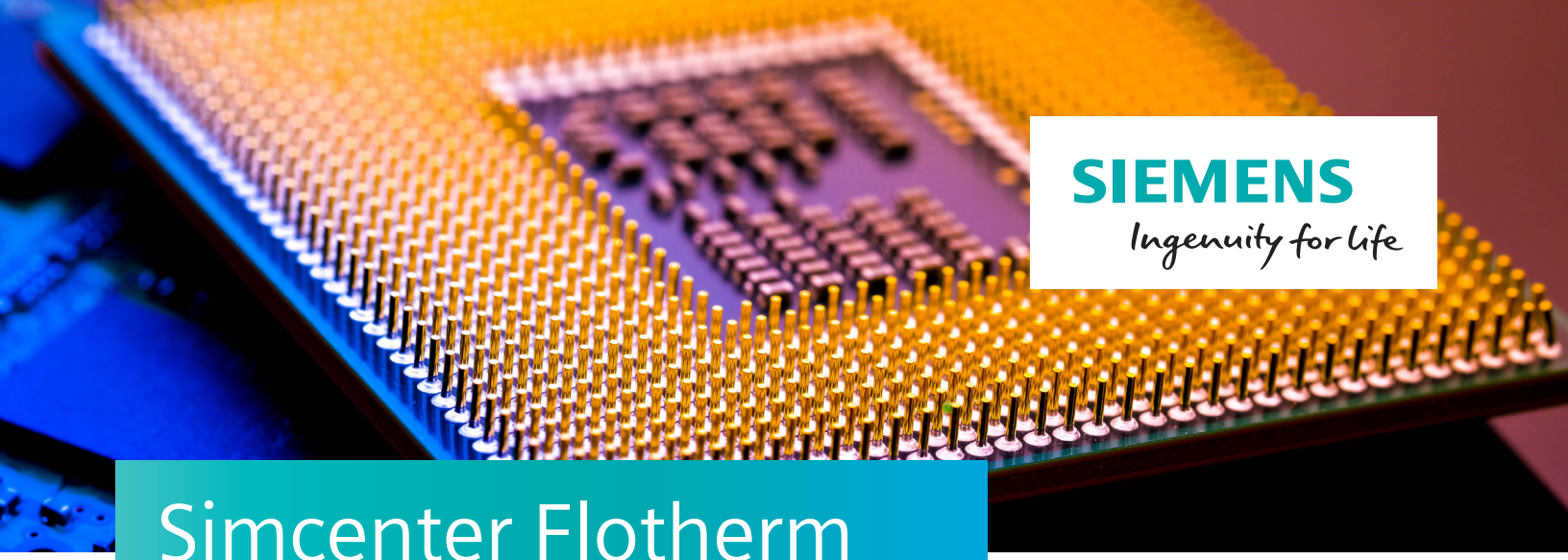

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Simcenter Flotherm BCI ROM technology

Boundary-condition-independent reduced-order models accelerate electronics thermal design

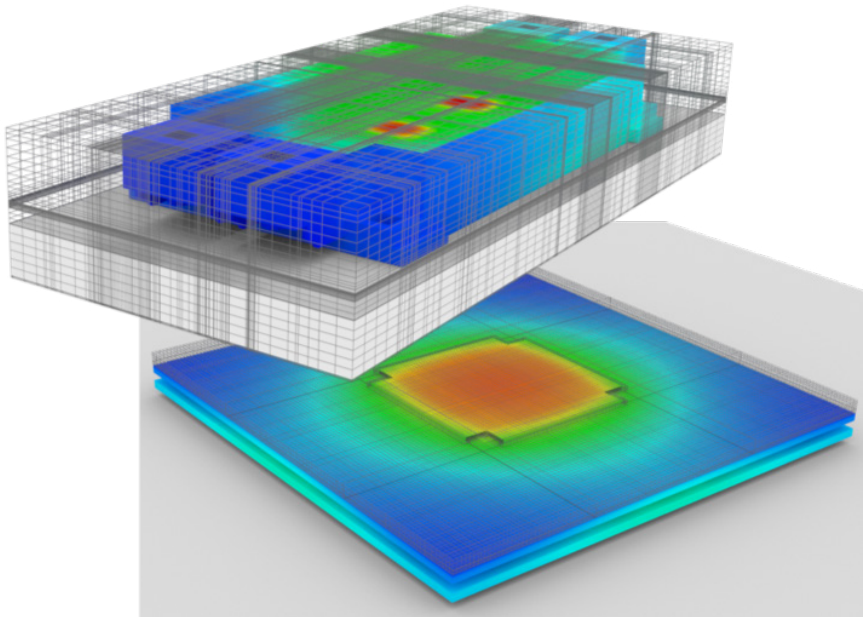
Benefits

- Up to 40,000 times faster than solving the full 3D detailed model
- No loss of effective accuracy versus full 3D detailed model
- Valid for all thermal environments - user defines range of heat transfer coefficients
- Makes possible transient simulations over very long durations, such as automotive drive cycles
- Derived directly from SimcenterTM FlothermTM software in a variety of formats
- Builds upon Simcenter Flotherm detailed model calibration against hardware measurement data

Summary

Transient simulations can present a significant challenge in electronics thermal design. Modern electronics design requires consideration of multiple transient power loads, various power control strategies and a wide range of expected operating conditions for the device. Even with the state-of-the-art computational fluid dynamics (CFD) solver in Simcenter™ Flotherm™ software, the calculation time needed to explore all possibilities is often prohibitive. Time pressures can prevent the full design space from being studied, causing mistakes to be made.

Accurately knowing temperature is essential to confirm that temperature specifications on components have not been exceeded. Accuracy in thermal prediction is important as increases in temperature, temperature gradient, temperature swing and rate of change of temperature all contribute to a reduction in the reliability of the equipment through a variety of damage mechanisms. Accurately predicting temperature in space and time is key to understanding how reliable the product will be when it is shipped.



