University of Stuttgart
Institute of Space Systems

Pfaffenwaldring 29 · 70569 Stuttgart · www.irs.uni-stuttgart.de

Task Description Master's Thesis

Für First and Last Name

Enhancement of the Design Process of an RF Birdcage Antenna for a Helicon-based Plasma Thruster

Optimierung des Entwurfsprozesses einer RF-Birdcage-Antenne für ein helikonbasiertes Plasmatriebwerk

Motivation:

Very low Earth orbits (VLEO) with an altitude range of 150-400 km can provide significant advantages for satellite missions. Optical instruments or communication devices would greatly benefit from lower altitudes either to gain better resolution or to reduce cost. However, due to residual atmosphere, a satellite orbit would decay in short order. A solution could be atmosphere-breathing electric propulsion (ABEP) utilizing the atmospheric particles as propellant for an electric propulsion device. Continuous thrust compensates the drag, allowing feasible mission lifetimes.

Within the EU DISCOVERER project, an advanced RF Helicon-based plasma thruster (IPT) was developed at the Institute of Space Systems and successfully operated with Ar, N_2 and O_2. Its electrodeless design mitigates erosion of its components caused by atomic oxygen, while it delivers a quasi-neutral plasma plume, avoiding the need for a neutralizer. The antenna design is of paramount importance for the IPT because allows a linear polarization of EM-fields fostering the acceleration of the charged propellant particles and maximizing the electrical coupling efficiency by matching the load of the circuit. The so-called birdcage antenna operates on resonant modes, making the design an iterative process. This requires the correct resonance selection to achieve a high ionization degree and plasma density within the flow. A preliminary investigation on specific antenna geometries and capacitors was conducted and a design process developed. However, the dependencies of all parameters are not fully known yet. Therefore, a study on the improvement of the antenna design process has to be performed. The activity includes the improvement of the current simulations and exploitation of additional parameters aiding the design process as well as optimizing the current thruster model designs.

The student shall conduct a literature study of the thruster's working principle, the concept of impedance matching and antenna resonance. Then, antenna as well as thruster simulations shall be conducted. An improvement of the antenna design process shall be implemented based on the new findings. An updated design procedure to assess the antenna performance in terms of resonant frequency and impedance matching shall be presented. Potential design limits shall be identified. Documentation of the methodology and the results shall conclude the thesis.

Task Description:

- Literature study on RF Helicon plasma thrusters and relevant RF antenna theory,
- Investigation on antenna geometries and capacitors, and EM-field visualization using an EM-field software,
- Improvement of the existing design process and procedure for the birdcage antenna including plasma simulations,
- Sensitivity analyses for different antenna designs and exploitation of different parameters with respect to antenna performance,
- Design and build the birdcage antenna and thruster,
- Documentation in English.

Research is performed at IRS, University of Stuttgart.

Internal Advisor:	apl. Prof. G. Herdrich, K. Papavramidis
External Advisor:	Dr. A. Köhn-Seemann, L. Herrera Quesada
Start Date:	Flexible
Submission Deadline:	Choose Date

Acknowledgement of Receipt:

I hereby confirm that I read and understood the task of the thesis, the legal framework as well as the study and exam regulations.

apl. Prof. Dr.-Ing. Georg Herdrich (Verantwortlicher Hochschullehrer)	External advisor	Student

Declaration

I, First and Last Name hereby certify that I have written this **Master's Thesis** independently with the support of the supervisor, and I did not use any resources apart from those specified. The thesis, or substantial components of it, has not been submitted as part of graded course work at this or any other educational institution.

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