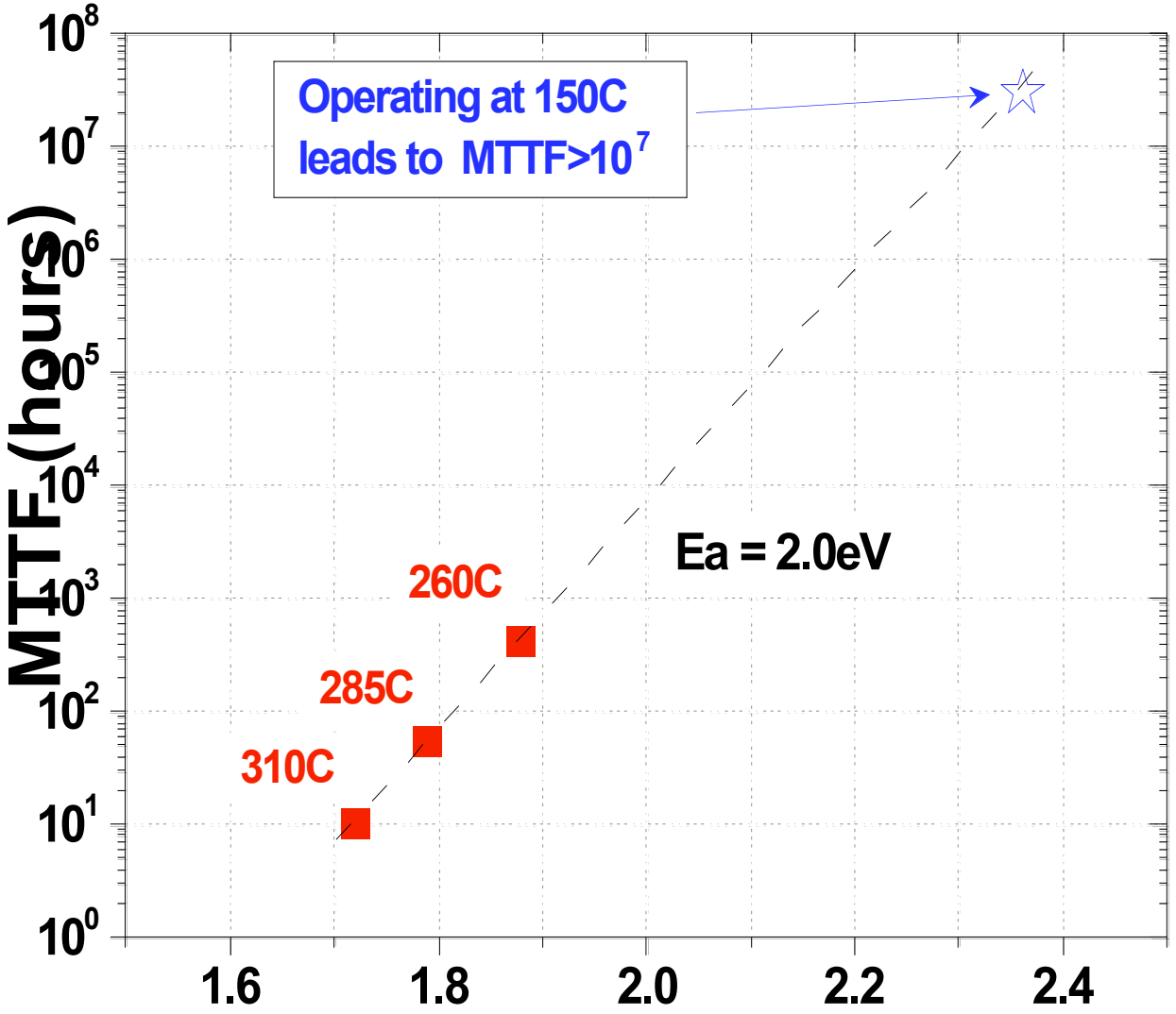
NITRONEX CORPORATION

MTTF Calculator User's Guide

10/4/07

MTTF(T_J) Formula



NRF1

$y = 5E\text{-}17 * e^{23192x}$

R2 = 0.9988

Ea = 2.0eV

"x" is 1/Tj in Degrees K

CW MTTF Code

Calculate Pdis, T_J from user input

MTTF formula parameters derived
By S.Singhal from $I_{D(Q)}$ Drift
(electromigration formula)

