UCF Senior Design I

Powering Roller Coaster Sensors
Via Piezoelectric Transducers

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Initial Project Document and Group Identification
Divide and Conquer

Group 25

Kristopher Walters	Electrical Engineer
Richard Klenotich II	Electrical Engineer
Juan Rodriguez	Computer Engineer
Nicholas Villalobos	Computer Engineer

Project Narrative

Many roller coasters don't have any means to power onboard devices. Roller coasters that do have means to power onboard devices require complex and expensive solutions. Being able to implement power onboard the coaster can extend its functionality, such as using sensors for analytics.

Sensors on roller coaster cars have nearly limitless applications and opportunities for data acquisition. Many parameters can be monitored such as noise levels, vibrations, acceleration, velocity, position, etc. This kind of information could provide critical safety and maintenance related feedback to ride engineers. Furthermore, certain sensors require very little power during operation.

In this study, we are proposing the use of energy harvesting methods to power the onboard sensors of rollercoasters. The energy harvesting method under consideration is the use of piezoelectric transducers to generate electricity through the mechanical vibrations provided by the coaster. While piezoelectric transducers are not yet capable of producing large amounts of power, being able to power a miniature accelerometer only requires microwatts. We plan to research, design, and implement an energy capturing device that will intermittently power relevant diagnostic sensors on the coaster.

Many roller coasters are located outdoors making durability an important factor for consideration. Extraneous environmental conditions, which include temperature, condensation, and vibrations will be exposed to the device, requiring the overall design to be robust. Pre-existing coasters are not designed to include this product. Therefore, size and weight must also be limited to make installation more feasible.

In order to provide sufficient amounts of data, the onboard sensors must be operating as often as possible. Sensor operation time will be limited by the transducers ability to efficiently convert power. While the sensors do not need to operate every time the coaster runs around the track, the transducers can still capture energy while the sensors are off. Therefore, the transducer’s efficiency will limit the amount of time the sensors can be on. The efficiency of the power conversion will dictate the amount of data obtainable. As with all engineering projects, low cost is a key factor as well.

Typical customers and stakeholders would include amusement parks like Disney, Universal, Fun Spot, SeaWorld, Cedar Point, etc. While the applications of this study are focused on the energy harvested from roller coasters, this specific application for the use of powering sensors can be a much broader concept. Sensors powered in this manner could be utilized for diagnostic information in aviation, military vehicles, and other mechanical systems prone to vibrations.

List of Requirements

- Transducer
  - Mechanical vibrations are converted into electrical energy and stored for later consumption

- Onboard energy storage
  - Powers onboard microcontroller and sensors
  - As energy storage becomes low, enter low power mode (turn off sensors)

- Onboard Sensors
  - Recording data during each run
  - Accelerometers, temperature sensors, and noise sensors will be considered
  - Recordable data limited by power available

- Microcontroller
  - Distributes power to sensors
  - Collects and stores data
  - Transmits data

- Transmitter & Receiver
  - Shares recorded data between microcontroller and local receiver

