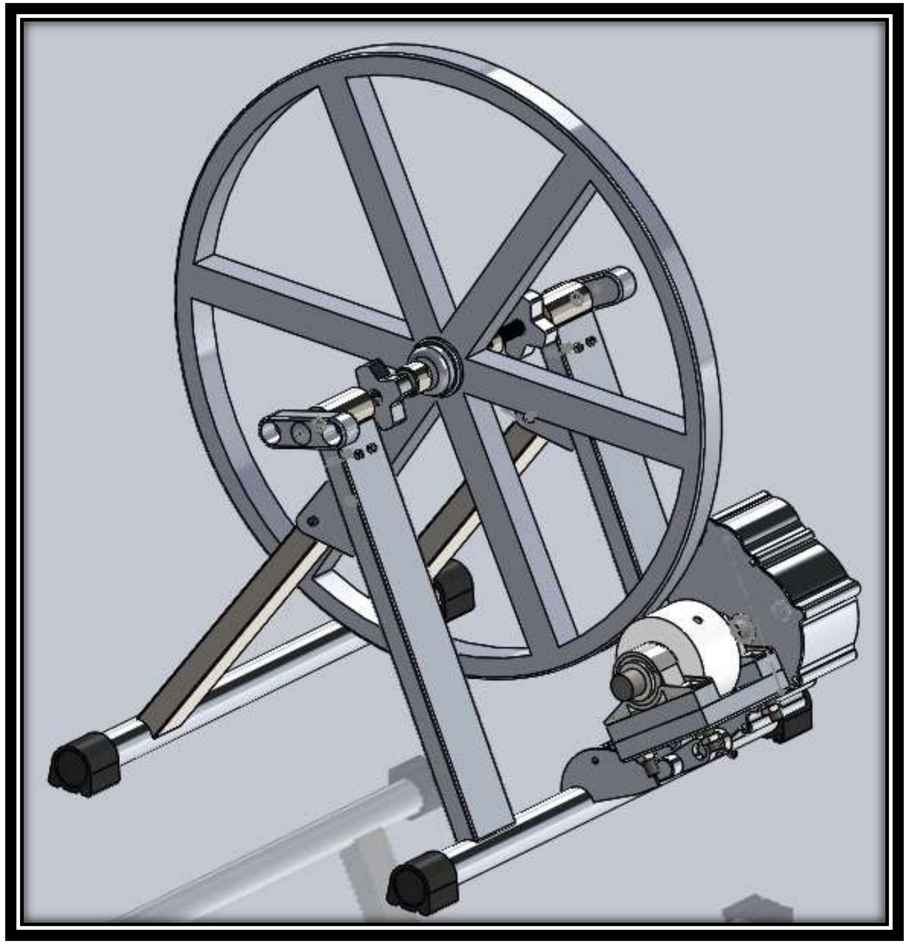
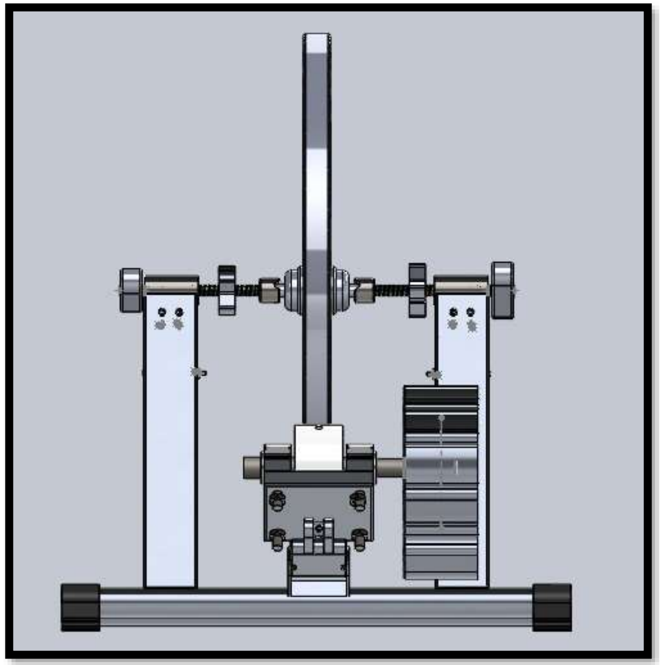
Bicycle-Powered Charger

Design Team:
Alex Howell
Daylon Roitsch
Taylor Wollert

Advisor:
Dr. Kevin Kilty





Overview

1. Project Description
2. Background
3. Design Considerations
4. Objectives
5. System Design
6. Testing
7. Results & Conclusions
8. Commercial Viability

Project Description

- Bicycle-powered charging system
- Charge typical 5 V electronics
- Accommodate any adult bicycle
- Quick transition

Background

- Rationale:
  - Sustainability movement
  - Reliance on small electronic devices
    - 2% of all home electrical consumption
  - Cycling popular form of exercise/transportation
    - 50% of fuel consumption used for trips less than 10 miles

- History:
  - Bottle-cap generator
  - Atom
  - Wheel-belt system

a.

b.

c.

Figure 1: (a) bottle cap generator (Chicargobike, 2010), (b) Atom charger (Siva, 2015), (c) wheel-belt system (DIY Bike Generator, 2015)

