

Team 5

Small, Lightweight Speed and Distance Sensor for Skiers & Snowboarders

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Introduction



Project Goals

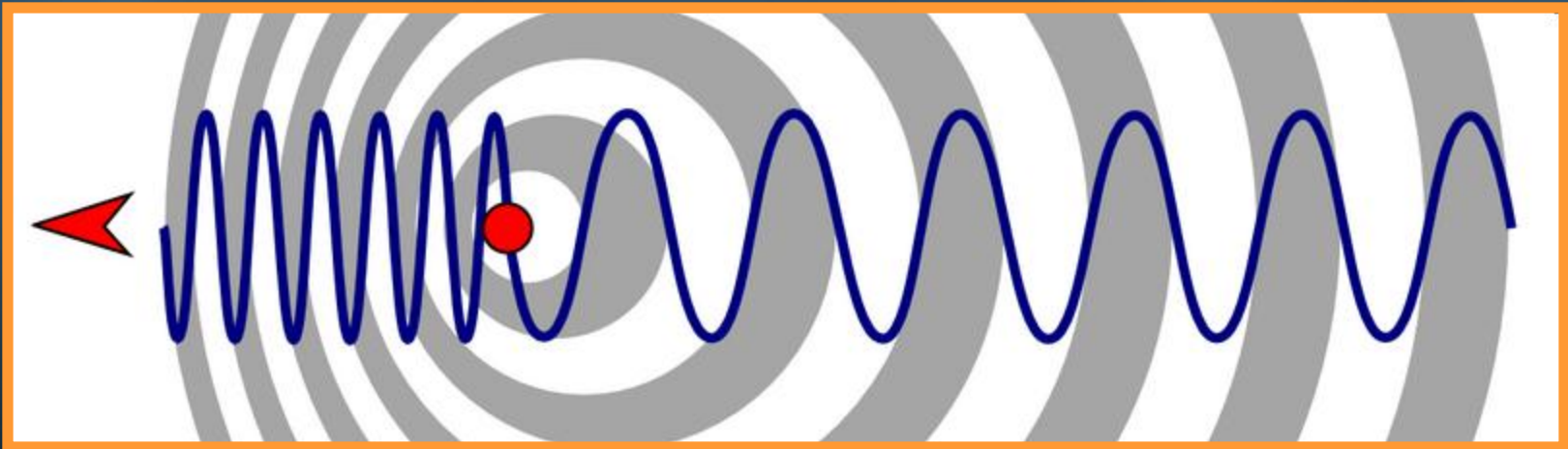
Create a device with the following features:

- 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
$$f = \left(1 - \frac{v_{s,r}}{c}\right) f_0 \quad \Delta f = -\frac{v_s - v_r}{c} f_0 \quad v_s = 0$$
- Calculate speed using frequency deviation
$$v_r = c \cdot \frac{\Delta f}{f_0}$$



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)