Block Diagram

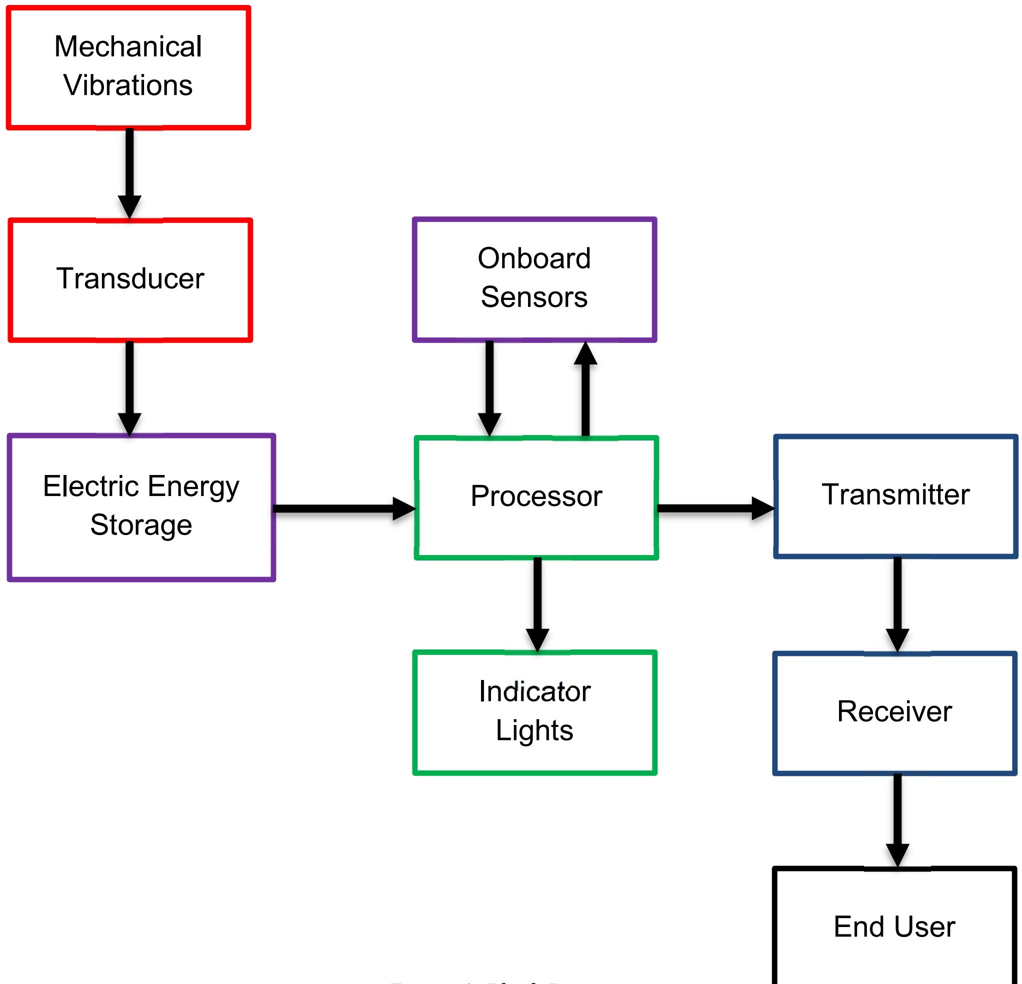


Figure 1: Block Diagram

Status of Each Block

- Research: Each block is currently being researched.
- Design: All blocks are being designed.
- None of the blocks have been purchased or acquired.
- None of the blocks have been prototyped or completed.

Legend:

- **Red**: Kristopher Walters
- **Blue**: Juan Rodriguez
- **Green**: Nicholas Villalobos
- **Purple**: Richard Klenotich II

Estimated Budget

Item Description	Item Amount	Cost per Item	Estimated Cost
Piezoelectric Sensors	4	$45.00	$180.00
Battery	1	$30.00	$30.00
Microcontroller	1	$40.00	$40.00
PCB (8x8)	1	$15.00	$15.00
LED	1	$0.15	$0.15
Accelerometer	4	$6.02	$24.08
Wireless Trans/Rec	1	$40.00	$40.00
*Misc Components	TBD	TBD	$100.00
		Total Amount:	$429.23

**Includes other items such as resistors, capacitors, display, etc. that may be integrated into the design*

Table 1: Estimated Budget

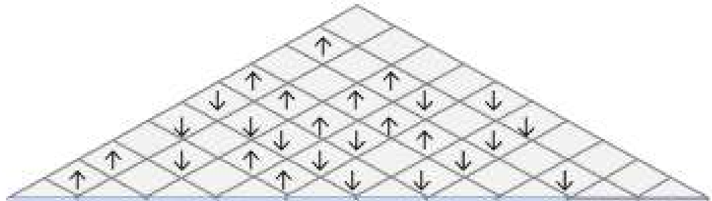
Project Milestones

#	Task	Start Date	Due Date	Status	Responsibility
Senior Design I					
1	Idea Creation	8/25/2020	9/2/2020	Complete	All Members
2	Idea Selection and Roles Assignment	9/1/2020	9/8/2020	Complete	All Members
Project Report					
3	Initial Document: Divide and Conquer 1.0	9/8/2020	9/18/2020	In Progress	All Members
4	Initial Document Updated: Divide and Conquer 2.0	9/22/2020	10/2/2020	In Progress	All Members
5	Table of Contents	9/22/2020	10/9/2020	In Progress	All Members
6	Parts List	9/22/2020	10/23/2020	Researching	All Members
7	First Draft	9/22/2020	11/12/2020	In Progress	All Members
8	Final Draft	9/22/2020	11/27/2020	In Progress	All Members
Senior Design II					
9	Build Prototype	TBD	TBD		All Members
10	Testing and Redesign	TBD	TBD		All Members
11	Finalize Prototype	TBD	TBD		All Members
12	Peer Presentation	TBD	TBD		All Members
13	Final Report	TBD	TBD		All Members
14	Final Presentation	TBD	TBD		All Members

Table 2: Project Milestones

Decision Matrix

House of Quality



Marketing Requirements	Polarity	Efficiency	Dimensions	Transducer Quality	Battery Capacity	Power Consumption	Cost	Weight	Runtime	Charge Time	Time of Data Transmission
Engineering Requirements polarity		+	-	+	+	-	-	-	+	-	-
Durability	+		↑	↑↑	↑	↑	↓↓	↑			
Charging Capacity	+	↑↑	↓↓		↑↑		↓↓	↓↓	↑	↓	
Installation Ease	+	↑	↓↓				↓	↓			
Safety	+				↓	↓	↓↓	↓		↓	
Low Maintenance	+			↑↑		↑	↓↓		↑		
Cost	-	↓↓	↓↓	↓↓	↓↓	↓↓	↑↑	↓	↓	↓↓	↓↓
Targets for Engineering Requirements		> 30%	< 250x250x250 mm	< 40 (Q Factor)	> 1500 mAh	< 5 Watts	< $700	< 5 kg	> 2 minutes	< 1 Day	< 1 minute

Correlations Legend

- ↑: Positive
- ↑↑: Strong Positive
- ↓: Negative
- ↓↓: Strong Negative
- +: Positive Polarity
- -: Negative Polarity

Figure 2: Block Diagram