Background: Small Household Electronics

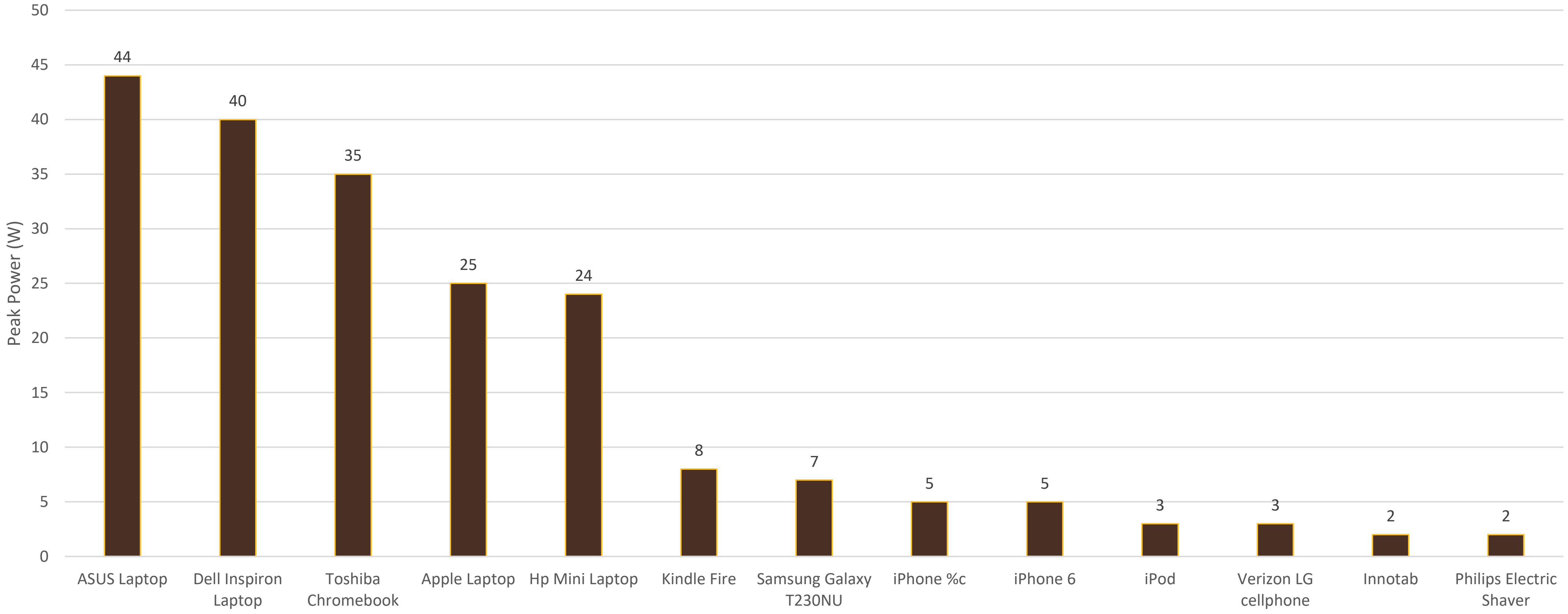


Figure 2: Electronic device peak power consumption. Values were self-obtained from personal electronics.

Design Considerations

Table 1. Design constraints for each sub-system of the Bicycle-Powered Charger system.

Item	Considerations	Other Constraints
Support Frame	Must support standard retail bicycles (focusing on wheel sizes) and riders weighing a maximum of 95% of male weight to a minimum of 5% female weight	Weight, Size, Strength, Safety, Cost, Aesthetics, Ease of Use
ATV Magneto	Must generate power required for 12V charging system	Size, Level of Resistance, Cost
Battery Pack	Must store 12V DC and have multiple removable charge outlets	Longevity of Charge Cycles, Safety, Cost
Unified Electronics	Must increase/decrease input voltage to meet battery voltage requirements	Compatibility, Safety, Cost
Display	Must show calories burned, distance covered, current speed, and charge accumulated	Weight, Durability, Safety, Readability, Ease of Use, Cost

Objectives

- User Desirability
- System Integrity
- Overall Cost
- Charge Capabilities

Objectives: User Desirability

- Aesthetics
  - Reduce bulkiness
  - Appearance
- Ease of Use
  - Light weight
  - Fast transition
  - Universal compatibility
- Cost
  - Between $200-$400
- Safety
  - Consumer Product Safety Commission
  - American Society for Testing and Materials

Objectives: System Integrity

- Support frame
  - Durable
- Charging system
  - Robust
    - Lead-acid battery
  - Effectiveness
- Display
  - Accurate
  - Rugged
  - Relevant

Objectives: Overall Cost

- Budget: $700 provided by Dr. Kevin Kilty
  - Bicycle trainer
  - Generator
    - Shaft manufacture
  - Battery pack
  - Aesthetic components
  - Display

Table 2. Current expenditures for prototype

	Support Frame	ATV Magneto	Electrical Components	Shaft System	Total
Price	$59	$0	$4.50	$72.23	$135.73
Manufacture Time	-	-	-	24 hrs.	24 hrs.

Objectives: Charge Capabilities

- Convert variable AC voltage into consistent DC voltage
- Directly charge small electronic devices
- Charge 12 V battery pack
  - Lead-acid battery
  - Removable storage
  - Multiple USB 5 V charge outlets

