February 16, 2009

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

Re: ENSC 440/305 Functional Specification for Electric Guitar Multi-FX Device

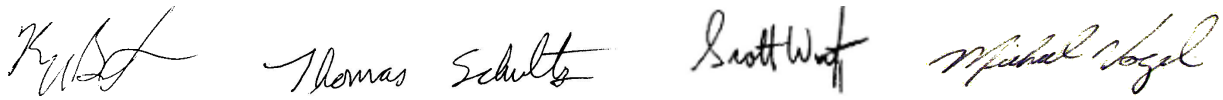
Dear Professor Leung,

The attached document, *Function Specification for Electric Guitar Multi-FX Device*, provides a high level functional description of In Tune's ENSC 440/305 project. The product is a standalone unit which creates live audio effects based on an electric guitar input. Users will have the ability to adjust and save the sound of each effect as well as change the order in which the effects are processed, all in real time.

This document presents all project requirements. We will refer to this document frequently during the semester to ensure that all requirements are being met.

In Tune Innovations consists of four engineers, each in fourth-year: Kyle Balston, Tom Schultz, Scott Witzel and Michael Vogel. If there are any questions, feel free to contact us at **ensc440-intune@sfu.ca**.

Sincerely,



In Tune Innovations: Kyle Balston, Tom Schultz, Scott Witzel, Michael Vogel

In Tune Innovations

Functional Specification

Electric Guitar Multi-FX Device

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Submitted to: Patrick Leung: ENSC 440
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Executive Summary

Electric guitars are among the most versatile musical instruments in existence. Interestingly, this versatility comes as a result of the "electric" nature of the electric guitar. Manipulation of an electric guitar's signal creates new sounds, ultimately shaping the genre of music being played.

In Tune is developing an electric guitar Multi-FX system designed to give musicians full control over both the FX sound and processing order of three built-in effects. This emulates the daisy-chain approach used by musicians when using multiple guitar effects, and allows users to change the sequence on the fly without the hassle of re-routing patch cables. Quick electronic control over the internal daisy chain means that musicians will now be able to easily experiment creatively with the effects sequence in order to create more specialized sounds. The net result is that many different sounding effects are possible. Users will also be able to save presets, which will be easily selected during performances.

Software and hardware components are being concurrently developed, and proof-of-concept project completion is on track for April 1st 2009. Upon completion of the effect circuitry, the user interface and usability features can begin to be properly tested.

In Tune Innovations is dedicated to producing performance-quality musical electronics. In Tune's Multi-FX system enhances the inherent versatility of the electric guitar, while greatly simplifying the task of preparing effect sequences for musical performance. For the up and coming musician, professional sounding effects and effect sequences are now more achievable (and more portable) than ever with In Tune Innovations Multi-FX system.

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Glossary

Boost	To amplify or make louder. With respect to “treble boosting,” high frequency signals are singled out and amplified.
Distortion	Effect which seeks to introduce inharmonics into guitar signal by reducing signal peaks. Also known as overdrive.
Effect Pedal	Footswitch-activated guitar effect, usually packaged to produce a single effect. Also known as a stompbox.
Effect Sequence/ Daisy Chain	The order in which guitar FX are internally “chained.” The order/sequence of this chain affects the resultant sound.
FX	Short for “effects”.
Multi-FX	Multiple guitar effects integrated into a single standalone unit. In this document, refers to In Tune’s Multi-FX device.
Overdrive	See “Distortion”.
RoHS	*Restriction of Hazardous Substances Directive*. Electronic components meeting RoHS compliancy are more recyclable, and contain less environmentally unfriendly materials.
Stompbox	See “Effect Pedal”.
Tone	Refers to audible frequency spectrum. Musicians adjust tone to control volume of different frequency ranges (bass, treble).
Tremolo	Time based effect which changes signal volume over time, and at different frequencies.
User	In this document, the “user” is defined as an electric guitar musician (anywhere from beginner to professional), with basic understanding of the instrument.
Wah (or Auto-Wah)	Frequency based effect which envelope filters a moving frequency range. Associated with the funk music genre.

1 Introduction

In Tune Innovation's Multi-FX device is a standalone hardware unit designed to create a variety of user programmable electric guitar effects. The user has exclusive control over the sound characteristics of each effect, and also has the ability to select the order in which the effects are processed. The programmable aspect of the device allows the user to cycle through different combinations of effects without having to change a single cable. This means that users can preset and store multiple versions of the effect at different settings, as well as store preset effect sequences. This allows for much more user-friendly musical experimentation than exists with products currently on the market.

