Ansys
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2020

平面变压器设计与仿真

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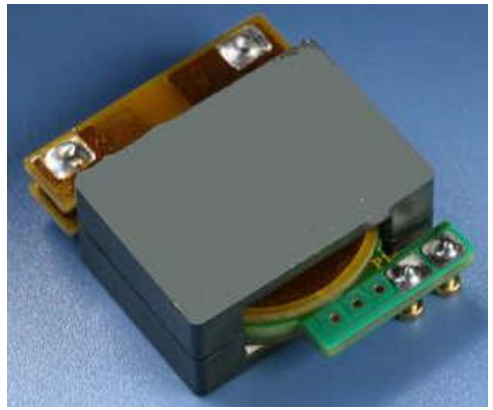
行业与产品概述

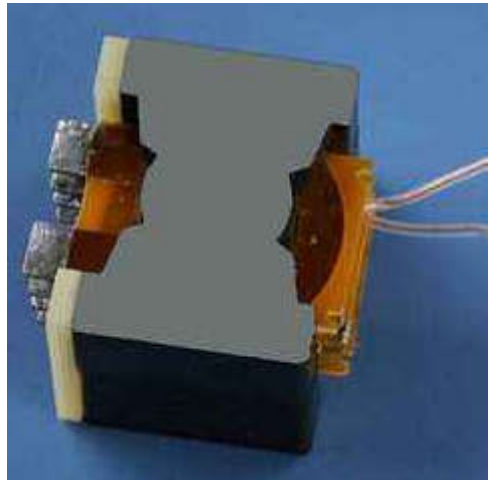
- 行业背景

  通讯及伺服控制领域广泛使用模块电源，产品微型化设计对变压器提出了更严格的要求，如小尺寸、低剖面、大输出电流、小电磁辐射。传统变压器已经成为制约开关电源技术进一步发展的一个重要因素。

- 产品特点

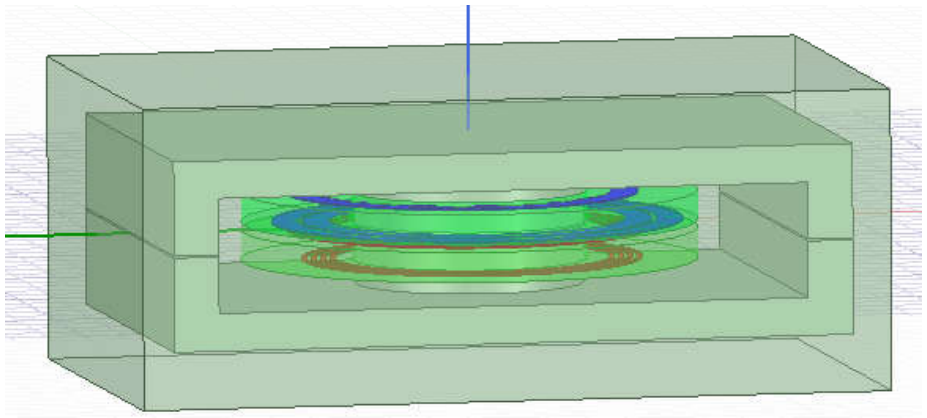
  平面变压器由于体积小，工作频率高，高频寄生参数得到了很大的降低，近年来在开关电源中得到了广泛应用。其中PCB型平面变压器可以省去绕组骨架，电流密度最高可达20A/mm，功率大、工艺简单。随着电子、信息技术向微型化发展的趋势，未来平面变压器必然成为变压器、变流器、电感器的首选。

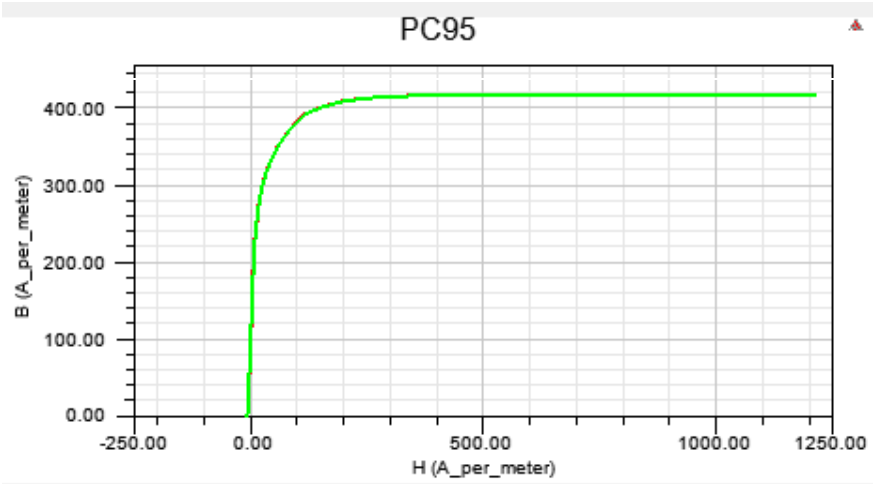




仿真需求分析

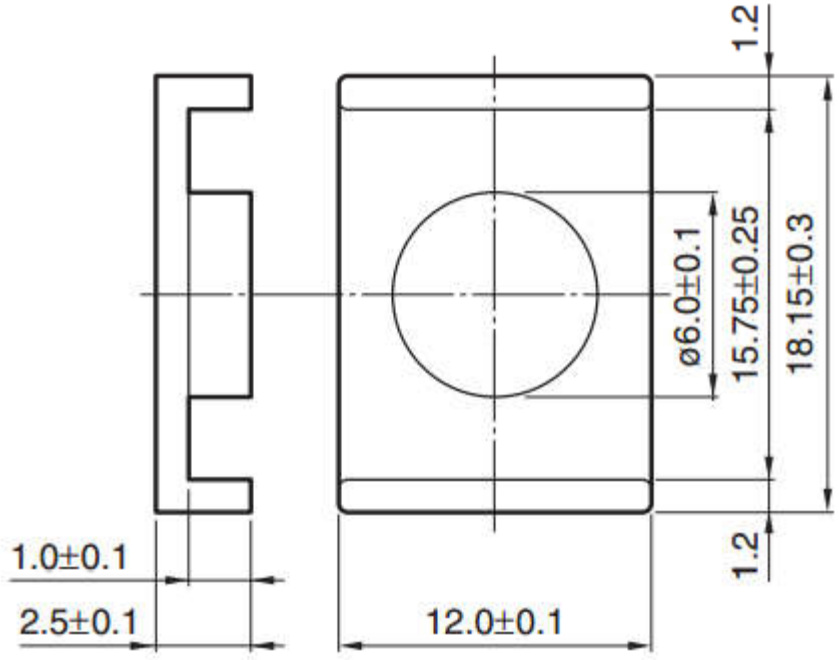
- 设计中的关键问题
  - PCB绕组有不同的简化方式，不同模型简化方式对等效漏感及温升计算精度有较大的影响。不合理的简化方式影响PCB绕组的布铜及对PCB及磁芯温升的评估并影响变压器设计的合理性。
- 仿真需求分析
  - 利用Maxwell计算各个绕组的欧姆损耗，铁心损耗，初级等效漏感及各绕组等效电阻，评估PCB布铜的合理性
  - 利用Fluent或Icepack计算绕组的温升及磁芯的运行温度，根据温度分布及最高温升点评估温度安全裕度。