System Integration

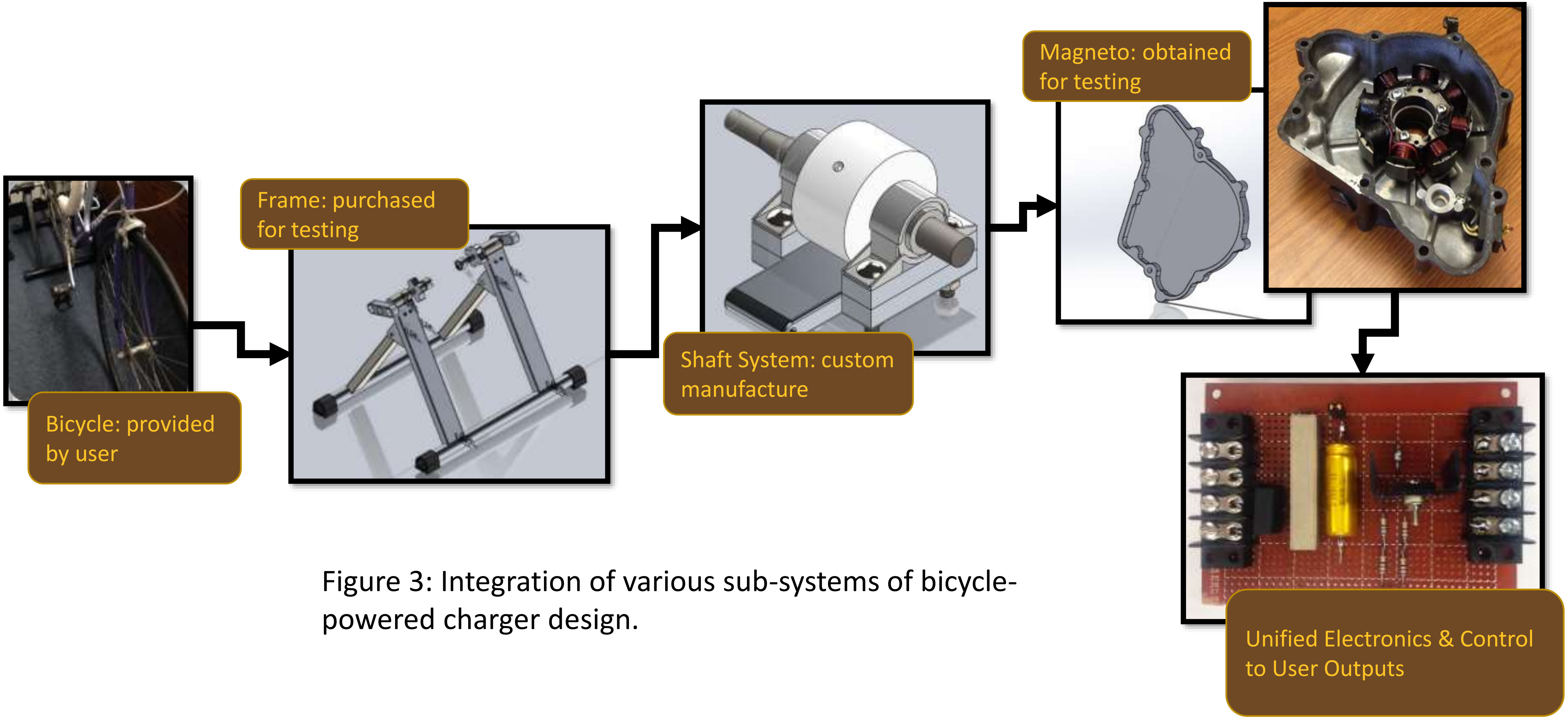
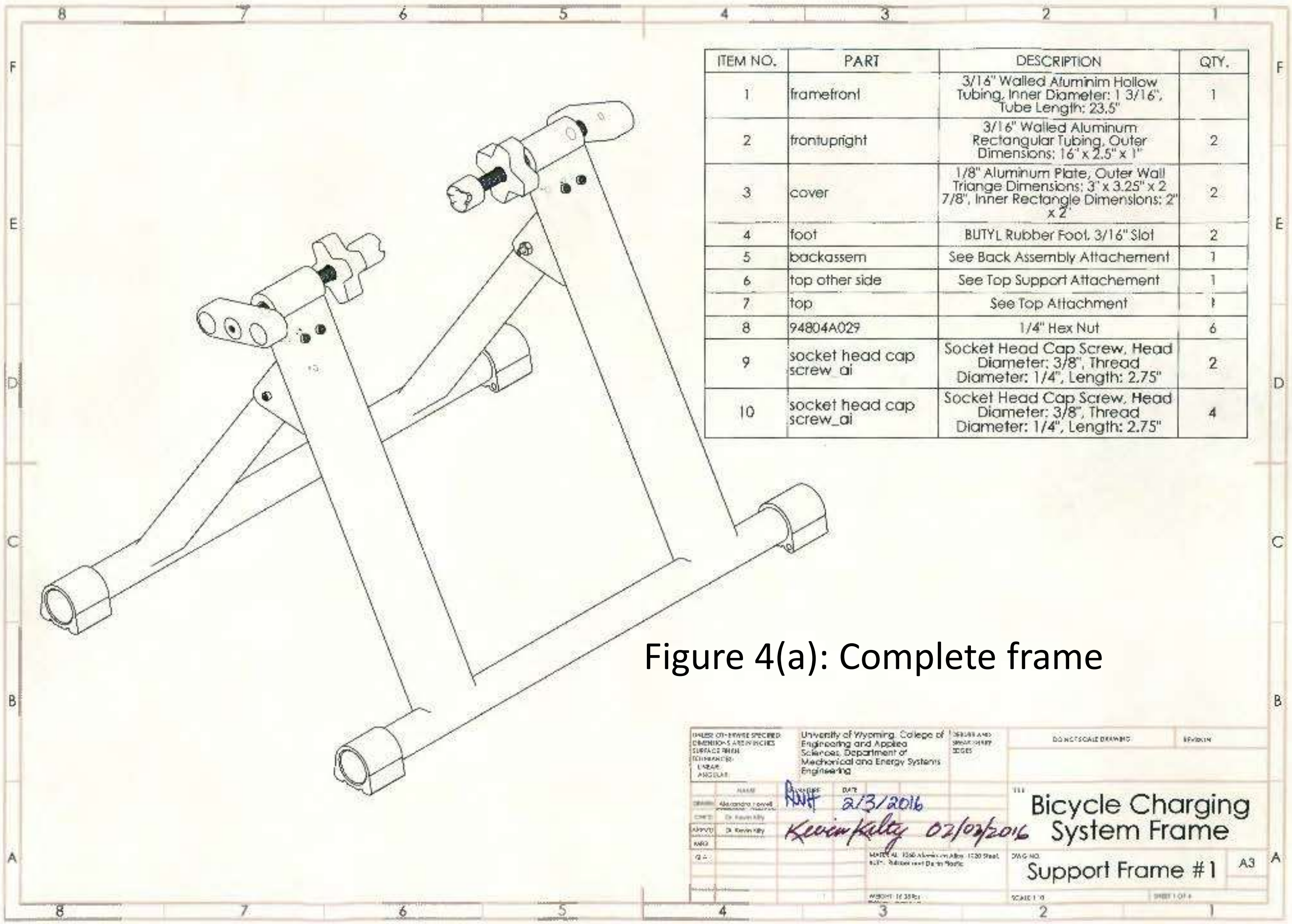


Figure 3: Integration of various sub-systems of bicycle-powered charger design.

