

ANSYS

PERVASIVE ENGINEERING SIMULATION

ANSYS 18 新产品发布会

18

北京 · 上海 · 成都 · 深圳 · 台北

Simplorer用于定制化高级建模
及高性能开关电源仿真方法

杨利辉/高级应用工程师

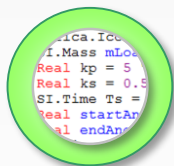
ANSYS

内容提要

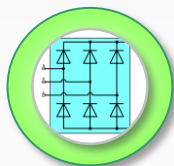
- **Simplorer用于定制化高级建模方法**
 - Simplorer建模平台概述
 - Simplorer基本库模型应用
 - Simplorer基本库模型定制化高级应用模型（以脉冲功率负载为例）
- **Simplorer用于高新能开关电源仿真**
 - 移相全桥电源变换器原理
 - Simplorer R18中实现移相全桥电源变换器方法
 - PExprt设计移相全桥变换器变压器
- **总结**

ANSYS平台价值: Modeling the System

*Powerful Capabilities for Assembly and Reuse
Simplorer*



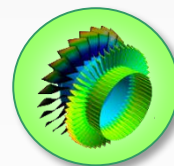
Language-Based Modeling



Multi-Domain Model Libraries



Co-simulation with 3D Physics



Reduced Order Model Creation



Embedded Software Integration



Functional Mockup Interface (FMI)



VHDL-AMS
C/C++
SPICE
SML
Modelica

Multi-Domain

Analog

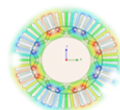
Digital

Power Systems

Manufacturers

App-Specific

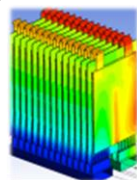
ANSYS 3D Physics



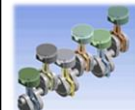
EM



Fluid

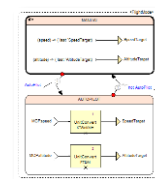


Thermal



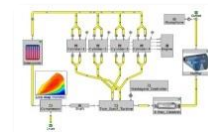
Mech

ANSYS SCADE



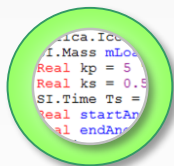
Simulink
C Code

3rd Party System Modeling tools
(AMESim, Simulink, Dymola, GT Suite etc.)

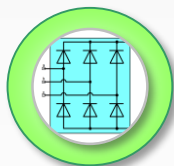


ANSYS平台价值: Modeling the System

*Powerful Capabilities for Assembly and Reuse
 Simplorer*



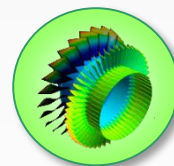
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ANSYS 3D Physics

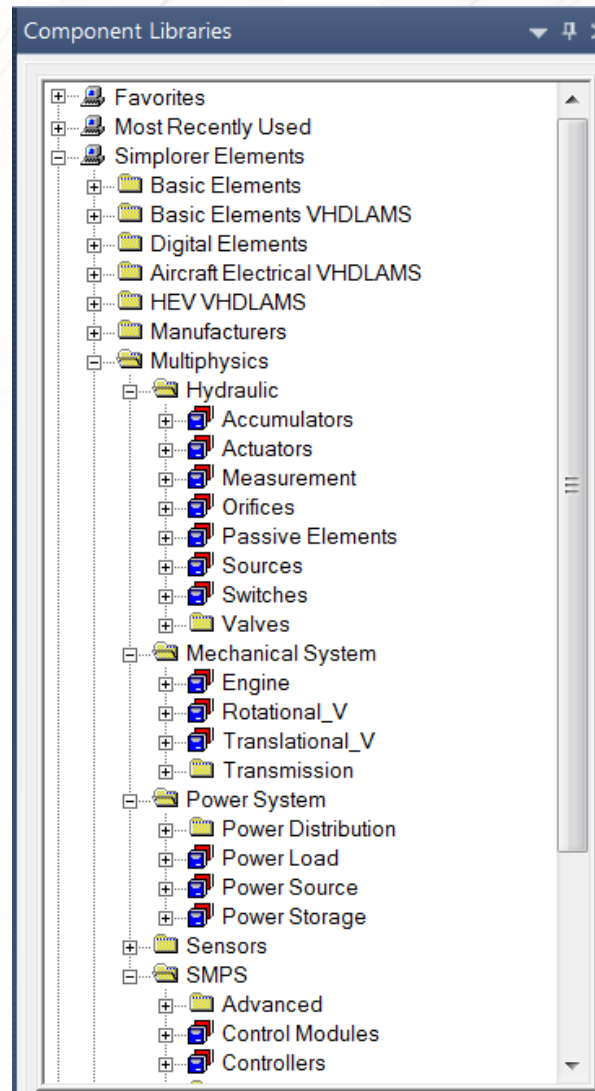
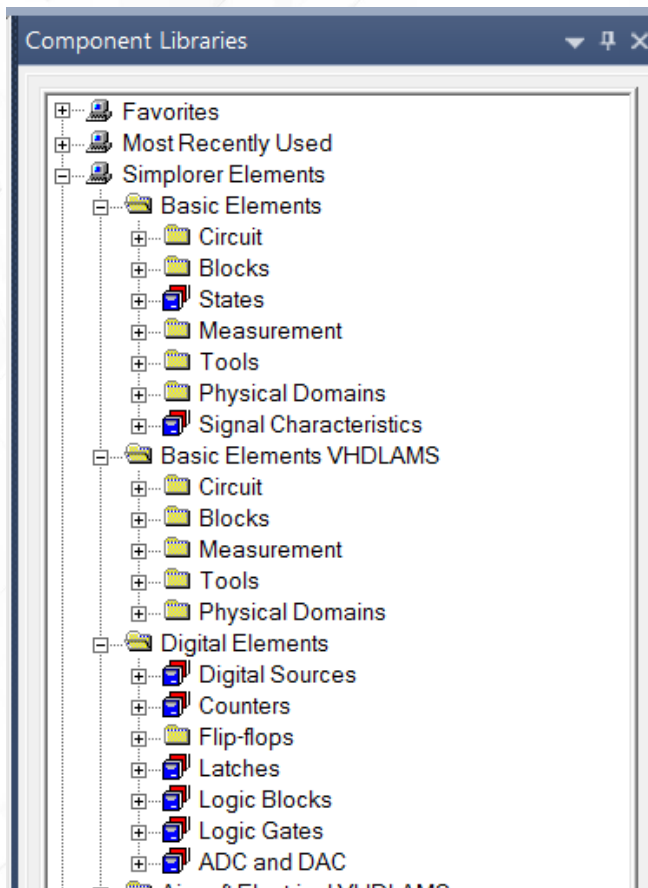
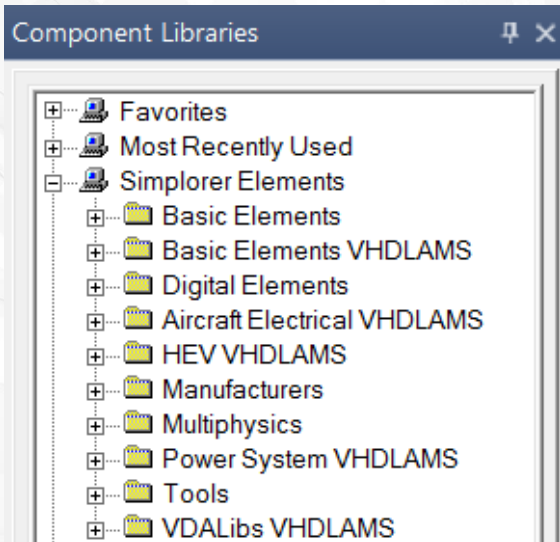
EM Fluid Thermal Mech

ANSYS SCADE

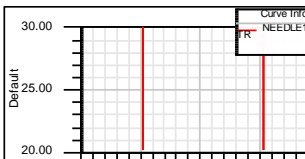
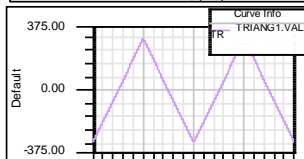
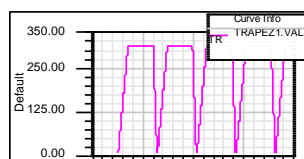
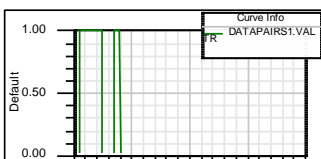
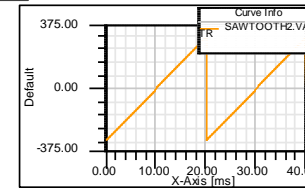
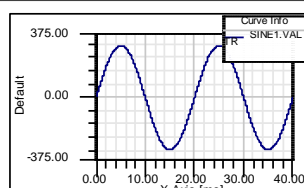
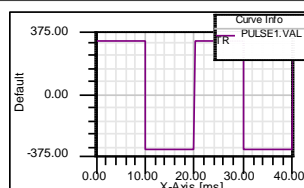
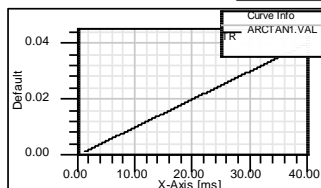
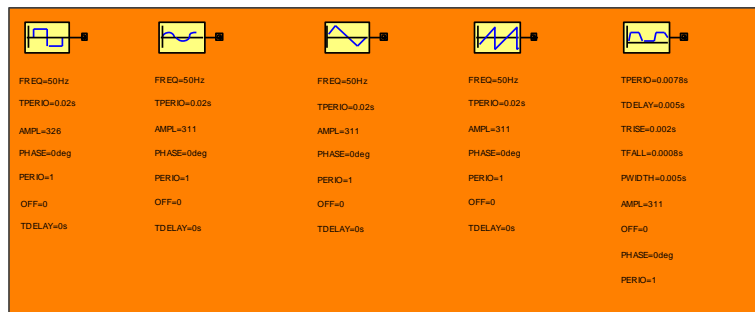
Simulink
 C Code

3rd Party System Modeling tools (AMESim, Simulink, Dymola, GT Suite etc.)

Simplorer基本库文件



Simplorer基本库文件模型搭建的仿真电路



Simplorer基本库文件模型搭建的仿真电路

The screenshot displays the ANSYS Electronics Desktop interface for a motor drive simulation. The main workspace shows a schematic of a three-phase bridge rectifier circuit connected to a motor. The circuit includes a three-phase AC source, six diodes (D1-D6), a DC link capacitor (C1), and a motor model. The simulation results are shown in three plots: Motor Current, Motor Speed, and Torque Load.

Motor Current Plot: Shows the current in Amperes (A) over time (ms). The current is a high-frequency AC signal with a peak amplitude of approximately 20 A.

Motor Speed Plot: Shows the motor speed in RPM over time (ms). The speed starts at 0 and increases linearly to approximately 1000 RPM.

Torque Load Plot: Shows the torque load in Nm over time (ms). The torque load is constant at approximately 10 Nm.

Properties Panel: Lists simulation parameters for the motor model.

Name	Value	Unit	SDB
AC_IM	0	V	<input type="checkbox"/>
EMF	1	V	<input type="checkbox"/>
FREQ	60	Hz	<input type="checkbox"/>
TPERIO	Tend+1		<input type="checkbox"/>
AMPL	169.70562748477	V	<input type="checkbox"/>
PERIO	0		<input type="checkbox"/>
OFF	0	V	<input type="checkbox"/>
TDELAY	0	s	<input type="checkbox"/>
TRISE	0.005	s	<input type="checkbox"/>
TFALL	0.01	s	<input type="checkbox"/>
PWIDTH	0.005	s	<input type="checkbox"/>

Component Libraries: Lists available components for the simulation.

