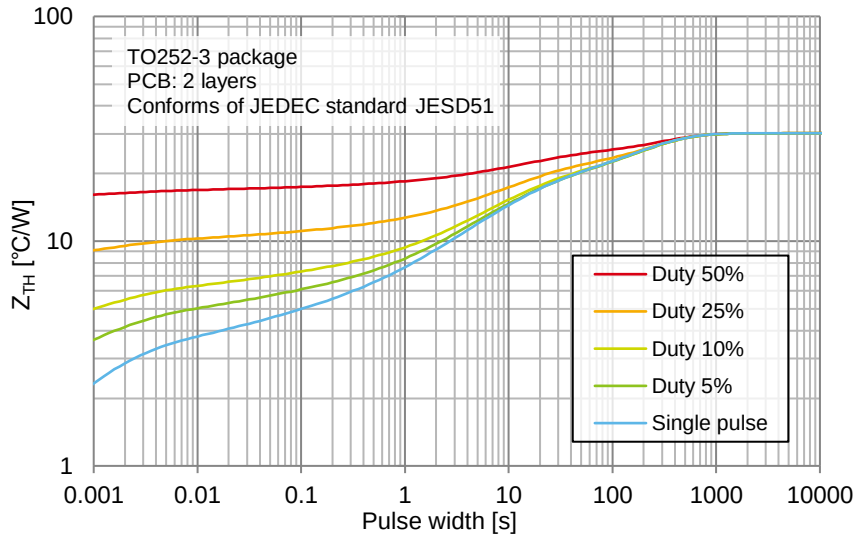
功率器件

使用瞬态热阻抗计算结温的方法

估算功率器件的结温时会使用热阻，当功率损耗随时间发生变化时，需要使用瞬态热阻抗。在本应用笔记中，记载了作为热设计初期的简易估算，使用瞬态热阻抗计算结温的方法。

瞬态热阻抗数据

图 1 是瞬态热阻抗数据的一个例子。



图表说明

- X 轴是 Pulse width (脉宽)、代表对器件施加功率的时间。
- Y 轴是瞬态热阻抗的值。
- 曲线簇是瞬态热阻抗数据。
- 曲线簇中的各个曲线之间的差别，在于施加的脉冲功率的占空比不一样。图 2 是测量时使用的脉宽和占空比的波形。