Support Frame



ITEM NO.	PART	DESCRIPTION	QTY.
1	framefront	3/16" Walled Aluminim Hollow Tubing, Inner Diameter: 1 3/16", Tube Length: 23.5"	1
2	frontupright	3/16" Walled Aluminum Rectangular Tubing, Outer Dimensions: 16" x 2.5" x 1"	2
3	cover	1/8" Aluminum Plate, Outer Wall Triange Dimensions: 3" x 3.25" x 2 7/8", Inner Rectangle Dimensions: 2" x 2"	2
4	foot	BUTYL Rubber Foot, 3/16" Slot	2
5	backassem	See Back Assembly Attachement	1
6	top other side	See Top Support Attachement	1
7	top	See Top Attachment	1
8	94804A029	1/4" Hex Nut	6
9	socket head cap screw_ai	Socket Head Cap Screw, Head Diameter: 3/8", Thread Diameter: 1/4", Length: 2.75"	2
10	socket head cap screw_ai	Socket Head Cap Screw, Head Diameter: 3/8", Thread Diameter: 1/4", Length: 2.75"	4

Figure 4(a): Complete frame

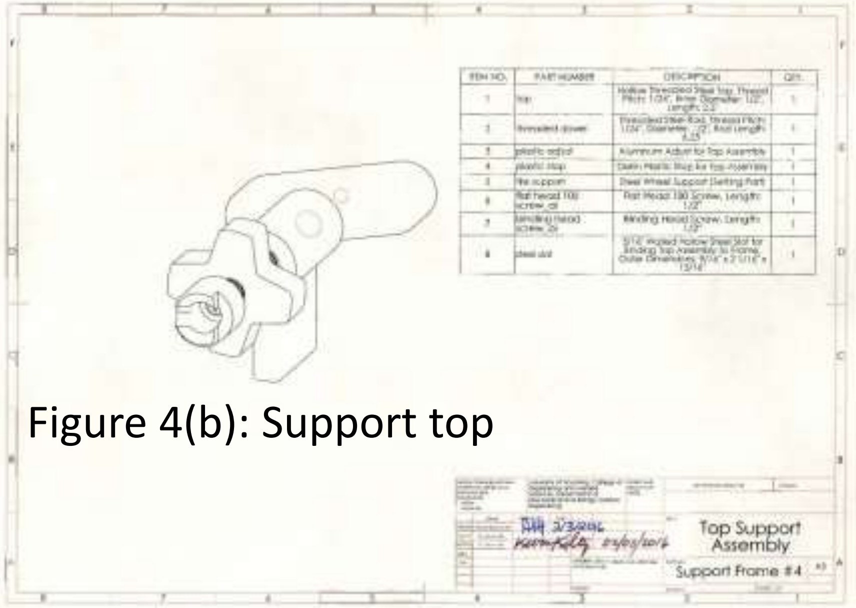


Figure 4(b): Support top

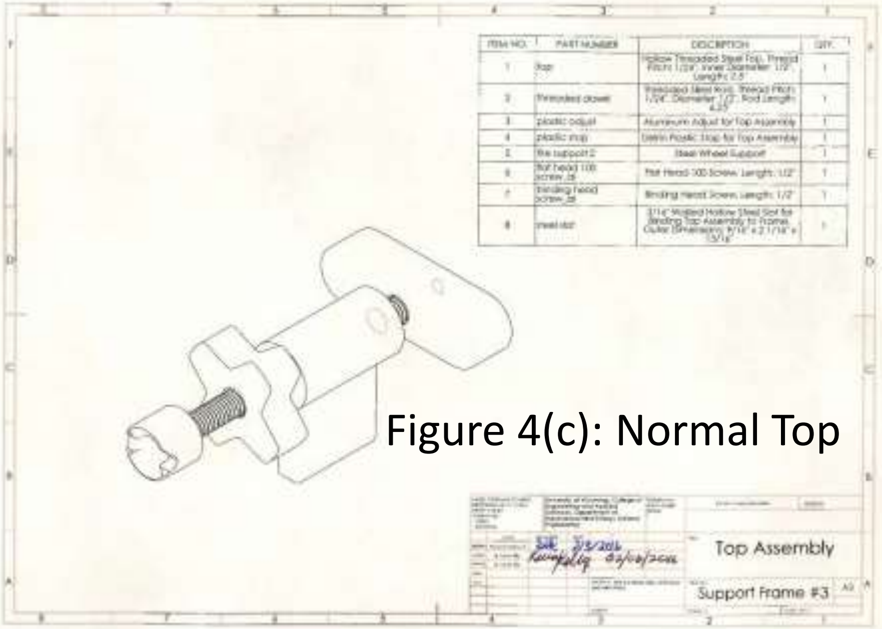


Figure 4(c): Normal Top

Shaft System

Table 3: Output of the new design plan for various bicycle tire diameters.

Diameter of Bicycle Tire (operating at 3 rps)	Output in RPM	Diameter of Bicycle Tire (metric) (operating at 3 rps)	Output in RPM
24”	1080	700x18	1165.5
25”	1125	700x23	1183.5
26”	1170	*700x25	1192.5
27”	1215	700x32	1201.5
28”	1260	700x35	1215
29”	1305	700x47	1233

