Paris Session 2022

Black-box and White-box models to evaluate GIC capability

SC A2 PS3

Q3.9: Is it relevant to realize GIC capability tests? Could white-box or black-box models be applied to evaluate the GIC capability of transformer electrically, mechanically and thermically

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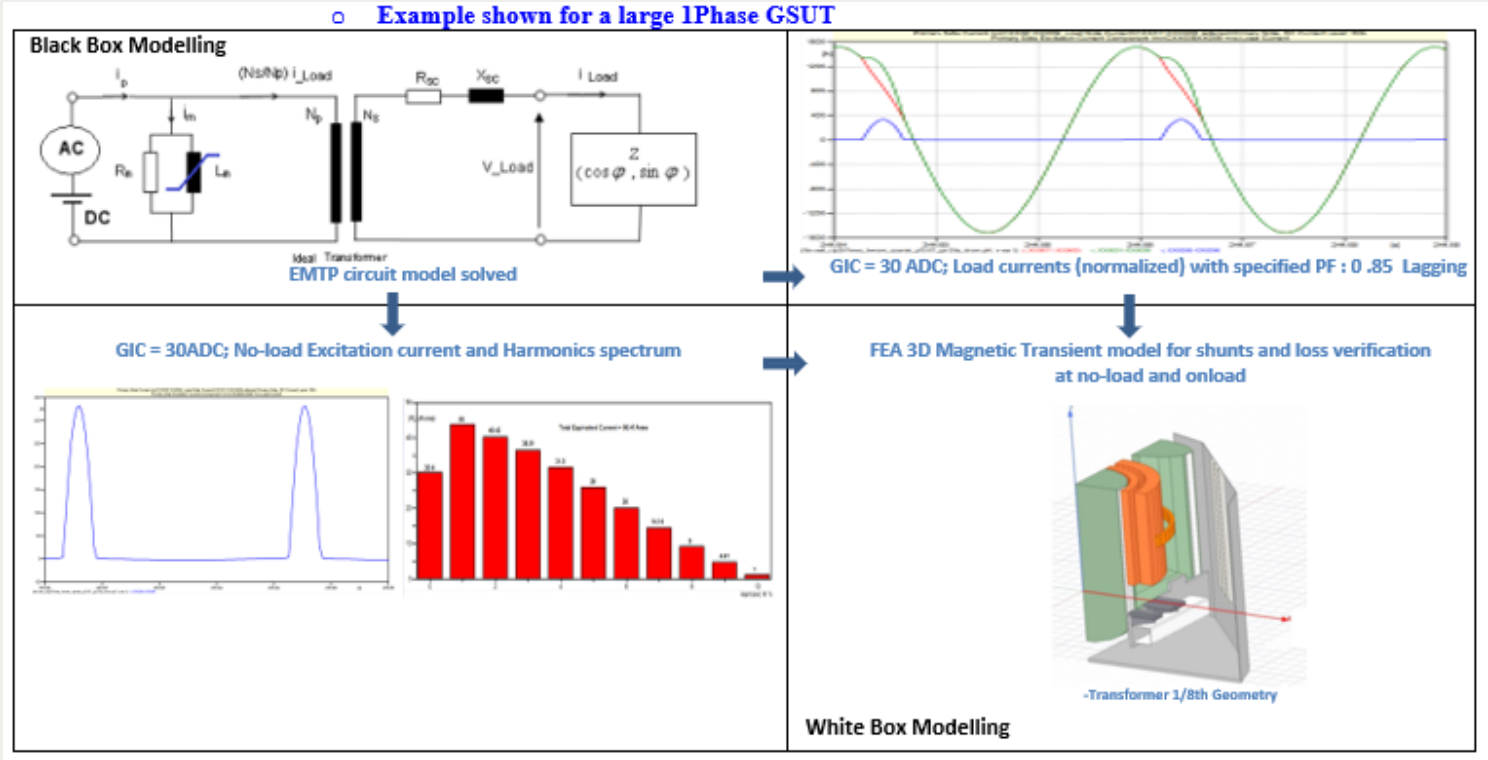
Black-box models and white-box models can be combined at the design stage to assess the effect of GIC events or man-made DC on a power transformer.

Typical requirements are about:

- Harmonics of the excitation current
- Reactive power consumption
- Transformer withstand duration vs varying GIC/DC current levels

The Black Box models are about deriving the transformers terminals characteristics.

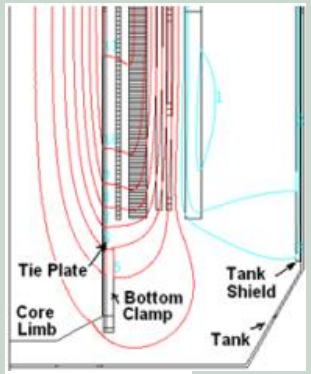
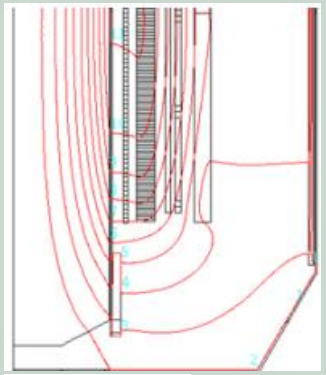
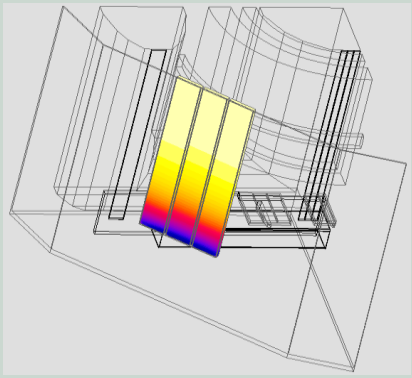
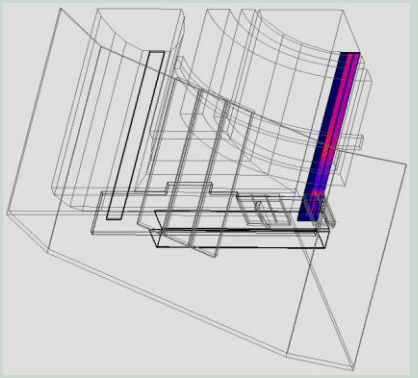
- The EMTPs tools can be used to derive the excitation currents and load currents under varying GIC levels



- Transformers response to GIC is core structure dependant. In the last years the EMTPs enable taking into account the type of the core.

The white Box models are about using the transformer internal detailed descriptions to derive the local hot-spots temperatures.

- The currents from the previous black box models can be used in the FEA as supply sources for local loss distribution determination

Example FEA2D Flux plot for windings loss determination and shunt sizing verification		Example FEA3D Flux plot for flitch plates loss distribution determination and further verification of shunt sizing	
 Leakage Flux Plot on Tank Bottom side GIC = 0 ADC	 Leakage Flux Plot on Tank Bottom side GIC = 50 ADC	 Verification of wall shunt sizing IDC = 30A	 Time average Loss density in the flitch plates, IDC =30A

- At present, applying FEA for structural parts as flitch plates evaluation may be too hardware and solving time consuming to be considered at each design stage.

Conclusion

Black-box transformer models to derive the transformer terminal characteristics can be combined with white-box transformer models to derive local hot spot temperatures inside the transformer, to give an assessment of the effect of GIC events or man-made DC on the power transformer.

The white box model may presently require significant hardware resources and solving time, but as a library of model output results and benchmark experimental tests is built-up, the need to perform detailed studies on every design may be alleviated.

Thank you for your attention !