BCI ROMs of component, subsystem and system geometries

Simcenter Flotherm BCI ROM technology

Simcenter Flotherm has the capability to extract a boundary-condition-independent (BCI) reduced-order model (ROM). These BCI ROMs maintain predictive accuracy in all situations and can be solved orders of magnitude faster than CFD, providing a huge increase in productivity.

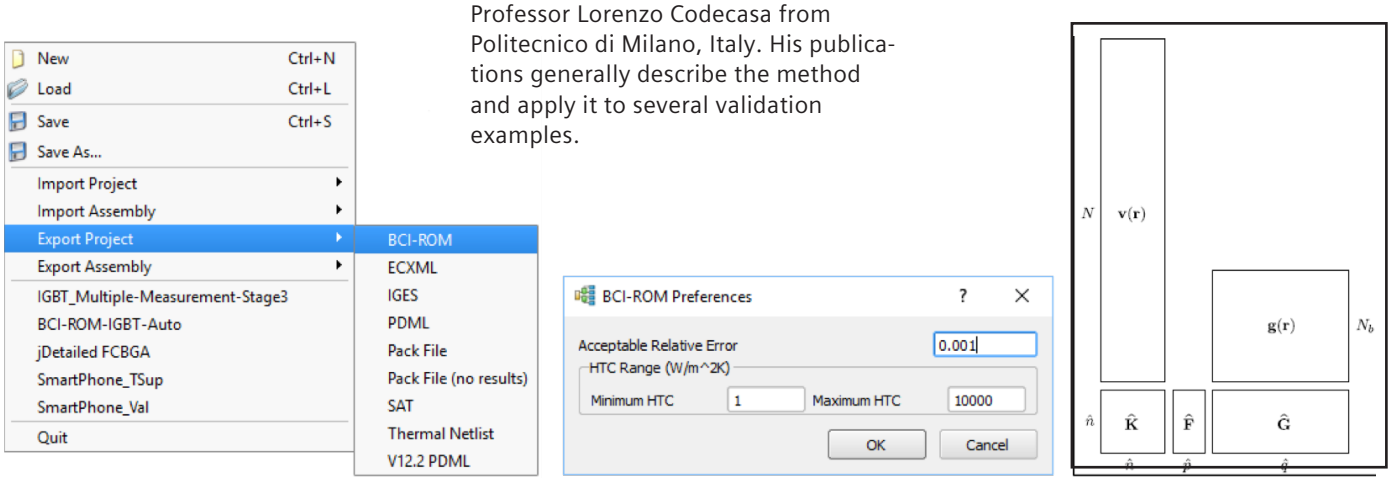
Simcenter Flotherm offers the solution

The BCI ROM method provides an alternative to extracting thermal resistor- and thermal capacitor-based dynamic compact thermal models, which have limited partitioning of the surface area and are typically only possible for single heat source packages. Simcenter Flotherm's BCI ROM technology allows linear conduction problems with any number of heat sources to be solved up to 40,000 times faster with the same accuracy as the full 3D conduction model.

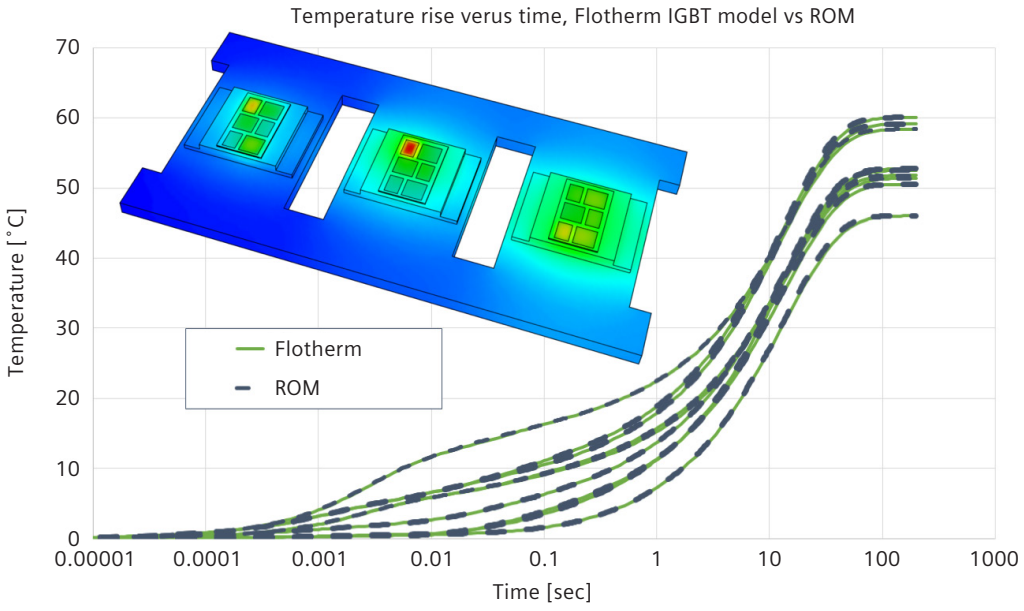
The BCI ROM technology is an extension of the fast novel thermal analysis simulation tool for integrated circuits (FANTASTIC) method pioneered by Professor Lorenzo Codecasa from Politecnico di Milano, Italy. His publications generally describe the method and apply it to several validation examples.

Accuracy is mathematically assured by the FANTASTIC method. The required accuracy is set by the user as the acceptable relative error when the BCI ROM is extracted. The heat transfer coefficient range is also set by the user on extraction.