1.1 Scope

This document provides all functional specifications for the completed prototype product, set to be completed in April 2009. It serves as the basis of which to refer when creating the design specification.

1.2 Intended Audience

Designed mainly for In Tune's own engineers as a record of production criteria, this document also serves as a high level specification for those interested in the complete functionality of In Tune's Multi-FX device. The team will also refer to this document during the prototype testing phase of the project, in order to ensure that the product is 100% functional according to specification.

1.3 Classification

Functional requirements are denoted using a [number-priority] scheme. For instance,

[R5-II] "Details of functional requirement"

5 is the requirement number, and *II* is the priority. Priorities may have a rank of *I*, *II*, *or III*.

I - Highest priority. Must be implemented in first prototype.

II - Lower priority. Will be included in all models, but not crucial to product functionality.

III - Future priority. Intended for production models only.

2 System Overview

In Tune Innovations' Electric Guitar Multi-FX is a device consisting of built in electric guitar effects and an embedded sequencing system. The user has electronic control over both the sound of each individual effect, as well as control over the sequence in which they are processed. The sequence can significantly change the resultant sound produced.

In Tune's Multi-FX device is connected in between the electric guitar and amplifier/speaker, as shown in Figure 1.

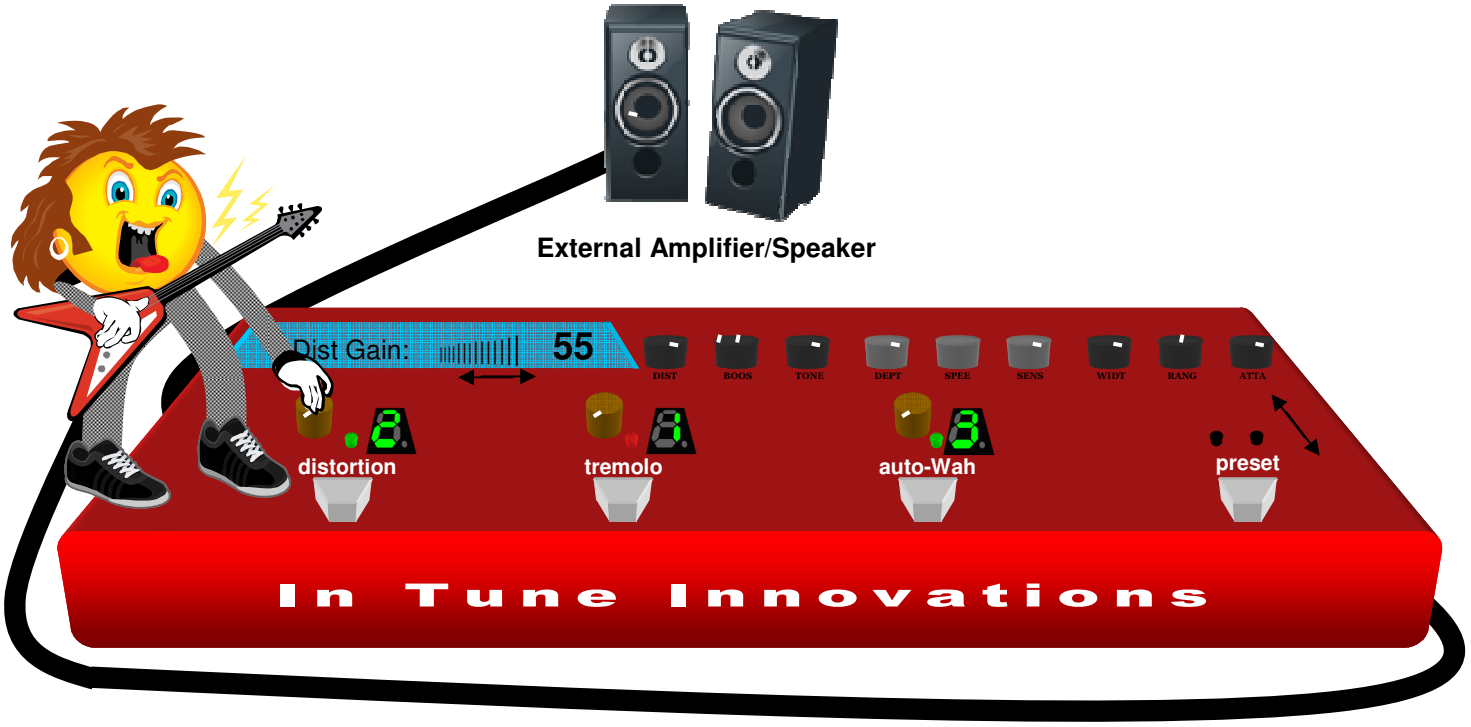

Figure 1: Electric Guitar Multi-FX

All features of the device are user-programmable. The user can store predefined effect sequences, and then retrieve any saved preset while still playing. Each of the three built-in effects (distortion, tremolo and Auto-Wah) can be fine tuned by the user, meaning a wide range of different sounds is possible within each effect type. The individual settings can be saved as presets and can be retrieved in a live setting.