图 1. 瞬态热阻抗数据的一个例子

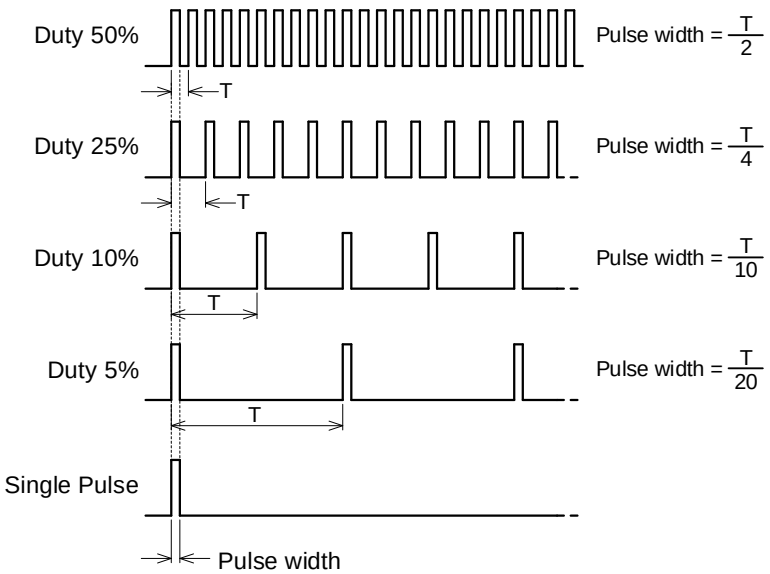


图 2. 测量时使用的脉宽和占空比的波形

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结温的计算方法

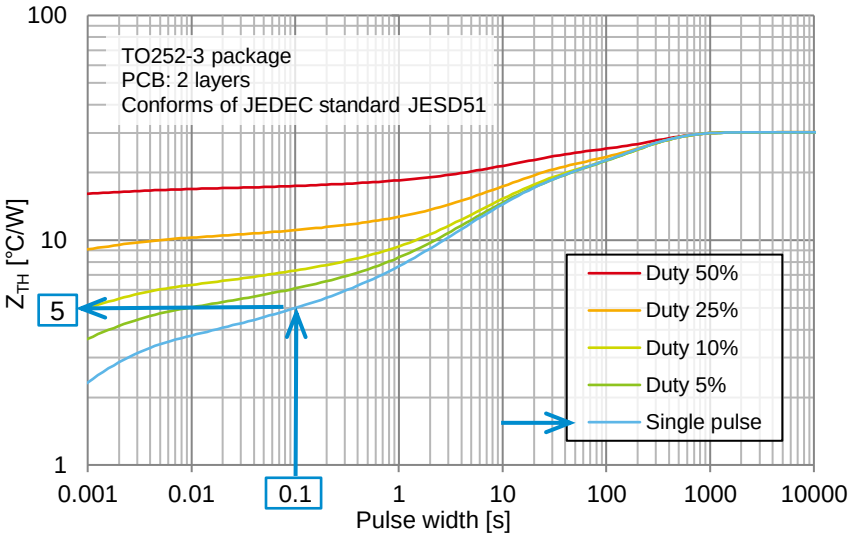
步骤 1. 查看对功率器件所施加的功率脉宽和占空比，记录数值。

例如：脉宽 $= 100\ [ms]$

占空比 $= Single\ Pulse$

步骤 2. 使用上一步记录的数值，从图表中读取瞬态热阻抗值。

例如：瞬态热阻抗 $Z_{TH} = 5\ [℃/W]$



步骤 3. 使用以下公式，计算结温[T_J]。

$$T_J = T_A + Z_{TH} \times P \quad [℃]$$

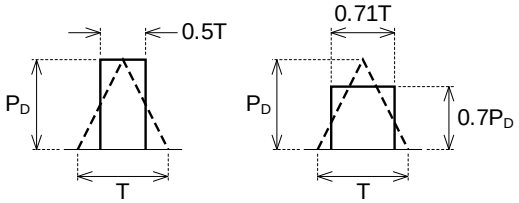
其中，

T_A：周围环境温度 [℃]

Z_{TH}：从结到周围环境的瞬态热阻抗 $[℃/W]$

P ：器件的功率损耗 $[W]$

- 对规定时间内的总损耗进行计算或者测量。
- 参考资料：应用笔记 [根据测定波形计算功率损耗]
  应用笔记 [开关电路的功率损耗计算]
- 因为瞬态热阻抗数据是施加矩形波功率时得到的数据，当实际功率波形不是矩形波时，需要近似为矩形波。例如，当希望进行变换的波形接近三角波时，如下图进行近似。左图是波形的幅值相同、将脉宽按照 0.5T 进行近似的例子，右图是将波形的幅值按照 0.7P_D、将脉宽按照 0.71T 进行近似的例子。两者的等效面积相同。



