

ECE 480

Ballistic Chronograph Design Issues Paper

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Introduction

While designing the Ballistic Chronograph for our sponsor the ECE Shop, three design issues were most important: product lifecycle management, protection of intellectual property, and product safety. Product lifecycle management was critical. The team had to consider reliable design, availability of supplies for manufacturing, and the end-user experience. Each of these considerations led to product safety and minimizing harm to the end-user. The design of the chronograph was explicitly different than chronographs available on the market, to ensure a unique product and defensible intellectual property. These three major design issues were examined and targeted from the early prototype to the final version of the product to improve stability and reduce future complications.

Product Lifecycle Management

The goal of product lifecycle management is to minimize any instability issues that can negatively impact the product's lifecycle. Materials were selected for manufacturability and product durability. The chronograph is constructed out of aluminum frames and steel brackets. This material is very durable and will be able to withstand a variety of common environmental conditions. The microcontroller chosen for this project was an Arduino Due. This one was chosen because of the low power consumption as well as the fact that it met the requirements needed by the design; it had an adequate amount of programmable I/O pins. Using the open source Arduino gives experienced users the ability to modify the product safely through programming. The design uses multiple banks of LEDs as sensors powered by a Line Laser. The LEDs are reverse biased to work as a receiver instead of as a light emitter. LED burnout is not a concern because the LEDs receive power optically, rather than through a supply voltage. The LEDs contain semiconductors that are used to detect the laser. The line laser will have to be on continuously. The line laser uses a low current draw and low power consumption to save battery life.

Safety

Users will interact directly with this product, making safety a top concern. Malfunction of some of the components of the ballistic chronograph can cause potential danger to the end-user.

Main components of the ballistic chronograph are the Arduino Due microcontroller, sensors, LCD screen, Batteries and LEDs. Power consumption should be considered as a main priority. The Arduino Due uses 3.3 V with 800 mA current draw. The power supply designed for the chronograph uses a 9 V battery, stepped down into 3.3 V and 5 V outputs. Users would mainly use the chronograph outdoors; temperature and light conditions should be considered when selecting components.

Component	Temperature
Battery	-18°C-55°C
Capacitors	max105°C
Voltage Regulator	max150°C
Altitude sensor	-40°C-85°C
Humidity/Temperature Sensor	-25°C-85°C
LEDs	max77°C
LCD	-50°C-105°C
Microcontroller	-40°C-85°C

Figure 1. Components and Operating Temperature Ranges

The table above shows the acceptable temperature ranges under which the components can safely operate. Batteries are the critical component with the smallest temperature range, therefore the temperature range of the chronograph is from -18°C to 55°C. To minimize the effect

of outside temperature on the final product, batteries should be put into a plastic box so they are shielded from the environment and insulated against dramatic temperature change. In order to protect the end-user from exposed electrical components, all wires should be covered, and each of the components should have housing.

Protection of Intellectual Property

The principles behind the ballistic chronograph are not new, but this particular implementation is unique. The market is saturated with chronographs that implement photo-detectors. The design is unique in both the method of detecting – LED receivers powered by line lasers – and the modification opportunity afforded by the exposed microcontroller. These two primary design decisions increase the potential consumer markets, extending into the do-it-yourself community and scientific research. The line laser is a very unique decision: it allows the chronograph to adjust to the ambient light conditions, rather than succumb like the commercial photo-detector implementations. An additional feature of the chronograph is wireless Bluetooth communication with an android phone. This feature allows the end-user to stay away from the chronograph while it is detecting projectiles, and access the recorded data at any time. These features give the chronograph an advantage in the market and a starting point to pursue intellectual property protection such as patents and copyrights.