- Favorites
 - R: Resistor (LIBRARY: Simplorer Eleme)
 - L: Inductor (LIBRARY: Simplorer Eleme)
 - C: Capacitor (LIBRARY: Simplorer Eleme)
 - D: Diode (LIBRARY: Simplorer Elements)
 - E: Voltage Source (LIBRARY: Simplorer Elements)
 - AM: Electrical Ammeter (LIBRARY: Simplorer Elements)
 - VM: Electrical Voltmeter (LIBRARY: Simplorer Elements)
- Most Recently Used
 - E: Voltage Source (LIBRARY: Simplorer Elements)
 - L: Inductor (LIBRARY: Simplorer Elements)
 - R: Resistor (LIBRARY: Simplorer Elements)
 - ECE3_Model: ECE 3-Phase Model (LIBRARY: Simplorer Elements)
- Simplorer Elements
 - Basic Elements
 - Basic Elements VHDLMAS
 - Digital Elements
 - Aircraft Electrical VHDLMAS
 - HEV VHDLMAS
 - Manufacturers
 - Multiphysics
 - Power System VHDLMAS
 - Tools
 - VDALbs VHDLMAS
- Project Components
 - dcmp: DC Permanent Magnet Excitation
 - dcmp_mine
 - SUM: Summation (LIBRARY: Simplorer Elements)
 - INTG: Integrator (LIBRARY: Simplorer Elements)
 - LIMIT: Limiter (LIBRARY: Simplorer Elements)
 - CONST: Constant Value (LIBRARY: Simplorer Elements)
 - E: Voltage Source (LIBRARY: Simplorer Elements)
 - DCMP: DC Permanent Magnet Excitation
 - D: Diode (LIBRARY: Simplorer Elements)

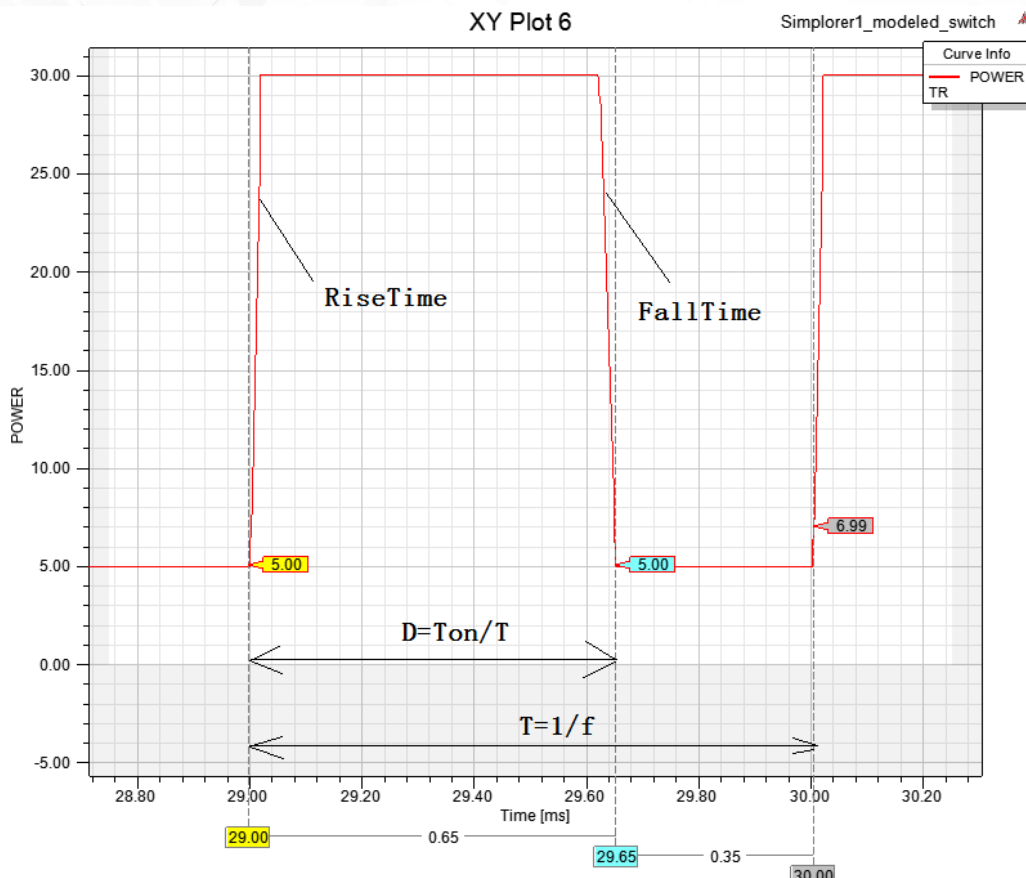
Message Manager: Shows the simulation progress.

WS04_VHDL_Motor_v2016 - Design1 - Simulation Started... on Local Machine - RUNNING

Calculate (TR)

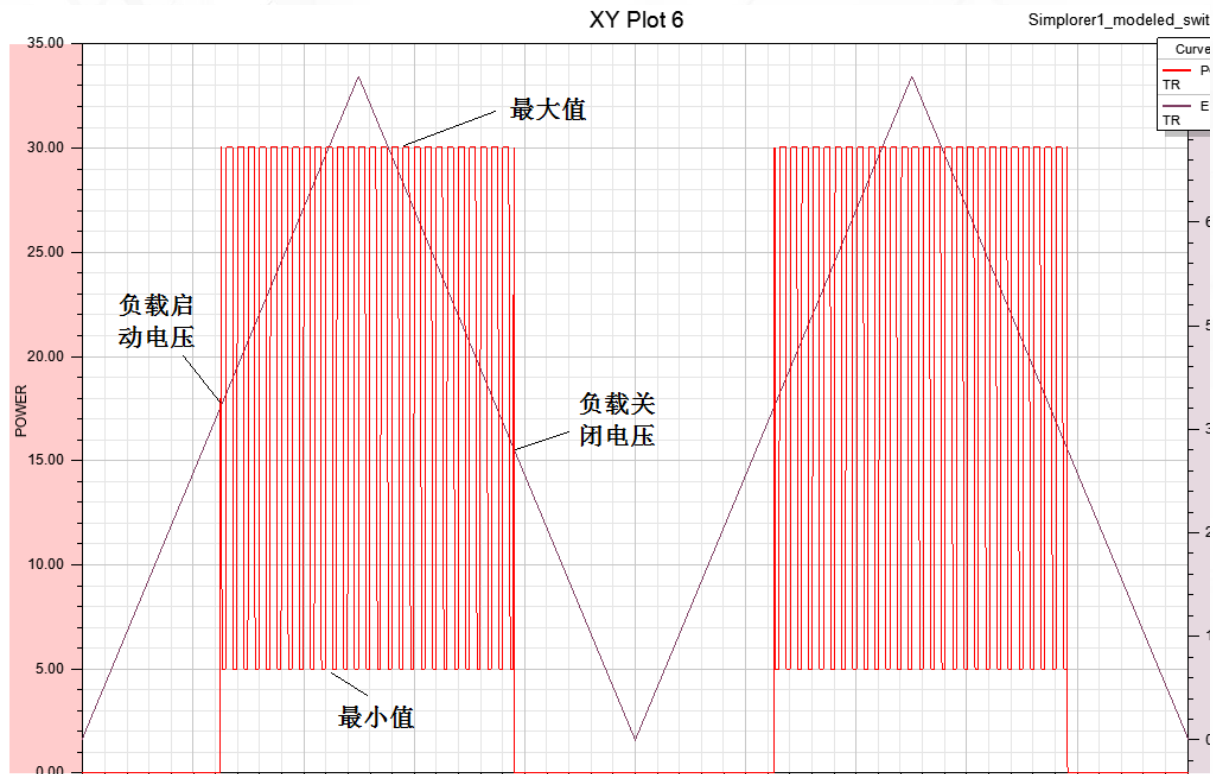
Simplorer基本库元件搭建复杂模型

脉冲功率负载模型： 负载脉冲频率可调、脉冲占空比可调、脉冲上升沿时间和下降沿时间可调、脉冲值最大值和最小值可调、负载启动和关闭电压可调，并可由用户通过界面输入。



Simplorer基本库元件可以搭建复杂模型

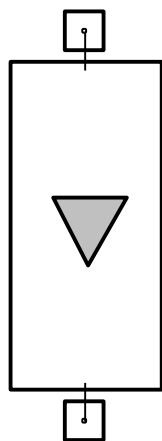
脉冲功率负载模型： 负载脉冲频率可调、脉冲占空比可调、脉冲上升沿时间和下降沿时间可调、脉冲值最大值和最小值可调、负载启动和关闭电压可调，并可由用户通过界面输入。



Simplorer基本库元件的基本器件模型

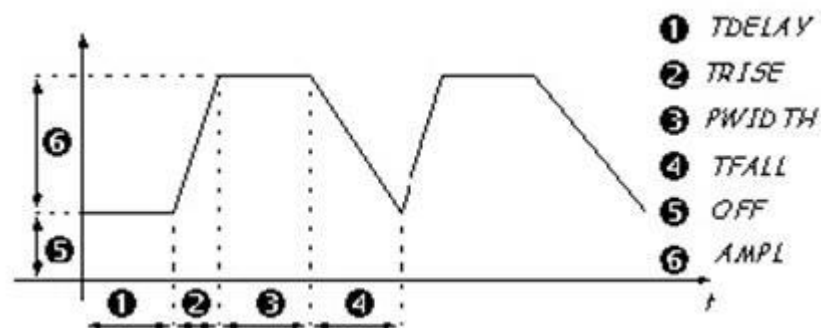
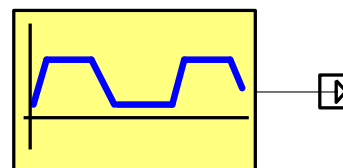
功率负载

POWER_L1



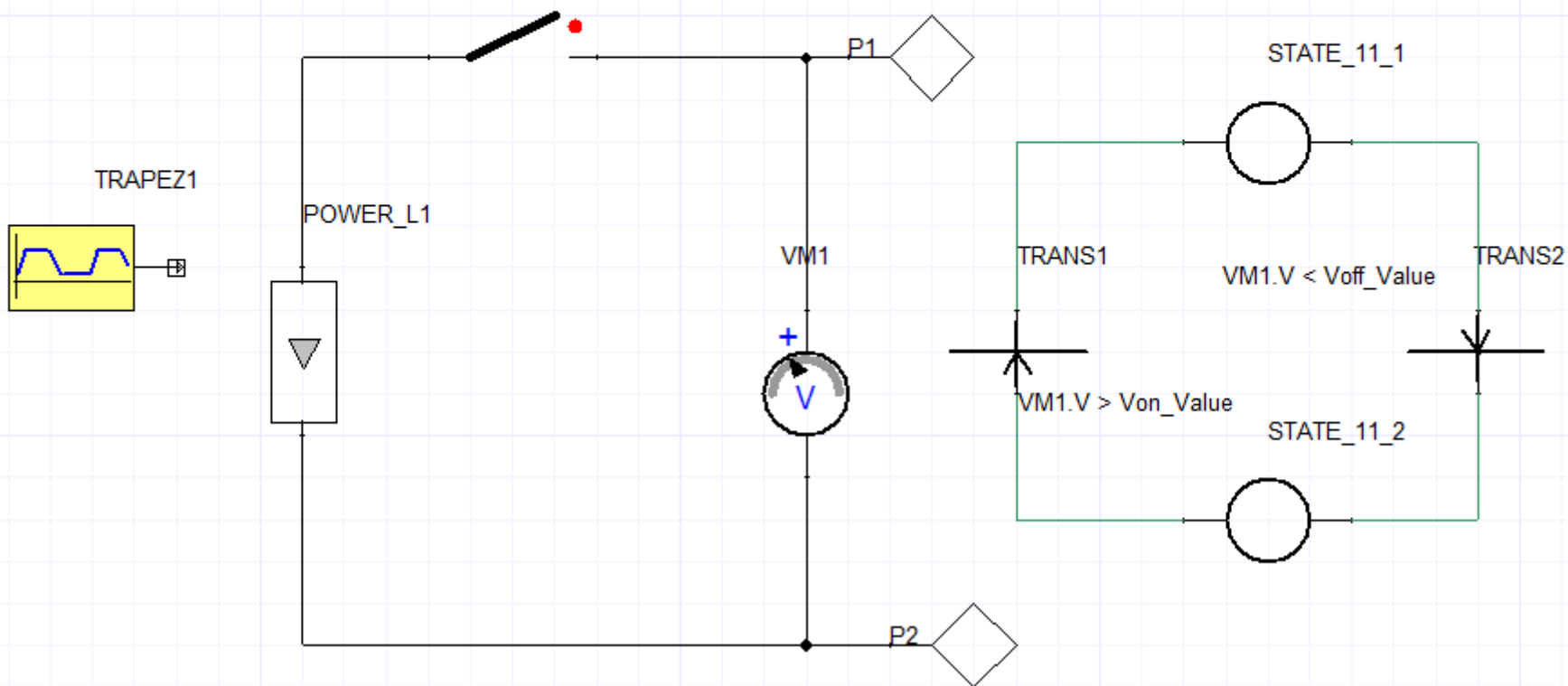
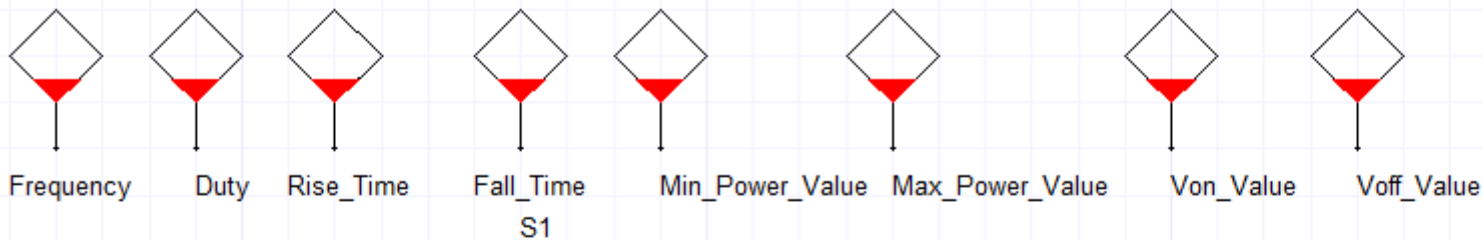
梯形波发生器

TRAPEZ1



脉冲功率负载实现方法：通过合适方式关联两个基本模型

Simplorer搭建脉冲功率负载子电路



Simplorer搭建脉冲功率负载子电路

Port Properties

Port Name:

OK

Cancel

Bus Element Selection

Common Attributes Bus Element:

Terminal Attributes

Domain:

Type:

Direction:

Port Value:

Port Source or Impedance

None

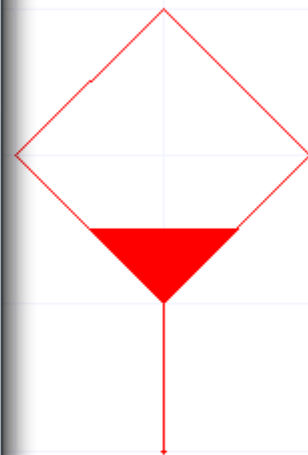
Source Properties...

Impedance Properties...

