

The background of the slide is a composite image with a warm, orange-brown color palette. It features a robotic arm in the upper center, a car in the lower center, solar panels on the left, and wind turbines on the right. The overall aesthetic is clean and modern, representing advanced technology and sustainable energy.

Elite Power 仿真工具

采用 **plecs**

用户指南

用户指南概述

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Elite Power 仿真工具简介：简介和优势

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仿真工具访问

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分步工具流程

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- PLECS 是一种系统级仿真工具，可通过优化的器件模型促进完整系统的建模和仿真，尽可能地提高速度和精度。PLECS 不是基于 SPICE 的电路仿真工具，此类工具重点关注的是电路元件的低级别行为。
- 功率晶体管被视为简单的开关，经过轻松配置后，可以显示与导通和开关转换相关的损耗。
- PLECS 模型称为“热模型”，包含导通和开关损耗的查找表以及 Cauer 或 Foster 等效网络形式的热链。
- 在仿真期间，PLECS 使用损耗表进行插值和/或外推，以获得电路运行偏置点下的导通和开关损耗。

www.onsemi.cn/elite-power-simulator

Elite Power 仿真工具特性

广泛的电路拓扑

涵盖 DC-DC、AC-DC 和 DC-AC 应用，包括工业（直流快充、UPS、ESS、太阳能逆变器）、汽车（OBC、主驱）和非主驱领域的 32 种电路拓扑

边界仿真能力

安森美的 PLECS 模型超越了数据表中的标称数据，纳入了基于制造环境中物理相关性的边界仿真，走在行业前列。

自定义 PLECS 模型上传

搭配使用安森美的业界首款 PLECS 模型自助生成工具 (SSPMG)，为您的应用量身定制模型并进行仿真。

软开关模型

安森美提供业界首款适用于软开关应用的 PLECS 模型，例如 DC-DC LLC 和 CLLC 谐振、双有源桥和移相全桥等应用。

损耗和热数据绘图

在多功能 3D 数据可视化实用程序中探索器件导通损耗、开关能量损耗和热阻抗。

灵活设计并快速提供仿真结果

灵活捕捉对各种属性的调整，例如栅极驱动阻抗、冷却设计和负载分析。

www.onsemi.cn/elite-power-simulator

安森美的先进 PLECS 模型

- 典型的工业 PLECS 模型由基于测量的损耗表组成，这些表与制造商提供的数据表一致。

这种方法存在四大问题：

1. 开关能量损耗数据取决于测量装置和电路的寄生效应。
 2. 导通和开关能量损耗数据有限，因此通常不够密集，无法确保 PLECS 的准确插值和最小外推。
 3. 损耗数据仅基于标称的半导体工艺条件。
 4. 开关能量损耗数据来自数据表双脉冲生成的损耗数据。这意味着 PLECS 模型仅适用于硬开关拓扑仿真。如果用于软开关拓扑仿真，这些模型非常不准确。
- 安森美的 PLECS 模型自助生成工具 (SSPMG) 为所有四个问题提供了解决方案。
 - 该工具有助于用户构建专为其应用量身定制的 PLECS 模型。请参阅此处：www.onsemi.cn/self-plecs-generator

在 Elite Power 仿真工具中部署 PLECS 模型



边界PLECS 模型

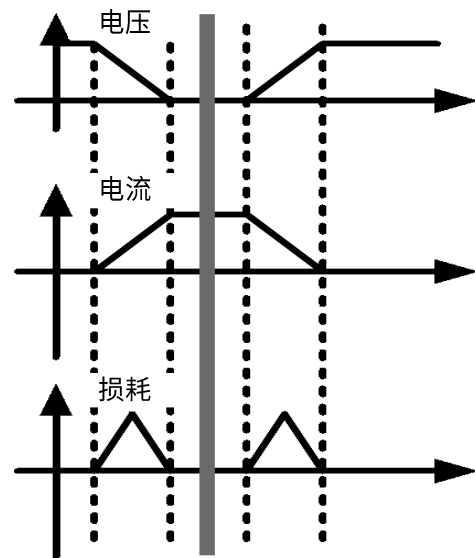
- 基于测量的传统 PLECS 模型仅适用于制造中的典型或标称工艺用例。安森美已开发出基于实际制造分布的精确边界PLECS 模型。
- 例如，物理意义上最恶劣情况下的导通损耗和开关损耗不会同时发生。
- 根据具体的应用，导通和开关能量损耗对整体系统性能的影响会有所不同。借助安森美边界 PLECS 模型，用户可以灵活地研究整个相关区域。
- 基于精准边界和统计学的建模详情参见
 - SiC MOSFET 边界和统计 SPICE 生成模型——国际功率半导体器件和 IC 研讨会 (ISPSD) 论文集，第 154-147 页，2020 年 9 月

工艺条件	R_{DSon} , V_{th} , 击穿电压	电容, 驱动电阻 R_G	导通损耗	开关能量损耗
标称值	标称值	标称值	标称值	标称值
最佳导通损耗, 最恶劣开关损耗	低	高	低	高
最恶劣导通损耗, 最佳开关损耗	高	低	高	低

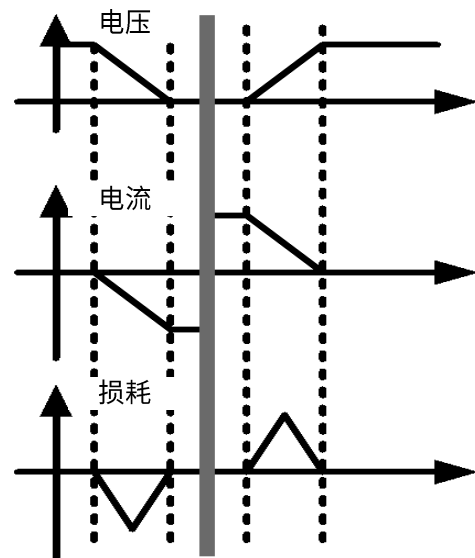
硬开关与软开关能量损耗

- 对于硬开关，传统的双脉冲测试是计算模型损耗的好方法。
- 对于软开关，它取决于拓扑结构和工作模式（转换或开关）
 - 双脉冲测试不能代表软开关的情况。在软开关拓扑的仿真中使用双脉冲开关能量损耗是非常不准确的。
 - 软开关能量损耗原理图在 SSPMG 中实现，以提供准确的软开关 **plegs** 模型来适应各种拓扑，例如
 - DC-DC LLC 和 CLLC 谐振、双有源桥、移相全桥等

