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PhD PROPOSAL 2012

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Title : Design of New Concepts of Lower Hybrid High Power RF Antennas for thermonuclear Fusion Reactor

Summary :

The goal of fusion reactor research is to demonstrate the scientific and technological feasibility of fusion power for peaceful purposes. In order to achieve the conditions similar to those expected in an electricity-generating fusion power plant, very hot plasmas, with temperature exceeding 100 million of degrees must be generated and sustained for long periods.

In order to achieve long pulse operations, a tokamak -- such as ITER -- requires additional heating and current drive systems. Radio Frequency (RF) antennas, delivering multi-megawatts level of power into the plasma, are presently used in many different tokamaks all around the world. The most efficient method to generate additional current drive in the plasma is currently the Lower Hybrid Current Drive (LHCD) systems. The tokamak Tore Supra is the world leader in this field, with two 3.7 GHz LHCD antennas able to inject 7 MW in continuous wave into the plasma and thus sustain long plasma discharges. In ITER, a 20 MW Lower Hybrid Range of Frequency launcher at 5 GHz is proposed aiming at extending plasma performance and duration and a pre-design using the RF schemes of present antennas has been performed. However, these antennas are cumbersome, heavy weight and delicate to manufacture. The extrapolation of these antennas to reactor grade devices is a challenge.

The objective of this thesis is to study, design and test at low power level some new and innovative concepts of Lower Hybrid antenna which could be more compatible with fusion grade reactors. In order to generate an additional toroidal current in the plasma, such antennas should synthesize a travelling wave with a toroidal phase velocity resonant with a fraction of the plasma bulk electrons. Some new antenna designs fulfilling these properties, such as slotted waveguides [1] or interdigital-line antennas [2], are being proposed for study. These concepts should be easier to manufacture and to water cool, while being more robust to the high energy neutron streaming of future fusion reactors.

During this thesis, the student will have to familiarize with the Lower Hybrid current drive systems -- such as the ones currently used in the Tore Supra tokamak -- from the RF sources to the plasma. Then, the study will focus on new innovative RF antenna designs fitting fusion grade tokamak environment. The student will use commercial modeling tools (such as Ansys HFSS / Ansys Workbench) as well as internal codes (such as ALOHA) to model the loading and the cooling of such antennas facing a tokamak fusion plasma. A new module will have to be implemented in the coupling code to design the matching system which can be required for this new type of antenna. The manufacturing and the RF tests of a low-power prototype are also envisaged.

Envisaged collaborations

- Turino University (Italy)

References

[1] G. Bosia, P. Testoni, *A proposal for a thin Lower Hybrid antenna*, IRFM internal technical note CH/NTT-2003.005

[2] Michael C. Kaufman, *Lower Hybrid Experiments Using An Interdigital Line Antenna On The Reversed Field Pinch*, PhD Thesis 2009, University Of Wisconsin-Madison

Skills : Radio Frequency engineering, notions of mechanical engineering and plasma physics.