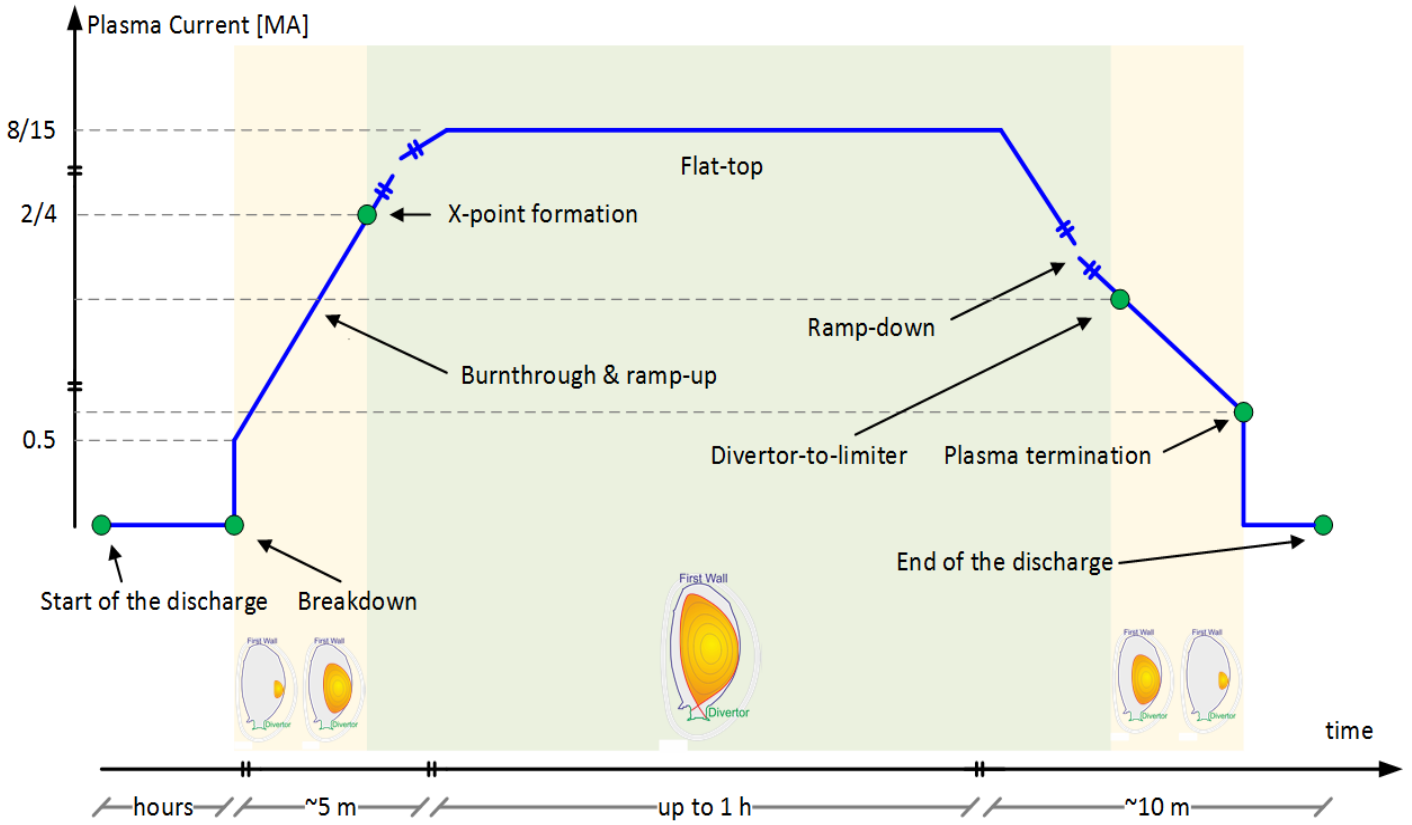
FMPCMP Project

ITER reference scenarios and disturbances for performance assessment

Presented by A. Pironti on behalf of CREATE team

A typical plasma scenario

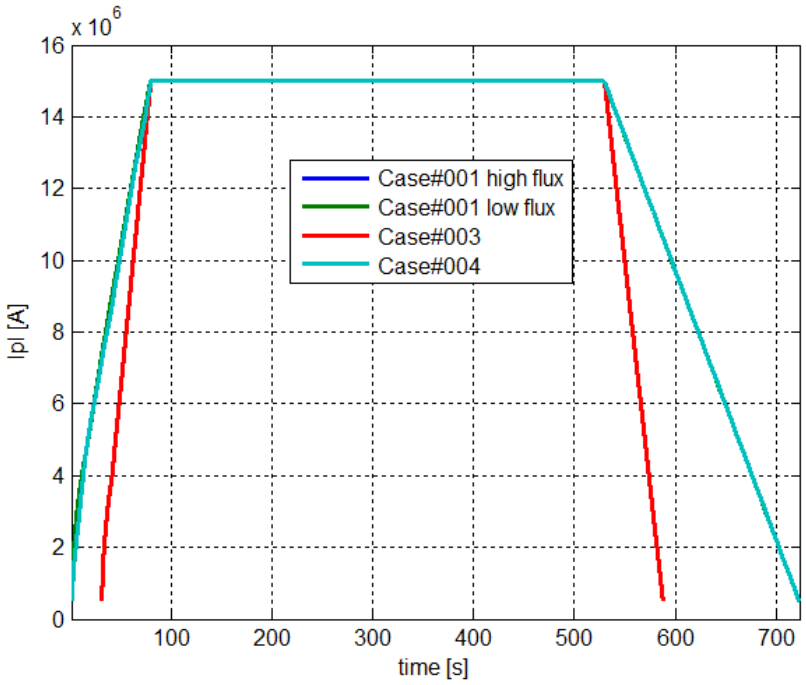


Modelling Assumptions for ITER Scenario Simulations with CREATE-NL code

- Configuration ITER_D_33NHXN_v3.4, Dec. 2010
- Axial-symmetric simulations
- No ferromagnetic inserts
- No TF coil busbars and building effects
- Vacuum vessel shells, outer triangular support, divertor rail ring passive structures;
- First order elements FEM mesh with about 10knodes → limited precision
    - up to 1-2 cm on plasma boundary;
    - up to few percent in magnetic measurements;
    - up to few percent in the determination of max field in coils (in the scale of T);
    - up to few percent in the determination of forces (in the scale of MN).

CASE#001/#003/#004 – 15 MA DT Scenario

- Various cases can be considered
  - Case001a Low flux (artificially lowered)
  - Case001b High (normal) flux consumption
  - Case003 Fast Ramp up and Ramp Down
  - Case004 Late X-Point formation (7.5MA)



Disturbance for performance assessment

Disturbance	Definition
Uncontrolled ELMs (H mode)	β_p decreases of 0.05 in 200 μs l_i increases of 0.05 in 200 μs
