Bike Generator with Fitness Monitoring

ECE 445 Design Document

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1 Introduction

1.1 Objective

Obesity is a serious threat to the well-being of people. It affects 93.3 million American adults and is often the cause of type 2 diabetes [1][2]. Exercise is the most important action humans can take towards keeping a healthy body. Unfortunately, many Americans have cut exercise from their daily routine. We drive to work only to sit at work. There are standing desks but standing is similar to sitting in terms of exercise. For many working Americans, the only time they exercise is during their leisure times. Many of them do not have the motivation to exercise because the consequences for inactivity occur far into the future for them. The objective of this project is to provide additional benefits including charging a battery and monitoring their fitness to give them more reasons to exercise. The impact of this project could be huge since over 100 million Americans have bikes but don't use them, and the average American watch over two hours of television every day [3][4].

The project has two main aspects. One aspect is creating a micro power generation station for bicycles. The other aspect is creating a subsystem which calculates and displays a user's exercise stats. All that is required from the user is to have a bike on which to use the device. It should not be an invasive process, so the user does not need to take apart the bike. The power generator of this project is meant to charge small devices. Larger machines would not be suitable with this project.

1.2 Background

There are few companies that tackle the same problem the same way and their products are $600 [5]. Exercise bike allow for cycling indoors but those can be $60 to over $1000 [6]. There are also smaller products that can charge smaller things like your phone or headlights but use dynamos instead of a typical generator. These dynamos can cost anywhere from $10 to $50 and do not generate much power [7]. In addition, most people have a plug that they can charge their phone with. These phone chargers cost less than $10 [8]. We want our product to be relatively cheap, be used as an exercise machine, be easy to set up, and generate power that can charge a laptop. For example, if there is a blackout, our device can charge phones to be used in emergency communications.

1.3 High-Level Requirements

- Bike generator must be able to net at least 25 watts of power, which is the power generated by the alternator minus the power taken from the battery to energize the alternator.
- Our fitness monitor must be able to track the calories burned and energy generated to 3 significant digits. Calories burned must be estimated using an algorithm. Energy generated must be measured.
- Our setup must take less than 5 minutes and require zero outside tools besides the user's bike. The user can remove the bike from our setup in less than 5 minutes. This requirement would differentiate our project from other bike generator projects as invasive procedures in the setup would require more than 5 minutes and outside tools.

