Thesis/trainee project for the ITER ECRH group - Control System for Modular High Voltage Power Supply

Background

The Electron Cyclotron Heating and Current Drive (EC HCD) excites the electrons in the plasma with a high-intensity microwave beam at a frequency of 170 GHz, corresponding to the electron resonance frequency along a vertical plane near the plasma axis. The electrons in turn transfer the absorbed energy to the ions by collision. The EC HCD system is also used to heat and drive current in a localized region for controlling the plasma current and temperature profiles and control plasma instabilities that either evacuate the plasma stored energy or lead to a disruption.

The ITER project foresees 40 MW (including 20 MW from baseline) in SRO phase and up to 66.7 MW in DT-1 phase of EC power injected into the plasma, in continuous operation at 170 GHz, using RF Sources (known also as “Gyrotrons”) each with an output power of 1 MW (could be increased up to 1.2 MW). Today, 20 MW of RF power is already procured and their installation on ITER site is in progress. Therefore, the upgrade for the DT-1 phase requires additional 46.7 MW of EC power.

HVPS for Gyrotrons

Each couple of (2) Gyrotrons is powered by a so-called High-Voltage Power Supply (HVPS) system, which is made of a Main HVPS (MHVPS), 2 Body Power Supplies (BPS), 2 Filament Power Supplies (FPS) and 2 Anode Power Supplies (APS, only for ‘Triode-type’ gyrotrons). The ITER ECRH group is currently procuring 22 HVPS systems through the ITER Korean Domestic Agency (KO-DA or KFE), which has started the development of the MHVPS, shown in Fig.1. The power supply is composed of a multi-phase transformer that provides input power to a multilevel converter, made of 86 power modules (PM) in series. The PM internal topology is shown in Fig. 2. By applying a Pulse Step Modulation (PSM), the modular converter can output voltage and current (up to 55 kV and 110 A) required by the couple of gyrotrons. The BPS has a similar but simplified topology, and it is not shown for simplicity.

Main goals of the project

- Develop an electrical model of the Main and Body High Voltage Power Supply
- Develop a control strategy for MHVPS and BPS systems.
- Build a MATLAB/Simulink model of said control system and simulate the model during a typical operating scenario.
- Interface with the ECRH team to update the model and be aligned with the supplier design development.

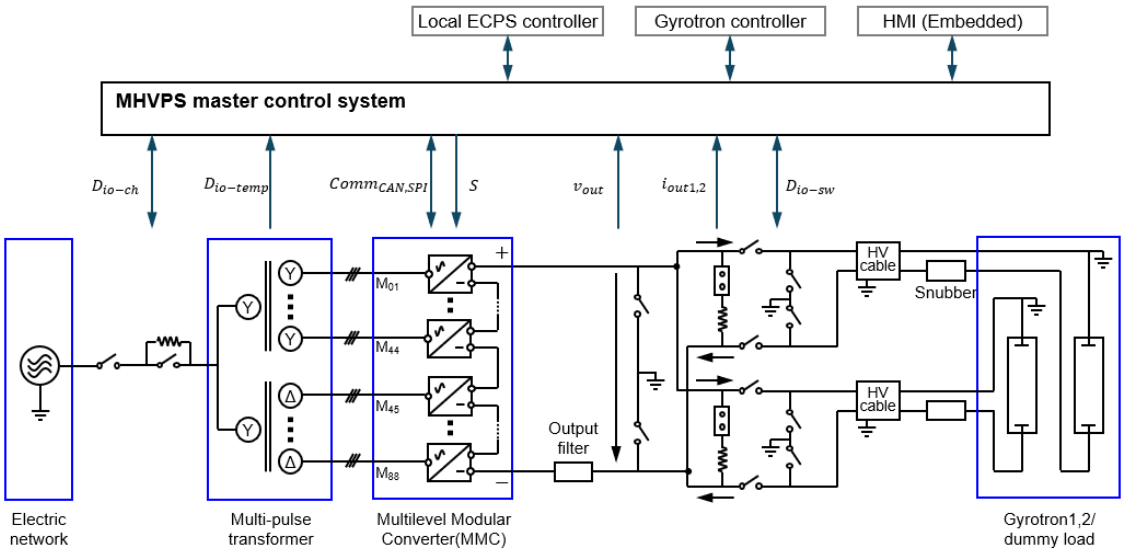
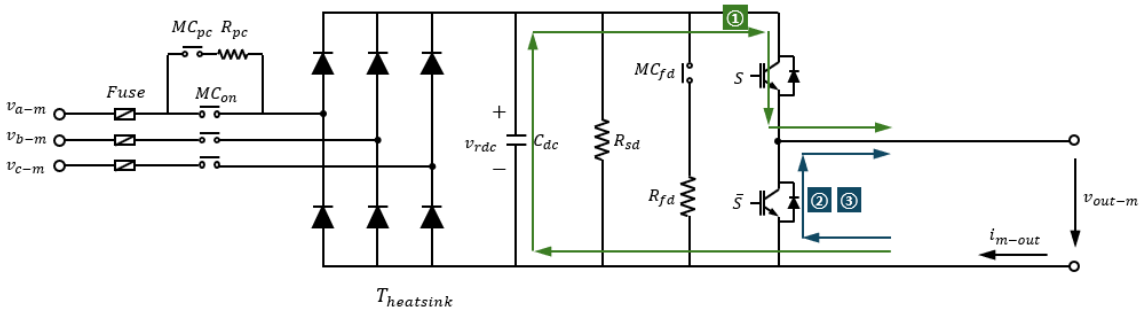


Fig. 1: MHVPS simplified diagram.



No.	Gating signals		Output voltage	Normal operation	Arc protection	Internal fault detection
	S	$\bar{S}$				
①	ON	OFF	$v_{out-m} = -v_{ndc-m}$	○		
②	OFF	ON	$v_{out-m} = 0$	○	○	
③	OFF	OFF	$v_{out-m} = 0$			○

Fig. 2: MHVPS power module diagram and its different states.