Comparing the MHD Cell Stability of an Aluminium Reduction Cell at Different Metal Pad Height and Ledge Thickness

Marc Dupuis

Valdis Bojarevics

GENISIM

University of Greenwich,
School of Computing and Mathematics

Plan of the Presentation

- Introduction
- Full Cell 3D ANSYS® Based Model
- Full Cell Partially 1D ANSYS® Based Model
- MHD-Valdis 1D Model
- Current Density Modeling Results
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  - 10 cm Ledge Thickness Case
- Influence of the Metal Pad Current Density on the MHD Cell Stability
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  - 10 cm Ledge Thickness Case
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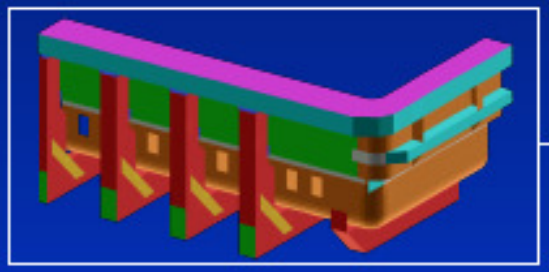
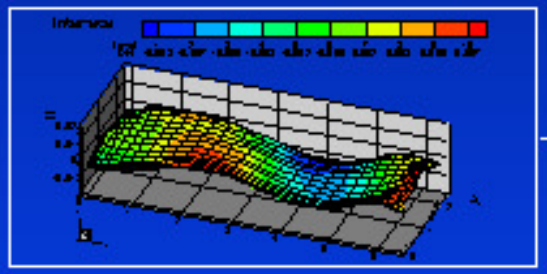
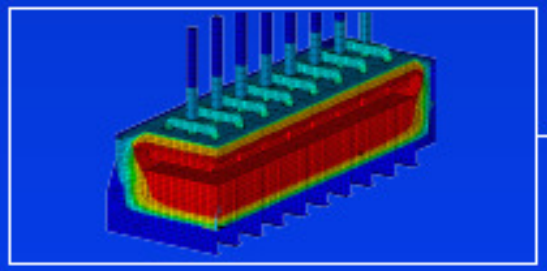
Introduction

Currently, we can fit Hall-Héroult mathematical models into three broad categories:

- Stress models which are generally associated with cell shell deformation and cathode heaving issues.
- Magneto-hydro-dynamic (MHD) models which are generally associated with the problem of cell stability.
- Thermal-electric models which are generally associated with the problem of cell heat balance.







Cell Design

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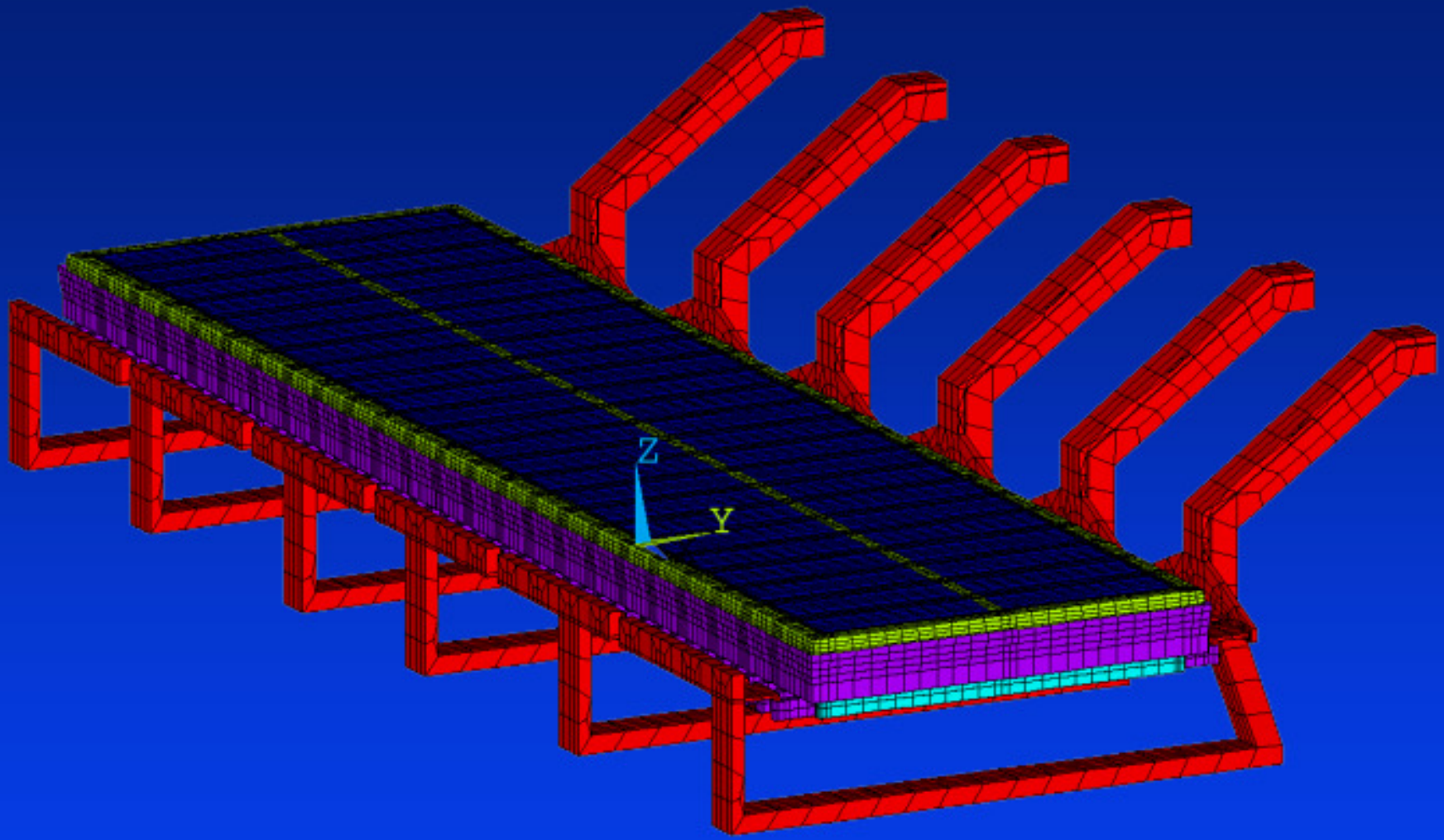
Full Cell 3D ANSYS® Based Model



Full Cell 3D ANSYS® Based Model Mesh

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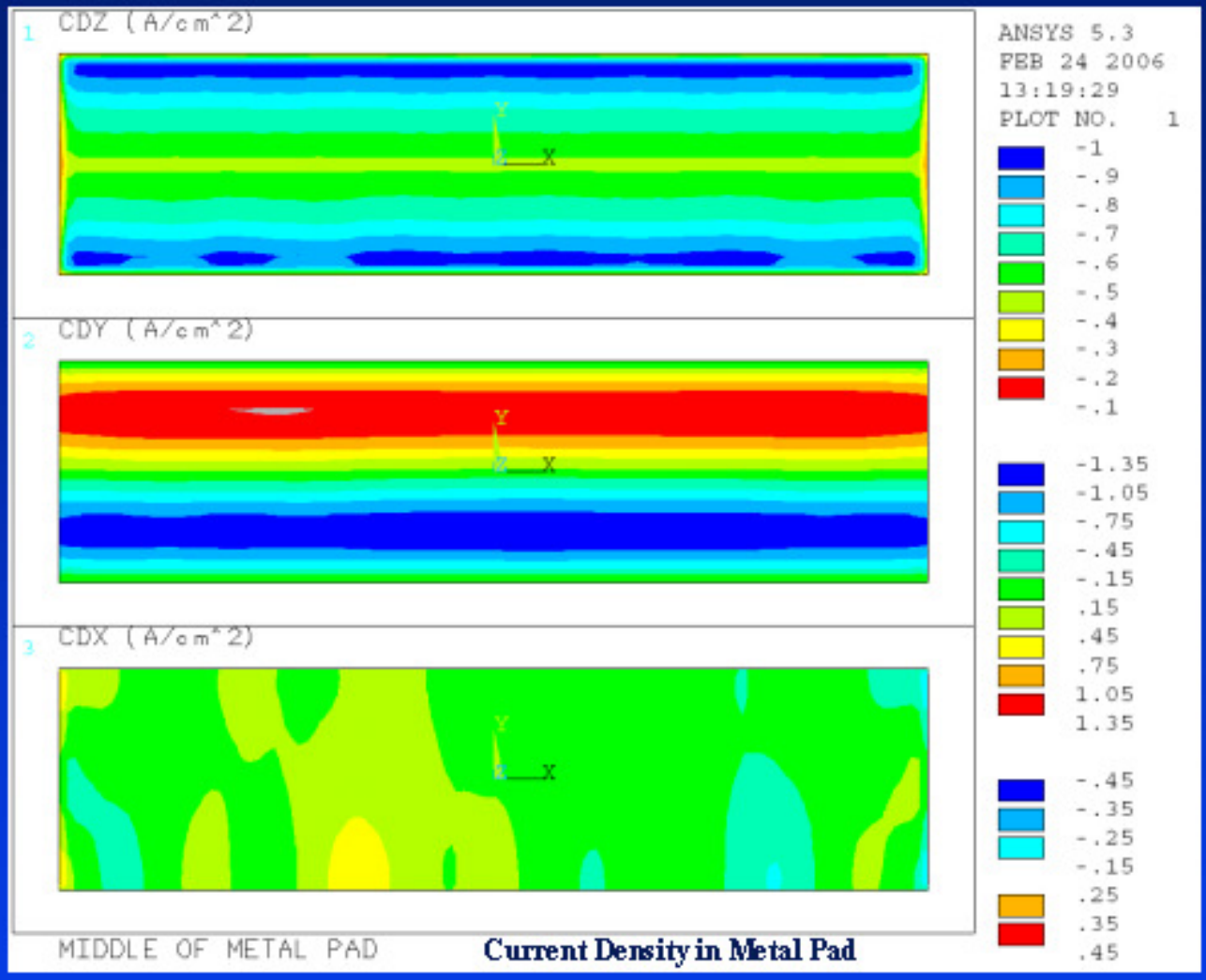
Full Cell 3D ANSYS® Based Model



Current Density in Metal Pad

Solution obtained after "only" 1 hour and 39 minutes of CPU time of computation

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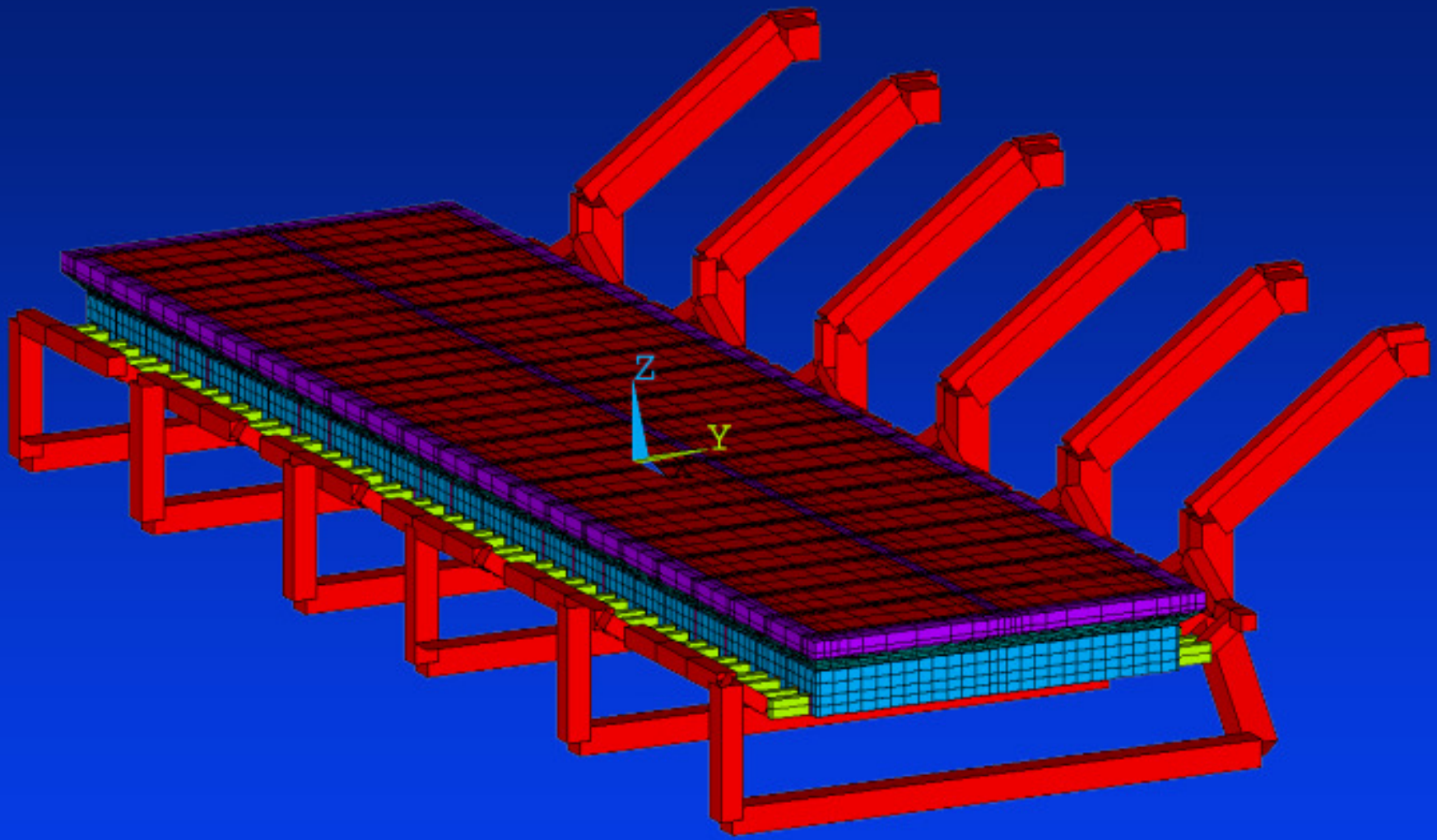
Full Cell Partially 1D ANSYS® Based Model