2 Design

2.1 Block Diagram

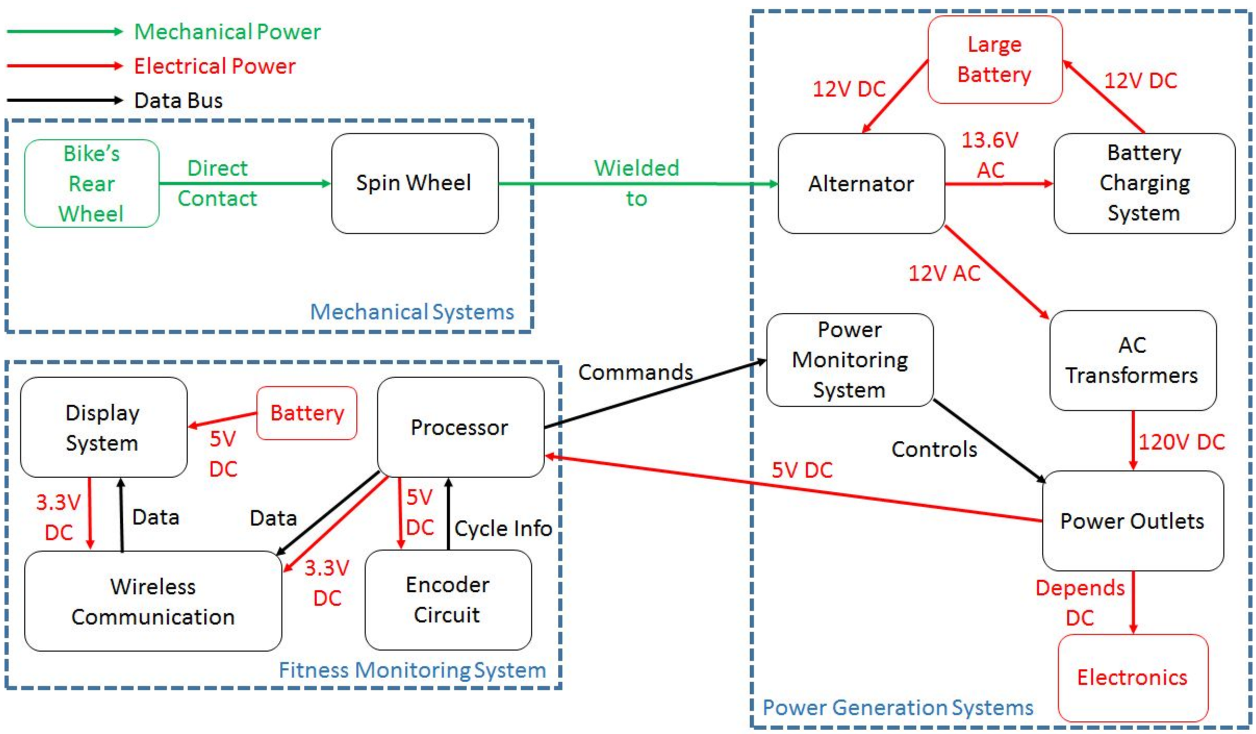

Figure 1: Block Diagram

2.2 Physical Design Sketch

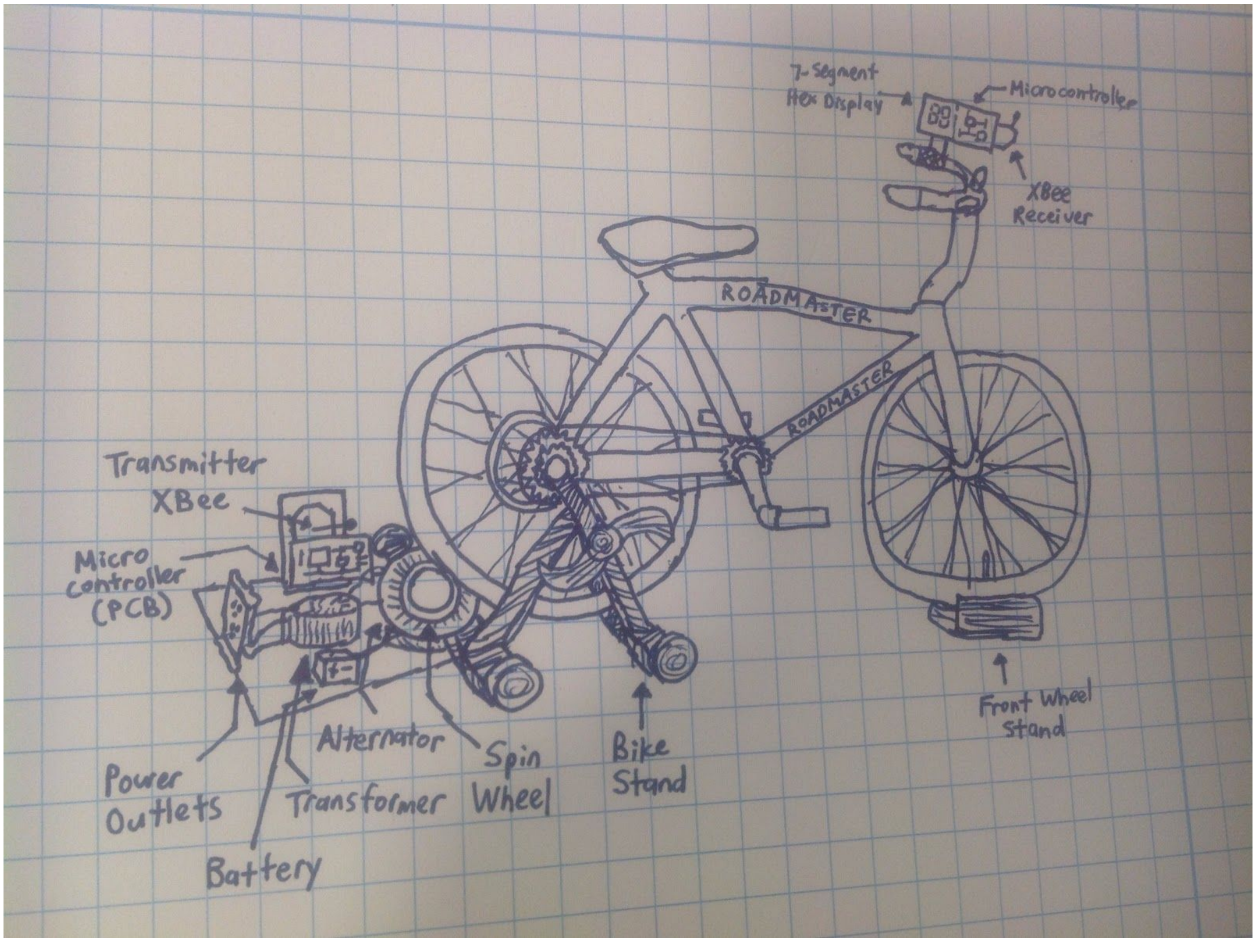

Figure 2: Physical Design Sketch*

***Please note that the sketch only gives where each important item of our design would be generally located. Other details like how many digits our 7-segment display contains or how the wires are connected in this sketch may not be representative of the final model.**

2.3 Mechanical Systems

The mechanical system will be created by the ECE machine shop. There are two aspects of the mechanical system. The mechanical system will need to support the bike, and keep it stable, as well as spin the alternator at a fast enough speed for it to generate power. The alternator has a turn on speed of 1415 revolutions per minute [9]. The torque constant at the turn on rate is 1.28 newton meters which comes from knowing that the diameter of the alternator wheel is 1.75 inches. As the alternator moves faster, it will generate more current, but will also require a higher torque. The mechanical system will have to spin the alternator at the turn on rate to generate any power. This is a concern since it requires 190 Watts of mechanical power to run the alternator at that speed and torque. Additionally there will be frictional losses which will require more mechanical power to overcome. To prevent slipping between the bike and alternator 80 N needs to be applied between them.

Since this portion is mainly made from the machine shop, there would be no need to create a requirement and verification. Likewise, there would be no need to assign points here.

2.4 Power Generation Systems

The power generation systems will consist of systems which are needed for the generation, storage, regulation and monitoring of electric power. The alternator is the generator used to generate AC power. The alternator will be energized by a large 12 volt battery, which will in turn be hooked up to a battery charging system. In parallel, to the battery charging system, the alternator will output 120 volts to household power outlets, which can be used to provide power to the user's electronics. Additionally, the power monitoring system will monitor the voltage and current produced by the alternator, and will send these signals to a microprocessor, which will be used to calculate the power produced. This value will then be wirelessly communicated to a hex display which will display the value to the user.
The goal of this project is to produce 25 watts net power. The alternator requires 17 watts in order for the system to generate any power. An additional sub goal is the have a power generation system with the highest efficiency by reducing or eliminating as much power consumption by the system as possible. The project will need to produce at least 50 watts gross power in order to be a successful power generation project.

