MARBLE SORTER

PRODUCT DESIGN SPECIFICATION

Version 1.0

10/14/2013

CONTRIBUTORS

Person	Role	Contribution
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VERSION HISTORY

Version	Implemented By	Revision Date	Approved By	Approval Date	Reason
1.0	Team	10/14/2013	-	-	Initial design specification draft

TABLE OF CONTENTS

1 INTRODUCTION

1.1 PURPOSE OF THE PRODUCT DESIGN SPECIFICATION DOCUMENT

The Product Design Specification document documents and tracks the necessary information required to effectively define architecture and system design in order to give the development team guidance on architecture of the system to be developed.

2 GENERAL OVERVIEW AND DESIGN GUIDELINES/APPROACH

This section describes the principles and strategies to be used as guidelines when designing and implementing the system.

2.1 GENERAL OVERVIEW

The system to be designed is a device that will sort black and white marbles, fed through a hopper, into bins corresponding to their color. The system will use the ATmega328P microcontroller to interface with servo motors and infrared sensors to divert and detect different marbles, respectively. The goal of the system is to sort marbles accurately and rapidly.

2.2 ASSUMPTIONS / CONSTRAINTS / STANDARDS

1. The final product will be a prototype for further development and will not be intended for productions.
2. The sorting system will contain a hopper capable of holding at least 25 marbles, each colored black or white.
3. The marbles will be sorted into bins corresponding to their color.
4. An LCD display will show the count of black and white marbles that have been sorted and the elapsed time since the beginning of the sorting process.
5. Two momentary push buttons will be used to start/stop the sorting process, and to reset the system, resetting the count to zero.
6. Upon stopping the sorting process, the process should resume when the start/stop button is pressed again, starting from the same place it left off.
7. Sorting information should be retained even after the system has been powered down.
8. An RGB LED status indicator will show a green light when the process is running, yellow if the process is powered down, and red when the process is complete.
9. Process completion will be determined by the use of a watchdog timer. If, by the end of the process, if less than 10 marbles were sorted, the LED will turn RED and blink on and off in 1 second intervals until the start/stop button is pressed.
10. The system will be powered by an AC-DC power supply.
11. Auxillary control circuitry such as the voltage regulators, sensor circuitry, servo control, etc. will be manufactured on a printed circuit board.
12. The cost of all electro-mechanical parts must not exceed $50.

3 SYSTEM DESIGN

This section outlines the system and hardware design of the prototype that is being built.

The solution that was chosen was to sort multiple marbles at the same time. Four marbles will enter 4 individual sorting chambers, each in series, where four sensors will determine the color (and existence) of zero to four marbles. Once the color and order of all the marbles are determined, all four (assuming maximum number of marbles from this point on) will be diverted into the proper bin by the implementation of four servo motors, which are attached to a diverter structure that protrudes down over the marbles. The diverter structure, seen in **Appendix A**, **Figure A.0**, shows the lambda-shaped piece which rotates about an axel, kicking the marble either to the right or left into the corresponding bin.

3.1 USER EXPERIENCE

The user interaction is quite simple. By pressing the start/stop button, the user will start or stop the sorting process. If stopped in the middle of the sorting process, the process will resume to its previous state upon pressing the start/stop button once again.

By pressing the reset button the counts and elapsed time will be reset on the display.

The user is communicated with via the LCD screen. Information such as the elapsed time and the count for black and white marbles is displayed on the Hitachi HD44780 compatible LCD.

The user is also alerted to the sorting status and any sorting error via an RBG LED.