Full Cell Partially 1D ANSYS® Based Model Mesh

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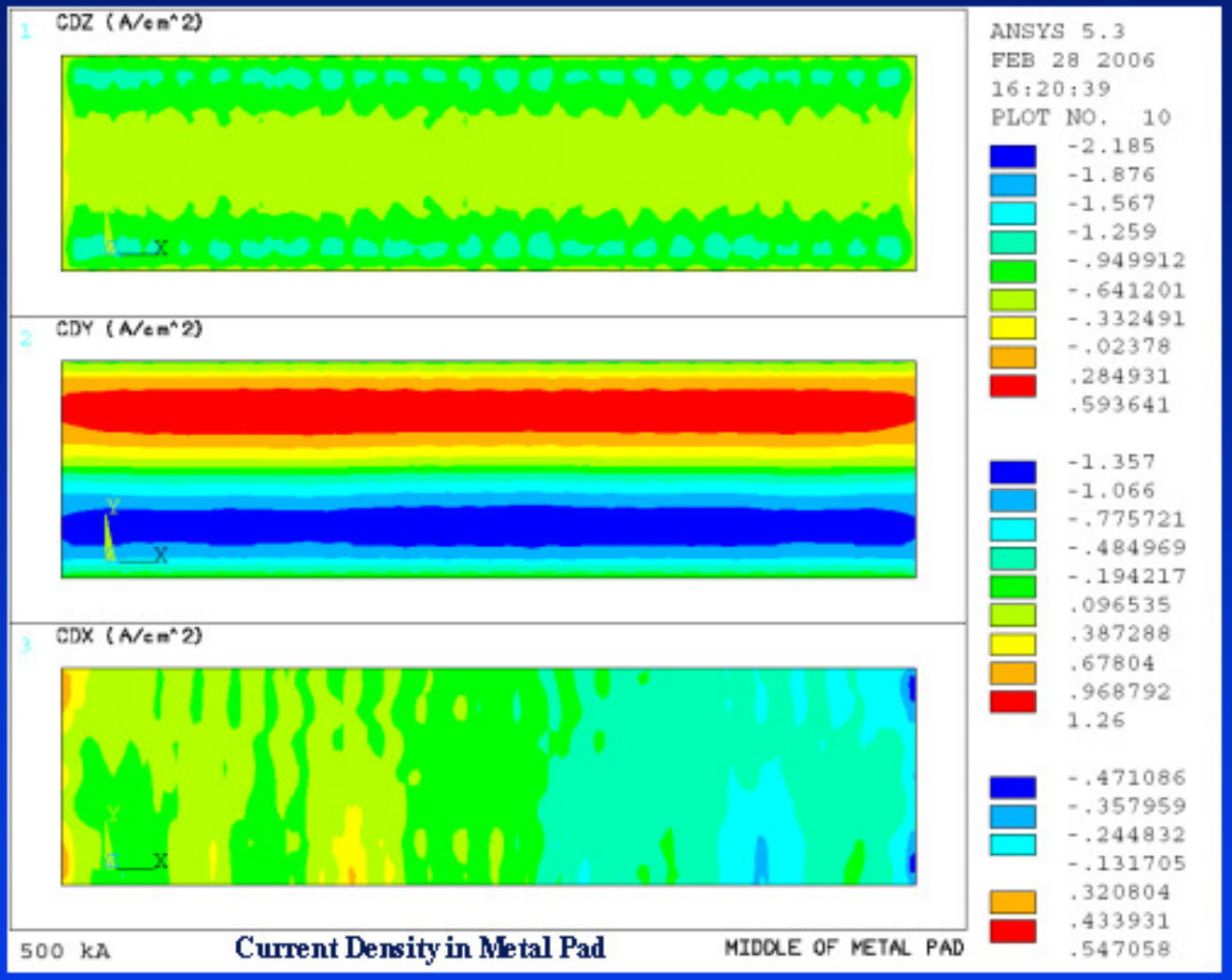
Full Cell Partially 1D ANSYS® Based Model



This simpler model took 7 minutes CPU time to compute the metal pad current density

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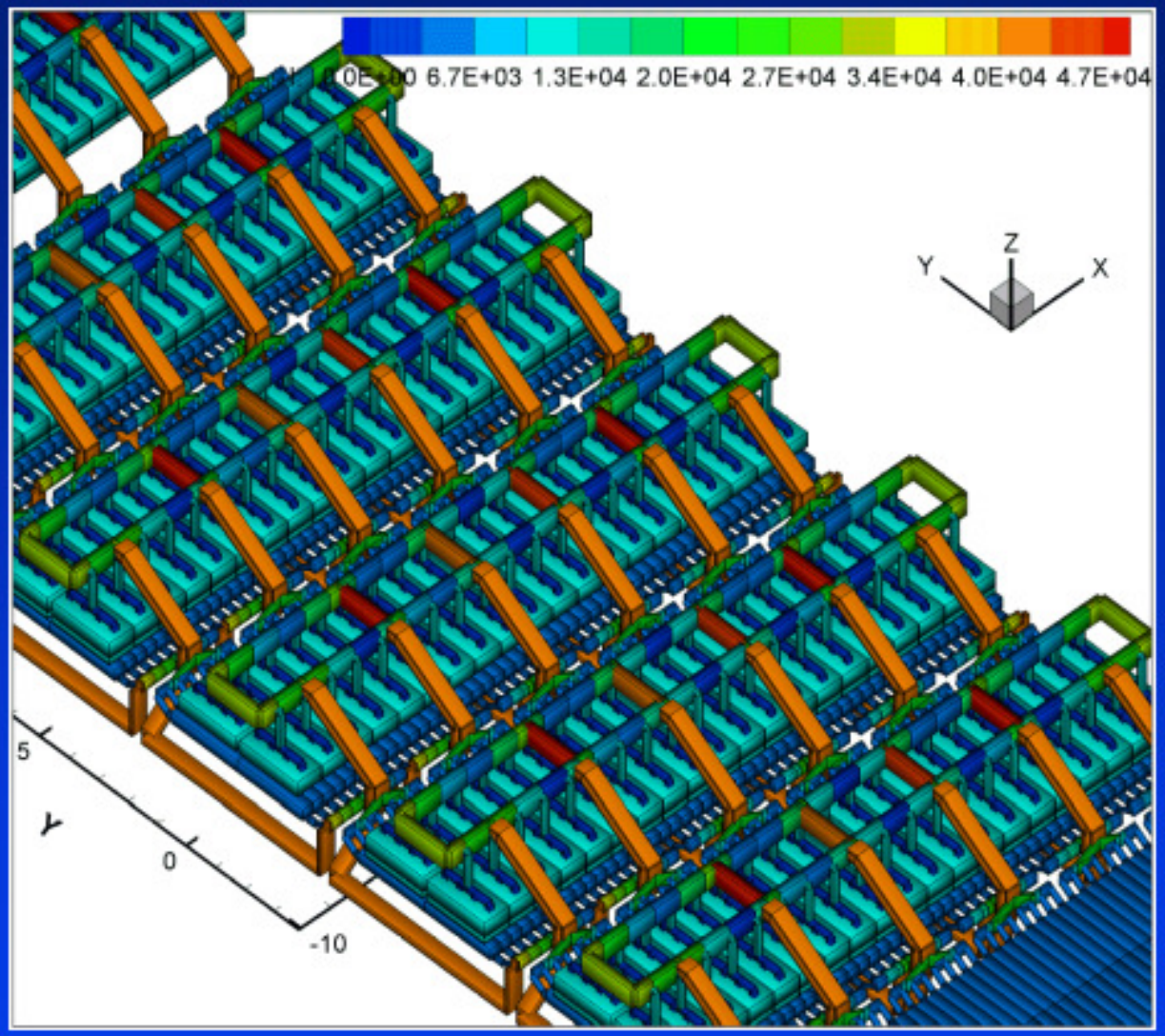
MHD-Valdis 1D Model

Network of 1D conductors



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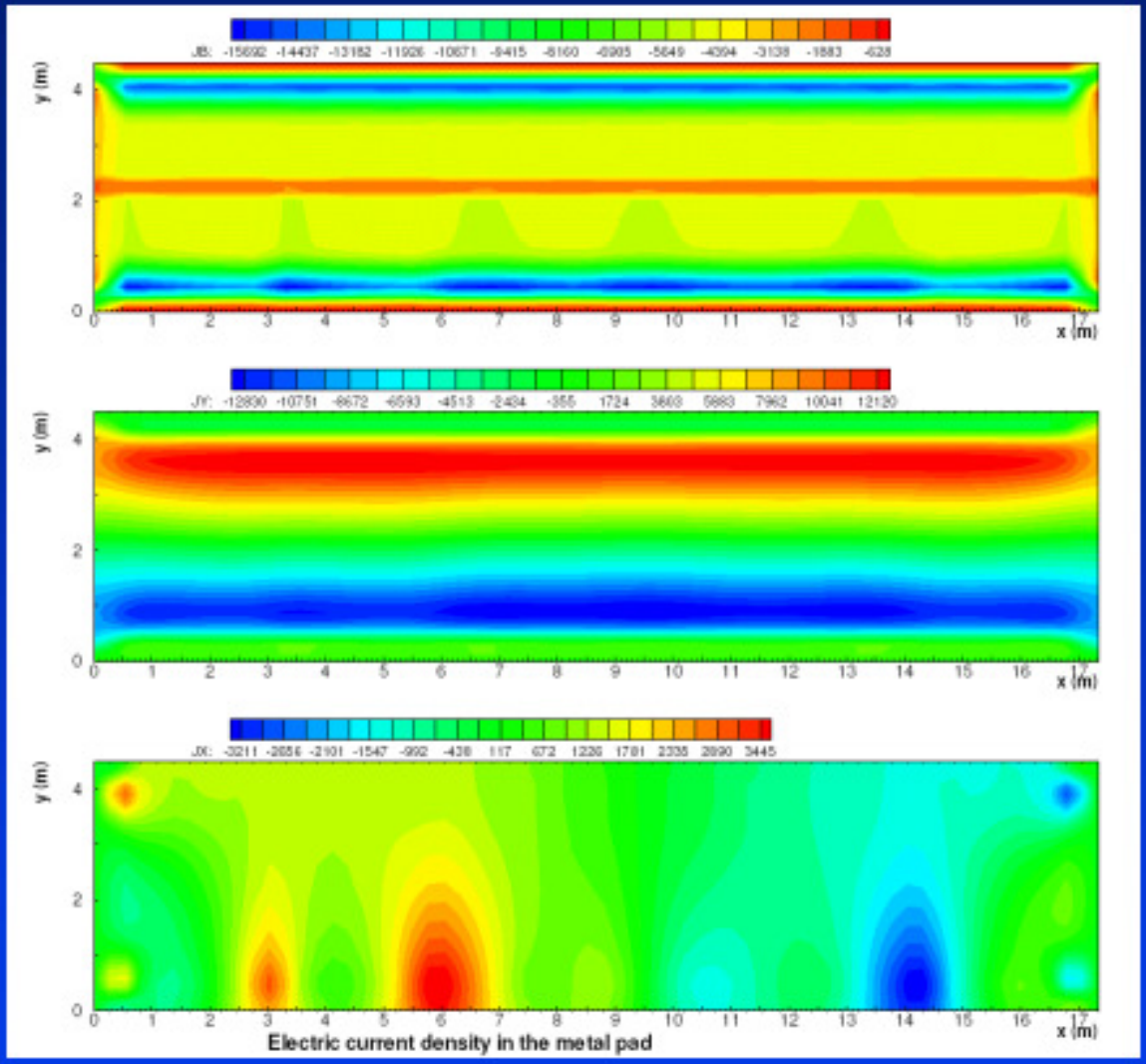
MHD-Valdis 1D Model



MHD-Valdis model took only a few CPU seconds to compute the metal pad current density