2.4.1 Alternator

An alternator will be used to generate AC power. The alternator has been purchased from advanced auto parts. The alternator has an excitation power of about 17 Watts. This means that for the alternator to be energized, it will consume 17 watts from the battery. The alternator also has a turn on speed of 1415 revolutions per minute [9]. As the alternator spins faster, it will generate more power, but also have a higher torque constant.

Since this portion is bought, there would be no need to create a requirement and verification. Likewise, there would be no need to assign points here.

2.4.2 Battery Charging System

The battery charging system will use a bridge rectifier to convert the AC voltage into DC voltage. A switching regulator will then be used to ensure safe operation of the battery. Currently, the regulator design will be a buck regulator. The maximum theoretical efficiency of a bridge rectifier is 81.2% [10], so 80% efficiency should be achievable. A buck regulator often has an efficiency exceeding 90% [11], thus 90% should be easily achievable. Both of these parts will be purchased, thus a requirements and verification table is unnecessary.

$$P_{stator} = V_{stator} \cdot I_{stator} = 6.8\ V \cdot 2.5\ A = 17\ W \tag{1}$$

To excite the alternator, 17 watts will be required. This value was found by multiplying the field current and the excitation voltage [9].

$$Eff_{total} = Eff_{Reg} \cdot Eff_{Rectifier} = 81.2\% \cdot 90\% = 73\% \tag{2}$$

Given the efficiencies of the components mentioned above, the efficiency of the total battery charging system will be 73%. This means that the battery charging system will use 25.8 Watts.

The work below is for a buck regulator.
Buck Rectifier calculations:
Vbe=0.2,
α=100
Unsafe battery voltage =13V
Voltage after rectifier=13.1V
Voltage after rectifier=VC
Battery voltage=Ve
In linear region:

$$IE = IB \cdot (1 + \alpha) \tag{3}$$

$$VB = Ve \cdot R_1 \div (R_1 + R_2) \tag{4}$$

$$VBE = VE \cdot R_2 \div (R_1 + R_2) \tag{5}$$

When the battery voltage increases, V_B will increase making V_{BE} and V_{BC} decrease. This will decrease the current conducted into the battery. The BJT will decrease the rate at which the battery increases its stored energy. Once the battery voltage reaches 13 volts, the bjt will open the circuit, and cut the current down to zero amps.

For switching transitions, the energy stored during steady-state operation:

$$E = .5 \cdot V^2 \cdot C + .5 \cdot I^2 \quad (6)$$

The capacitor will dominate the voltage transfer characteristics when the regulator has turned off.

2.4.3 AC Transformers

Different voltage levels are required by the electrical system. Due to this fact, AC transformers will be required to step up and down the voltage. AC transformers will be purchased. AC transformers will be used to step the voltage level to 120 volts. An AC transformers may also be used to step the voltage down to charge the battery.

$$Eff = \frac{P_{out}}{P_{in}} \quad (7)$$

Efficiency of transformer = 93.75%. According to the transformer, the input is 120 volts and 0.52 amps , the output is 11.7 volts and 5 amps [12]. The input power is 62.4 watts and the output power is 58.5 watts. The efficiency is assumed to be similar when it is operated in reverse. [12]

2.4.4 Power Monitoring System

The two key components of the power monitoring system are a microprocessor, and a current to voltage transducer. The transducer is used to change the current produced by the alternator into a voltage signal. The voltage divider circuit is used to scale the voltage down and then have the voltage read by the analog input of a microcontroller. The voltage divider circuit will use a very high resistance. This is because a high resistance voltage divider will divert less power from the circuit than a lower resistance voltage divider circuit. To calculate the power produce by the alternator, the instantaneous voltage and current must be measured by the circuit, then instantaneous power is determined by multiplying by the absolute value of the two values. This is not useful by itself since the average power is what is wanted; since instantaneous power cycles between 0 and max value. So the energy of the cycle must be calculated using the riemann sum of the values and divided by the time of a complete cycle.

Requirements	Verification
1. The power monitoring system will need to accurately calculate the power generated during operation. The expected amperage produced will be between 15 and 20 amps at 12 volts dc +/- 5%. The power monitoring system will be calibrated to be very accurate in this range. The goal will be at least 90% accuracy. [5 points] 2. The processor should be processing rate of at least 10 kHz. It can be higher.[5 points]	1. A. Using the oscilloscope, measure the voltage and current using the two probes and calculate the power being produced. B. Have the monitoring system calculate power being produced. Compare the two different output power and make sure they do not have a 10% difference. 2. A. Set the clock rate of the processor to highest possible setting. B.Connect the clock signal to an oscilloscope and check to make sure it is above 10 kHz.

2.5 Fitness Monitoring Systems

The fitness monitoring system will use a rotary encoder to determine how far a bike has travelled. Edge detection will be used to count the number of transitions of the Z signal of the rotary encoder. There will be circuitry which will ping the digital input of the microprocessor to let the microprocessor know that how far that the wheel has travelled. The resolution of the fitness monitoring system will depend on the size of the encoder wheel, and can be modified. The microprocessor will then calculate how fast the user is travelling. This velocity value can then be used to calculate the energy burned. The fitness monitoring systems will also wirelessly transmit data from the processor to a hex display.