硬开关



软开关



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使用 MYON 帐户访问 Elite Power 仿真工具

需要 MyON 才能使用 Elite Power 仿真工具

MYON 登录

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EN

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通过直接链接或产品页面访问

除了直接访问 Elite Power 仿真工具
www.onsemi.cn/elite-power-simulator
也可在每个 EliteSiC 产品页面上访问。

onsemi Products Solutions Design Support Company Careers Search the Site & Cross Reference EN

Products / Discrete & Power Modules / Silicon Carbide (SiC) / Silicon Carbide (SiC) MOSFETs

Silicon Carbide (SiC) MOSFETs | NTBG015N065SC1

Silicon Carbide MOSFET, N-Channel, 650V, 15.3 mΩ, D2PAK-7L

Availability & Samples Email Sales Favorite

EliteSiC Start Simulator

Overview

Silicon Carbide (SiC) MOSFET uses a completely new technology that provide superior switching performance and higher reliability compared to Silicon. In addition, the low ON resistance and compact chip size ensure low capacitance and gate charge. Consequently, system benefits include highest efficiency, faster operation frequency, increased power density, reduced EMI, and reduced system size.

- Applications
- End Products
- Features

Product Overview Material Composition Product Change Notification

Availability & Samples

Product	Status	CAD Models	Compliance	Package Type	Case Outline	MSL Type	MSL Temp (°C)	Container Type	Container Qty.	Channel Polarity	Config
NTBG015N065SC1	Active			D2PAK7 (TO-263-7L HV)		1	245	REEL	800	N-Channel	Single

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Vehicle Electrification Energy Infrastructure DC Fast Charging

EliteSiC Superior Performance. Exceptional Quality.

LEARN MORE

了解有关 EliteSiC 的更多信息，
请访问
www.onsemi.cn/silicon-carbide

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分步工具流程

第 1 步：选择应用和拓扑

1 Application — 2 Device Selection — 3 Device Configuration — 4 Circuit Parameters — 5 Cooling — 6 Simulation — 7 Summary

Target application

Start by selecting target application

Automotive Industrial

Automotive converter topologies

AC/DC

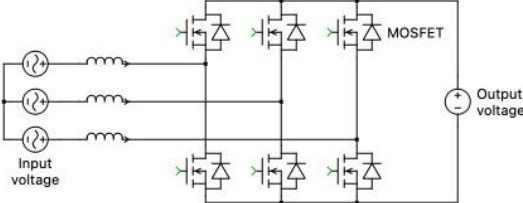
- Active Front End (1 phase, 2 level)
- Active Front End (3 phase, 2 level)
- Active Front End (3 phase, 2 level) (Traction)
- Asymmetrical Bridgeless PFC Converter
- Boost PFC Converter (diode bridge) (1/2 phases)
- Classic Bridgeless PFC Converter
- Totempole Bridgeless PFC Converter (1/2/3 phases)
- Vienna Rectifier (3 phase, 1 switch per leg)
- Vienna Rectifier (3 phase, 2 switches per leg)

DC/DC

DC/AC

Active Front End (3 phase, 2 level)

显示了基本电路原理图



Next Step

选择应用后会筛选出可用的拓扑

按变换器类别
分组的拓扑

显示了基本电路原理图

Next Step

第 2 步：选择器件

Application — 2 Device Selection — 3 Device Configuration — 4 Circuit Parameters — 5 Cooling — 6 Simulation — 7 Summary

Voltage and power rating

Input voltage V_{in} Output voltage V_{out}

Value * Value *

300 600

Vrms,I-I Vdc

Rated power P_{out}

Value *

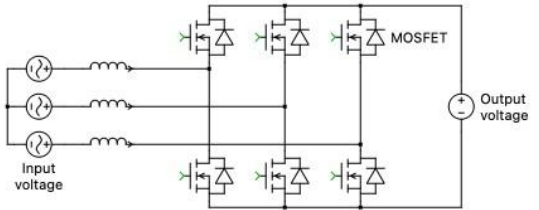
4000 W

Use SiC MOSFETs or modules?

Select option *

SiC MOSFETs (discretes)

用于筛选出有效器件的输入信息



Select MOSFET

Please select device from the list to continue. Devices in gray do not match the criteria and are not selectable. Show all

Product name	Family	V_{MAX}	$R_{DS(on)}$	$I_{D(max)}$	Package	Data Sheet
<input type="radio"/> NVBG015N065SC1	M2	650	12	145	D2PAK7	PDF
<input type="radio"/> NVBG025N065SC1 new	M2	650	19	106	D2PAK7	PDF
<input type="radio"/> NVBG045N065SC1	M2	650	31	62	D2PAK7	PDF
<input type="radio"/> NVBG060N065SC1 new	M2	650	44	46	D2PAK7	PDF
<input type="radio"/> NVBG075N065SC1 new	M2	650	56	37	D2PAK7	PDF
<input type="radio"/> NVBG095N065SC1 new	M2	650	70	30	D2PAK7	PDF
<input type="radio"/> NVH4L015N065SC1	M2	650	12	142	TO-247-4	PDF

选择分立器件或模块

选择器件以进入下一步

直接下载数据表

第 3 步：配置器件

The screenshot shows the 'MOSFET configuration' step in a multi-stage process. The progress bar at the top indicates the current step is '3 Device Configuration', with previous steps 'Application' and 'Device Selection' completed, and subsequent steps '4 Circuit Parameters', '5 Cooling', '6 Simulation', and '7 Summary' pending.

