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Perceptum Technologies

February 21, 2008

Mr. Patrick Leung
School of Engineering Science
Simon Fraser University
8888 University Drive
Burnaby, British Columbia
V5A 1S6

Re: ENSC 440/305 Functional Specification for *RockIt*

Dear Mr. Leung,

The enclosed document is entitled *Functional Specification for Motion-Control Guitar Effects*. The document will further outline details of our ENSC 440/305 project entitled *RockIt*.

Functional specifications of our prototype and commercial product are detailed in the attached document. Development goals for both iterations are described.

Our product gives guitarists greater stage mobility by allowing musicians to control their effects using an innovative sensor scheme. Our design affords musicians greater show presence as their effects can be directly linked to their motions. *RockIt* is composed of motion and touch sensors mounted on the guitar, which control effects using industry standard protocols. These protocols allow the musician to control many other elements related to musical performances such as lighting. Potential improvements are discussed, which include wireless transmission, intelligent user interface, and in-situ sensitivity control.

Perceptum Technologies consists of four engineers: Kyle Huffman, Daniel Galeano, Paul Carriere, Ben Shewan. Each team member is an accomplished engineer in their own right. If you have any questions or concerns about our product, please contact us through our email address: ensc440-spring08-perceptum@sfu.ca

Sincerely,

Kyle Huffman

Director of QA, Perceptum Technologies

PERCEPTUM TECHNOLOGIES

RockIt Functional Specification

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Executive Summary

"Without music, life would be a mistake." - (Nietzsche, 2008)

Since its creation in the 1930's (Wikimedia Foundation, Inc., 2008), the electric guitar has revolutionized all genres of music. In fact, Rock'n'Roll music is defined by the crunchy, distorted sounds of the electric guitar. During the 1960's, the full creative power of the electric guitar was unleashed with the introduction of the effects into the guitar signal path. The effects processor transformed the timbre of the electric guitar, and created a whole new domain for musicians to explore their craft. Effects have become so predominant, that many genres are identified solely by the effects used.

Our product, *RockIt*, will rely on motion and touch-sensors to control various guitar sound-effects. Previously when performing, one needed to remain near foot pedals and effects boards to change distortions. By transplanting the same functions to a guitar, an artist increases freedom during performances. With motion-controlled effects, the guitarist's passion during a song can better be conveyed with sound effects that are responsive to leaning, jumping, and shaking.

The first stage of our product, completed by April 15, 2008 will have the following features:

> *Fuzzy guitar effects modulated by motion sensors*
> *Touch Sensors which toggle distortions*

We outline a secondary development phase which will build on the progress of our initial proof-of-concept. This secondary phase will incorporate the following features:

> *User-defined memory to store sensor settings*
> *Display to indicate the current sound mode the guitarist is using*
> *Wireless RF transmission of control signals*

The following pages will act as a roadmap for the design and testing of the *RockIt* system. Each decision will be evaluated based on its applicability to our specifications. These specifications represent our goal to develop a system which allows musicians to create music that would otherwise be impossible.

Image used: (Brain, 2008)

Table of Contents

List of Figures

1 Introduction

Perceptum Technologies is designing a novel method to control guitar distortions. Leveraging the advances in touch sensors and motion sensors, we are creating a product called *RockIt* which gives musicians an entirely new means of triggering their effects. Using *RockIt*, musicians activate their effects anywhere on stage while modulating distortions through intuitive guitar movements. This is a significant departure from the current stomp-boxes, which require the musician to be stationary and trigger effects using their foot.

