Wireless Charging

General Description

The wireless charging portion of the project is very experimental. The goal for this was to be able to wireless charge and/or power the robot while in the test arena to prevent the need for stopping to recharge the battery.

Equipment, Parts, Software Used

Amazon Basics Aluminum Foil	https://www.amazon.com/Amazon-Basics-Aluminum-Foil-Pack/dp/B093WS3YGV
28 AWG Magnet Wire	https://www.digikey.com/en/products/detail/cnc-tech/610222/4924056

Schematic

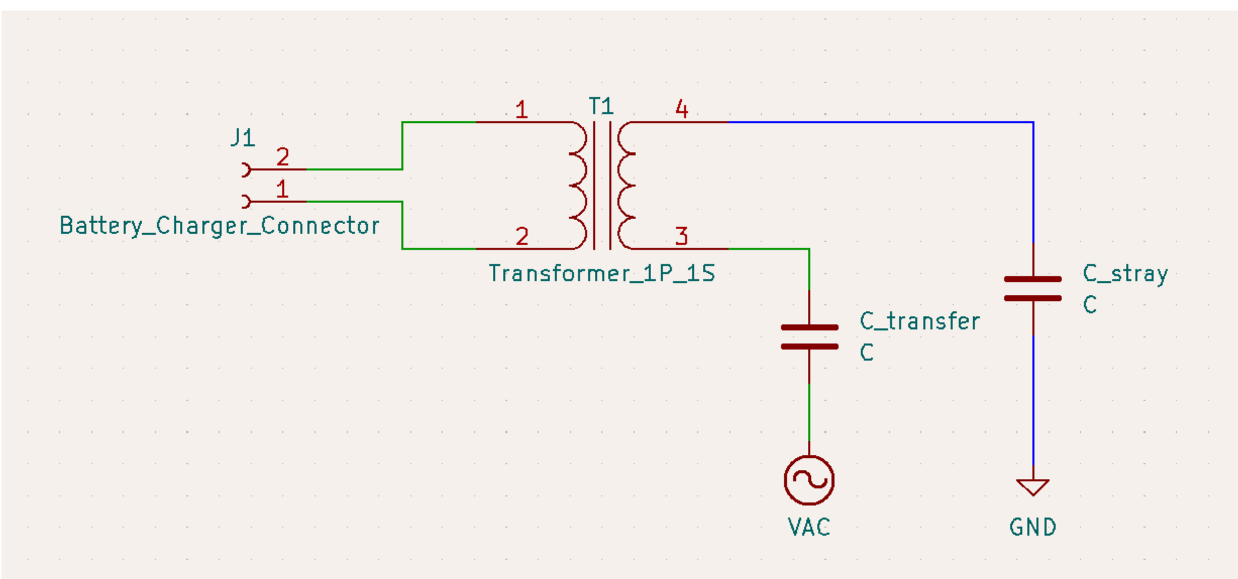

Figure 1. Basic Setup of Capacitive Wireless Power Transfer System.