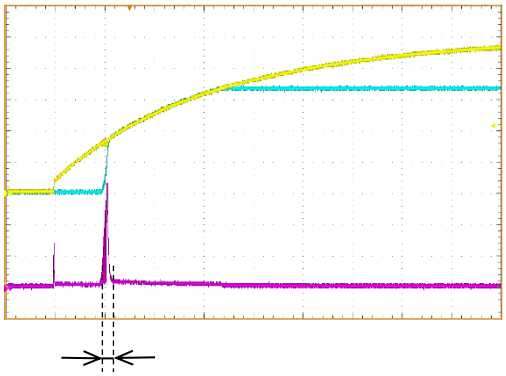
从三角波变换为矩形波的近似波形

计算例 1

对于电路起动时对电容电荷充电而流过的浪涌电流等、只在短时间内发生一次的现象，使用 [Single Pulse] 曲线估算结温。

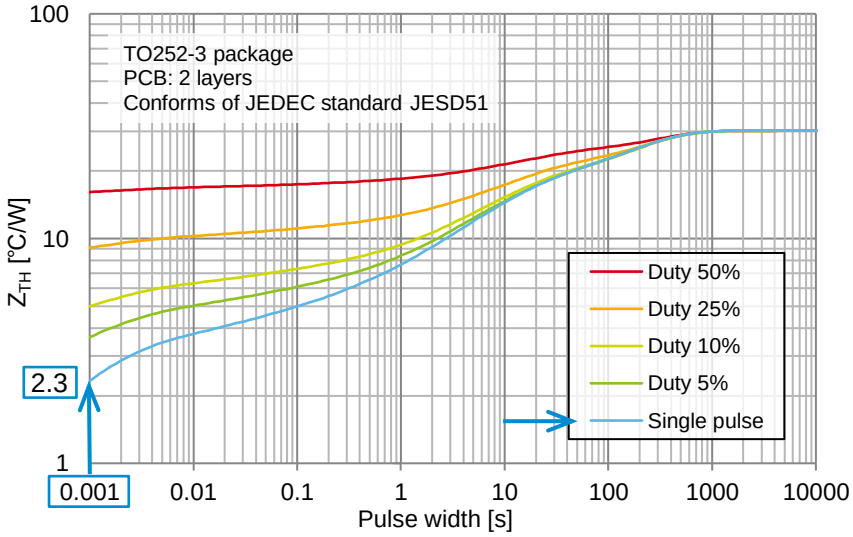
步骤 1. 查看大功率在短时间内产生的脉宽，记录数值。

例如：脉宽 $= 1\ [ms]$



步骤 2. 使用上一步记录的数值，从图表中读取瞬态热阻抗值。

例如：瞬态热阻抗 $Z_{TH} = 2.3\ [℃/W]$



步骤 3. 使用以下公式，计算结温[T_J]。

$$T_J = T_A + Z_{TH} \times P \quad [℃]$$

其中，

T_A：周围环境温度 [℃]

Z_{TH}：从结到周围环境的瞬态热阻抗 $[℃/W]$

P ：器件的功率损耗 $[W]$

例如，当 T_A和 P是以下条件时，通过以下公式求得 T_J。

$T_A = 60\ [℃]$

$P = 10\ [W]$（通过计算或者测量求得）

$T_J = 60 + 2.3 \times 10 = 83\ [℃]$

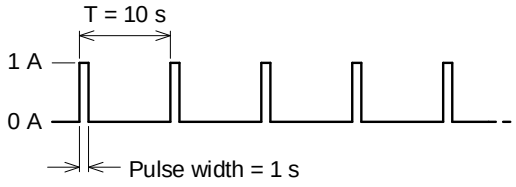
计算例 2

当电路进行 ON-OFF 的断续工作时，使用 [Duty xx%] 曲线估算结温。

步骤 1. 查看功率损耗发生时的脉宽和占空比，记录数值。

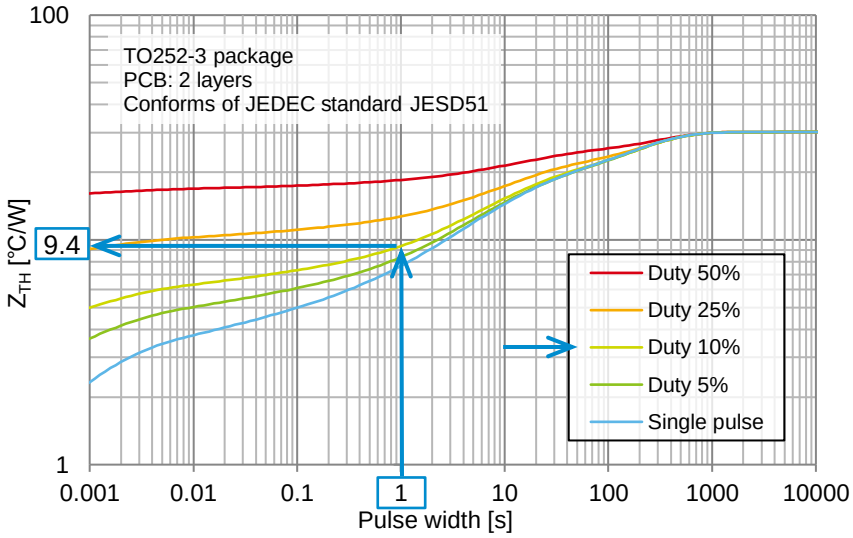
例如：脉宽 $= 1\ [s]$

占空比 $= 10\ [\%]$



步骤 2. 使用上一步记录的数值，从图表中读取瞬态热阻抗值。

例如：瞬态热阻抗 $Z_{TH} = 9.4\ [℃/W]$



步骤 3. 使用以下公式，计算结温[T_J]。

$$T_J = T_A + Z_{TH} \times P \quad [℃]$$

其中，

T_A：周围环境温度 [℃]