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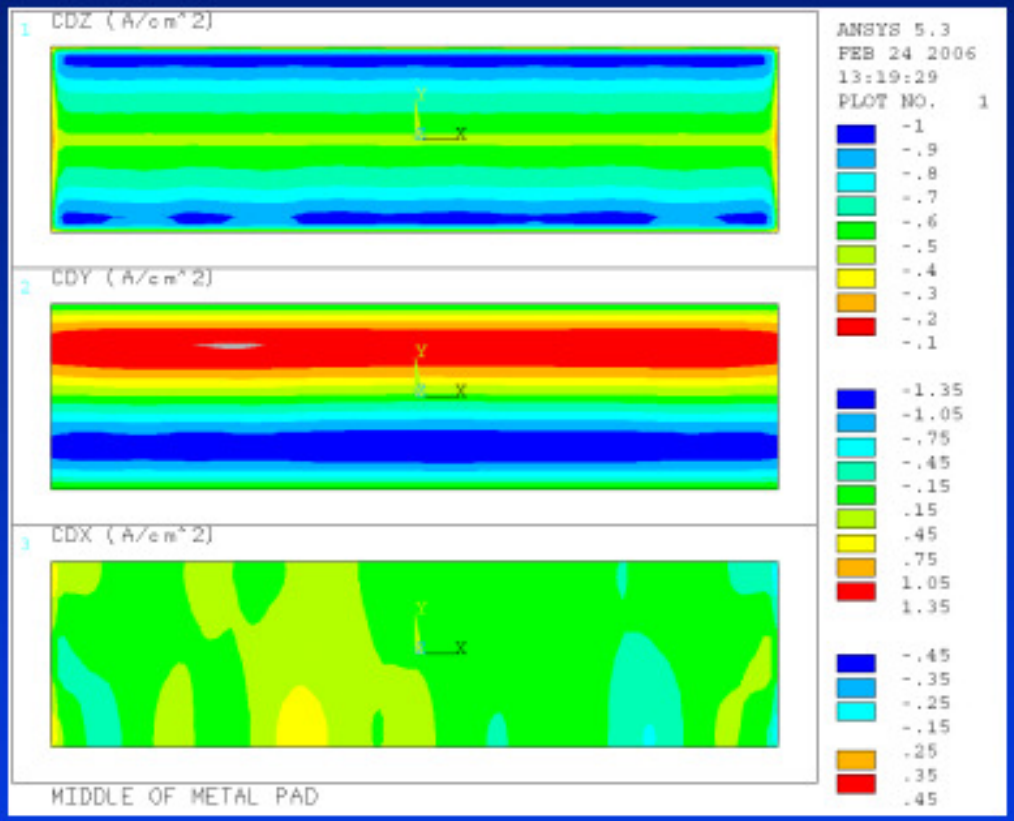
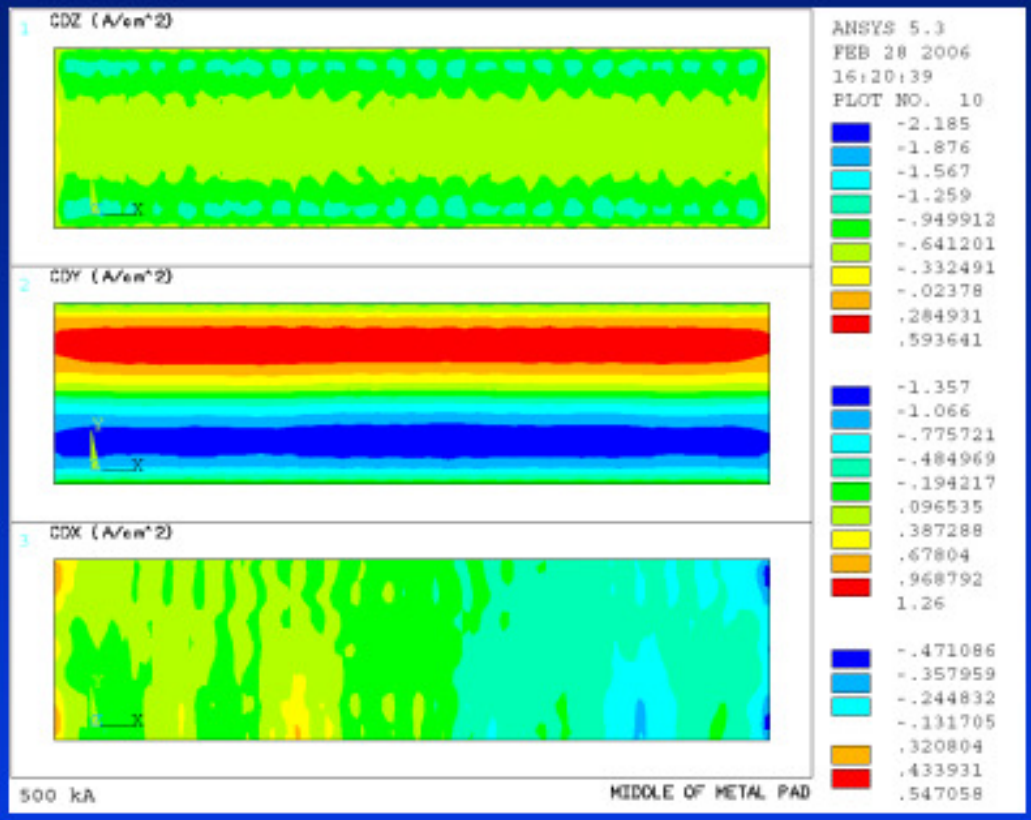
Base Case: 20 cm Metal, 4 cm Ledge





Almost identical results between the 2 ANSYS® based models

Maximum horizontal current: 1.35 A/cm^2

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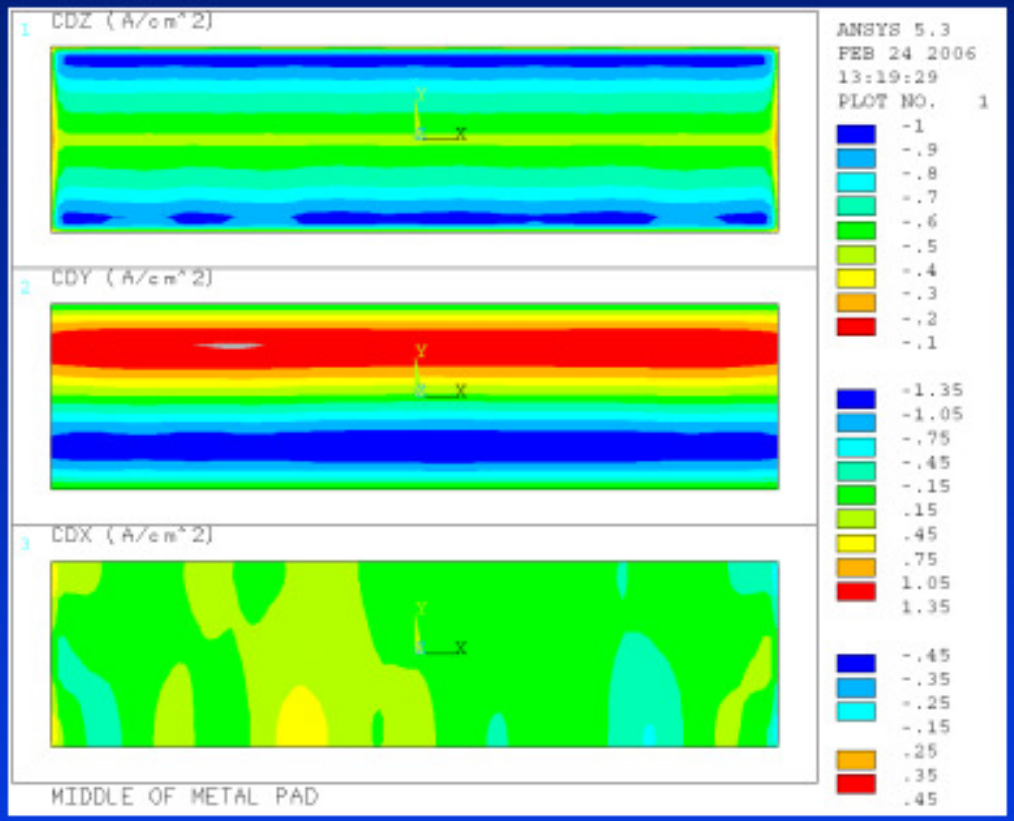
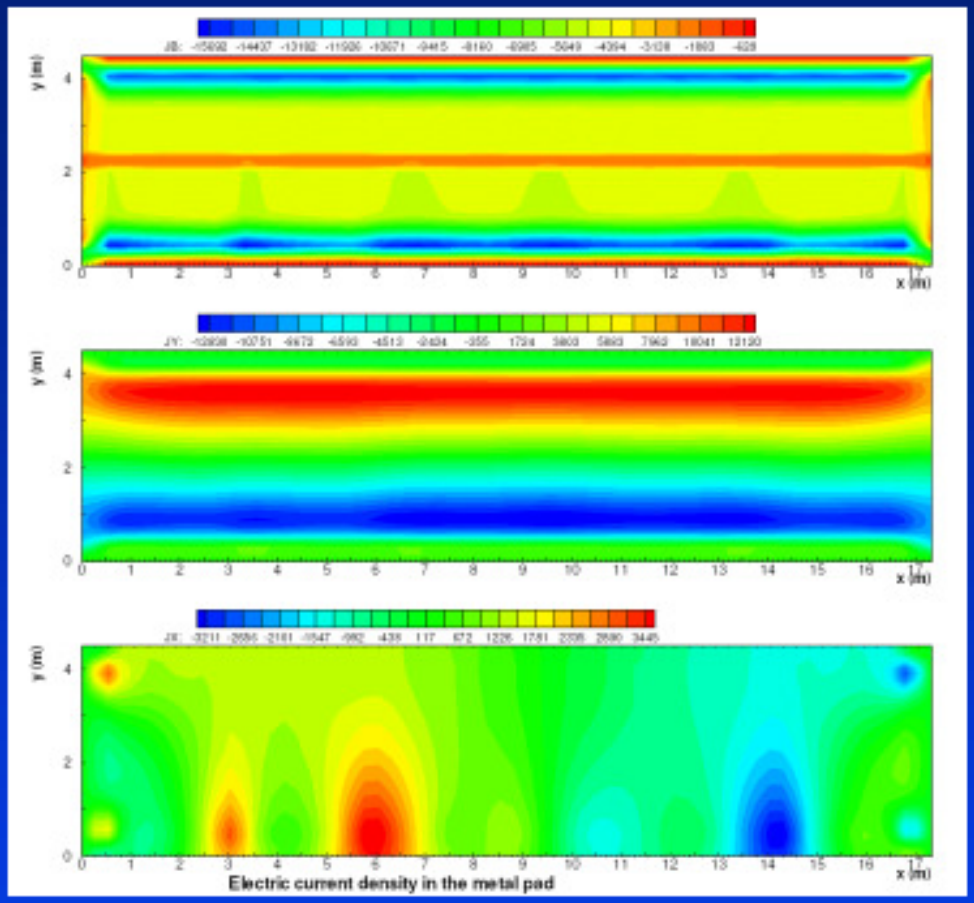
Base Case: 20 cm Metal, 4 cm Ledge





