On the use of fibre-optic current sensor for plasma current measurements in Tore Supra tokamak

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Traditionally, the plasma current in tokamaks is measured by inductive sensors such as arrays of pick-up coils or Rogowski coils. In order to mitigate the risk of measurement drift during long plasma discharges, measurements based on steady state sensors have been considered in ITER as a backup system. An innovating and attracting technique consists in using Fibre Optic Current Sensors (FOCS). Their principle of operation is based on the Faraday rotation experienced by a polarised light beam passing through a fibre optic subjected to a magnetic field.

Recently, 3 different optical fibres have been installed and tested on the Tore Supra tokamak. The Faraday rotation measurement was performed in these fibres using a polarization scheme able to acquire the full state of polarization (full Stokes analyzer). The sensors can operate in transmission mode (light passes once in the fibre) or reflection mode (light is reflected at the end of the fibre by a Faraday rotator mirror and passes twice in the fibre). The linearity response of the FOCS has also been addressed on a wide range of plasma current from 0.3 to 1.4 MA.The first results in transmission mode show that the sensitivity of the fibres is about 0.7 rad/MA and the signal noise is about 0.005 rad. Nevertheless, the FOCS are sensitive to temperature gradients and stress through local modifications of the optical properties of the fibre (typically linear birefringence) causing non linear response of the sensor and requiring frequent recalibration.

This paper reviews the results obtained on Tore Supra. In particular the type of fibre optic and the mode of operation of the FOCS are assessed. A modelling of the light propagation in the fibre optic taking into account the optical imperfections in the fibre is also performed. As the final aim of the FOCS is to be used on ITER, the results obtained on the Tore Supra tokamak have been extrapolated to identify the issues to be addressed for the future. Possible solution and measurement techniques to improve the present sensor are finally suggested.

Topic D: Diagnostics, Data Acquisition and Remote Participation