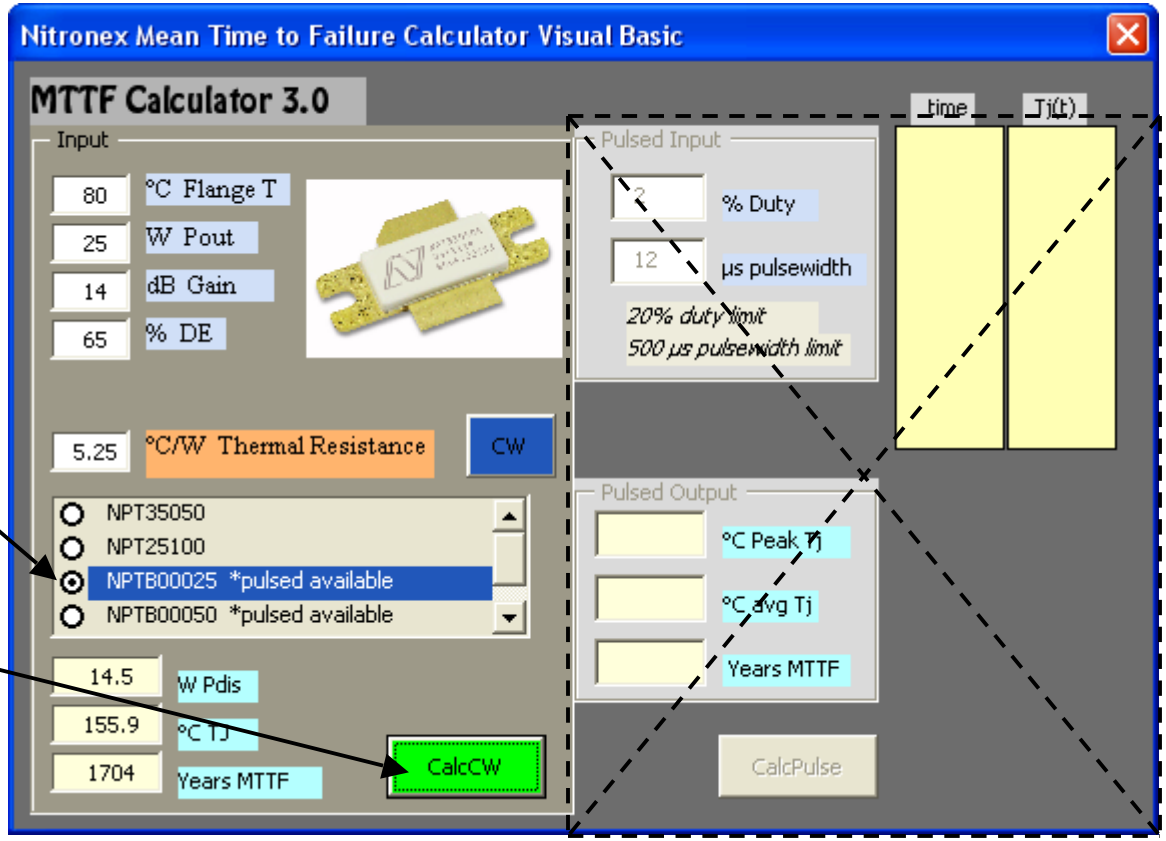
```
Dim TF, POUT, GAIN, DE, RJC, TJ, MTTF, PDIS As Double
 TF = TFbox.Value
 POUT = POUTbox.Value
 GAIN = GAINbox.Value
 GAIN = 10 ^ (GAIN / 10)
 DE = DEbox.Value
 DE = DE / 100
 RJC = RJCbox.Value
 PDIS = POUT * (1 / GAIN + 1 / DE - 1)
 TJ = TF + RJC * PDIS
 MTTF = 5E-17 * Exp(23192 / (TJ + 273.16))
 MTTF = MTTF / 24 / 365
 PDISbox.Text = Round(PDIS, 1)
 TJbox.Text = Round(TJ, 1)
 MTTFbox.Text = Round(MTTF, 0)
End Sub
```

CW Section

Select a product from the list to set default "Input" values for flange T, P_{OUT}, gain, DE, and thermal resistance.