3.2 **IMPLEMENTATION FLOW**

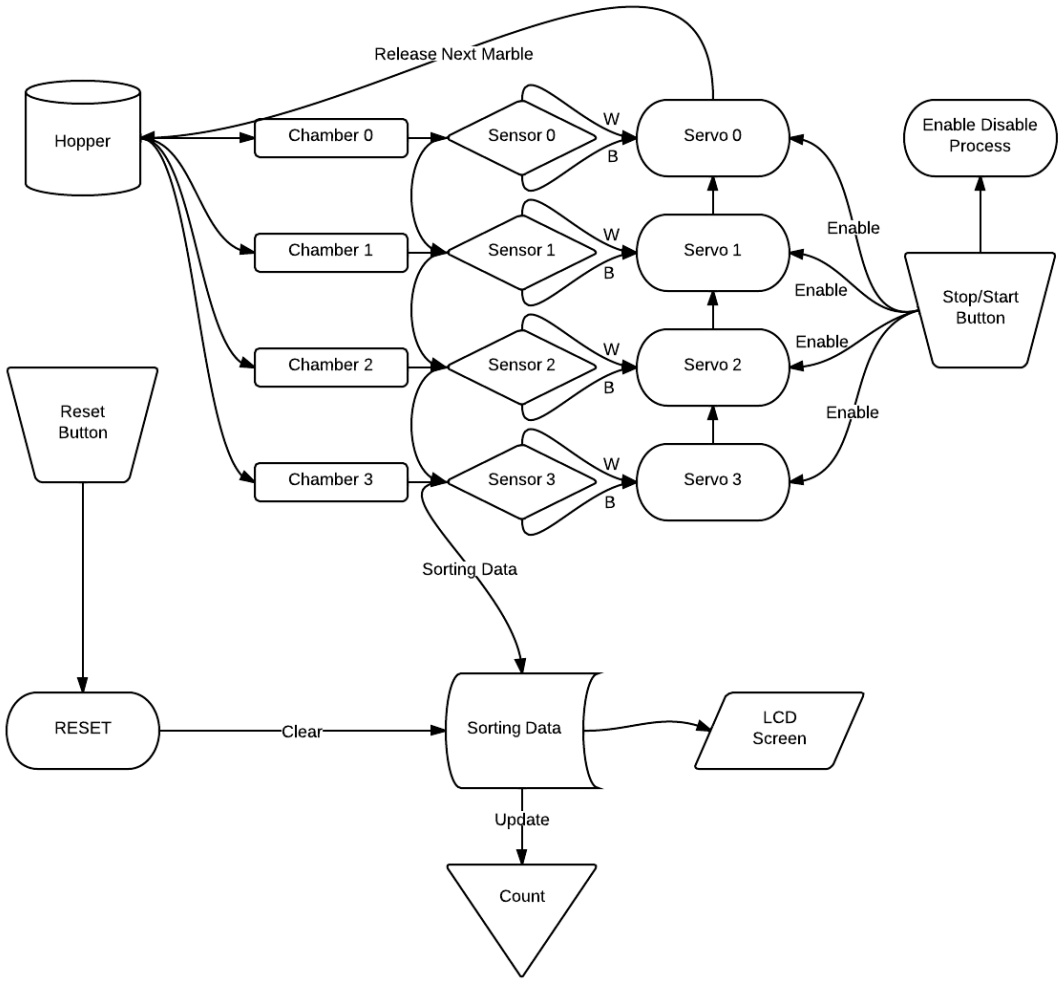

Figure 3.0. State diagram illustrating the high-level functionality of the marble sorter

3.3 MECHANICAL ARCHITECTURE

The structure of the device will be made from a combination of 3D-printed plastic, metal, other plastics and possibly even wood.

The mechanical design incorporates a hopper and track system with four sorting chambers, each capable of sensing and sorting on its own. The sorting mechanism uses servos, which can be seen in **Appendix A**, **Figure A.1**.

3.4 ELECTRICAL ARCHITECTURE

An infrared diode and infrared phototransistor combination will be used as the sensor for this application. Four pairs will be used to independently sense the color and existence of a marble at each position. A colored backdrop may be used to facilitate the detection of a marble's presence. The electrical schematic can be seen in **Appendix A**, **Figure A.2**.