Very similar results between the ANSYS® based models and MHD-Valdis

MHD-Valdis maximum horizontal current: 1.28 A/cm^2

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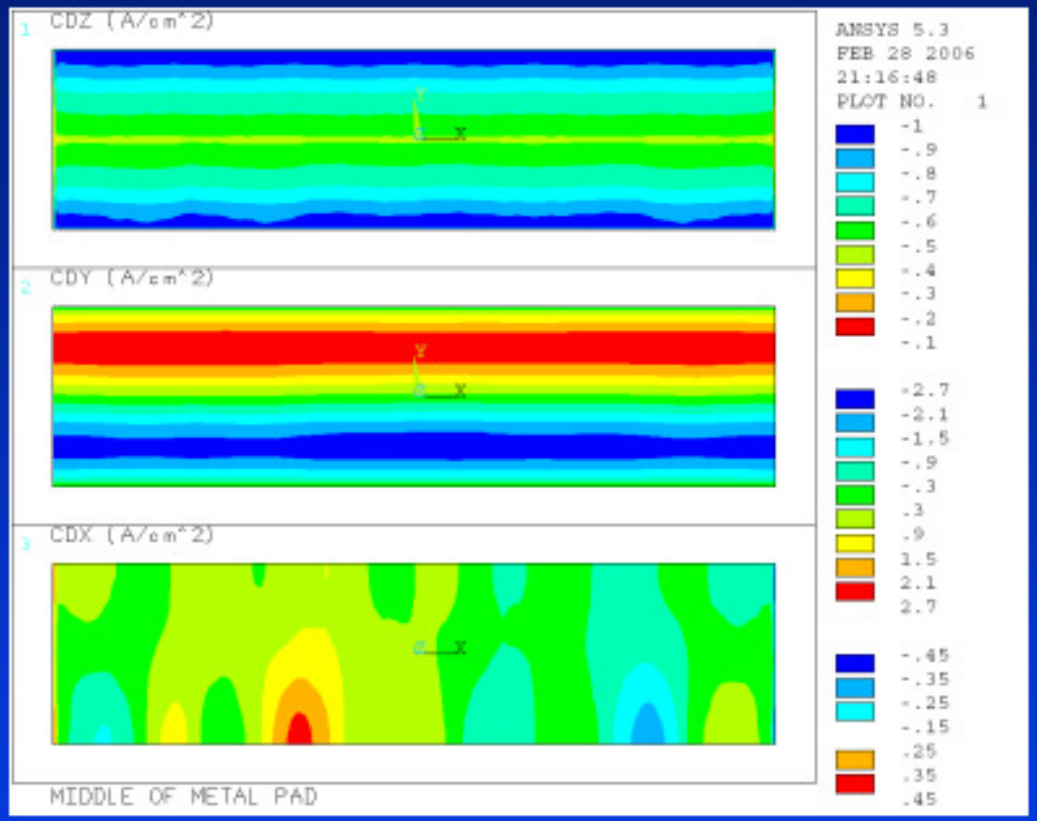
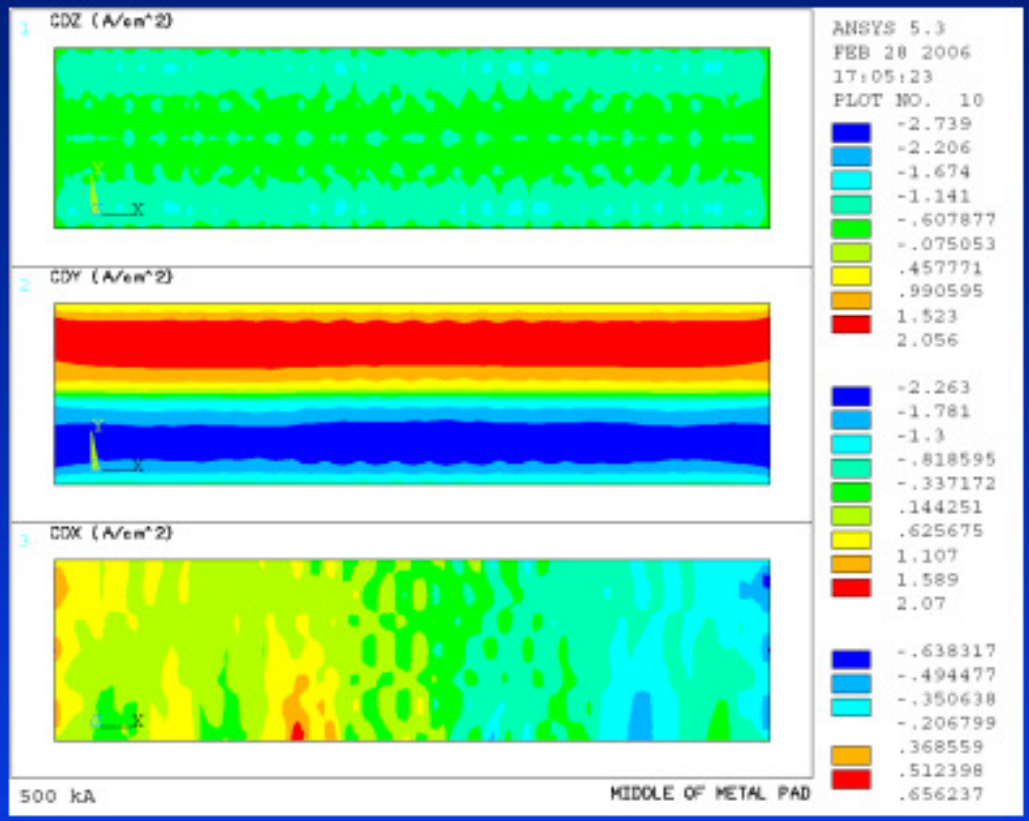
10 cm Metal Pad Case





Almost identical results between the 2 ANSYS® based models

Maximum horizontal current: 2.7 A/cm^2

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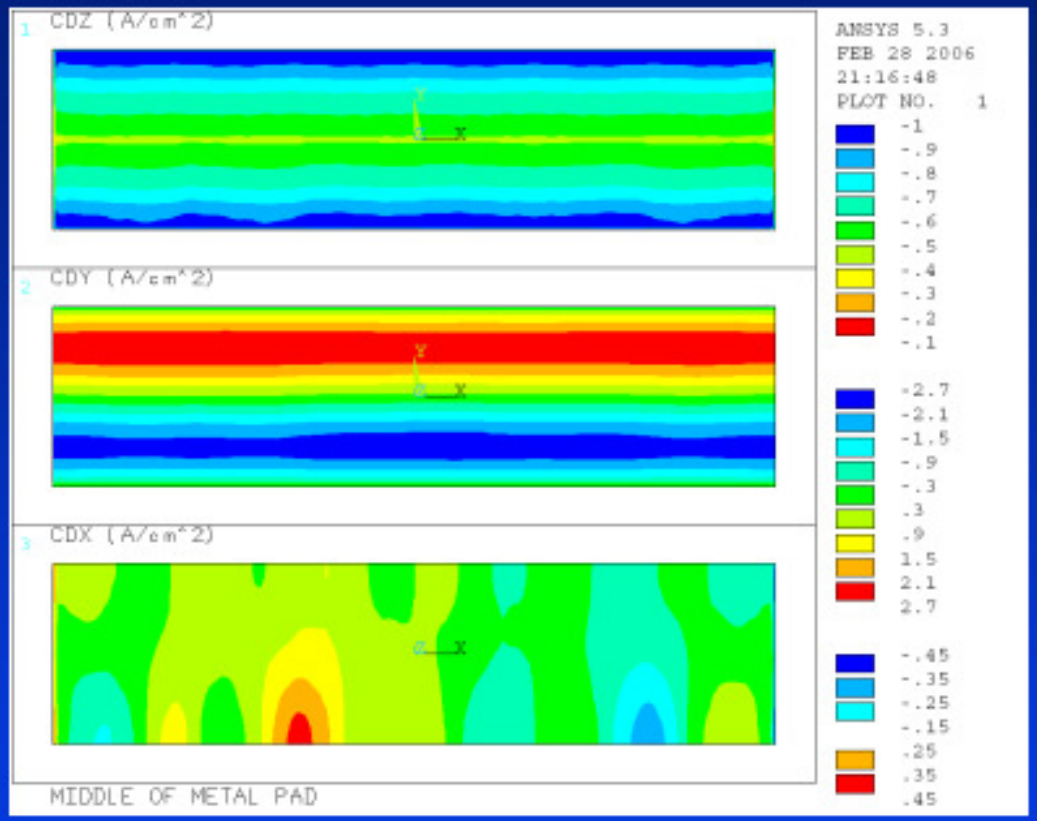
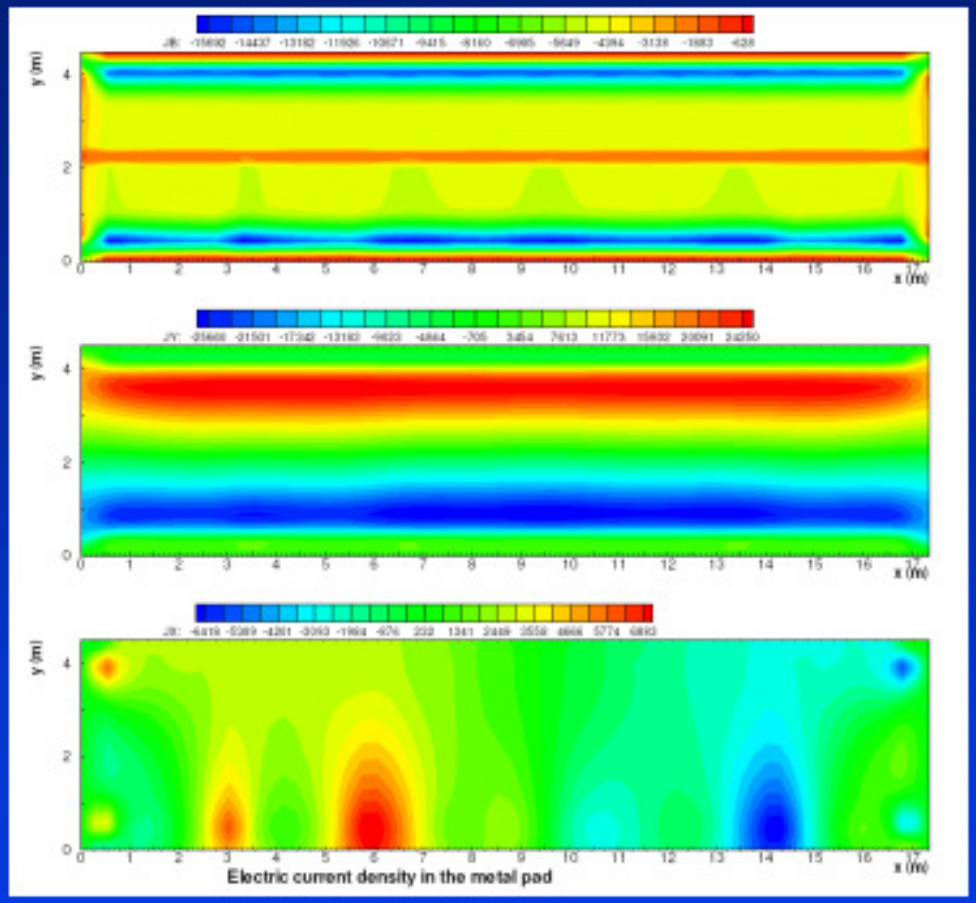
10 cm Metal Pad Case





Very similar results between the ANSYS® based models and MHD-Valdis

MHD-Valdis maximum horizontal current: 2.57 A/cm^2

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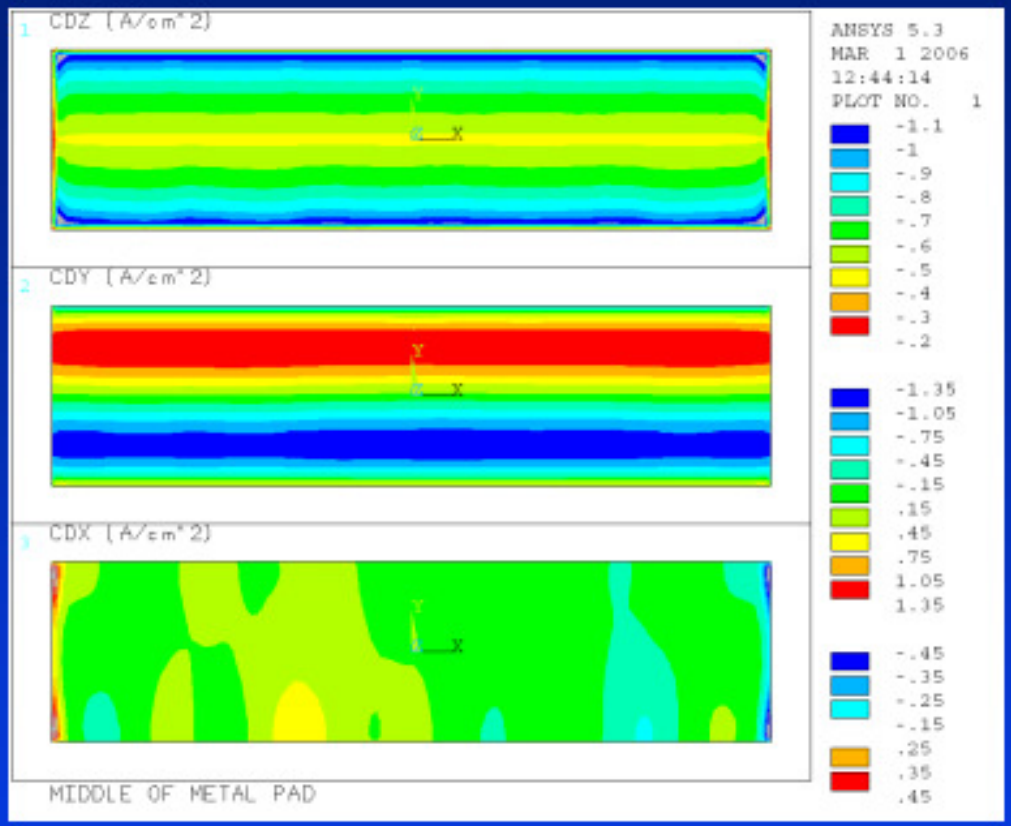
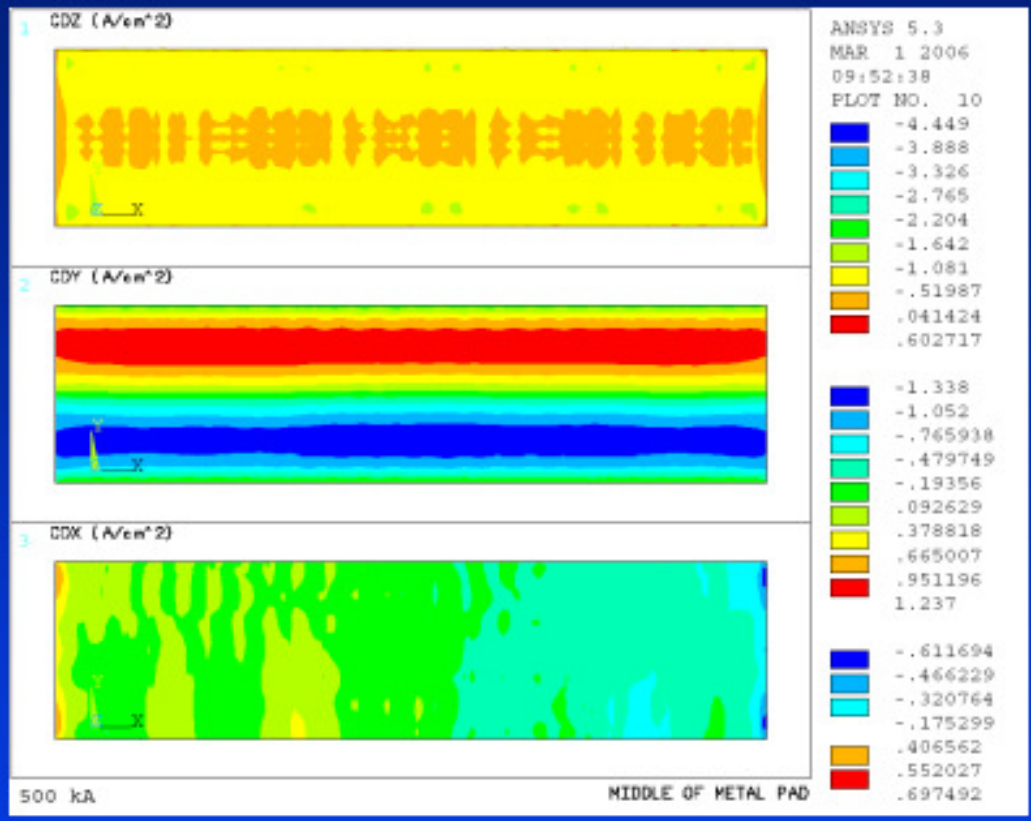
10 cm Ledge Thickness Case