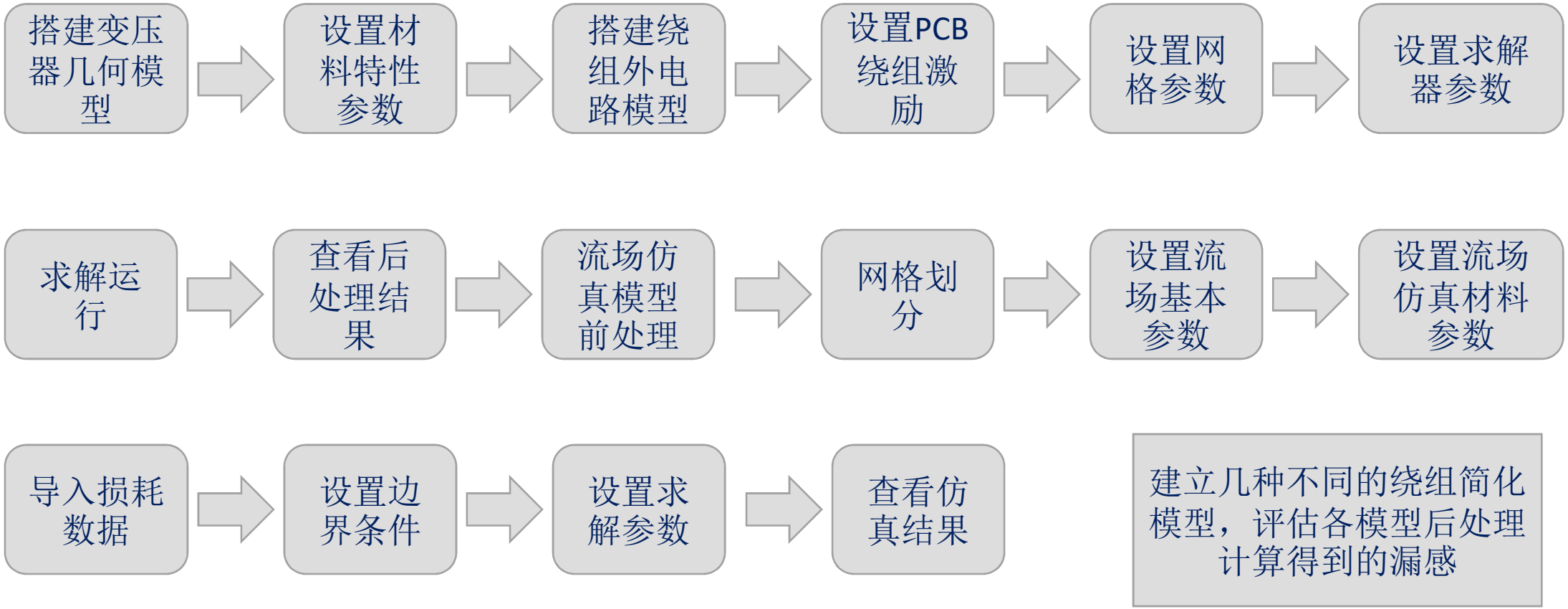


仿真需要具备的条件

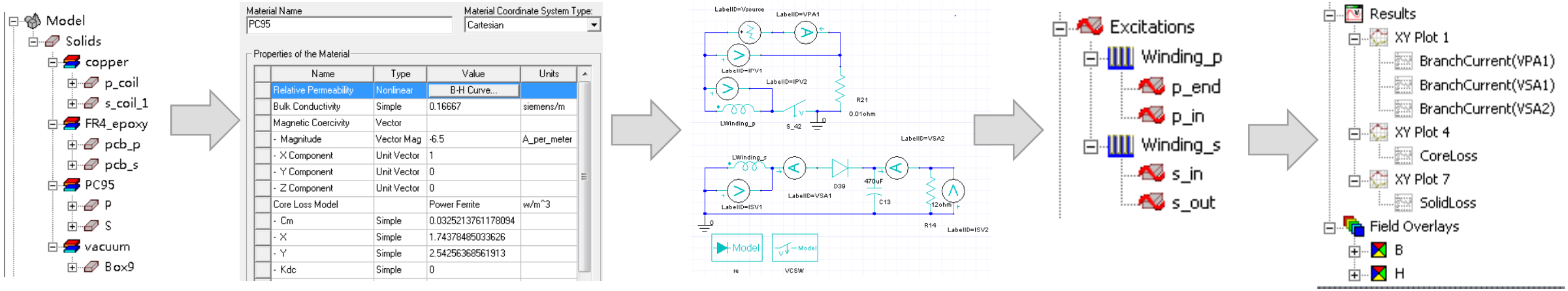
- 模型或数据
  - 磁芯尺寸及PCB绕组匝数、布铜位置及覆铜厚度等模型尺寸数据
- 参数与条件
  - 反激电路参数
  - 磁芯的材料性能数据，包括BH曲线、BP曲线、导热系数
- 软件与硬件
  - Ansys Maxwell及Fluent或Icepack、32核、64G内存图形工作站
- 其他准备
  - 印制电路板生产商为设计提供可制造性方面的评估

