Update of Joule Losses Calculation in the ITER Cold Structures during Fast Plasma Transients

FUSION FOR ENERGY

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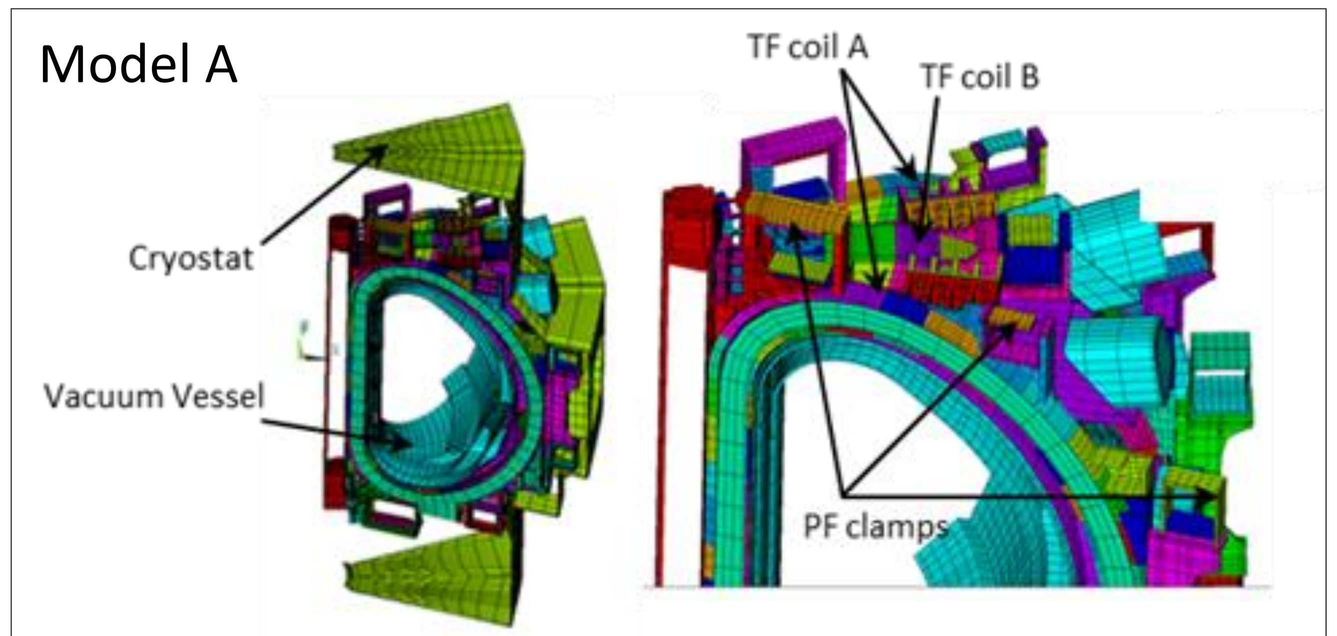
Abstract. *As part of the design verification of the ITER magnet system and in preparation of the commissioning activities, the heat deposition on the ITER cold structures has been computed in order to generate input loads for subsequent thermo-hydraulic analyses, which are essential for the assessment of the temperature margins of the superconducting cables. The Finite Element model of a 40 degree sector of the ITER magnet system has been updated, including Poloidal Field (PF) coils clamps and Correction Coils (CC) supports. A new inductive plasma scenario (DINA-2017) as well as the Toroidal Field (TF) coils fast discharge have been simulated with the electromagnetic code CARIDDI. The results are in line with the old computations. In addition to these events, the effects of the voltage ripple generated on the TF coils by the power supply have been analyzed and the induced eddy currents assessed.*

