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Enhancement of Localized ICRF Heating and Current Drive in TFTR D-T Plasmas

G. Schilling, J. C. Hosea, R. Majeski, J. H. Rogers, J. R. Wilson
Princeton University Plasma Physics Laboratory, Princeton, New Jersey 08543

Abstract. Theoretical advantages have led to an increased importance of the modification and sustainment of pressure and magnetic shear profiles in plasmas. We have demonstrated electron heating and current drive in TFTR plasmas with the existing 43/63.6 MHz ICRF system, both via the fast wave and via mode conversion of the fast wave to an ion Bernstein wave. In order to achieve both on and off-axis mode conversion in a pure D-T plasma, we have changed the operating frequency of two of our transmitters and antennas to 30 MHz and improved the launched directional wave spectrum. As a second step, two new four-strap fast wave antennas have been installed, and a new four-strap direct-launch IBW antenna has been added as well. This reconfiguration and the resulting operating characteristics of the TFTR ICRF system in a variety of discharges will be presented.

INTRODUCTION

Radiofrequency power in the Ion Cyclotron Range of Frequencies has been coupled to TFTR plasmas during the deuterium-tritium phase (1). The straightforward heating experiments have yielded to an increased emphasis on the modification and sustainment of pressure and magnetic shear profiles (2). While the initial electron heating and current drive experiments utilized either fast wave direct electron heating on axis (3) or mode conversion of the fast wave to an ion Bernstein wave via an additional ion species (4), on and off axis electron heating and current drive in a pure D-T plasma gained in importance (5). In addition, the possibility of generating an internal transport barrier with a direct launched ion Bernstein wave was investigated (6,7,8).

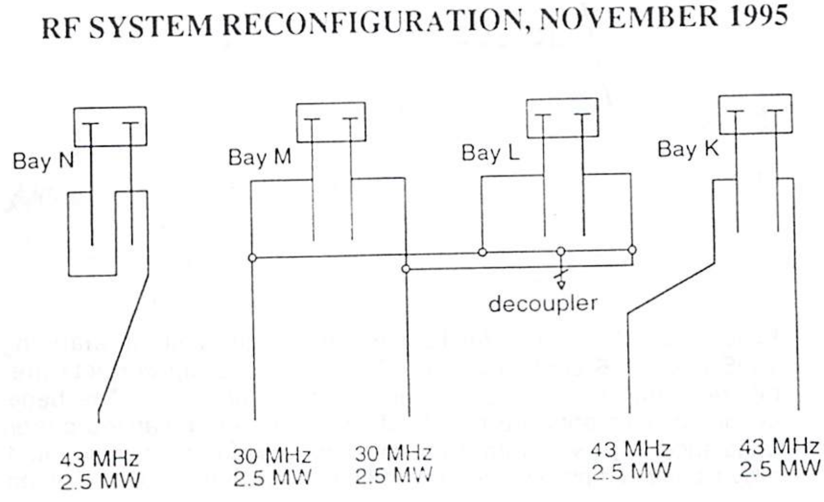

FIGURE 1. Nov. 1995 reconfiguration to allow mode conversion in pure D-T plasmas.

The TFTR ICRF system with its antenna and transmitter configuration has been described at the previous conferences of this series (9,10). In November, 1995, the two antennas at bays L and M were reconnected in parallel to two transmitters whose frequency had been reset from 43 to 30 MHz. Pinsker-style decouplers were added as well to compensate the adjacent current straps' mutual inductance. This first reconfiguration allowed mode conversion heating and current drive to be performed in a pure D-T plasma, while retaining the physics capability at 43 MHz of the remaining half of the system.

IMPROVED PHASED OPERATION

Addition of the decouplers in the 1995 reconfiguration now allowed phased operation, i.e. balanced but phased strap currents, with balanced antenna input power. This offered the advantage of higher total directed power, since now both antennas are operating at full power, and a much improved match.

