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The attached document describes the functional specification for *DreamBox* Musical Entertainment System of Mutrix Technology. We aim to design and implement an innovative musical ornament with potentials to be widely applied in various situations.

The functional specification provides a set of functional requirements of the system at its various stages of development. This document shall be used as the guideline and measurement of the project progress to all members in Mutrix Technology.

Mutrix Technology consists of five motivated, hard working, and talented fifth-year engineering students: Benson Lam, Gary Heng, Winfield Zhao, Shuozhi Yang and Weiguang Mou. If you have any questions or concerns about our proposal, please feel free to contact me by phone at (604)537-9289 or by e-mail at btl2@sfu.ca, or to contact the company by email at mutrixtechnology@gmail.com.

Sincerely yours,

Benson Lam

President and CEO

Mutrix Technology

Enclosure: ***Function Specification for Dreambox***

Functional Specification

for

DreamBox Musical Entertainment System

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EXECUTIVE SUMMARY

As digital entertainment system market grows, innovative digital home ornaments have become more and more popular among modern people's home decoration choices. Creative digital entertainment systems bring people enjoyable and artistic lifestyle while introducing brand-new concepts of home entertainment. Customizability also becomes one of the key features that appeal to the users full of creativity.

DreamBox musical entertainment system, or *DreamBox* for short, from Mutrix Technology is an innovative digital musical ornament that can fulfill the modern people's requirement of fashionable, creative and entertaining lifestyle. Music flows are easily visualized into three-dimensional form as *DreamBox* displays full range of different crystal bar and colorful LED patterns with presentation of strong rhythmic sense. Moreover, *DreamBox* introduces great customizability to fulfill the users' pursuit of unique personal artistic design in their homes.

The architecture of *DreamBox* can be divided into three parts: central control unit (CCU), motor mechanics system (MMS) and software graphic user interface (GUI). Central control unit determines the proper crystal bar patterns to represent the music fed from any audio devices in real-time and sends the control command for each motor to motor controller, as well as providing a communication interface to PC. The software user interface offers the users the ability to real-timely create their own *DreamBox* patterns for static decoration. The sophisticated mechanical structure of motor mechanics system guarantees the precise movement of crystal bars.

Two functional modes are supported by *DreamBox*, dynamic (music) mode and static mode, and users are able to switch *DreamBox* between these two modes by simply pressing the push button on the central control unit board:

- Dynamic Mode: *DreamBox* receives audio signal from audio devices and presents rhythmic patterns along with the music flow
- Static Mode: *DreamBox* is fully controlled by software user interface through USB connection to PC and real-timely presents the design of users

In future development, besides improving and calibrating the precision of crystal bar positioning, we will employ more pre-designed crystal bar patterns to entertain and inspire the users. Furthermore, when *DreamBox* is commercialized we plan to improve the smoothness of display and enrich the crystal bar patterns by increasing the resolution of the crystal bar matrix.

TABLE OF CONTENTS

LIST OF FIGURES

GLOSSARY

PCB	Print Circuit Board
LED	Light Emission Diode
DSP	Digital Signal Processing
ADC	Analog-to-Digital Converter
DAC	Digital-to-Analog Converter
CCU	Central Control Unit
MMS	Motor Mechanical System
GUI	Graphic User Interface

1. INTRODUCTION

DreamBox is a digital musical entertainment system that provides innovative visual music experience and creative customization ability for users who are pursuing special and artistic modern lifestyle. With the support of *DreamBox*, users can enjoy the presentation of various pre-designed crystal bar and LED patterns along with the rhythmic music play, as well as the full customizability to design their own home ornament. The requirement of *DreamBox*, as proposed by Mutrix Technology, is described in this functional specification.

1.1. SCOPE

This document describes the design requirements for *DreamBox* musical entertainment system, including the full description of the proof-of-concept prototype and partial description of the production model. The requirements described in this document will drive the design of *DreamBox* in the future and will be traceable in future design documents.