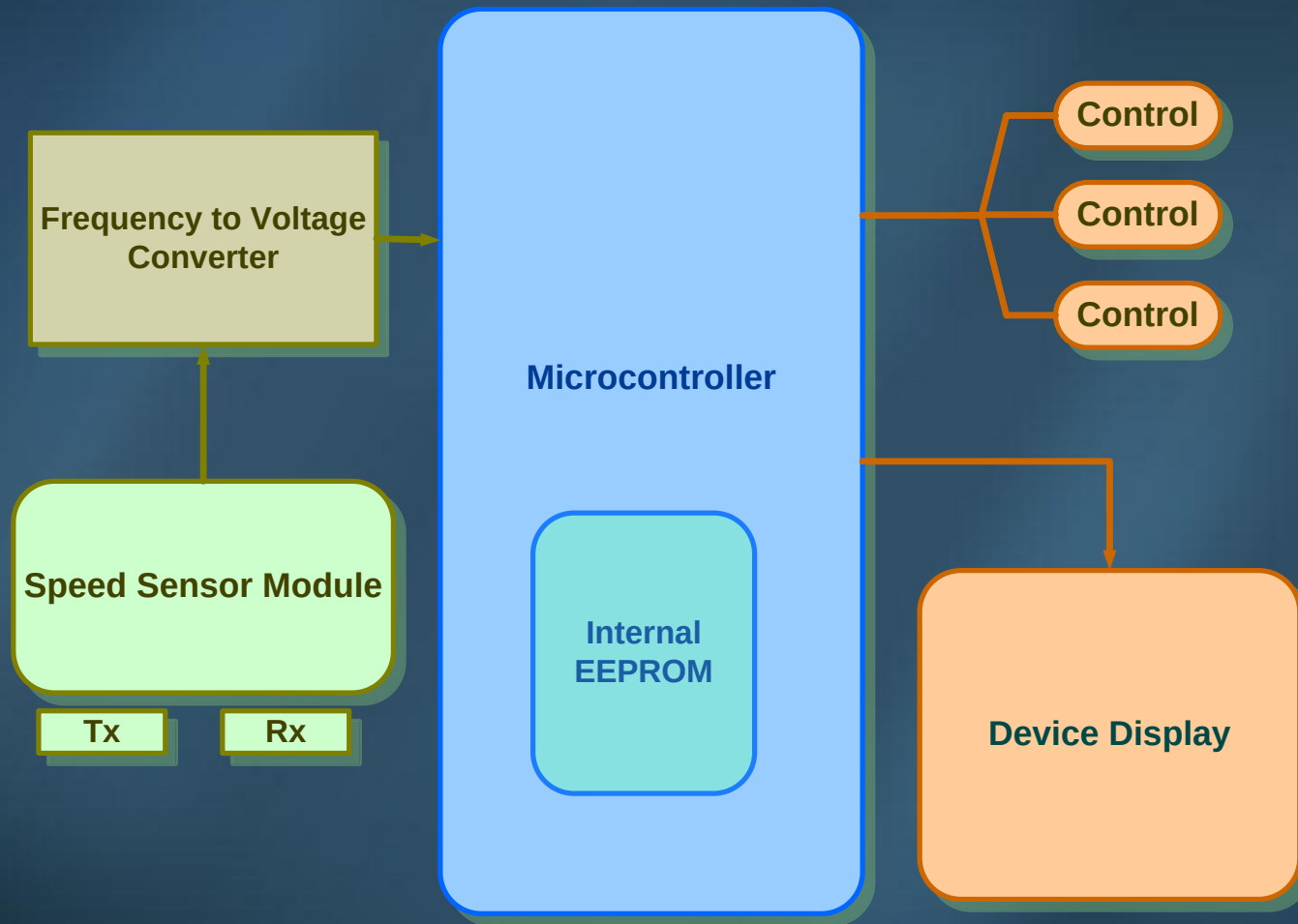
● Control System

- 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

Block Diagram





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

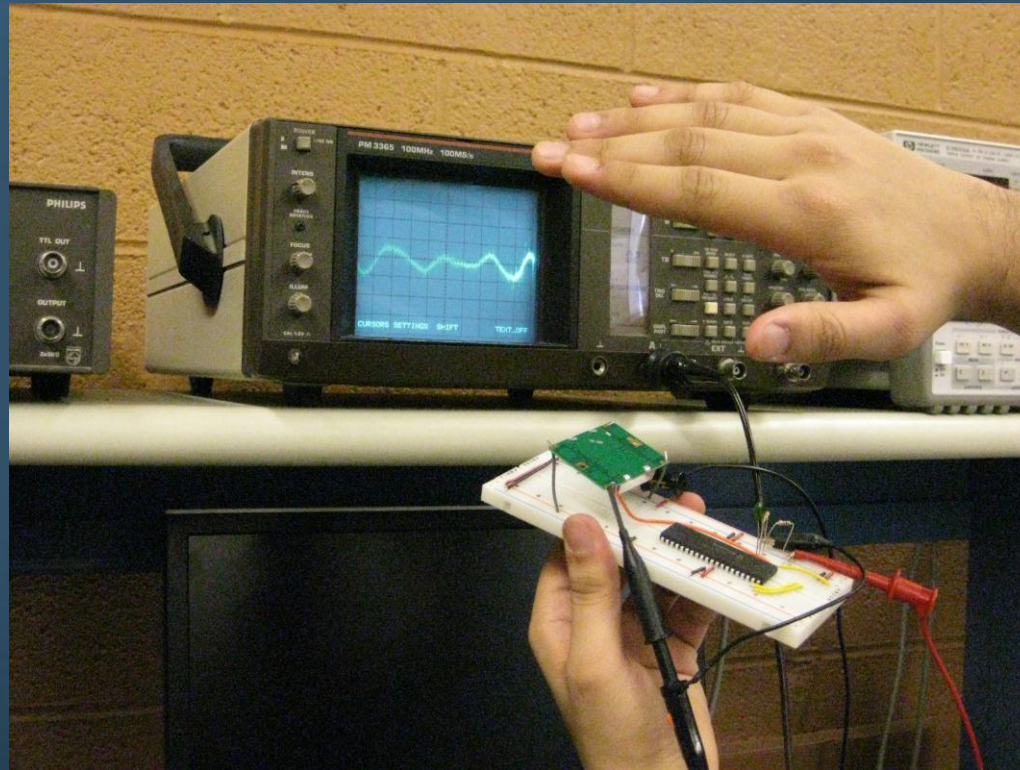