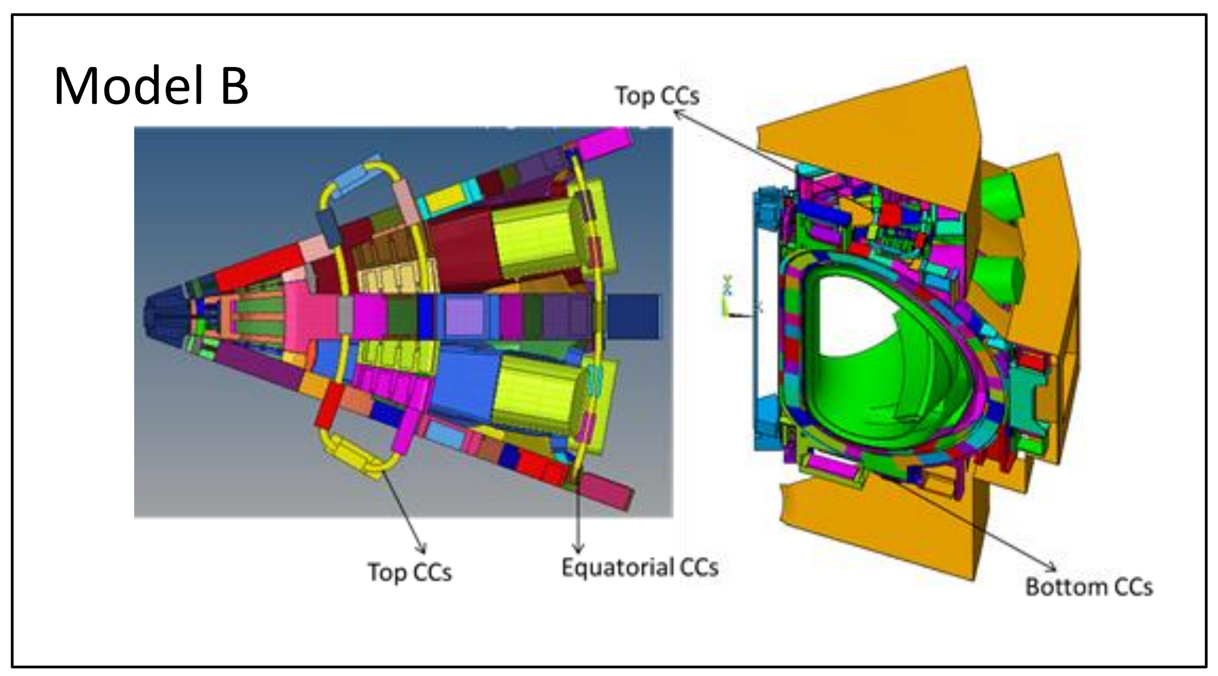
1. Finite Element Model

Model A: The 40-degree model includes a pair of TF coils, identified as TF coil A and TF coil B; TF coil type A supports the poloidal field coils PF1 to PF6, TF coil type B supports from PF2 to PF6 and in addition the CS. The PF clamps and the outer and inner inter-coil structures have been also modeled.

Model B: Model B is obtained from Model A by adding CC rails and supports. The 18 CCs are placed between TF and PF coils; 6 are placed on the top, 6 on the bottom and 6 on the side of the machine .Being the symmetry of the CCs 60 degree, the CC rails and supports have been squeezed in order to fit into the 40 degree model..



