Wireless Laptop Charging System

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1. Introduction

1.1 Objective

Laptops are everywhere in classrooms. Many laptops do not boast a long-lasting battery, making them reliant on their chargers. Despite efforts to make outlets closer and more available in order to clean up cable traffic, long cables and tedious clean-up remain a problem in the student ecosystem. We know that wireless charging solutions enable integration of charging transmitters in discreet locations, which minimizes cable chaos with multiple people. However, in its current state, this technology has only been applied to phones. Our solution is to create an adapter that allows laptops to harness the same wireless charging technology, cutting down on cables in a classroom setting.

1.2 Background

There is currently almost nothing on the market that serves the purpose of our product. Every wireless receiver is designed to be installed to a small device, such as a smart phone, and some tablets. All of these loads have a smaller power requirement, so in order to power larger electronic devices such as laptops, we have to build our own. There is one exception: Dell Wireless Charging Mat for the Latitude 7285. However, the high price ($200 MSRP)[2] and limited compatibility prohibits it from being a classroom integrated product.

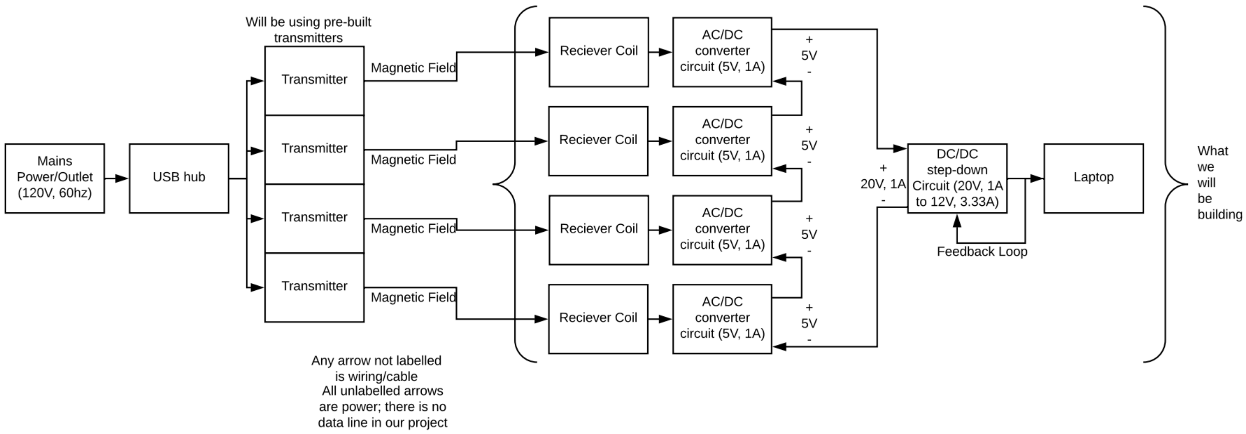
1.3 High-Level Requirements

- The receiver output reads 12V, 3.33A. This is the power requirement for our test laptop.
- The coils allow for power transfer up to 10 mm.
- The receiver adapter can operate for at least 12 hours without damaging the circuit.

2. Design

The design has two main blocks, transmitter block and receiver block. Within the transmitter block, we start with mains power from a standard US outlet and this powers a USB hub. The USB hub supplies power to four pre-made transmitters. The AC current goes into the transmitter coil and induces a magnetic field that creates a current in the receiver coil. This AC power in the four receiver coils is then turned into DC power by using a AC/DC converter with voltage regulator. The voltage outputs of the AC/DC are then added together and inputted to a buck DC/DC converter that outputs the required power to the laptop. A feedback loop is also incorporated to regulate the output of the DC/DC converter.

2.1 Block Diagram



2.2 Functional Overview

2.2.1 Transmitter Coil

The transmitter coil will be purchased and it will be powered by a DC output USB hub, which is connected to a standard US outlet. The transmitter has to transmit a strong enough magnetic field to power a receiver coil and its components to ultimately charge a laptop.

