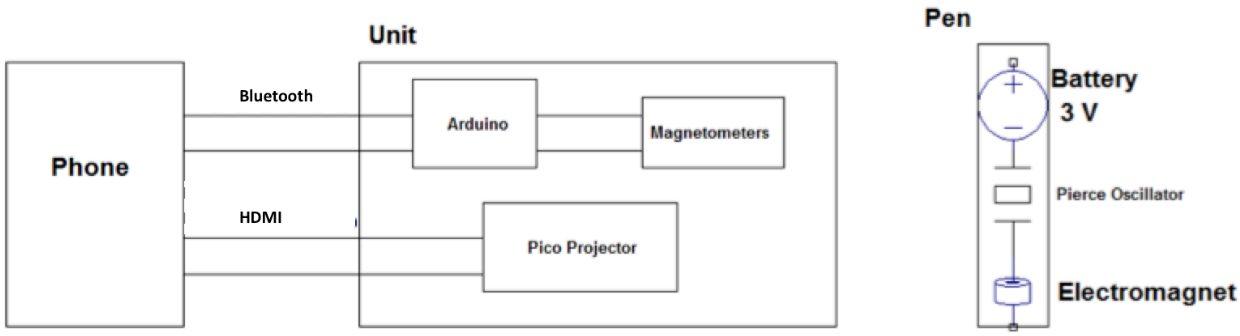

Figure 5- Hardware Systems Diagram

Two magnetometers will read the strength of an emitted magnetic field from an electromagnet in the pen. The electromagnet will be powered by a Pierce oscillator resonator, which will convert 3 V DC into an AC signal. The Pierce oscillator resonator consumes very little power. An Arduino board will read data from the magnetometers, and will digitally filter out electrical noise and the Earth's magnetic field. From there, calculations will be performed to ascertain the coordinates of the electromagnet. The coordinates of the electromagnet will correlate to pixels on the phone's screen for accurate placement of writing on the PDF document. The Arduino board is connected to the phone via Bluetooth connection.
The projector will project the phone's screen onto a flat surface, and will connect via HDMI.

3.3.2 Magnetometer Requirements (HMC5883)

[Req 3.3.2.1 - PC] Input voltage for magnetometers will be between 3.6 and 2.16 V.
[Req 3.3.2.2 - PC] The magnetometers will draw no more than 100 µA of current during operation.
[Req 3.3.2.3 - PC] Data will be transmitted to the Arduino board via I2C bus interface.

[Req 3.3.2.4 - PT] The magnetometers will sense a magnetic field of magnitude +/- 8 Gauss, with a resolution of 4.3 mili Gauss.
[Req 3.3.2.5 - PT] The magnetometers will take no more than 50 ms to turn on.
[Req 3.3.2.6 - PT] The magnetometers will consume no more than 0.36 mW each.

[Req 3.3.2.7 - FP] The magnetometers will sample every 6 ms at a 75 Hz output rate.
[Req 3.3.2.8 - FP] Each magnetometer will be no more than 3.0 x 3.0 mm.
[Req 3.3.2.9 - FP] Each magnetometer will weigh no more than 18 g.

[Req 3.3.2.10 - FP] Input voltage for magnetometers will be between 3.6 and 2.16 V.
[Req 3.3.2.11 - FP] The magnetometers will draw no more than 100 μA of current during operation.

3.3.3 Arduino Requirements

[Req 3.3.3.1 - PC] The Arduino board will use a 12 V power adapter and be plugged into an outlet.
[Req 3.3.3.2 - PC] The Arduino board will have analog inputs to receive data from the magnetometers.

[Req 3.3.3.3 - PT] The Arduino board will supply 20 mA per GPIO pin.
[Req 3.3.3.4 - PT] The Arduino board will have a reset button to re-execute code in case of sudden shut-down.
[Req 3.3.3.5 - PT] The Arduino board will have a 16 MHz crystal as an alternative to the Pierce oscillator.
[Req 3.3.3.6 - PT] The Arduino board will have digital signal processing capabilities for bandpass filtering.
[Req 3.3.3.7 - PT] The Arduino board will not exceed dimensions of 68.6 x 53.4 mm.
[Req 3.3.3.8 - PT] The Arduino board will not exceed 25 g in weight.
[Req 3.3.3.9 - PT] The Arduino board will process data faster than the sampling period (6 ms) of the magnetometers.
[Req 3.3.3.10 - PT] The Arduino board will supply the required voltage of 3.6 to 2.16 V for the magnetometers.

3.3.4 Electromagnet Requirements

[Req 3.3.4.1 - PC] The electromagnet will have a core made from nickel, which has a relative permeability of 100.
[Req 3.3.4.2 - PC] No turns will overlap, and will be packed tightly together.