The first phase of our project is the development of a prototype device. Our aim is to demonstrate the capabilities of *RockIt*, and how it can be incorporated into a musician's repertoire. This prototype will:

1. Monitor the sensor system, which includes touch and motion sensors
2. Appropriately process the sensor output
3. Trigger or modulate the appropriate effects using a commercially available effects system

The purpose of our project is to develop the effects control system and not the effects themselves. This has motivated our choice to use a commercial effects processing system for our demonstration. For clarity, a *RockIt* flow diagram has been included below:
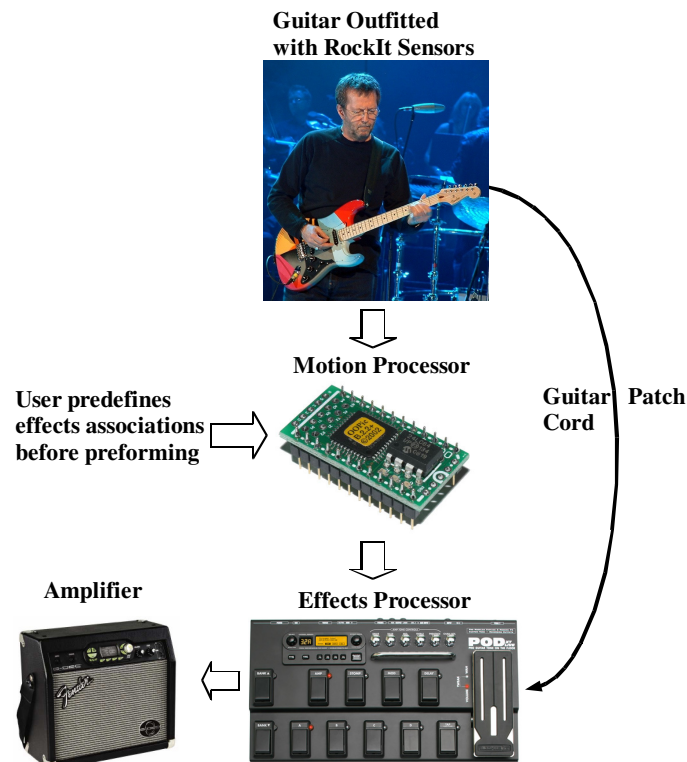

Figure 1 High level diagram of *RockIt*

Images used from: (Active Robots, 2006) (Line6 Inc., 2008) (Sonicftp, 2005) (Dudes 411, 2004)

After the completion of the prototype, we plan to conduct rigorous usability and optimization research. The second phase of the project will include a refinement of the motion sensing algorithms using a musician sample group, improved user interface and a more robust physical package. The final product will intuitively control the effects, while remaining unobtrusive to the user. Our goal is to create a device that gives musicians new avenues to explore their artistry.

1.1 Scope

This document outlines the areas of research and the required specifications of the *RockIt*. We will focus primarily on the proof-of-concept features during the first phase of development. To provide the reader with a vision of our proposed unit, advanced features implemented in later development stages are mentioned. The document will discuss possible modifications, updates and additions to future versions of the design. These modifications are meant to meet the specific needs of our target markets.

1.2 Intended Audience

This document is intended for the design team responsible for creating the *RockIt* prototype. It will serve as a high level reference for design decisions and testing procedures. Engineers will use this document during the prototype, optimization and final design phase, ensuring that the specifications are met.

Supervisors and project managers will use this document as a reference in determining future milestones and development goals. Lastly, this document will help marketers understand our product, such that they can tailor Perceptum's marketing strategy.

1.3 Classification

The following convention shall be used throughout this document to denote the functional requirements.:

> [XXn-k] : A functional requirement

Where **XX** is an acronym for the specification group, **n** is the requirement number and **k** is the applicable development cycle. The convention index (**XX**) for the specification groups is presented below:

DR: Design Requirement	**TP**: Test Plan
UI: User Interface	**PP:** Physical Package
D: Documentation	

The development cycle index is as follows:

  I: Denotes requirement for proof of concept
  II: Denotes requirement for production model
  III: Denotes requirements for proof of concept and production model