2.5.1 Encoder Circuit

A rotary encoder enables the circuit to determine how far the user has travelled. A 3 phase incremental rotary encoder will be used in this experiment. This encoder will be mounted on a very small wheel which is in contact with the bicycle wheel. Phases A and B are normally used to determine changes in position which account for less than one rotation, and phase Z is used to determine when the encoder has completed a full rotation. In this case, since this wheel will already be of very small diameter when compared the the bicycle wheel which it is tracking, extreme precision is not needed. As such, only phase z will be tracked.

Edge detection will be used to determine when phase z changes from high to low. This will be accomplished using two d latches set up in series. When the D latches register the transition from high to low, this will send a high signal to a digital input pin on the processor to let it know that a transition has happened. The width of the z phase of the encoder varies depending on the speed of the wheel. This is because it will pulse high whenever the encoder passes a specific position in its rotation. As such, if the processor is sampling the encoder, it may result in an inaccuracy when the wheel is stopped, or is rotating slowly.

The processor will interface with module to calculate the speed of the bicycle wheel, and the distance that the wheel has traveled. The processor will calculate the calories burned using algorithms which estimate these values based off of basic biometric inputs such as weight, age and height.

Requirements	**Verification**
1. The encoder circuit will accurately detect edges in phase z, to make sure the processor accurately counts turns of the wheels.[5 points] 2. The encoder circuit will be created on a pcb, which interfaces with the processor.[5 points]	1. A. Oscilloscope traces of the encoder circuit will be included,the circuit must count once per turn regardless of the speed at which the encoder is turning. B. The encoder will need to accurately resolve the speed and distance the wheel has travelled. 2. The PCB must have the components required for the encoder to count, and must interface reliabally with the processor, this will be verified using oscilloscope traces.

2.5.2 Processor

The main purpose of the processor is to calculate the rider's exercise statistics. This will include the distance travelled, current speed, and total mechanical energy output from his or her session. The mechanical energy comes from the adding the instantaneous power multiplied by the time it for the processor to get a new value for instantaneous power (Riemann Sum calculation). This is the value for energy produced by the alternator. Which can be used to estimate how much energy he or she has burned [13]. The processor has a switch to turn itself on and off, as to not take away power that is generated.

Assuming a 26 inch bike wheel, (26 inch is the diameter), the circumference is πd, or 26 * 3.14159 * 2.54(cm/inch) / 100 (cm/m) = 2.07 meters. Ten cycles would mean 20.7 meters. 20.7 * 0.9 = 18.7. 20.7 * 1.1 = 22.8. Therefore, the number of cycles should be between 19 and 22 to be within 10%.

The power analyzer will determine the voltage and current that is produced at the power outlets. Our processor must output a value within 10% of that in kilojoules. We will attempt to match the load before calculating the maximum wattage.

Requirements	**Verification**
1. The processor must calculate distance travelled in meters to within 10% based on encoder input. [4 points] 2. The processor must calculate energy produced from the generator to within 10% in kilojoules. [6 points] 3. The processor must calculate speed in meters per second in tenths of meters to within 10% based on encoder input. [4 points]	1. A. Connect the bike to the spin wheel of the alternator. B. Using hands on the rear wheel, spin it for a ten cycles. C. Check the bits output to the XBee. The number should be between 19 and 22. Calculations above. 2. A. Connect the bike to the spin wheel of the alternator. B. Connect a power analyzer to the outlet. Alter the resistance connected in series with the alternator until the load is matched. C. One person should ride the bike. The other person checks the bits output to the XBee. D. Multiply the current squared with the resistance to get the wattage. Divide by 1000 and check that the output of the XBee is within 10%.

	3. A. Connect the bike to the spin wheel of the alternator. B. One person use his hands on the rear wheel and spin it steadily for ten cycles. Another person records the input and time to complete ten cycles using a stopwatch. (1 cycle is equal to 2.07 meters with calculations above.) C. Count the number of cycles in the recording, and compute speed.

2.5.3 Wireless Communication

XBees are wireless chips that can act like serial ports except without a wire. This design is useful as it spares a wire to connect between a display, which is shown to the user at the front of the bike, and the processor, which is located at the back of the bike with all the other parts. Check Figure 2 for reference.

Requirements	**Verification**
1. XBee must transmit 80 bits to the other XBee correctly. [5 points] 2. Takes less than 1 second to transmit between the two Xbees. [1 point]	1. A. 80 bits of low and high voltages will be sent into transmitting pin of a XBee one at a time. B. A voltmeter will measure the voltage of the receiving pin of the other XBee and see if all 80 bits are displayed correctly. 2. A. Use a stopwatch to measure the time it takes to get a update on pins.

2.5.4 Display System

Power will be supplied by a battery to provide a voltage to the display system, which is composed of a microprocessor and a four digit 7-segment display. The microprocessor is responsible for deserializing the input from the XBee into an input that the 7-segment can recognize. The 7-segment display will display the digits of the number. The display system will cycle through calories burned, current speed, and energy generated. It will cycle between the three values every 5 seconds,

Requirements	Verification
A binary representation of a 4 digit number will be passed into the microprocessor via XBee. The 7-segment display must show that specific 4 digit number. [10 points]	A. Check to make sure XBee is operational. B. Send a binary representation of a 4 digit number into one of the XBee. C. Check that the 7-segment hex display reveals the correct 4 digit number. D. Check to see that display changes what current value is being shown (between the three values), every 5 seconds.

