A MODULAR MULTIJUNCTION GRILL FOR CURRENT DRIVE STUDIES AT 3.7 GHz FOR PETULA-B AND TORE SUPRA

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1 INTRODUCTION

A 8 MW - quasi continuous - 3.7 GHz Lower Hybrid Heating system is being designed for mainly current-drive studies on the TORE SUPRA Tokamak. A large simplification of the L.H. antenna and of the RF transmission line is obtained by applying two main ideas : (i) modular design, (ii) internal RF power division - 3 dB hybrid junction and E-plane multijunction (M.J.). The E-plane M.J. system /1/ brings not only simplification in the building of the antenna, but also, when used in travelling wave, lowers strongly the power reflection coefficient towards the generator. This is a very important point, because such a system allows to avoid the use of circulators - expensive elements for large machine.

In order to test the physical and these technical options chosen for the TORE SUPRA experiment, a 500 kW-30 ms-3.7GHz experiment has been successfully operated on PETULA-B (see other papers in this conference /2/ to /4/.

2 GENERAL DESCRIPTION

2.1 The RF power, provided by a 500 kW-30 ms-3.7 GHzThCSF klystron is injected to the coupler by means of an Aluminium, 6m long, SF6 pressurized, standard WR 284 transmisssion line. The RF losses including the insertion losses of the circulator and flexible waveguides are measured equal to 0.14. 3 dB hybrid junctions allow the RF power to be divided in the ratio 1/4:1/2:1/4 between the 3 modulus (1/2 in the central one).

Fig. 1 shows the general view of the low hybrid coupler on Petula. A vacuum tank composed by a large movement bellow and a rigid sector for the vacuum pumping is connected by means of Ø 400 vacuum valve to a Petula port.

2.2 Fig. 2 shows the front view of the 18 waveguide-9 column-2 line-network made from 3 juxtaposed identical modulus. Each modulus is composed of : (i) a RF alumina vacuum window with its associated arc detector, (ii) a 3 dB hybrid junction, (iii) a 90° phase shifter in order to balance the 90° phasing of the hybrid junction, (iiii) the 0-120°-240°-3 wg E-plane M.J. system (cf. fig. 3a, 3b). The phase shifters are obtained by changing the waveguide length in the wg by reducing its height. The RF matching of such sections is obtained by step transformers.

By changing the phase of the injected wave between the 3 modulus, the $N_{//}$ spectrum excited by the launcher can vary from 1.6 to 3. From code calculations /5/, the $N_{//}$ spectra obtained with a ± 90° phasing between modulus is plotted in fig. 4.

3 LOW LEVEL TEST

As expected by theorical predictions, self matching property of the 3 wg -J-120°-240°-E-plane M.J. is obtained when the 3 loads are in the same plane (fig. 5a) and the power reflection coefficient (P.R.C.) is the square of the P.R.C. of the loads. For a $\lambda_g/6$ spacing of the loads, which leads to the same phasing (180°) in each secondary wg, no self matching property is observed (fig. 5b). Self matching property is confirmed on plasma /2/.

The SWRV of each element of the modulus is lower than 1.06.

4 CONDITIONING TECHNIQUES

4.1 On a separated test line, argon glow discharges have been tested /6/ Such a technique, currently used for the 1.3 GHz experiments has been simplified by using a common longitudinal electrode. High pressure (~1 torr) argon glow discharge is needed in order to obtain a quasi homogeneous discharge in the 3 reduced waveguides (fig. 6). Due to the lower ion numbers striking the surface with a sufficient energy (~300 eV) /6/, the time duration of such a discharge has to be of the order of 10 hours. This procedure has to be verified at high RF power on the launcher itself.

4.2 Up to now, on Petula, the conditioning technique, derived from previous high RF power tests in a test bed, is the following : (i) during the cleaning session of the machine with a 10^{-4} H_2 pressure, the RF power is gradually increased with a duty cycle of 1 RF=3ms long-shot every 10 seconds. 300 to 400 pulses are so performed during such a session, (ii) between two plasma shots, about 10 short RF pulses are powered at a level slightly greater than that required for the following plasma shot.

4.3 Performances : As expected, the power density limitation due to the multifactor effect ($\mathcal{P} \sim f^2$), is greatly decreased by working at 3.7 GHz and the cleaning of the surface has been achieved by using RF shots conditioning technique.