2 System Overview

Throughout this document, various elements of our project are referenced and discussed. For clarity, a high level diagram of the system architecture is presented in figure 2. This figure demonstrates the core elements of our design, and their respective interconnections.
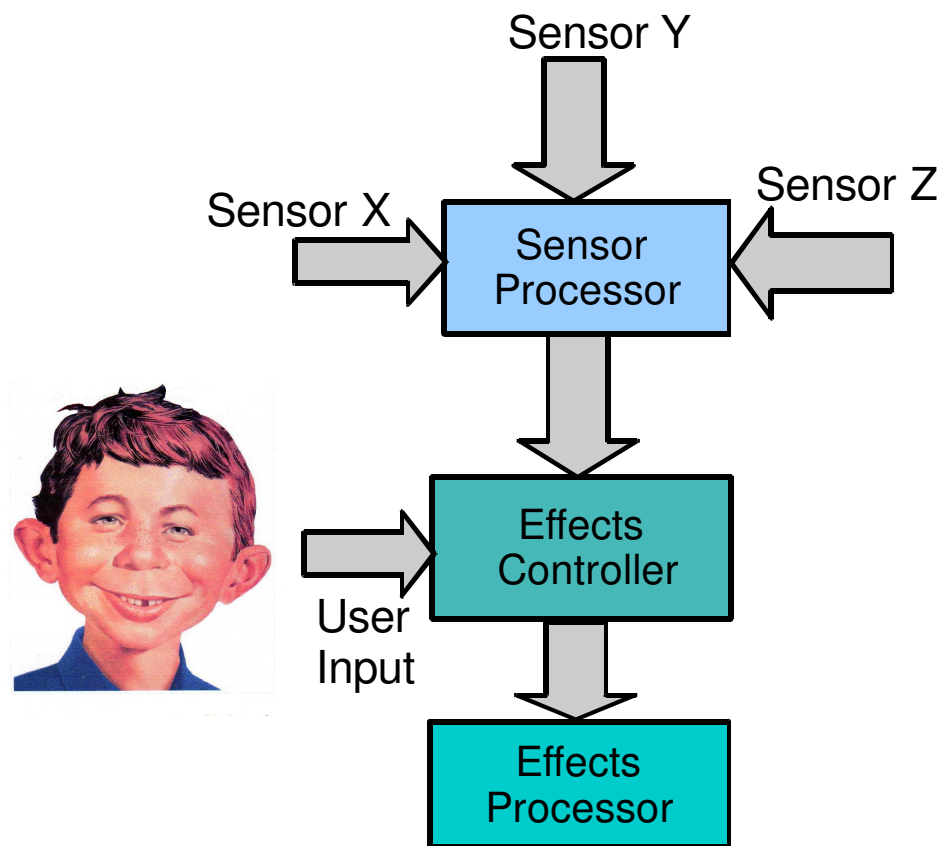

Figure 2 System diagram of *RockIt*

Images used from: (223Nation, 2008)

The following sections outline the design, physical, user, and testing requirements of each subsection.