Almost identical results between the 2 ANSYS® based models

Maximum horizontal current: 1.34 A/cm^2

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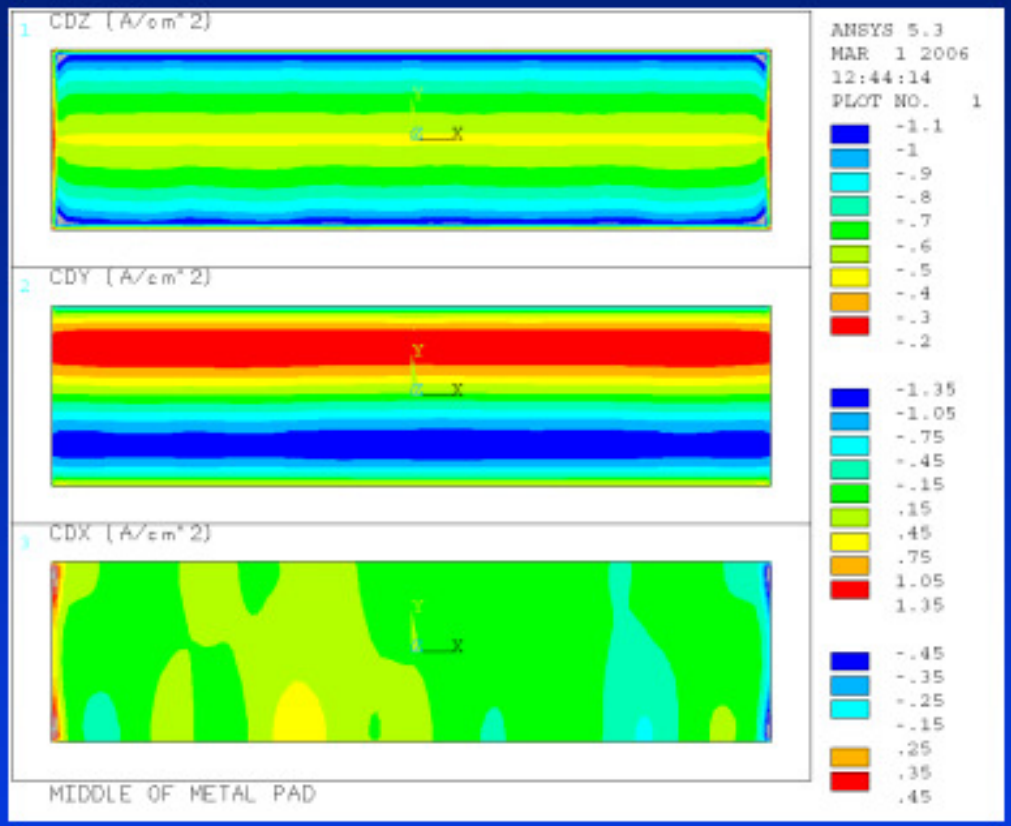
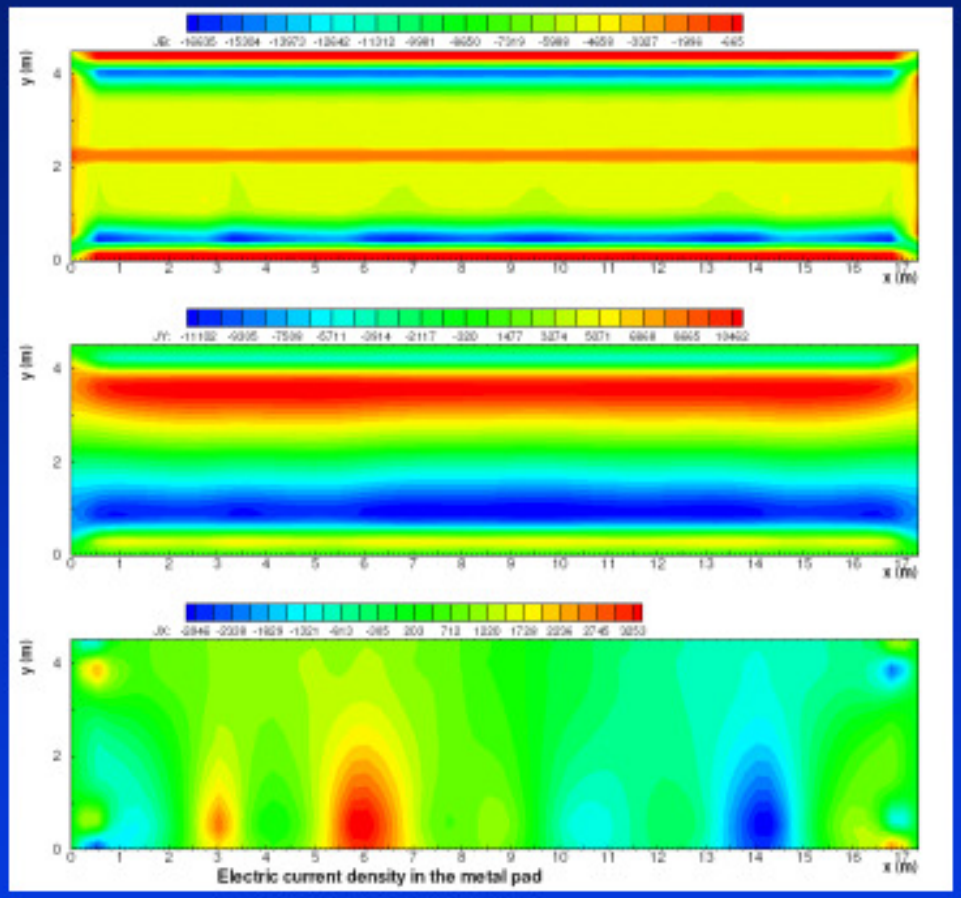
10 cm Ledge Thickness Case





Very similar results between the ANSYS® based models and MHD-Valdis

MHD-Valdis maximum horizontal current: 1.11 A/cm^2

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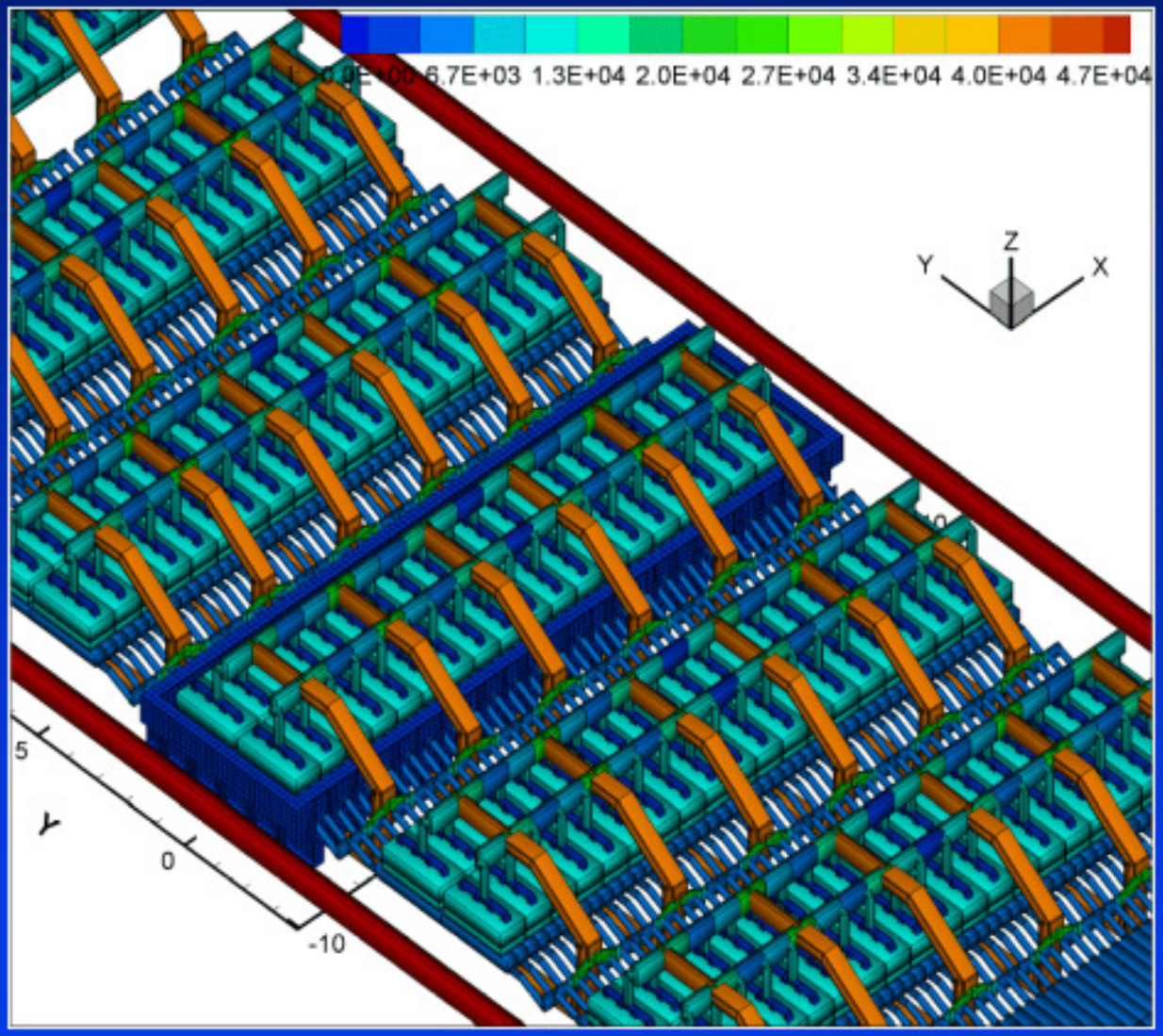
MHD-Valdis Stability Analysis: Base Case