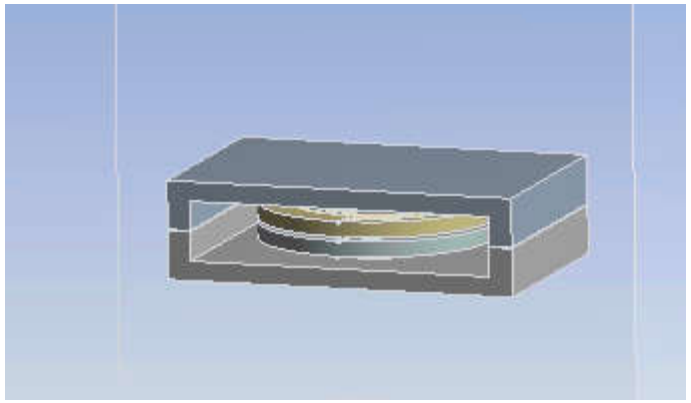


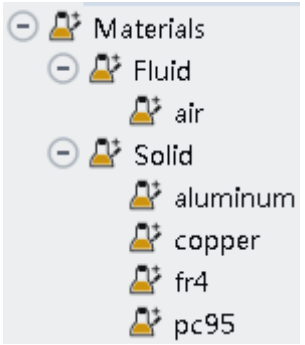
仿真设计过程简述



仿真设计过程简述

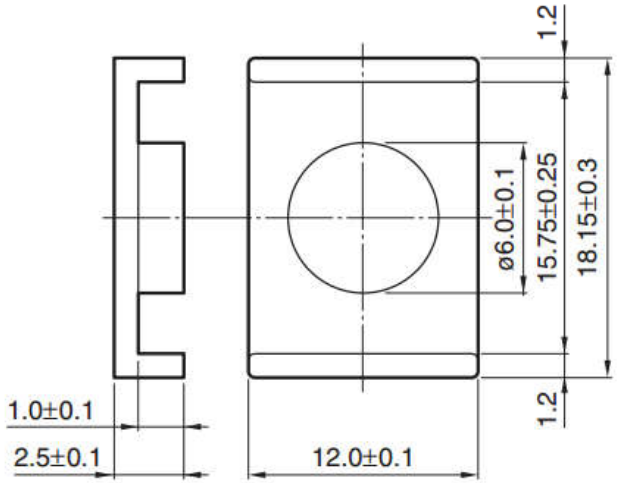




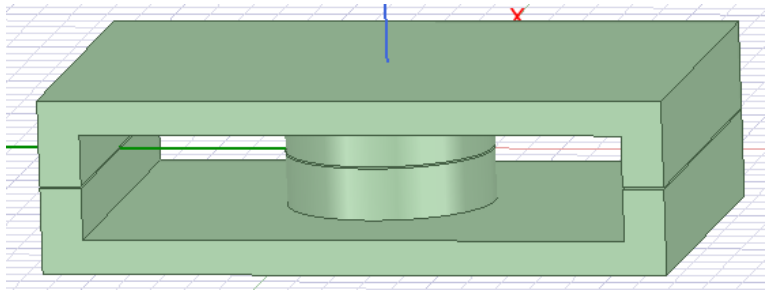


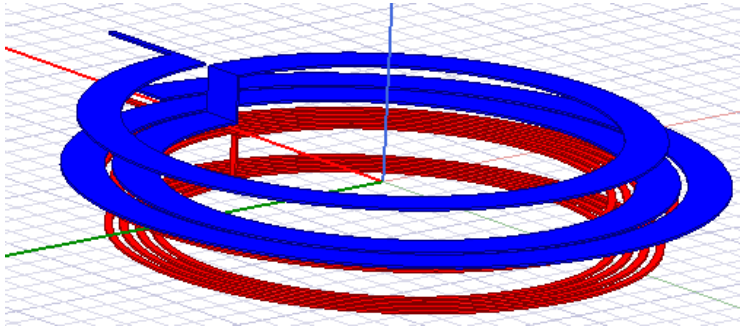
仿真设计过程详解

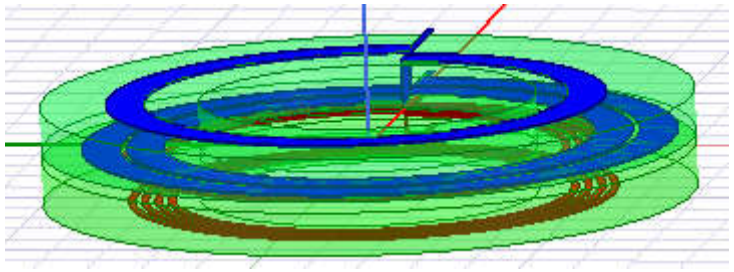
- 根据磁芯选型及实际PCB布板空间搭建模型，建立PCB详细模型，尽量还原实物模型。