MOSFET configuration

Device name: NVBG015N065SC1

Number of parallel devices: Value * 1 (Annotation: 设置并联器件)

Turn-on gate resistance $R_{g-on,ext}$: Value * 2.2 Ω (Annotation: 设置电路 RG)

Turn-off gate resistance $R_{g-off,ext}$: Value * 2.2 Ω (Annotation: 设置器件工艺边界条件)

Loss model type:

- Nominal loss data
- Best case conduction loss/worst case switching loss
- Worst case conduction loss/best case switching loss
- Upload PLECS custom loss model from onsemi's SSPMG tool (Annotation: 从安森美PLECS 模型自助生成工具 (SSPMG) 上传自定义 PLECS 模型)

Select semiconductor:

- MOSFET (Annotation: 查看损耗和热数据)
- Diode

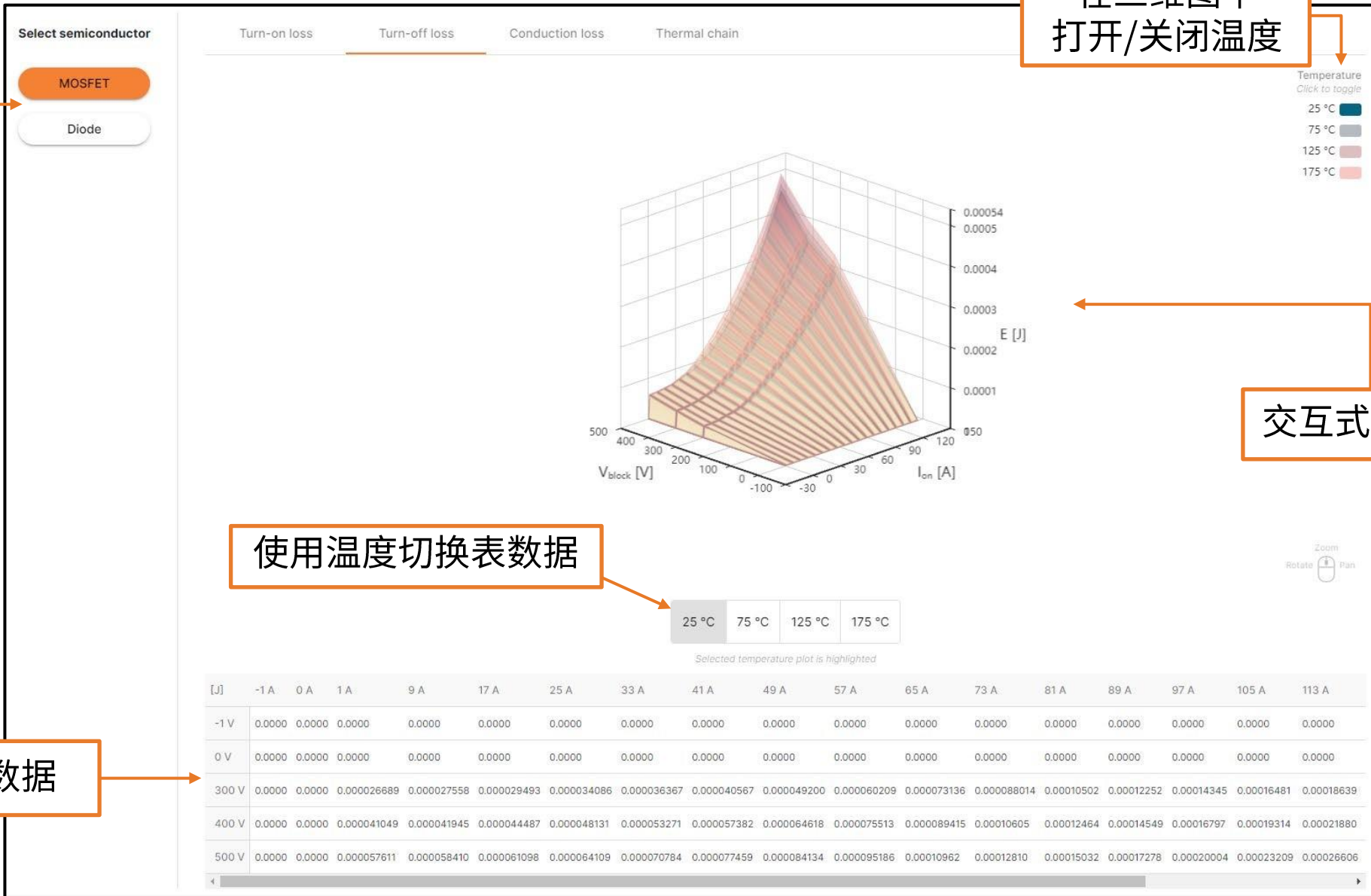
Navigation: Previous Step (disabled), Next Step (disabled)

Additional links: Datasheet, Product page (Annotation: 链接到产品页面)