3.5 SOFTWARE AND I/O ARCHITECTURE

The software refers to the control system written for the ATmega328P in the C language. The microcontroller receives inputs from the four sensors and the two buttons, in addition to possible serial communication. The microcontroller has outputs to three LEDs (red, green and yellow), an LCD interfaced via I^2C, control signals to enable/disable each of the infrared LEDs, and PWM signals to each of the servos. The I/O requirements are as follows:

Inputs:
Sensor 0 (ADC) - A0
Sensor 1 (ADC) - A1
Sensor 2 (ADC) - A2
Sensor 3 (ADC) - A3
Start/Stop Button (Digital) - D13
Reset Button (Digital) - D12

Outputs:
Sensor Enable (Digital) - D8
Servo 0 (Digital PWM) - D11~
Servo 1 (Digital PWM) - D10~
Servo 2 (Digital PWM) - D9~
Servo 3 (Digital PWM) - D6~
Green LED (Digital) - D5
Yellow LED (Digital) - D4
Red LED (Digital) - D3
LCD Pin 1 - (Digital) - A4
LCD Pin 2 - (Digital) - A5

For a total of 4 analog inputs and 2 digital inputs, and 6 digital outputs and 4 digital PWM outputs, totaling 16 pins in all.

4 PRODUCT DESIGN SPECIFICATION APPROVAL

The undersigned acknowledges he/she has reviewed the Marble Sorter **Product Design Specification** document and agrees with the approach it presents.