Collapses of internal barriers (H mode Scenario 4, only high beta configuration)	β_p decreases of 0.85 and l_i increases of 0.2 with an exponential time behaviour characterized by a time constant of 0.25 s (settling time about 1s)
Minor disruptions (L mode)	β_p decreases of 0.14 in 1 ms and l_i decreases of 0.15 in 3 ms
Fast H-L transition (H mode)	Phase 1: β_p decreases from 0.65 to 0.60 and l_i increases by 0.05 (0.85 to 0.9) with an exponential time behaviour characterized by a time constant of 0.025 s (settling time about 100 ms). Phase 2: β_p decreases from 0.60 to 0.2 with a time constant of 0.36 s (settling time of about 1.5 s) and l_i increases from 0.9 to 1.0 with a time constant of 1.8 s (settling time of about 7 s)
L-H transition (L mode)	β_p increases from 0.2 to 0.65 and l_i decreases from 1.1 to 0.85 with an exponential time behaviour characterized by a time constant of 700ms (settling time about 3.5s)

Modelling the disturbances

$$L^*\delta\dot{x}(t) + R\delta x(t) + L_E\delta\dot{w}(t) = S\delta v(t)$$

Linearized models (presented by Gianmaria)

$$\delta w(t) = \begin{bmatrix} \delta(\beta_p(t)I_p(t)) \\ \delta(l_i(t)I_p(t)) \end{bmatrix}$$

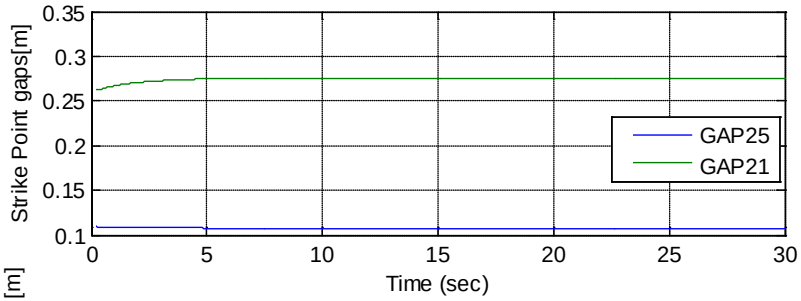
Simulation results

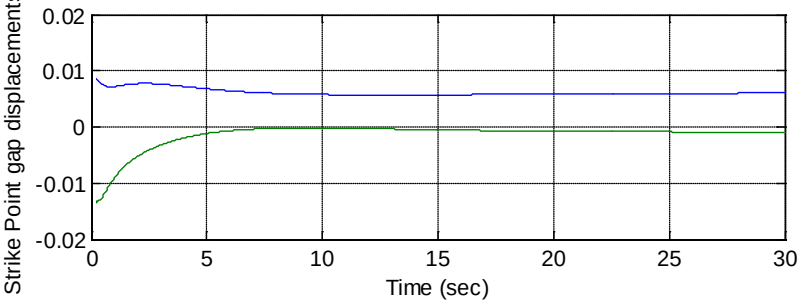
- Rejection of disturbance during the flat-top phase
- Nonlinear simulation of the L-H transition

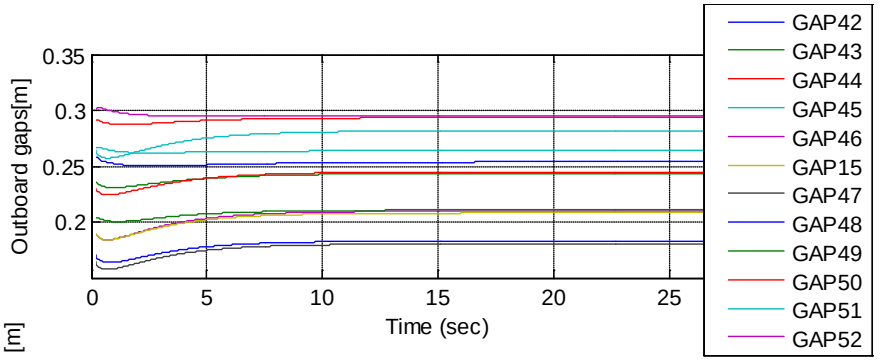
Disturbance rejection in the flat-top phase

