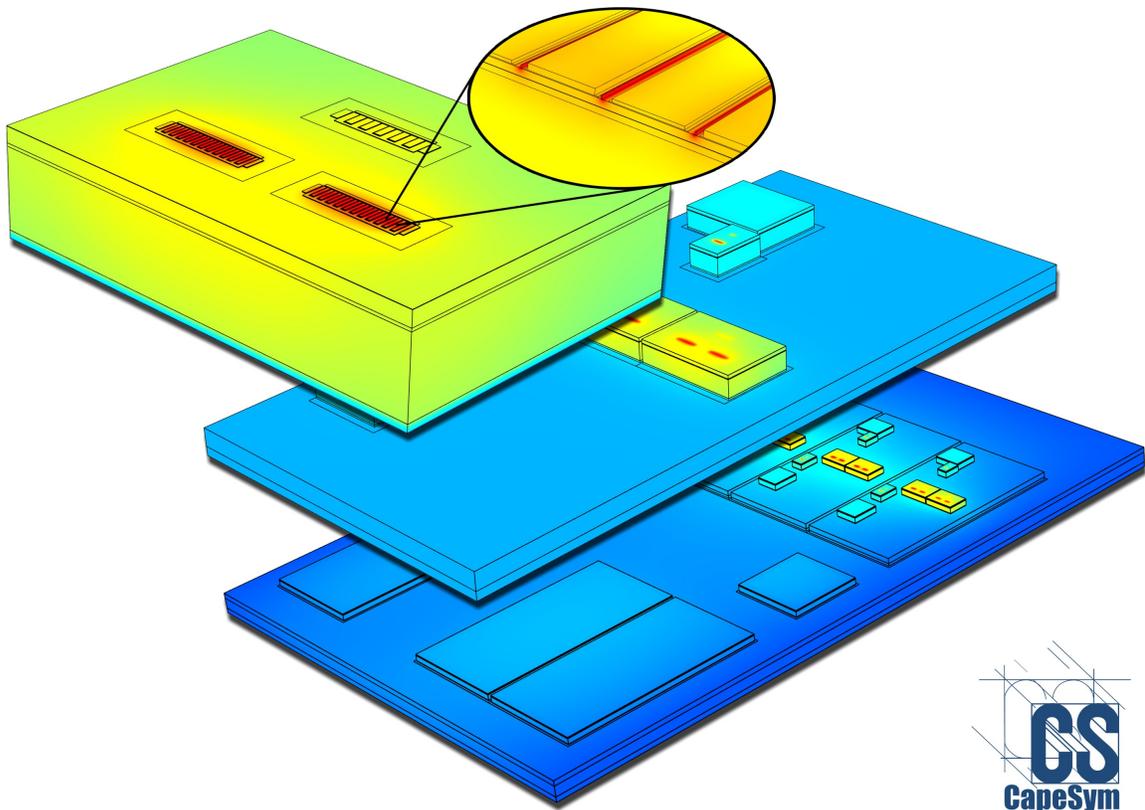


SYMMIC™ Application Note:

List of Worked Examples



™ SYMMIC: Template-Based Thermal Simulator for Monolithic Microwave Integrated Circuits is a trademark of CapeSym, Inc.

List of Worked Examples

A set of device templates represents the design kit for a process from the thermal perspective. Each template is an XML file which describes a parameterized thermal model. A device template describes the thermal analysis problem to SYMMIC with sufficient detail to allow the software to compute a finite element temperature solution to the heat transfer partial differential equations. A device template often models a single transistor. A layout is an arrangement of device templates that share identical common layers. A layout template may model a monolithic integrated circuit, for example, with all the devices sharing common substrate and packaging layers.

A layout template can be converted into a device template through an "export" operation. Layouts exported on to the same set of common layers create a new set of device templates that allow the hierarchical construction of complex subsystems, such as printed circuit boards containing multiple monolithic integrated circuits.

A set of generic device templates is installed with the software, and additional examples are available for download to all licensed SYMMIC users. A discussion of these device templates may be found in the introductory video available on the downloads page. Device templates have been created for families of devices in specific foundry processes, often under non-disclosure agreements with our customers. These templates are not publicly available, but the generic templates may be reconfigured to provide a reasonable approximation to many different foundry processes.