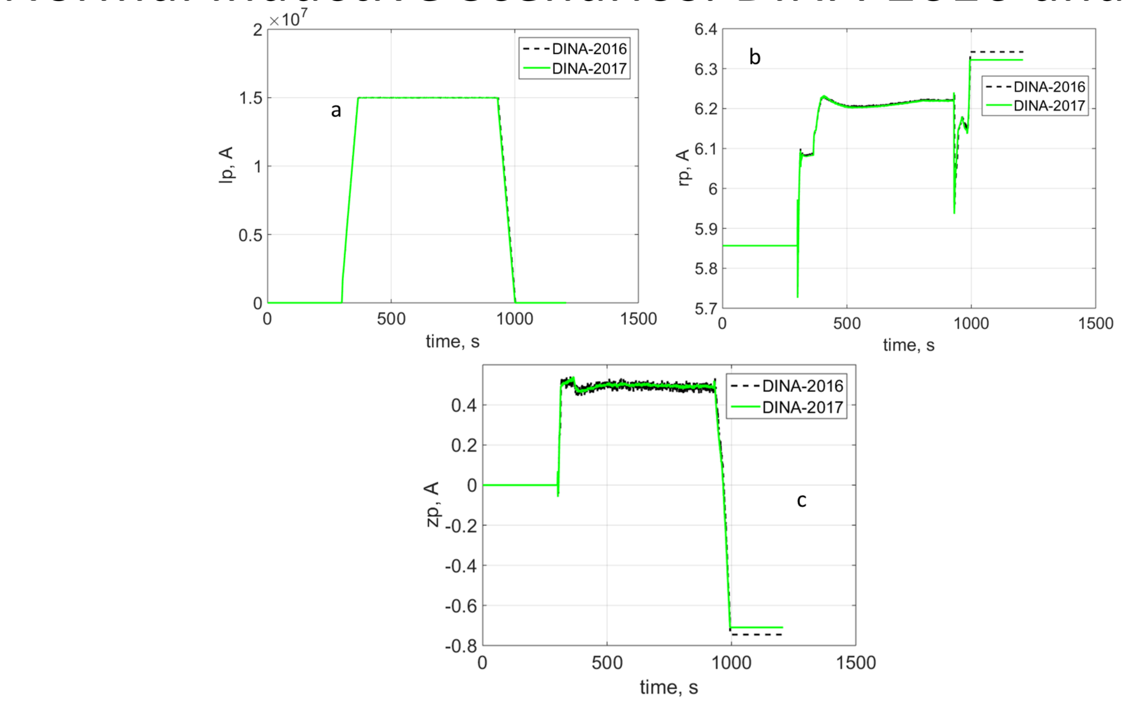
80573 elements
138763 nodes



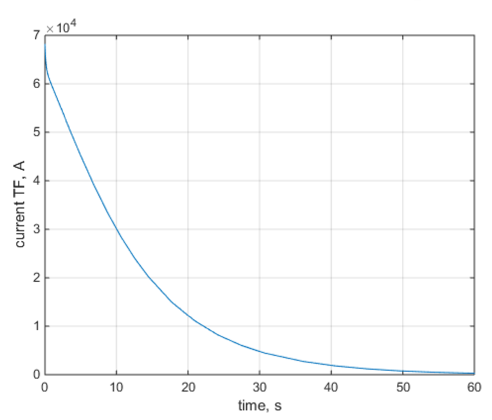
117371 elements
203084 nodes

2. Load Cases

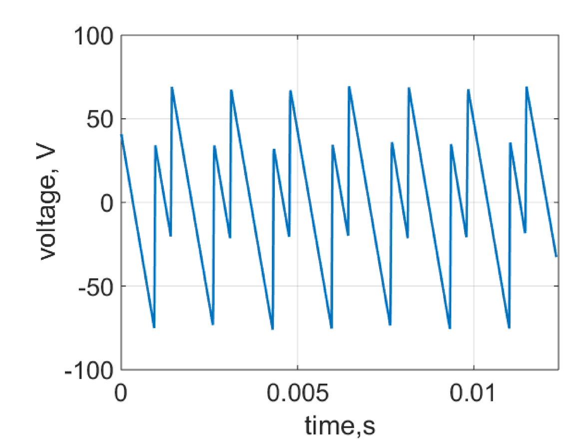
Normal Inductive Scenarios: DINA-2016 and DINA-2017