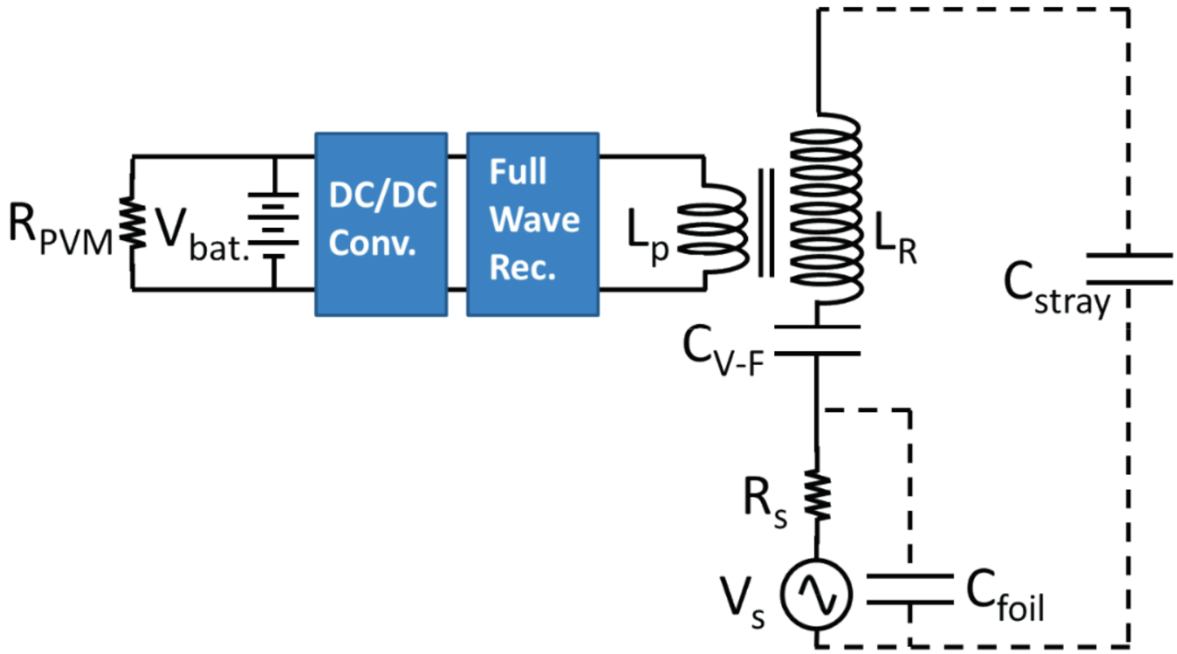

Figure 2. Alternative Schematic of Capacitive Power Transfer System [1].

Logic, General Notes, Reasonings

The goal of the wireless charging was for the robot to be able to be powered and/or charged over the full size of the test arena so that testing could be ongoing without the need for stopping to recharge. Given the space requirements, capacitive wireless power transfer (CPT) is more likely to be a viable option than inductive, but is very experimental.

For anyone who works on this in the future, discussion with Dr. Van Neste will be needed as the wireless power transfer is one of his research focuses. The basic setup of this system is shown above with some modifications that have come about from research developments. A function generator is plugged into a large amplifier (the “blue box” as they are called). The output positive lead of this is connected to a sheet of aluminum foil or metal plate. The negative lead is left somewhere not connected to anything. Above the sheet is another sheet (not physically connected but held a few inches above) and connected to this upper sheet is a quarter-wave resonator. With this setup at the right frequency power will flow from the amplifier, between the sheets, to the quarter-wave resonator, and through the stray capacitance back to the amplifier.

To get power to other devices there are two methods. The first is having a transformer in series with the resonator as shown above. This then steps the voltage down to whatever is needed to then be sent to the battery charger. The second method is to “tap” the quarter wave resonator. This is where some of the protective coating will be scratched off at specific places on the resonator and wires will be connected at these exposed points. This will then be connected to a transformer and potentially an impedance matching circuit.

An issue with the current setup so far is that the resonant frequency of the CPT system is in the MHz range, while the charger (and most devices) are designed to use the standard wall socket frequency of 60 Hz. To fix this issue, the idea was that the voltage coming from the CPT system after the transformer can be rectified down to DC. Alternatively, if someone can find a way to convert several MHz to 60 Hz, that could be used. This rectified DC wave can then be gated using a transistor, which can be turned on and off at 60 Hz by a microcontroller to provide a 60 Hz wave to the charger. As of writing this, this setup has not yet been tested. As can be found in the experimental analysis for wireless charging in the repository, a proof-of-concept was done by powering a small load (an LED) on the robot wirelessly using a CPT system. For the low amount of power required, an amplifier was not even needed, only a function generator. More information can be found about this in the experimental analysis directory.

There are some safety concerns with this setup going forward. If this is to be used, the bottom sheet should be securely insulated so that nobody can touch it. If someone touches it when it is energized, they could be shocked. To provide power over the full area of the arena, high voltages will likely need to be used, meaning that safety needs to be taken seriously to prevent injury. Additionally, there may be University rules that could apply if the voltages used get to very high levels, which should also be taken into account.

On a final miscellaneous note: of the aluminum foil and magnet wire purchased, there is plenty of it and so future teams should not need to buy more for quite a while.

[1] C. W. Van Neste, A. Phani, R. Hull, J. E. Hawk, and T. Thundat, “Quasi-wireless capacitive energy transfer for the dynamic charging of personal mobility Vehicles,” in 2016 IEEE PELS Workshop on Emerging Technologies: Wireless Power Transfer (WoW), Knoxville, TN, USA: IEEE, Oct. 2016, pp. 196–199. doi: 10.1109/WoW.2016.7772091.