端口名字

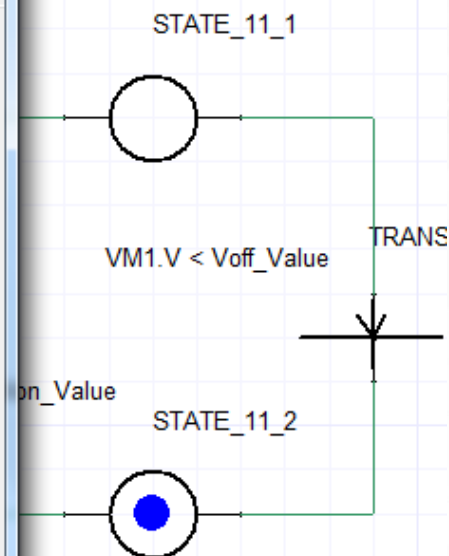
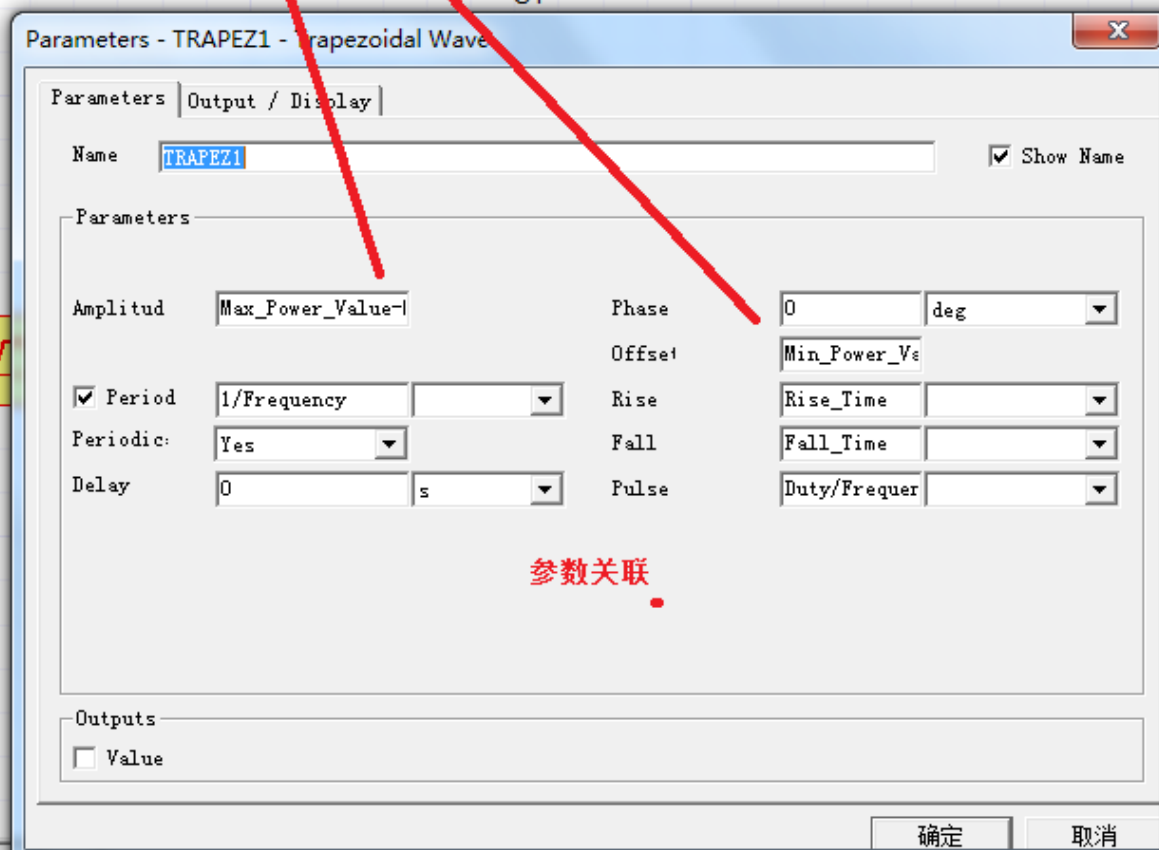
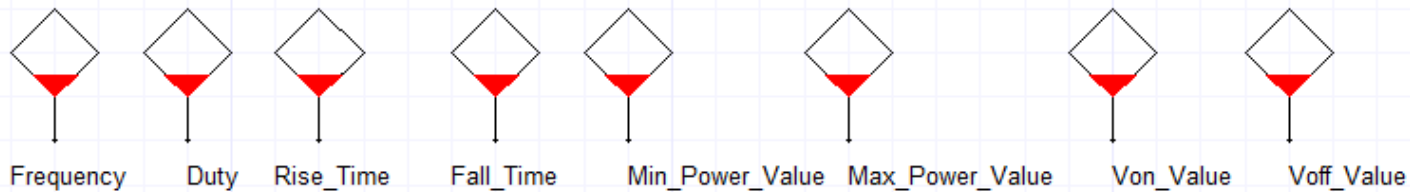
端口数据
数据类型

默认值

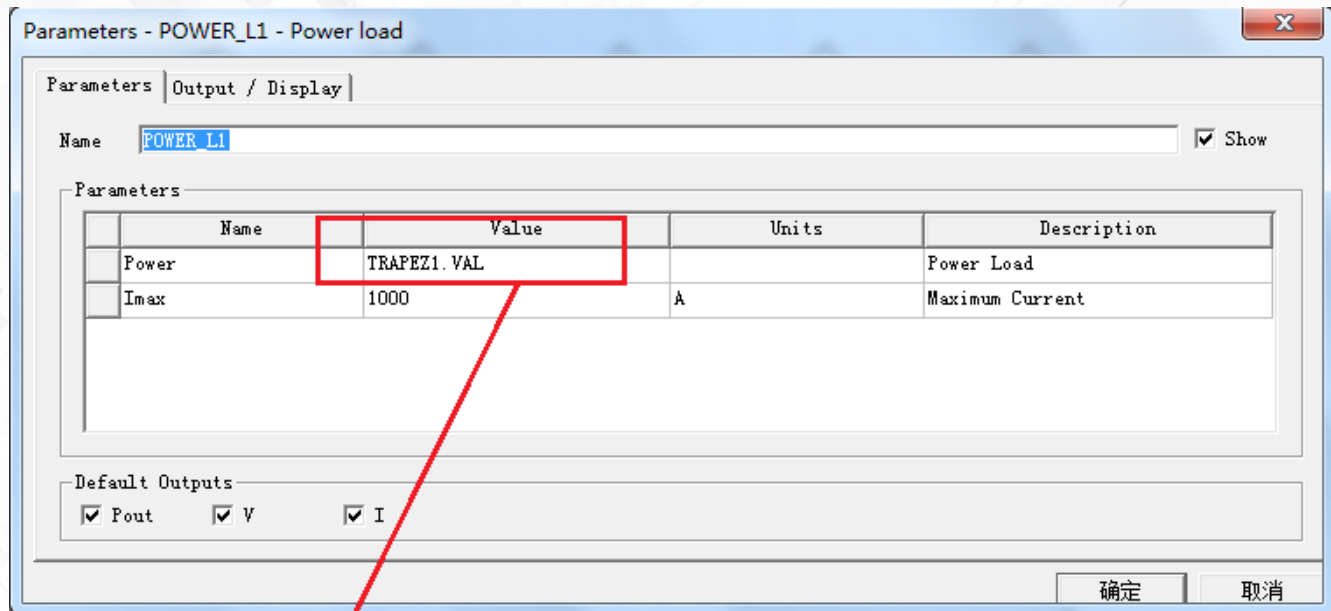


Frequency

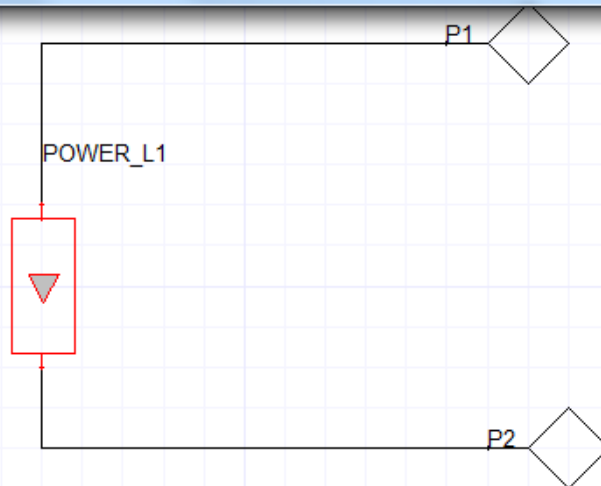
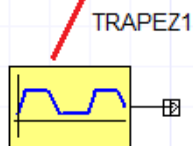
Simplorer基本器件参数和端口参数相关连



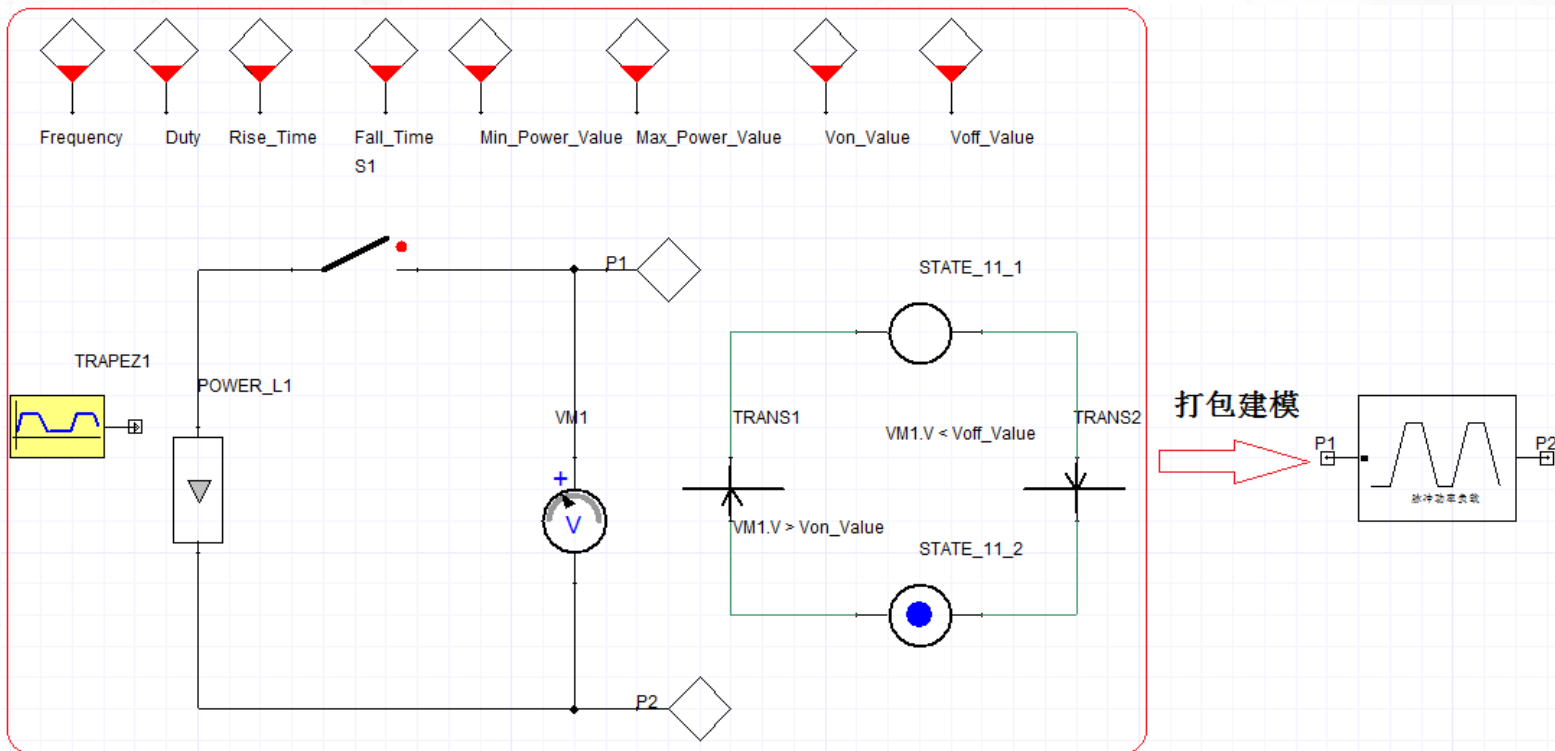
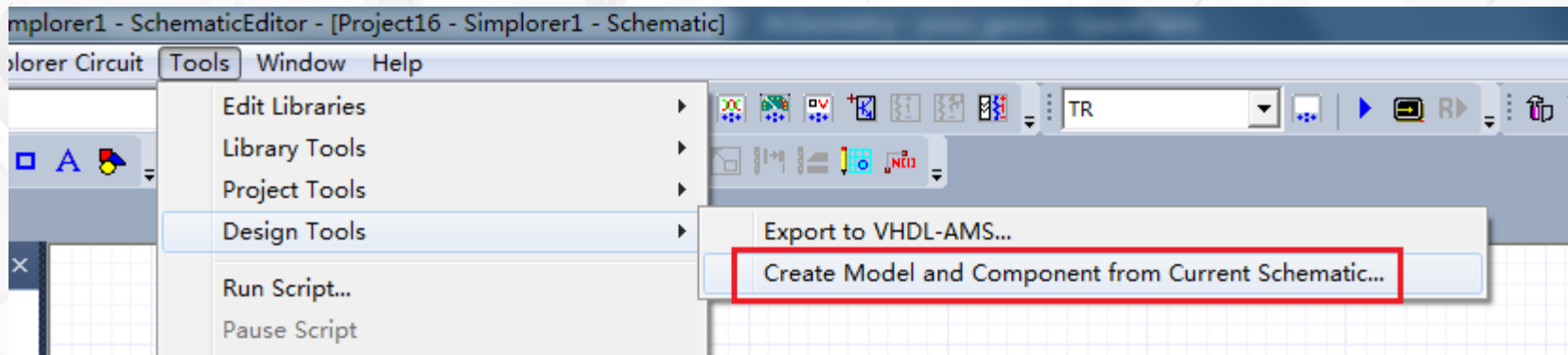
Simplorer基本器件参数和端口参数相关连