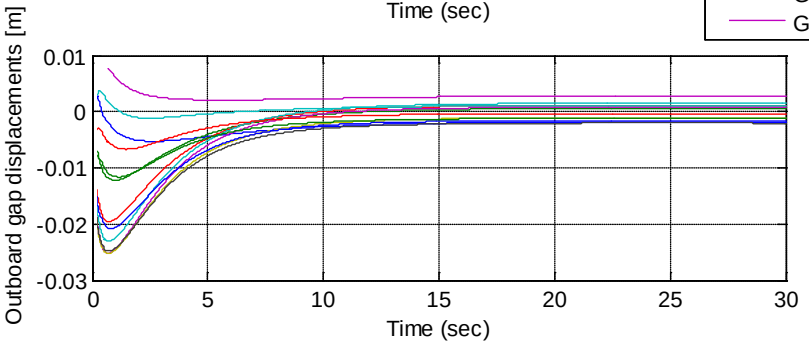
Disturbance	Models	Simulation
Uncontrolled ELMs (H-mode Case 1 Scenario)	SOB equilibrium (Equil_PCSSP_Scenario01_t090_CL.mat)	simA1
Minor disruptions (L-mode Case 1 Scenario)	SOB equilibrium (Equil_PCSSP_Scenario01_t090_CL.mat)	simA2
Fast H-L transition (Case 1 Scenario)	SOB equilibrium (Equil_PCSSP_Scenario01_t090_CL.mat)	simA3
L-H transition (Case 1 Scenario)	SOF equilibrium (Equil_PCSSP_Scenario01_t080_CL.mat)	simA4
Fast H-L transition (Case 1 Scenario)	EOB equilibrium (Equil_PCSSP_Scenario01_t520_CL.mat)	simA5

simA1 (Uncontrolled ELMs) simulation









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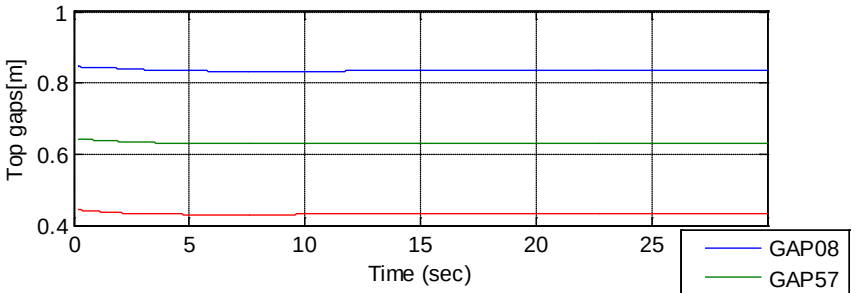