2.6 Schematics

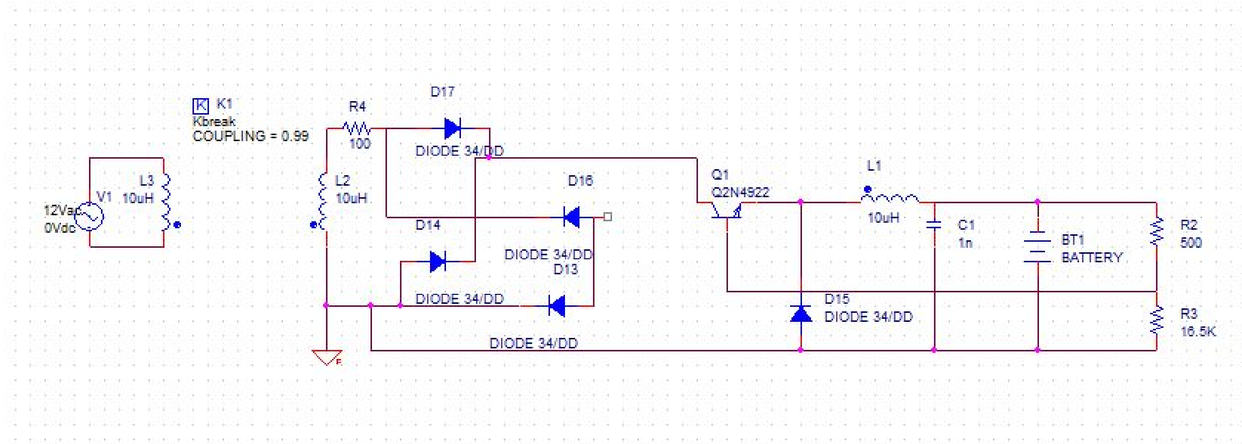

Figure 3: Schematic of the regulator

2.7 Board Layout

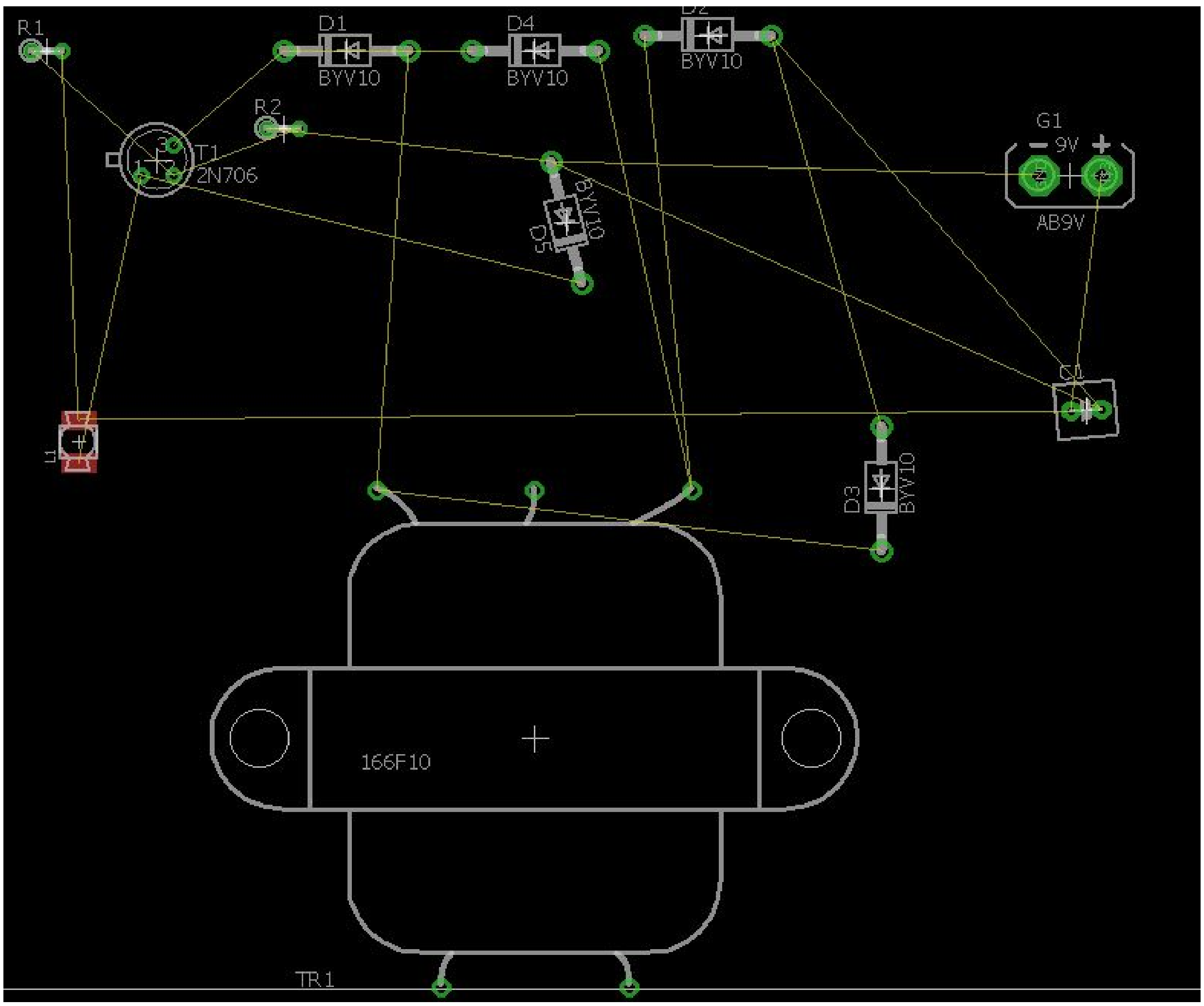

Figure 4: Board layout for power regulator with a transformer

2.8 Software

There are two microprocessor that will be programmed. The first microprocessor will be connected to the encoder circuit and calculate various statistics of an exercise session. The clock on the microprocessor will determine which statistic needs to be displayed. This data will then be sent to the XBee to transmit to the display system.