查看器件损耗数据

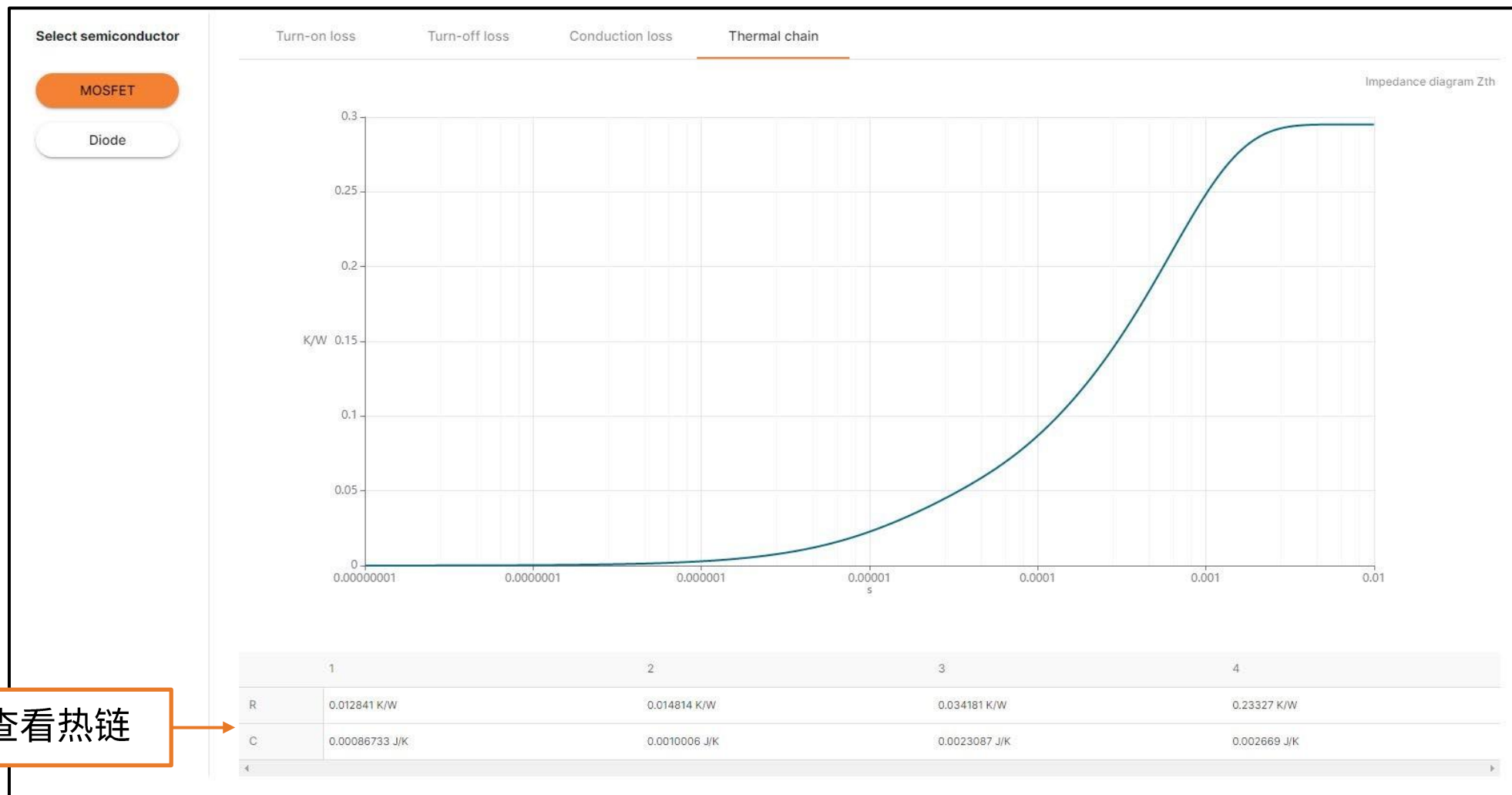
在三维图中
打开/关闭温度

选择
MOSFET 或
体二极管



查看损耗数据

查看器件热数据



查看热链

第 4 步：配置电路参数

Application — Device Selection — Device Configuration — **4 Circuit Parameters** — 5 Cooling — 6 Simulation — 7 Summary

Circuit parameters

Power factor pf
Value *
1

Grid frequency F_{ac}
Value *
50 Hz

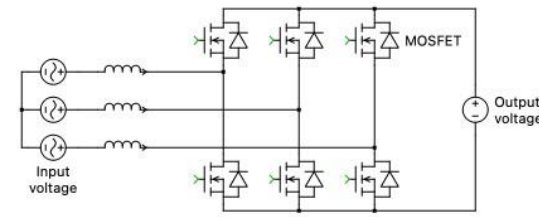
Inductance L
Value *
1 mH

Switching frequency F_{sw}
Value *
50 kHz

Deadtime t_{dead}
Value *
200 ns

Modulation scheme?
Select option *
Sine PWM

设置电路参数，因拓扑而异



设置调制方案，因拓扑而异

Previous Step Next Step

第 5 步：配置冷却

Application Device Selection Device Configuration Circuit Parameters **5 Cooling** 6 Simulation 7 Summary