Any effect combination is possible, and not all effects need to be turned on at the same time. Users can simply use a single effect, or two, if desired. Footswitches activate the effects and presets, and intuitive buttons control the parameters of each effect and also control the user interface. The user does not need to rely on presets, however. The system functions in real time and the user can change the system settings at any time.

The present effect sequence and current status of each effect (e.g. on/off) is visible above each effect footswitch, allowing for clear identification of the current settings. A central screen displays settings and presets.

3 System Requirements

I - Highest priority. Must be implemented in first prototype.

II - Lower priority. Will be included in all models, but not crucial to product functionality.

III - Future priority. Intended for production models only.

3.1 General Requirements

[R1-I] The device shall accept input from the user.

[R2-III] The internal construction of the device shall be modular, allowing for substitution/addition of effects in future models.

3.2 Physical Requirements

[R3-I] The device casing shall be durable and able to withstand repetitive pressure due to footswitches.

[R4-I] Unit dimensions shall not exceed 60 cm long, 25 cm wide and 15 cm high.

[R5-I] The footswitches shall be spaced such that their use does not obstruct with use of the control knobs.

[R6-II] The user must have clear access to control knobs.

[R7-I] Input and output jacks shall be on the right and left side of the device, respectively, as per unofficial convention of most professional musical audio equipment.

[R8-III] Weight of device (excluding external power supply) shall not exceed 4.5 kg.

[R9-I] The device will not have any sharp edges in order to protect the user.

[R10-I] Unit accepts any 1/4" audio jack.

3.3 Electrical Requirements

[R11-I] Device shall accept electric guitar AC input 0-1V RMS.

[R12-I] Device can be used in conjunction with other professional audio equipment without interference.

[R13-I] Device will be powered via any North American household outlet (120 VAC 60 Hz).

[R14-I] Device will be powered from a wall socket via DC adapter.

[R15-III] The power cord will be long enough as to not hinder the set up of the equipment on stage or get in the way of the performer.

[R16-III] Device will turn off effects when not in use, in order to increase energy efficiency.

[R17-I] Device will be enclosed in RF shielding to prevent unwanted signals from interfering with the function of electrical components

[R18-I] Output signal will not damage external amplification devices (e.g. will contain no DC offset).

[R19-I] The device will have no exposed wiring.

3.4 Mechanical Requirements

[R20-I] Footswitches shall be durable enough to handle repeated use.

[R21-I] Each effect shall have a corresponding footswitch.

[R22-I] User interface shall include clearly marked pushbuttons.

3.5 Effect Requirements

[R23-I] All effects shall be functional within the 50-2000 Hz input frequency range (encompasses electric guitar frequency range).

[R24-III] All effects shall contain output volume and/or tone control.

[R25-I] User shall have ability to bypass any effect and have signal pass through unprocessed.

[R26-I] Output level control excluded, setting controls to zero should not result in silent output volume.

3.5.1 Distortion/Boost

[R27-I] Distortion effect shall have 5 functions: Overdrive / distortion, treble boosting, clean signal mixing, tone control, and output level control.

[R28-I] Distortion shall include no more than four user-control knobs.

[R29-I] At minimum, user shall have control over distortion gain, amount of treble boost and tone.

[R30-I] Adjusting distortion gain to zero shall not result in silent output volume (for audible input).

3.5.2 Tremolo

[R31-I] User shall have the ability to adjust tremolo oscillation frequency.

[R32-I] User shall have the ability to adjust the depth (amount) of tremolo oscillation.

[R33-I] Tremolo oscillation frequency shall remain aurally recognizable.

3.5.3 Auto-Wah

[R34-I] User shall have the ability to adjust sensitivity (trigger) of Auto-Wah filter.

[R35-I] User shall have control over the range of Auto-Wah filter envelope.

3.6 Audio Requirements

[R36-I] Output audio shall be monophonic.

[R37-I] Device shall not introduce any audio hum.

[R38-I] Device will not negatively affect the quality of the output audio.

3.7 User Interface Requirements

[R39-I] The user will program effects through a menu.

