Validation of the Electrical Properties of the ITER ICRF Antenna using Reduced-Scale Mock-Ups

P. Dumortier, F. Durodié, D. Grine, V. Kyrytsya, A. Messiaen, F. Louche, M. Vervier, M. Vrancken

LPP-ERM/KMS, Euratom Association, Belgium, TEC partner

One ITER ICRF antenna consists of a close-packed array of 24 straps arranged in a 6 poloidal by 4 toroidal array. Three poloidally adjacent straps (a “triplet” of straps) are fed in parallel from one single feeding line through a 4-port junction. A shunt service stub is inserted on the feeding line inside the antenna. It has been optimized to provide a broad-band RF frequency response of the array. Load tolerance is achieved by feeding two poloidal triplets through a 3dB hybrid coupler. The array has to radiate 20MW of RF power (with a 45kV limit on the system) in quasi-CW operation for frequencies ranging from 40MHz to 55MHz and different toroidal phasings to provide a wave spectrum appropriate for both heating and current drive. Two identical ICRF antennas are foreseen on ITER.

A first flexible reduced-scale mock-up (scale 1:4) of one triplet of the antenna, based on the October 2007 reference design, has been built to validate the RF performances predicted by the numerical RF optimization of the design. It allows varying parameters such as the strap width, the antenna box depth, the vertical septum recess with respect to the front of the current strap and allows checking the influence of the Faraday screen.

After optimization a second mock-up has been built featuring the optimized front-end geometry and 4-port junction as well as the implementation of a service stub. Provision is made to adapt the frequency response of the antenna by acting on the 4-port junction arms’ lengths, the service stub length and its position in the feeding line. These measurements validate the optimization that resulted in a new reference design in July 2008.

A mock-up of the whole optimized antenna array in its frame has also been constructed. It is used to characterize the full array (including mutual coupling effects, Faraday screen and vertical septum recess). It also allows testing different grounding solutions to avoid the excitation of modes in the gap between the antenna and the vessel.

Finally the control of the antenna wave spectrum is performed by implementing feedback controlled load-resilient matching and decoupling options and gives the opportunity to test control algorithms.

An overview of the measurement results on the different mock-ups is given. It validates the numerical optimization, confirms the broad-banding effect of the service stub and validates the overall performance of the ITER ICRF antenna for the different proposed phasings and for a given maximum voltage on the antenna. Comparisons with simulations performed by various codes (Topica, CST MWS and ANTITER II) are given together with the expected performance on plasma deduced from measurements with dielectric load.