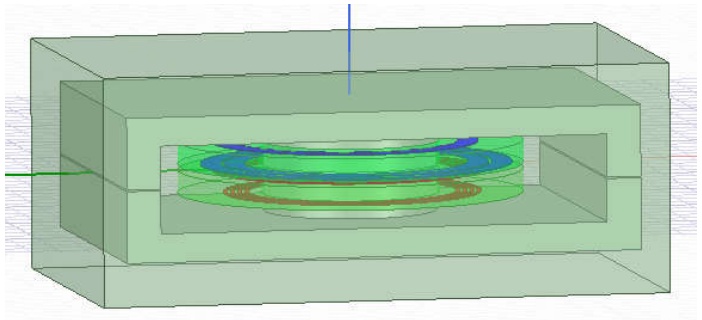


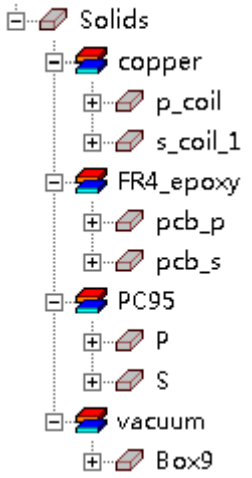
布板空间搭建模





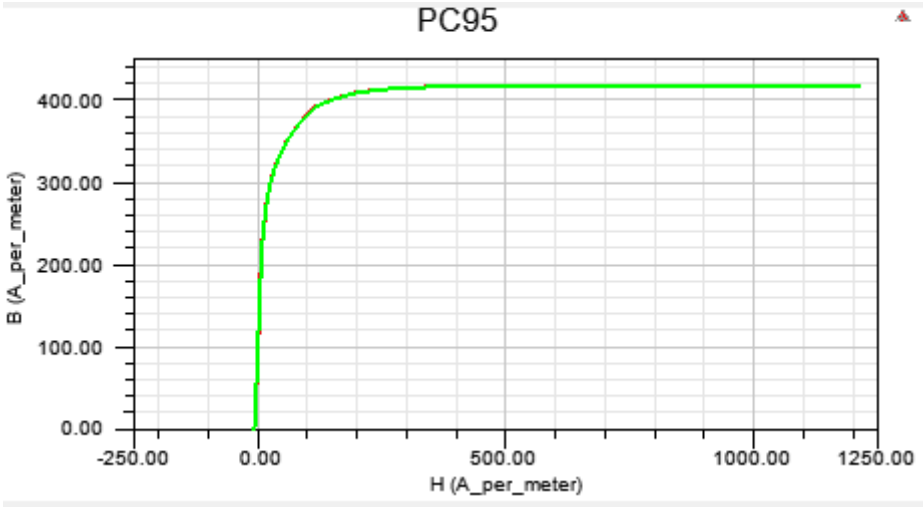






仿真设计过程详解

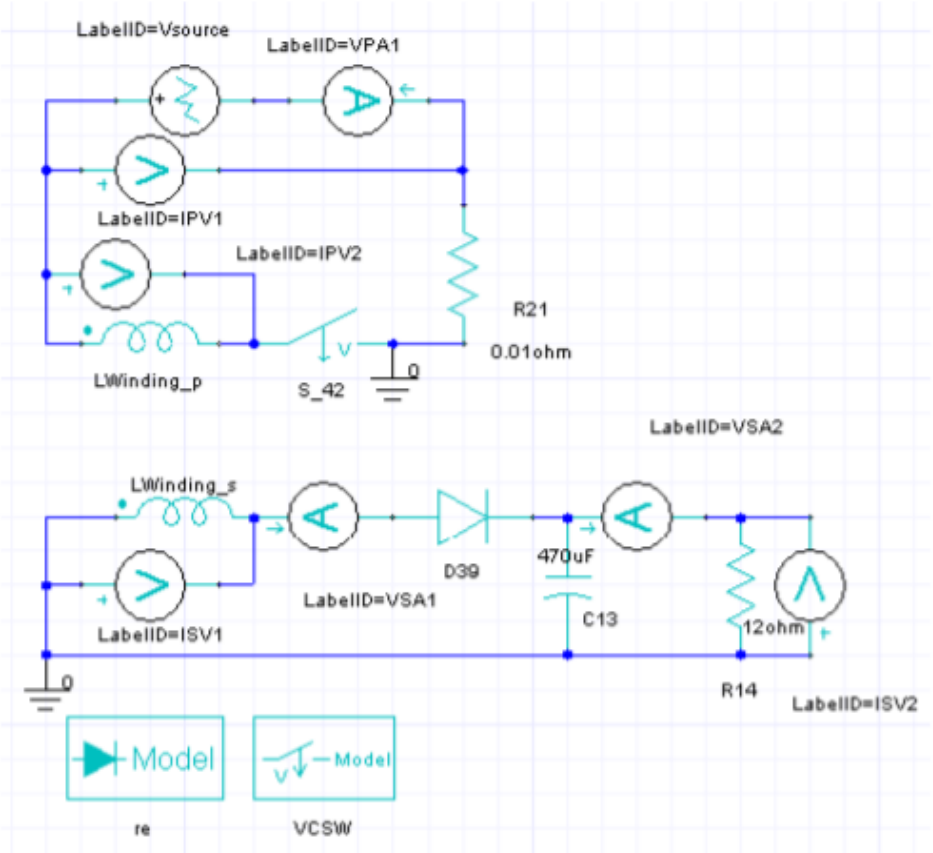
- 设置材料参数，包括BH、BP曲线。

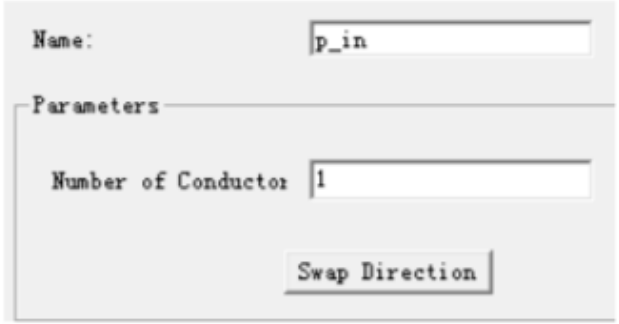


Core Loss Model		Power Ferrite	w/m^3
- Cm	Simple	0.0325213761178094	
- X	Simple	1.74378485033626	
- Y	Simple	2.54256368561913	
- Kdc	Simple	0	
- Equiv. Cut Depth	Simple	0.001	meter