1.2. INTENDED AUDIENCE

The functional specification is intended to be referenced by all members of Mutrix Technology. The project group leader should refer to the functional specification as a design standard to examine the project progress throughout the development phase. Hardware and software design engineers should refer to the specification listed in this document as the design goal in their development. Test engineers should use this document to design and implement the testing procedures to verify the performance of the system.

1.3. CLASSIFICATION

The following convention will be used to denote the functional requirement:

[R**n**-**p**] A functional requirement

where **n** is the requirement number, and **p** is the requirement's priority with one the three values:

- **I** This requirement applies to the proof-of-concept prototype only.
- **II** This requirement applies to both the proof-of-concept prototype and the final production model.
- **III** This requirement applies to the final production model only.

2. SYSTEM REQUIREMENTS

The general requirements applicable to *DreamBox* musical entertainment system as a complete system are presented in this section.

2.1. SYSTEM OVERVIEW

DreamBox musical entertainment system can be represented by the system block diagram shown below:

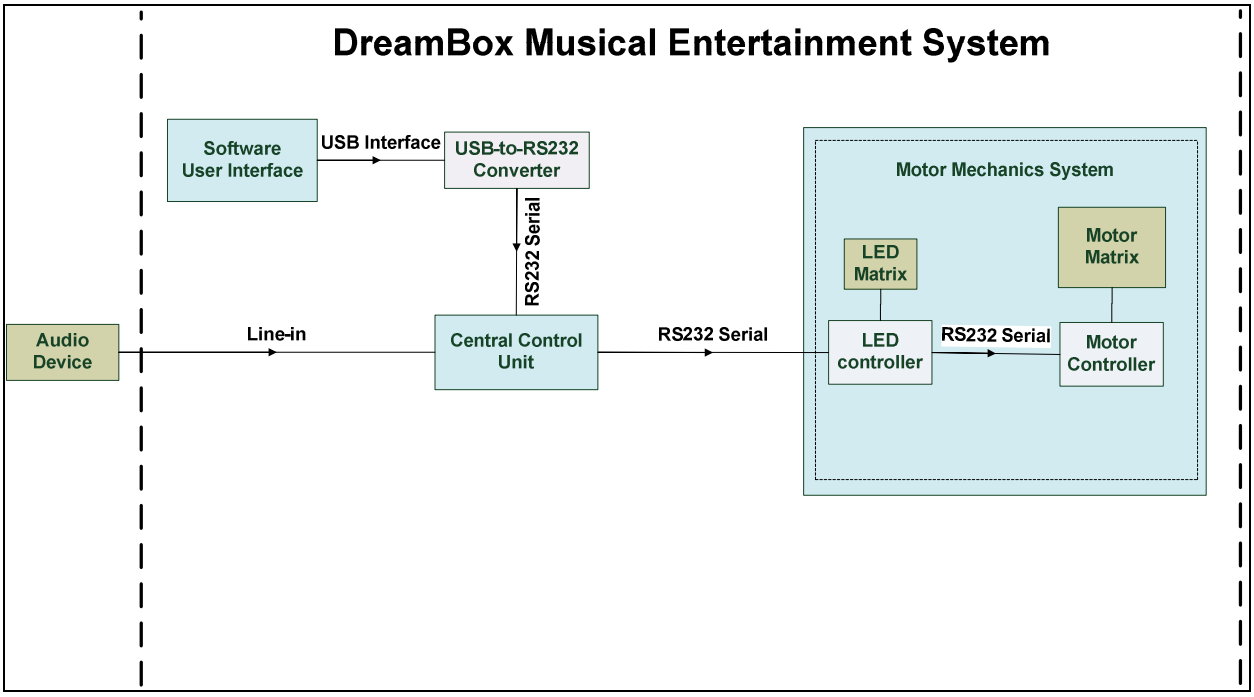

Figure 1: System Block Diagram

The high-level functional block diagram is shown below for both static mode and dynamic mode operations:

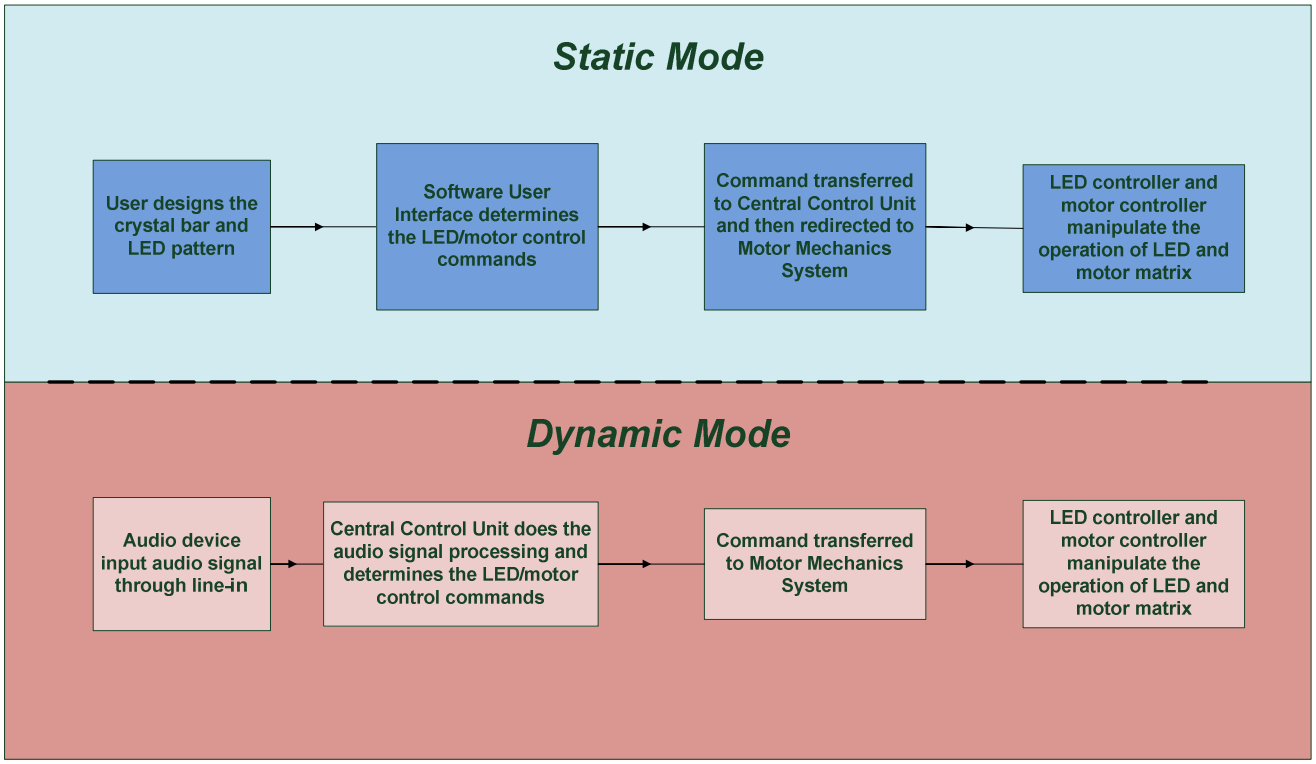

Figure 2: High-Level Functional Block Diagram

Operating in real-time manner is a major feature as well as an important concern of our system design. The audio signal processing capacitor and control command transfer rate must be carefully considered to balance the positioning precision and the delay caused by signal processing and transfer.

The dimension of the proof-of-concept prototype is not necessarily restricted; however, this size of the final production model will be strictly controlled due to the consideration of the acceptable space occupied by conventional home ornaments and the portability of the product. Thus, the size of motors and mechanical components should be put in mind when making the selection.