Each device template represents choices made by the template designer rather than limits of the software. A template will have a certain number of layers in the stackup and parameters with specific limits; a different template may have completely different layers and parameters. The installed templates embody a tiny subset of the wide variety of heat transfer problems that SYMMIC can analyze. Although SYMMIC does not include a library of commercial parts, the template formats are completely open and can be easily modified using a text editor that is aware of XML syntax. The software also includes tools to aid in the creation, editing and validation of template files. Furthermore, CapeSym engineers can build templates for any process to provide custom, parameterized thermal models that can be used over a large domain of MMIC, package, and board designs.

Device Templates

Generic Devices: A set of generic device templates is installed with the software. Generic devices include FET, HBT, and mesa resistor, in half-device and quarter-device versions. These templates can be reconfigured to match a lot of different processes, by simply changing parameter values. Because these templates use the same set of common layers, they can be easily laid out to create thermal models of different chip designs, and these MMICs can then be placed on top of additional common layers and laid out to form multi-chip modules and multi-module subsystems.

Description: See Chapter 5 of the SYMMIC Users Manual.

Video Tutorials: <http://www.capesym.com/SYMMIC/tutorial02.html>

Application Notes: <http://www.capesym.com/SYMMIC/thermalFET.pdf>
<http://www.capesym.com/SYMMIC/IRmeasurements.pdf>
<http://www.capesym.com/SYMMIC/epilayerEffects.pdf>
<http://www.capesym.com/SYMMIC/passiveEffects.pdf>

Files: <http://www.capesym.com/SYMMIC/downloads/>

FETbig: The generic FET.xml modified to represent up to 49 gates in half of a device (i.e. 98-gate FET).

Description: See help (.chm) file associated with the device template (.xml) file.

Video Tutorial: <http://www.capesym.com/SYMMIC/downloads/introToDeviceTemplates.mp4>

Files: <http://www.capesym.com/SYMMIC/downloads/FETbig.xml>

Simple FETs: A simplified representation of parallel finger devices with minimal top-side metalization and no through-substrate vias.

Description: See help (.chm) files associated with the device template (.xml) files.

Video Tutorial: <http://www.capesym.com/SYMMIC/downloads/introToDeviceTemplates.mp4>

Files: <http://www.capesym.com/SYMMIC/downloads/simpleFET.xml>,
[infiniteFET.xml](http://www.capesym.com/SYMMIC/downloads/infiniteFET.xml), [xSimpleFET.xml](http://www.capesym.com/SYMMIC/downloads/xSimpleFET.xml), [vSimpleFET.xml](http://www.capesym.com/SYMMIC/downloads/vSimpleFET.xml)

Distributed-Gate FET: A derivative of the simpleFET.xml with parallel gates having active regions separated by inactive regions along the gate.

Description: See help (.chm) file associated with the device template (.xml) file.

Files: <http://www.capesym.com/SYMMIC/downloads/distributedGateFET.xml>

HEMT: Parallel finger FET with more details in the epi-layers and top-side metalization than either SimpleFET.xml or FET.xml.

Description: See help (.chm) file associated with the device template (.xml) file.

Video Tutorial: <http://www.capesym.com/SYMMIC/downloads/introToDeviceTemplates.mp4>

Files: <http://www.capesym.com/SYMMIC/downloads/HEMT.xml>

T-Gate FETs: Detailed representation of T-shaped gate structure covered with a passivation layer.

Description: See help (.chm) file associated with the device template (.xml) file.

Video Tutorial: <http://www.capesym.com/SYMMIC/downloads/introToDeviceTemplates.mp4>

Files: <http://www.capesym.com/SYMMIC/downloads/TGateFET.xml>

Arrays FETs: Representations of arrays of T-gate FETs with a fixed number of gates that are connected by

source pads with through-substrate vias.

Description: See help (.chm) file associated with the device template (.xml) files.

Video Tutorial: <http://www.capesym.com/SYMMIC/downloads/introToDeviceTemplates.mp4>

Files: <http://www.capesym.com/SYMMIC/downloads/ArrayFETtemplates.zip>

LDMOSFET: Example of laterally-diffused metal oxide semiconductor field effect transistor with up to 50 parallel gates in the full device.

Description: See help (.chm) files associated with the device template (.xml) files.

Files: <http://www.capesym.com/SYMMIC/downloads/LDMOSFET.xml>,
QuarterLDMOSFET.xml

HBTs: Additional examples of detailed bipolar transistor structures.