3   Usage

3.1   User Interface

The *RockIt* user interface is quite simple. There will be touch sensitive sensors located on the body of the guitar for the musician to toggle distortion effects. The guitar will also be fitted with motion sensors to measure the motion of the guitarist. These motions will control certain fuzzy effects such as wah-wah, volume and delay. For clarity, the sensor placement in shown in the below figure:
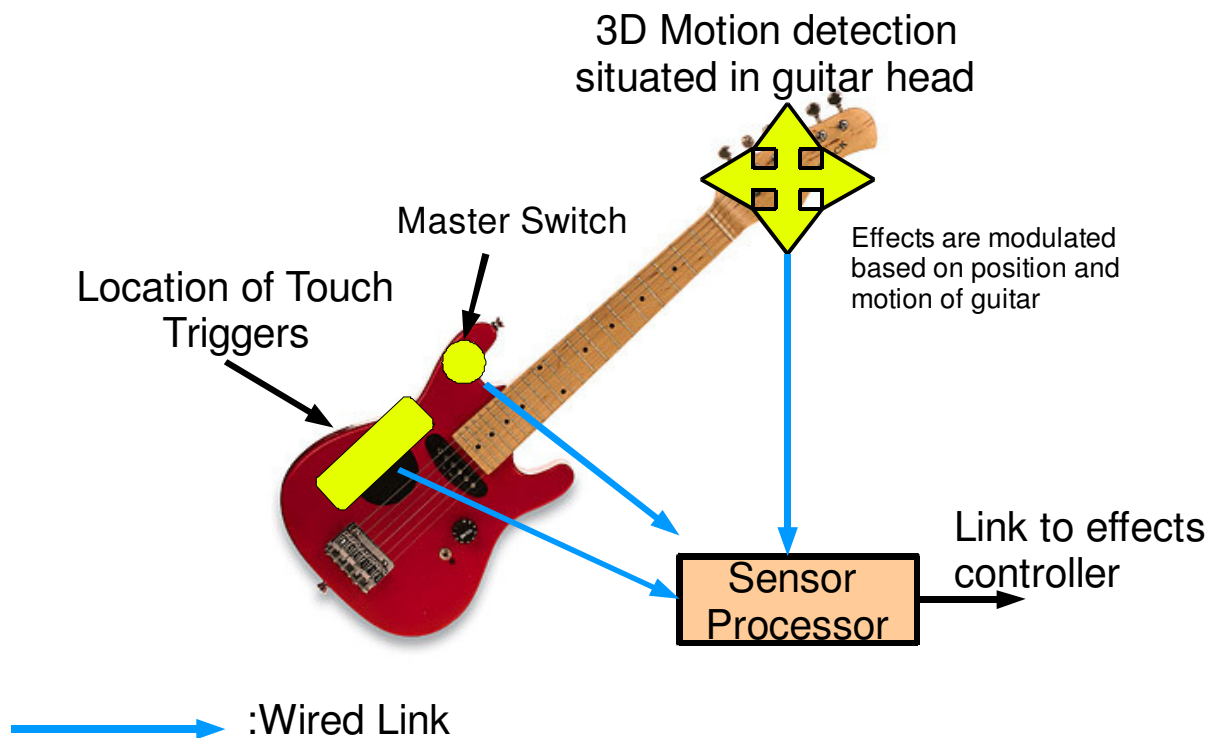

3D Motion detection situated in guitar head

Master Switch

Location of Touch Triggers

Effects are modulated based on position and motion of guitar

Link to effects controller

Sensor Processor

:Wired Link

Figure 3 Sensor placement of *RockIt*

Images used from: (Time, 2006)

3.2   Sensor Subsystem

[UI-1-III] User will trigger system using motions resembling those used during normal guitar usage.

[UI-2-III] When activated, system will modulate effects through natural motions.

[UI-3-III] User will be visually notified when trigger is activated and when system is active.

[UI-4-III] System will have an on-board master on/off button.

[UI-5-II] User will be able to tune sensor sensitivity in-situ.

[UI-5-III] System will not infer with normal electric guitar usage, or respond to guitar interference.

[UI-6-II] Number of sensors may be varied in order to accommodate user needs.

3.3   Effects Controller Subsystem

[UI-7-II] User will be able to interact efficiently with the unit, implying that special knowledge or research is not required for operation.

[UI-8-II] System will recognize connected devices, and display the appropriate user-selectable effects.

3.4   Reliability & Safety

[UI-9-III] The packaging of all system components will protect the user from electrical shock and physical injury.

[UI-10-III] The casing encompassing the sensor and sensor module will be rigid and be able to withstand compression stress.

[UI-11-III] User will be notified when portable sensor unit batteries are low.

[UI-12-III] Each sensor will independently communicate with the sensor processor to ensure reliability.

[UI-13-II] Effects controller will soft-shutdown if it does not receive data from the sensor processor for longer than 15 seconds.

[UI-14-II] Master On/Off shall supersede sensor processor in priority. For instance, system shutdown can occur regardless of state of sensor sub-system.

[UI-15-II] After 30 minutes of inactivity, the system will auto-shutdown.