仿真设计过程详解

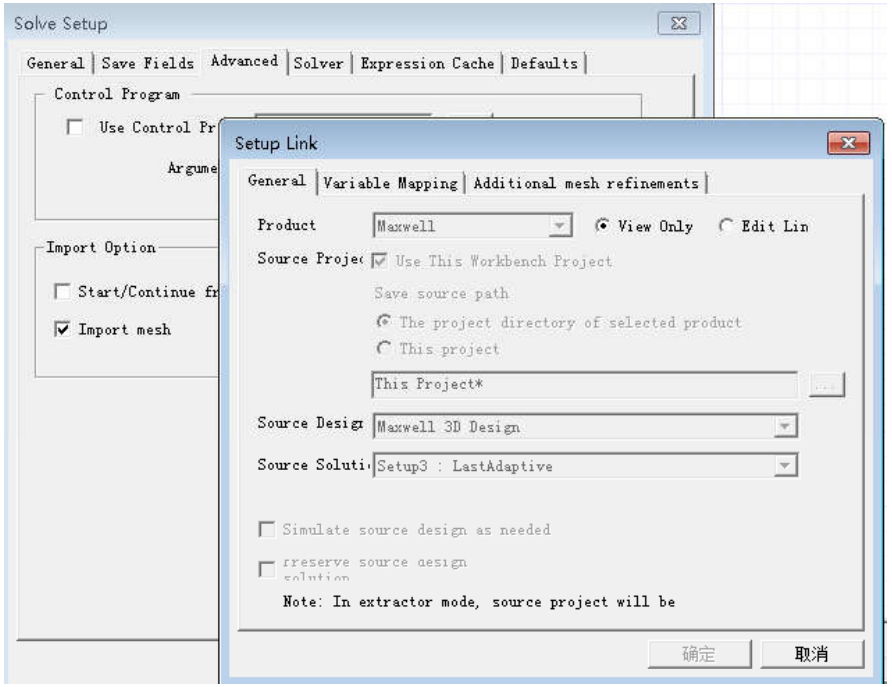
- 搭建PCB线圈的驱动电路外电路模型并设置绕组参数

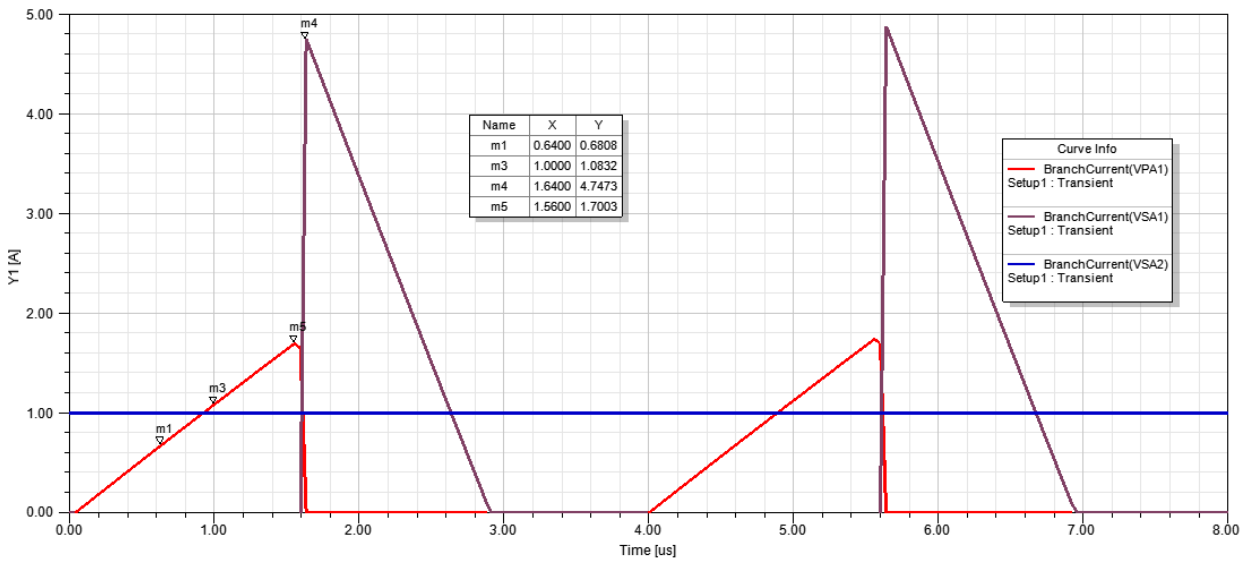




仿真设计过程详解

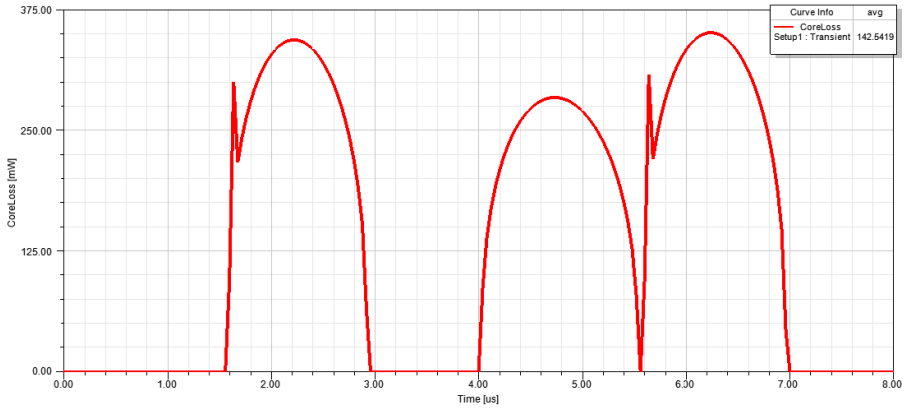
- 创建静态仿真模型并生成自适应网格，瞬态仿真导入静态仿真模型的自适应网格，查看电流波形，确保外电路的正确性。