The BCI ROM technology of Simcenter Flotherm provides a workflow into the wider electronics simulation environment. By exporting the ROM as a matrix, it can be solved in MathWorks MATLAB or in GNU Octave, or steady-state in Microsoft Excel or imported into



Simple workflow supports BCI ROM export as a matrix, SPICE sub-circuit or VHDL-AMS model

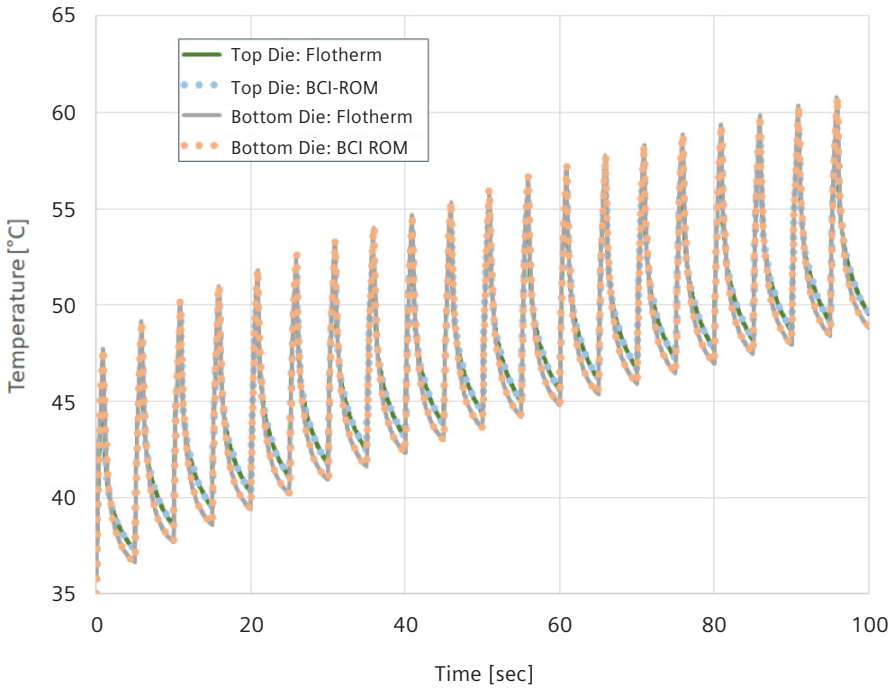


Spatial temperature response of the BCI ROM is identical to that of the detailed model

electrothermal circuit simulators like Siemens SystemVision Cloud as VHDL-AMS, a general language definition capable of describing many types of device models, including the BCI ROM matrices. A separate standalone command line BCI ROM solver is also provided to support downstream workflows.

Any transient powering profile of an arbitrary number of heat sources, or temporal or spatial change in environmental conditions can be simulated, fully accounting for changes in the heat flow paths within the 3D structure. Hours of real time can be simulated in just a matter of minutes.

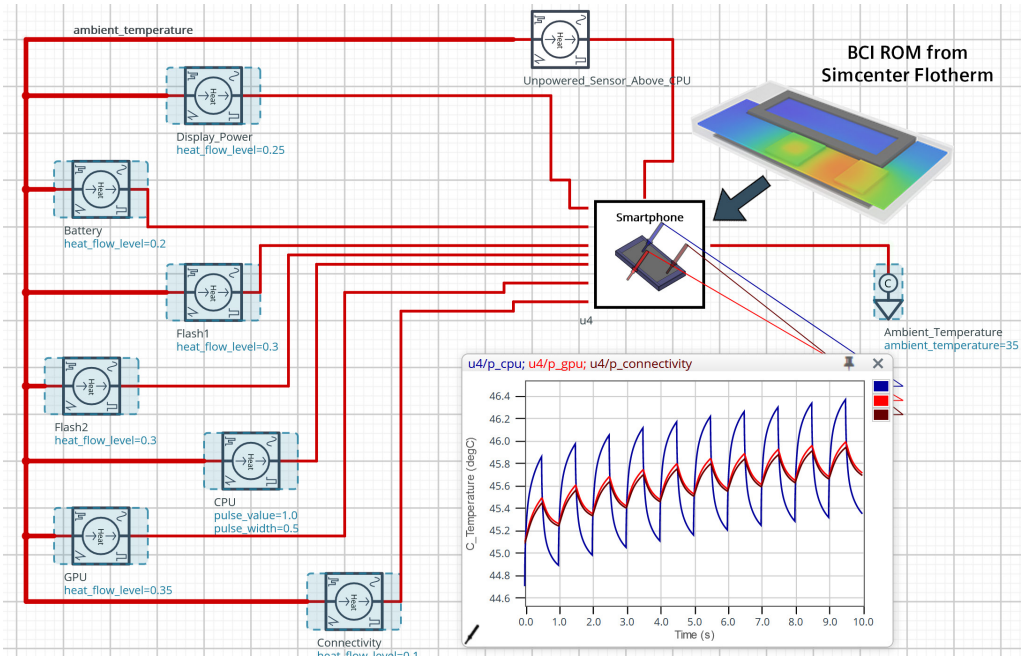
Applications in power electronics
In electric vehicle (EV) powertrain applications, simulating the temperature excursions experienced by the power electronics components in the inverter between the motor drive and the battery is key to assessing field reliability. Speed versus time across a standard drive cycle can be converted into inverter power dissipation versus time using Simcenter™ Flomaster™ software to model the EV power and cooling system. This power-verses-time data can be used as an input to a BCI ROM of the inverter unit imported as a functional mockup unit (FMU) to predict temperature versus time accurately across the entire drive cycle. Rainflow counting of the number and magnitude of the temperature swings can be used to calculate the resulting fatigue damage (and hence lifetime) within the inverter assembly.



BCI ROM response to complex powering profiles is identical to the detailed model

Applications in digital electronics
Modern digital electronics have complex active power management strategies that can be tested against a wide range of use cases and environmental conditions. Each use case has a unique set of component powers and even a specific power map for each die. The simulation can consider combinations of use cases, for example, using a mobile phone for a phone call, then streaming a video, then using a satnav application with the phone on charge in a car. These use cases put different thermal demands on different parts of the system. By importing the BCI ROM in VHDL-AMS format, electrothermal simulators such as SystemVision Cloud can consider changes to both the powers and thermal environment, for example due to a change in fan speed.