*Size of test bicycle

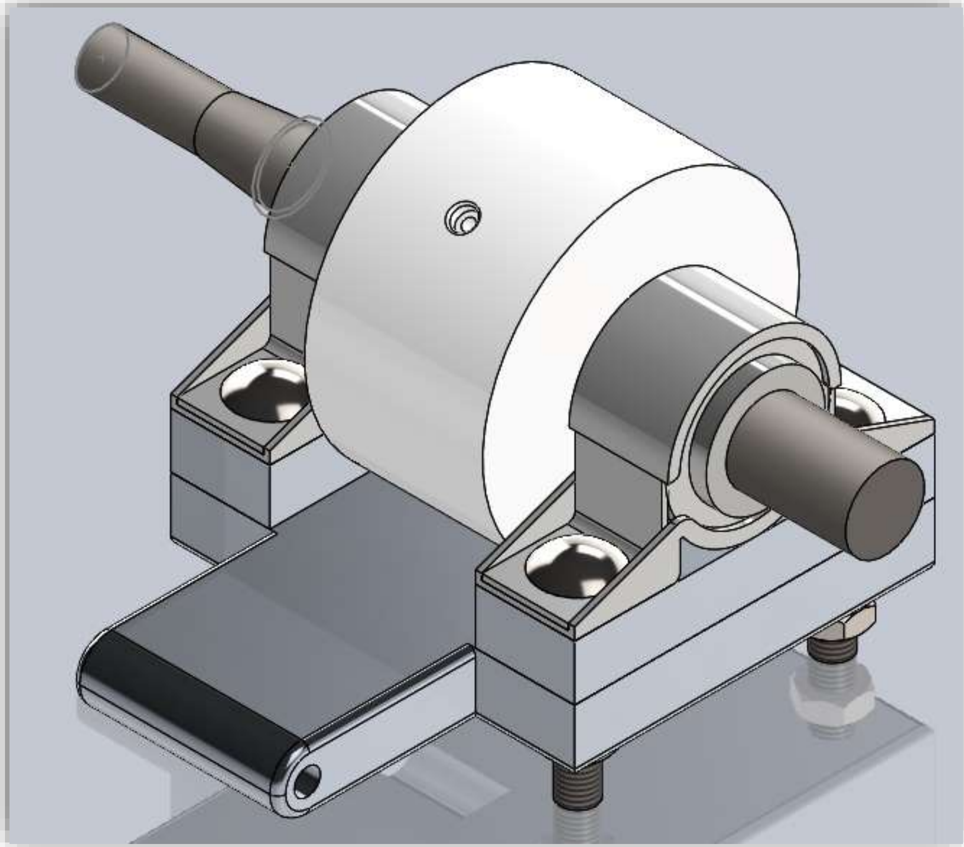


Figure 5: SolidWorks model of the shaft system spun by the rear bicycle wheel used to spin the rotor.

Generator

- ATV magneto stator
  - Bought rotor
  - Manufactured cover
- 13.4V generator
- Two outputs

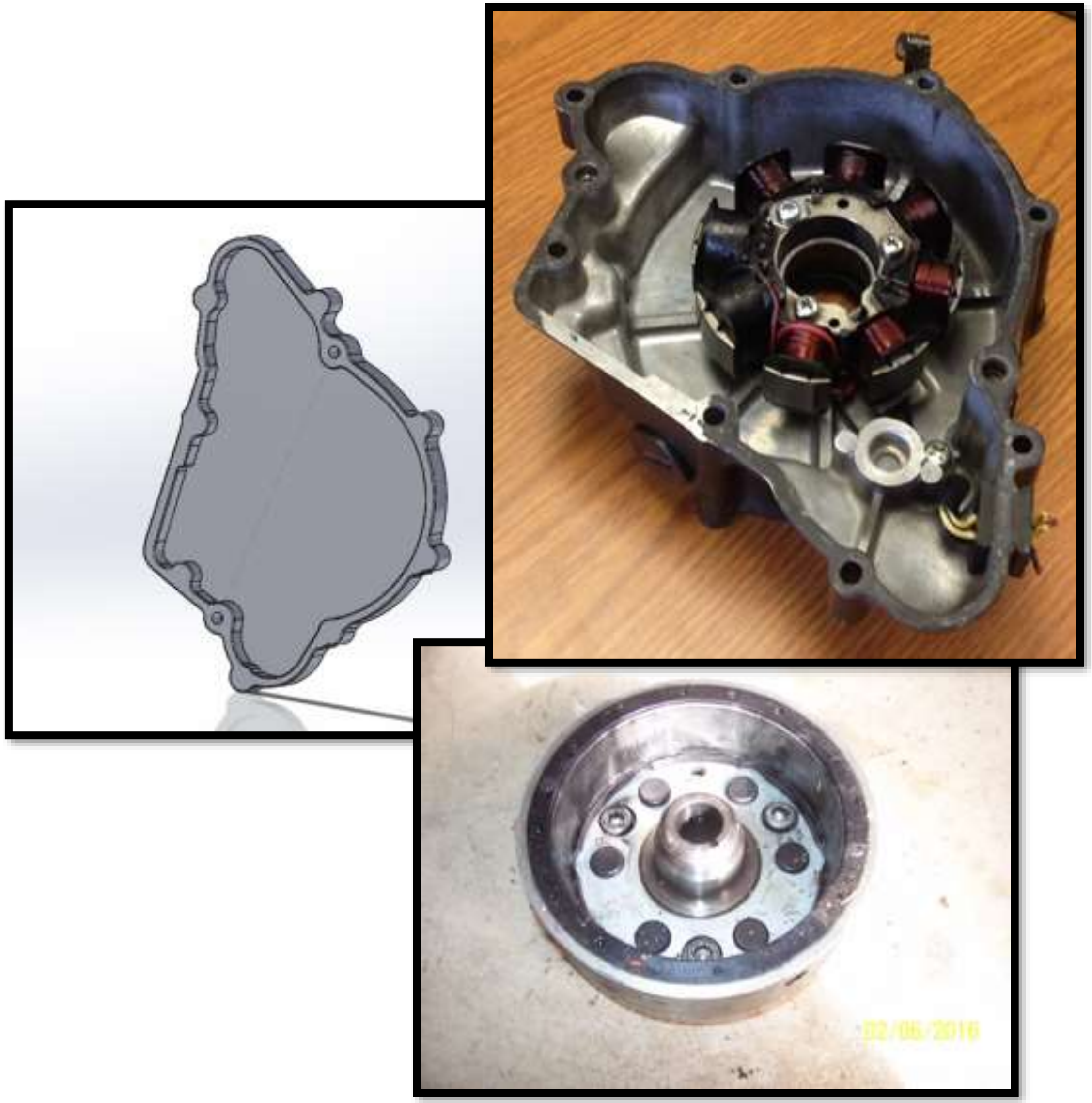


Figure 6. ATV magneto components.