4   Design Requirements

4.1   Interference

[DR-1-III] System will meet EMC requirements for a stage performance environment.

[DR-2-II] Two nearby *RockIt* system will not interfere with each other.

[DR-3-III] System will not interfere with other audio equipment or internal componentry.

[DR-4-III] System will not be susceptible to external noise; such as electromagnetic, thermal or acoustic.

4.2   Standards

[DR-5-II] The product will be certified by CSA and/or ETL

[DR-6-II] System will comply with the code of Federal Regulations regarding Radio Frequency Devices. In particular, FCC Title 47, chapter 1, section 15

[DR-7-II] System will comply with Industry Canada standards for both *Unintentional & Intentional Radiators* (Gubisch)

4.3   Performance

[DR-8-II] System will incorporate robust transmission algorithms.

[DR-9-II] The product shall have an operational temperature range of 0°C - >40°C and a storage temperature range of -40°C -> 90°C.

[DR-10-II] System will have operational range of 100 meters.

[DR-11-II] The battery will power the system in active mode for no less than 12 hours on a single charge. While in standby, battery will maintain charge for no less than 2 weeks.

[DR-12-II] Visible elements of *RockIt* will be physically appealing.

[DR-13-III] The product shall have an operational humidity range of 5% - 95%.

[DR-14-III] Latency between triggering and corresponding audio output will not be perceivable by the user

4.4   Environmental

 [DR-15-III] External power supplies shall conform to Energy Star specifications.

[DR-16-II] All components will be RoHS compliant.

[DR-17-II] The sensor unit will operate on a rechargeable power source.

5   Documentation

The hardware is intended for use by musicians of all skill levels and technical expertise. The associated documentation must reflect this broad group and remain accessible to all intended users.

5.1   General

[D-1-III] A user manual will be provided with the system. The manual will outline the functionality, maintenance, along with other user considerations.

[D-2–III] The manual will outline the integration of *RockIt* system onto an electric guitar. The correct positioning of sensors and communication lines will be specified.

[D-3-II] Users of the proof of concept device will be instructed in the use of the device by Perceptum engineers. The use of the proof of concept device must also be supervised by Perceptum engineers.

[D-4- III] All documentation will initially be written in English. As the product matures, manuals will also be provided in French and Spanish.

5.2   Customer

[D-5-III] The user manual shall be written for an audience with minimal technical ability or experience.

[D-6-III] Details outlining compatibility with commercially available DSP and effects units will be made explicit.

5.3   Patenting

[D-7-II]Patent will be filed with American and Canadian Patent Office for unique design of a guitar control system.

[D-8-II] Applications will be filed as a family of related patents with specific details for more increased intellectual property protection.

[D-9-II] Existing patents will not match our level of detail.

6   Physical Package

The physical specification of the *RockIt* system can be broken into three separate sub-sections. The motion sensors as well as any part of the system attached to the guitar itself will constitute the first section. A robust design and an unobtrusive nature are the primary physical requirements of this system. The second and third sections will be the sensor processor and the effects controller units, respectively. The sensor processor unit will be affixed to the body of the user and will also require a small form-factor and durable design. The effects controller will be not be subject to the small size requirements that dictate the physical packages of the sensor processor and sensors. Figure 4 shows the proposed physical packaging for *RockIt.*
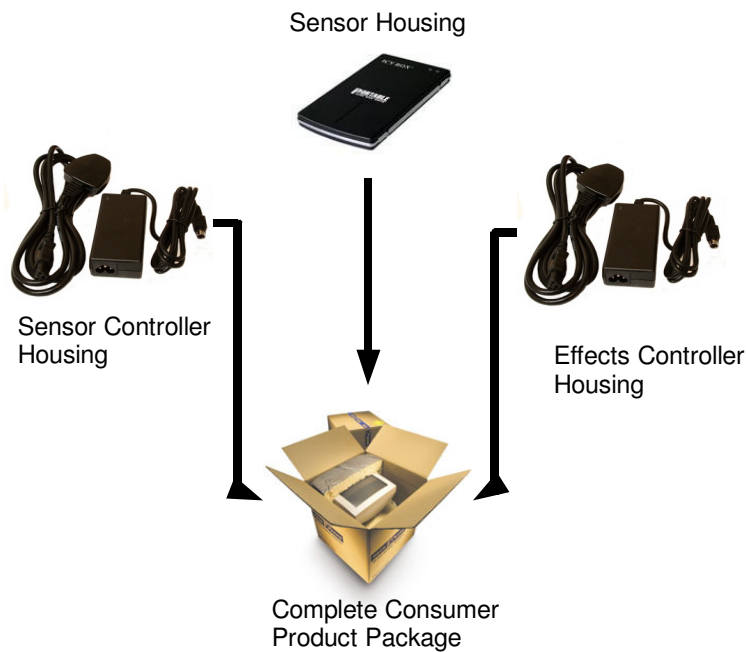
Sensor Housing