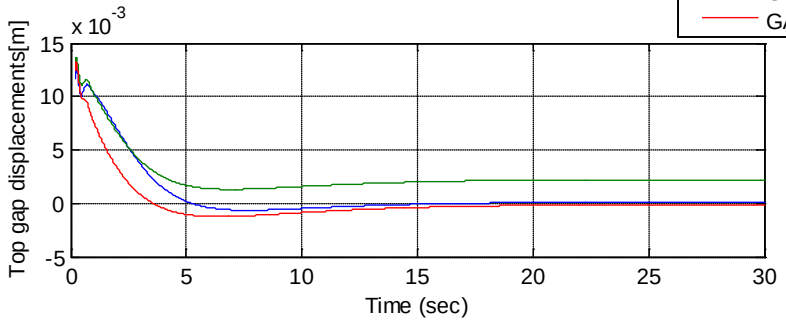

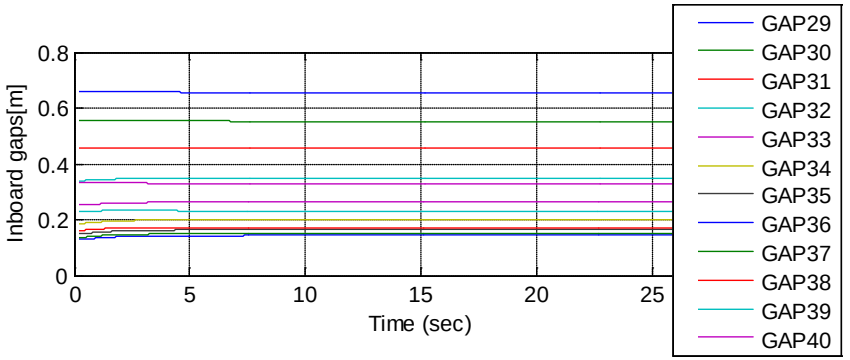

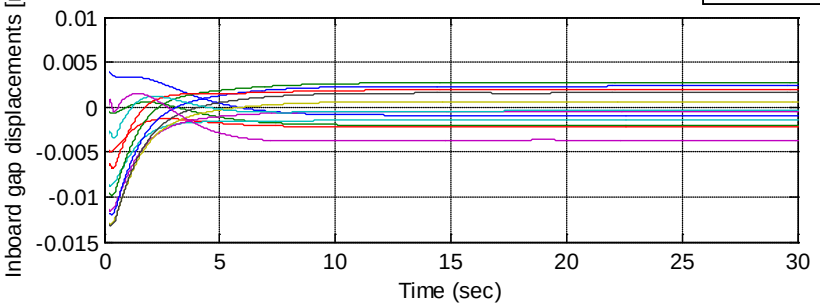

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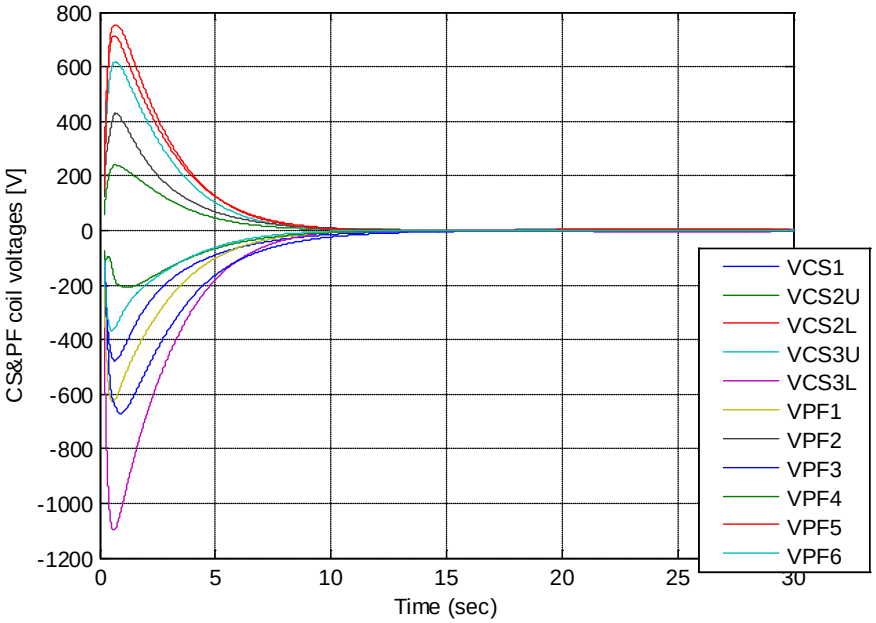