参数关联

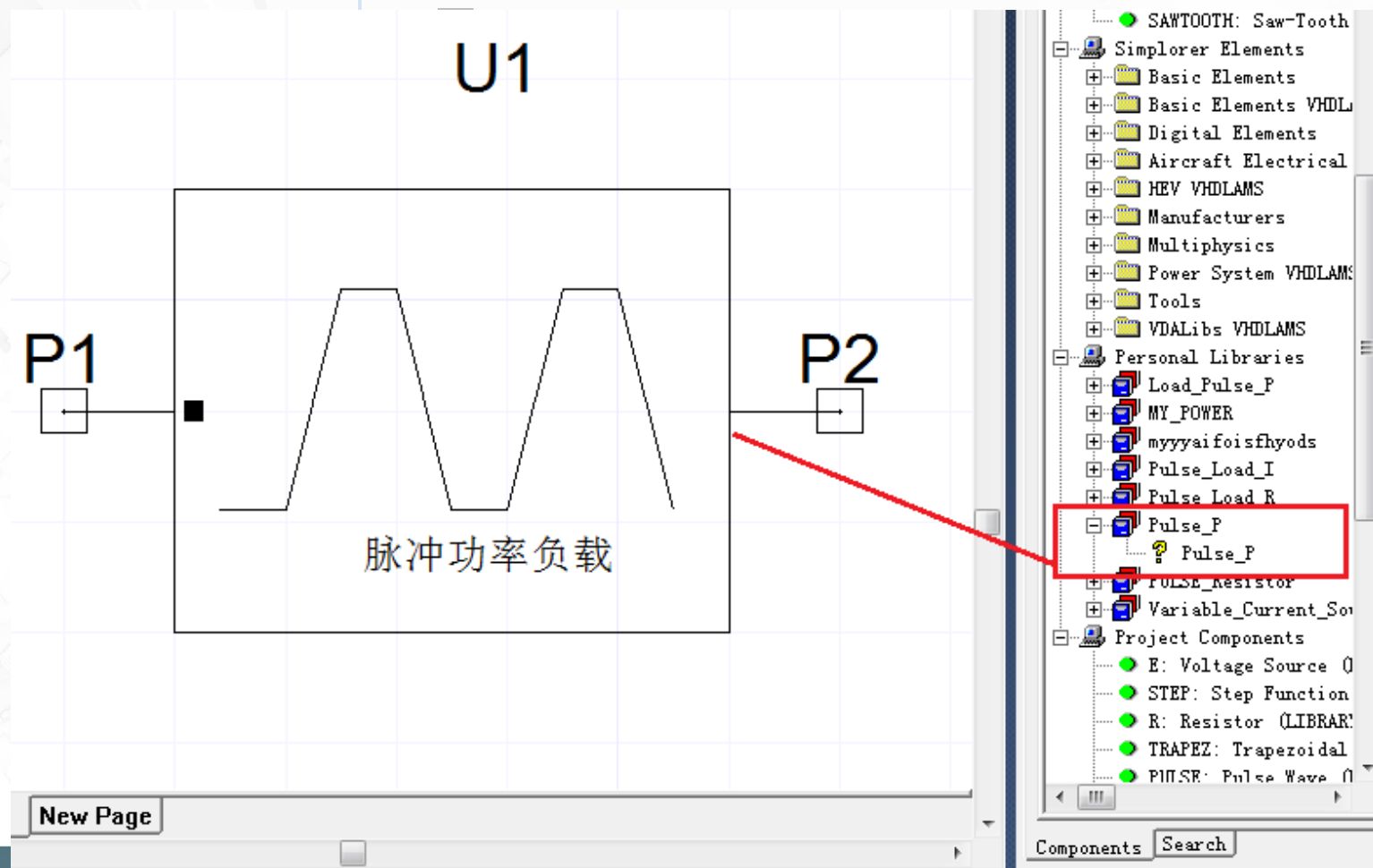


脉冲负载建模过程：模型打包建库



脉冲负载建模过程：获取建模结果

建模结果为后缀分别为 .ac1b、.as1b、.asmd 的文件，把这三个文件拷贝并粘贴在其 PersonalLib 中，用户则可以直接使用这些模型



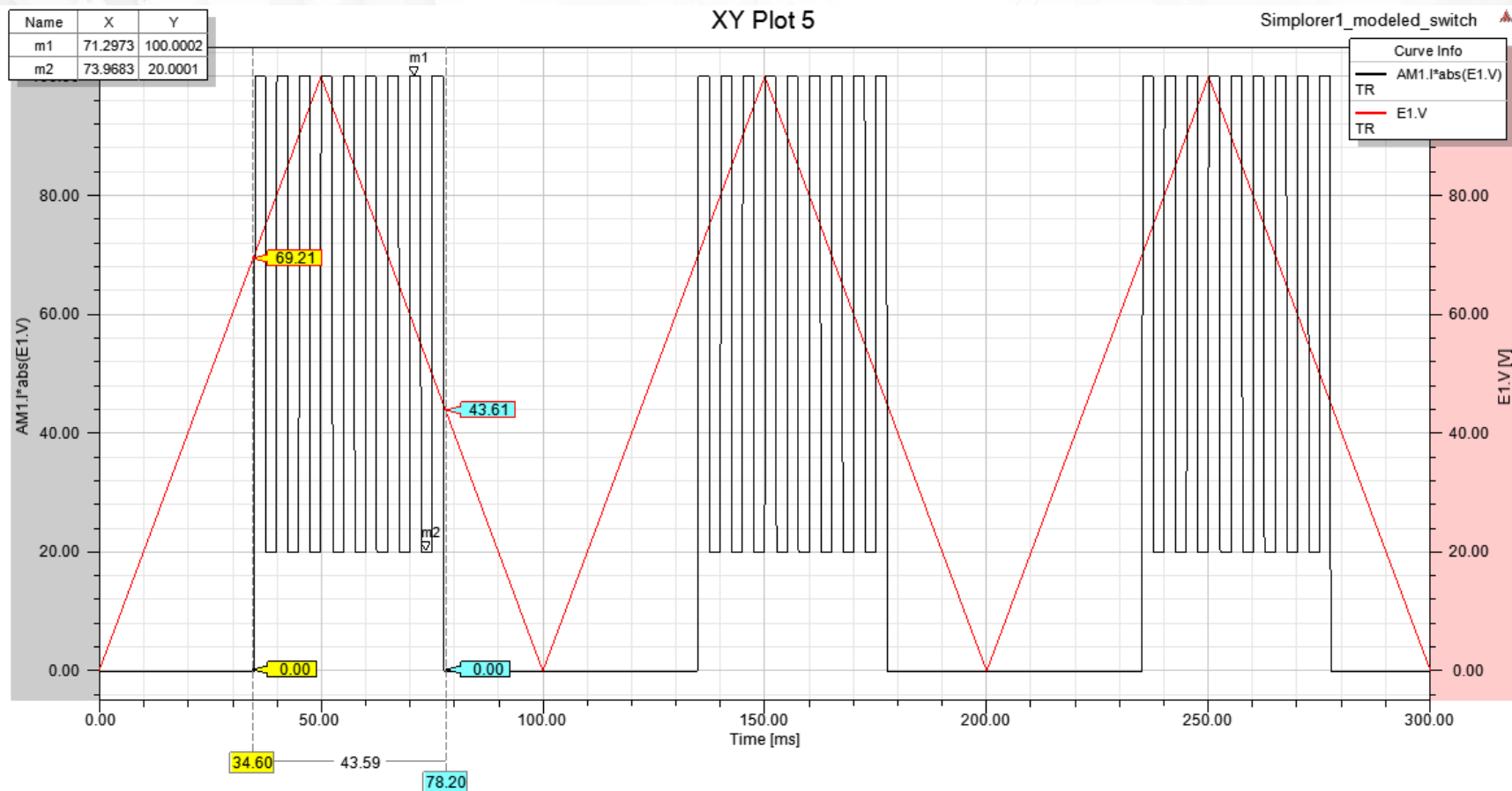
脉冲负载模型测试：简单测试电路

The image displays a circuit diagram on the left and a software window on the right. The circuit diagram shows a pulse load model labeled "脉冲功率负载" (Pulse Power Load) connected between terminals P1 and P2. A red arrow points from the load model to the software window. The software window is titled "U1:Pulse_P Properties: Pulse_Load_Power_V2 - Simplorer1_modeled_switch". It has tabs for "Quantities", "Parameter Values", and "Property Displays". The "Value" tab is selected. Below the tabs are radio buttons for "Value", "Optimization / Design of Experiments", "Tuning", "Sensitivity", and "Statistics". A table lists the parameters and their values:

Name	Value	Unit	Des...	Callback	Override	Dire...	Show Pin	Sweep	SDB
Frequency	200	Hz		...	<input checked="" type="checkbox"/>	In	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Duty	0.5			...	<input checked="" type="checkbox"/>	In	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Rise_Time	20	us		...	<input checked="" type="checkbox"/>	In	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Fall_Time	40	us		...	<input checked="" type="checkbox"/>	In	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Max_Power_Value	100	W		...	<input checked="" type="checkbox"/>	In	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Min_Power_Value	20	W		...	<input checked="" type="checkbox"/>	In	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Von_Value	70	V		...	<input checked="" type="checkbox"/>	In	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Voff_Value	44			...	<input checked="" type="checkbox"/>	In	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>

At the bottom right of the window, there is a checkbox for "Show Hidden". Below the window, there are three buttons: "确定" (OK), "取消" (Cancel), and "应用 (A)" (Apply). A ground symbol is also visible at the bottom center of the image.