[Req 3.3.4.3 - PT] The electromagnet will weigh no more than 100 g.
[Req 3.3.4.4 - PT] The electromagnet will ideally emit a magnetic field of approximately 75μT, or 750 Gauss.

[Req 3.3.4.5 - FP] The electromagnet will have a core made from nickel, which has a relative permeability of 100.
[Req 3.3.4.6 - FP] The nickel core will be wound with 34 AWG copper wire, for N = 100 turns.
[Req 3.3.4.7 - FP] The coil will be no wider than 10 mm, and no taller than 50 mm.

3.3.5 Pierce Oscillator Resonator Requirements

[Req 3.3.5.1 - FP] Crystal will oscillate at 32.768 kHz for flexibility to be divided down to 64 - 128 Hz for easier filtering.
[Req 3.3.5.2 - FP] Crystal will have a frequency sensitivity of +/- 20 ppm.
[Req 3.3.5.3 - FP] Buffer will perform such that it draws low supply currents.
[Req 3.3.5.4 - FP] Proof-of-concept board will consist of through-hole components, and will not exceed dimensions of 5 x 5 cm.
[Req 3.3.5.5 - FP] Product PCB will consist of SMD components, and will not exceed dimensions

of 3 x 0.4 cm.

[Req 3.3.5.6 - FP] Both boards will not exceed 100 g

[Req 3.3.5.7 - FP] Oscillator will supply electromagnet with a 4 Vpp square wave 32.768 kHz signal.

[Req 3.3.5.8 - FP] Oscillator will draw no more than 3 µA to preserve life of battery.

[Req 3.3.5.9 - FP] Oscillator will consume no more than 9 µW of power.

[Req 3.3.5.10 - FP] Transistors in oscillator will provide a high gain at low collector currents of 20 µA.

[Req 3.3.5.11 - FP] Resistors and capacitors will be chosen such that they are resistant to temperature, frequency, and piezoelectric effects.

[Req 3.3.5.12 - FP] Resistors and capacitors will have a tolerance of no more than 5%.

The circuit diagram for the Pierce oscillator resonator is shown below:

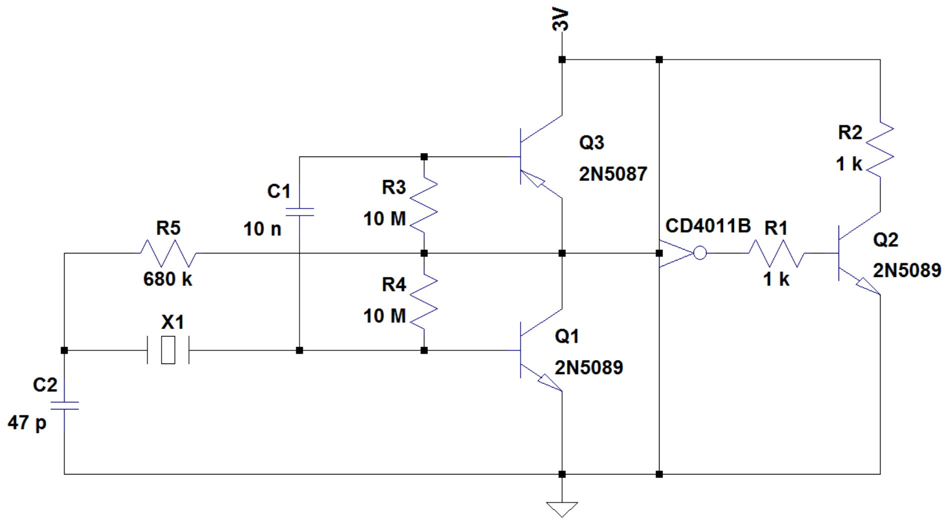

Figure 6-Pierce Oscillator Resonator

3.3.6 Microcontroller Requirements

[Req 3.3.6.1 - FP] The microcontroller will have an RC oscillator as an alternative to the Pierce oscillator.

[Req 3.3.6.2 - FP] The microcontroller should not lose information due to sudden loss of power.

[Req 3.3.6.3 - FP] The microcontroller will have the capability to implement digital filtering.

[Req 3.3.6.4 - FP] Microcontroller must have capability to support data transmission from the magnetometers with an I2C bus interface.

[Req 3.3.6.5 - FP] The microcontroller will be compatible with a 5 V rechargeable battery.

[Req 3.3.6.6 - FP] The microcontroller will have low power consumption.

[Req 3.3.6.7 - FP] The microcontroller will take no longer than 1 s to power on and initialize.

3.3.7 Pico projector Requirements

[Req 3.3.7.1 - FP] The Pico projector will consume little power.

[Req 3.3.7.2 - FP] The Pico projector will have the capability to allow user to focus beam.
[Req 3.3.7.3 - FP] The Pico projector will be compatible with Android phones and Bluetooth.