Thermal parameters

Thermal interface (grease) resistance $R_{th,ch}$

Value *
0 K/W

Heat sink model

Fixed temperature Custom thermal impedance

Fixed temperature T_h

Value *
75 °C

Previous Step Next Step

设置界面热阻

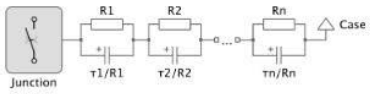
将散热器配置为理想的固定温度或输入自定义热阻抗

自定义散热器热阻抗实用程序

Heat sink thermal impedance

Thermal chain Foster Cauer

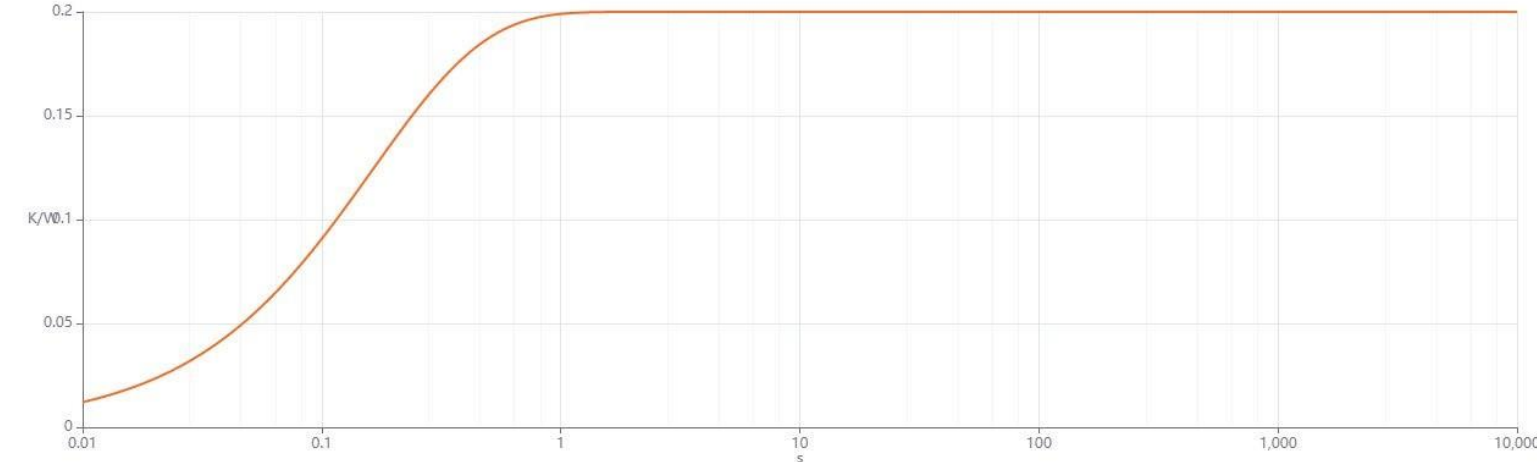
选择具有自动转换功能的 Foster 或 Cauer 格式



Thermal resistance $R_{th,ha}$	Time constant τ_{th}
0.05	K/W 0.1 s
0.15	K/W 0.2 s

Impedance diagram Z_{th}

支持最多 5 阶



切换对数/线性 Y 轴

第 6a 步：运行仿真

- Application
- Device Selection
- Device Configuration
- Circuit Parameters
- Cooling
- 6 Simulation**
- 7 Summary

启动仿真

Simulation Control

Simulate Hold Result

Less details

Simulation completed

System Overview

Input Voltage	Output Voltage	Power Rating	Power Factor	Grid Frequency	Switching Frequency
300.0 V _{I-I,rms}	600.0 V _{dc}	4.000 kW	1.0	50.0 Hz	50.0 kHz

报告了详细的
温度、损耗和效率数据

Temperatures and Total Loss

MOSFET	NVBG015N065SC1
Module	
MOSFET Max T _J	77.7 °C
Heatsink Max Temp.	75.0 °C
Ambient Temp.	75.0 °C
Combined Losses *	43.08 W
Efficiency	98.93 %

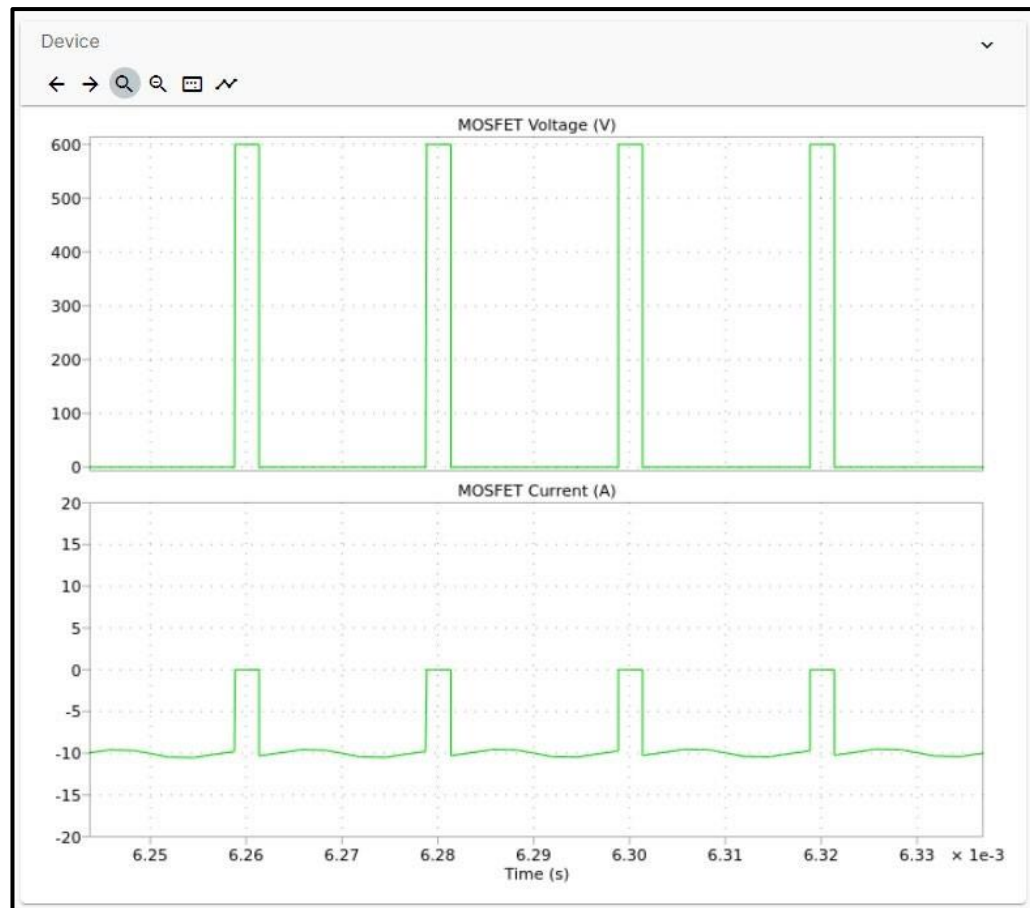
Losses Breakdown

Turn-on Losses E _{on}	12.55 W
Turn-off Losses E _{off}	8.76 W
Recovery Losses E _{rr}	18.59 W
Forward Conduction	0.31 W
Reverse Conduction	1.65 W
Body Diode Conduction (Deadtime)	1.22 W

数据透视表，
导出 CSV

第 6b 步：查看绘图

- Application
- Device Selection
- Device Configuration
- Circuit Parameters
- Cooling
- 6 Simulation
- 7 Summary