Signature: _____ Date: _____

Print Name: _____

Title: _____

Role: _____

APPENDIX A

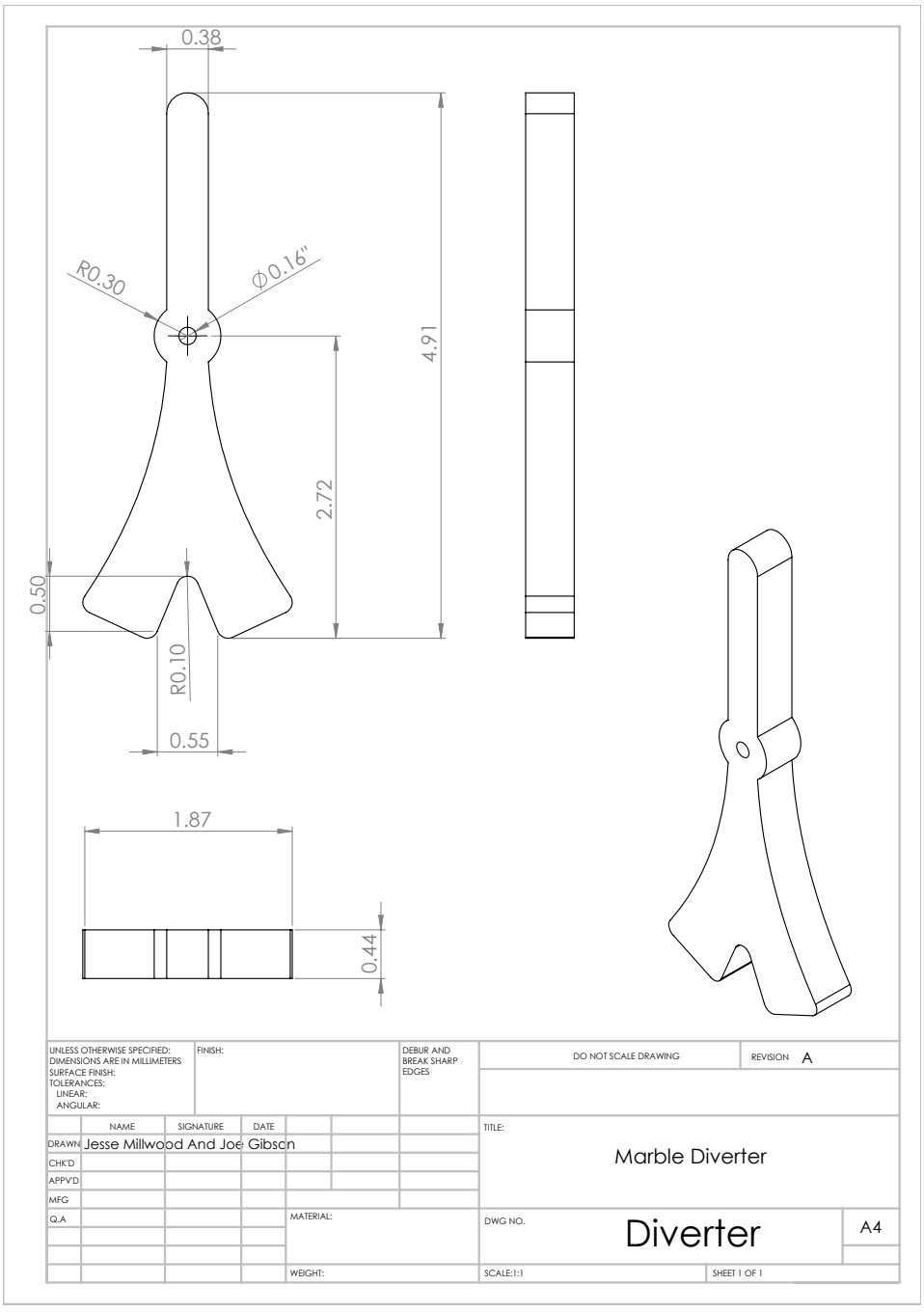

Figure A.0. Diverter Schematic

APPENDIX A