Z_{TH}：从结到周围环境的瞬态热阻抗 $[℃/W]$

P ：器件的功率损耗 $[W]$

例如，当 T_A和 P是以下条件时，通过以下公式求得 T_J。

$T_A = 60\ [℃]$

$P = 2\ [W]$（通过计算或者测量求得）

$T_J = 60 + 9.4 \times 2 = 78.8\ [℃]$

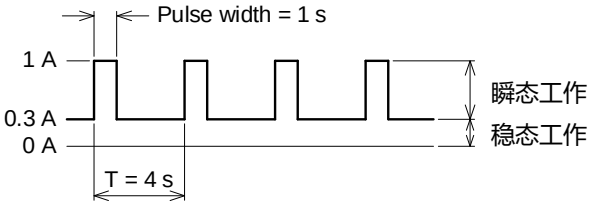
计算例 3

当电路的工作状态是不断变化的断续工作状态时，使用稳态工作和瞬态工作的合成值估算结温。

步骤 1. 查看功率损耗发生时的脉宽和占空比，记录数值。

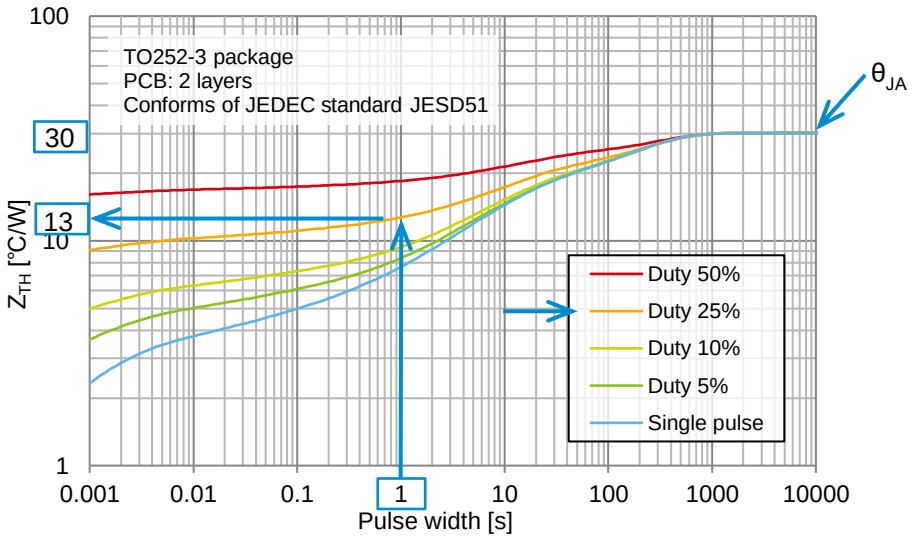
例如：脉宽 $= 1\ [s]$

占空比 $= 25\ [\%]$



步骤 2. 使用上一步记录的数值，从表格中读取瞬态热阻抗值。之后，读取稳态时的热阻[θJA]。θJA 的值对应曲线右边的数值。

例如：瞬态热阻抗 $Z_{TH} = 13\ [℃/W]$、稳态时的热阻 $\theta_{JA} = 30\ [℃/W]$



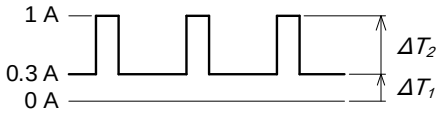