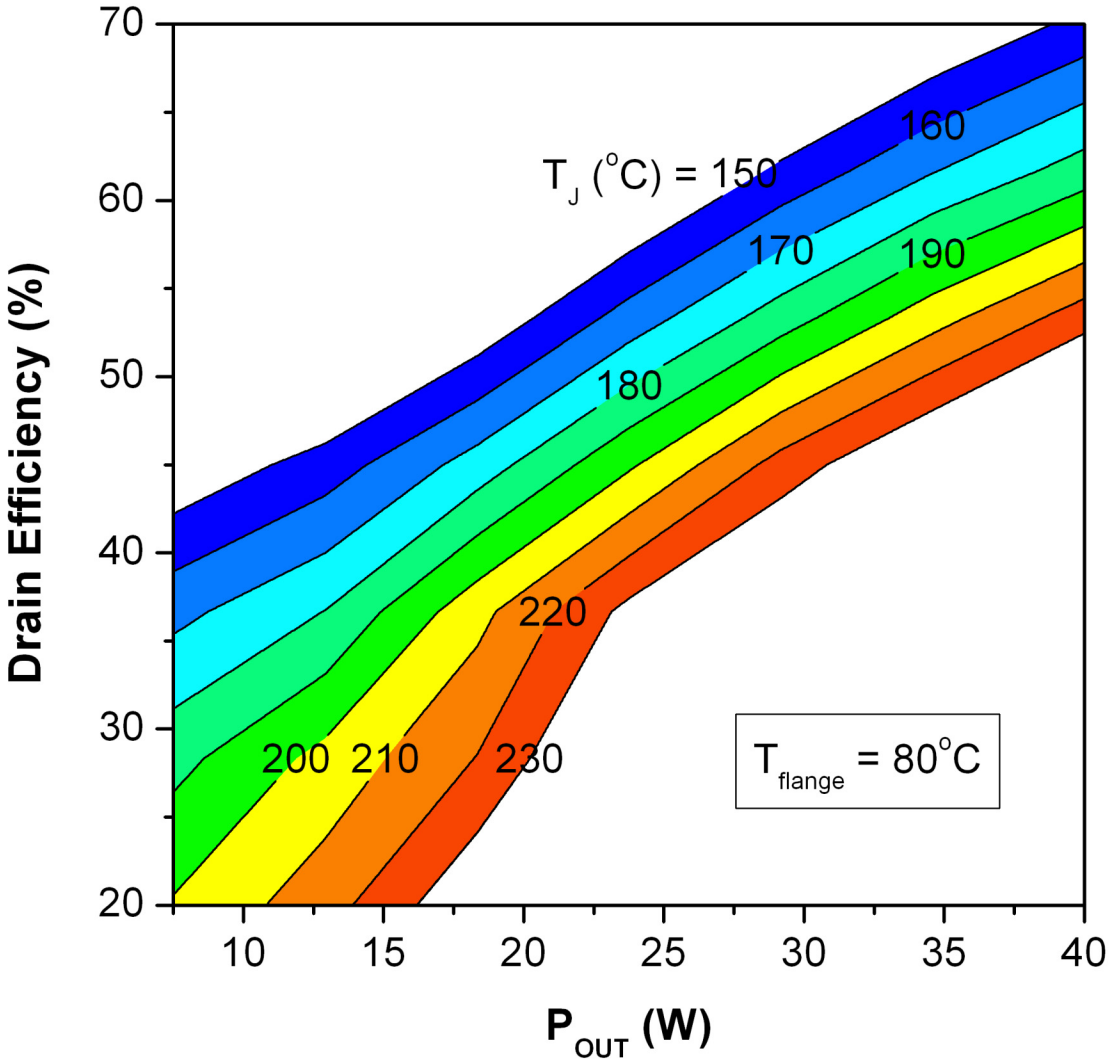
Press CalcCW to calculate P_{DIS}, T_J, and MTTF.

Each time you change any of the "Input" boxes, press CalcCW to Recalculate T_J and MTTF.