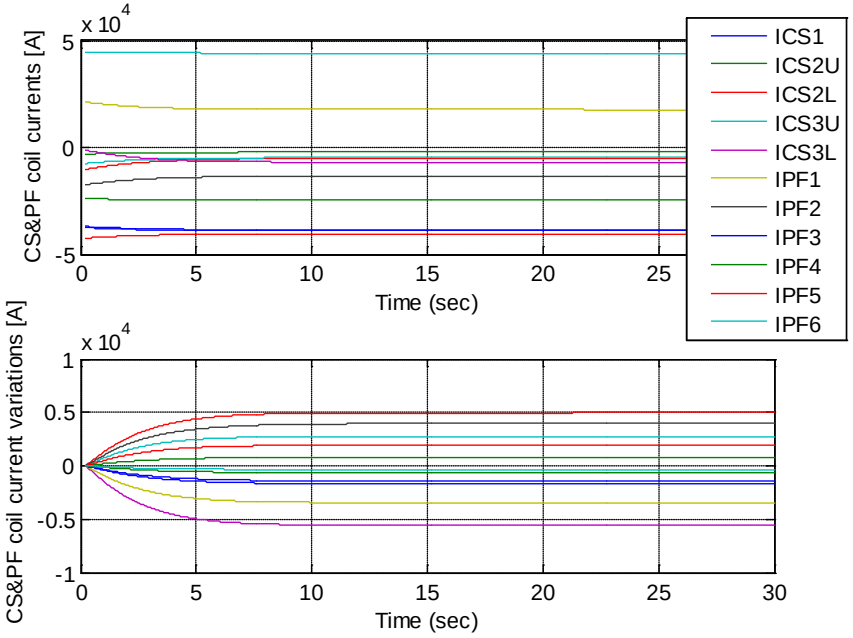

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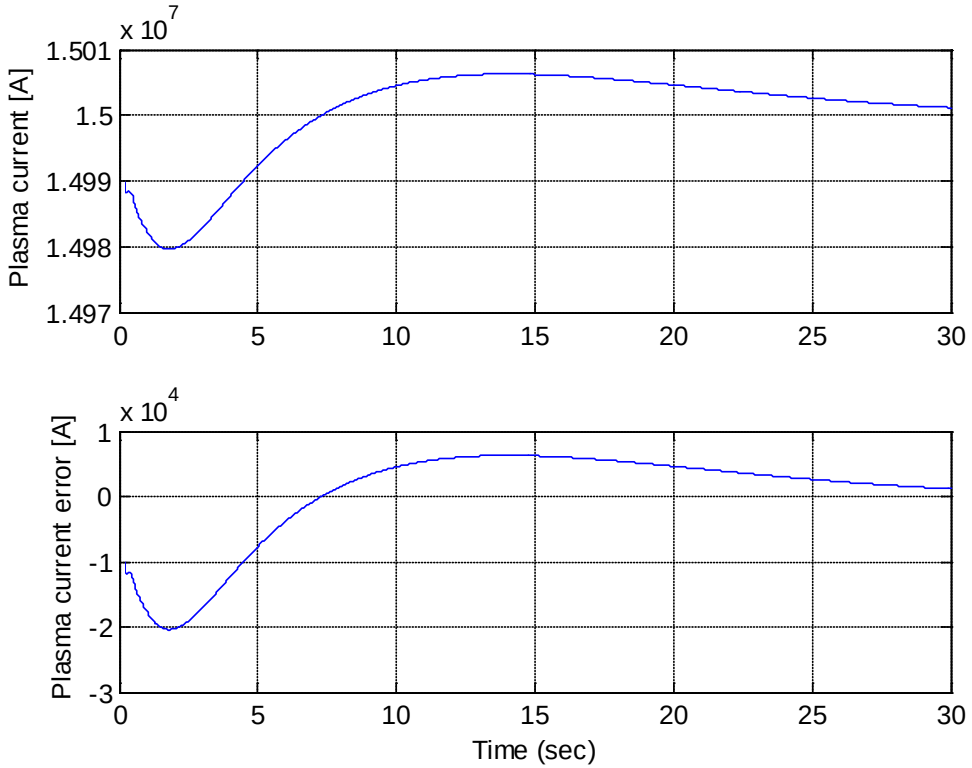
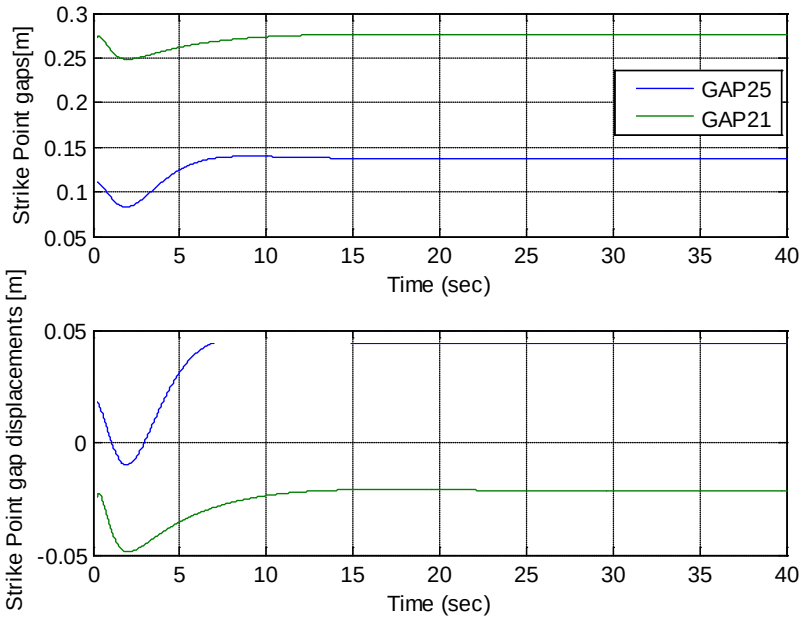
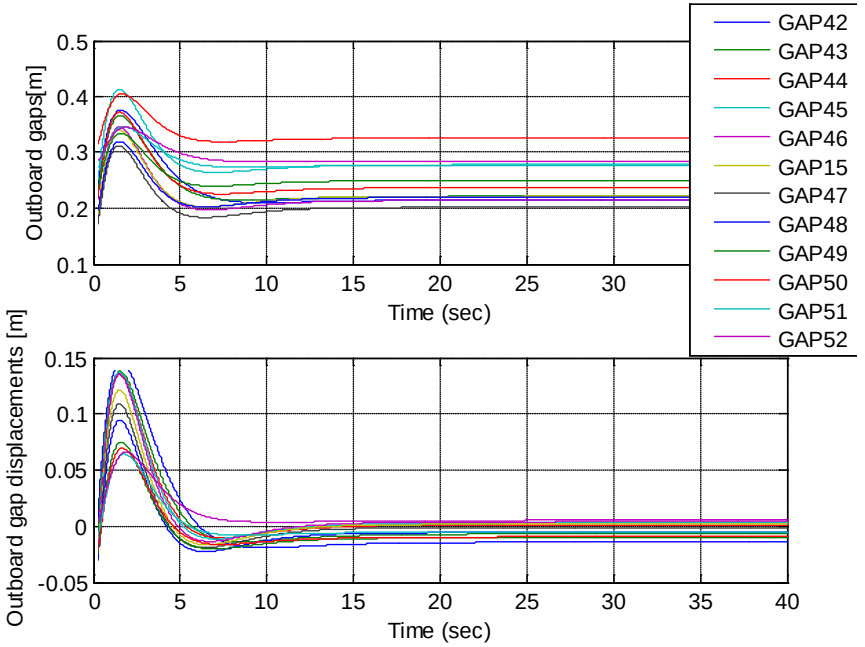


simA5 (Fast H-L transition) simulation





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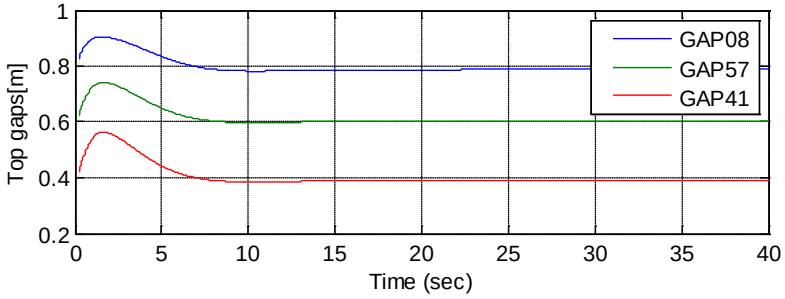