Sub-System Integration: Unified Electronics & Control

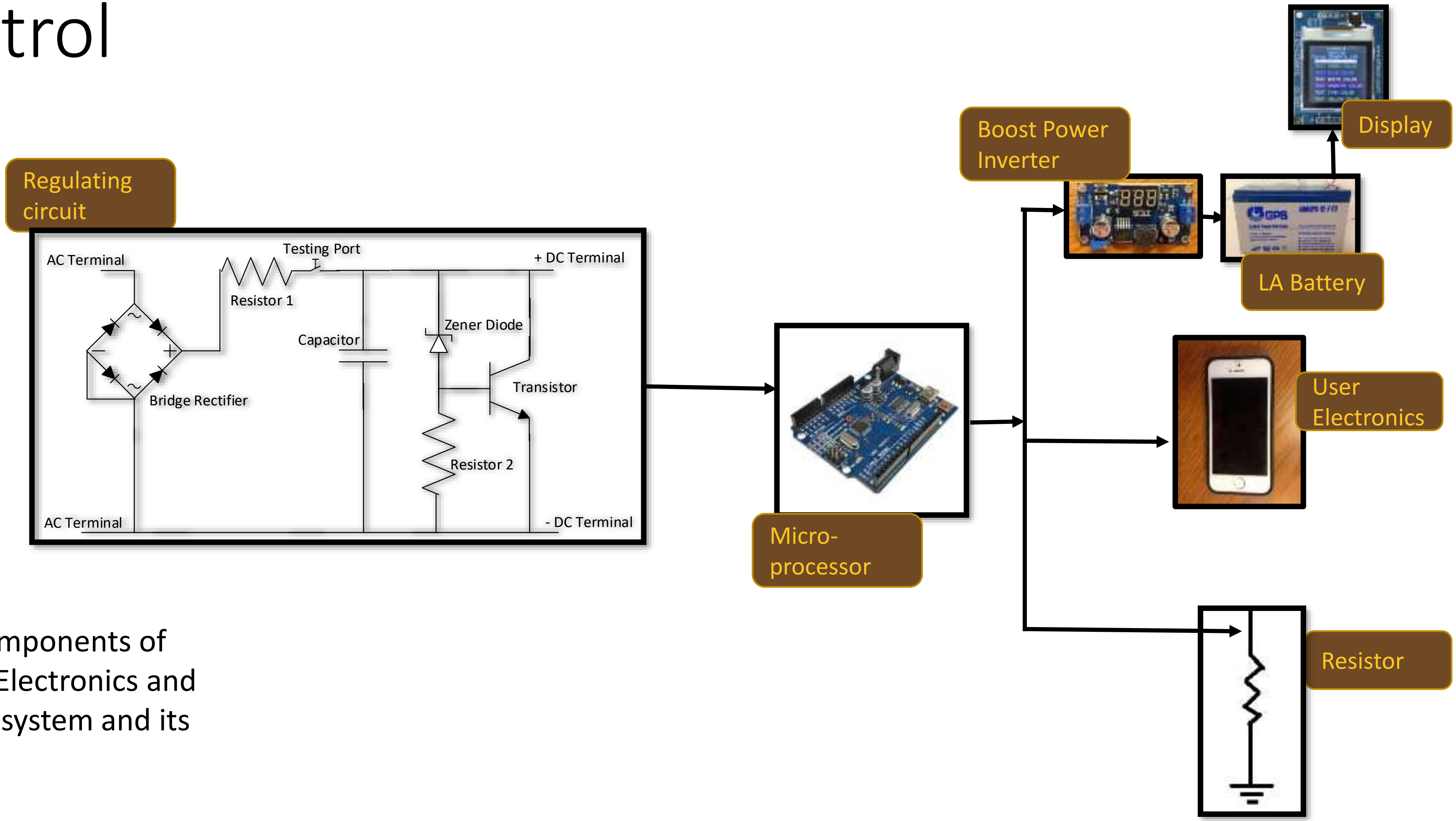


Figure 7: Components of the Unified Electronics and Control sub-system and its outputs.