The second microprocessor is programmed to convert the input from the XBee to the appropriate input of a 7-segment display.

Potential flaws within our algorithm is that it cannot deal with numbers larger than four digits as that is the number of digits the 7-segment can display. As of now, our algorithm will have the number reset whenever a number requires more than four digits. For example, this value could be 10 megajoules of energy produced, 10 kilometers travelled, or 100.0 meters per second, depending on the context.

There are different models on how to calculate the calories burned from the user, and since we don't the exact efficiency of the system we don't know the exact values that should be used. In general using speed of the bike and the energy produced from the alternator will allow the user to determine calories burned for an average person. The calories burned should always be higher than the energy produced from the alternator. It will be a riemann sum as the calories burned as the user non-constant biking speed will have to be taken into account.

One example model from Bike Review:

$$Calories/\,hour = 7.2 * [V\,W(0.0053 + \%G/100) + 0.0083\,V^3] \tag{8}$$

where V is the speed, W is the weight of the bike and the rider (which will be approximated at 75 kilograms), and %G is the grade in percent. [17]

2.8.1 Flow Chart

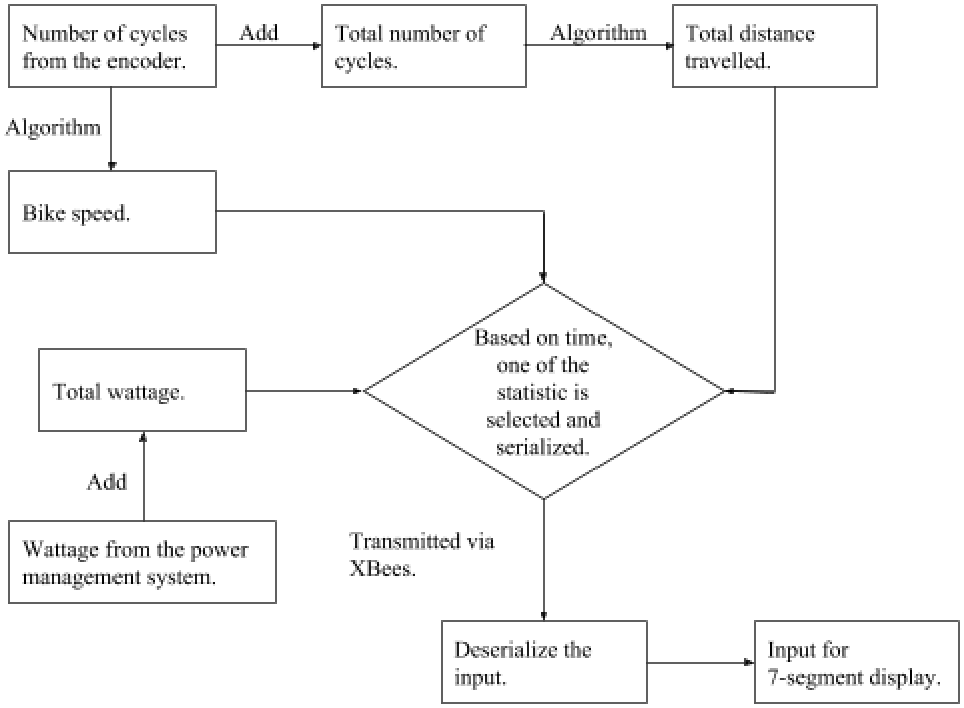

Figure 5: An abstract flow chart on how our microcontroller will be programmed.

2.9 Tolerance Analysis

The most important feature of the project is generating power at comfortable biking speeds with the alternator. The alternator has a performance curve showing the current at different RPMs, and shows a linear relationship from 0 A, 1250 RPM to 31 A, 2000 RPM.

$$I = \frac{31A}{750RPM} \cdot v - 51.67A \tag{9}$$

The tolerance of the alternator is not specified and cannot be measured at the current time, so a +/- 5% tolerance is assumed for the current and the output voltage of 12V. Since power of a given electrical system is given by