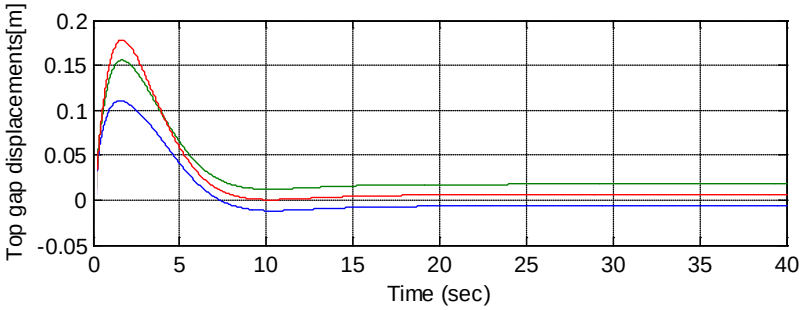

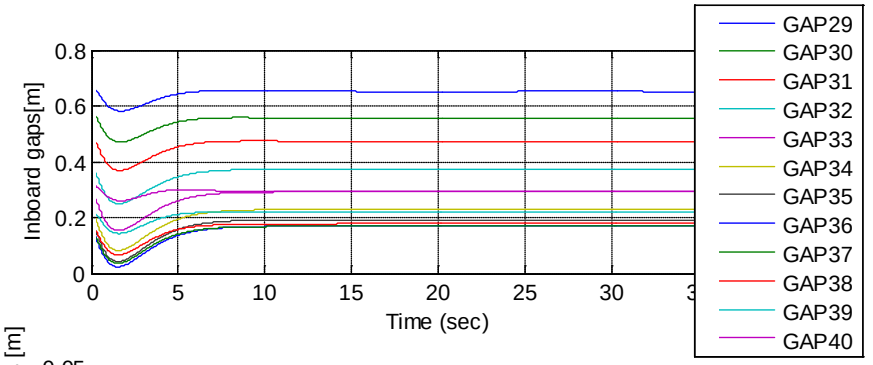

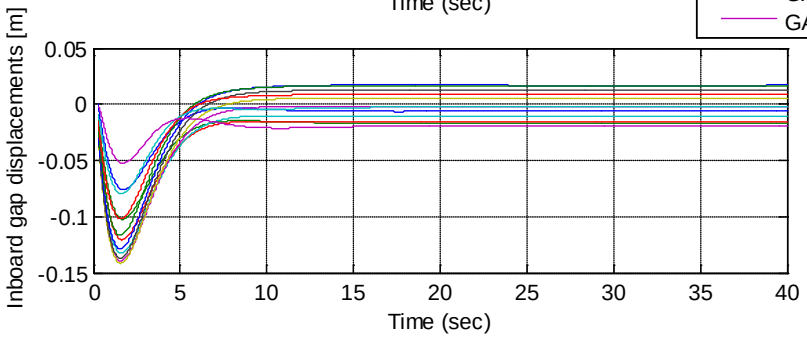

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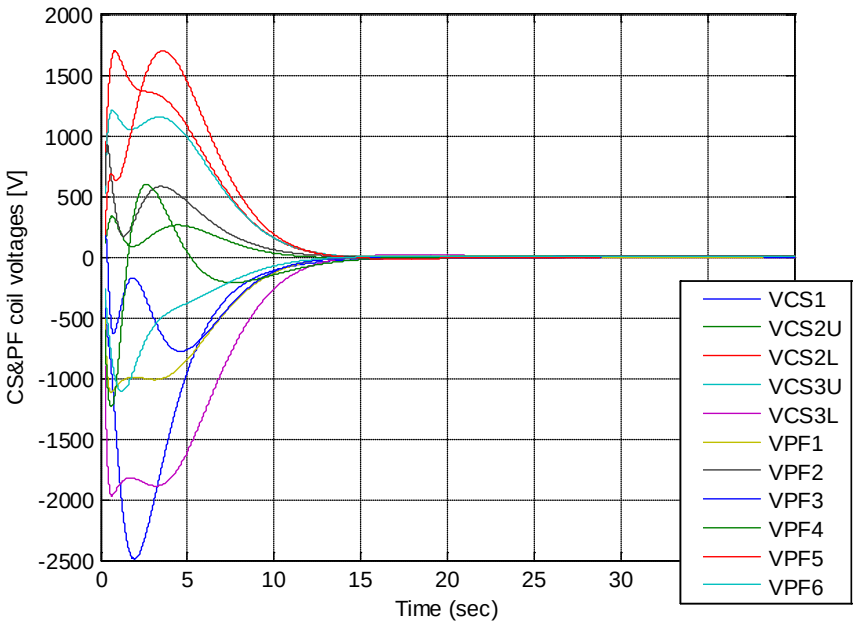