[R40-I] Current effect sequence shall be clearly visible to the user.

[R41-I] Using an individual effect's footswitch shall deactivate the effect, the next stomp will reactivate.

[R42-I] Preset switch shall cycle through all programmed presets.

[R43-I] Deactivating an effect (via footswitch) shall not remove the effect from the current sequence, but rather only turn off the effect processing.

[R44-I] User shall be able to see, or have simple access to, all current device settings.

[R45-I] Effect settings can be saved into presets (e.g. preset1: distortion gain = 50; preset2: tremolo width =25, distortion gain = 90).

[R46-I] Effect sequences can be saved into presets.

[R47-I] Effects currently being configured will automatically be saved to a preset (e.g. Preset 0).

[R48-I] Upon system power-up the last used preset will be loaded, including Preset 0.

3.8 Performance Requirements

[R49-II] There shall be no net volume attenuation with volume settings at maximum.

[R50-I] The device will respond to any user command within 500ms.

[R51-II] Any displays shall remain visible under bright stage lighting.

3.9 Bonus Feature Requirements

[R52-III] Device shall contain at least 5 built in presets which cannot be changed by the user.

[R53-III] Built in presets shall be given descriptive titles (e.g. funk, psychedelic, grunge, etc.).

3.10 Environmental Requirements

[R54-III] The device shall be able to operate in the -20 to 50 degree Celsius range.

[R55-II] Vibration will not adversely effect the operation of the device.

3.11 Standards Requirements

[R56-III] All electronic components shall be RoHS compliant.

[R57-III] Entire device shall be constructed of RoHS compliant materials, including solder.

4 Test Plan

4.1 Effects and Switching

The general test plan is to test each module as it is built, and to re-test the modules upon integration into the complete unit. The proof of concept unit will undergo a more rigorous testing regime than successive production units because the effects are intended to be of performance quality. When building production quality units, we can safely assume that the effects are still functional as intended, and testing will be reserved to completed units, and not on individual modules.

The key functionality of the Multi-FX unit is to alter sound from the guitar in a pre-defined and user configurable fashion. Given that the range of human hearing is 20Hz-20 kHz, testing of the effects will be made using a function generator sine wave input at 100, 1k and 10k Hz frequencies. Although the highest fundamental frequency an electric guitar can produce is slightly over 1200 Hz, the 10 kHz testing encompasses the guitar's upper harmonic range.

All circuitry will be first prototyped on a breadboard, and the above mentioned test signal will be applied to the "guitar" input. Both the input and output waves will be monitored by oscilloscope to verify that the module satisfies all its pre-defined requirements. Upon successful testing of the three test waveforms, the unit will be hooked up to an electric guitar as an empirical test for satisfactory sound performance. The user adjustable features will be tested by sweeping over the allowable range of max and min control values while simultaneously passing the test waves. The requirements are expected to be satisfied at both extremes.

When all the tests are satisfactorily completed on the breadboarded circuit, the circuit will be constructed on a perforated prototyping board for integration into the proof of concept model. The testing will then be repeated to ensure proper wiring and solder work. After each module has been added to the proof of concept unit, the full testing regime will again be repeated to ensure that performance remains unchanged as a result of adding the new model.

Upon full integration and construction, the unit will undergo full testing of all features and functionalities. The test waveforms will be applied once again, the output monitored by oscilloscope, and all possible combinations of effects will be tested for requirement compliance. The manual effect override will be tested at least twice during that period by overriding the active effects and verifying the effect has been bypassed without signal degradation. Throughout the entire design and manufacturing process, the unit

will be presented in various stages to a guitar professional who will give a qualitative assessment of the effects and the usability. Any major criticisms will be rectified.

4.2 PIC/User Interface

Software development is following agile programming practices, including pair programming (when possible) and a central focus on test cases. Each major software feature will be fully tested to assess desired functionality. Upon final completion, the unit must satisfy all requirements in terms of saved preset sequences, the ability to rotate through a series of effects, and the ability to save a unique effect setting. Final testing will begin with the device turned off, and then proceed to assess all functional aspects of the product, including conformation of the proper power up sequence, a complete test of all user scenarios, and confirmation of proper power down / system restart.

5 Conclusion

This functional specification clearly defines the capabilities and functionality of In Tune's Multi-FX unit. Development of the proof of concept model, which includes all functional requirements marked with "I" or "II", is well underway and will be completed by the target date of April 1 2009. The functional specifications shall be referred to during this development stage as a final checklist for the development team prior to integrating any new component or module. It shall also be used to resolve any disagreements regarding scope of project as well as differences in project vision.

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