$$P = IV \tag{10}$$

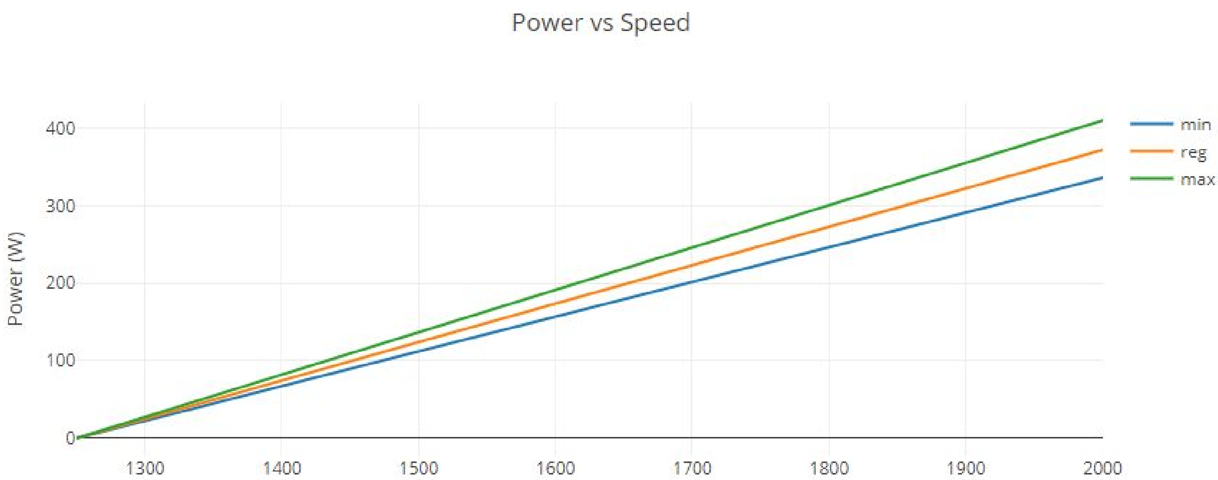

Figure 6: Power graph

The max power is 410 W, the regular power is 372 W, and the minimum power is 336W at 2000 RPM.

A human is comfortable at biking speeds from 10 mph to 20 mph. Most bikes have a wheel diameter of 26 in and the project is designed for a 26 in wheel, so the RPM at these speeds is given by

$$v = \frac{speed}{2\square\ D} = \frac{10\ mph}{2\pi \cdot 26\ in} \cdot \frac{63360\ in}{1\ mile} \cdot \frac{1\ hr}{60\ min} = 64.64\ \mathrm{RPM} \tag{11}$$

The comfortable speed range is 64.64 RPM to 129.28 RPM. The diameter of the spinning wheel of the alternator is 1.75 in. so the speed of the alternator wheel is given by

$$v_{alt} \cdot D_{alt} = v_{bike} \cdot D_{bike} \tag{12}$$

So the alternator would be spinning from 960 RPM to 1920 RPM on a comfortable ride. 960 RPM is lower than the required 1250 RPM, so the person is required to bike at least 84.13 RPM or 13 mph just to start making power. From our losses, it can be estimated to 50% efficiency for making power, so the alternator needs to make 50 W of power rather than the 25 W, so from (1) and (2) and the tolerances the alternator wheel needs to spin at 1362 RPM, and the person needs to bike at 91.65 RPM or 14.2 mph. The last thing to check is the force the person is exerting on the pedal. When a person walks they exert close to their weight on the ground but 2 - 2.9 times their weight when running to sprinting [14], so the force on the pedal exerted should not be beyond this limit. Torque is calculated using

$$P = \tau \cdot 2\pi \cdot v \tag{13}$$

The angular velocity of the pedal is dependent on the gear the bike is in and the length of the crank is 160mm to 185mm. Most bike have 3 gear which have ratios .733, 1, 1.364 [15]. Using the gear ratio of 1.364, the torque at the pedal is

$$50\ watts = \tau \cdot 2\pi \cdot \frac{91.65 RPM}{1.364} \cdot \frac{1 min}{60\ sec} \tag{14}$$

The torque is 7.11 Nm, with the smaller crank size of .160 m, the force applied is 44.4 N or 10 lbf. So a person should be able to comfortably generate the smallest amount of power required.

3 Costs and Schedule

3.1 Cost Analysis

The cost of this project depends on labor and the parts. The details are outlined below.

3.1.1 Labor

A decent rate for entry-level engineers is $30 an hour. Although the number of hours per week can range anywhere from 3 to 20 hours, the expected number of hours per week is 10. According to the schedule, this project would require 10 weeks of work, excluding the necessary paperwork that comes with the project. The factor of 2.5 is there to represent the cost of hiring, perks that come with employment, and insurance. The machine shop will take approximately 3 days to attach the alternator to the bike stand, which is 0.6 weeks.

Name	Hourly	Hours / Week	Weeks	Factor	Total
Daniel Davidar	$30	10	10	2.5	$7500
Micheal Westfall	$30	10	10	2.5	$7500
David Zhang	$30	10	10	2.5	$7500
Machine Shop	$50	40	0.6	1	$1200

3.1.2 Parts

The parts required by our project are listed below. Costs are estimates. Some of the items listed are already provided for us by the design lab. Certain items, like the power diodes, comes in a pack, which could result in a strange value for cost per unit.

Part	Quantity	Cost Per Unit	Total Cost
Bike Stand	1	$51.22	$51.22
Battery	1	$43.59	$43.59
Car Alternator	1	$79.56	$79.56
32-bit Microprocessor	2	$1.82	$3.64
Current to Voltage Transducer	1	$9.95	$9.95

Power Diodes	10	$0.924	$9.24
Rotary Encoder	1	$39.95	$39.95
Hex Display	1	$3.95	$3.95
High Current BJT	1	$10.29	$10.29
Capacitor	1	$0.10	$0.10
Inductor	1	$0.29	$0.29
Resistor	10	$0.15	$1.50
Transformer	2	$18.55	$37.10
Power Outlet	1	$4.34	$4.34
Switches	2	$3.60	$7.20
D-Latches	10	$0.37	$3.70
8-bit Adder	1	$1.60	$1.60
Logic Gates (ANDs)	10	$0.51	$5.10
XBee Transceivers	1	$19.00	$19.00
XBee Shield	1	$7.50	$7.50
Total	**59**		**$338.82**

3.1.2 Grand Total

The cost of the project is the cost of labor plus the cost of the parts. For development, the labor cost $23,700. The parts cost $338.82. Together, the cost is $24,038.82. The labor cost covers 98.6% of the total cost. In industry, the labor cost could be reduced as the number of hours needed make our project can be cut from 324 hours to about 4 hours as many parts are pre-made and the designing and testing portions of the process would be excluded. At a cost of $75 an hour, this project would cost $638.82.