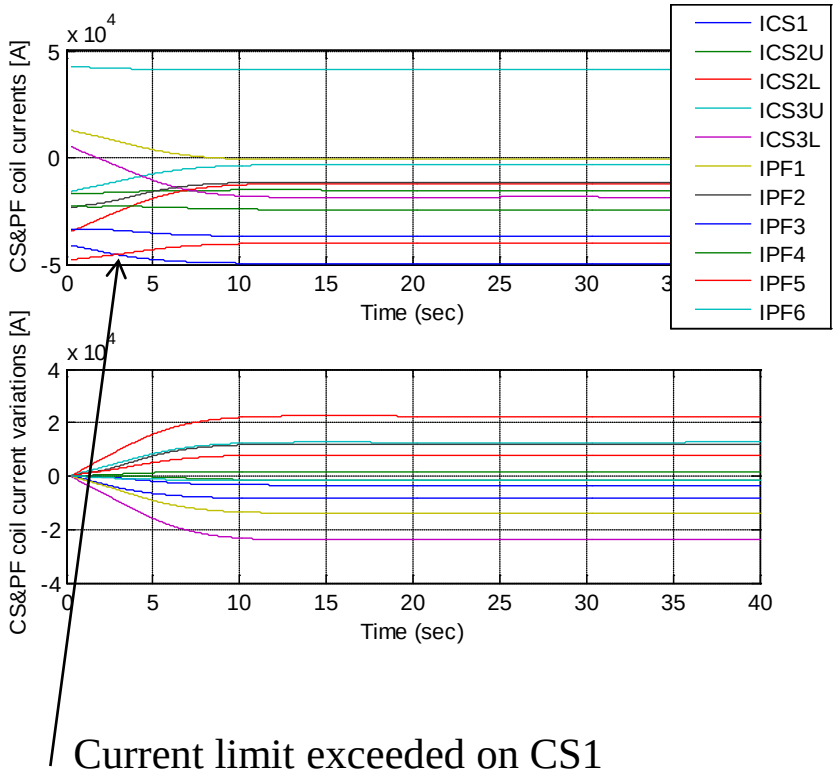

Current limit exceeded on CS1

Total power peak of about 110MW

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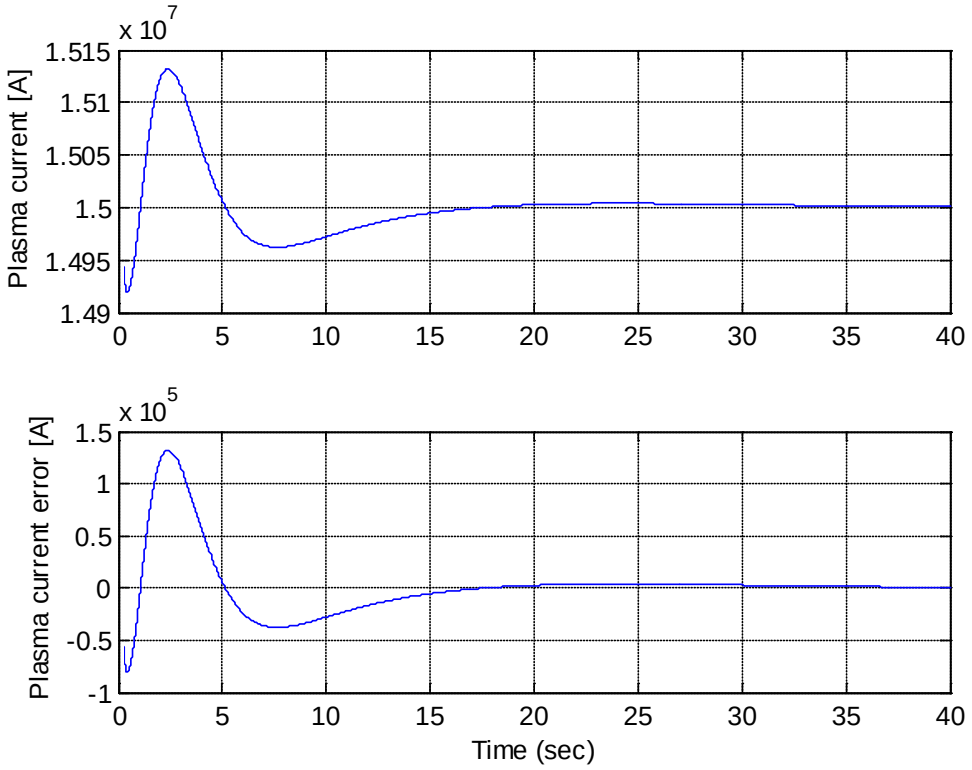

Nonlinear simulation of the L-H transition

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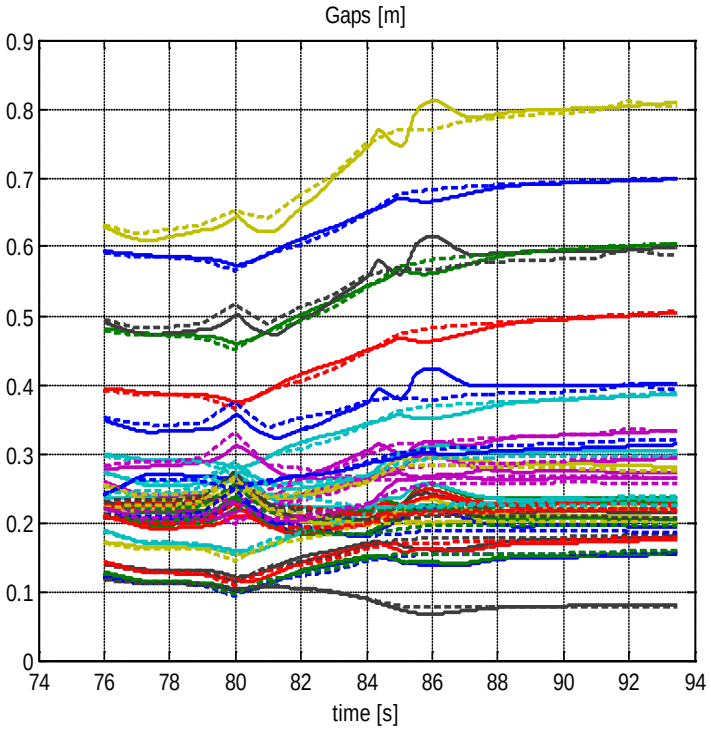

