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[REGULAR POSTER TWIN] Status of the WEST Travelling Wave Array antenna design and results from the high power mock-up

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An Ion Cyclotron Range of Frequency (ICRF) system can provide power for a number of tasks, experimentally verified on present machines: heating and current drive, first wall conditioning, plasma start-up, removing of impurities from the core, controlling sawteeth and current ramp down assist. The system has a high plug-to-power efficiency and most of the components external to the machine are sturdy, with industrial steady-state capability. Traditional ICRF antenna systems are often characterized by a high operating voltage and high power density. Low power density and low voltage, however, provides a bonus in terms of reliability. Therefore, travelling wave (TWA) type antennas have been proposed [1., 2.] (figure 1). They can be integrated into the blanket, using only a limited number of feeders and the same cooling loop. The $k_{//}$ spectrum is peaked and the dominant $k_{//}$ value can be optimized for coupling and bulk absorption while avoiding the generation of coaxial modes in the edge. Assuming the *ITER-2010-low* density profile \[3.], 50 MW can be easily coupled with a voltage on the antenna components of about 15 kV [4., 5], reducing the arcs phenomena and then increasing the reliability of the system.

A proof of principle of the TWA concept for ICRH on a medium size tokamak is a needed step in order to be accepted in the conceptual design of a reactor like DEMO or CFETR. The TWA concept was presented in the early '90 [6] and tested only for fast wave current drive (FWCD) at high frequency [7]. More recently, the travelling wave antenna concept has found new interests for application in the helicon current drive frequency domain [8, 9] and in the Lower Hybrid frequency range [10]. Despite that, a test for ICRH in a metal wall machine, in steady-state operation, has never been done before. Those two conditions are fundamental for a reactor. For this reason, a test on the WEST machine is presently under consideration [11] (figure 2) with a high power mock-up as first stage (figure 3).

This contribution presents the experimental results obtained from the exploitation of the TWA high power (2 MW) mock-up, the status of the WEST TWA antenna design and an extrapolation towards a reactor TWA antenna embedded in the machine breeding blanket.

An antenna mock-up has been designed based on the specifications defined by the requirements for a WEST in-vessel component. Particular attention has been devoted to the estimation of (*i*) plasma heat and particle loads, (*ii*) forces and momenta caused by vertical displacement events (VDE), (*iii*) RF losses, (*iv*) impact of the magnetic field ripple on the performance of the antenna and power deposition performances and profiles [11, 12]. The results have been used to dimension the relevant components of the WEST antenna, e.g. the strap thickness and the strap recess from the antenna aperture. The high power mock-up presents some differences with respect to the WEST TWA antenna. In particular, the number of strap is 6 instead of 8, the antenna is flat instead of being conformal to the poloidal and toroidal curvature of the device, and is not water-cooled. Those differences have a negligible impact on the characteristics which are subject of the high power test while allow to simplify the manufacturing process and to decrease the total cost of the procurement. An extensive use of EM and thermo-mechanical simulations results in a refined characterization of the mock-up that is compared to the experimental results of the test. The sensitivity of the antenna to several parameters relevant to future use in a reactor environment is assessed (e.g. figure 4), within the limitations of the used test-bed [13, 14]. A dedicated RF diagnostic system has been installed and used to characterize the RF response of the antenna at a different level of power (up to *2* MW) and at several frequencies within the TWA bandwidth (*50* MHz to *60* MHz).

The WEST antenna design is updated based on the return of experience from the design, manufacturing and exploitation of the high power mock-up. The interfaces with the WEST device are defined and presented for both in-vessel and out-vessels components, e.g. antenna support, cooling, resonant ring, dummy loads, and tooling for installation.

The Reliability, Accessibility, Maintainability and Inspectability (RAMI) approach has been used from the beginning of the WEST TWA design activity and for the proposed reactor TWA antenna. The definition of the interfaces with the blanket and the tokamak system is presented along with a preliminary assessment of the RF performance.

The comparison between experimental results and simulations provides a validation of the design process for both the WEST TWA antenna and its reactor extrapolation.

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References

\[1.] T. Franke et al 2018 IEEE Transaction on Plasma Science 46, 1633-1640
\[2.] J.M. Noterdaeme et al 2019 Fusion Eng. Des. 146 A, 1321-1324
\[3.] S. Carpentier and R. A. Pitts 2010 Report ITER_D_33y59M_v2,3
\[4.] R. Ragona et al 2020 Nucl. Fusion 60, 016027
\[5] A. Messiaen and R. Ragona 2016 43rd EPS conf. on Plasma Physics Vol.40A, 4-8 July Leuven BE.
\[6] Moeller C.P. et al 1994 AIP Conference Proceedings 289, 323
\[7] T. Ogawa et al 2001 Nucl. Fusion 41, 1767
\[8] H.H. Wi et al 2018 Fusion Eng. Des. 126, 67-72
\[9] J.F. Tooker et al 2017 Fusion Eng. Des. 123, 228-231
\[10] JG. Jo et al 2018 Physics of Plasmas 25, 082511
\[11] R. Ragona et al 2019 Fusion Eng. Des. 146 A, 854-85
\[12] R. Ragona et al Proceeding of the 23rd Topical Conference on Radio frequency Power in Plasmas,Hefei, China, May 14-17 2019
\[13] J.M. Bernard et al 2011 Fusion Eng. Des. 86, 876-879
\[14] J.M. Bernard et al 2011 AIP Conf. Proc. 1406, 49-52

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