Control logic can be optimized to ensure that the system cooling solution and active cooling strategy combine to provide the best possible user experience, minimizing the need for performance derating by reducing clock frequency, while maintaining component junction, component case and touch temperatures within allowable limits.



BCI ROM of Smartphone in SystemVision Cloud: https://www.systemvision.com/live-embed-design/330353

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Simcenter Flotherm Package Creator

Create clean, CAD-based detailed thermal models of the most common chip package families in minutes eliminating mistakes and saving days of effort.

Benefits

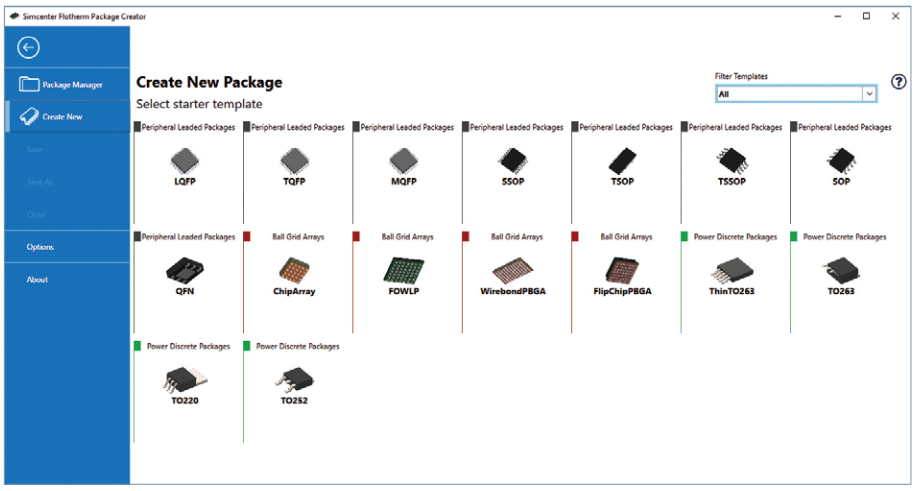
- All major chip package families covered
- Produces error-free CAD-based models
- All material and thermal attributes are attached, ready for use in Simcenter™ Flotherm™ XT and Simcenter FLOEFD™ (as part of the Electronic Cooling Center)
- Accurately predicts junction temperature as a lead indicator of thermal reliability
- Wizard-based with defaults to speed model creation, with full undo and redo functionality
- Utilizes JEDEC standard outlines
- Supports on-die power maps and Includes fine detail, like bond wires and on-die metallization
- Calibrate Package Creator models using Simcenter T3STER™ and Simcenter POWERTESTER™ to achieve greater than 99% accuracy in temperature prediction in time and space
- Packages designs that have been saved can be read back in, modified, and saved to update a package model or create another package of the same family

Summary

Electronics are increasing the complexity of products across all industry sectors, including automotive and transportation, aerospace and defence, electronics and semiconductor, and consumer products. While product complexity is increasing, the time and budget for product design is shrinking yet power densities are increasing. This makes it harder than ever to efficiently remove heat, which causes performance and reliability problems, and can cause safety concerns. Simcenter Flotherm Package Creator helps thermal engineers create accurate detailed thermal models in minutes, supporting fast, high-fidelity thermal design, allowing companies to close the thermal design activity faster, and with no printed circuit board re-spins.

Simcenter Flotherm Package Creator offers the solution

Package Creator provides support for 16 of the most common chip package families. With Package Creator you can create a model in just minutes, or seconds if you accept the default settings. Package creator models can be imported directly into Simcenter Flotherm XT,

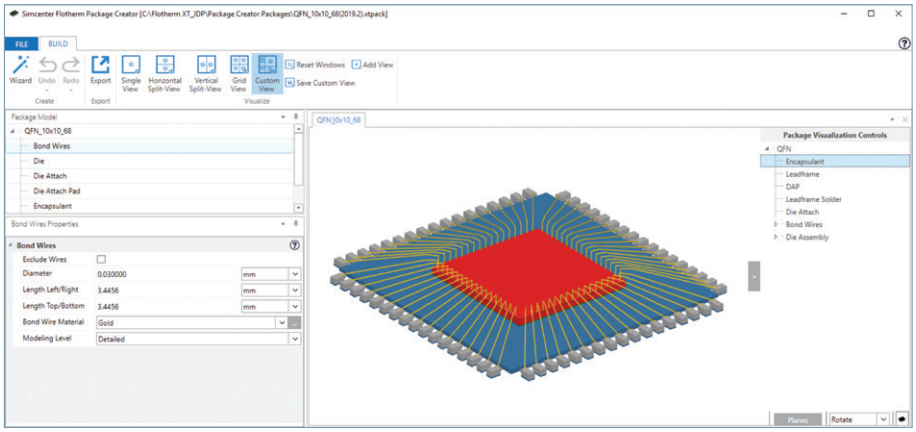


Package Creator

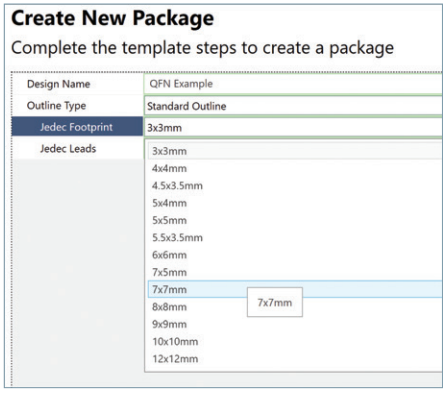
Simcenter Flotherm Package Creator

whereupon they are converted into Parasolid™-based CAD. The models are parametric and automatic creation means the CAD geometry is free from errors, requiring no clean-up before use. Simply plug and play!

Semiconductor companies and packaging houses can use Package Creator to create models for their customers, while system integrators and other end user companies can use Package Creator to create thermal models of packages where these are not available through the supply chain.



