Ballistic Chronograph

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ECE 480 – Design Team 3

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What is a Chronograph?

- A chronograph measures projectile velocity
- The most common application is measuring the velocity of bullets on a shooting range.
Basic Chronograph Function

First screen

Second screen

Detect Projectile at First Screen

Detect Projectile at Second Screen

Calculate Velocity
Commercial Options

Caldwell Ballistic Precision Chronograph

CED M2 Chronograph Set

The Pact Professional XP Chronograph w/ IR Sensors
Primary Specifications

• **Projectile Velocity** ➔ The chronograph should be able to detect and accurately report velocities up to 3500 feet per second

• **Wireless Reporting** ➔ The user should be able to receive data from the chronograph without having to interact with it

• **Data Storage** ➔ The user should be able to access and store the data acquired by the chronograph
Secondary Specifications

- **Environment Variables** ➔ The chronograph should record environment variables relevant to projectile flight such as: temperature, humidity, pressure and altitude.

- **Detection Scheme** ➔ Explore the effectiveness of a laser-based detection system.

- **Portability** ➔ The chronograph should be portable and have a dedicated power supply.
Laser & LED Screens
Laser and LEDs Concept

Voltage produce
Temperature and Humidity Sensor

• HIH-6130
• Humidity range: 10-90% RH
• Temperature range: 5°C - 50°C
• Operating Voltage: 2.3 V - 5.5 V
**Temperature and Humidity Sensor**

- I2C bus with SCL and SDA hooked up to microcontroller
- SCL (clock) is high, start transmitting data via SDA pin
- Using Bluetooth temp/humidity outputs to smartphone
Altitude and Pressure Sensor

- Altitude/Pressure Sensor - MPL3115A2
- 1.6 V to 3.6 V Digital Interface Supply Voltage
- Pressure: 20-bit measurement (Pascals)
- Altitude: 20-bit measurement (meters)
- I2C bus to transfer data to microcontroller
- Dead on Arrival
Wireless Transmission

- Bluetooth sensor
- ITEAD BT Boosterpack
- Breakout board for the HC-05
- BlueTerm application
- Open source
Texas Instruments MSP430 LaunchPad

- Original choice for microcontroller
- Did not support our I/O requirements
• Operating Voltage: 3.3 V
• Digital I/O: 54 Pins
• Analog I/O: 12 Pins
• Clock Speed: 84 MHz
Programming the Arduino

1. Initialize Screens
2. Detection Loop – 10 Sample Averaging
3. Detection Loop – 3 Sample Averaging
4. Fetch Sensor Data
5. Report Over Bluetooth

```c
// -- Detection code

// time variables
long time1 = 0;
long time2 = 0;

float threshold1 = (float) (led_screen1_min-led_ambient)*95.0/100.0;
float threshold2 = (float) (led_screen1_min-led_ambient)*95.0/100.0;

// screen1
while (1) {
    sensorValue = averagePin[AN, 10];
    if ((sensorValue-led_ambient) <= threshold1) {
        time1 = micros();
        break;
    }
} // end while

// screen2
while (1) {
    sensorValue = averagePin[AN, 3];
    if ((sensorValue-led_ambient) <= threshold2) {
        time2 = micros();
        break;
    }
} // end while
```
The Construction

• Aluminum frame with steel brackets
• Dimensions
  – 14 inch width x 14 inch length with 30 inch depth
• Wooden box that houses components
• Isolated ground (voltage changed)
Testing and Validation
Data Collection

• Mounted Nerf gun in a fixed position
• 100 samples with lights on
• 100 samples with lights off
Average Velocity: 64.1 ft/s
Range: 50.8 ft/s – 70.7 ft/s
Average Velocity: 62.6 ft/s  
Range: 53.43 ft/s – 68.16 ft/s
Validating Results

- **Precision**
  - The chronograph behaved the same in both ambient light and darkness

- **Accuracy**
  - Caldwell Chronograph → 50 ft/s to 70 ft/s
  - Sound Test → 62.5 ft/s
Prototype Capability

Complete Specifications

- Calculate Projectile Velocity up to 70 feet per second
- Temperature and Humidity
- Wireless Data Transmission
Unmet Specifications

- LCD screen
- Altitude and Pressure
- Data storage
- High Speed Velocity (untested)
Video Demonstration
Design Issues and Future Suggestions
Detection Area

- Laser detection region is limited
• LEDs are in series ➞ They will charge neighbors if too few are blocked
Future Design Improvements

• Increase the area of detection by using LED banks and using more line lasers
• Shield the LED banks from the sides (preventing the ambient light effect)
• LCD (better power supply)
• More sensors (altitude, air pressure, wind speed)
• More powerful microcontroller
• Parallel circuit design
• Opto-isolator
Current Schematic – Series LEDs
Improved Schematic design – Parallel LEDs
## Budget

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<tr>
<th>Part</th>
<th>Qty</th>
<th>Cost</th>
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<tr>
<td>Line Laser Diode - 5mW 650nm Red</td>
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<td>Humidity and Temperature Sensor - HIH6130 Breakout</td>
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<td>Standard LEDs - Through Hole RED DIFFUSED</td>
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Live Demonstration
Questions?