16.810 **IAP 2007**

Engineering Design and Rapid Prototyping

January 10, 2007
Version 1.3

Deliverable A

Requirements and Interface Document

System: Wireless Power Transmission System

Component or Subsystem: Rectenna Array

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1. Component Description

A rectenna is an antenna attached to a rectifying circuit. In order to power the climber, the rectenna system needs to be able to convert microwaves into DC. The current will then charge up a capacitor array on the climber and power the two onboard motors. Without the rectenna array the climber will not be capable of converting the beamed power into useable current. The higher the efficiency of the rectenna array the better. The design of the current system (for each unit) is composed of a tuned patch antenna, diodes and a capacitor.

2. Functional Requirements

1. Produce the necessary DC voltage output. The motors run at 24v, so in order to avoid use of inefficient DC step-up circuits, the *entire* array must provide at least 24v.
2. Provide the required current. Since the gearbox has not yet been built and the final climber weight has yet to be determined by the corresponding groups, it is impossible to determine the exact requirement here. Preliminary bench tests demonstrate a requirement of approximately 400W from 75m away. The governing requirement here is that the device have enough power to scale the 100m ribbon in 50 seconds.
3. Properly shield the upper portion of the climber from the microwave source

3. Constraints

The system shall be constrained by the following equation:

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Mass_climber * height * gravity >= integral of
[Beam_density(h) *
efficiency_of_rectenna(Beam_density, T) *
Efficiency_of_energy_storage -
work_being_done_by_climber(v)/efficiency_of_rest_of_system] dt
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This and other considerations produce the following set of constraints:

1. For maximum efficiency, total effective surface area of the rectenna array cannot go over the size of the beam plus swing tolerance of approximately 1m.
2. Rectenna cannot deliver too much power over a given period of time (due to capacitor restraints). This is fixed by merely running tests later on and increasing the speed of the climber as well as putting current-dissipating circuitry, if necessary.
3. Beam is 800W/SA for the current moment, which might change depending on the power delivery team's success. It is our group's hope that this number increases. We have made the following requests to the power transmission team: to increase output to 10kW and to ensure that the beam width is 308cm wide (to utilize the entire diameter of the current dish).
4. According to competition guidelines, not more than 25% of the total power needed on the system can be stored at any given time. This means the device needs to still deliver current from 75 meters away. Assuming a 25 kg climber moving at 2 m/s up a 100m ribbon, one quarter of this energy is 6,250J. Due to inherent inefficiencies and the subsequent need for more energy than the calculated 25,000J, the actual max power the system can store is slightly greater.
5. Rectenna needs to be able to receive power at distance of at least 75 meters (in order to not break 25% rule discussed above).
6. Materials are limited. Antennas will probably be made on PCB traces. If so, conventional PCB conductors include copper, tin-lead solder, immersion silver, and electroless nickel.
7. Temperature considerations. The array will be operating in a room-temperature plus or minus approximately 20 degrees environment. In addition, higher current delivery (such as when the device is closest to the transmitter) will mean the array will heat up from the high current delivery. Such temperature fluctuations have a direct effect on efficiency.

4. Interface Definition

1. Can provide power to a capacitor, ensuring no overload
2. Output is monitored by software
3. Shield must be structurally sound for items above it (the payload system)

5. Verification

A small sample board will be constructed and then placed in the beam with power traces running off of it. This will give an efficiency rating for the surface area. To test diffusion a system will have to be designed where the effective diffusion is the same (perhaps use a block of material that diffuses it well). It is assumed that the system will run into adverse situations such as swinging from wind, which not only causes non-perpendicularity with the field (causing lowered power absorption), but swing will also cause part of the antenna array to not be in contact with the directional field. Since there will be onboard capacitors to deliver current in sub-optimal conditions, testing of our system will be done under an optimal configuration. That is, the array will be perpendicular to the field, and the array will cover the entire field. Under these conditions, we need to be able to deliver approximately 400 watts, or

Signatures ______________________________
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