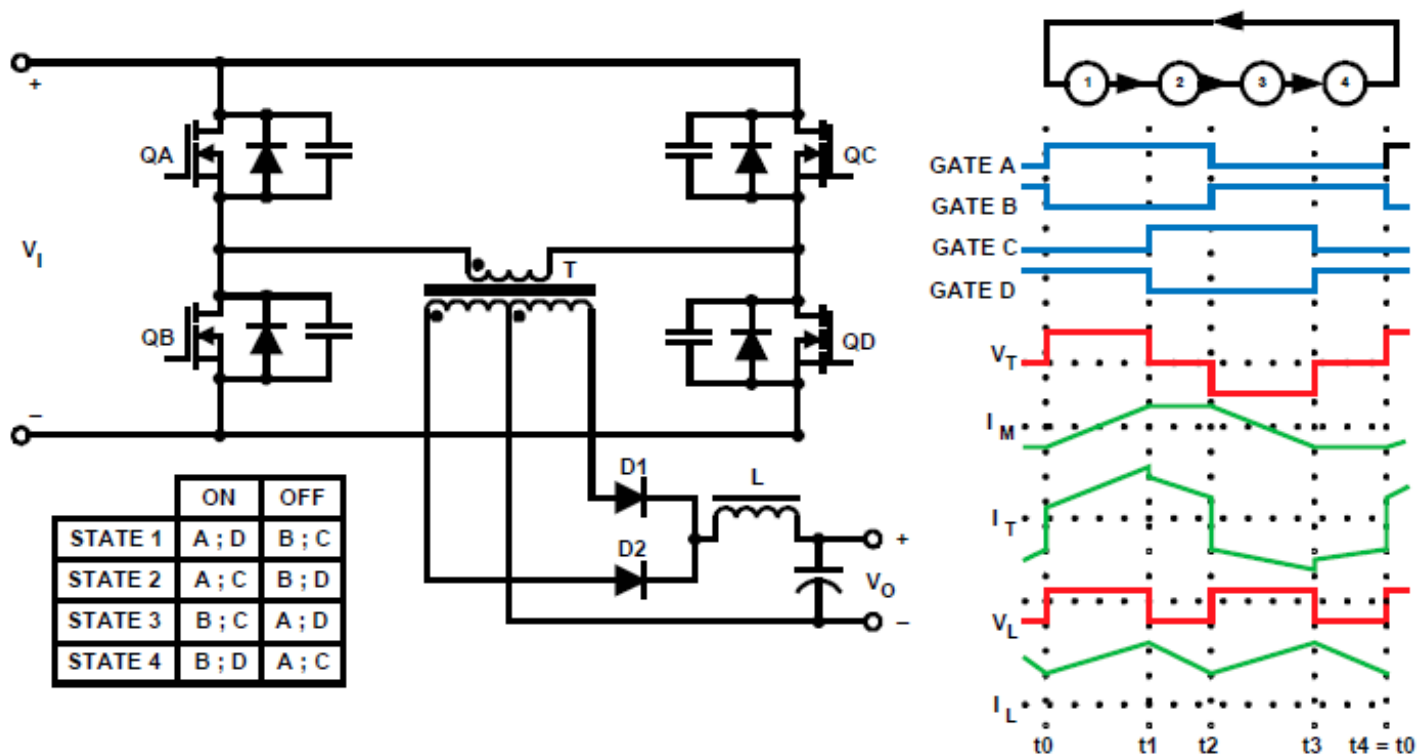
脉冲负载模型测试：测试结果



内容提要

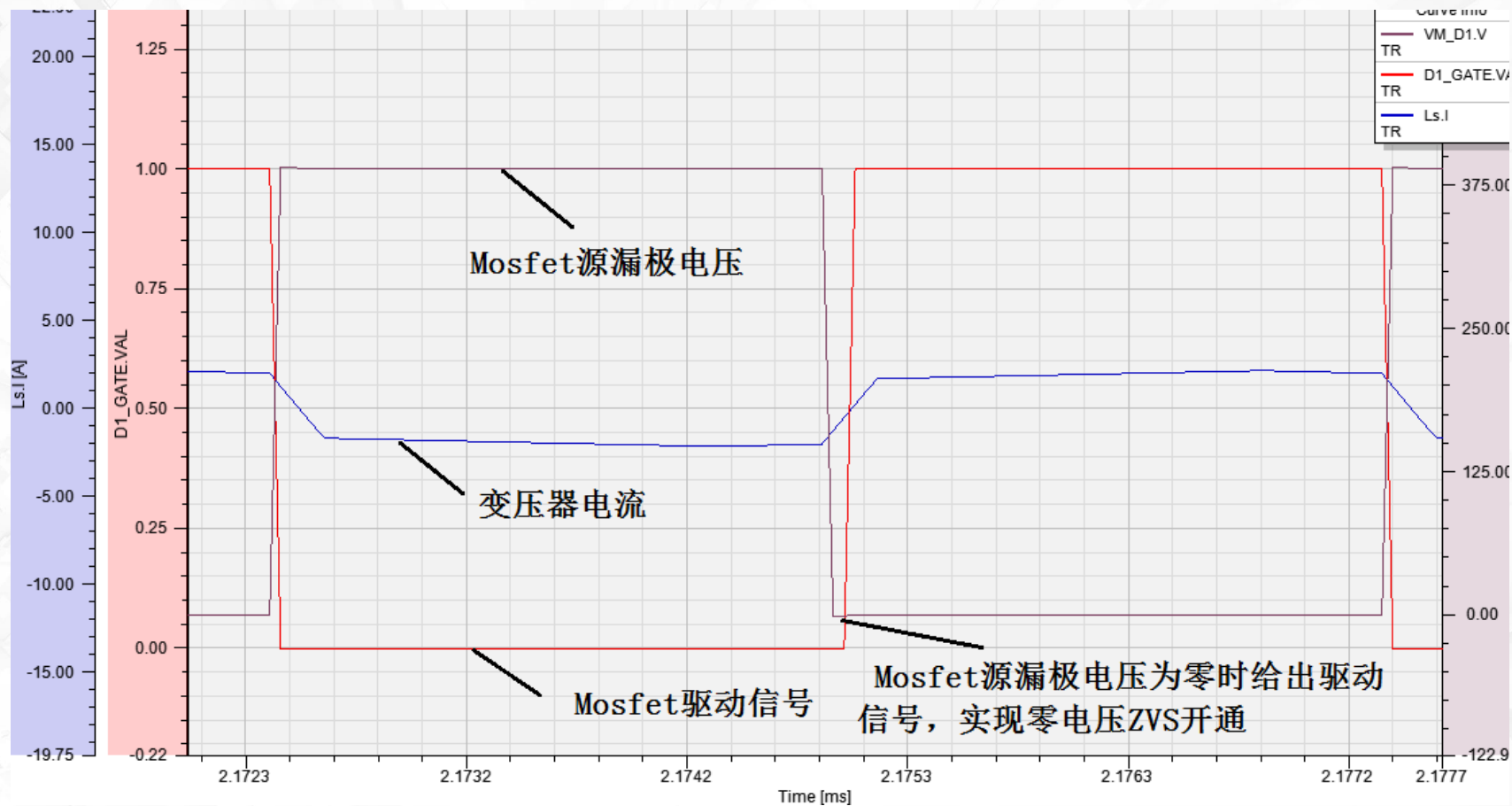
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 - PExprt设计移相全桥变换器变压器
- 总结

移相全桥工作原理-通过电容电感的谐振实现开关管零电压开通



复杂的移相全桥变换器仿真设计对仿真软件和工程师设计水平要求高

移相全桥工作原理-通过电容电感的谐振实现开关管零电压开通



复杂的移相全桥变换器仿真设计对仿真软件和工程师设计水平要求高

移相全桥工作变换器优点和难点

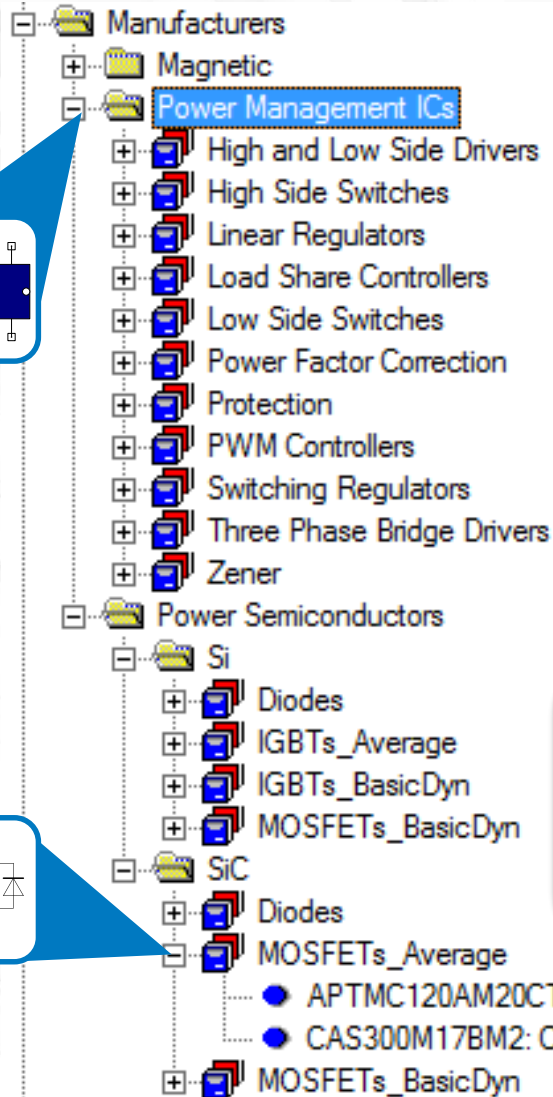
- 优点

- 软开关 (ZVS)
- 开关频率高
- 电源模块转换效率高
- 低EMI/EMC问题

- 难点

- 硬件设计，因为谐振的需要，对变压器的原边漏感需要精确设计
- 对电源主控芯片性能要求高
- 对工程师设计水平要求高，仿真保证设计成功

More Devices in Manufacturers Library R18



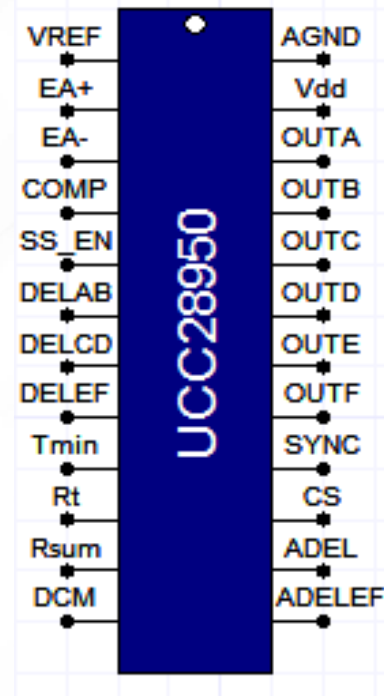
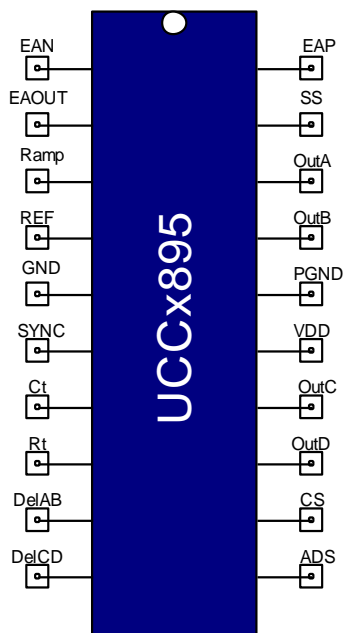
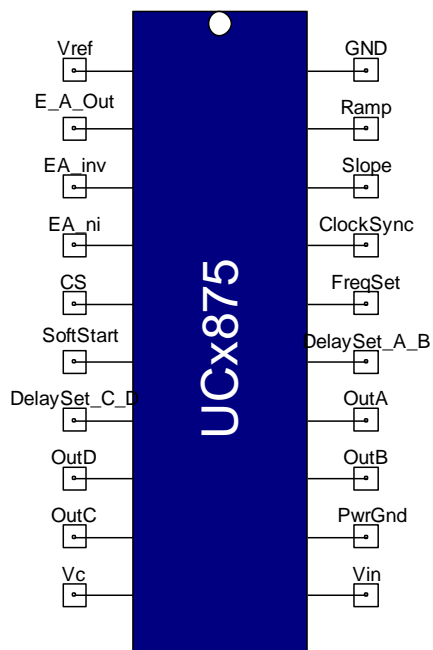
New Power Management ICs from