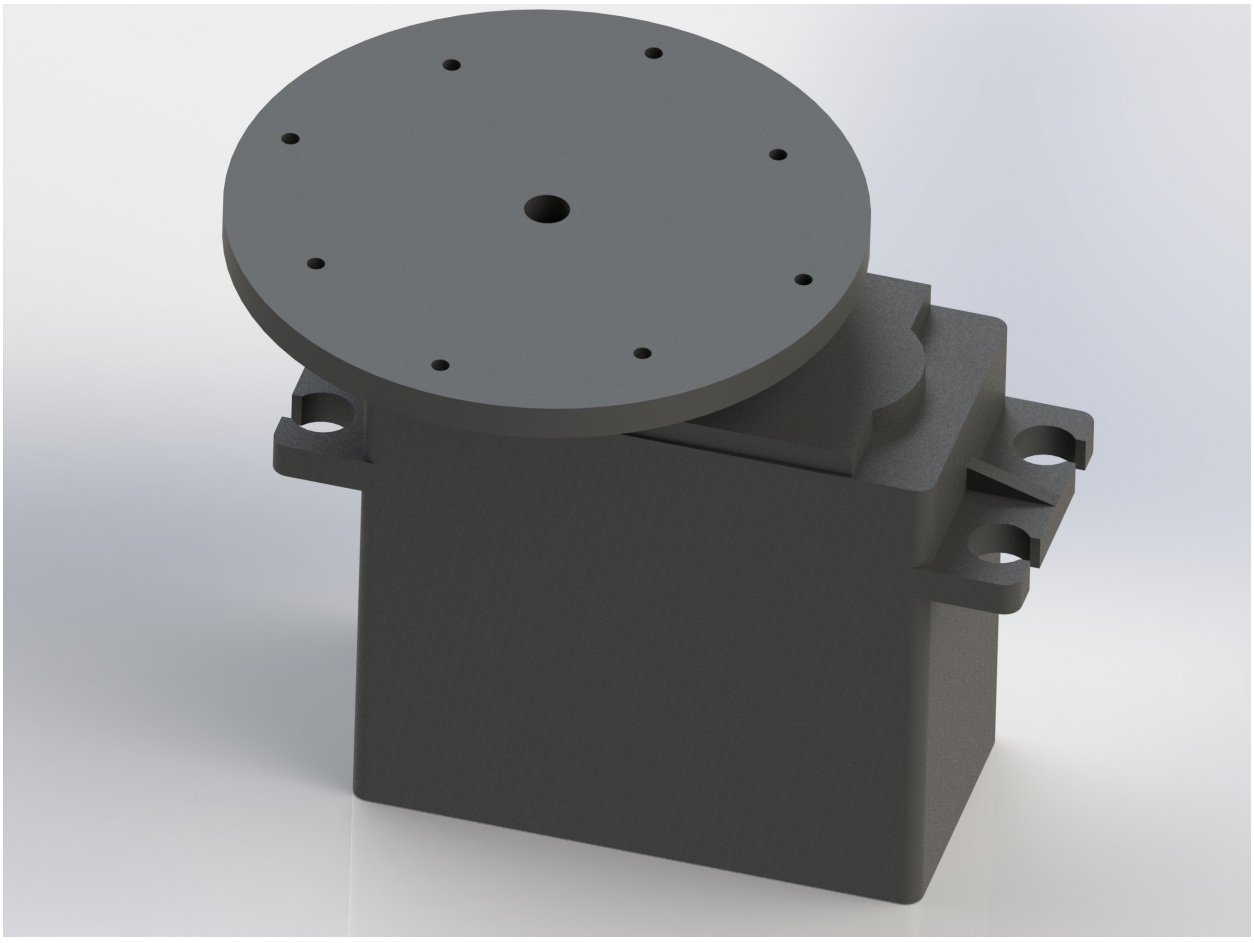

Figure A.1. Servo Rendering

APPENDIX A

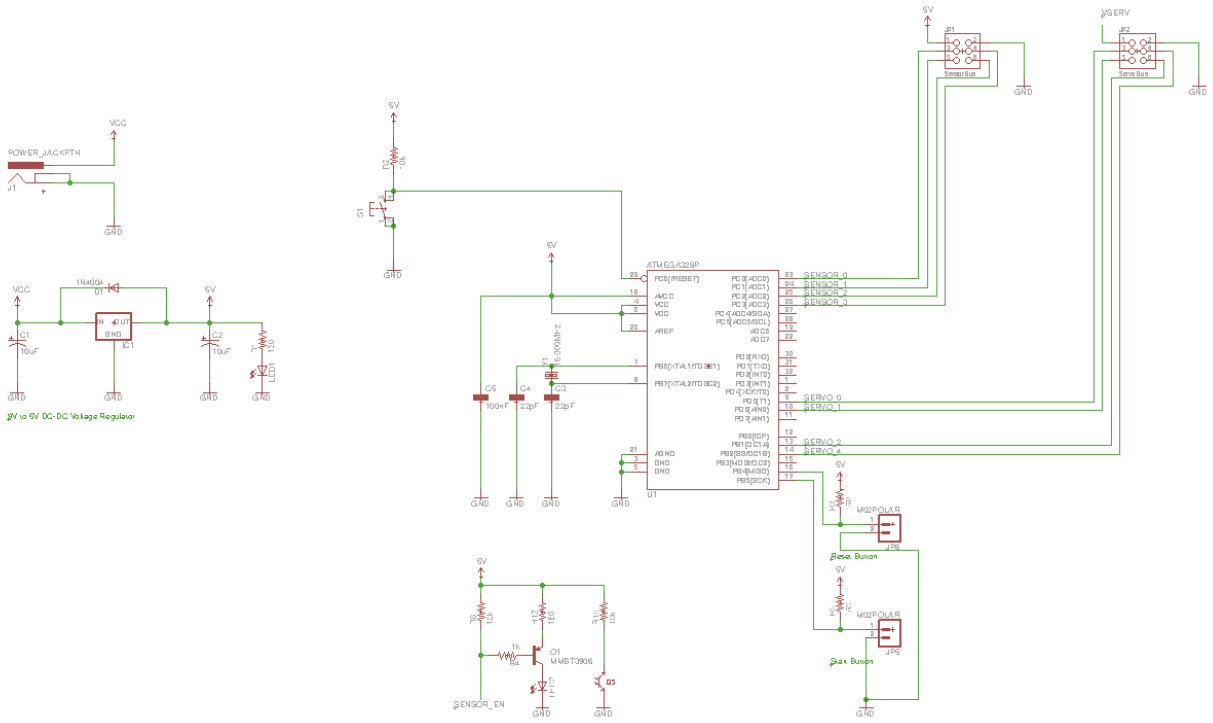

Figure A.2. Partial Electrical Schematic