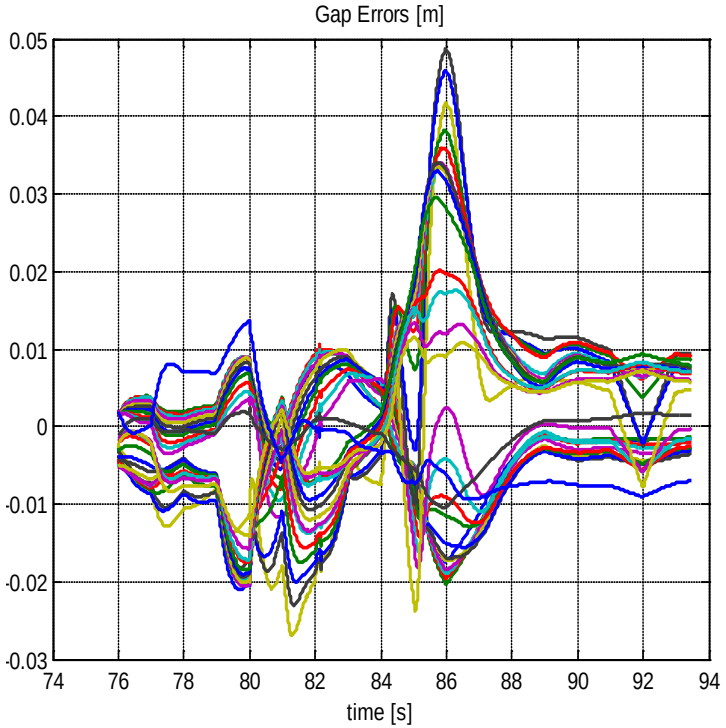

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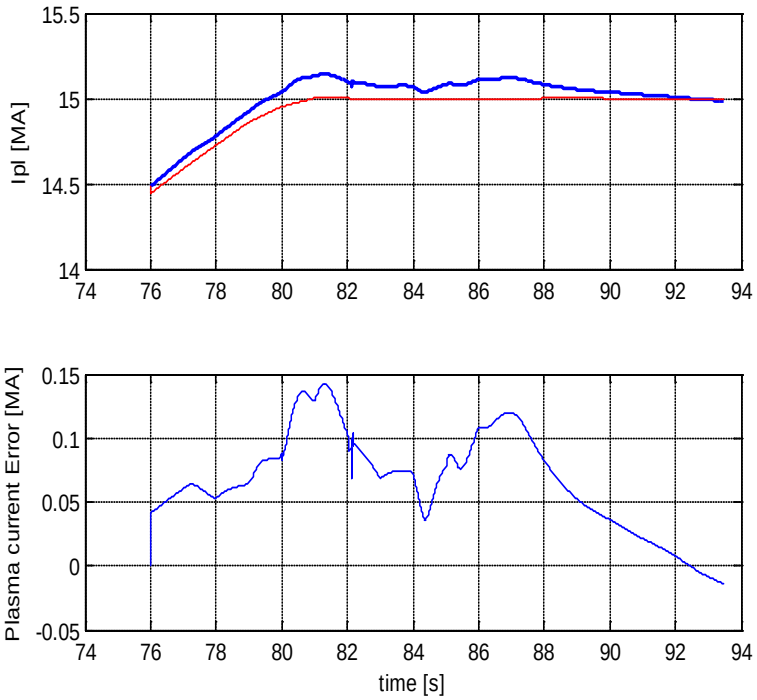

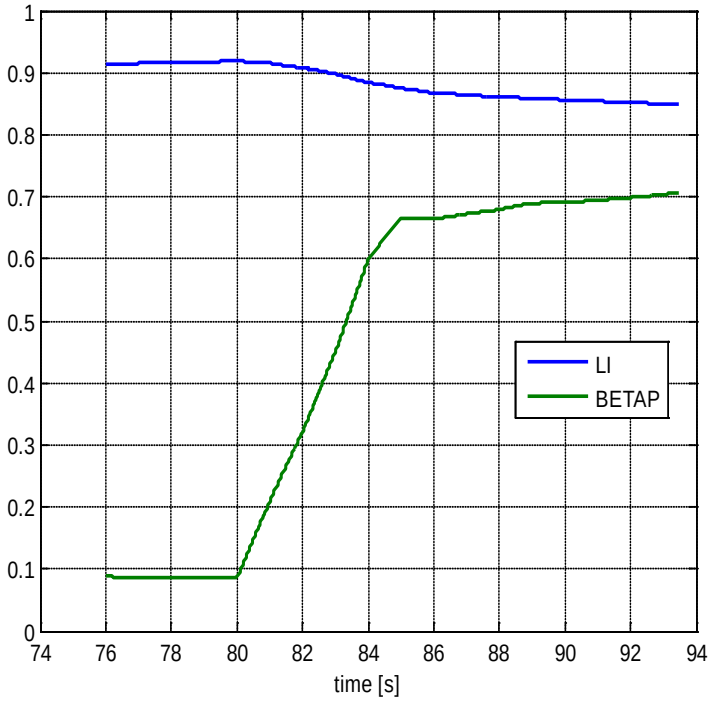

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