T_J Contours (NPTB00040B)

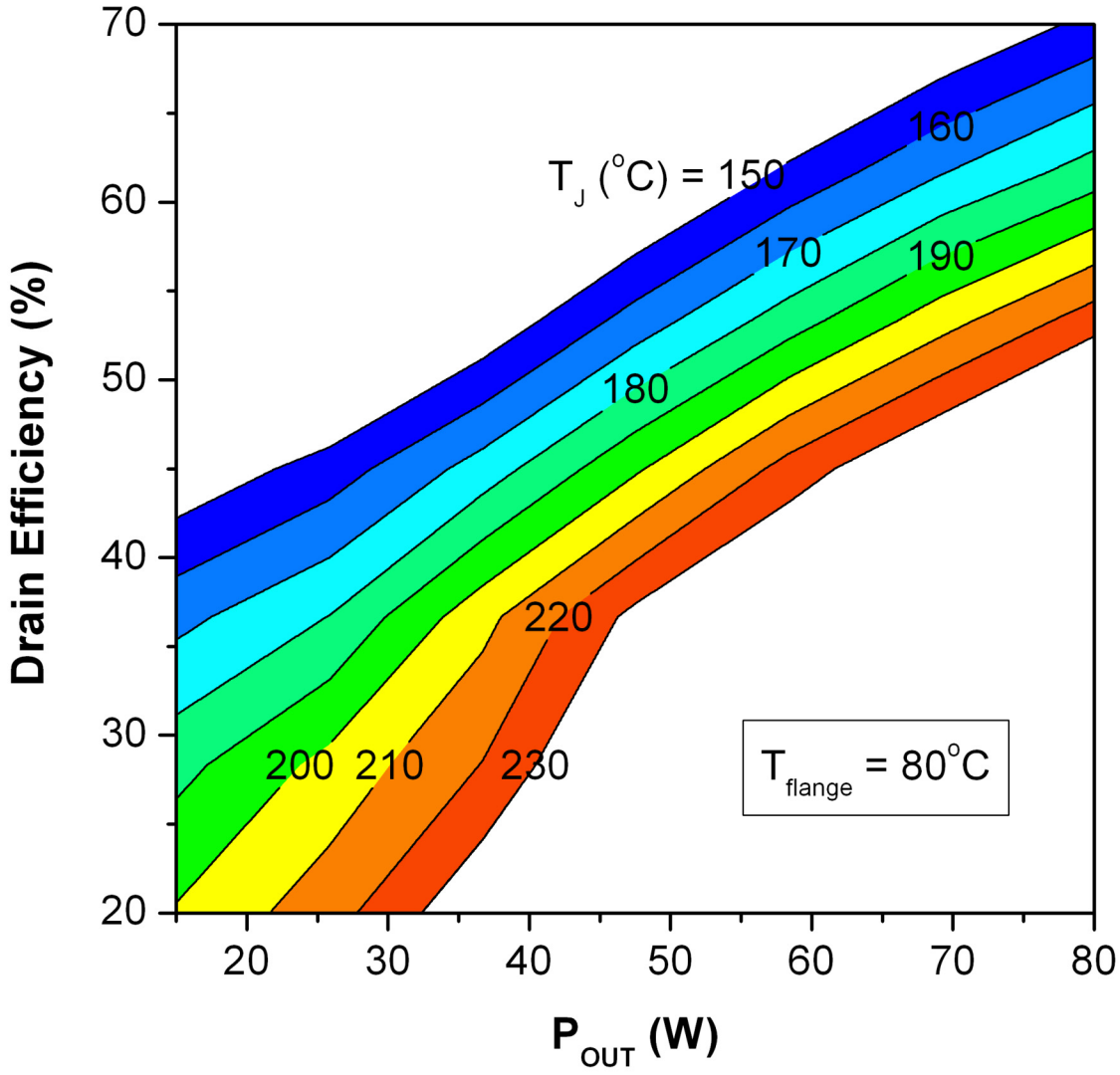
NPTB00040B



An example of results from TJ data generated using calculator.