500 kA cell busbar design inspired from the Pechiney 1987 patent



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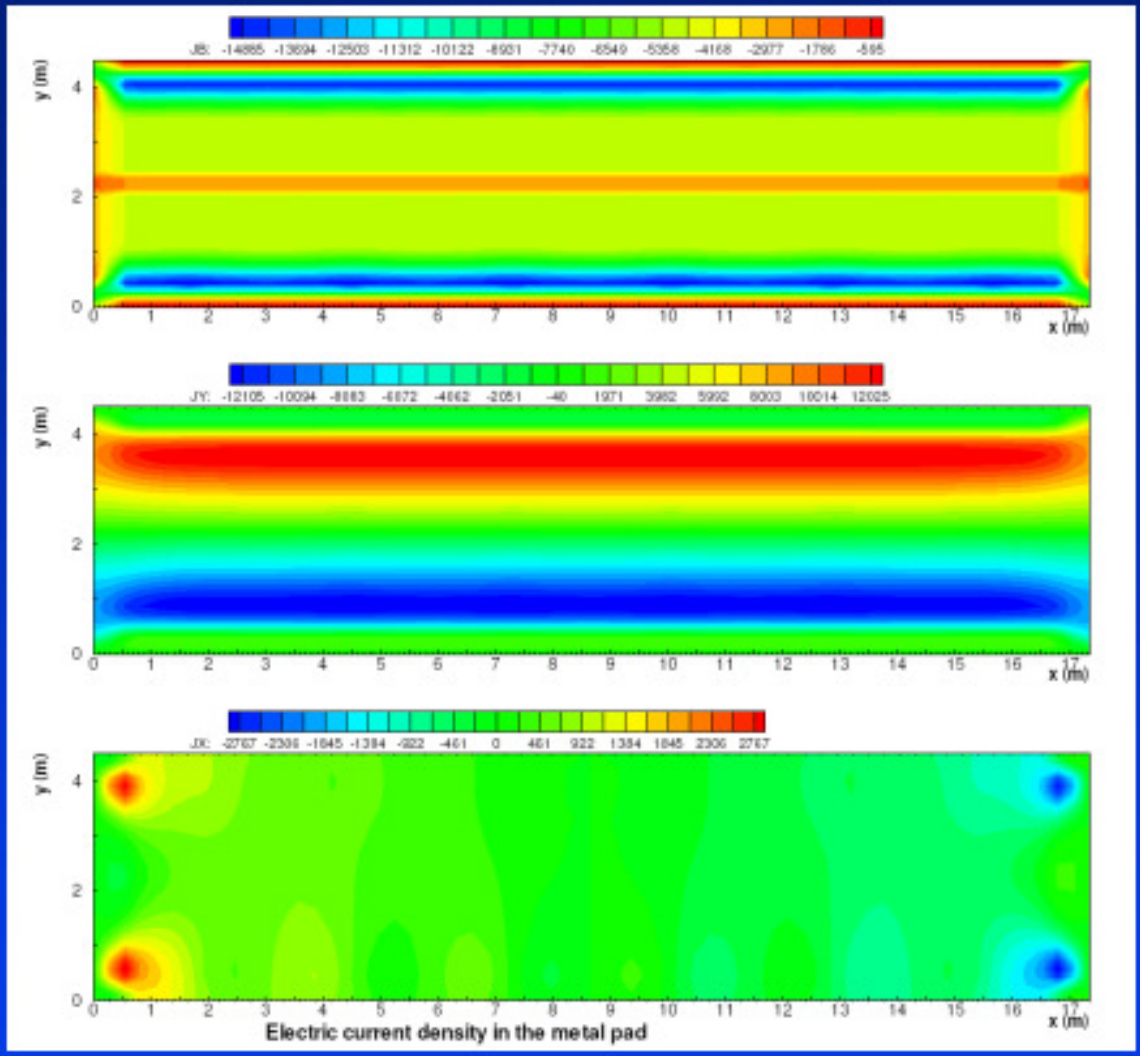
MHD-Valdis Stability Analysis: Base Case

Current density for base case at 20 cm metal pad thickness and 4 cm ledge thickness.

Maximum horizontal current: 1.21 A/cm^2



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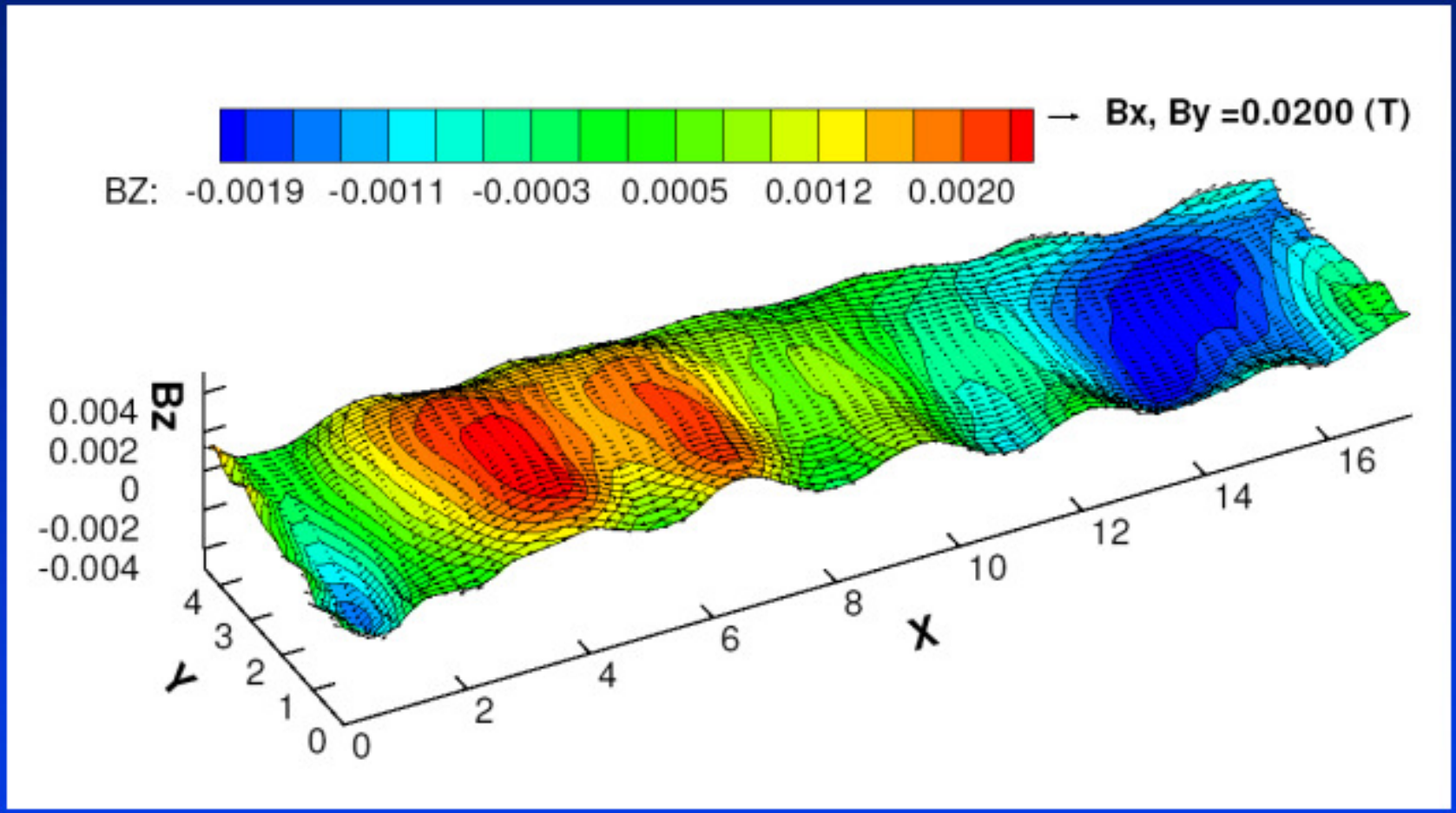
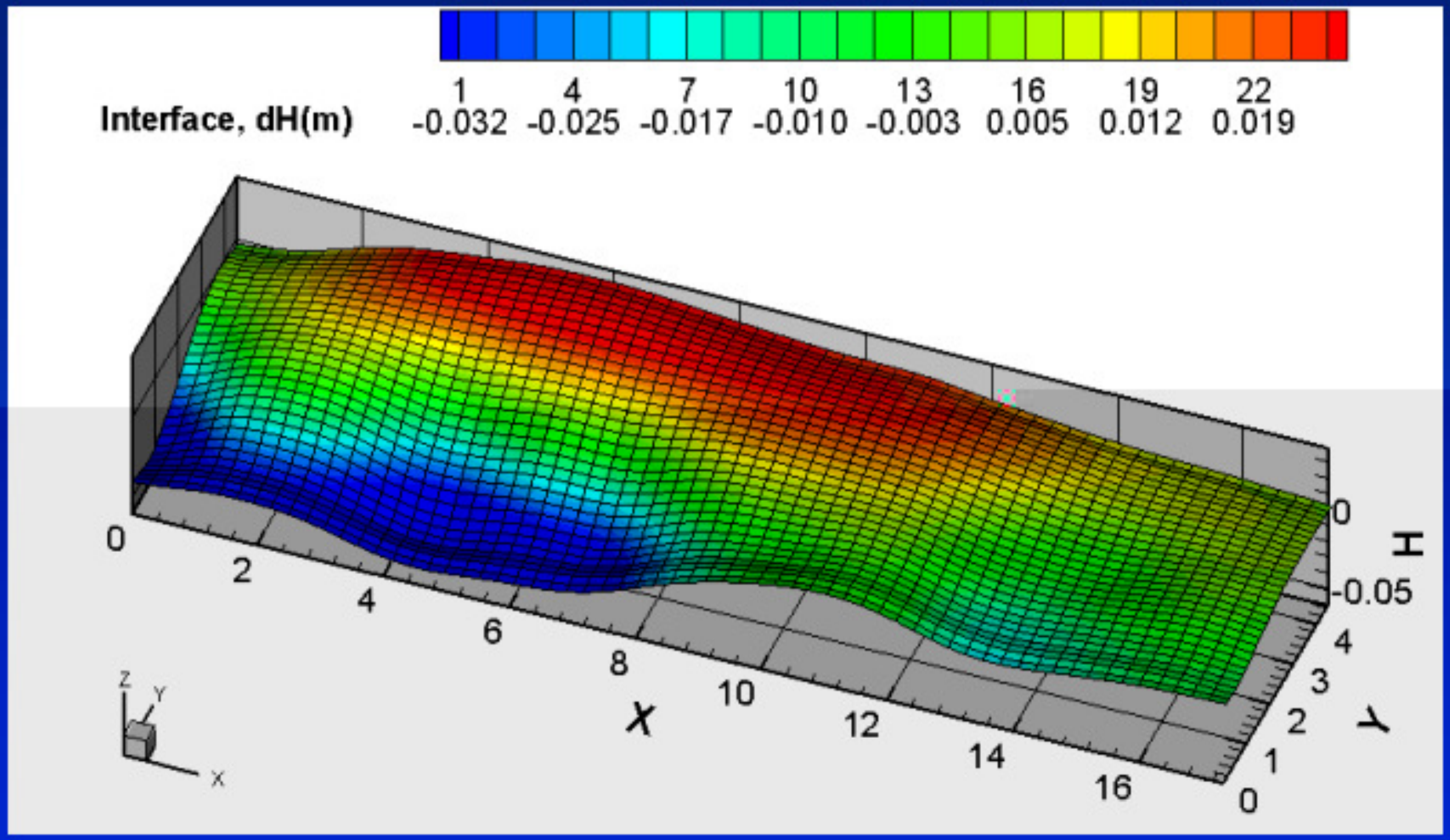
MHD-Valdis Stability Analysis: Base Case



Corresponding Bz magnetic field component

MHD-Valdis Stability Analysis: Base Case



Corresponding bath/metal interface wave

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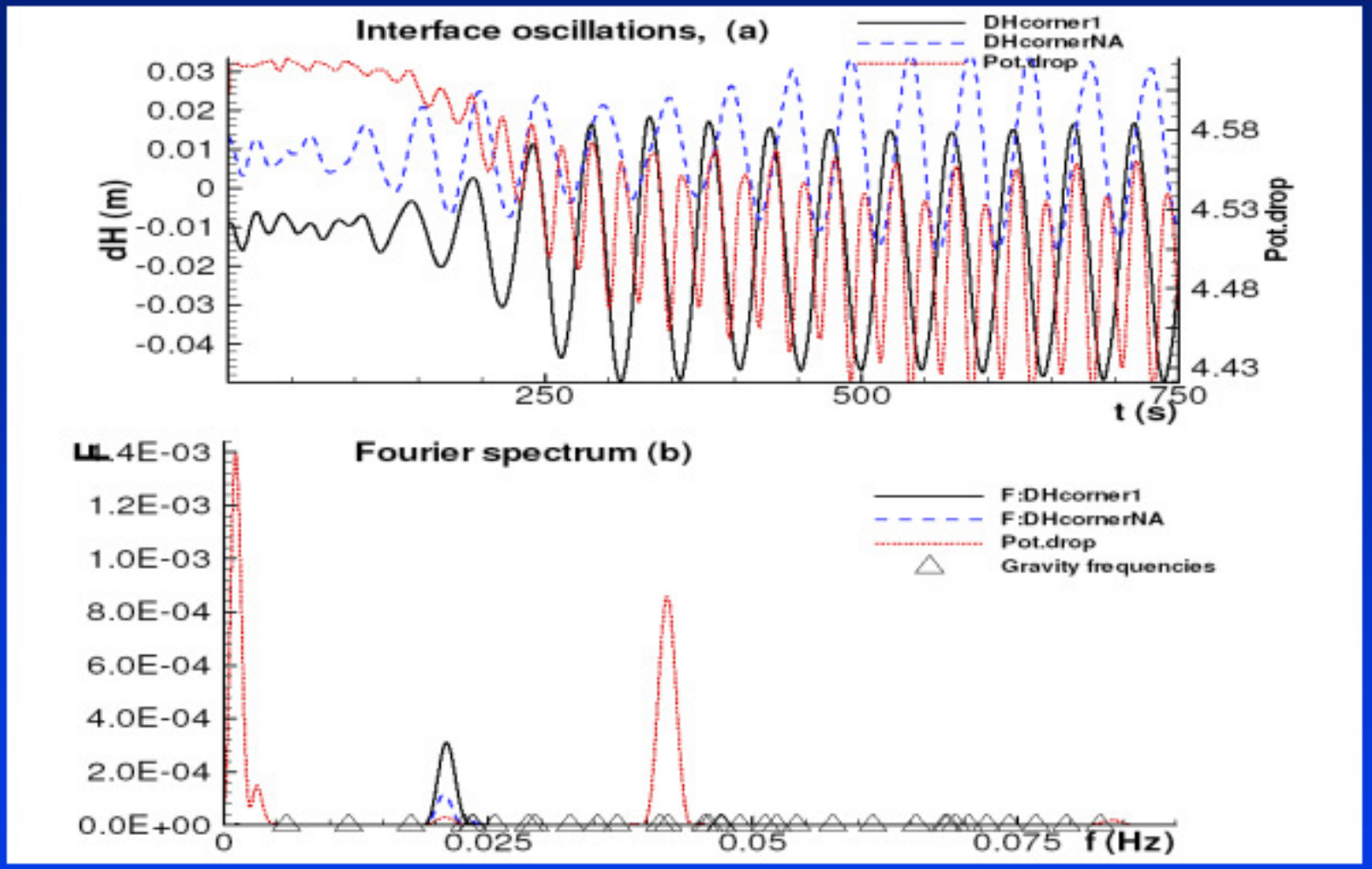
MHD-Valdis Stability Analysis: Base Case