Sensor Controller
Housing

Effects Controller
Housing

Complete Consumer
Product Package

Figure 4 Complete Physical Package for *RockIt*

Images used from: (Analogic, 2008), (Cable-Trader, 2008), (PackSend, 2008)

6.1   Sensor Subsystem

[PP-1-III] The sensors and wiring shall be unobtrusive and easily affixed to the guitar body.

[PP-2- II] The weight of the sub-system shall be no more than 150 grams.

[PP-3- III] Sensor output shall be connected to the pre-processor via a wired connection.

[PP-4- III] The sensors and related hardware must be durable and able to withstand sustained periods of repeated mechanical shock without failure.

6.2   Sensor Processor

[PP-5- III] The sensor processor unit shall be unobtrusive and easily kept on the users person.

[PP-6- III] The weight of the sensor processor shall be no more than 500 grams.

[PP-7- III] The sensor processor shall output communication signals to the effects controller.

[PP-8- III] The hardware must be durable and able to withstand sustained periods of repeated mechanical shock without failure.

[PP-9- III] The enclosure shall not have any sharp edges or corners that may potentially cause harm to the user.

6.3 Effects Controller

[PP-11- III] The effects controller shall be aesthetically pleasing.

[PP-12-III] The weight of the effects controller shall be no more than one kilogram.

[PP-13- II] The effects controller shall accept input signals from the sensor processor.

[PP-14- II] The hardware and enclosure must be durable and crush resistant.

[PP-15- II] The enclosure shall not have any sharp edges or corners that may potentially cause harm to the user.

[PP-16- III] The effects controller shall not have exposed wiring.

[PP-17-III] The effects controller shall be powered by 120V AC power supply and will require a power cord.

