**Plaque Laser Engraver Device Specifications Document**  
  
  
  
  
  
  
  
  
  
  
  
  
  
  
  
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Initial Release Date: Spring 2016

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**Revision History**

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| --- | --- | --- | --- | --- |
| **Revision** | **Description** | **Author** | **Date** | **Approval** |
| 1 | Draft | Zachary Garrard, Casey Wood | 10/29/2015 | Pending |
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**Specifications**

# SCOPE

## General

This specification establishes the design, construction, performance, development, and test requirements for the Plaque Laser Engraving Machine (herein referred to as the PLED). The PLED is a laser engraving machine that recreates grayscale images on wooden plaques. It functions like a CNC milling machine, moving along an xy axis and varying time of contact on wood using a pulse width modulation (PWM).

## Acronyms

PLED – Plaque Laser Engraving Machine

LASER - Light Amplification by Stimulated Emission of Radiation

CNC – Computer Numerical Control

OSHA – Occupational Safety and Health Administration

FDA – Food and Drug Administration

ANSI – American National Standards Institute

# APPLICABLE DOCUMENTS

## General

This section specifies documents which are related to components integrated into PLED. In particular, documents related to government restrictions, regulations, and safety standards, as well as those related to industry standards will be included.

The following documents shown shall form part of the specifications for this project. In the event of a conflict between requirements, priority shall first go to the contract, second do this document, and lastly to these reference documents.

## Government Documents

These documents specify government regulations that must be met which are related to PLED.

### FDA Code of Federal Regulations

2.2.1.1 U.S. FDA/CDRH: 21 CFR 1040.10/11

2.2.2 ***Radiation Control for Health and Safety Act of 1968***

## Industry Documents

These documents specify industry standards related to the operation of components integrated into PLED.

### OSHA Technical Manual

* + - 1. Section III: Chapter 6

Clauses III, IV, and VI

### ANSI Z136.1

# CLIENT REQUIREMENTS

## General

This section details the requirements as given by the customer.

### Functional Requirements

* + - 1. PLED shall use a laser to burn grayscale images onto wooden plaques.
      2. PLED shall operate like a CNC cutter to create facsimile images.
      3. PLED laser shall turn off immediately upon system error.
      4. PLED shall not function after the xy axis alignment is disturbed.
      5. PLED shall use commercial laser driver to control laser diode.
      6. PLED shall utilize a PC, microcontroller, and laser module.
      7. PLED shall utilize G-Code for positioning.
      8. PLED shall use no more than 7 Watts to drive diode and shall utilize a single 120 VAC power input.

### Non-Functional Requirements

* + - 1. PLED shall create novelty plaques with wood burnt images up to 9”x12” in size.
      2. PLED shall not require user input beyond an image and power to the system.
      3. PLED shall operate independently after an image is provided and a plaque is clamped in place.
      4. PLED shall meet laser industry/government standard laser safety specifications.
      5. PLED shall be less than 3 cubic feet in size.
      6. PLED shall weigh less than 30 pounds.
      7. PLED shall be capable of surviving gentle motion, but no drop tests are required.
      8. PLED structure shall be made of aluminum.
      9. PLED shall be capable of operating in a temperature range of 40° - 110° F.
      10. PLED shall operate in regions with less than 90% humidity.
      11. PLED shall use a noise-free power source.
      12. PLED shall cost commercially no more than $1000 (PC not included).

# REQUIREMENTS

## Item definition

The PLED shall operate similar to a CNC milling machine with xy axis movement of the laser head. As the laser module moves over the wooden surface the beam will pulse in order to engrave the wood to varying degrees of darkness. The movement of the laser will be determined by a Tiva C microcontroller and the image will be loaded onto the microcontroller via the operating PC. The position of the laser head shall be monitored at all times by the microcontroller and shall halt operation immediately if any misalignment is detected.

### Illustrations or Functional Block Diagram



Figure 1. System block diagram.

### Interface Definition

Definition of system inputs and outputs.

Physical

Laser diode heat sync.

Mechanical servos.

Light shielding

Electrical

AC outlet

USB

Functional or Informational

Input: grayscale JPEG image; Output: Engraved plaque

## Characteristics

### Performance Characteristics

* + - 1. PLED shall use a 450 nm laser at 2 watts power to keep engraving time under 45 minutes.
      2. PLED shall burn images with a minimum resolution of 8 bits.
      3. PLED motion on a two dimensional axis shall be accurate to a minimum of 0.5 mm.
      4. PLED laser shall turn off immediately upon system error.
      5. PLED shall utilize a microcontroller for processing and control.
      6. PLED shall utilize G-Code for position tracking and movement of the laser module.

### Physical characteristics

* + - 1. PLED shall be less than 3 cubic feet in size.
      2. PLED shall weigh less than 30 pounds.
      3. PLED structure shall be made of aluminum.
      4. PLED shall not function after the xy axis alignment is disturbed.
      5. PLED shall use no more than 7 Watts to drive diode and 120 VAC power input.
      6. PLED shall meet laser industry/government standard laser safety specifications.