Corresponding interface oscillations Fourier spectrum analysis

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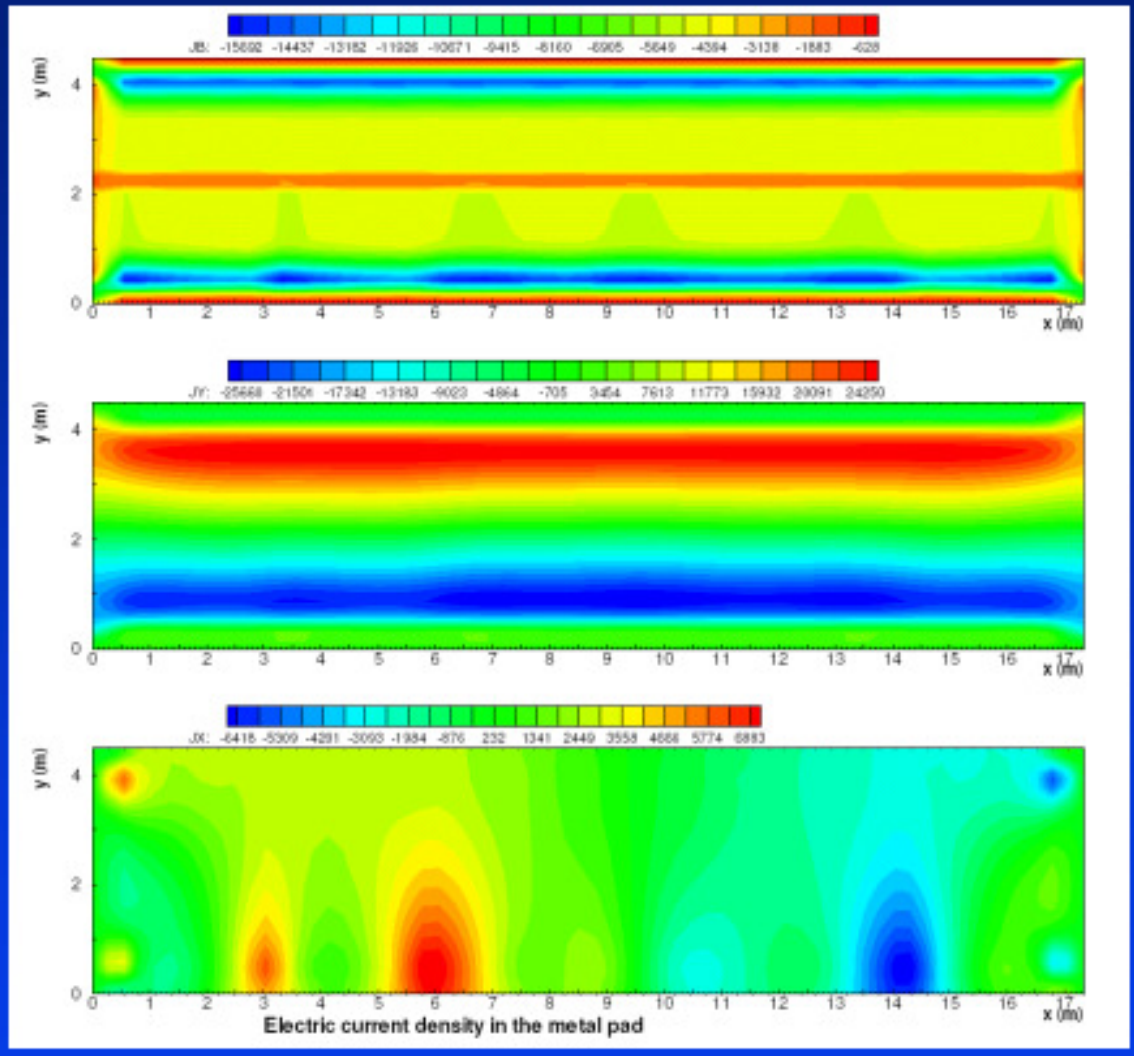
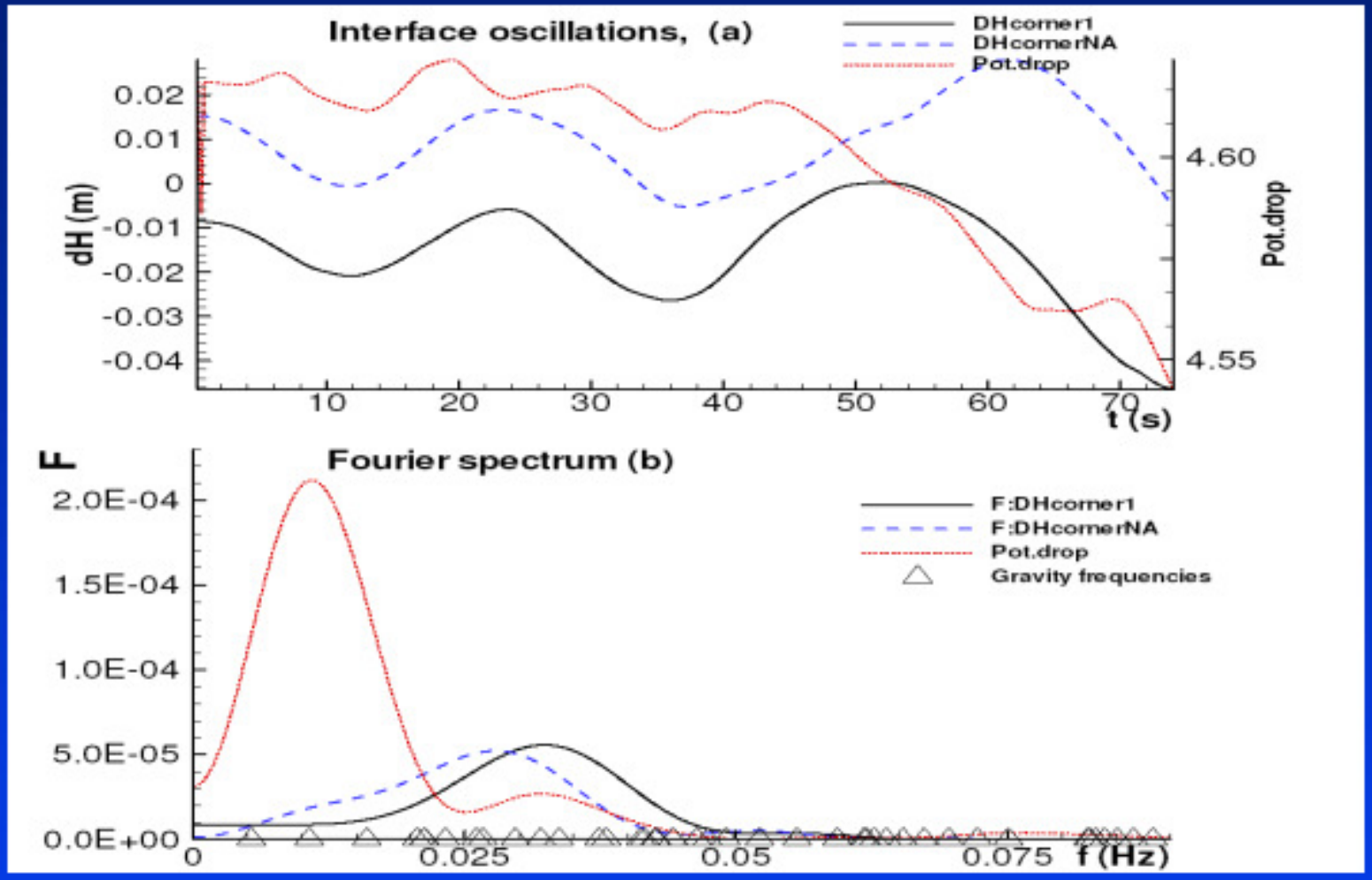
Stability Analysis: 10 cm Metal Pad Case

Current density for 10 cm metal pad thickness.

Maximum horizontal current: 2.57 A/cm^2



Stability Analysis: 10 cm Metal Pad Case



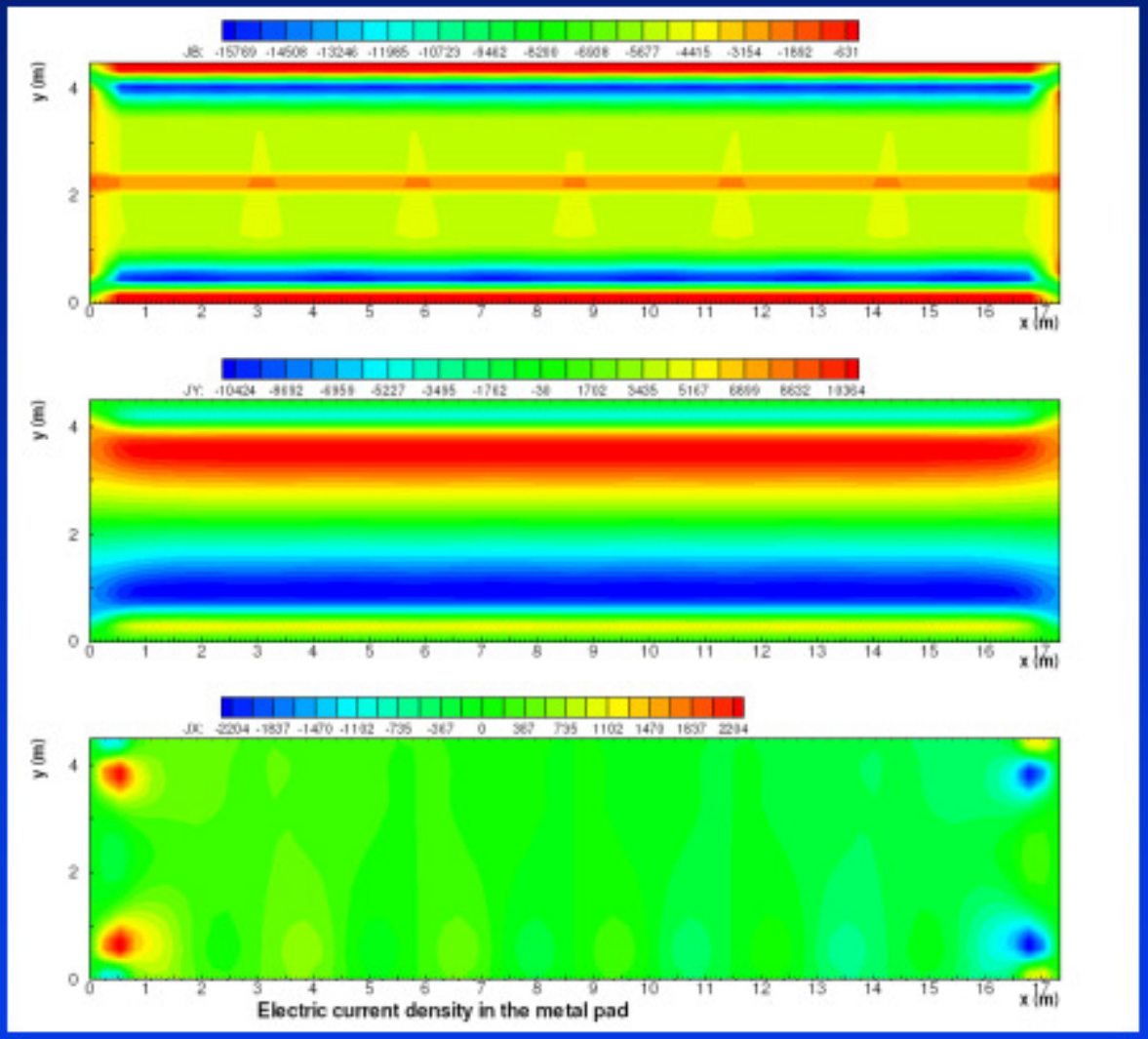
Corresponding interface oscillations Fourier spectrum analysis