Description: See help (.chm) files associated with the device template (.xml) files.

Files: <http://www.capesym.com/SYMMIC/downloads/BiCMOS.xml>,
TrenchHBT.xml

Device Array: Representation of a two-dimensional array of rectangular heat sources such as found in arrays of BiCMOS and other HBT devices.

Description: See help (.chm) file associated with the device template (.xml) file.

Files: <http://www.capesym.com/SYMMIC/downloads/DeviceArray.xml>

g-Family: The g-family templates provide a consistent set of device models for a generic high-electron mobility transistor (HEMT) process. All of the templates in the family (gCapacitor, gConnect, gHEMT, gHEMTarray, gHEMTnoVia, gHEMTquarter, gPad, gResistor, gVia) use the same stack-up for the package, substrate, and epi-layers, so they can be easily used together in a MMIC layout. The layers and materials are configured as GaN-on-Silicon as initial demonstration of a potential process application.

Description: See the help (.chm) file associated with each device template (.xml) file.

Files: <http://www.capesym.com/SYMMIC/downloads/gFamily.zip>

Creating Device Templates

There are many options for creating device templates. For an overview, see the following presentation:

<http://www.capesym.com/SYMMIC/downloads/Template-Creation.pdf>

Creating from Editor: The Device Template Editor in SYMMIC is used to produce an accurate thermal model of a single channel from a blank template.

Description: <http://www.capesym.com/SYMMIC/downloads/createFromEditor.pdf>

Files: <http://www.capesym.com/SYMMIC/downloads/createFromEditor.zip>

Creating from Parts Layout: This example demonstrates how the "export" operation in SYMMIC, available from File > Create device template... can be used to create a complex device from simpler pieces arranged in a layout.

Description: <http://www.capesym.com/SYMMIC/downloads/TemplatesFromParts.pdf>

Files: http://www.capesym.com/SYMMIC/downloads/x_fromParts.zip

Creating from GDS Artwork: The utility GDS2SYMMIC, installed with SYMMIC, can be used to create a device template from a simple representation of the device in GDS format.

Description: <http://www.capesym.com/SYMMIC/downloads/GDS2SYMMIC.pdf>

Files: <http://www.capesym.com/SYMMIC/downloads/HBT.gds>,
HBT_process.csv

Creating from XML: XML syntax version of the **Creating from Editor** example above. Starting from a blank template, XML is written in a text editor to reproduce the single channel template, and compare the simulation results to actual temperature measurements on a real device.

Description: <http://www.capesym.com/SYMMIC/downloads/HowToCreateSingleChannel.pdf>

Application Note: <http://www.capesym.com/SYMMIC/microRaman.pdf>

Files: <http://www.capesym.com/SYMMIC/downloads/HowToCreateSingleChannel.zip>

Creating from XML: This example shows how to create a thermal model for a SOT608 packaged device starting from a blank template.

Description: HowToCreateExample.pdf contained in the zip file.

Files: <http://www.capesym.com/SYMMIC/downloads/HowToCreateSOT608.zip>

Thermal Analysis of MMICs

Also available are several worked examples of MMIC designs and subsystems based on the device templates listed above.

X-Band Amplifier Example: Thermal analysis of a GaN-on-SiC X-band power amplifier can be setup from the generic device templates in about 20 minutes.

Description: Chapter 5 of the SYMMIC Users Manual.

Files: <http://www.capesym.com/SYMMIC/trial/XbandAmp.zip>

Flip-Chip Example: Use of "export" to create a thermal model of a chip attached upside to the package via solder bumps.

Description: <http://www.capesym.com/SYMMIC/flipChipExport.pdf>

Files: <http://www.capesym.com/SYMMIC/downloads/FlipChipExample.zip>

g-Family Power Amp: A SYMMIC power amplifier design created to demonstrate how the individual g-family templates can be configured and combined to setup a large MMIC thermal analysis problem. The amplifier consists of two stages. The first stage contains four instances of the gHEMT.xml template, and the second stage contains four instances of the gHEMTarray.xml template. This MMIC demonstrates that all connectors, pads, resistors, capacitors, and vias may be included in a layout in SYMMIC, although most of these have no bearing on the temperatures that affect performance and reliability.

Description: See **The G-Family Templates** in the **Top-Down Analysis** chapter of the Users Manual.