New SiC Average MOSFET devices from

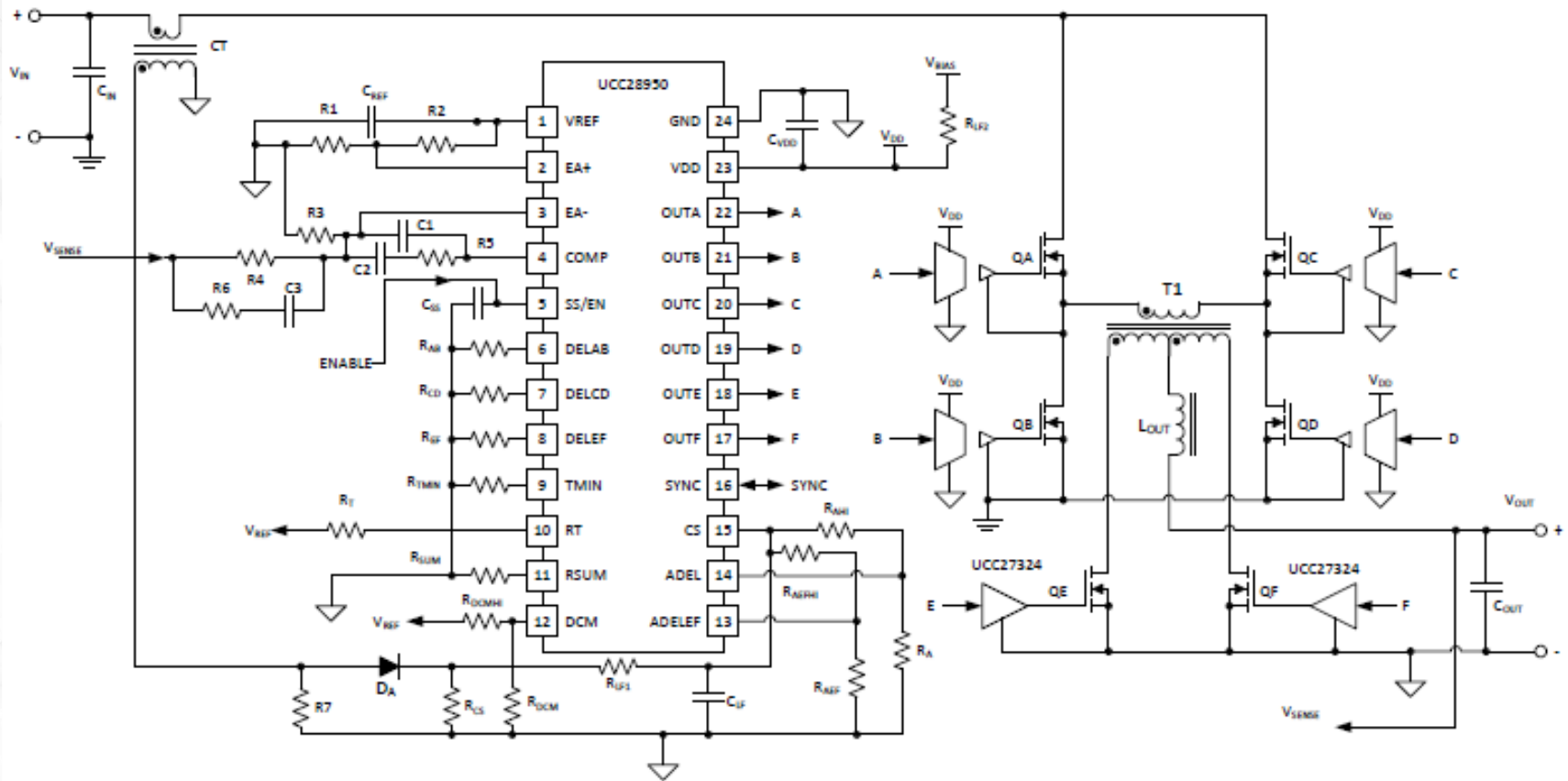


Simplorer R18中可实现移相全桥变换器的IC

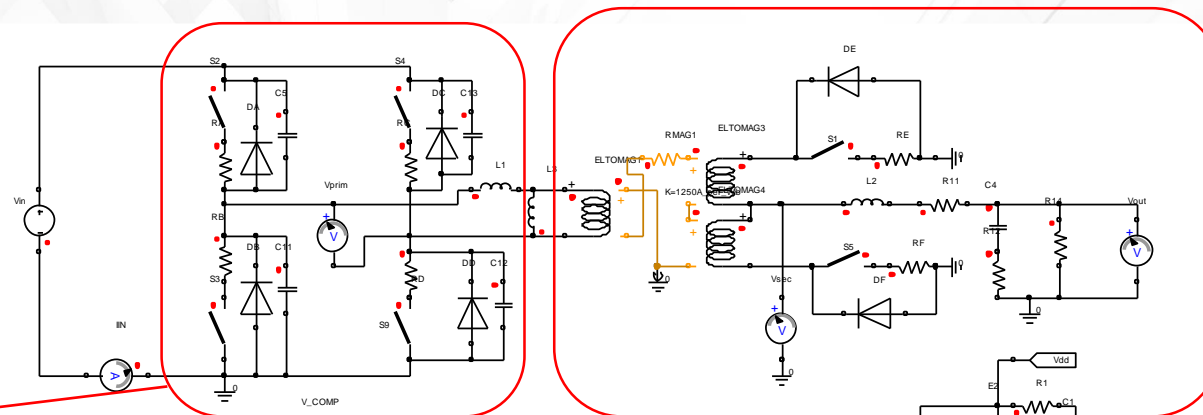


UCC28950是TI公司进一步改进的移相全桥控制IC,功能更为强大

Ti 公司UCC28950移相全桥典型解决方案

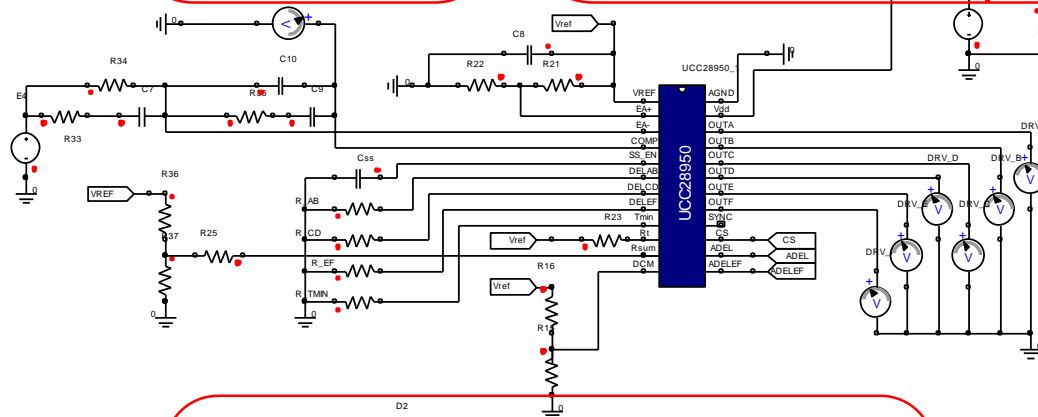


ANSYS公司UCC28950移相全桥解决方案

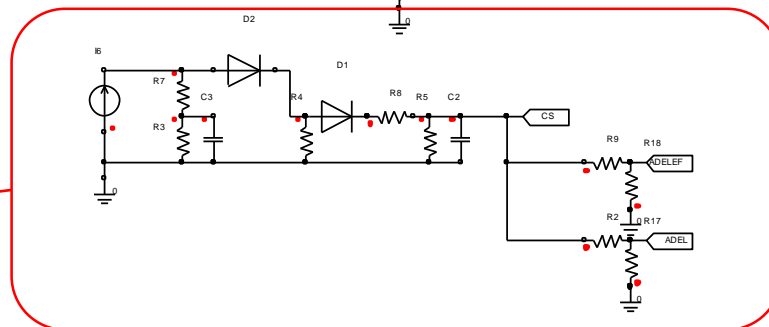


全桥电路

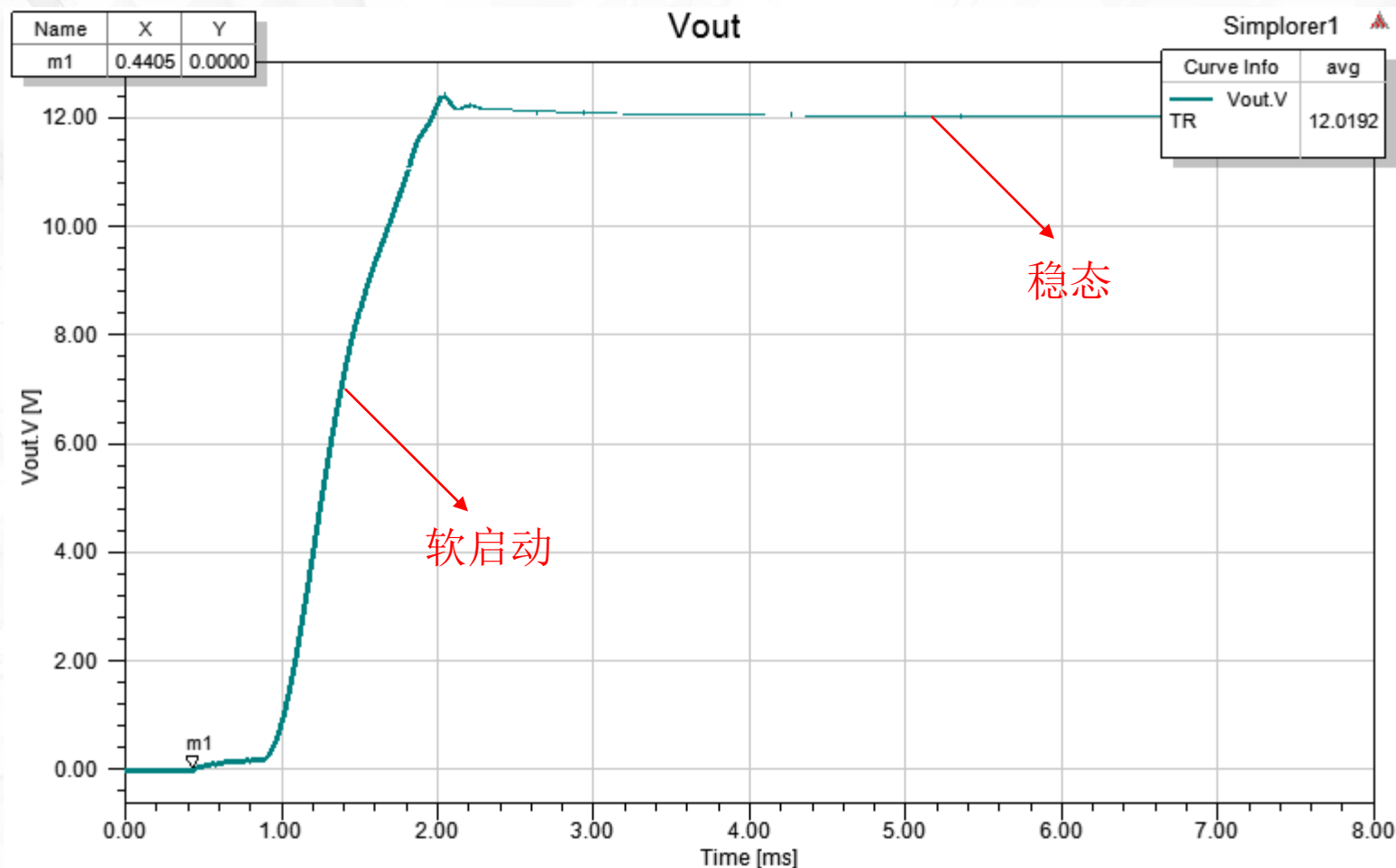
变压器及副边整流



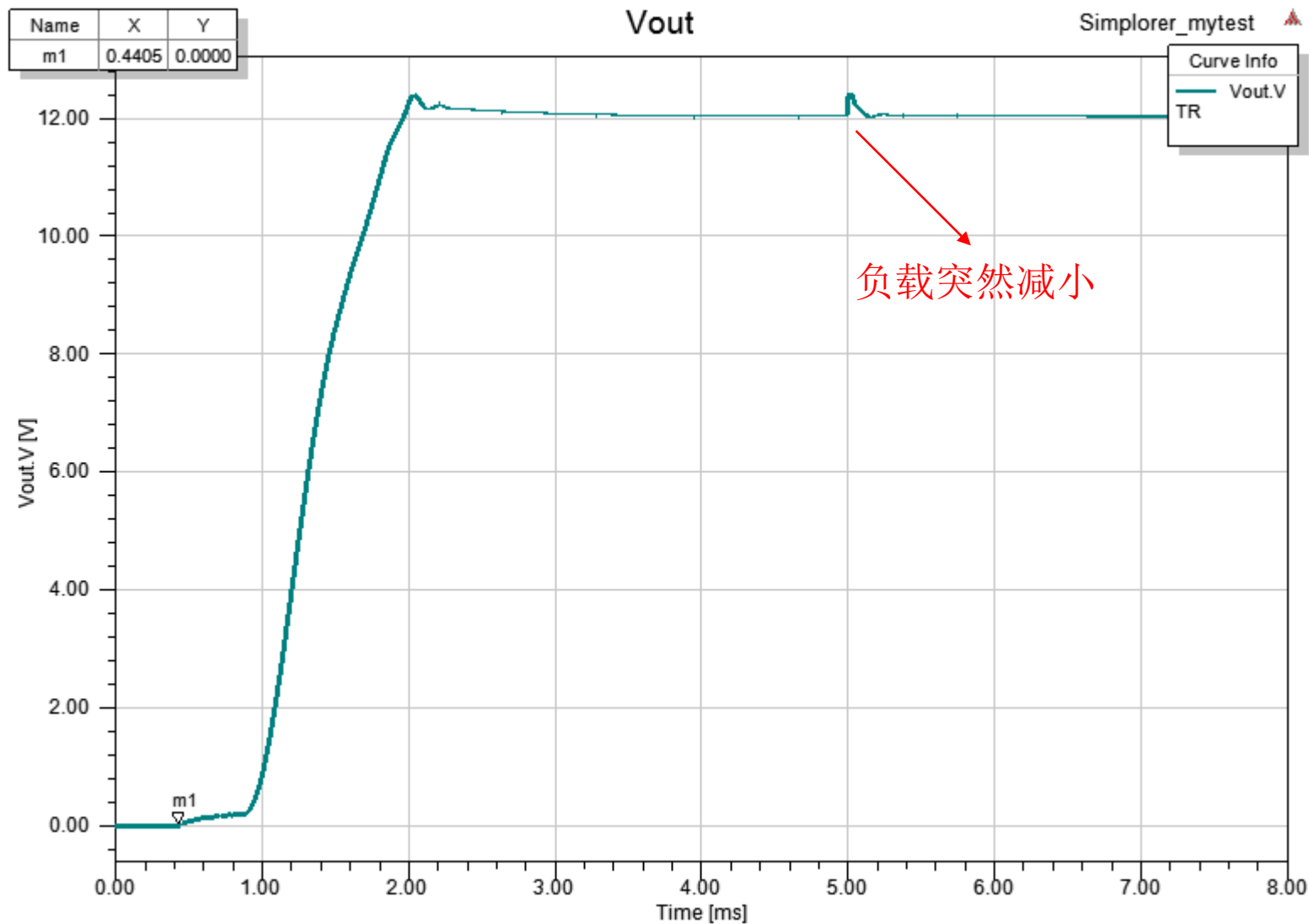
输入电流检测



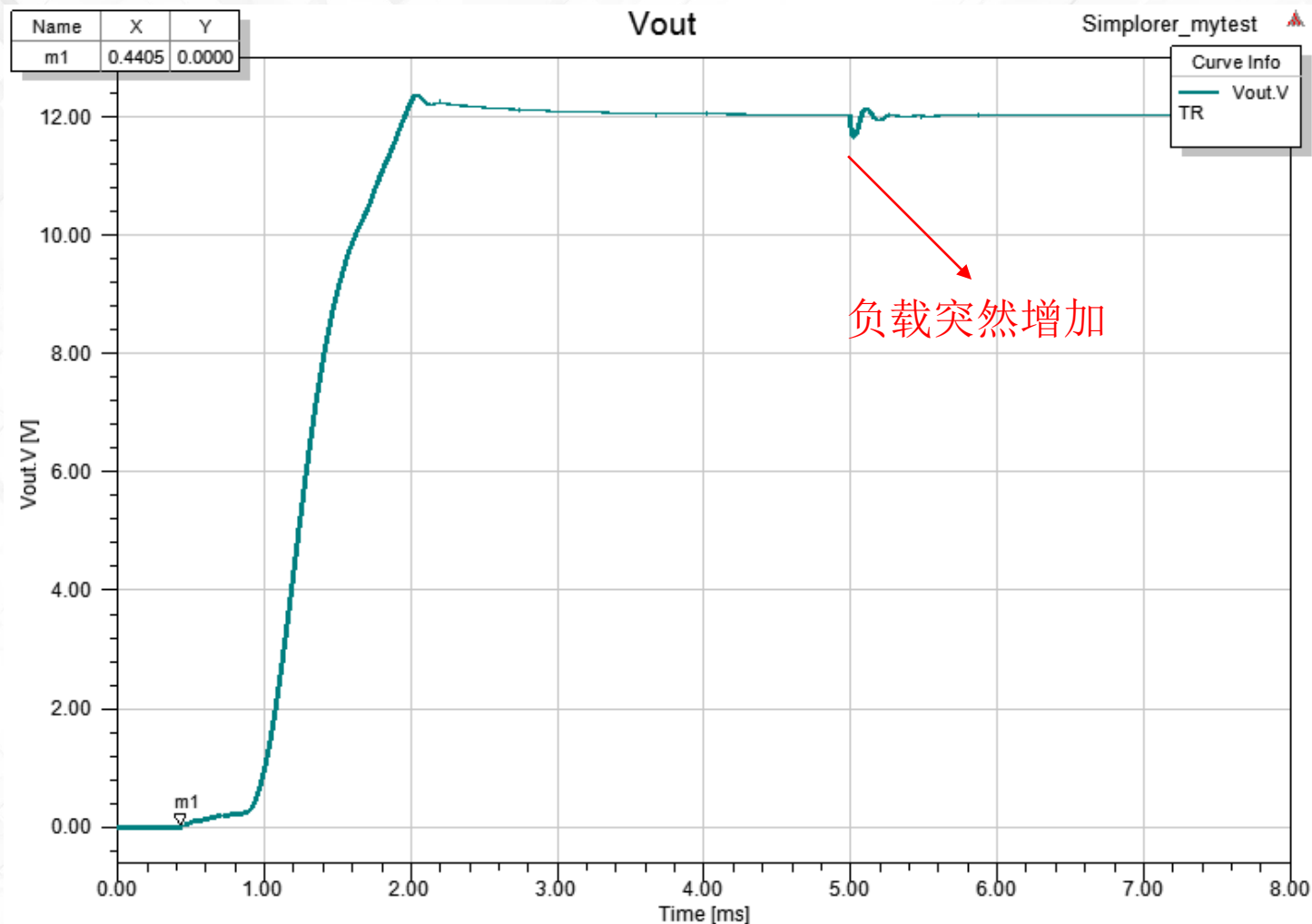
UCC28950移相全桥变换器输出电压



UCC28950移相全桥变换器输出电压



UCC28950移相全桥变换器输出电压



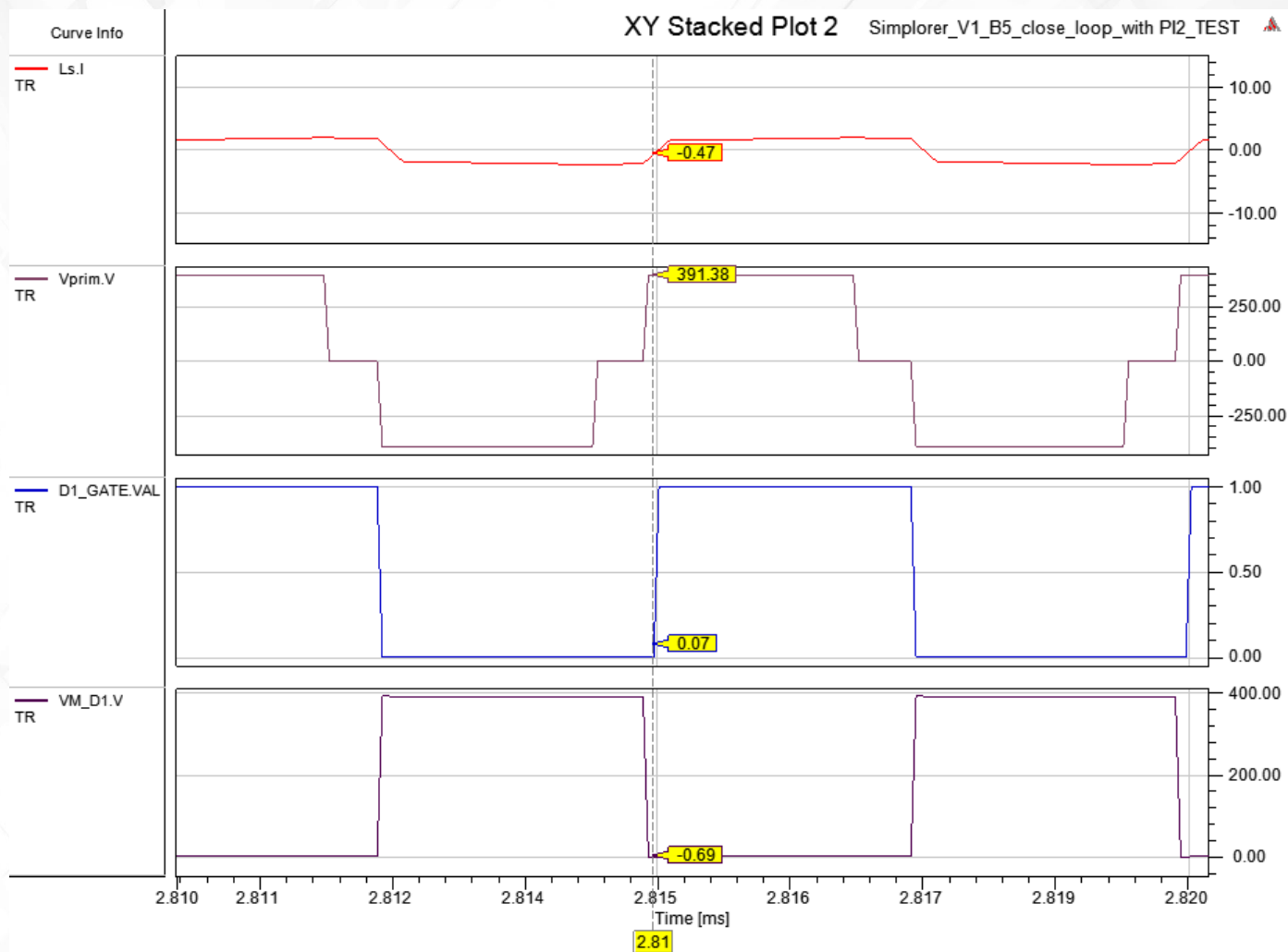
UCC28950移相全桥变换器关键信号波形

变压器原边电流

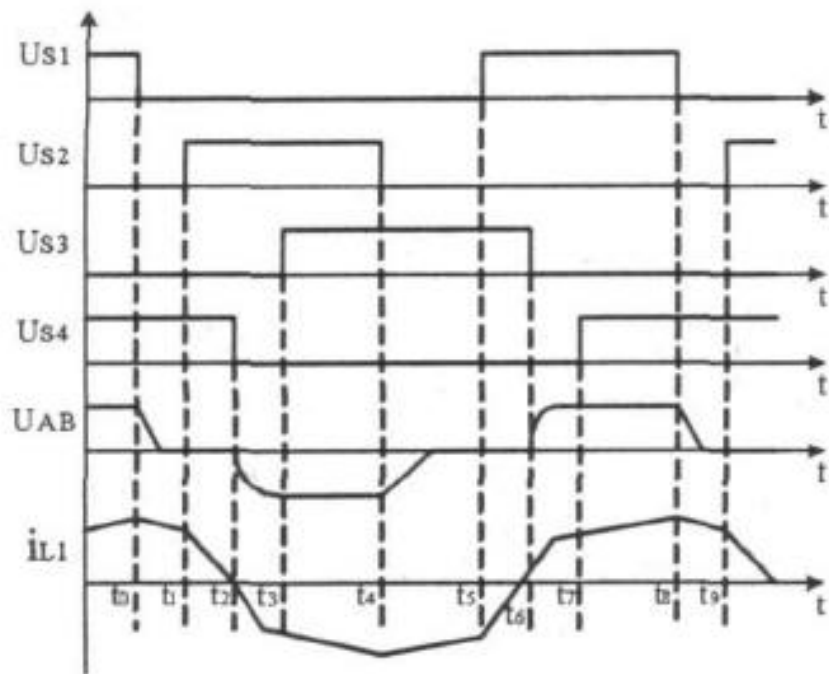
变压器原边电压

Mosfet1驱动信号

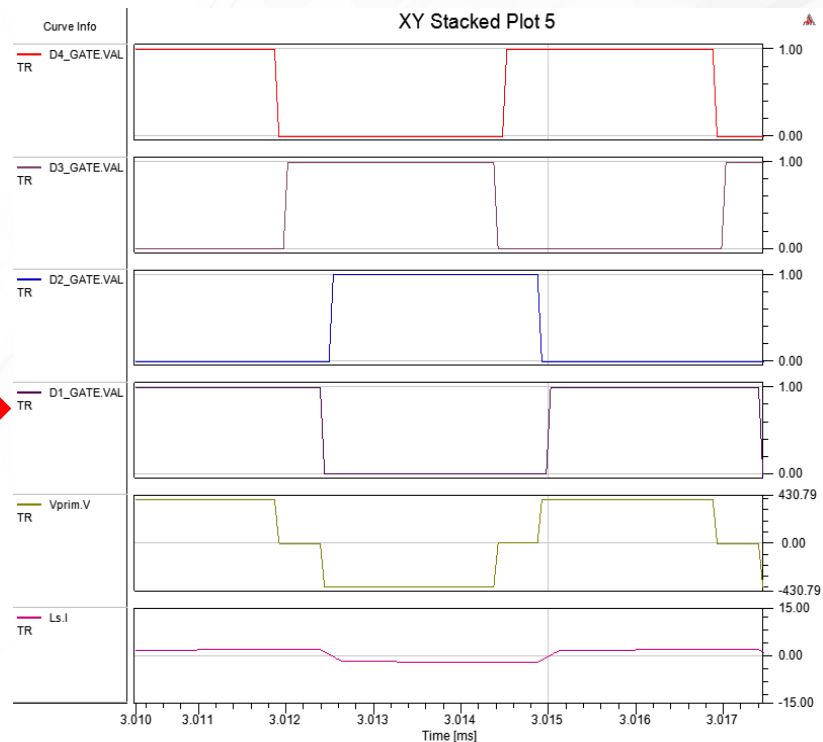
Mosfet1源漏电压



UCC28950移相全桥变换器关键信号波形

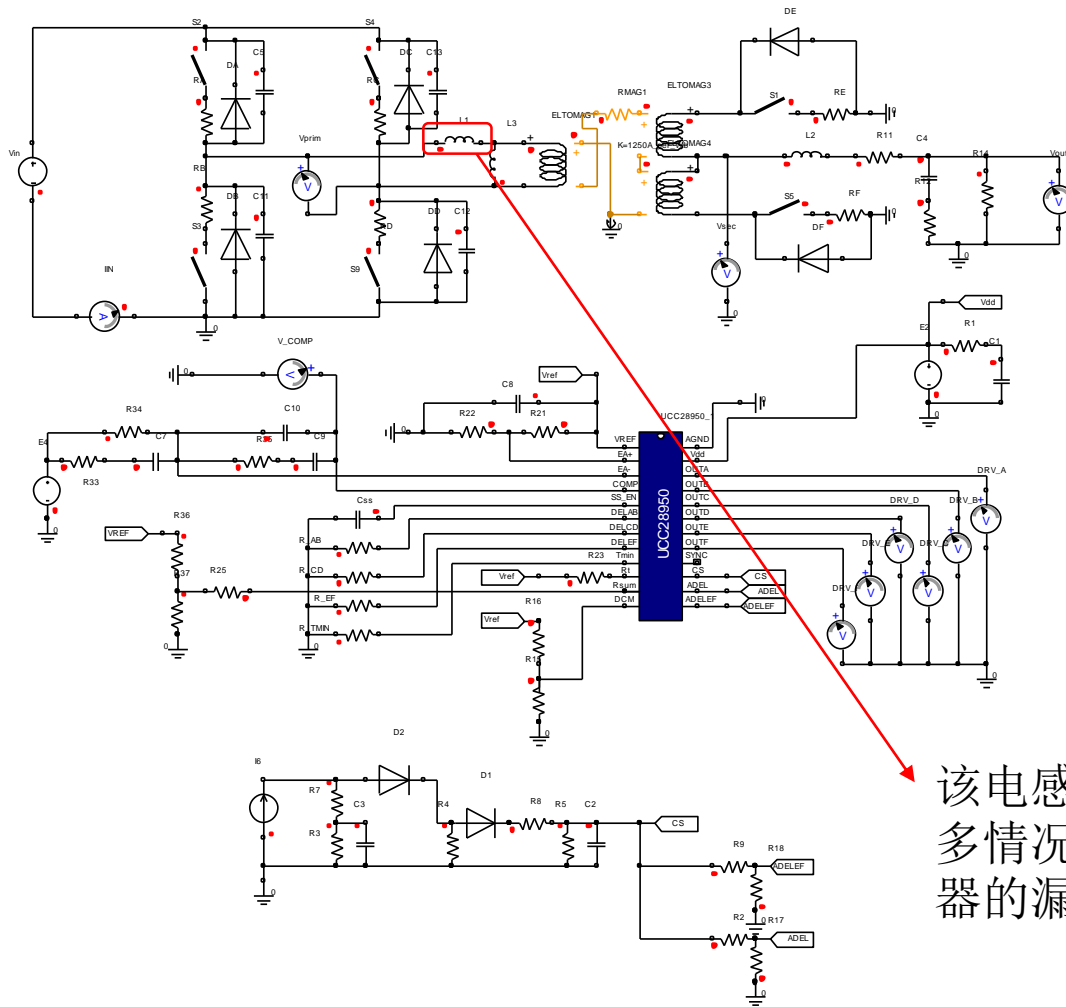


文献波形



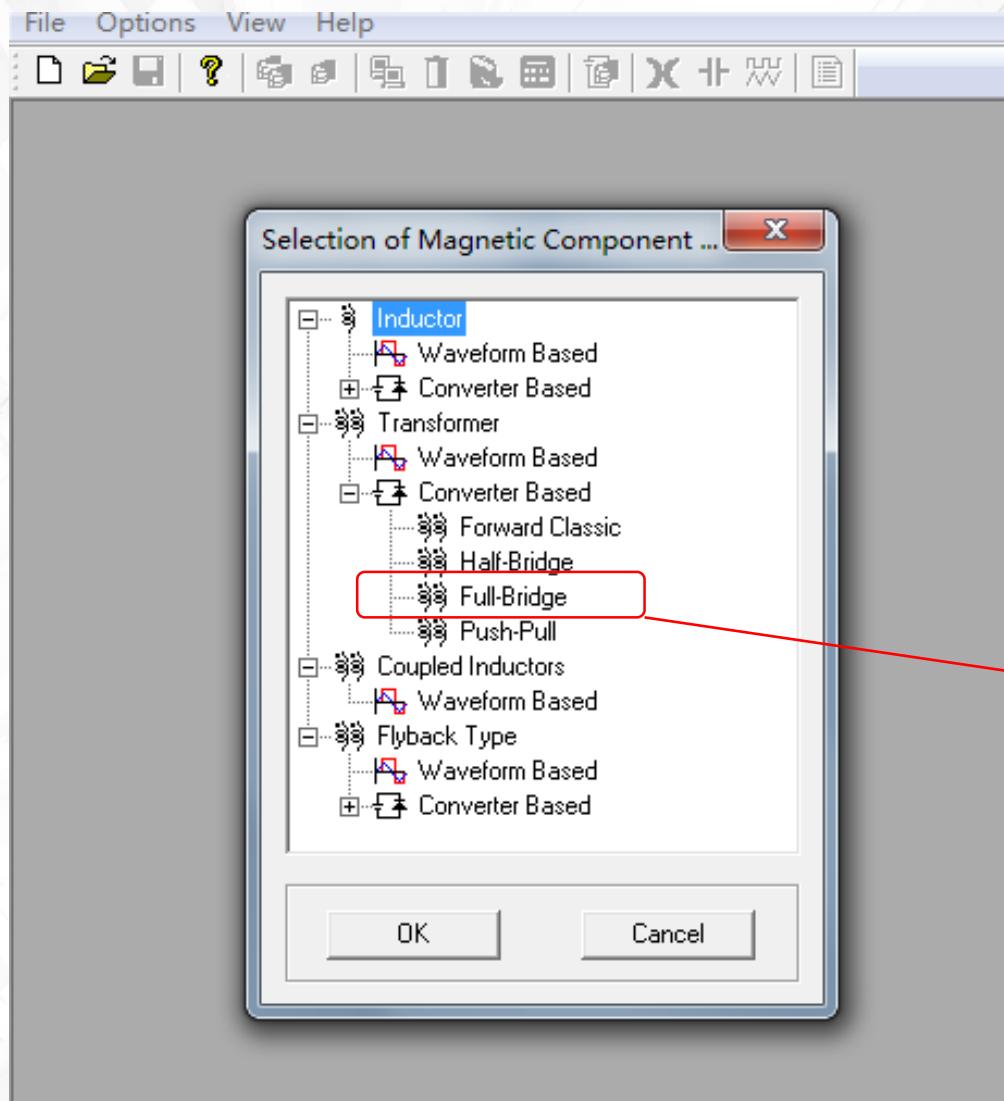
仿真波形

ANSYS UCC28950移相全桥变换器



该电感值非常重要，很多情况下是直接用电感器的漏感

UCC28950移相全桥变换器变压器设计-PExpert



选定全桥变
压器类型

UCC28950移相全桥变换器变压器设计-PExprt