7 Test Plan

This section outlines the tests that will ensure the prototype and the production models meet the functional requirements. Figure 4 presents the overlap between structural and functional tests during the design of the proof-of-concept. Regression tests are performed every time individual or integrated modules are intentionally altered, in order to monitor the basic functionalities of the system. The functional tests in this section are considered part of the regression tests.
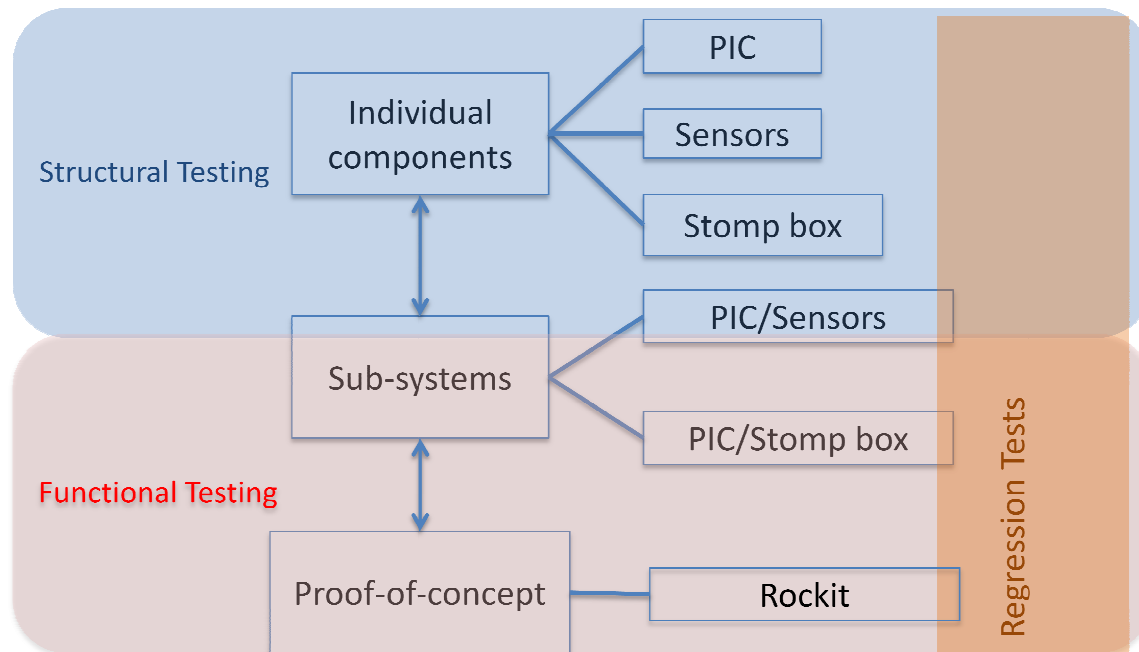
Figure 5 Test plan for proof-of-concept

[TP-1-I] Ensure that controller and sensors characteristics meet minimum requirements for the system.

[TP-2- I] Test the touch and motion sensors to confirm sensitivity and overall performance.

[TP-3-I] Reproduce basic audio effects functionality using *RockIt.*

[TP-4-I] Validate remaining electronic components to ensure expected performance.

[TP-5-I] Ensure proper communication between controller and sensors, and between effects controller and effects processor.

[TP- 6-I] Test touch sensor at a system level by performing triggering of sound effects.

[TP-7- III] Verify the minimum wireless range between the guitar and the stomp box.

[TP-8-II] Ensure that safety standards are met to avoid shock and fire hazards of electrical products.

[TP- 9-II] Verify battery life and overall power consumption of the system.

[TP-10-II] Test motion sensitivity of *RockIt*.

[TP-11-II] Reproduce and validate the integrity of the sound effects supported in the system, and the playing modes offered by *RockIt*.

[TP-12-III] Verify that user manuals and setup procedures of *RockIt* are clear and intuitive for targeted audience.

[TP-13-III] Ensure compatibility of *RockIt* with commercially available effects processors.

[TP-14-III] Test trigger latency and optimize the signal processing algorithms accordingly.

[TP-15-II] Perform numerical analysis on the motion sensor signals in order to better isolate unwanted triggering.

[TP-16-III] Recreate test scenarios to verify robustness of the system. These scenarios include:

> i- Have experienced and novice guitar players use *RockIt*. This test will compare the learning curves between skilled and unskilled guitarists.

> ii- Test *RockIt* with different styles of music.

> iii- Monitor the overall performance of *RockIt* under excessive usage conditions, which can be defined as >12 hrs of constant use.

[TP-17-III]Ensure *RockIt* can be configured to control other devices such lighting or pyrotechnics.

8   Conclusion

Due to the experimental nature of our project, we expect a high probability of obstacles to overcome during our construction of the first prototype. With this in mind, requirements and goals for the first and second prototype may be slightly different from each other. We are strongly committed, however, to producing a final product that fulfills the functionality requirements of this document, and we are very confident that our proof of concept will be a success.

9 Appendix

9.1 Glossary

CSA   Canadian Standards Association
ETL   Electrical Testing Laboratories
FCC   Federal Communications Commission
RoHS Restriction of Hazardous Substances

9.2 References

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