With such a technique, after a overall one thousand RF conditioning shots, the full power - 500kW-30ms - of the klystron has been injected to the coupler. When the central modulus is fed alone with the RF power, the corresponding power density - assuming no reflected power - is ~ 20kW/cm^2 at the RF window and ~ 10kW/cm^2 at the reduced section of the grill. Such values - however with short time pulses - are twice the ones planned on TS Low Hybrid experiments.

5 REFERENCES

/1/ T.K. NGUYEN and D. MOREAU - Proc. 12th Symp. on Fusion Tech. (Jülich) Vol. 2 1381 (1982)
/2/ M. GONICHE et al. - This conf. paper n° 213
/3/ C. GORMEZANO et al. - " " " n° 217
/4/ D. VAN HOUTTE et al. -" " " n° 218
/5/ D. MOREAU, T.K. NGUYEN - Report EUR-CEA F 1199 (9-83)
/6/ D. BOILOT, M. GONICHE - Internal report 1239 (1985)

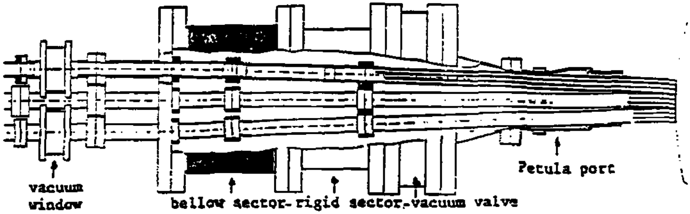

Fig. 1 - Implementation of L.H. coupler on Petula

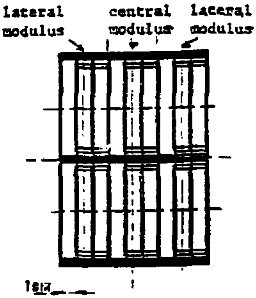

Fig.2-Front view of the 18wg grill

Fig. 3a - Top view of the 3wg E-plane multijunction

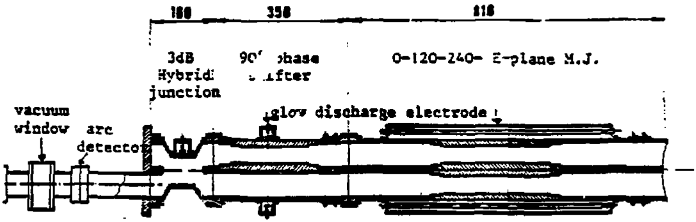

Fig. 3b - Cross section of one modulus

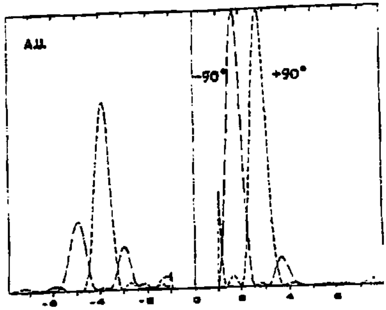

Fig.4 - $N_{//}$ spectra excited by the antenna for -90° and +90° phasing between modulus

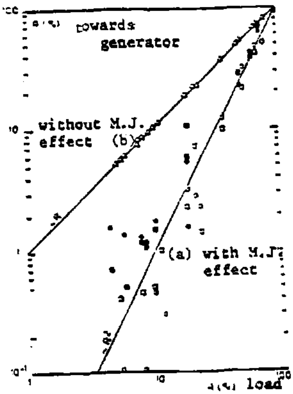

Fig.5 - Power reflection coefficient with and without M.J. effect

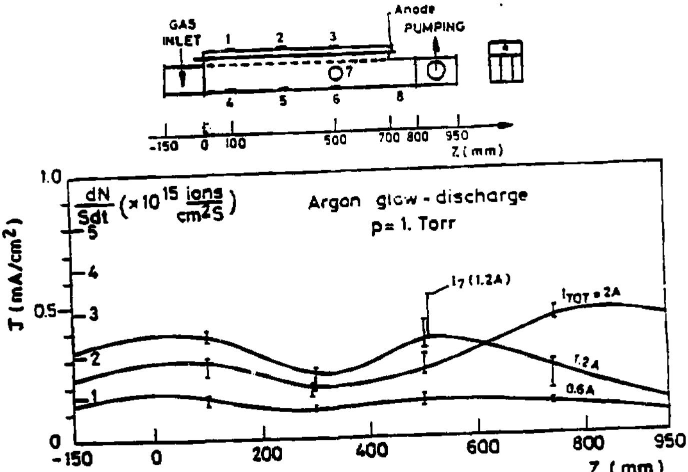

Fig.6 - Spatial distribution of ion current in a test line