Property

Property	Value

File Libraries Calculations Modeler Reports FEA Link Options View Window Help

Waveforms Design Inputs Modeling Options

Input Voltage: 380 V

Switching Frequency: 100 kHz

Output Values: Voltage: 12 V, Current: 4.0, Power: 50 W, Load: 2.8, Current ripple (%): 0

Select Waveform: Primary Winding, Secondary Winding

Ratios: Primary: 95, Secondary: 6

Output/Input Definition: Duty Cycle (0.25), Turns Ratio (n2/n1)

Average Current: Primary: 65, Secondary: 2

Design Library

- AVX
- Electrical steel
- Epcos
- Ferroxcube
- Magnetics
- Metglas
- Micrometals
- Steward
- TDK
- Design Library
 - Ferroxcube_Design
 - EE
 - EFD
 - EI
 - EP
 - ETD
 - POT
 - PQ
 - RM
 - UI

指定设计库

指定变换器电气参数

PExprt ? Version 2017.0.0. ? 2017 Universidad Politecnica de Madrid (UPM) and SAS IP, Inc.

UCC28950移相全桥变换器变压器设计-PExpert

Designing Magnetic Component

Core Size 10/17
RM10/I

Core Material 3/3
3C94

Wire 33/49
AWG30

Global Process

Number of Components
Analyzed: 1547
Rejected: 888
Valid: 659

Abort

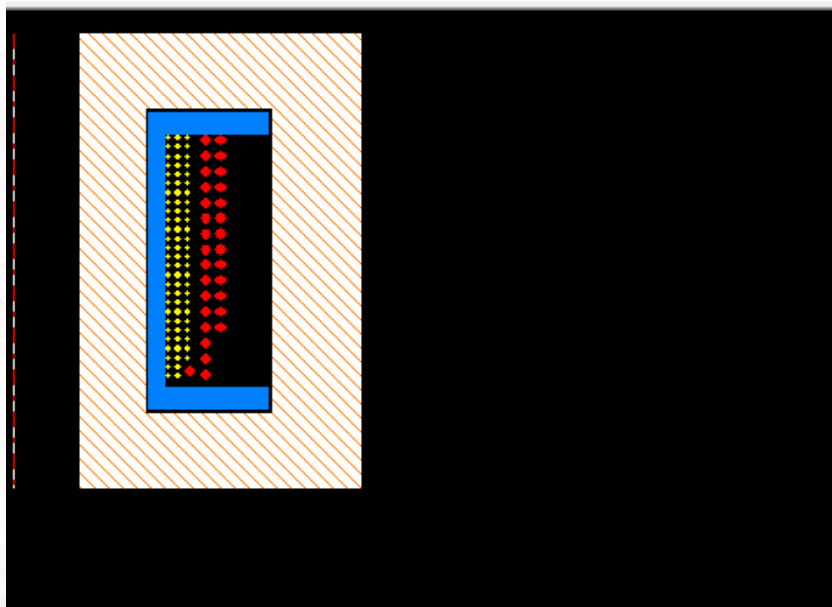
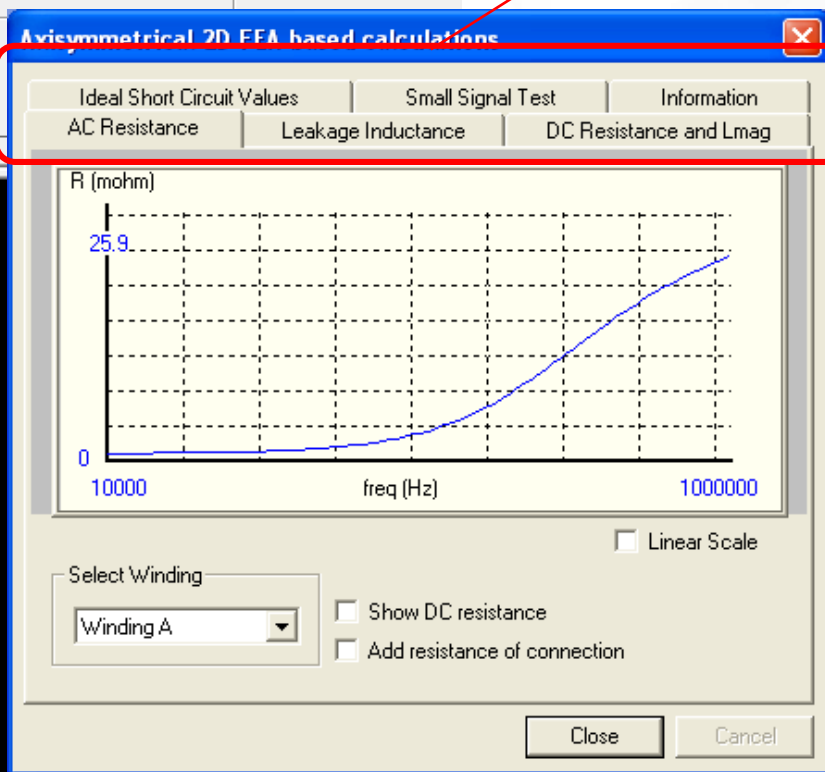
根据变换器
电气参数自
动设计

UCC28950移相全桥变换器变压器设计-PExprt

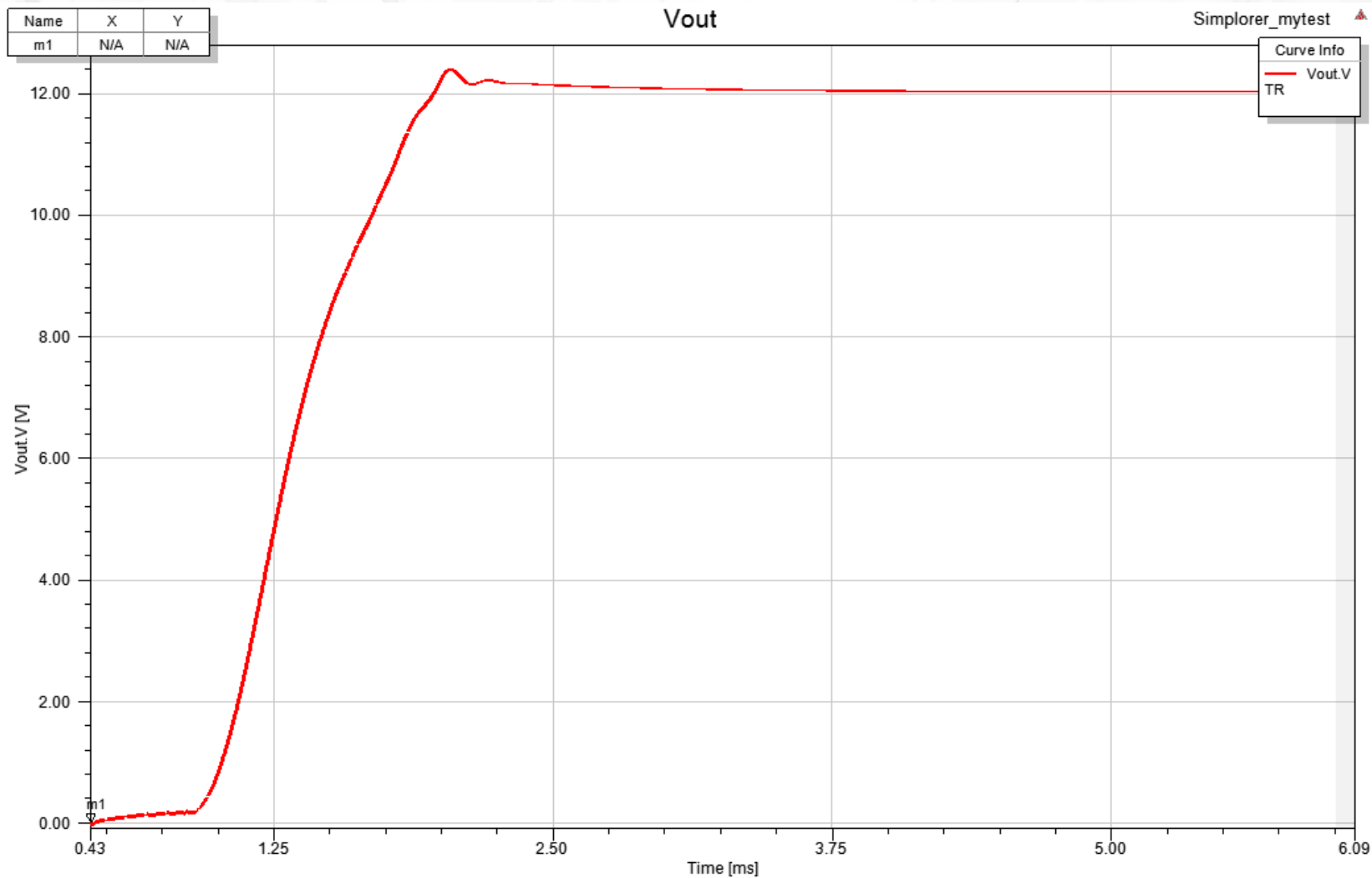
Waveforms | Design Inputs | Modeling Options | Constructive Results | Performance Results | List of Results 1

Component		Windings	
Core Size:	RM10	Winding 1	
Bobbin:	RM10	Wire:	AWG30
Core Material:	3C94	Number of Turns:	79
Library:	Ferrocube_Design	Parallel Turns:	1

包含漏感的变
压器详细参数



PExprt设计的变压器代替理想变压器



内容提要

- **Simplorer用于定制化高级建模方法**
 - Simplorer建模平台概述
 - Simplorer基本库模型应用
 - Simplorer基本库模型定制化高级应用模型（以脉冲功率负载为例）
- **Simplorer用于高新能开关电源仿真**
 - 移相全桥电源变换器原理
 - Simplorer R18中实现移相全桥电源变换器方法
 - PExprt设计移相全桥变换器变压器
- **总结**

总结

- Simplorer基本模型库丰富
- 可利用Simplorer基本模型定制化高级模型，并可打包加入Personal Libraries重复使用
- Simplorer可以方便实现复杂移相全桥变换器的仿真设计
- PExprt可设计考虑原边漏感的移相全桥变换器，并集合Simplorer进行仿真分析

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