2.2.2 Receiver Coil

The receiver coil takes the transmitters magnetic field and it induces its own AC current, which is then outputted to the AC/DC converter.

2.2.3 AC/DC Converter

The AC/DC converter takes the receivers AC power from the receiver coil and outputs DC power by rectifying the AC signal, filtering, and regulating the signal. This DC signal from the AC/DC converter is then connected in series with the other three AC/DC converters, which sums the voltages. This increased voltage is then fed into the buck DC/DC converter.

2.2.4 DC/DC Converter

The DC/DC converter takes the DC output from the AC/DC converter and steps the voltage down using a buck converter. The output is then fed to the laptop, while also being regulated by a feedback loop to keep a constant voltage with very small ripple.

2.3 Block Requirements

2.3.1 Transmitter Coil

- Must be able to power a receiver coil that outputs enough voltage and current for rest of system.

2.3.2 Receiver Coil:

- Must be able to receive magnetic field waves from transmitter coils within 110 - 205 kHz.
- Must output AC voltage to use in the AC-DC converter.
- Must be isolated from the series connection in order to protect it from frying.

2.3.3 AC/DC Converter:

- Must be able to support AC power coming from the receiver coil.
- Must be able to convert AC signal into DC signal with tolerance of less than 1%.
- Must be able to be connected in series in order to generate a large voltage.

2.3.4 DC/DC Step-down Converter:

- Must be able to decrease the voltage coming out of the AC/DC Converter module.
- Output should have a ripple less than 1% of original value.
- Output should be connected to a cable that can connect to a laptop.

2.4 Risk Analysis

There are two major obstacles that we face in making the project work. The first one is the coil coupling. We will have to make sure that our coils will be able to properly receive the magnetic fields and get an AC voltage out of them. Frequency analysis will not be easy, and the entire project hinges on this block working. The second, more subtle obstacle will be interfacing the blocks together. There may be unforeseen consequences when connecting the modules, and we will have to put in effort to solve it. If we cannot get the modules to work together, our project will be rendered useless.

3. Ethics and Safety

The following tenets of the IEEE Code of Ethics[1] are the ones relevant to our project:

1. to 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;
3. to be honest and realistic in stating claims or estimates based on available data;
5. to improve the understanding by individuals and society of the capabilities and societal implications of conventional and emerging technologies, including intelligent systems;
6. to maintain and improve our technical competence and to undertake technological tasks for others only if qualified by training or experience, or after full disclosure of pertinent limitations;
7. to seek, accept, and offer honest criticism of technical work, to acknowledge and correct errors, and to credit properly the contributions of others;
9. to avoid injuring others, their property, reputation, or employment by false or malicious action;

Tenets 1 and 9 go hand in hand. Considering we are designing a circuit that works with somewhat high power, it is possible that we could build something that could potentially harm its user. As such, we will implement checks and warnings in our design to prevent its misuse. This is to protect users of the product, as well as ourselves while we work on it.

Tenet 3 is very straightforward; we aim to record our data honestly and accurately, as well as not being too ambitious with what we think we can do with our project.

With tenet 5, we will create a brief documentation in the final report detailing how existing wireless charging technology works, as well as the specifics of our own project.

Tenet 6 will be followed by doing the necessary research in order to design a wireless receiver. While nobody in the group has previous knowledge in directly designing a wireless charging interface, but we will make sure that we have that knowledge by the time we finish designing the project.

We will seek to follow tenet 7 to the best of our ability; in fact, we will likely be seeking much guidance in this project, as none of us has done anything like it before. It ties closely with tenet 6, where we will be building our knowledge in order to create a competent product.

4. References

[1] "IEEE IEEE Code of Ethics." *IEEE - IEEE Code of Ethics*. N.p., n.d. Web. 07 Feb. 2018. https://www.ieee.org/about/corporate/governance/p7-8.html

[2] "Dell Wireless Charging Mat - PM30W17." *Dell United States*. N.p., n.d. Web. 07 Feb. 2018. http://www.dell.com/en-us/shop/dell-wireless-charging-mat-pm30w17/apd/580-agli/pc-accessories