QFN Package with Encapsulant hidden, showing Bond Wire properties



Selecting JEDEC Outline in Package Creator

Package Families Supported

Peripheral Packages:

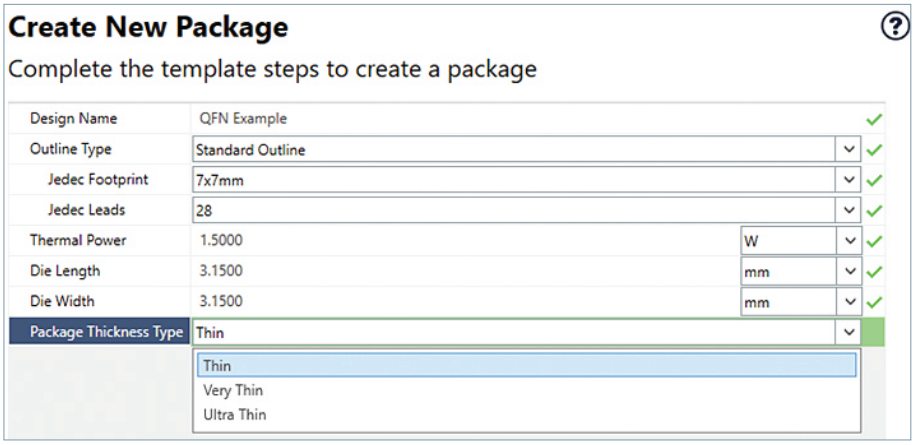
- LQFP, TQFP, MQFP, SSOP, TSOP, TSSOP, SOP, QFN

Ball Grid Arrays:

- FOWLP, Wirebond PBGA, Flip Chip PBGA, Chip Array

Power Discrete Packages:

- Thin TO263, TO263, TO220, TO252



Package Family Variants in Package Creator

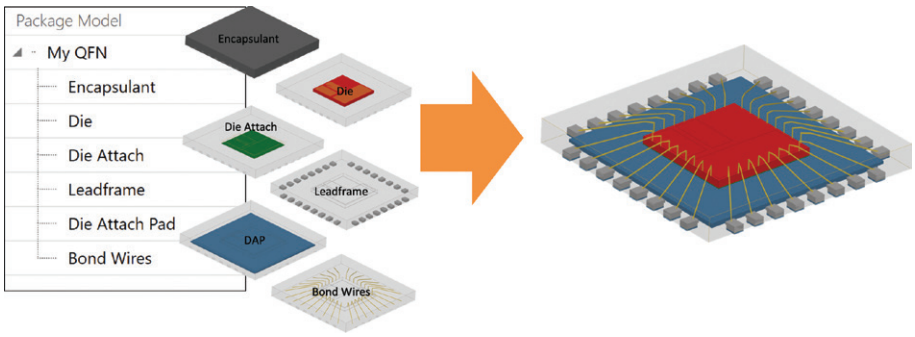
Wizard-based Workflow

Package Creator's wizard-based workflow walks you through the steps of creating a package, starting with choosing the package style and giving the package a name, a thermal power and optionally a die size if this is known. Default values are automatically provided for all other parameters, which can be changed in the wizard.

SmartPart™-based Construction

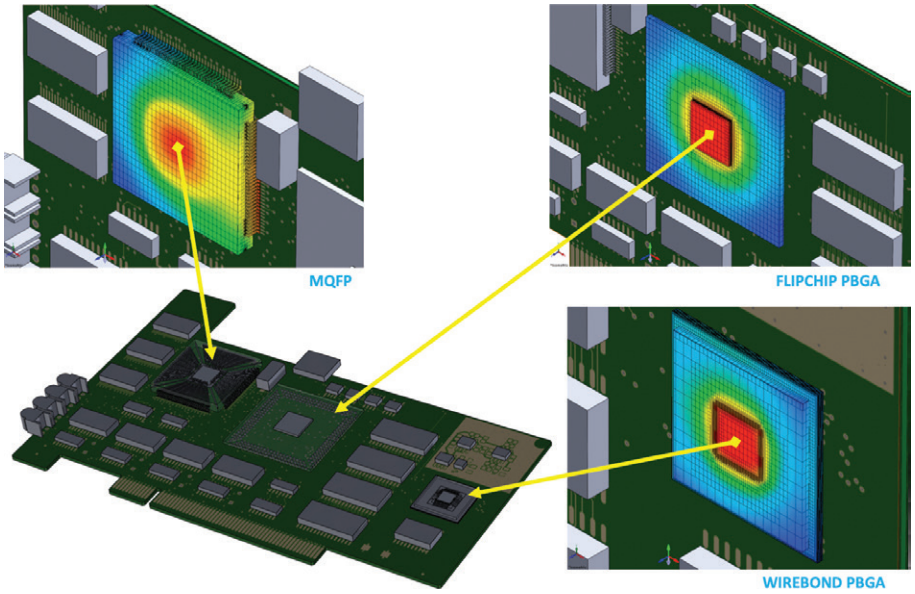
The wizard gives access to the various geometric features that make up the construction of the chosen package family. These features, such as the die, bond wires, die attach, etc. are SmartParts internal to Package Creator, providing parametric definitions of these features. Some features, can be modelled in different levels of detail. Bond wires, for example, can be represented in full geometric detail of every wire or a compact representation of each bond wire region. The die can be a single power, or a power map specified as a table or imported from a file.

Detailed Model Thermal Calibration
Responses of the actual part in different environments can be measured with Simcenter T3STER and Simcenter POWERTESTER. Using the Ultra version with additional calibration license, detailed thermal models can be calibrated against the measurement data, tuning model parameters to match provides the response of the actual part, to provide greater than 99% model accuracy in both space and time.