GBNISIM

Stability Analysis: 10 cm Ledge Thickness Case

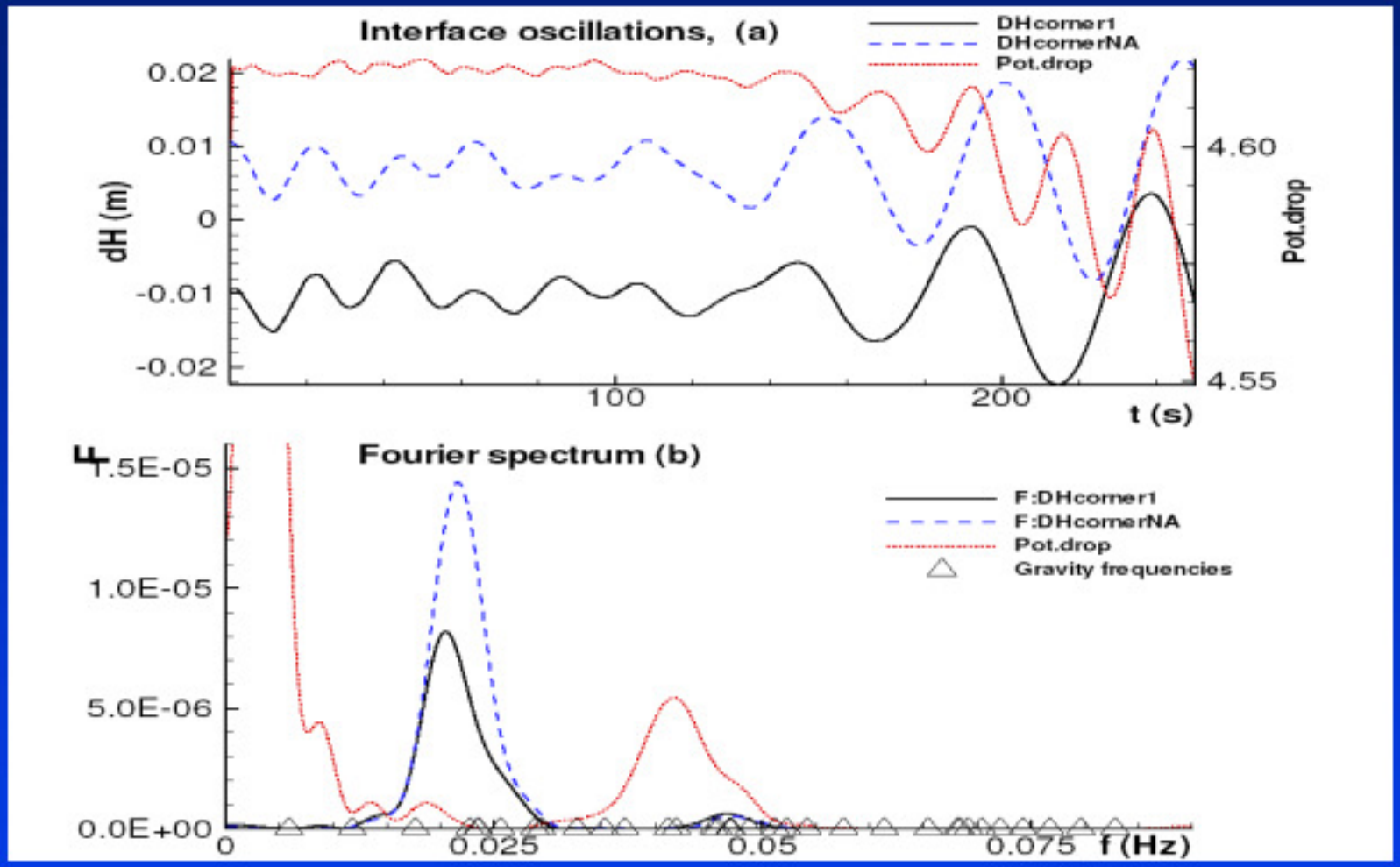
Current density for 10 cm ledge thickness.

Maximum horizontal current: 1.04 A/cm^2



GENISIM

Stability Analysis: 10 cm Ledge Thickness Case



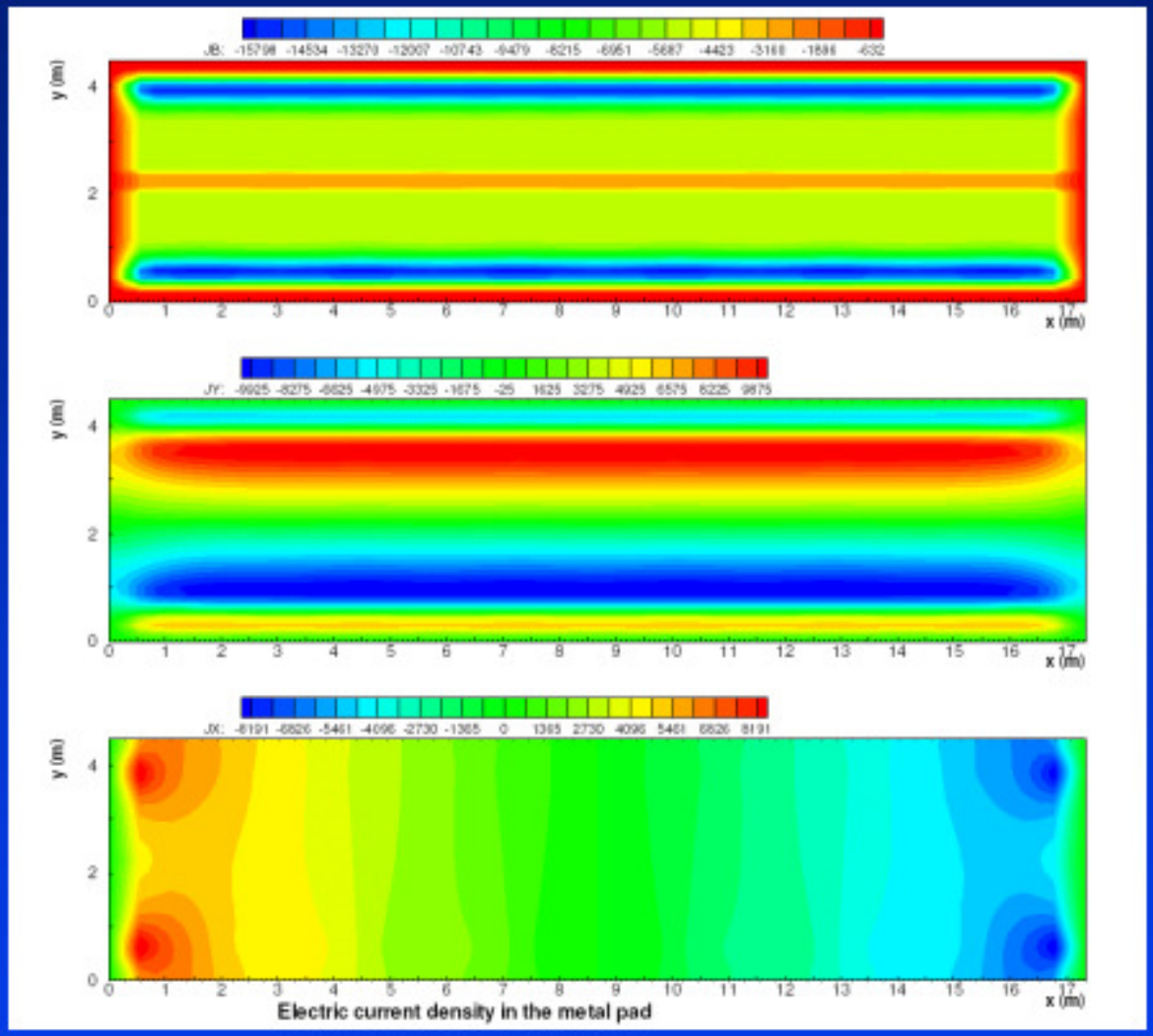
Corresponding interface oscillations Fourier spectrum analysis

GFNISIM

Stability Analysis: 20 cm Ledge Thickness Case

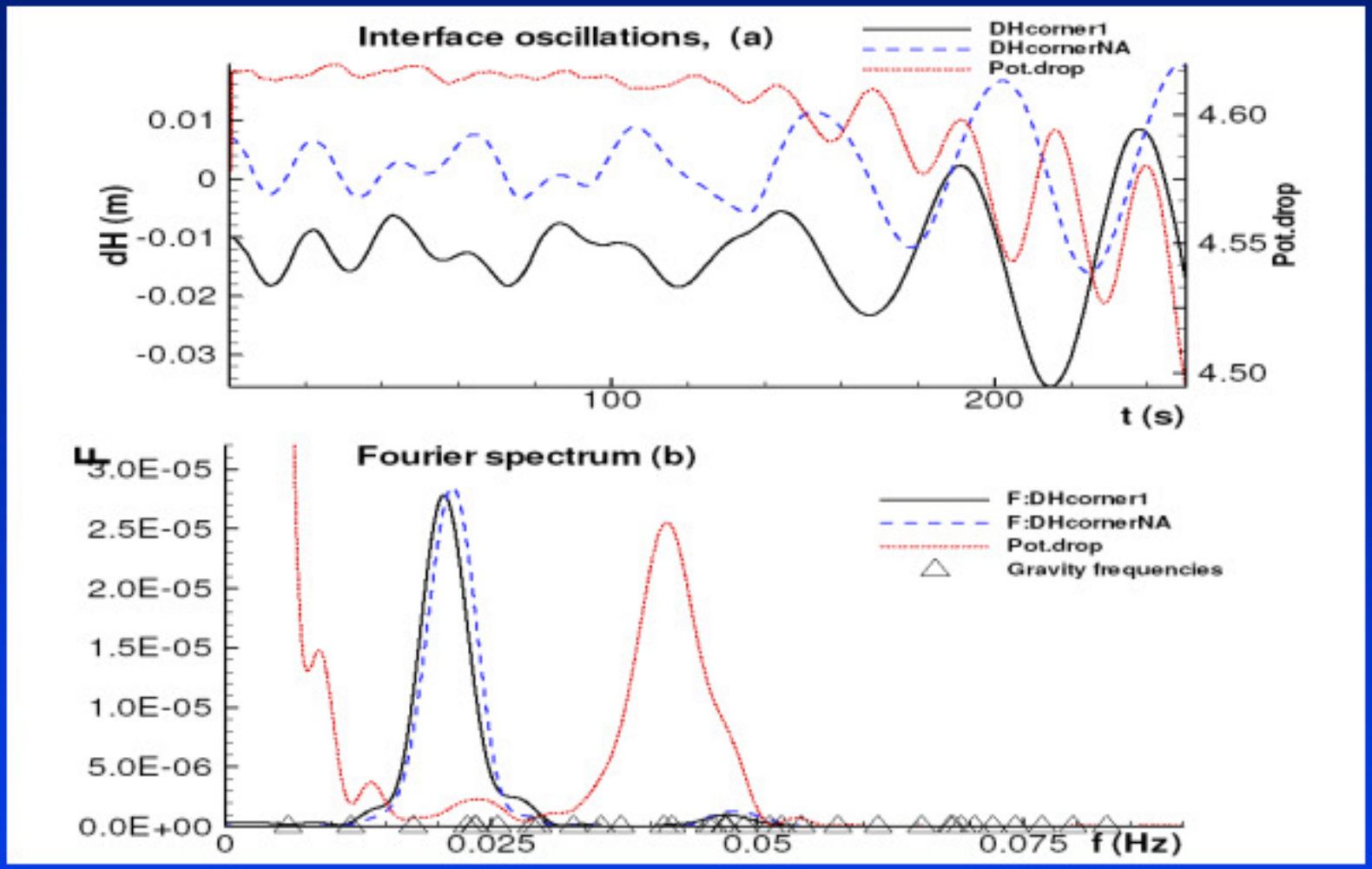
Current density for 20 cm ledge thickness.

Maximum horizontal current: 0.99 A/cm^2



GENISIM

Stability Analysis: 20 cm Ledge Thickness Case



Corresponding interface oscillations Fourier spectrum analysis

GBNISIM

Conclusions

- It has been demonstrated that, despite the fact that it is solving the metal pad current density field in only a few CPU seconds, MHD-Valdis is obtaining very similar metal pad current density results as those obtained by much more detailed but much more CPU demanding ANSYS® models .
- The negative impact of horizontal current in the metal pad on the cell stability is highlighted in both the metal pad thickness and the ledge thickness change examples .
- Those extra examples of practical applications in addition to the ones presented previously continue to demonstrate the usefulness and convenience of using MHD-Valdis as MHD non-linear cell stability analysis tool to carry out a new cell design study or a cell retrofit study .