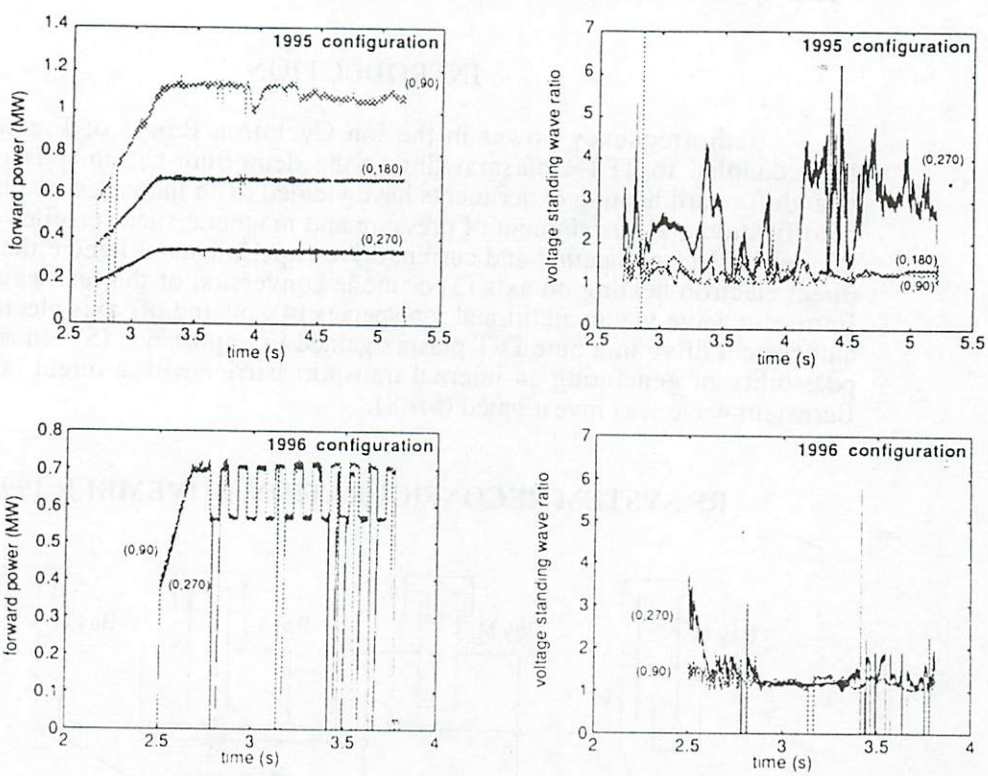

FIGURE 2. Waveforms for forward power and voltage standing wave ratio for the 1995 and 1996 configurations. The antenna strap currents are balanced, but with different phasing, in each of the two configurations. The beneficial effects of the decoupler elements are clearly shown. In 1995 balanced currents required a large unbalance in power, with a corresponding strong mismatch. In 1996 the decoupling allows balanced power levels (modulated here) to be applied, with an excellent match.

RECONFIGURATION AND ANTENNA UPGRADES, NOVEMBER 1996

A second reconfiguration was carried out in November, 1996. The original two-strap fast wave antennas at bays L and M were replaced by four-strap fast wave antennas offering an improved launched directed wave spectrum, connected to four transmitters set to 30 MHz. The original two-strap fast wave antenna at bay N was replaced by a four-strap direct-launch ion Bernstein wave antenna, connected to two transmitters whose frequency was set to either 76 or 50.6 MHz. This second reconfiguration allows improved mode conversion in D-T plasmas and an investigation of the possibility of achieving core high confinement in TFTR via the CH mode found in PBX-M.

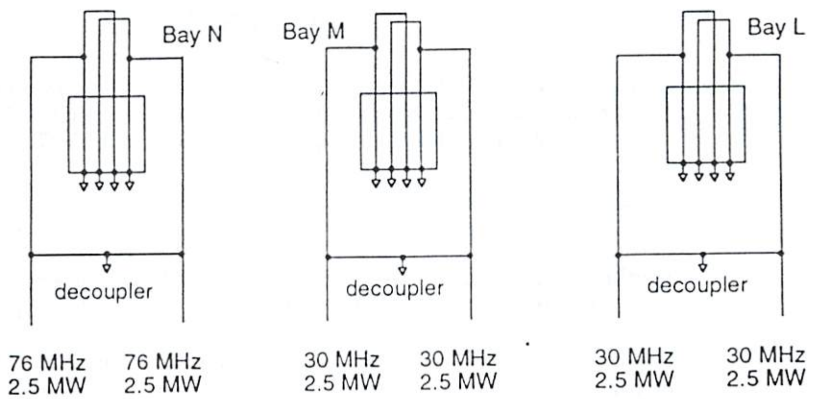

FIGURE 3. Nov. 1996 reconfiguration to allow direct launch IBW and an improved fast wave directed spectrum.

The resulting system operating parameters are shown in the following table:

Antenna	Operating frequencies	Faraday shield	$k_{\parallel}$ (m^{-1}) (0,180 phase)	Source power
Bay K	none	single row, slanted 6° oval rods		
Bay L new (4-strap)	30 MHz	single row straight oval rods	12.5	2.5 MW
Bay M new (4-strap)	30 MHz	single row straight oval rods	9.5	2.5 MW
Bay N new (4-strap)	76/50.6 MHz	single row straight oval rods	IBW	5.0 MW

Calculations of the wave spectra launched by the four-strap antennas indicate a considerable improvement in directionality. Initial experiments show voltage holding and loading comparable to the earlier two-strap versions.

ACKNOWLEDGMENT

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