Package Creator SmartParts

Material Library
Package Creator has its own material library. It is possible to add other libraries including the full library from Flotherm XT. Materials can be cloned and modified, and new materials added. Materials can have isotropic, biaxial or orthotropic thermal conductivities, with all options supporting thermal conductivity of a function of temperature defined via a table providing full flexibility.



Package Creator Packages on PCB in Simcenter Flotherm XT

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Simcenter FLOEFD BCI-ROM and Package Creator Module

Faster thermal design inside CAD with boundary condition independent reduced order models (BCI-ROM) and create thermal models of electronic packages effortlessly with Package Creator.

Benefits

- Up to 40,000 times faster than solving full 3D detailed models without loss of accuracy
- Available for all thermal environments - user defines range of heat transfer coefficients
- Embedded inside Siemens NX™, Solid Edge®, Creo® and CATIA V5 user interfaces
- Conduct transient simulations over extended period of time ie optimizing automotive drive cycle
- Enables the supply chain hide sensitive IP contained within the detailed model
- Builds upon Simcenter FLOEFD Calibration capability ensuring that the detailed model is highly accurate by calibration against Simcenter T3STER™ or POWERTESTER™ Hardware measurement data

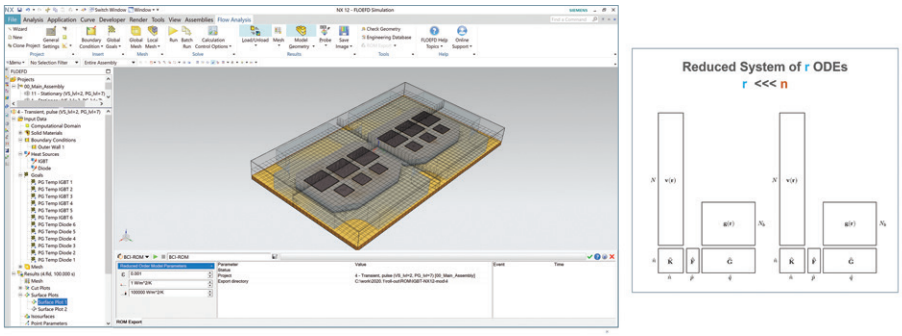
Boundary Condition Independent Reduced Order Model (BCI-ROM)

Transient simulations can present a significant challenge in electronics thermal design. Modern electronics design requires consideration of multiple transient power loads, various power control strategies, and a wide range of expected operating conditions for the device.

Accurately predicting temperature is key to understanding reliability of electronics devices in the field during use.

Simcenter FLOEFD is part of Xcelerator, the comprehensive and integrated portfolio of software and services from Siemens Digital Industries Software. It is able to extract Boundary Condition Independent Reduced Order Model, or BCI-ROMs. They maintain predictive accuracy in all situations, can be solved orders of magnitude faster, providing a huge increase in productivity.

This method provides an alternative to extracting thermal resistor and thermal capacitor based dynamic compact thermal models, which have limited partitioning of the surface area and are typically only possible for single heat source packages. Simcenter FLOEFD's BCI-ROM technology allows linear conduction problems with any number of heat sources to be solved with the same accuracy as the full 3D conduction model up to 40,000 times faster.

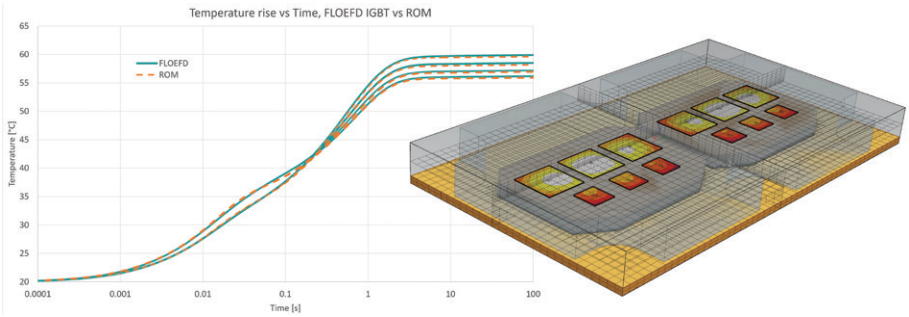


Simple workflow supports BCI-ROM export as a matrix, SPICE sub-circuit or VHDL-AMS model.

Simcenter FLOEFD BCI-ROM and Package Creator Module

The accuracy is mathematically guaranteed by the FANTASTIC method. The required accuracy is set by the user as the 'acceptable relative error' when the BCI-ROM is extracted. The heat transfer coefficient range is also set by the user.

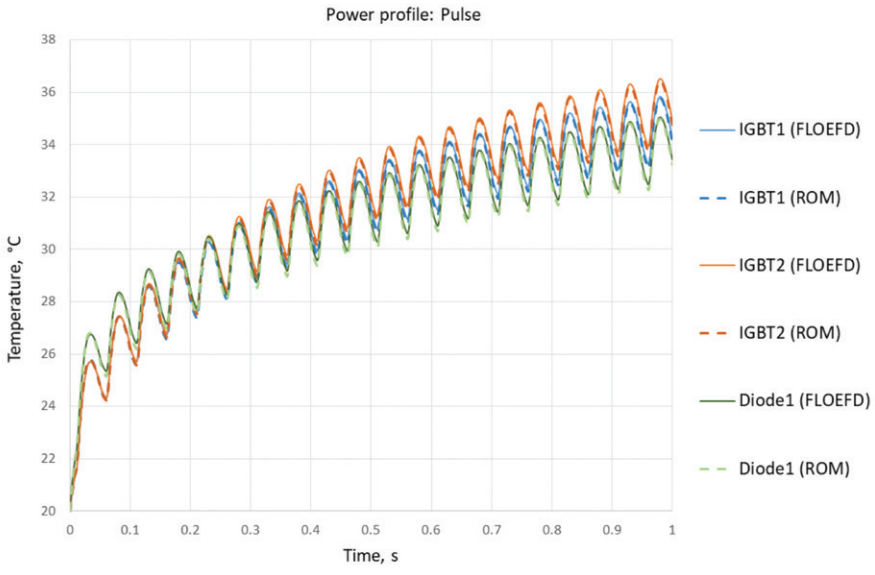
The Simcenter FLOEFD BCI-ROM technology provides a workflow into the wider electronics simulation environment. By exporting the ROM as a matrix, it can be solved in MathWorks MATLAB or in GNU's Octave, or steady-state in Microsoft Excel. It also supports the SPICE sub-circuit for electro-thermal simulators such as Mentor's SystemVision® Cloud.