Files: <http://www.capesym.com/SYMMIC/downloads/gFamilyPA.zip>

Thermal Analysis of Radar

LRU Example: In this example, MMICs are laid out in a transmit/receive module with a 70 Watt heat load. Multiple T/R modules are then laid out for thermal analysis of the line-replaceable unit (LRU) of the radar system.

Description: Chapter 5 of the SYMMIC Users Manual.

Video Tutorial: <http://www.capesym.com/SYMMIC/tutorial06.html>

Files: <http://www.capesym.com/SYMMIC/trial/LRUexample.zip>

Thermal Analysis from Microwave Office

MMIC Two Stage Amplifier: Project for a MESFET amplifier used to demonstrate the script for exporting the layout to SYMMIC for thermal analysis.

Description: <http://www.capesym.com/SYMMIC/evaluate/AWR-SYMMIC-Examples.pdf>

Script: http://www.capesym.com/SYMMIC/evaluate/Layout_To_SYMMIC.zip

Script Guide: http://www.capesym.com/SYMMIC/Layout_To_SYMMIC.html

Files: <http://www.capesym.com/SYMMIC/evaluate/AWR-SYMMIC-Examples.zip>

MMIC HPA: Project for a high-power amplifier with 12 MESFETs used to demonstrate scripts for exporting the layout and the dissipated powers from MWO to SYMMIC for thermal analysis.

Description: <http://www.capesym.com/SYMMIC/evaluate/AWR-SYMMIC-Examples.pdf>

Video Tutorial: <http://www.capesym.com/SYMMIC/tutorial10.html>

Script: http://www.capesym.com/SYMMIC/evaluate/Layout_To_SYMMIC.zip

Script Guide: http://www.capesym.com/SYMMIC/Layout_To_SYMMIC.html

Files: <http://www.capesym.com/SYMMIC/evaluate/AWR-SYMMIC-Examples.zip>

MMIC Module: This example demonstrates how a module consisting of a MMIC amplifier with a large FET is placed in its package for thermal analysis in SYMMIC.

Description: <http://www.capesym.com/SYMMIC/evaluate/AWR-SYMMIC-Examples.pdf>

Script: http://www.capesym.com/SYMMIC/evaluate/Layout_To_SYMMIC.zip

Script Guide: http://www.capesym.com/SYMMIC/Layout_To_SYMMIC.html

Files: <http://www.capesym.com/SYMMIC/evaluate/AWR-SYMMIC-Examples.zip>

Iterative Electro-Thermal Analysis

Distributed Amplifier: Amplifier with four TOM3 temperature-dependent FETs is used to demonstrate electro-thermal simulations in MWO via compact thermal models extracted by SYMMIC, as well as iterative electro-thermal simulations with SYMMIC thermal analysis in the loop.

Description: <http://www.capesym.com/SYMMIC/electro-thermal.pdf>

Video Tutorial: <http://www.capesym.com/SYMMIC/evaluate/usingSYMMICwithMWO.mp4>

Scripts: Available in the MWO project files.

Files: http://www.capesym.com/SYMMIC/evaluate/Distributed_Amplifier.zip

Thermal Port Transistor Models

UCSD HBT: Simple example using the thermal port on the UCSD HBT transistor model.

Description: See the design notes in the MWO project file.

Video Tutorial: <http://www.capesym.com/SYMMIC/evaluate/usingSYMMICwithMWO.mp4>

Files: <http://www.capesym.com/SYMMIC/evaluate/AHBT.zip>

Multi-finger HBT: This example demonstrates current collapse in a multi-finger HBT by combining SYMMIC and MWO for electro-thermal simulation.

Overview: <http://www.capesym.com/SYMMIC/Electrothermal-Datasheet.pdf>

Description: See the design notes in the MWO project file.

Files: <http://www.capesym.com/SYMMIC/evaluate/MultifingerHBT.zip>

Transient Electro-Thermal Analysis

Thermal Impedance of a FET: This example uses SYMMIC to generate an equivalent RC thermal circuit of a FET. The circuit netlist is then used in Microwave Office to reproduce the turn-on transient of the FET's peak temperature. A brief description can be found in the project's Design Notes. For more details see

Recording Thermal Impedances in Chapter 6 of the SYMMIC Users Manual.

Description: <http://www.capesym.com/SYMMIC/evaluate/thermalImpedance.pdf>

Files: <http://www.capesym.com/SYMMIC/evaluate/FETimpedance.zip>

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