步骤 3. 使用以下公式，计算稳态工作时的温升。

$$\Delta T_1 = \theta_{JA} \times P_1 \quad [℃]$$

其中，

θ_{JA}：从结到周围环境的热阻 $[℃/W]$

P_1：稳态工作时的器件功率损耗 $[W]$



温度计算的范围

之后，计算瞬态工作时的温升。

$$\Delta T_2 = Z_{TH} \times (P_2 - P_1) \quad [℃]$$

其中，

Z_{TH}：从结到周围环境的瞬态热阻抗 $[℃/W]$

P_2：瞬态工作时的器件功率损耗 $[W]$

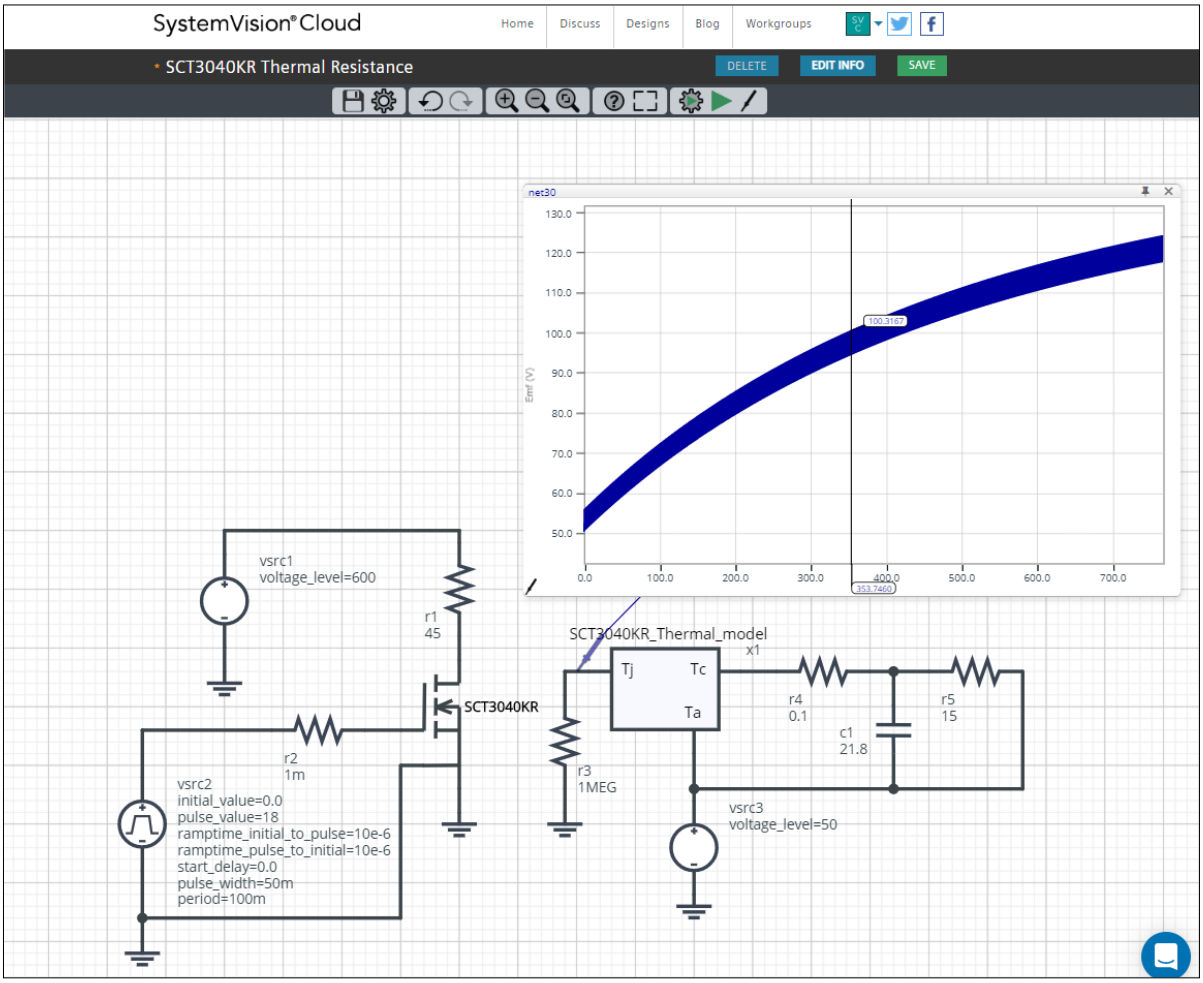
通过以下公式计算 T_J。

$$T_J = T_A + \Delta T_1 + \Delta T_2 \quad [℃]$$

T_A：周围环境温度 $[℃]$

计算例 4

当功率损耗的变化比较复杂时，可以使用热模型通过热仿真求得结温。详细内容请参考应用笔记 [热模型使用方法]。



使用热模型进行仿真的例子

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