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Simulation, Design and Construction of Moreno directional coupler with 50 dB coupling coefficient for Alborz Tokamak pre-ionization system

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Abstract

In tokamaks, so as to create a steady non-induced current, sending radiofrequency waves into the plasma is considered as a successful method to raise the plasma temperature to the level required for self-ignition. This procedure is based on the wave- particle intensification and it helps bind plasma and ohms by creating a toroidal current stimulator in the tokamak. In the plasma heating method, using radiofrequency waves in order to measure the power transmitted from the RF generating source to the plasma, as well as the returning power from the plasma to the RF generating source, directional coupler system is adopted. In the present study, simulation and experimental outcomes of Moreno directional coupler with 50 dB coupling coefficient for application in the s frequency band of and design frequency of 2.45 GHz were assessed.

Keywords: Directional Coupler, Tokamak, Coupling, Plasma

Introduction

Research in the field of radio frequency waves indicated that wave conductor structures play a very efficacious role in the development and evolution of radio frequency system and circuits. Accordingly, proper cognition and accurate analysis of subsystems is of great importance. One of the passive and most useful parts of in the radio frequency range is the directional coupler.

Directional couplers contain networks that have three, four or more ports, depending on their usage, which are used to combine and distribute power and sample radio frequency signals. In this work, designing and manufacturing Moreno directional coupler, with 4 input, output, coupled and isolated ports have been performed.

Regarding this issue, various experiments and studies have been conducted on tokamaks and the results of which have been published [1], [2], [3]. The results of experiments and calculations resulted in a formulation, through which the relationship between the geometric parameters of the waveguide and the coupling coefficient can be expressed. It is called Bet relation and it is used in designing and optimizing the operational parameters of the tokamak per-ionization system [4].

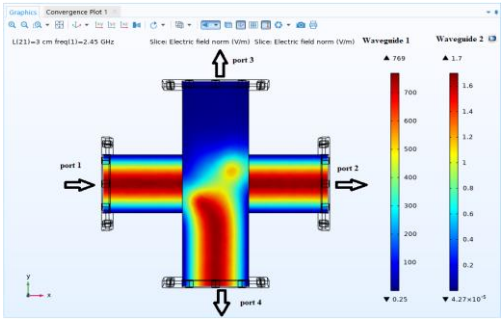
Experimental

Preparation of the materials

In the present study, we obtained the Lorentz equation for the amplitude of the moving waves in the direction of the coupling and isolated ports, solving wave equations and using Lorents theorm. Subsequently, we obtained the amount of power transmitted in the direction of coupled and isolated ports, by using these amplitudes, based on the definition of coupling and isolation coefficients. Besides, we designed slots with certain geometric dimensions that perform the coupling between two waveguides and we did this given the tolerable power of measuring sensors that are installed so as to measure the power of the coupled port.

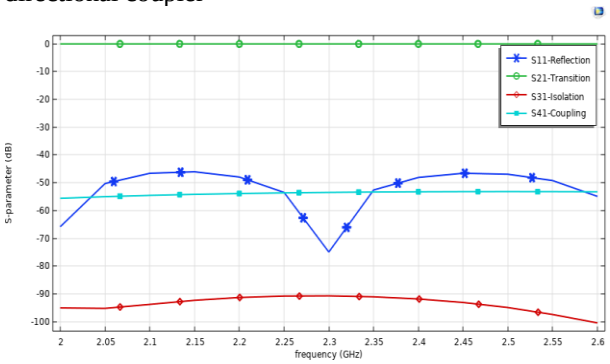
Simulation results

After preforming model processing operation in Comsol software, the distribution of electric field size, in which port 1 is selected as the input port and port 2 as the output port and 2.5 GHz wave propagates from port 1 into the primary waveguide, is represented in Figure (a).



(a)

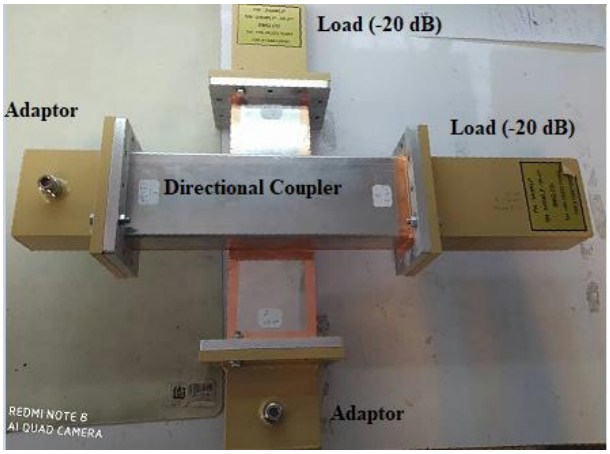
Figure1. Electric field size distribution in Moreno directional coupler



(b)

Figure 3. Diagram of S parameters from simulation

The diagram of the S parameters, which shows the quantitative measurement of the amount of transmitted and reflected power at different frequencies, was obtained according to Figure (b). As it is clear,at the desired frequency (2.45GHz) in the Alborz Tokamak pre-ionization system, the coupling and isolation coefficient are 53.20 dB and 93.18 dB.



(c)

Figure 4. Manufactured Moreno directional coupler

References

[1] Abhinav, J and Adav, P.R; "Development of high power 20 dB directional coupler for Ion Cyclotron Resonance frequency system of Tokamak"; International Journal of Electronics Letters; (2021).

[2] Changhong, Z et al; "Design of a High Power Directional Coupler with High Directivity Used in the LHCD Launcher for EAST"; Plasma Science and Technology, Vol. 11, Number 6; (2009).

[3] Ohkubo, K; "A directional coupler for installation near the waveguide-array mouth in lower hybrid heating of plasma"; Journal of Physics E: Scientific Instruments, Vol.16, Number 7; (1983)

[4] Bethe, H.A; "Theory of diffraction by small holes", The Physical Review, vol. 66, pp. 163-182, (1944).