缩放和光标功能



第 6c 步：比较多个仿真用例

比较

- 器件选择
- 器件配置
 - ✓ 边界过程损耗数据
 - ✓ SSPMG 模型
- 电路参数
- 散热系统参数



返回第 2、3、4 或 5 步
进行更改

2 Device Selection

MOSFET: NVBG025N065SC1

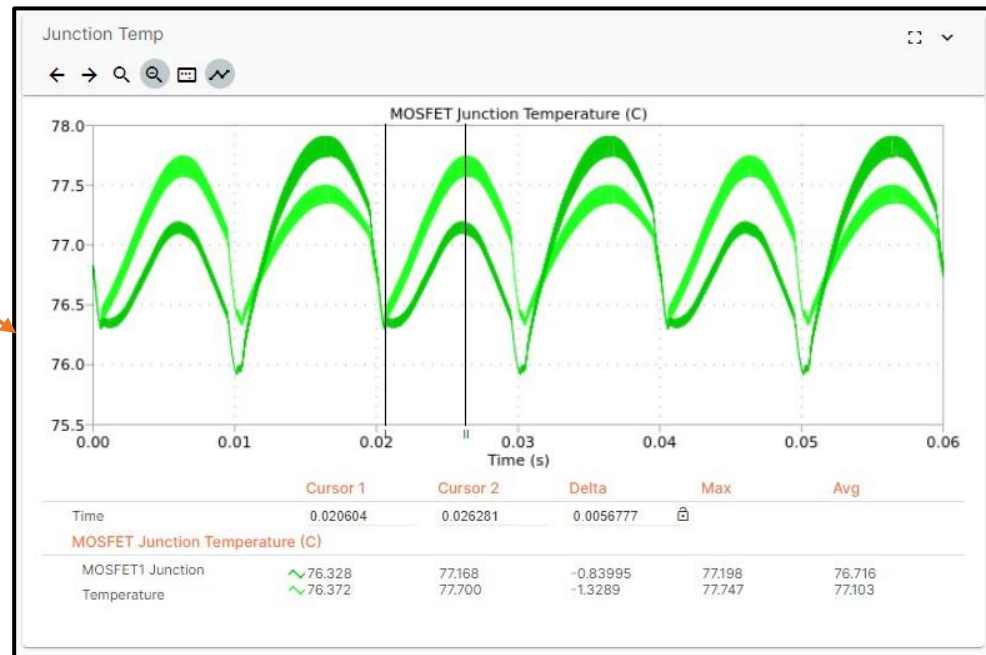
Change

比较结果

Simulation

Simulate

Temperatures and Total Loss		
	Sine PWM, NVBG015N065SC1, Nominal loss data, Trace 1	Sine PWM, NVBG025N065SC1, Nominal loss data
MOSFET	NVBG015N065SC1	NVBG025N065SC1
Module		
MOSFET Max T _J	77.7 °C	77.9 °C
Heatsink Max Temp.	75.0 °C	75.0 °C
Ambient Temp.	75.0 °C	75.0 °C
Combined Losses *	43.08 W	31.86 W
Efficiency	98.93 %	99.21 %



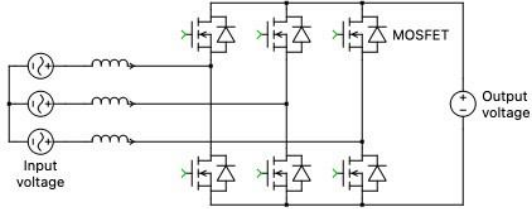
步骤 7: 查看汇总表

Application Device Selection Device Configuration Circuit Parameters Cooling Simulation **7 Summary**

Summary for Active Front End (3 phase, 2 level) topology (automotive)

下载 PLECS 模型

Download Thermal Descriptions Print CSV Download



You can highlight rows by clicking on them

突出显示要打印或下载到 CSV 的行

Parameter	Sine PWM, NVBG025N065SC1, Nominal loss data	Sine PWM, NVBG015N065SC1, Nominal loss data, Trace 1
Variables ▾		
Selected part	NVBG025N065SC1	NVBG015N065SC1
Input voltage V_{in}	300 Vrms,I-I	300 Vrms,I-I
Output voltage V_{out}	600 Vdc	600 Vdc
Rated power P_{out}	4000 W	4000 W
Use SiC MOSFETs or modules?	SiC MOSFETs (discretes)	SiC MOSFETs (discretes)
Number of parallel devices	1	1
Turn-on gate resistance $R_{g-on,ext}$	4 Ω	2.2 Ω
Turn-off gate resistance $R_{g-off,ext}$	4 Ω	2.2 Ω
Loss model type	Nominal loss data	Nominal loss data
Power factor pf	1	1
Grid frequency F_{ac}	50 Hz	50 Hz
Inductance L	1 mH	1 mH
Switching frequency F_{sw}	50 kHz	50 kHz
Deadtime t_{dead}	200 ns	200 ns
Modulation scheme?	Sine PWM	Sine PWM

负载曲线仿真

- 负载曲线仿真支持在多个用户定义的工作点进行功率和热估算
- 简单直观的流程

带有负载分析的拓扑

NPC 逆变器 (1 相, 3 电平)

NPC 逆变器 (3 相, 3 电平)

T 型逆变器 (1 相, 3 电平)

T 型逆变器 (3 相, 3 电平)

ANPC 逆变器 (1 相, 3 电平)

ANPC 逆变器 (3 相, 3 电平)

逆变器 (3 相, 2 电平, 电网负载)

逆变器 (3 相, 2 电平, 电机负载)

主驱逆变器 (3 相)

4 Circuit Parameters

Circuit parameters

Use variable toggle to enable mission profile

Output voltage V_{out} Value * 380	<input checked="" type="checkbox"/>	Power factor pf Value * 1	<input checked="" type="checkbox"/>
Load frequency F_{ac} Value * 50 Hz		Switching frequency F_{sw} Value * 20 kHz	<input type="checkbox"/>
Deadtime t_{dead} Value * 50 ns		Inductance L Value * 1 mH	
Output Current Value * 15 A			<input type="checkbox"/>

Modulation scheme?