DreamBox musical entertainment system consists of three major parts: central control unit, motor mechanics system and software user interface. Central control unit is responsible for audio processing, sending commands to motor controller as well as interfacing with PC. Motor mechanics system should guarantee the fast and precise positioning of crystal bars when commands arrive. Software user interface is to inspire creativity of users while providing them full control over all *DreamBox* functionalities.

The operations *DreamBox* must be clearly indicated and as simple as possible for all users to avoid potential confusions. The user is supposed to be able to use *DreamBox* with some simple pushbutton operations.

When *DreamBox* is powered up, the system enters idle state and displays a pre-designed pattern as welcome message. User should switch the system to dynamic mode using pushbuttons or static mode by plug in the USB cable to the PC, while the working modes are indicated by the on-board LED indicators. Depending on the working mode, *DreamBox* receives either the line-in audio signal from audio device or command data from PC software user interface in dynamic mode or static mode, respectively. In dynamic mode the audio signal is real-timely processed and the used to determine the proper crystal bar and LED pattern while the control signals are generated in central control unit; in static mode, the software user interface provides a straight-forward control panel and transfers all user input commands to central control unit through USB interface. Both central control unit signals and user commands are eventually delivered through RS232 serial interface to the motor controller in motor mechanics system, which stays in standby state and ready to respond to the control signals.

2.2. CONSTRAINT

Our device focuses heavily on digital as well as mechanical design. The movement of the servo motor is controlled by specialized microcontroller. The motor controller sends control signal to the servo motors and consequently elevates the crystal bars. The motors are capable of turning 180 degrees. Therefore, adequate gears have to be made in order to maintain a smooth movement for the crystal bar on top. The overall system constrains is listed below:

- AC power is required for CCU at all time
- 6 cell NiMH battery pack is required for motor controller in prototype
- External music player is required for the dynamic mode
- Under static mode, the device and a computer has to connect using USB port
- The size of the product limits the available movement on the crystal bars

2.3. GENERAL REQUIREMENT

[R1-II] The system should support two mode of operation, static and dynamic.

[R2-II] Simple user interface

[R3-II] Plug and play for dynamic mode

[R4-II] Use mouse to design arbitrary shape for static mode

[R5-II] The crystal bar movement should be fast enough to achieve a smooth sequence

[R6-II] System will sleep when it is idle

[R7-II] Crystal bars shall be easily replacable

[R8-III] Retail price under $100

2.4. PHYSICAL REQUIREMENT

[R9-I] The height of the prototype shall not exceed 15 cm

[R10-I] The base dimension of the prototype shall not exceed 20 cm x 20 cm

[R11-II] The product shall look artistic

[R12-II] The noise of the motor shall be acceptable

[R13-III] The crystal bars shall look shiny and clear

[R14-III] The size of final product shall be limited to 15 cm (L) x 15 cm (W) x 15 cm (H)

2.5. MECHANICAL REQUIREMENT

[R15-II] Motor can stop and hold at a specific position

[R16-II] All crystal bars should move with limited friction

[R17-II] All crystal bars should move vertically with error tolerance of 2 mm

2.6. ELECTRICAL REQUIREMENT

[R18-II] Power supply of 110/120 V with 60 Hz

[R19-II] The product shall enter energy saving state after 10 minutes of inactivity

[R20-II] Current in the system shall be limited to a safe level to avoid overheat (125°C) [1]

[R21-III] The power supply shall be sufficient to support both CCU and MMS

[R22-III] Built-in power adaptor shall be used to avoid occupying extra space

[R23-III] Rechargeable battery shall be available to increase the portability

[R24-III] The battery shall be able to last for 5 hours of operation

2.7. PERFORMANCE REQUIREMENT

[R25-II] All motors should be able to move at same time with various speeds and direction

[R26-II] The audio processing shall be fast enough to support real-time operation

[R27-II] Software GUI shall generate and send control command in real-time manner

2.8. ENVIRONMENT REQUIREMENT

[R28-II] The system shall be functional in dry environment

[R29-II] The system shall operate under normal room temperatures (10-28°C) [2]

