Bike Generator with Fitness Monitoring

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ECE 445 Project Proposal - Fall 2018
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1 Introduction

1.1 Objective

Obesity affects 93.3 million American adults [1]. Obesity is a serious threat to the well-being of people and often is the cause of type 2 diabetes with over 100 million people who have it [2]. Exercise is the most important action humans can take towards keeping a healthy body. Which is why is it's bad that Americans have cut it out of their daily routine. We drive to work only to sit at work, there's standing desks but standing isn't all to different form sitting in terms of exercise. The only time we exercise is during our leisure time and we don't have many reasons to exercise. The consequences for inactivity are in the far future, so we want to give a tangible reason to exercise. Since most people have bikes, over 100 million Americans, but don't use them [3]; and people watch over 2 hours of television every day [4], we want to make a device that charges other electrical devices from the power of cycling.

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 shouldn't be an invasive process, so the user doesn't need to take apart the bike. It's meant for low power devices so no dryer or other heating devices.

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 and can be costly from $10 to $50 [7] and don't achieve much since most people have a plug that they can charge their phone with and phone charger cost less than $10 [8]. We want our product to be cheap enough for typical people to buy and to use as a exercise routine but be useful during a emergency and generate power that can charge a laptop.

1.3 High-Level Requirement

- Bike generator must be able to generate 25 watts of power.
- Our fitness monitor must be able to track the calories burned and energy generated.
- Our setup must not be invasive to the user's bikes. This includes requiring the user to remove bike parts like the rear wheel.
- Our setup must be mechanically and electrically stable. For example, there should be no tipping over while a user is exercising. There should be no sudden electrical discharge that could damage electronics on the bike or are charging by the bike generator.

2 Design

2.1 Block diagram

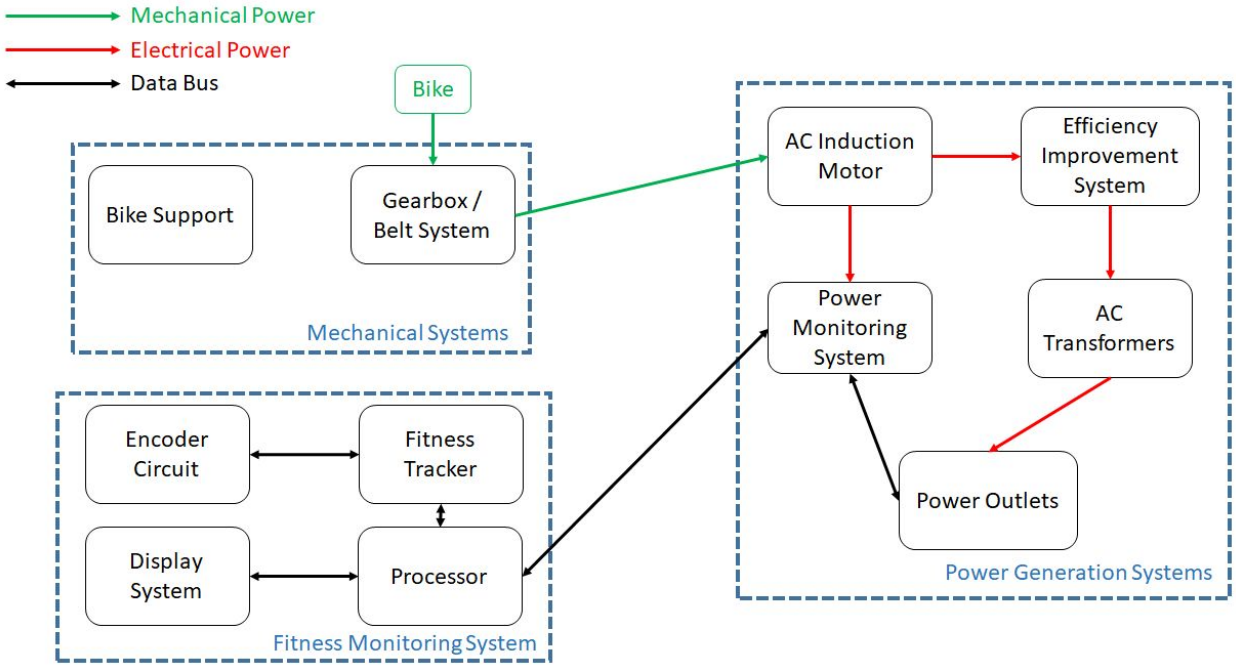

Figure 1: Block diagram of our bike generator.

