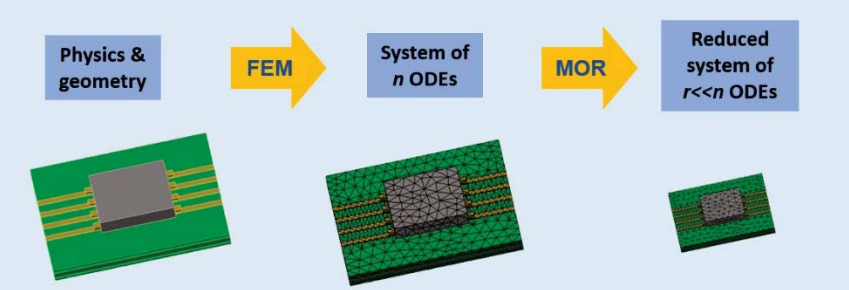
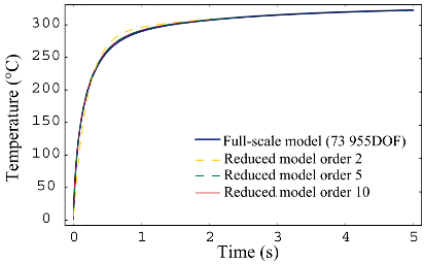
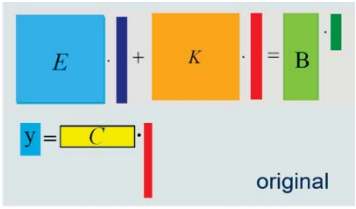
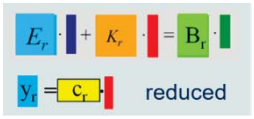
QUICK REFERENCE GUIDE

EFFICIENT THERMAL SIMULATION USING COMPACT MODELS

Model Order Reduction of Thermal Finite Element Models

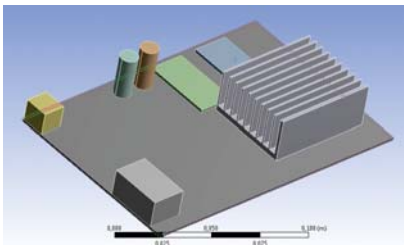
MODEL ORDER REDUCTION (MOR)

GUI, Command, Sketch	Input, Arguments, Description	Comment
		Physics and geometry are described by a partial differential equation. Its spatial discretisation via finite element method (FEM) leads to a large-scale system of ordinary differential equations (ODEs). MOR is used to construct a compact digital twin.
 A reduced order model is a faithful approximation of the full FE model.	 	Model reduction **automatically** derives compact models from **linear** FE models. Reduced order models (ROMs) are highly accurate and can be solved **several orders of magnitude faster** than the original three-dimensional FE models.

NEW TOOL: MODEL REDUCTION INSIDE ANSYS

GUI, Command, Sketch	Input, Arguments, Description	Comment
	GUI is available for reduction of thermal models. Model Reduction inside Ansys is a command line tool, which can be run from Ansys Mechanical via APDL macros. It can read matrices from Ansys full files or in the Matrix Market format.	ROMs can be represented in common file formats used in system simulation (VHDL-AMS, Spice,…). Linear FE models from other physical domains (thermo-mechanical, piezoelectric,…) can also be reduced using APDL macros.

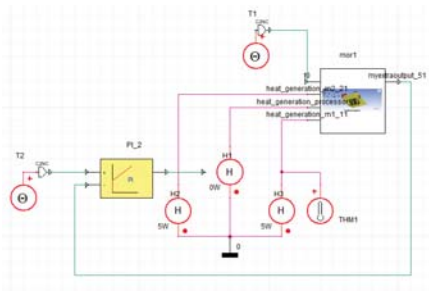
Example: Model-based controller design



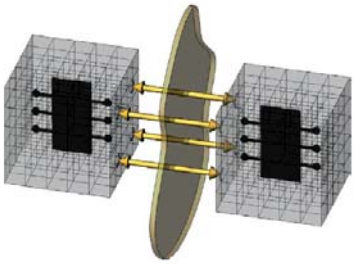
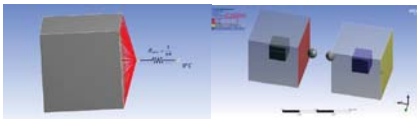
The graphic board contains a heat sink with extruded fins, PCB, capacitors, memory cards and ports.

The FE thermal model is reduced using Model Reduction inside Ansys to enable system-level simulation.

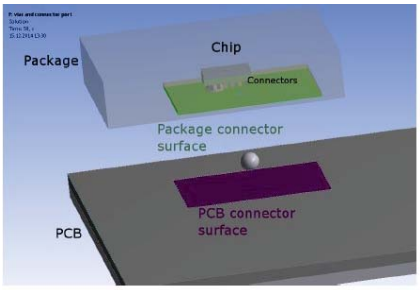
The ROM is used in a feedback control with a PI-controller in Ansys Twin Builder.



COUPLING OF REDUCED ORDER THERMAL MODELS

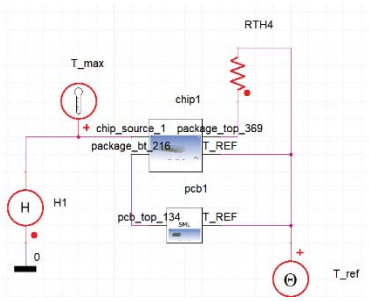
GUI, Command, Sketch	Input, Arguments, Description	Comment
	Complex thermal models are usually composed of interconnected subsystems. It is possible to extract individual thermal macro-models for each subsystem and to couple them at the system-level.	Convection boundary conditions can be approximated by thermal ports and modelled by a thermal resistor at the system-level. The contact surfaces can be approximated by thermal ports. 

Example: Coupling of Package-PCB reduced order models

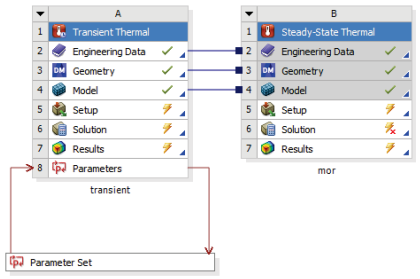
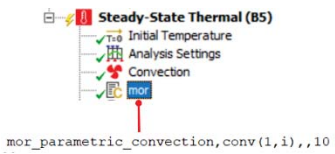


In the original FE model, the contact is created between the package and the top surface of the PCB.

Package and PCB are reduced separately and coupled in Ansys Twin Builder.



PARAMETRIC MODEL ORDER REDUCTION (pMOR)

GUI, Command, Sketch	Input, Arguments, Description	Comment
	APDL macros for parametric MOR have to be used. 	pMOR within Model Reduction inside Ansys constructs highly accurate and boundary condition independent compact thermal models. Film coefficients, ambient temperature and thermal material parameters are inputs of the pROM.