[R30-II] The system shall operate under normal room humidity (50%) [3]

[R31-II] The system shall be used indoors only

[R32-II] The noise level of the system shall be minimized

2.9. RELIABILITY AND DURABILITY

[R33-II] Electronic components shall act normally under their operating conditions

[R34-II] The unit shall be resistible to electronic and mechanical damage cause by minor spillage of liquids

[R35-III] The surface of the system shall be durable to daily abrasion

[R36-III] The software is upgradeable

[R37-III] The mechanical components shall have system protection mechanism under external force

[R38-III] All crystal bars and motors should be replaceable

[R39-III] The life of the system shall be no shorter than 3 years

3. SOFTWARE REQUIREMENT

The general requirements applicable to the software GUI of *DreamBox* musical entertainment system are presented in this section.

3.1. USER INTERFACE OVERVIEW

A cross-platform graphical user control program is provided to users for easy and direct control of the crystal bar amplitude and the LED configuration in each cell of *DreamBox* during the Static Mode. The Graphical User Interface (GUI) has three tabs: the Amplitude Tab, the LED configuration Tab.

3.2. GENERAL REQUIREMENT

[R40-II] The GUI shall be user friendly.

[R41-II] The amplitudes of the crystal bars and the LED configuration are converted into hardware serial data automatically and fed to *DreamBox* in real-time manner.

[R42-II] The hardware serial data conversion shall not take too long or else it will lose the meaning of real time.

[R43-II] The GUI is applicable on Windows 2000/XP/Vista.