2.2 Mechanical Systems

The purpose of our mechanical system is to support the bike and provide an efficient mean of transferring power from the rotation of the pedals or wheel to our power generation system. We plan on having several methods to accomplish this, as listed below. Ultimately, we will build and test each mechanical system and select the one with the best efficiency of transferring power

while at the same time, not be difficult to use in terms of setting the exercise system up and exercising on it.
Requirements: We will try to maximize the mechanical efficiency of this system. We will aim for a mechanical efficiency of 10% of better. We expect the mechanical system to be the least efficient part of the project.

2.2.1 Bike Support

We figured that a bike support is needed for a non-invasive approach to setting up our exercise system. We will purchase a bike trainer stand for this section. This will hold the bike in place. We decided to use a pre built product for safety reasons and because designing a bike stand from scratch is time consuming and does not meet the requirements of this course. However, we will modify it to allow our motor to connect to the bike wheel through the gearbox/belt system.
Requirements: This part will be purchased. The mechanical linkage will need to provide significant mechanical resistance to ensure that the bike remains stable.

2.2.2 Gearbox/Belt System

We will use some combination of a belt driven system and or a gearbox system to drive the ac induction motor. This is required because the motor is rather large and heavy, which means that it will have to be located relatively far from the bike. The belt will help link it to the bike, and a gearbox may be used to improve efficiency by changing the speed and torque ratio between the wheel and the motor's rotor..
Requirements:This part will be assembled to run the motor at as high a speed as possible. Our current target speed is 3600 rpm at the motor or better. The target for the torque ratio is that it meets or exceeds the torque constant.

2.3 Power Generation Systems

The power generation system is the key component of our project. It will consist of an ac induction motor, which will be run as a generator, a system to improve the efficiency of the generator, ac transformers, a power monitoring system, and wall power outlets.
Requirements: We expect an overall electrical efficiency of at least 30%. We will try to beat this efficiency.

2.3.1 AC Induction Motor

The AC induction motor will be run "backwards" so that it can be used as a generator. This will generate ac power which will be supplied to the wall outlets. A major aspect of this project will

be making sure that the induction motor is being spun with a speed and torque which allows maximum power generation. Additionally, a big part of this project is making sure that the motor is not generating reactive power.
Requirements: We expect that the ac induction motor will have non linearities, and possibly a large amount or reactive power which will need to be eliminated.

2.3.2 Efficiency Improvement System

In order to make sure that the efficiency of the motor is fairly high, we may need to create circuitry which can increase the power coefficient of our power line. Additionally, we will likely need to create a circuit which can help decrease any non linearities which the motor as generator might experience. The more well behaved and efficient the motor, the less sophisticated this subsystem will be.
Requirements: It depends on the motor as it encompasses any additional circuits we build to help increase the motor's efficiency.

2.3.3 AC Transformers

AC transformers will be used to allow the user to charge the ac voltage to two levels, 120 and 240 volts. This will allow the the user to theoretically run any device .
Requirements: The AC transformer will be purchased.

2.3.4 Power Monitoring System

The power monitoring system will allow the user to see how much electrical energy they have generated. This system will interface with the processor and allow the user to view how much power they are producing. Additionally, there will be a safety aspect to this system which will allow the user to make sure that they are not damaging the system, or their devices.
Requirements:

2.3.5 Power Outlets

We will purchase wall power outlets which will allow the user to plug in their devices.
Requirements:We will purchase power outlets with a ground. We will use have these connect to a system which earth grounds the system for safety.

2.4 Fitness Monitoring System

The fitness monitoring system will calculate a user's exercise stats and display them in real time.

Requirements: The power requirements for this system will be low.

2.4.1 Encoder Circuit

We will use an encoder to determine how far the user has riden. We will create a small discrete circuit which will ping the processor with data at predefined distances (examples: half a revolution,a quarter revolution, etc). This will allow us to calculate both the total distance traveled and the angular velocity of the bike. It is important to know the speed with which a bike wheel is travelling because travelling a distance faster burns more calories than traveling slower, even though the same amount of work has been done.
Requirements: We will try to use a PCB to implement this circuit.

2.4.2 Processor

We will use the processor to calculate the rider's exercise stats. This will include the distance travelled, their current speed, their mechanical power output, and their total mechanical energy output from their session. This can be used to estimate how much energy they have burned.
Requirements: We will pick a processor which has low power requirements, and has the ability to drive a VGA monitor. We will start with the Altera fpgas provided, but there is a high probability we might want to switch to a xilinx breadboardable fpga.

2.4.3 Display System

The display system will be a screen which holds the exercise stats.We have not decided which particular screen size or technology to use, but will use a small screen which interfaces with our processor to allow the user to see their exercise and power generation stats in real time.
Requirements:We will try to make the monitor run off of the power generated.

3 Ethics and Safety

3.1 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;" [9] 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;" [9]. 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.

3.2 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.

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