3.4 Firmware/Software Requirements

For software and firmware requirements, a program will be written in C in Arduino development environment to convert the raw data received from magnetic sensors into usable data by filtering out the unwanted noise. Then by using android *Monkeyrunner* API we are able to control the android device from outside of android code. Thus, the process data from Arduino is scaled and mapped to mobile phone coordinates in real time manner. The connection between phone and the image-processing unit will be via micro USB cable. The image-processing unit is then connected the projector via HDMI cable. The data from the location of the pen is collected by magnetic sensors and processed in C language on Arduino board. The system will support at least note-taking application on android phones.

[Req 3.4.1 - PC] Location of the pen should be sent to the phone via Bluetooth connection.
[Req 3.4.2 - PC] The screen of smart phone should be accessed by the image-processing unit and processed on Arduino board.
[Req 3.4.3 - PC] The system should be able to handle run-time errors and external interrupts from different hardware components in order to avoid a fatal breakdown in the device.

[Req 3.4.4 - PT] Using android APIs available, the processed data from Arduino is scaled and mapped to mobile phone pixels.
[Req 3.4.5 - PT] The system will support at least one note-taking application on android phones.
[Req 3.4.6 - PT] The synch interval of the data from the projected screen to the phone pixels must be done in the shortest time considering battery life conditions.

[Req 3.4.7 - FP] The installed software on the PCB will be upgradable for feature enhancements.
[Req 3.4.8 - FP] System must use Open source projects if available to reduce cost and copyright issues.
[Req 3.4.9 - FP] Software system should be advertisement free.
[Req 3.4.10 - FP] Application should not access and/or store personal data or excess system resource unethically.

3.5 Safety Requirements

[Req 3.3.5.1 - PC] System should be free of any lead contamination or any other toxic chemicals of that kind.
[Req 3.3.5.2- PC] The device should not have sharp edges.
[Req 3.3.5.3 - PC] Intensity of the projector's light shall be regulated so there will be no permanent damage to the eyes.
[Req 3.3.5.4 - PC] The device should not collect excessive electrostatic charge that is harmful to humans and electronic circuits inside the device.

[Req 3.3.5.5 - PT] All electrical devices/components should be properly placed inside the box.
[Req 3.3.5.6 - PT] Device should be non-flammable, non-explosive, and easily transported.

[Req 3.3.5.7 - FP]	Wires and board shall be properly insulated and grounded to prevent shocks and electrical fires.
[Req 3.3.5.8 - FP]	The unit must be resistant to different physical forces such as dropping or getting hit.
[Req 3.3.5.9 - FP]	All components must withstand operation temperature, humidity, and currents.
[Req 3.3.5.10 - FP]	The unit should not overheat under continuous usage.
[Req 3.3.5.11 - FP]	The electronic components shall not cause interference with other devices.

4. Environmental Standards

LumoTech does not want to impact the environment negatively and does want to support recycling. CSA Group works with international stakeholders to provide consensus-based standards in environmental management, natural resources management, energy efficiency & performance, carbon management and other important sustainability-related subjects. Therefore, we should adhere to the following CSA requirements to ensure that the StyLight and its components do not have a negative impact on the environment. [2] [3]

CAN/CSA-ISO 14040-06 (R2016)	Environmental Management - Life Cycle Assessment - Principles and Framework
CAN/CSA-ISO 14044-06 (R2016)	Environmental Management - Life Cycle Assessment - Requirements and Guidelines
CAN/CSA-SPE-890-15	A Guideline for accountable management of end-of-life materials
CAN/CSA-ISO 14001:16	Environmental management systems — Requirements with guidance for use
CAN/CSA-ISO 14004:16	Environmental management systems - General guidelines on implementation
CAN/CSA-ISO 20121:13	Event sustainability management systems - Requirements with guidance for use

5. Engineering Standards

The thermoplastic polymer type material will comply with the ISO 7245:1984 standard in terms of waste and recycling. [4] [5]

The device will comply with Industry Canada Electric Standards (ICES) ICES-003, ISO, CSA, and ANSI rules shown here:

IEEE 802.4	Standards for token passing bus access
IEEE 802.6	Standards for information exchange between systems
IEEE 802.15.2	Bluetooth
IEEE 829	Software Test Documentation
IEEE 830	Software Requirements Specifications
IEEE 1003 Unix	Compatibility programming standard – POSIX
IEEE 1016	Software Design Description

IEEE 1074	Software Development Life Cycle
CSA C22.1-15 PACKAGE - 2015	Canadian electrical code package
CSA SPE-2000-94	Guide for Electrical Equipment for Installation and Use in Canada
CAN/CSA-C22.3 NO. 3-98 (R2013)	Electrical Coordination
CAN/CSA-C22.2 NO. 60065:16	Audio, video and similar electronic apparatus - Safety requirements (Adopted IEC 60065:2014, eighth edition, 2014-06, with Canadian deviations)
CAN/CSA-C22.2 NO. 107.2.01	Battery Chargers
CAN/CSA-C22.2 NO. 0.17-00	Evaluation of Properties of Polymeric Material

