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Real-time Control of Gas-Feed Pulses to Reduce Wall Loading of Fuel Gas in Aditya-Upgrade Tokamak

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Apart from the initial gas feed (pre-fill) pulse for initiation of plasma and plasma current ramp-up periodic gas feed pulses are required to maintain the density in the flat-top region of the plasma current in Aditya-Upgrade tokamak [1]. In the absence of real time density feedback at present, these gas-feed pulses are pre-fixed prior to the initiation of the discharge. The pre-fill gas feed is applied about 150mS prior to the application of loop voltage. In a typical standard plasma discharge of Aditya Upgrade tokamak (Plasma current ~ 100 kA; discharge duration ~ 180 ms), this scheme of gas-feed pulses work quite well. However, in the discharges which do not evolve fully or are disrupted in the break-down or current ramp-up phases, hydrogen gas injection through the pre-fixed gas-feed pulses load the vessel wall with hydrogen gas and subsequently hamper the next plasma discharge during break-down as well as in the current ramp up phase. To avoid these occurrences, a microcontroller based circuit is designed and developed to control the applied number of gas-feed pulses according to the discharge duration. After the onset of loop voltage the plasma current reaches to its flat-top value of ~ 100 kA in about 30 ó 40 ms in typical discharge of Aditya Upgrade. The developed circuit constantly monitors the value of plasma current (Rogowski coil signal) at 1 ms time interval after 30 ms of application of loop voltage. The circuit is programmed in such way that it allows the gas feed valve to insert gas according to the pre-set configuration as long as the plasma current value remained above a threshold value (~ 60 kA for typical discharges of Aditya Upgrade). The steering of the gas-feed voltage to the gas-feed valve is controlled through an analog switch. If the plasma current disrupts at any point of time from 30 ms into the plasma discharge till the end of the discharge, the circuit shuts off the analog switch and stops the gas feed into the vessel. The circuit is tested successfully and helped significantly in achieving repetitive long plasma discharges in Aditya Upgrade tokamak. The complete design, development, installation and operation of the circuit will be described in detail in this paper.

References:

[1] Ghosh J. et al 2016 Upgradation of ADITYA tokamak with limiter configuration to ADITYA upgrade tokamak with divertor configuration 2016 IAEA Fusion Energy Conf. (Kyoto), 17-22 October, 2016 (FIP/P4ó46) Nucl. Fusion submitted.Pre-print:https://nucleus.iaea.org/sites/fusionportal/Shared%20Documents/FEC%202016/fec2016-preprints/preprint0720.pdf