## Environment

### Natural Environments

* + - 1. PLED shall be capable of operating in a temperature range of 40° - 110° F.
      2. PLED shall operate in regions with less than 90% humidity.

### Induced Environments

* + - 1. PLED shall be capable of surviving 3 G’s, but no drop tests are required.
      2. PLED shall use a power source with no more than 2% total harmonic distortion.

## Cleanliness

### Electromagnetic interference (EMI)

* + - 1. The unit shall met the EMI requirements for class IV equipment as specified in MIL-STD-461.

### Ventilation

* + - 1. If smoke particles exceed 500 ppm concentration a fan will start to vent fresh air

# VERIFICATION OF REQUIREMENTS:

## Scope

This section will outline the test procedures necessary to ensure that engineering requirements are met. Any tests indicating a requirement has not been met shall require calibrations or modifications and retesting before any PLED shall be approved.

## Characteristics

Definition of system inputs and outputs.

### Performance

* + - 1. An optical power meter shall be used to measure the intensity of the laser radiation to ensure it does not exceed 2 Watts. Also engraving shall be timed to ensure it does not exceed 45 minutes.
      2. 8 bit images shall be loaded and reproduction quality graded by tester.
      3. Finished engraving pixel width shall be measured to ensure it does not exceed 0.5 mm.
      4. The table the PLED is on shall be bumped into to by a force of 5 Newtons to simulate an accidental perturbation by a tester to ensure that the unit safely shuts down.
      5. Tester shall validate that a microcontroller and PC are in use.
      6. Tester shall verify G-code is in use.

### Physical

* + - 1. PLED external measurements shall be taken to ensure they do not exceed 3 cubic feet in volume.
      2. PLED shall be weighed to ensure it does not exceed 30 lbs.
      3. Tester shall verify PLED frame is constructed of aluminum.
      4. Servo motors shall be disconnected to simulate misalignment when movement commands are sent to determine if the system halts safely.
      5. Tester shall measure power consumption with a multimeter to ensure it does not exceed 7 Watts.
      6. Industry and government documents shall be reviewed to ensure the PLED meets all required standards.

## Environment

### Natural Environments

* + - 1. PLED shall be run in 40° and 110° environments to assure functionality is not adversely affected.
      2. PLED shall be tested at 90% humidity to ensure functionality is not adversely affected.

### Induced Environments

* + - 1. PLED shall be perturbed by tester with a force of 3 G’s after which functionality shall be verified.
      2. PLED power source shall be measured for harmonic distortion by a power quality meter.

## Cleanliness

### Electromagnetic interference (EMI)

* + - 1. Radiant EMI shall be measured and verified to ensure it does not exceed class IV equipment requirements.

### Ventilation

* + - 1. Smoke production shall deliberately exceed 500 ppm to ensure that the ventilation fan turns on.

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| --- | --- | --- | --- | --- | --- |
| **Number** | **Name** | **Test** | **Met** | **Not Met** | **Comments** |
| 5.1.1.1 | Heat sync | Analysis |  |  |  |
| 5.1.1.2 | Servos | Inspection |  |  |  |
| 5.1.1.3 | Light shielding | Inspection |  |  |  |
| 5.1.2.1 | Low noise outlet | Analysis |  |  |  |
| 5.1.2.2 | Low noise USB | Analysis |  |  |  |
| 5.1.3.1 | Input/Output | Inspection |  |  |  |
| 5.2.1.1 | Laser power draw | Test |  |  |  |
| 5.2.1.2 | 8 bit images | Inspection |  |  |  |
| 5.2.1.3 | Misalignment measurement | Analysis |  |  |  |
| 5.2.1.4 | System error halt | Demonstration |  |  |  |
| 5.2.1.5 | Microcontroller | Inspection |  |  |  |
| 5.2.1.6 | G-Code use | Inspection |  |  |  |
| 5.2.2.1 | Dimensions | Inspection |  |  |  |
| 5.2.2.2 | Weight | Inspection |  |  |  |
| 5.2.2.3 | Structure | Inspection |  |  |  |
| 5.2.2.4 | Alignment halt | Demonstration |  |  |  |
| 5.2.2.5 | Voltage/Current | Inspection |  |  |  |
| 5.2.2.6 | Laser Safety | Inspection |  |  |  |
| 5.3.1.1 | Temperature | Test |  |  |  |
| 5.3.1.2 | Humidity | Test |  |  |  |
| 5.3.2.1 | Gentle motion | Test |  |  |  |
| 5.3.2.2 | Quiet power | Analysis |  |  |  |
| 5.4.1.1 | EMI | Analysis |  |  |  |
| 5.4.2.1 | Ventilation | Inspection |  |  |  |

Table 1. List of requirements, related tests, and results.