Unachieved Design Specs

- Auto LCD Shutoff
- Weather-resistant
 - ▣ Temperature - Untested

How It Works

Doppler signal processing procedure:

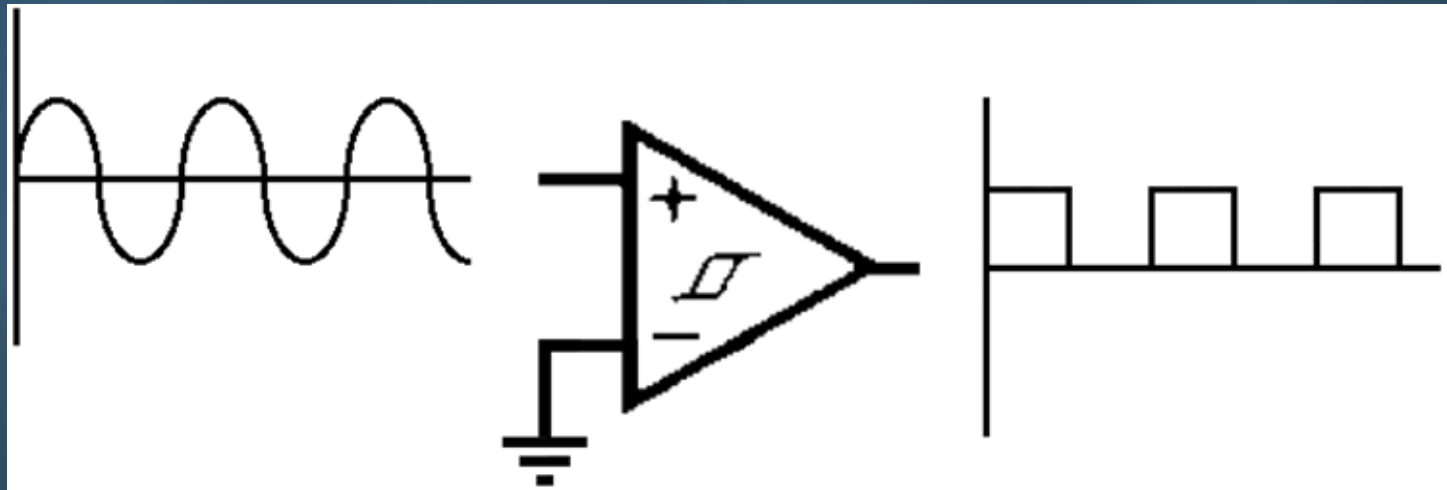
Signal amplification of the Doppler signal.