Unified Electronics & Control

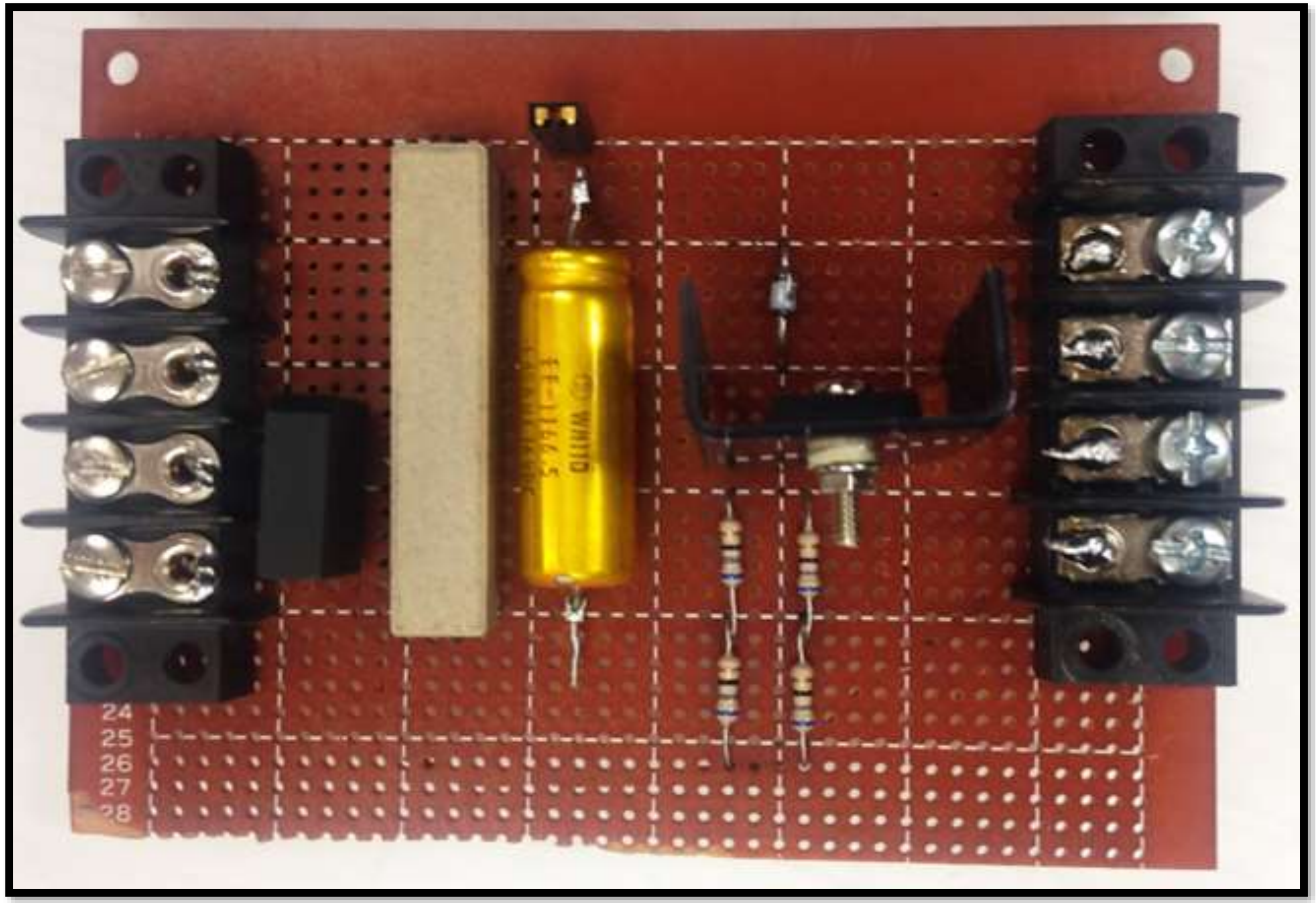


Figure 8: Shunt regulated power supply prototype.

System	Bicycle Powered Charging System	**Potential Failure Mode and Effects Analysis (Design FMEA)**	FMEA Number	1
Subsystem			Prepared By	Alexandra Howell
Component	Motorcycle Magneto		FMEA Date	4/5/2016
Design Lead		Key Date 4/30/2016	Revision Date	
Core Team	Alexandra Howell, Daylon Roitsch, Taylor Wollert		Page	1 of 1

											Action Results				
Item / Function	Potential Failure Mode(s)	Potential Effect(s) of Failure	Sev	Potential Cause(s)/ Mechanism(s) of Failure	Prob	Current Design Controls	Det	RPN	Recommended Action(s)	Responsibility & Target Completion Date	Actions Taken	New Sev	New Occ	New Det	New RPN
Permanent Magnet Motorcycle Magneto	Crack/break. Burst. Side wall flex. Lost magnets.	Magnetic field broken. System won't operate. During breakage may be hazardous to the user.	8	System operating at too high rmp. Movement of magnetic field. Child or pet tampers with system.	2	Display, detectable cracks, bends, breakage	5	**80**	Construction of lid to shield moving parts, testing of system limits	Design Team by May 2016	Construction of lid to shield moving parts, testing of system limits	8	1	5	40
Bicycle Trainer Frame	Crack/break/bend	Drops the bicycle	8	Overload the yield strength	2	Cracks, bend, breakage	5	**80**	Test for yield strength, tensile strength, stress	Design Team by May 2016	Test for yield strength, tensile strength, stress	8	1	5	40
Shaft System	Crack/break/bend	Damage and halt of product operation	9	Overload the yield strength of shaft and/or fasteners	2	Cracks, bend, breakage, audibility during operation	2	**36**	Test for yield strength, tensile strength, stress	Design Team by May 2016	Test for yield strength, tensile strength, stress	9	1	2	18
Electrical Components	Crack/break/bend /frayed wires	Harm to user, harm to system, fire hazard	5	Burn out/ cuts from sharp edges / long-term use	3	Visible crack/break/ bend/frayed wires	5	**75**	Purchase for durbility, shield from potential damage	Design Team by May 2016	Purchase for durbility, shield from potential damage	5	1	6	30
Battery	Explosion, leaks of corrosive/acidic fluids	Fire hazard, acid burns, toxic fumes, shrapnel	10	Failure of Electrical components	2	Display, visible corrosion	3	**60**	Prevent overcharge of battery, prevent damage to electrical components	Design Team by May 2016	Prevent overcharge of battery, prevent damage to electrical components	10	1	4	40

FMEA: Bicycle Frame

- Sources of Failure and Effects
- Testing:
  - Yield strength
  - Ultimate strength
  - Stress
  - Stability
  - Strength and fatigue of welds

Testing: Plan

- Strength
- Stability
- Safety
- Electrical Outputs
- Display

Testing: Generator Output

- Voltage & current outputs from ATV magneto

Table 4. ATV magneto output results.