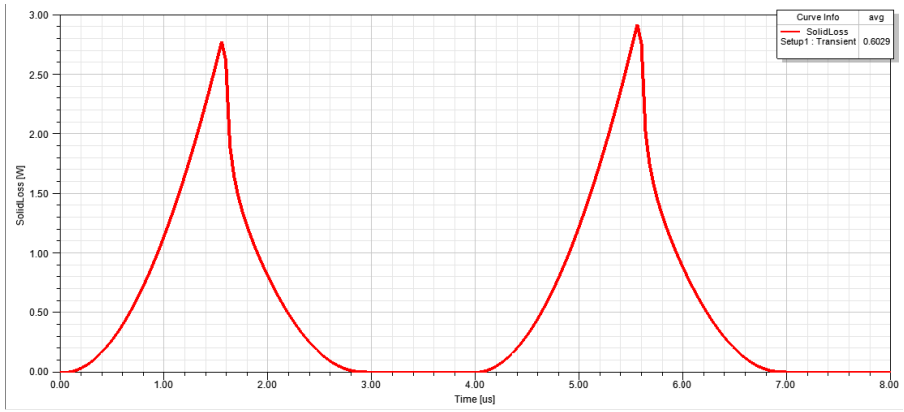


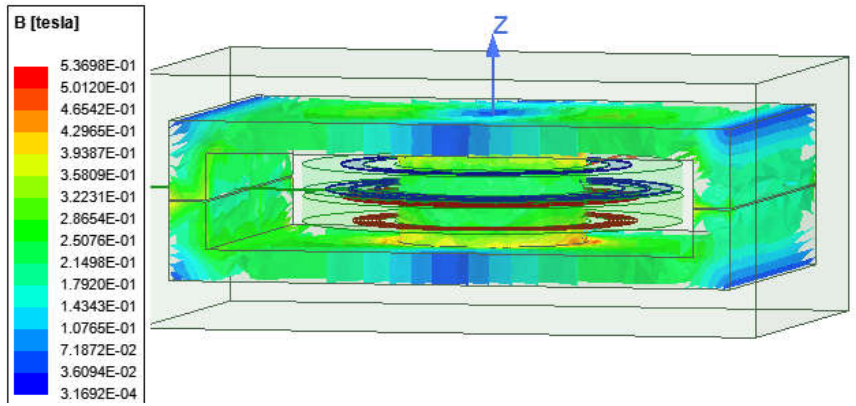


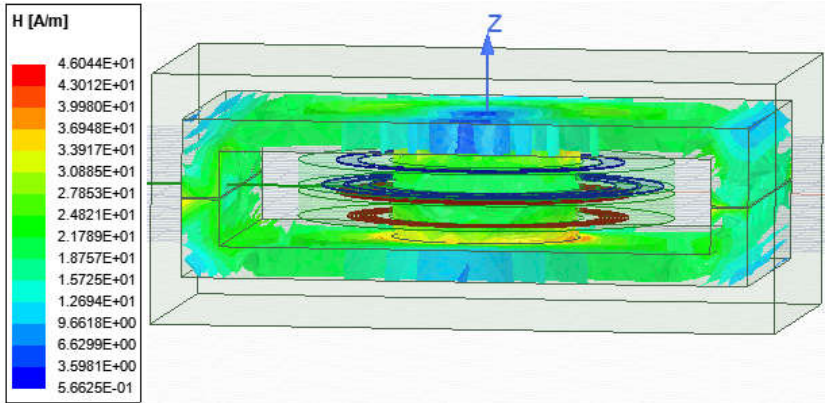
仿真设计结果

- 查看铁损曲线及铜损曲线并计算平均值、B及H云图



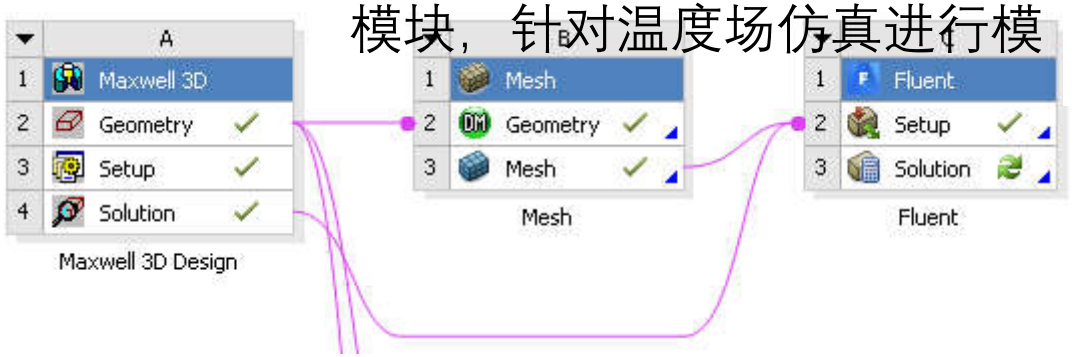


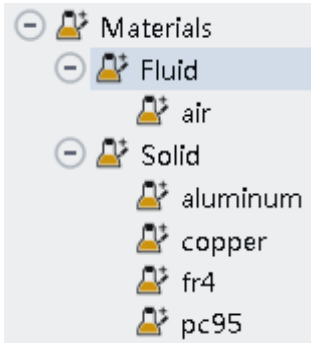


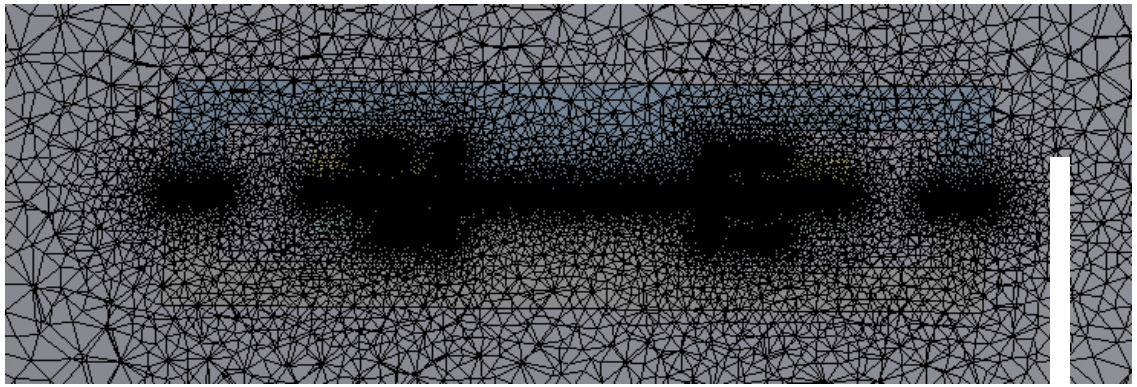


仿真设计过程详解

- 将模型导入Mesh模块，针对温度场仿真进行模型前处理并划分网格。

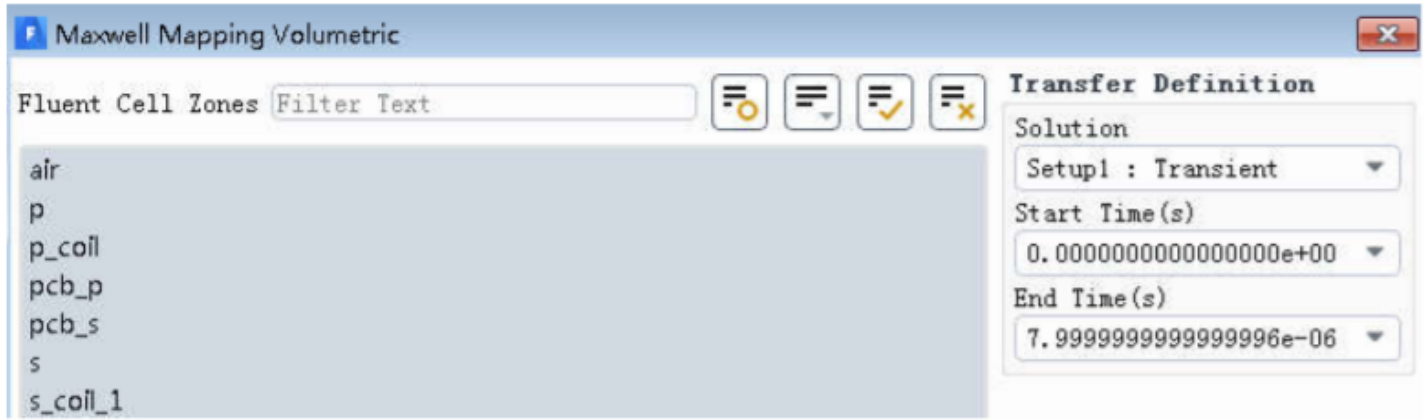






仿真设计过程详解

- 将Maxwell中的损耗数据通过EM Mapping导入到Fluent中。修改自然对流散热相关选项




```
  Fluent generated 'Input_to_Ansoft.xml' file successfully

  Launching D:\ProgramFiles\AnsysEM\AnsysEM19.3\Win64\ansysedt.exe ....
