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Design Considerations for the Implementation of a High-Field Side Transient CHI System on QUEST

Journal: IEEE Transaction of Plasma Science (2022)

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Keywords: CHI, Helicity, Noninductive, ST, Startup, Tokamak

Abstract

Transient Coaxial Helicity Injection, a method first developed on the small HIT-II experiment and then validated on the much larger NSTX device, is a method to initiate an inductive-like tokamak plasma discharge without reliance on the central solenoid. A CHI discharge is initiated by driving current along magnetic flux that connects the inner and outer divertor plates on one end of the tokamak. To permit this, on both HIT-II and NSTX, toroidal ceramic insulators were used to electrically separate the inner and outer vessel components. The use of such large toroidal vacuum insulators may not be easy to implement in reactors. To address this issue, the QUEST ST is developing a reactor-relevant CHI configuration in which one of the divertor plates is electrically insulated from the rest of the vessel. The first application of transient CHI on QUEST biased the CHI electrode to the outer vessel. While the CHI discharges could be easily generated, it was found that as the discharge filled the vessel, the separation distance between the injector magnetic flux footprints widened, a condition that is not favorable for the generation of closed flux surfaces. Biasing the electrode to the inner wall is a configuration similar to that used on NSTX and HIT-II, but initial testing in this configuration has proved to be challenging. The design described here overcomes the present limitation by locating the CHI electrode much closer to the CHI injector flux coil and using an NSTX-like gas injection manifold to enable high-field side transient CHI startup on QUEST. The concepts described in this paper should also benefit the future implementation of transient CHI systems in other tokamaks and spherical tokamaks.

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Figure data provided in digital text format

Figure 4a

Figure 4b

Figure 4c

The other figures for which text data is not provided are either drawings or postprocessed output from an MHD code in its final form.

Figure 4:

Out-fig-q4a: Top frame (text format)

Column 1: Time (s)

Columns 2 to 3: Injector voltage in Amps for the blue trace (column 2) and the red trace (column 3)

Out-fig-q4b: Middle frame (text format)

Column 1: Time (s)

Columns 2 to 3: Injector current in Amps for the blue trace (column 2) and the red trace (column 3)

Out-fig-q4c: Bottom frame (text format)

Column 1: Time (s)

Columns 2 to 3: Toroidal current in Amps for the blue trace (column 2) and the red trace (column 3)