Team 5

Small, Lightweight Speed and Distance Sensor for Skiers & Snowboarders

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Introduction
Project Goals

Create a device with the following features:

- Speed, Distance, and Time Recording
- User-Friendly
- Safe/Robust Design
- Inexpensive
- Long Battery Life
- Easy Data Retrieval
- Preferred: Doppler Radar
Doppler Radar

- Signal is sent out at a fixed frequency
- Received signal has a shifted frequency from the reflection
- Calculate speed using frequency deviation

\[ f = \left(1 - \frac{v_s}{c}\right)f_0 \quad \Delta f = -\frac{v_s - v_r}{c}f_0 \quad v_s = 0 \]

\[ v_r = c \cdot \frac{\Delta f}{f_0} \]
Design Specifications

Our design has several requirements that must be met:

- **Measurements** (minimum one minute intervals)
  - Average speed
  - Max Speed
  - Distance Travelled

- **Safety**
  - Lightweight (< 2 lbs.)
  - Disabled display during recording
  - Weather resistance
  - Low temperature operation (-10F)

- **Power and Efficiency**
  - Auto-off after 10 minutes of operation
  - At least 2 hours of battery life

- **Operation**
  - Data storage requirement for at least 10 minutes of run data
  - Data report on LCD or data export to external device
Final Design

- **Radar Device**
  - Sends and receives EM waves off the ground
  - Produces output voltage dependent upon frequency shift in the returning wave
  - Prefabricated Doppler radar module (easy to replace)

- **Control System**
  - Microprocessor (PIC) based implementation
  - Handles interaction with the user interface
  - Performs calculations and storage of data from radar device

- **User Interface**
  - Will consist of an LCD display and controls
  - Layout will allow for easy manipulation of controls and high visibility
Final Prototype
Achieved Design Specs

- **Measurements** *(minimum one minute intervals)*
  - Average speed
  - Max Speed
  - Distance Travelled

- **Safety**
  - Lightweight *(< 2 lbs.)*
  - Disabled display during recording

- **Power and Efficiency**
  - At least 2 hours of battery life

- **Operation**
  - Data storage requirement for at least 10 minutes of run data
  - Data report on LCD or data export to external device
Unachieved Design Specs

- Auto LCD Shutoff
- Weather-resistant
  - Temperature - Untested
How It Works
Doppler signal processing procedure:
Signal amplification of the Doppler signal.
Doppler signal processing procedure:
Zero-crossing detection of the amplified signal.
How It Works

Doppler signal processing procedure:
Charge-pump to provide a linear relationship between input frequency and output voltage.
How It Works
Doppler signal processing procedure:
Analog to Digital Conversion of the scaled voltage.

```c
ConvertADC(); //perform ADC conversion
while(BusyADC()); //wait for result
Speed = ReadADC();

AVG = ((unsigned float) Speed / 1024.0) * 4.97 * (1.5863 * ((unsigned float) Speed / 1024.0) * 4.97) + 8.3087;
```
How It Works

Doppler signal processing procedure:
Speed calculation in software.

```
DISTANCE = AVG * TIME * (5280.0/18000.0);

Distance_Int = DISTANCE;
Max_Int = MAX;
Avg_Int = AVG;
Mins = TOTAL_TIME/60;
Secs = (TOTAL_TIME) % 60;
```
How It Works

Simple Menu System

- Start Run
- Recorded Runs
- Delete Runs
- Settings

Start Run

- Shuts off LCD and waits for user to being moving
- Records Run Speeds throughout run
- At end of Run, stores Run data
How It Works

- Recorded Runs
  - Access old runs
  - Stores up to 20 runs

- Additional features
  - LCD Screen shuts down on user movement
  - Adjustable Contrast on LCD Screen
## Final Cost Breakdown

<table>
<thead>
<tr>
<th>Item</th>
<th>Price</th>
<th>Our Costs</th>
<th>Production Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>PIC</td>
<td>$6.32</td>
<td>$0.00</td>
<td>$3.95</td>
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<tr>
<td>Battery</td>
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<td>Printed Circuit Boards</td>
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<tr>
<td>Capacitors (x5)</td>
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<td>Inductors (x2)</td>
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<td>Resistors (x14)</td>
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<tr>
<td>Phono Jack Set (x2)</td>
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<tr>
<td><strong>Savings</strong></td>
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<td><strong>$16.03</strong></td>
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<td><strong>Total</strong></td>
<td>$86.24</td>
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<td><strong>$70.21</strong></td>
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</table>
Final Results

• Measured device performance in both a vehicle and on a skateboard.

• Instantaneous speed measurement were calibrated to match real world testing

• Max speed completely matched expected values

• Average speed showed no more than 10% in variation from expected results

• Run time is rounded to 2 second accuracy

• Distance measurements show same accuracy as average measurements.
Future Design Improvements

- External EEPROM
- Longer range detection
- Device Structure
  - Wireless Communication
  - One component
- USB Connection for data export
Avg Spd: 1 mph
Max Spd: 1 mph
Dist: 6 yds
Questions?