Spatial temperature response of the BCI-ROM is identical to that of the detailed mode.

There are many applications for the technology including:

- **Power Electronics:** Simulating temperature excursions experienced in the inverter between the motor drive and the battery is an important factor for assessing their field reliability. To model EV power and cooling system, speed versus time across a standard drive cycle can be converted into inverter power dissipation versus time using Simcenter Flomaster™ software. The power versus time data can then be used as input into a BCI-ROM of the inverter unit; thus, enabling temperature versus time to be predicted accurately across the whole drive cycle. Rainflow counting of the number and magnitude of the temperature swings can also be used to calculate the resulting fatigue damage within the inverter assembly and its lifetime.
- **Digital Electronics:** Modern digital electronics have complex active power management strategies. With the help of this module, the strategies can be tested against a wide range of use cases and environmental conditions. Each use case may have a unique set of component powers and specific power map for each die. Scenarios can even consider combinations of use cases. For example in the case of mobile phones – one minute they're used for a phone call, next for streaming a video, or navigation while the phone is being charged in a car. These use cases put different thermal demands on different parts of the system. Control logic can be optimized to ensure that the cooling solution provides the best possible user experience, minimizing the need for performance derating by reducing clock frequency, while maintaining component junction, component case, and touch temperatures within allowable limits. And importantly, hours of real time can be simulated in a matter of minutes.



BCI-ROM response to complex powering profiles is identical to the detailed model.

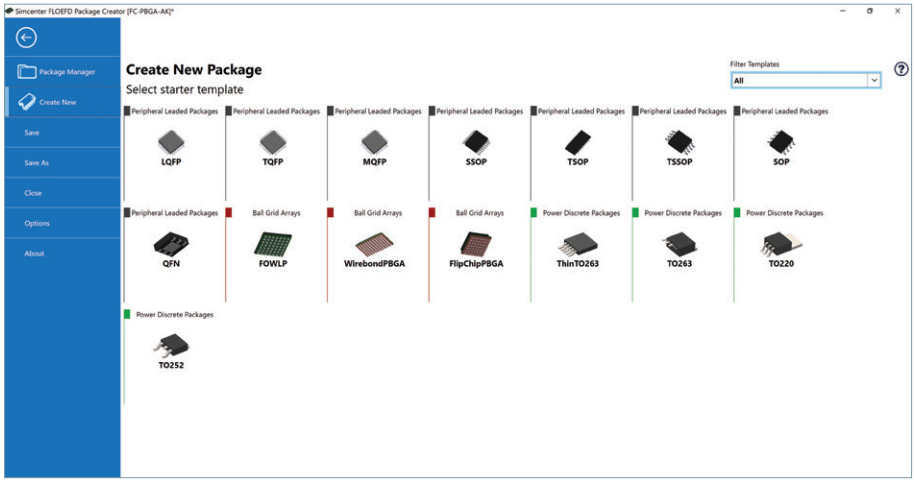
Package Creator

Simcenter FLOEFD Package Creator can help you create accurate detailed thermal models of electronic packages in minutes enabling you to complete projects faster, and without re-spins.

Benefits

- Create thermal models of electronic packages effortlessly
- Accurately predict junction temperature as a lead indicator of thermal reliability.
- Wizard-based with defaults to speed model creation.
- Achieve greater than 99% accuracy in temperature prediction in time and space upon calibrating Package Creator models using Simcenter T3STER™ and Simcenter POWERTESTER™

It supports 15 of the most common chip package families. The models can be imported directly into Simcenter FLOEFD. The models require no clean-up before use. Simply plug and play! Semiconductor companies and packaging houses can use Package Creator to create models for their customers, while system integrators and other end user companies can use Package Creator to create thermal models of packages where these are not available through the supply chain.



Selection of 15 most common chip package templates.

Package Families Supported

Peripheral Packages:

- LQFP, TQFP, MQFP, SSOP, TSOP, TSSOP, SOP, QFN

Ball Grid Arrays:

- FOWLP, Wirebond PBGA, Flip Chip PBGA

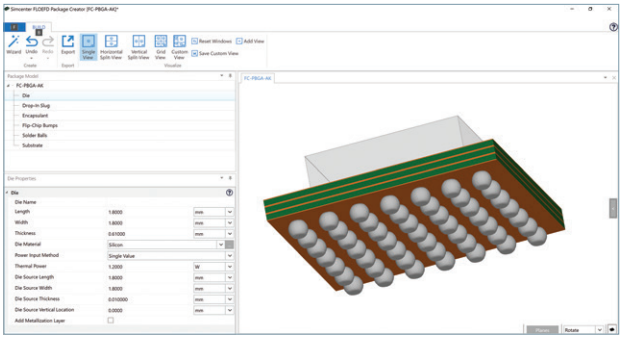
Power Discrete Packages:

- Thin TO263, TO263, TO220, TO252

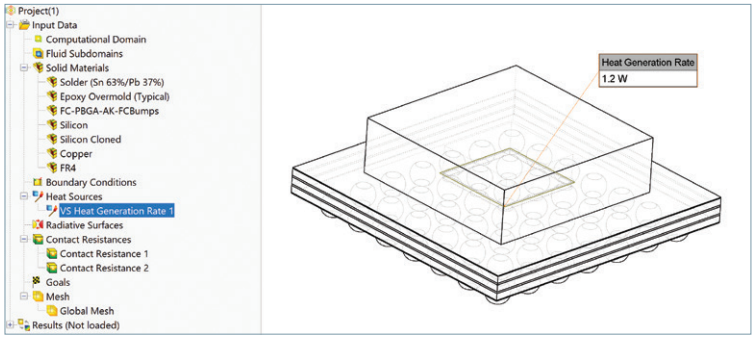
Wizard-based Workflow

Package Creator's wizard-based workflow helps you create a package – simply choose the package style, enter a name, the thermal power and optionally a die size if this is known. Default values are automatically provided for all other parameters, but you can change them.