3.2 Schedule

Week	David	Daniel	Micheal
9/17/18	Partner with Daniel to obtain a suitable alternator.	Partner with David to obtain a suitable alternator.	Search online for funding sources.
9/24/18	Obtain a suitable bike stand and check for issues.	Test the alternator for issues.	Obtain a suitable battery to power up the alternator.
10/1/18	Complete the design document with emphasis on any section requiring math or technical details. Focus on buying parts for the fitness monitor.	Complete the design document with emphasis on any section requiring drawings or requirements. Focus on buying parts for the encoder circuit.	Complete the design document with emphasis on any section requiring extensive writing or research. Focus on buying parts for the power generator system.
10/8/18	Test the product from the machine shop and measure the wattage produced by the generator.	Visit the machine shop and check on the status for the bike stand and alternator. Once completed, pick up the product.	Obtain the appropriate processor and power outlet.
10/15/18	Partner with Daniel on designing the control logic for power management.	Partner with David on designing the control logic for power management.	Attach the power outlet onto the bike stand and measure the wattage of the outlet.

Week	David	Daniel	Micheal
10/22/18	In the case that the wattage of the outlet is less than 25W, the entire team implements a fix with the help of the machine shop. Otherwise, continue with next week.	Design the PCB for the fitness monitor and power management. If there is time and the wattage of the outlet is less than 25W, assist the rest of the team to implement a fix.	In the case that the wattage of the outlet is less than 25W, the entire team implements a fix with the help of the machine shop. Otherwise, continue with next week.
10/29/18	Partner with Micheal on incorporating the power analysis tool onto the bike stand.	Obtain the PCB and test for compatibility issues. Incorporate the PCB onto the bike stand.	Partner with David on incorporating the power analysis tool onto the bike stand.
11/5/18	Partner with Micheal on the	Design and construct the	Partner with David on the

	display system.	encoder circuit.	display system.
11/12/18	Test the fitness monitoring system and check that there is enough power being delivered.	Partner with Micheal in programming the processor to compute energy generated and calories burned.	Partner with Daniel in programming the processor to compute energy generated and calories burned.
11/19/18	Fall Break. This time slot is left blank and reserve for any incomplete assignments.	Fall Break. This time slot is left blank and reserve for any incomplete assignments.	Fall Break. This time slot is left blank and reserve for any incomplete assignments.
11/26/18	Partner with Daniel to test the entire bike generator and fitness monitoring system and ensure all requirements are met. Prepare the slides on power generation.	Partner with David to test the entire bike generator and fitness monitoring system and ensure all requirements are met. Prepare the slides on fitness monitoring.	Prepare the introduction, design process, cost, and conclusion portions of the presentation.
12/3/18	Begin on the final paper by writing the power generation portion.	Begin on the final paper by writing the fitness monitoring portion.	Begin on the final paper by writing the design process, objectives, introduction and conclusion portion.
12/10/18	Finish up the final paper.	Finish up the final paper.	Finish up the final paper.

4 Ethics and Safety

4.1 Ethics

We believe that this project will serve the general public in a beneficial way. However, we are aware of potential hazards our project could provide and will attempt to prevent or minimize all possible occurrences. We also will take responsibility for any damage caused by our project to users, bikes, or environment under proper use of our project. However, the user must consent to the potential risk and safety standards before operating the bike generator.

We will follow the IEEE Code of Ethics during the design, the production, and the usage of our bike generator. We will *"hold paramount the safety, health, and welfare of the public, to strive to comply with ethical design and sustainable development practices, and to disclose promptly factors that might endanger the public or the environment;"* [16] We will make sure that our bike
support can hold any bike that has a 24 to 28 inch rear wheel with up to a 250 pound user on it. Our structure we design would prevent the bike from tipping over to the side while the user is exercising, minimizing injury.

We will also *"be honest and realistic in stating claims or estimates based on available data;"* [16]. We will estimate how much power is put into the bike and measure how much power is coming out to give a number on how efficient the bike generator is.

4.2 Safety

There are a few safety concerns with this project. They can be grouped into two categories, mechanical and electrical. Mechanically, our safety concerns come from the fact that we will have a lot of moving parts. Additionally, since we have a person riding a bike, there will be problems if the user tries to ride the bike too fast. Other people will have to stand clear of the belt system during operation.

Electrical safety concerns are related mostly to the power generation aspect of this project. Since we will have large currents and relatively high voltages involved in this project, grounding the circuits will be important for safety reasons. Additionally, we will have to be careful when designing the power circuits in order to make sure that the system is not overloaded.

The last concern is use of an lead acid battery, the battery will be used indoor, so corrosion is not an issue. Batteries can explode if overcharged, so a regulator to the battery is needed. If gas is released for the battery, then it needs to be disconnected and let cool down before using again making sure to leave the immediate area. The battery produces a large current so, hands should never touch the contact points without coverings as to ensure safety of parties involved in handling it. The battery should never be dropped or roughly handled such as hitting it, doing so can cause a short inside the battery and cause an explosion. The battery should never be taken apart as acid can get on persons causing serious immediate harm and lead causing lasting damage.

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