3.3. AMPLITUDE TAB

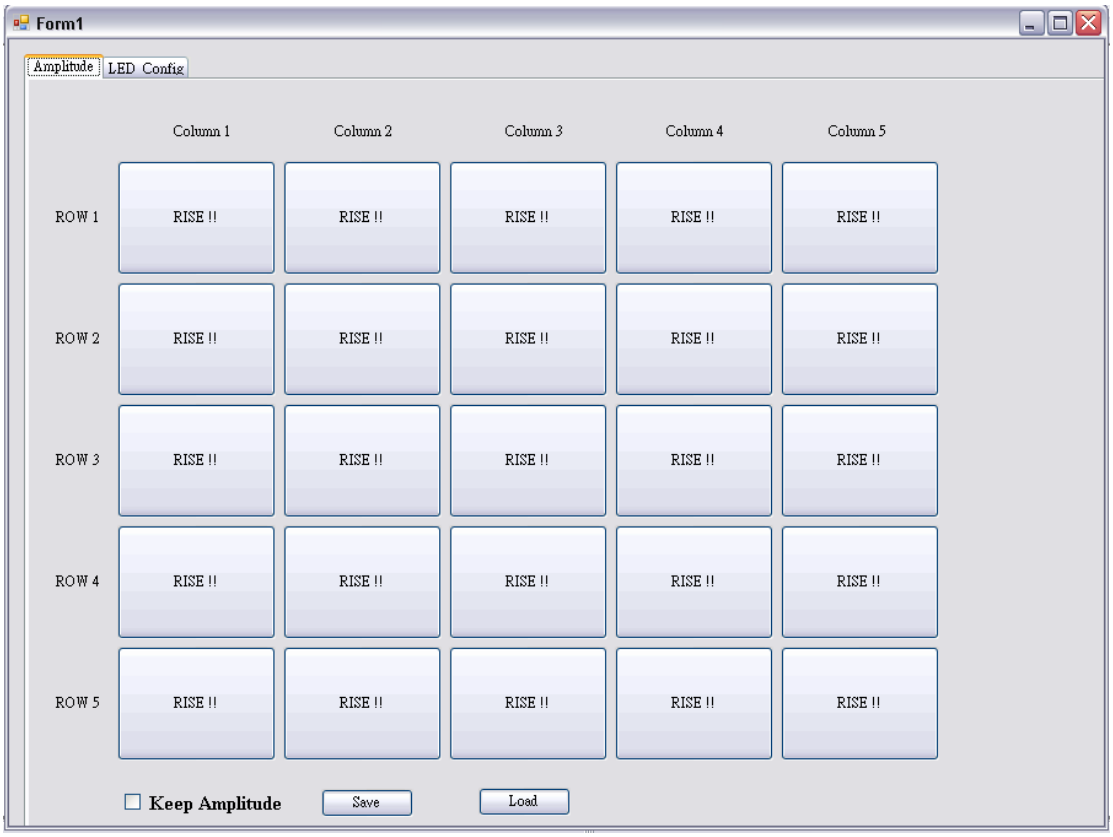

Figure 3: Crystal Bar Amplitude Tab

[R44-II] GUI provides a display window which enables the users to visually monitor the amplitudes of crystal bars on *DreamBox* facilitating them to build the 3D shape of their interest without the need of looking at *DreamBox* while operating on the GUI.

[R45-II] Each button represents a cell on *DreamBox*. The longer the users press the buttons with the mouse's left-click, the higher the corresponding crystal bars will be elevated, while the users press the buttons with the mouse's right-click, the corresponding crystal bars will start descending.

[R46-II] A "Save" button at the bottom of the GUI enabling the users to save the pattern they create.

[R47-II] A "Load" button at the bottom of the GUI enabling the user to load the patterns they created previously onto the GUI for further modification.

3.4. LED CONFIGURATION TAB

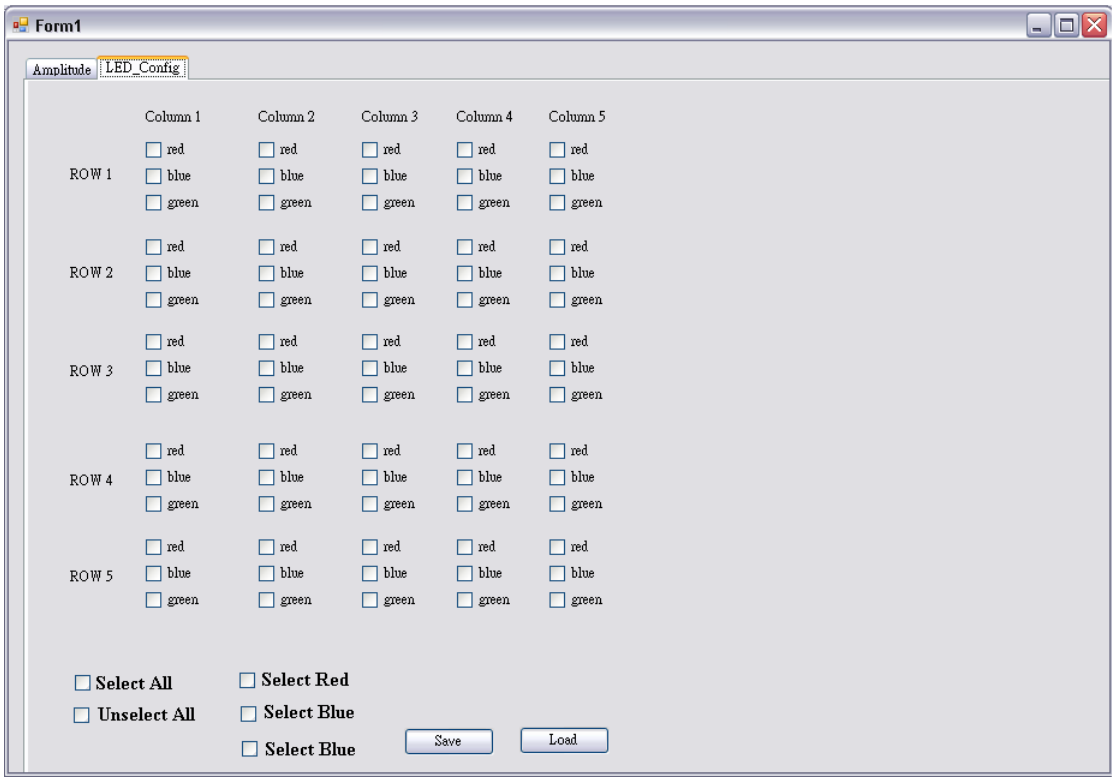

Figure 4: LED Configuration Tab

[R48-II] Each square represents a cell on *DreamBox*. In each square there are three check boxes to control the LEDs.