Select option *
Sine PWM

负载曲线设置

Mission Profile

设置参数曲线

Enable stepped changes

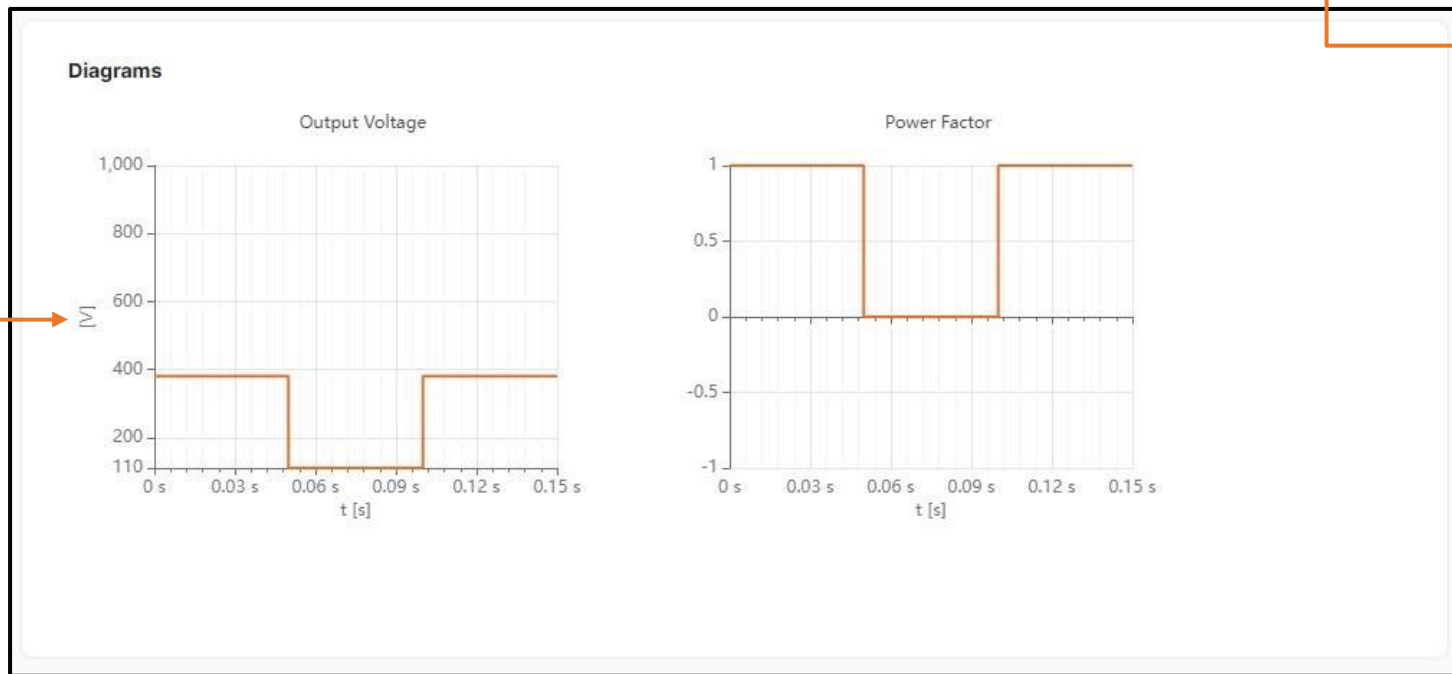
Time [s]	Output Voltage [V]	Power Factor
Value * 0	Value * 380	Value * 1
Value * 0.05	Value * 110	Value * 0
Value * 0.1	Value * 380	Value * 1
Value * 0.15	Value * 380	Value * 1

设置时间间隔

未启用步进更改时为线性斜坡

增加或减少时间间隔

实时绘制负载曲线参数，以便在启动仿真前进行检查



负载曲线仿真

6 Simulation

The screenshot displays a simulation environment for an NPC Inverter (3 phase, 3 level). The circuit diagram shows a three-phase inverter with 14 MOSFETs (s11-s14), 14 diodes (D1-D14), and a central DC link with a capacitor (C1). The input is a 800 V AC source (Vin). The output is a three-phase load (L1, L2, L3) connected to a three-phase motor (Vout). The simulation control panel shows the 'Mission Profile' button highlighted in orange, indicating that the simulation is running or about to start. The simulation is completed, and the system overview and temperatures are displayed.

NPC Inverter (3 phase, 3 level)