Wire type	Voltage	Current	Power
Charge	7 V rms	2 A	14 W
Spark Plug	140 V rms	-	-

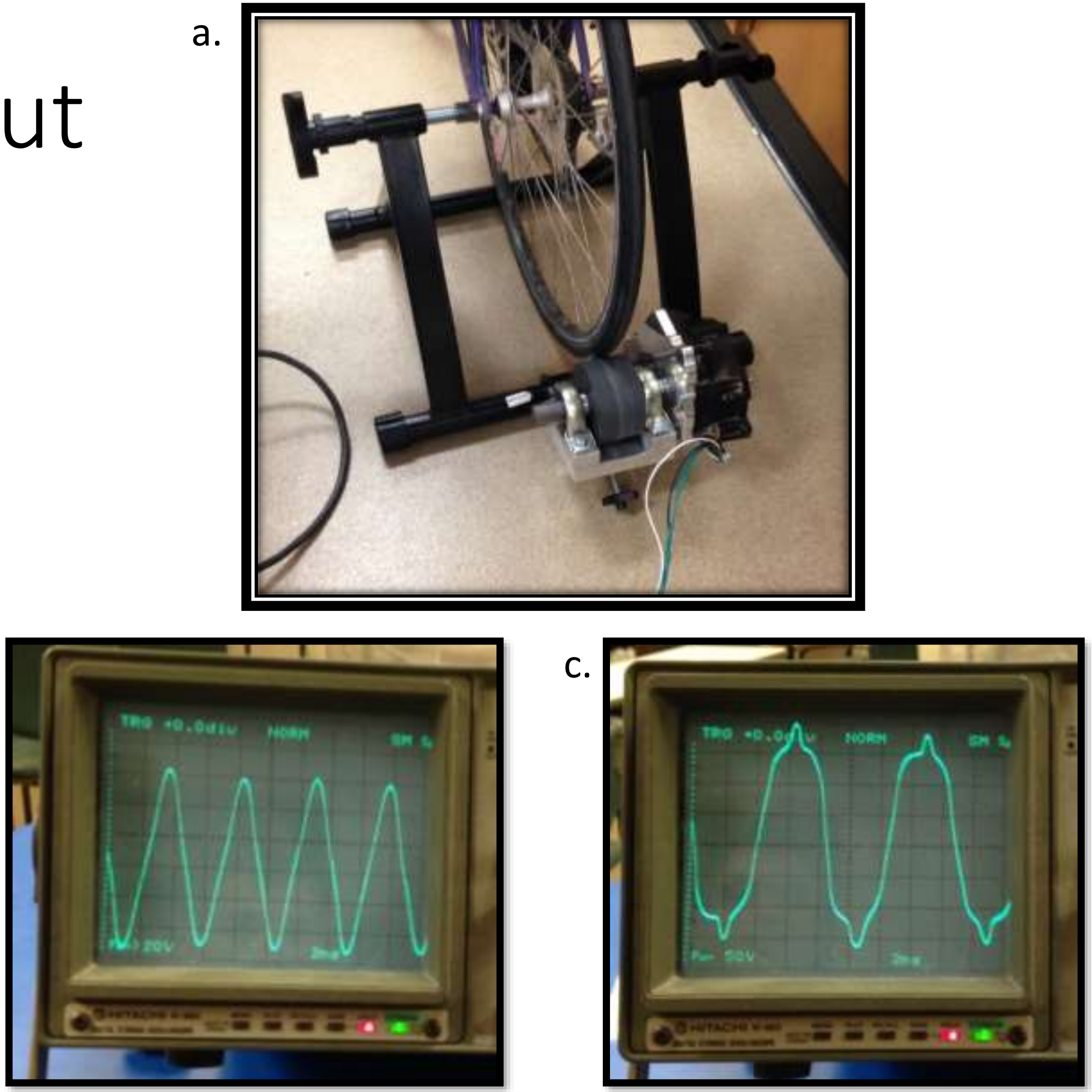


Figure 9: (a) Bicycle test setup, (b) charge wire test, (c) spark plug wire test.

Testing: Generator Output

Testing: Shunt regulated power supply

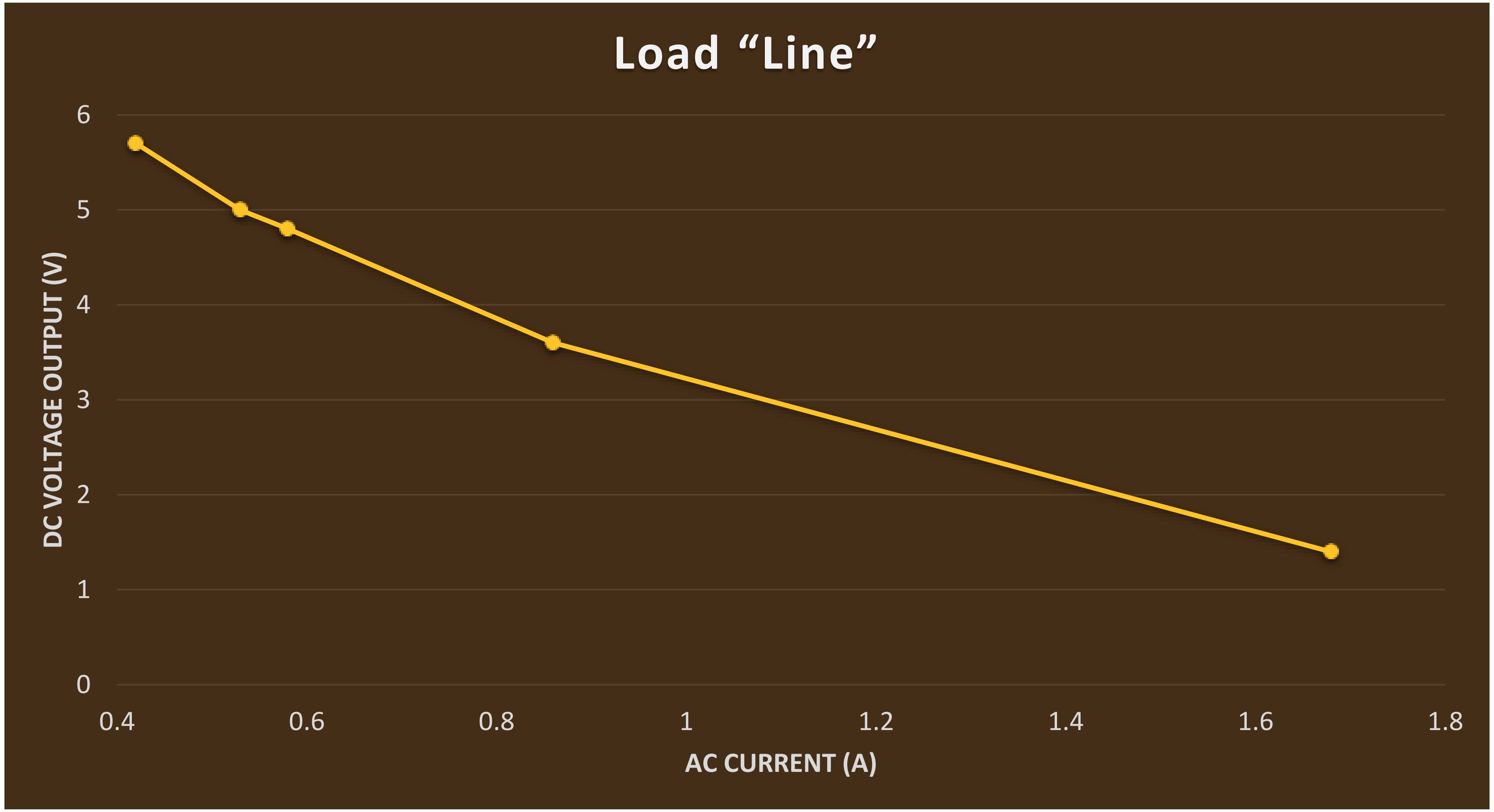


Figure 10. Shunt regulated power supply testing results. A standard 7 V RMS AC source was used.

Commercial Viability

Table 5. Material & manufacturing costs spreadsheet used to analyze commercial viability of mass producing bicycle-powered charger systems.

Sub-system	Cost
Unified Electronics and Control	$ 16.45
Display	$ 15.00
Charging System	$ 35.50
Roller System	$ 47.12
Contracted Generator	$ 20.00
Contracted Frame	$ 30.00
Total Integration Cost	$ 164.06

Consumer Price Range $300-$400