[R49-II] A "Select All" button at the bottom of the GUI enabling the users to click all the check boxes in each square.

[R50-II] A "Select Red" button at the bottom of the GUI enabling the users to click all the red LED check boxes only.

[R51-II] A "Select Blue" button at the bottom of the GUI enabling the users to click all the Blue LED check boxes only.

[R52-II] A "Select Green" button at the bottom of the GUI enabling the users to click all the green LED check boxes only.

[R53-II] An "Unselect All" button at the bottom of the GUI enabling the users to unclick all the check boxes in each square.

[R54-II] A "Save" button at the bottom of the GUI enabling the users to save the LED configuration they define.

[R55-II] A "Load" button at the bottom of the GUI enabling the user to load the LED configuration they defined previously.

4. SYSTEM TEST PLAN

This section will describe the overall system test plan for *DreamBox* musical entertainment system. The product is in the prototyping stage; therefore, a set of tests must be performed to ensure that the design has met the specification of each component. The tests will be carried out in each stage throughout the development cycle. The test plan can be divided into three subsets of test: software, hardware and mechanics. Each subset of tests works closely together. For example, in order to test LED circuitry design, test software must be written to control the LED circuit.

The procedure of each test will be listed out in the test and verification plan document. After each test had been performed, test data need to be collected and compared with the specification of the components. At the final stage of the development cycle, the prototype will be tested by potential users to obtain feedback about the appearance and the functionalities of *DreamBox* musical entertainment system.

The technical details of each test will be explained in the design specification. A brief description of each test will be list below:

Software Test:

1. Audio Filter Test
   - Frequency Display of the Audio
2. LED Control Software Test:
   - LED Light up Sequence
   - LED Color Control
3. Motor Control Software Test:
   - Speed of Motor Control
   - Turning Angle Control
4. Computer Interface and Communication Test:
   - Data Flow from Computer to the Processers

Hardware Test:

1. Connectivity of Circuitry
   - LED Circuitry Connection
   - Communication Connection of each Processors
2. Power Consumption of each PCB
   - Servo Control PCB
   - Audio Process PCB
   - LED Control PCB

Mechanics Test:

1. Servo Motor Movement Test:
   - Turning Speed vs Different Load
   - Maximum Load
   - Start-up Current
   - Current Consumption vs Different Load
2. Gear Movement Test:
   - Speed of the Movement of Crystal Bar vs Speed of the Motor
   - Verification of Ratio of the Gears
   - Maximum Load of the Gears
3. Stress Test:
   - Stability of the Overall Mechanical System

5. CONCLUSION

The functional specification clearly defines the requirements and functionalities of *DreamBox* musical entertainment system – an innovative musical ornament with potentials to be widely applied in various situations. There are two phases involve in the development: proof-of-concept prototype and finalized product for commercial use. We are confident that all functional specifications stated in this document for the prototype will be completed by April 17th, 2009.

6. REFERENCE

[1]. *dsPICDEM GP 1.1 Development Board User Guide*, page 67. Microchip: 2006.

[2]. Wikipedia.org, *Room Temperature*, [Online]. Available: http://en.wikipedia.org/wiki/Room_temperature. [Accessed: February 15, 2009].

[3]. Blueflame.org, *Humidity and Indoor Environment*, [Online]. Available: http://www.blueflame.org/datasheets/humidity.html. [Accessed: February 15, 2009].