Seminar

Institute for Plasma Research

Title : Design & Analysis of Pulse Power Supply for Diverter Coils in Aditya U Tokamak

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Date : 05th August 2021 (Thursday)

Time : 11.30 AM

Venue : Online - Join the talk:
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Abstract :

ADITYA tokamak (limiter configuration) has been upgraded to Aditya-U Tokamak, which is equipped with 3 pairs of Diverter coils, namely, one pair of main diverter coil, one pair of auxiliary diverter coil and one pair of outer diverter coil, to obtain shaped plasma operations. Main and auxiliary pairs of diverter coils are placed in the high magnetic field (inner) region of the tokamak. Each pair, consists of two coils placed symmetrically in the top and bottom halves of the horizontal mid-plane of the machine. In this thesis, an adequate power supply with its detailed topological design, for powering the main diverter coils has been presented. The power supply is designed to fulfill the power pulse requirements for shaped plasma operations in Aditya Upgrade. The main diverter coil pair, each having 6 turns are made up of continuously transposed conductor of soft annealed copper with short-circuit (1 second) current carrying capacity of 180 kA-turn. Electrical parameters of these coils (top & bottom) are: resistance of ~ 3 mΩ and inductance of ~ 200 μH. Based on the simulations carried out using IPREQ code, to obtained a typical plasma in divertor configuration having plasma current ~ 150 kA, the requirement of the power pulse from the power supply is as follows: DC current ~ 30 kA (maximum); variable rise time ~ 30 – 50 ms; current flat top duration ~ 100 ms; ramp down time ~ 150 ms; output current Ripple ≤ 1% of full scale at rated current for voltage range between 40% and 100%. Due to other magnetic field coils, present in tokamaks, in the vicinity of divertor coils, such as Ohmic Coils, Vertical Field Coils, Fast Feedback Coils, Auxiliary Diverter Coils, mutual coupling between the divertor coil and other coils also needs to be taken in to account for deciding the parameter of the power supply. Hence, the total Inductance of the Diverter Coils is a combination of mutual inductance and self-inductance. During the plasma operation other coils in vicinity are also magnetized, hence the mutual coupling between the Diverter coils and other coils generate voltage across the load in the range of ~5-10 Volts. As the plasma shape needs be dynamically controlled in real time, the power supply needs to have a robust feedback control system, which should control the output current in the Diverter coils in a millisecond timescale (desirable), so that the plasma shape profile is sustainable during the plasma shots. Based on the requirements, preliminary calculations suggest a high current, low voltage (~ 400 V, 30 kA) regulated DC power supply is required for the purpose. This thesis examined different topologies of the power supplies in detail, such as capacitor bank based power supply, pulse forming networks, 6 pulse convertor power supply, 12 pulse convertor power supply and chopper based power supply. Merits and demerits of the topologies have been discussed for the above mentioned application of powering a pair of divertor coils in ADITYA-U. The power supply should ramp the current in 30-50 milliseconds to its maximum by providing higher voltage during the initiation of the current pulse and during the flat-top of the current pulse, it should reduce the output voltage across the load. Further, the output current ripple requirement of ~ 1% needs to be fulfilled. Out of the different topologies explored for fulfilling the ADITYA-U requirements, the 12 pulse convertor topology based power supply has been found out to be the most suitable for the desired application.