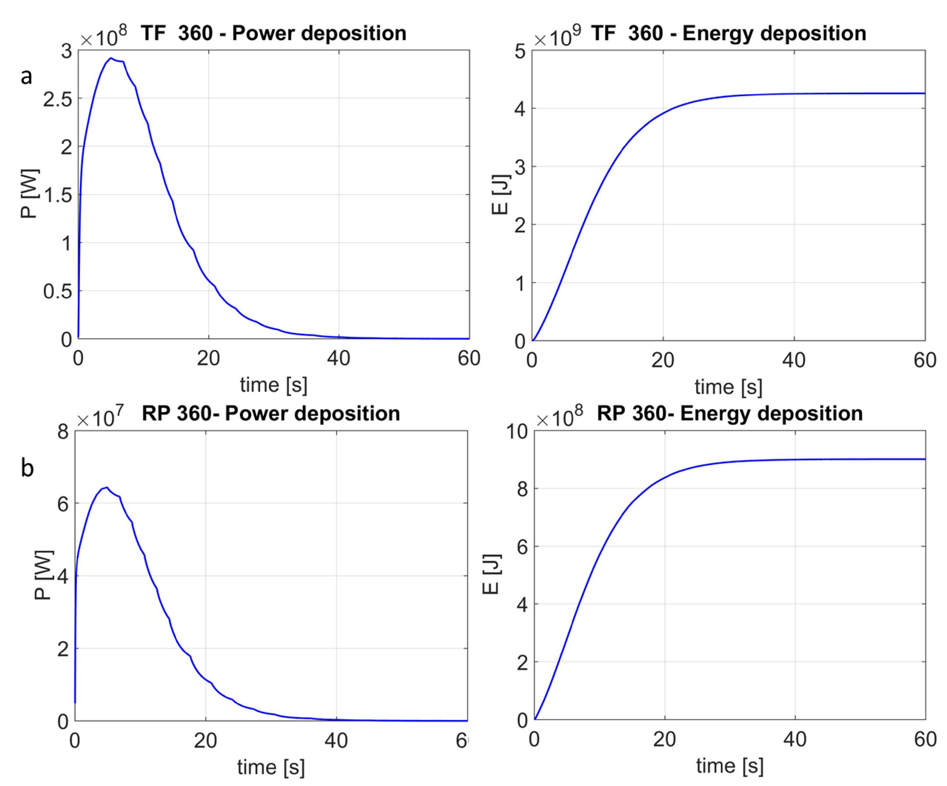
TF Fast Discharge

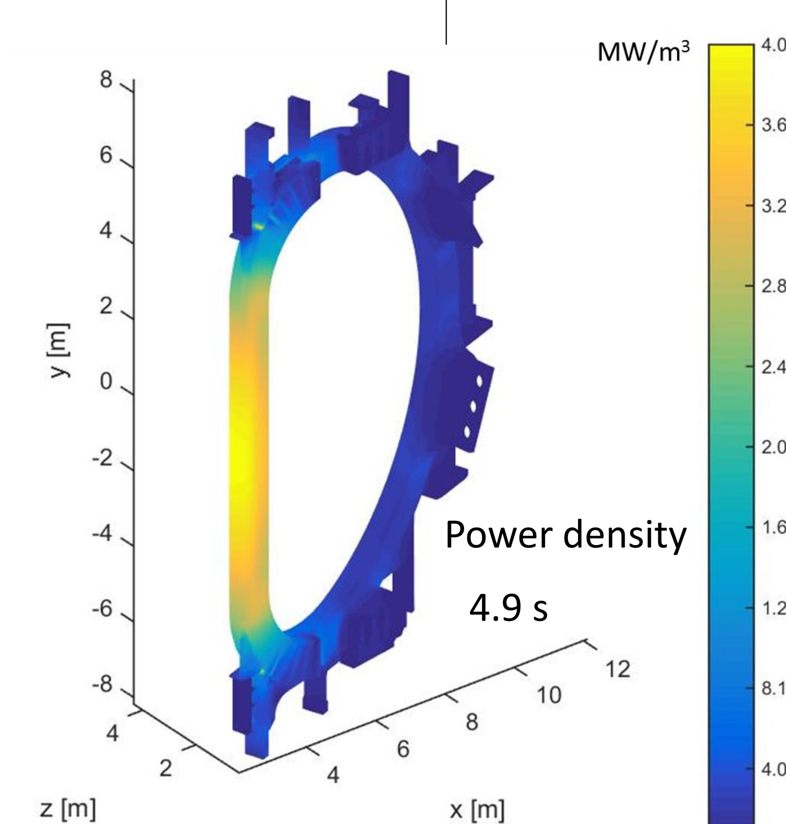


Voltage Ripple



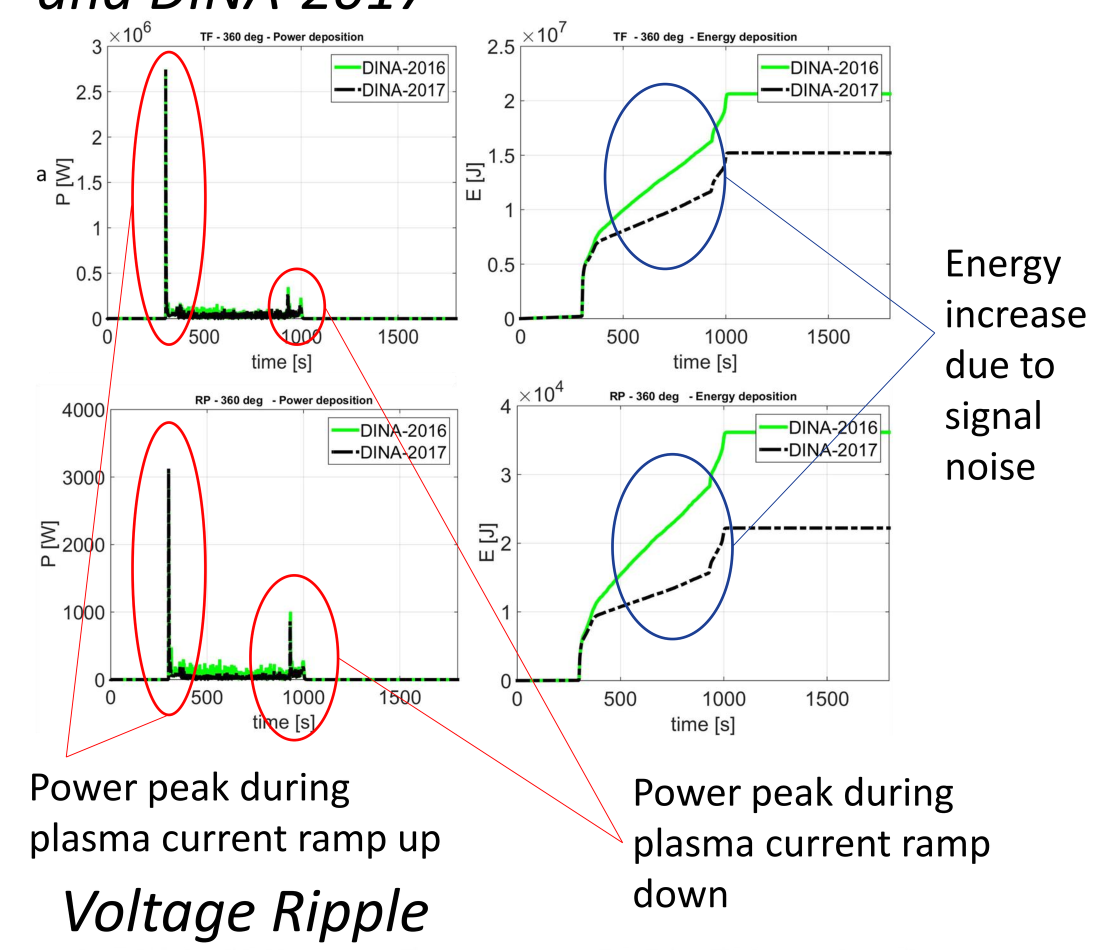
TF Fast Discharge



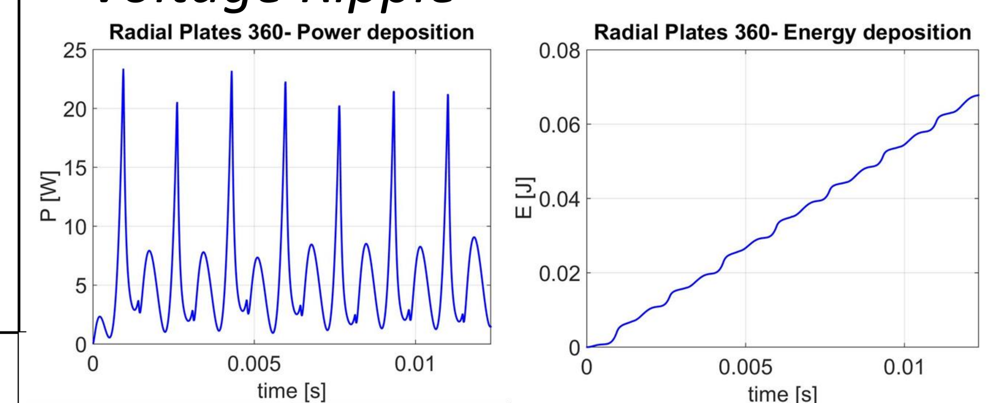


3. Results

Normal Inductive Scenarios: DINA-2016 and DINA-2017



Voltage Ripple



Summary Energy Dissipation

Component	Energy dissipation Model A	Energy dissipation Model B
DINA 2016		
TF Coils	20.63 MJ	20.79 MJ
Radial Plates	36.15 kJ	37.3 kJ
Thermal Shield	1.12 MJ	1.12 MJ
Cryostat	27.37 MJ	27.01 MJ
Vacuum Vessel	80.34 MJ	80.29 MJ
DINA 2017		
TF Coils	15.21 MJ	-
Radial Plates	22.21 kJ	-
Thermal Shield	1.02 MJ	-
Cryostat	25.46 MJ	-
Vacuum Vessel	70.30 MJ	-
TF Fast Discharge		
TF Coils	4.26 GJ	-
Radial Plates	0.90 GJ	-
Thermal Shield	0.55 MJ	-
Cryostat	2.87 kJ	-
Vacuum Vessel	0.56 GJ	-
TF Coils	4.26 GJ	-

The analysis of the normal inductive scenario shows that the coil current (plasma control) noise plays an important role in the power dissipation. The analysis of the TF fast discharge confirms the huge power deposition in the Radial Plates and TF coils. Thermo-hydraulic analyses should be carry out in order to confirm the capability of the superconductors to with-stand such a high thermal loads. The Voltage ripple on the TF coils on the contrary does not induce significant currents on the metallic structures, being therefore completely negligible from the heating point of view. The data presented in this paper can be used as updated input data for thermo-hydraulic analyses aiming and verifying the suitability of the magnet system design.