Simulation Control

Simulate → **Mission Profile** → Hold Result

Simulation completed

System Overview

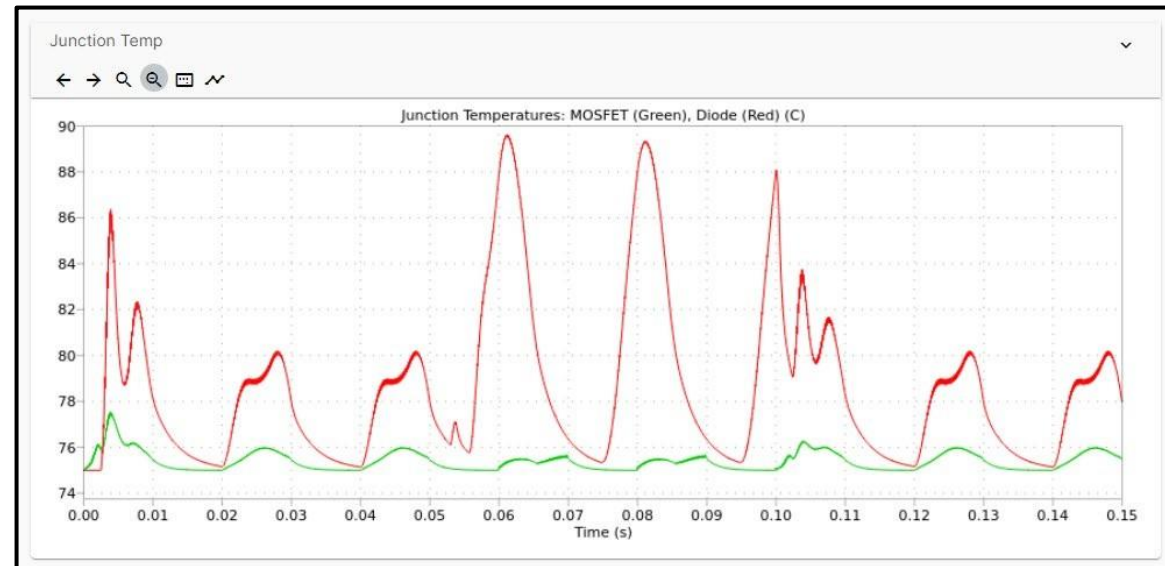
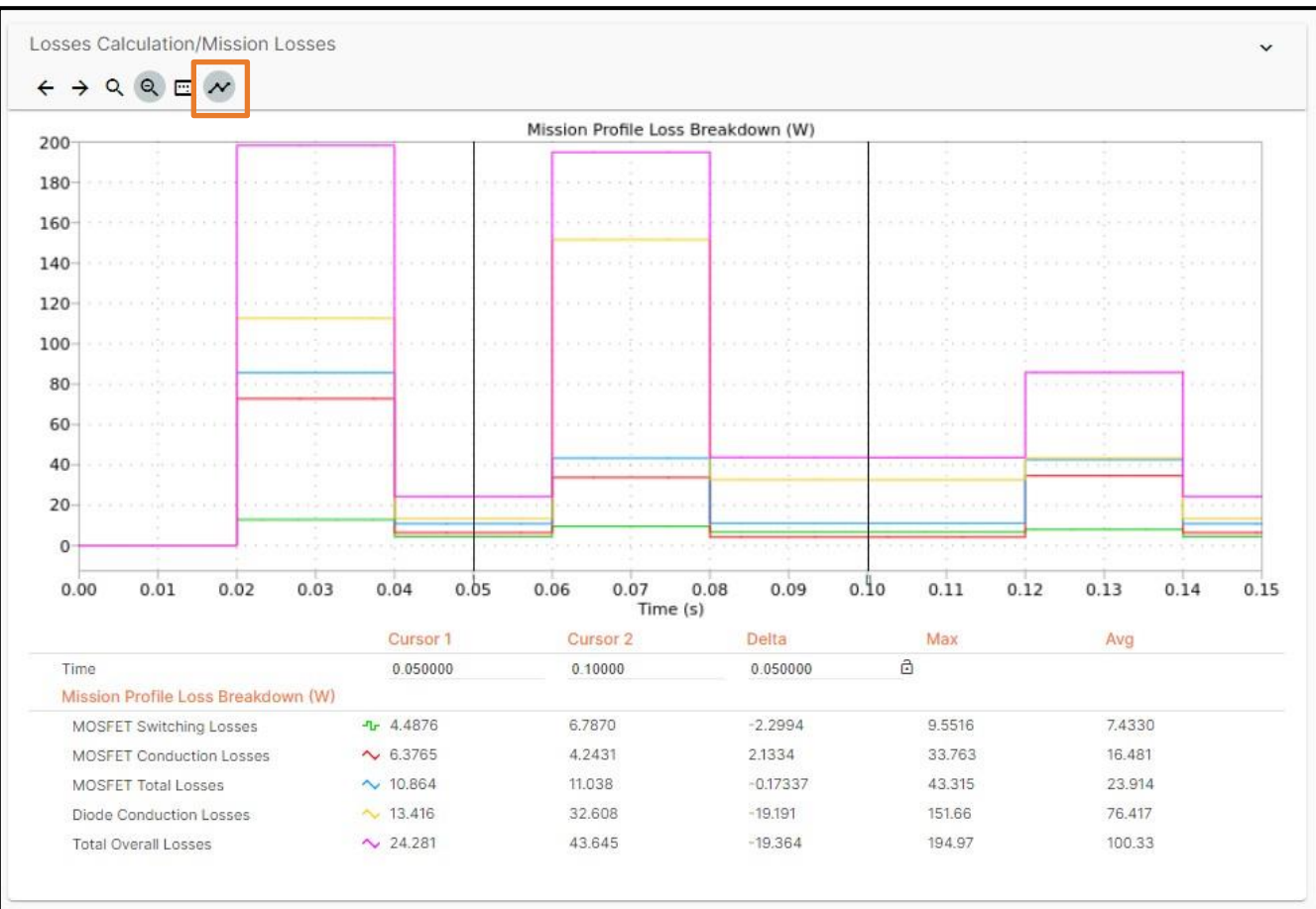
Input Voltage	Output Voltage	Power Rating	Power Factor	Load Frequency	Switching Frequency
800.0 V	380.0 V	20.00 kW	1.0	50.0 Hz	20.0 kHz

Temperatures

SIC MOSFET	MOSFET Max TJ	SIC Diode	Diode Max TJ	Heatsink Max Temp.	Ambient Temp.
NTBG015N065SC1	77.5 °C	FFSB2065B	89.6 °C	75.0 °C	75.0 °C

当负载曲线的任何
电路参数启用时，
将启用任务曲线仿真
按钮（橙色）

示例负载曲线仿真结果



结温

可以通过启用光标在负载曲线上跟踪损耗

有问题吗？

对您的 PLECS 模型自助生成工具需求有疑问、意见或需要支持？我们随时为您提供帮助！
通过以下地址给我们写电子邮件：simulator@onsemi.com

- PLECS 模型自助生成工具：www.onsemi.cn/self-plecs-generator
- Elite Power 仿真工具：www.onsemi.cn/elite-power-simulator



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