Design Considerations and Research and Development of a Comb-line Traveling Wave Antenna for Helicon Current Drive in DIII-D*

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A project to demonstrate high-efficiency off-axis current drive intends to couple 1 MW of power at 476 MHz to DIII-D plasmas in the fast wave polarization, also known as the whistler or helicon wave, to enable a proof-of-principle experiment on helicon current drive [1]. A traveling wave antenna of the comb-line type is in the final stages of design for installation in the DIII-D tokamak in late 2018. The antenna consists of a toroidal array of 30 modules, each 5 cm wide, so that the array is 1.5 m wide. Power is fed from one end of the array to generate a wave traveling in one toroidal direction at a value of $n_{\|} = 3$ to drive current non-inductively. A 12-element prototype comb-line was operated at low power (< 0.5 kW) in DIII-D in 2016, where it was demonstrated that the plasma-antenna coupling was adequate to transfer at least 75% of the power to propagating helicon waves in the plasma, rather than being resistively dissipated in the structure or coupled out of the antenna at the 'downstream' end [2]. The scaling of the measured coupling efficiency for the low-power prototype to the high-power antenna depends crucially on two factors: the resistive losses in each element and the strength of the mutual reactance between adjacent elements. In this contribution we quantify the importance of these parameters in determining the optimum number of modules for a wave-launching structure of this kind. To assess the significance of multipactor discharge in the antenna and feed structures and to qualify the module design for operation at high electric fields, a test stand has been constructed with up to 0.1 T dc magnetic field available and with more than 10 kW of rf power in the operating band of the antenna (~0.5 GHz). Initial testing of one quarter of one module at high 'Q' has already demonstrated conditioning out of multipactor in the module, and investigation of the effect of the magnetic field on multipactor and on high-voltage standoff has begun. In the near future, we will use the test stand to qualify the vacuum transmission line that will convey 1 MW of power from the feedthroughs to the input end of the comb-line antenna and to investigate the effect of anti-multipactor coating techniques.

[1] R. Prater, C.P. Moeller, R.I. Pinsker, *et al.*, Nucl. Fusion **54**, 083024 (2014)
[2] R.I. Pinsker, *et al.*, IAEA Conference EX/P3-22 (2016)

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