Simulation of ICRF antenna plasma loading by a dielectric dummy load. Application to the ITER case.

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Each ICRF antenna of ITER is constituted by an array of 24 straps allowing heating and current drive phasing with load resilience in the frequency band 40-55MHz for a nominal radiated power capability of 20MW. In order to test the electrical performances [1] and validate the modelling used for the design a mock-up of the present status of the electrical design of an antenna plug has been constructed [2]. The simulation of the plasma loading is performed by a dielectric dummy load [3]. The aim of this paper is to compare the loading characteristics of the estimated plasma edge profile of ITER and of a dielectric medium.

This analysis shows the same determining dependence on the following plasma density and dielectric constant profile characteristics on the coupling performances: (i) distance antenna-cutoff layer and position of an optimum density or dielectric constant value layer with respect to the cutoff, (ii) their gradient between this optimum layer and the bulk regions. Even in absence of anisotropic effects and particularly of the gyrotropy, the dielectric load can fairly well simulate the inhomogeneous plasma loading. The best simulation of the considered ITER profiles (for frequency response and quantitative coupling measurements for the different toroidal phasing cases) is obtained by the relation $K_D'(x)=1+ (\omega_{pi}(x))^2/(\omega\omega_{ci}+\omega_{ci}^2)$ which puts the plasma and dielectric cutoff for all toroidal wavenumbers at the same position. The continuous profile can be replaced by a multilayer one but the number of layers has to be chosen as large as possible to avoid strong resonances and surface wave effects on the power spectrum and coupling value. In particular a single step K_D before the bulk K_D can produce very strong coupling resonances (as for plasma hollow edge profile cases). Good simulation of the frequency response is obtained with a homogeneous dielectric with $K_D'\cong 200$. A large loading domain covering the one expected for ITER (even in presence of ELM's) can be scanned by varying the distance antenna-dielectric load. For a given value of K_D' the imaginary part of the dielectric constant K_D'' decreases the coupling but has to be chosen to avoid standing waves in the finite dielectric volume.

Illustrations from measurements on the ITER mock-up are given.

[1] A. Messiaen et al., Nucl. Fusion **50**(2010)025026.

[2] P. Dumortier et al., AIP Conf. Proc. **1187**(2009)277.

[3] A. Messiaen et al., Fus. Eng. and Design **74**(2005)367