05/14/2020 18:01:19 [Info] Server started at ws://0.0.0.0:0 (actual port 55858)
Reading EM loss file "loss-data-t1"

     Total loss is :  7.4543e-01 (Watt)

     Total loss on zone    10 is  1.904e-01 (Watt)
     Total loss on zone     9 is  7.065e-02 (Watt)
     Total loss on zone    13 is  1.800e-03 (Watt)
     Total loss on zone    12 is  8.534e-03 (Watt)
     Total loss on zone    11 is  4.021e-01 (Watt)
     Total loss on zone     8 is  7.190e-02 (Watt)
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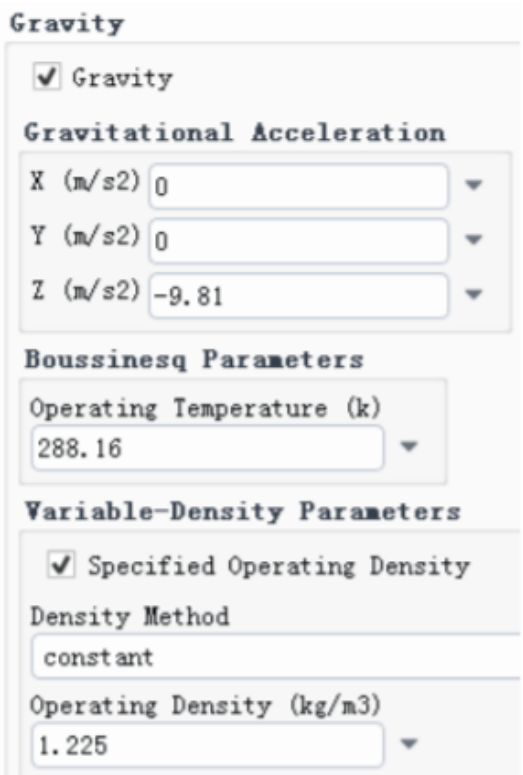
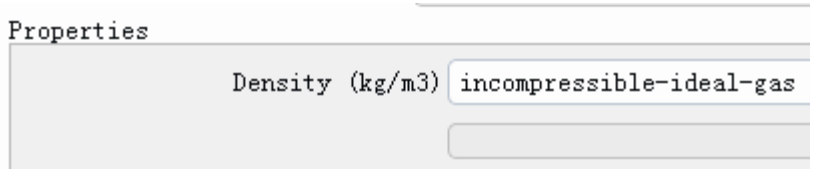