How It Works

Doppler signal processing procedure:

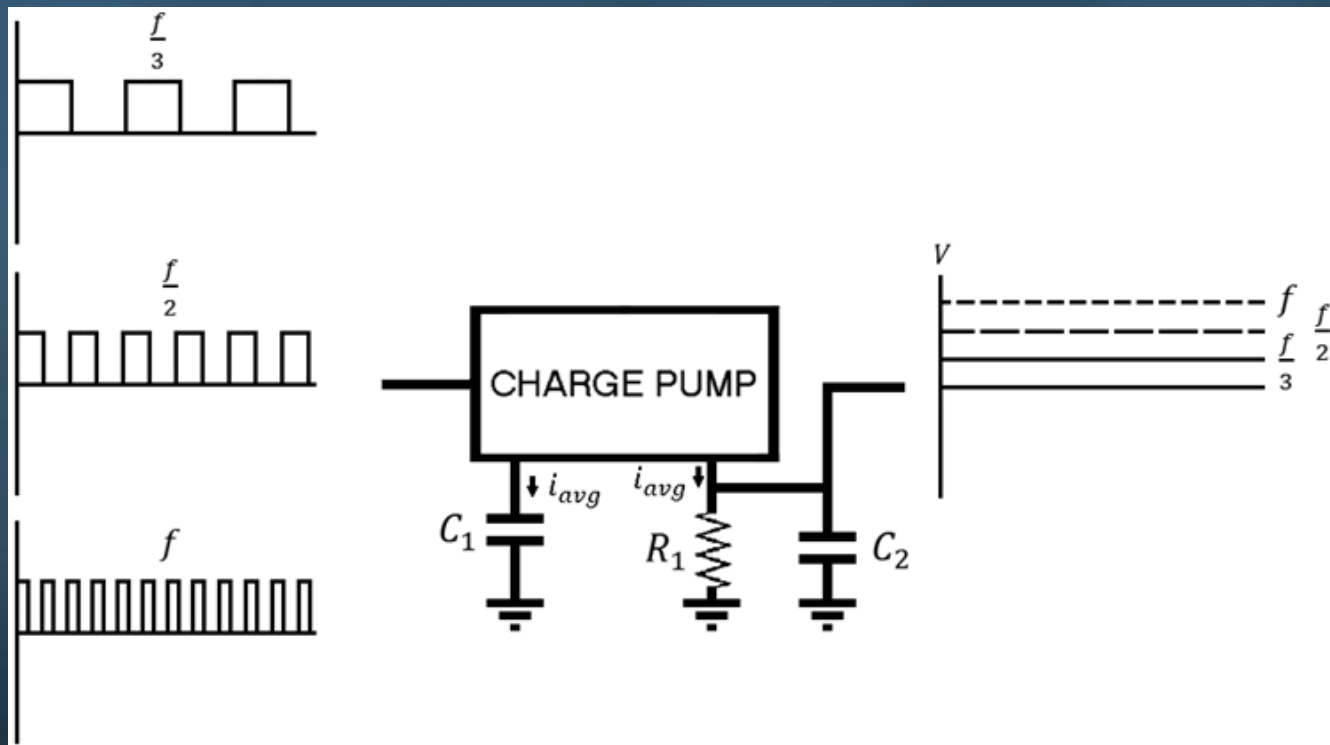
Zero-crossing detection of the amplified signal.



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.

```
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 begin 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

Budget

Final Cost Breakdown			
Item	Price	Our Costs	Production Cost
PIC	\$6.32	\$0.00	\$3.95
Battery	\$10.88	\$10.88	\$7.61
Switch	\$1.17	\$1.17	\$1.17
Large Project Box	\$3.69	\$3.69	\$3.69
Small Project Box	\$2.29	\$2.29	\$2.29
Printed Circuit Boards	\$3.98	\$3.98	\$3.98
LCD	\$33.00	\$0.00	\$25.00
Doppler Module	\$15.00	\$15.00	\$15.00
LM324N	\$0.46	\$0.00	\$0.29
LM2907	\$2.02	\$2.02	\$1.46
LM7805	\$0.60	\$0.00	\$0.38
MX045	\$3.35	\$0.00	\$1.91
Capacitors (x5)	\$0.10	\$0.00	\$0.10
Inductors (x2)	\$1.80	\$0.00	\$1.80
Resistors (x14)	\$0.98	\$0.00	\$0.98
Phono Jack Set (x2)	\$0.60	\$0.60	\$0.60
Savings			\$16.03
Total	\$86.24	\$39.63	\$70.21

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
 - or-
 - ▣ One component
- USB Connection for data export

Starting Run...



SELECT









Questions?