6. Sustainability

With the growing concern of unsustainable practices found in design and the corresponding strain on the environment, at LumoTech we believe in providing a quality product while doing our part for the environment. In “cradle-to-cradle” design, emphasis is placed on creating a product with sustainable materials and ensuring those materials can be recycled after the lifetime of the product. It shifts the emphasis from the beginning of the product lifecycle to include the end of the product lifecycle as well. LumoTech will be incorporating “cradle-to-cradle” design to achieve its goal of encouraging sustainability while providing a highly reliably product.

The StyLight will consist of relatively few physical parts. Given the small number of components involved, options for sustainability are somewhat limited. In building the product in the first phase, efforts will be made to reuse microcontrollers and sensors where applicable. Additionally, the components that are used may be taken apart and be reused in other projects when the proof-of-concept prototype is no longer needed.

The projector unit consists of a Pico projector and an image-processing unit. When the alpha product is no longer needed, the Pico projector can be used as a regular hand-held projector. The image-processing unit is a programmable Arduino board that can be used by itself in future projects. For the alpha production, the projector and the microprocessor will be bought only if used ones cannot be found.

The stylus unit consists of electromagnetic coil and two magnetometers on the Arduino board along with LED and IR transmitter and receiver. They can all be disassembled from the product and used in future projects.

StyLight also contains a plastic case and a plastic pen-shaped stylus. Efforts will be made to ensure that the components used do not have materials found on the Cradle-to-Cradle Banned List of Chemicals. These chemicals are noted for being damaging to the environment and human health [6]. At the end of the product’s life, LumoTech is responsible for disposing the plastic components according to SPE-890-15 [7].

As the product evolves from the alpha production to the prototype stage, our choices may have to change accordingly to meet our goal. The image processing unit and pen tracking system will no longer be implemented on Arduino board. Instead we plan on designing and printing a PCB to do image correction and pen tracking. When the prototype in this stage is no longer needed, we make sure the PCB is recycled according to the standards for waste electrical and electronic equipment (WEEE) in the SPE-890-15.

At the mass production stage, where our product is shipped to the end users, we ensure that the *StyLight* case and the remote stylus are made out of biodegradable materials instead of regular plastic. LumoTech will also demand the manufacturer of our PCB to recycle wasted materials and water used in the chip production. If *StyLight* goes into development of newer versions, LumoTech is committed to recycling older versions of the product for its customers according to CSA standards and free of charge.

7. Conclusion

The *StyLight* is a durable, compact solution to combining the large surface area of a tablet with the communication and file sharing capabilities of a smartphone. Connecting a smartphone to *StyLight* will enable students to project their lecture notes onto any surface, and with a specially designed stylus, write their notes onto the projected screen as they would normally on a tablet, storing the changes to the document for later. The system design consists of three major sections:

- Hardware development aimed to provide high accuracy pen tracking and high-resolution projection of the smart phone screen.
- Firmware development on the evaluation board to enable communication between hardware components.
- Software development aimed to develop an android driver, which is capable of sending touch events to the cell phone.

The prioritization system will allow the development team to efficiently allocate resources accordingly. We have put high priority on the features, which are necessary for the device to have basic functionality. Some of these high priority features include the ability to project smart phone screens and track pen movement. Whereas we have put lower priority on features that add extra polish to the StyLight but are not as necessary for its functionality, such as correction of the distortion of the image.

In the above requirement specifications, the characteristics and design constraints of the StyLight are clearly established to provide a detailed outline of the requirements for the physical, electrical, and computational aspects of the project. The physical requirements pertain to the size and weight of the unit being designed and how these meet usability constraints for users. Electrical specifications refer to the incorporation of the projector, microprocessors, magnetic and infrared sensors, and their connections.

At LumoTech the importance of sustainability is a major priority. Within every level of the functional specifications, care has been taken to consider the reusing and recycling of parts after each stage of the project.

8. Glossary

Bluetooth	A short range radio technology aimed communication method between devices and the internet
Modular	A design approach that subdivides a system into smaller parts which can be independently created and then used in different systems
Real time embedded programming	The art of programming a system with a dedicated function within a larger mechanical or electrical system considering the specified time constraints
Pico projector	A pocket or a handheld device that projects the content of a smartphone, camera, tablet, notebook or memory device onto a wall or a flat surface
HDMI	An audio/video interface for transmitting uncompressed video data
Infrared Camera	A non-contact device that detects infrared energy(heat) and converts it into electronic signal
Arduino Board	Refers to an open-source electronics platform or board and the software used to program it
Prototype	A first preliminary model of something

9. References

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