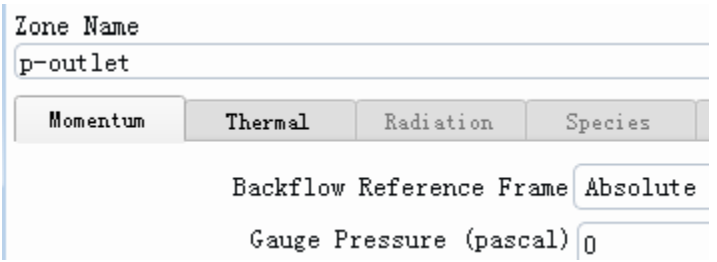
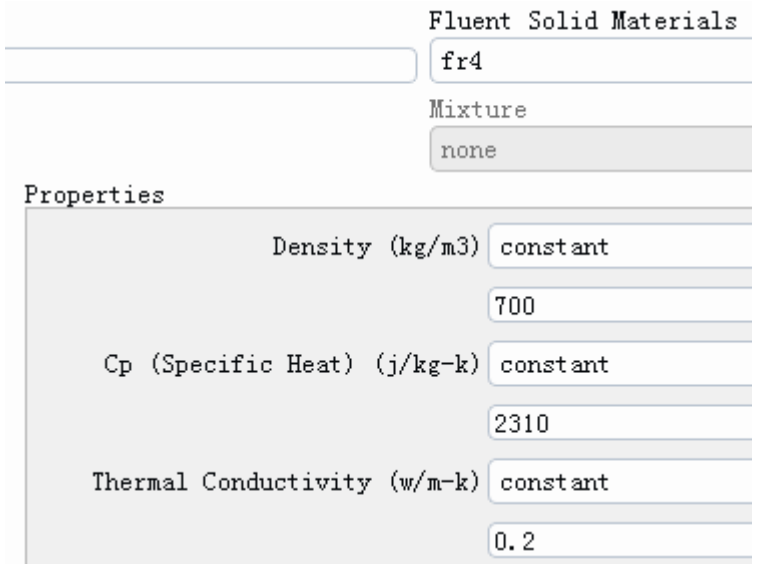


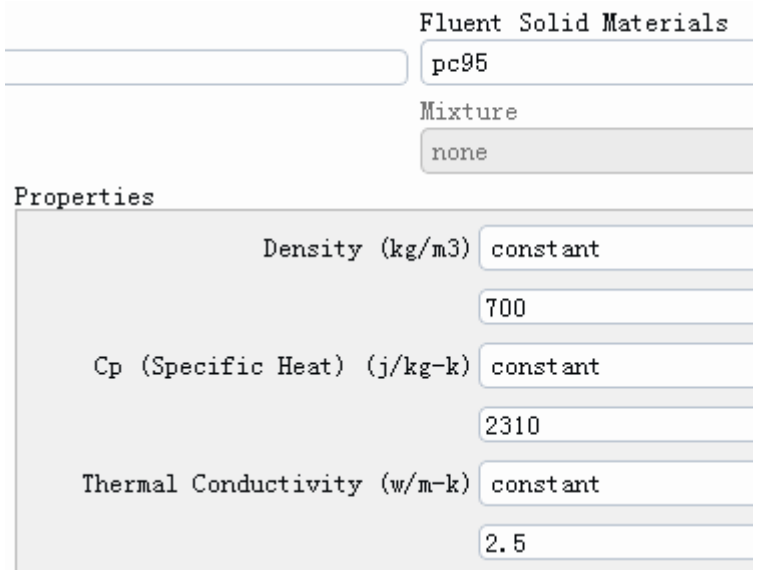
仿真设计过程详解

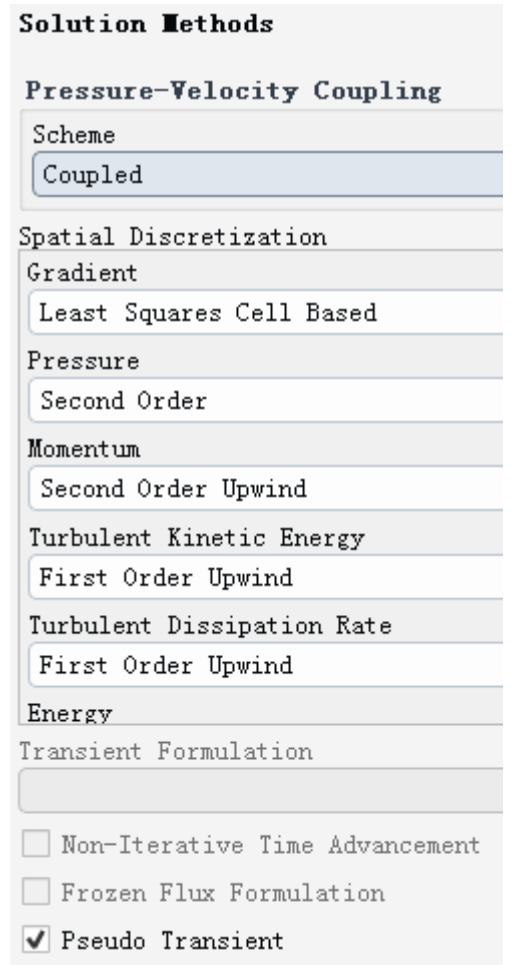
- 修改材料参数、边界条件及求解器相关选项





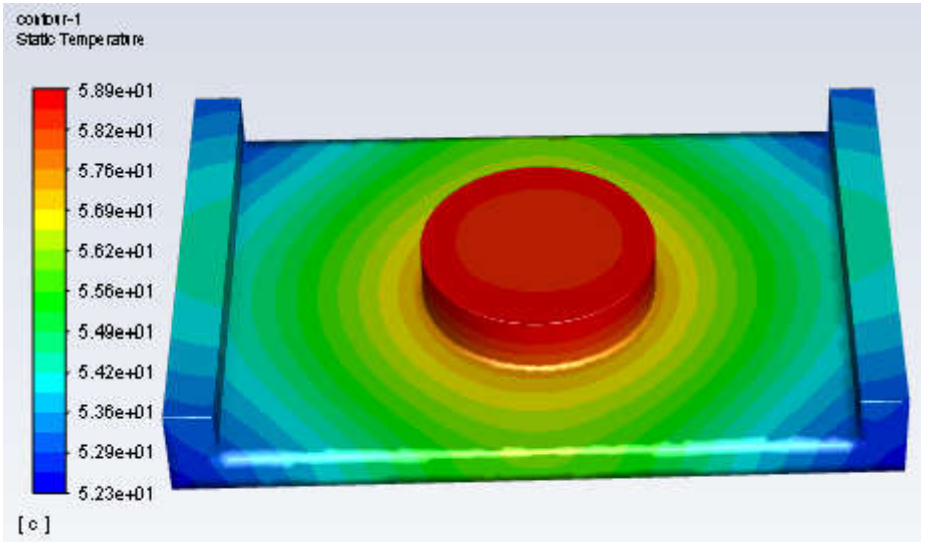


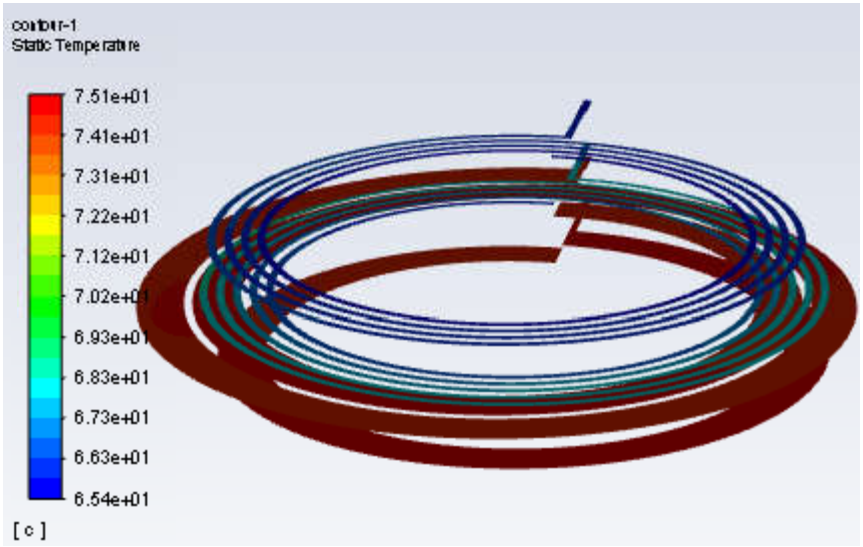




仿真设计结果

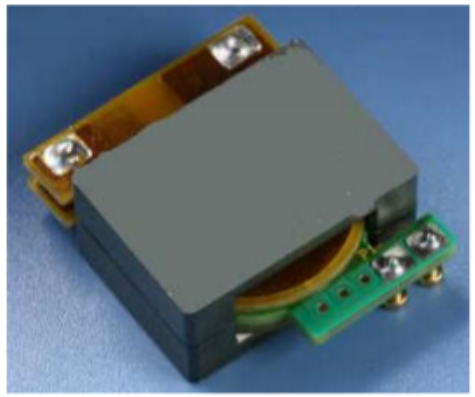
- 查看磁芯及绕组的温度分布

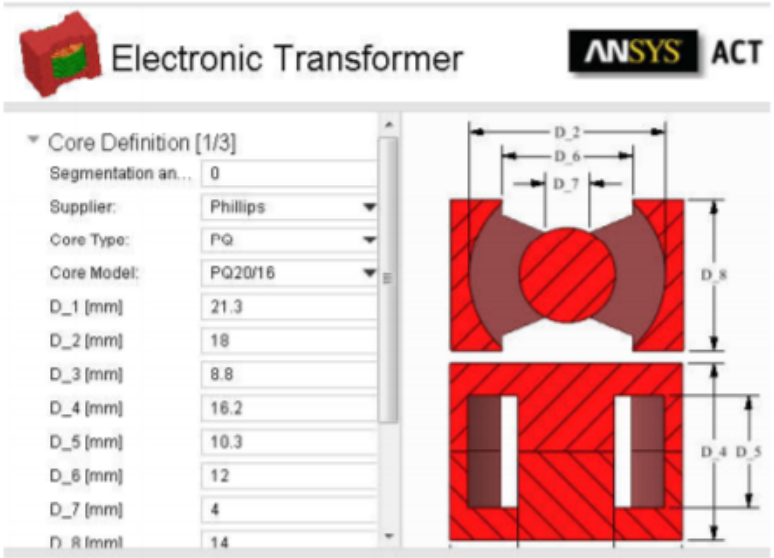




小结

- 使用ETK插件，先建立与仿真模型形状及尺寸近似的模型，再修改模型能极大的提升建模效率。
- 通过对比不同绕组简化模型的结果对仿真结果的影响，发现按绕组形状建模得到的电感矩阵及温升分别更接近实测值。
- 希望ANSYS的ETK插件能提供更多公司（例如TDK公司）的磁芯模型数据库。





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