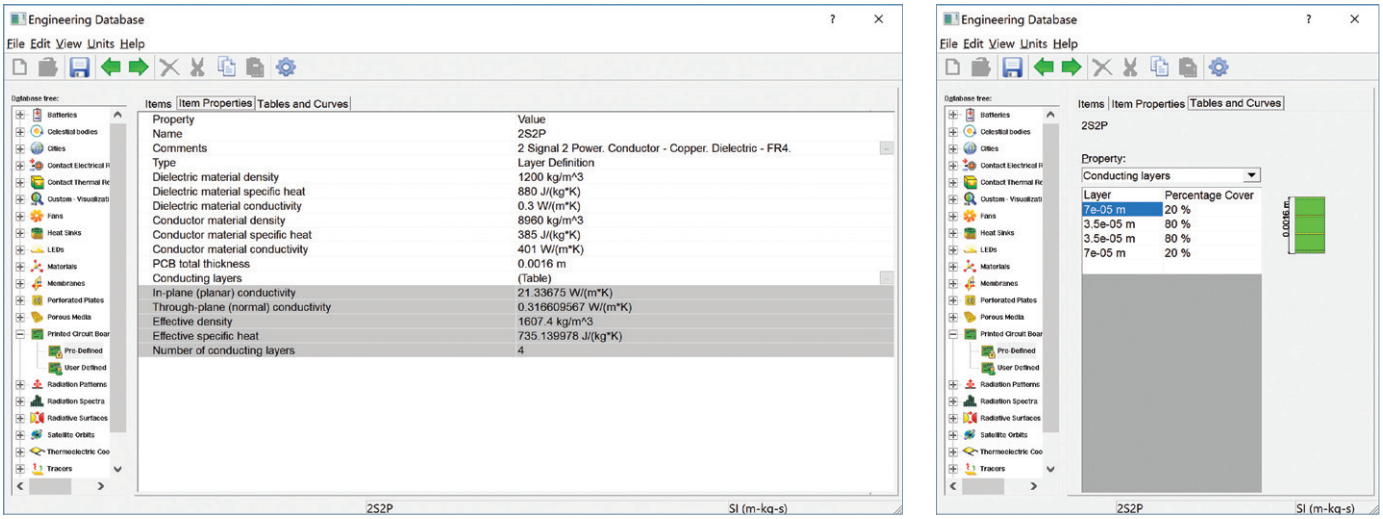
The wizard gives access to the various geometric features that make up the construction of the chosen package family, such as die, bond wires, die attach, etc. Some features, can be modelled in different levels of detail. For example, the die can be a single power, or a power map specified as a table or imported from a file.



Detailed package definitions are possible.



Packages import with detailed project definitions into Simcenter FLOEFD.



PCB Generator's bi-axial thermal conductivity definition in the Engineering Database.

Detailed Model Thermal Calibration

Responses of the actual part in different environments can be measured with Simcenter T3STER and Simcenter POWERTESTER. Detailed thermal models can be calibrated against the measurement data, tuning model parameters to match provides the response of the actual part, to provide greater than 99% model accuracy in both space and time.

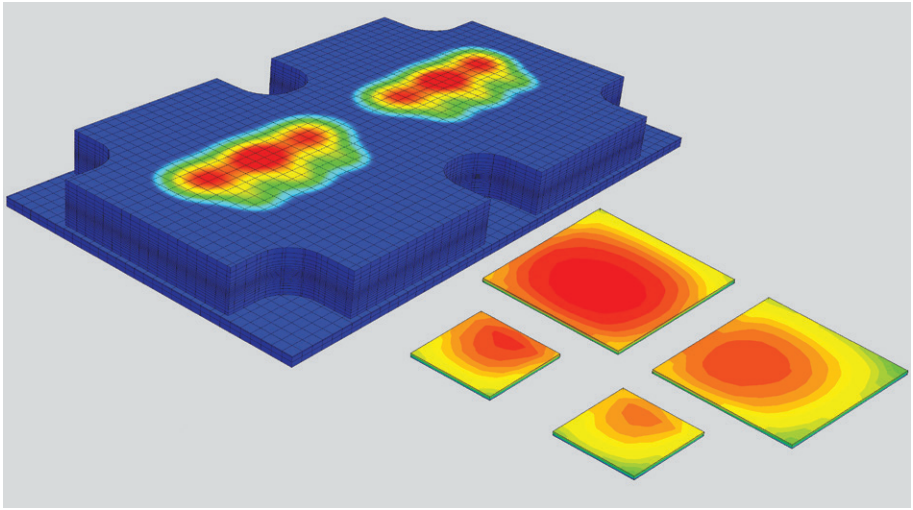
Material Library

The module also includes its own material library which can be augmented. Materials can be cloned and modified, and new materials added. Materials can have isotropic, biaxial or orthotropic thermal conductivities, with all options supporting thermal conductivity of a function of temperature defined via a table providing full flexibility.

Create faster and better electronics packages inside CAD with Simcenter FLOEFD.

PCB Generator

PCB generator is used for obtaining the bi-axial thermal conductivity values. Thermal conductivities can be automatically derived from the PCB structure and the properties of the specified conductor and dielectric materials can be accessed.



Detailed thermal simulation of an IGBT.

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