T_J Contours (NPTB00080B)

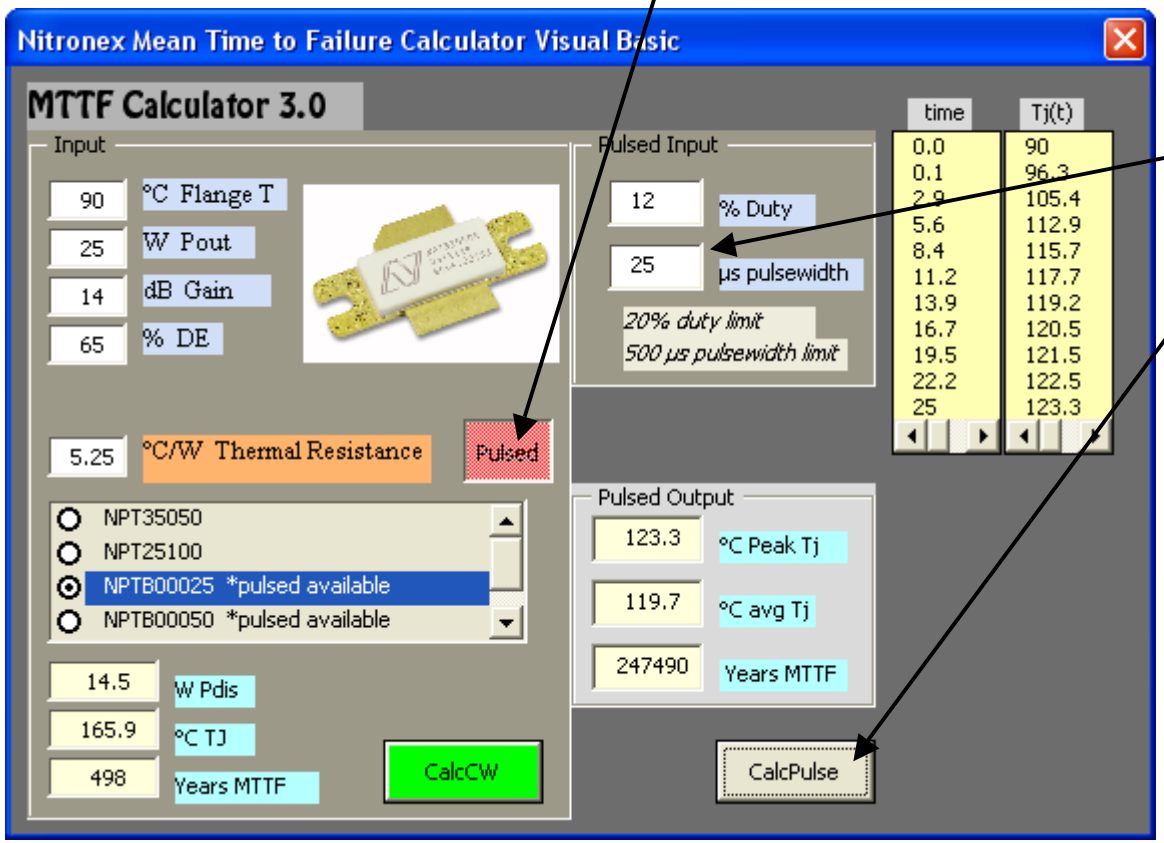
NPTB00080B



An example of results from TJ data generated using calculator.

Pulsed Section

If either NPTB00025 or 50 are selected then the CW/Pulsed button is able to turn on the "Pulsed Input" section.



Enter the desired duty cycle and pulse-width in µs.

Each time you change either of the "Pulsed Input" boxes, press CalcPulse to recalculate Peak T_J, average T_J, and MTTF, as well as the time-T_J(t) Profile.

One can also go back and change the CW "Input" boxes. Press CalcCW or CalcPulse to update their corresponding sections.

***To re-enable to product selection list, Press the CW/Pulsed button**

Pulsed MTTF Notes

- The fits for pulsed operation are done for 30,40, and 50% DE at the device default Pout and other values.
- Fits were made for a simulated device with the default θ_{JC}. User changes in θ_{JC} are handled by dumb scaling.
- Going outside of these fitting ranges, one can quickly get non-physical results.
- Pulsed calculator is a general guide only.

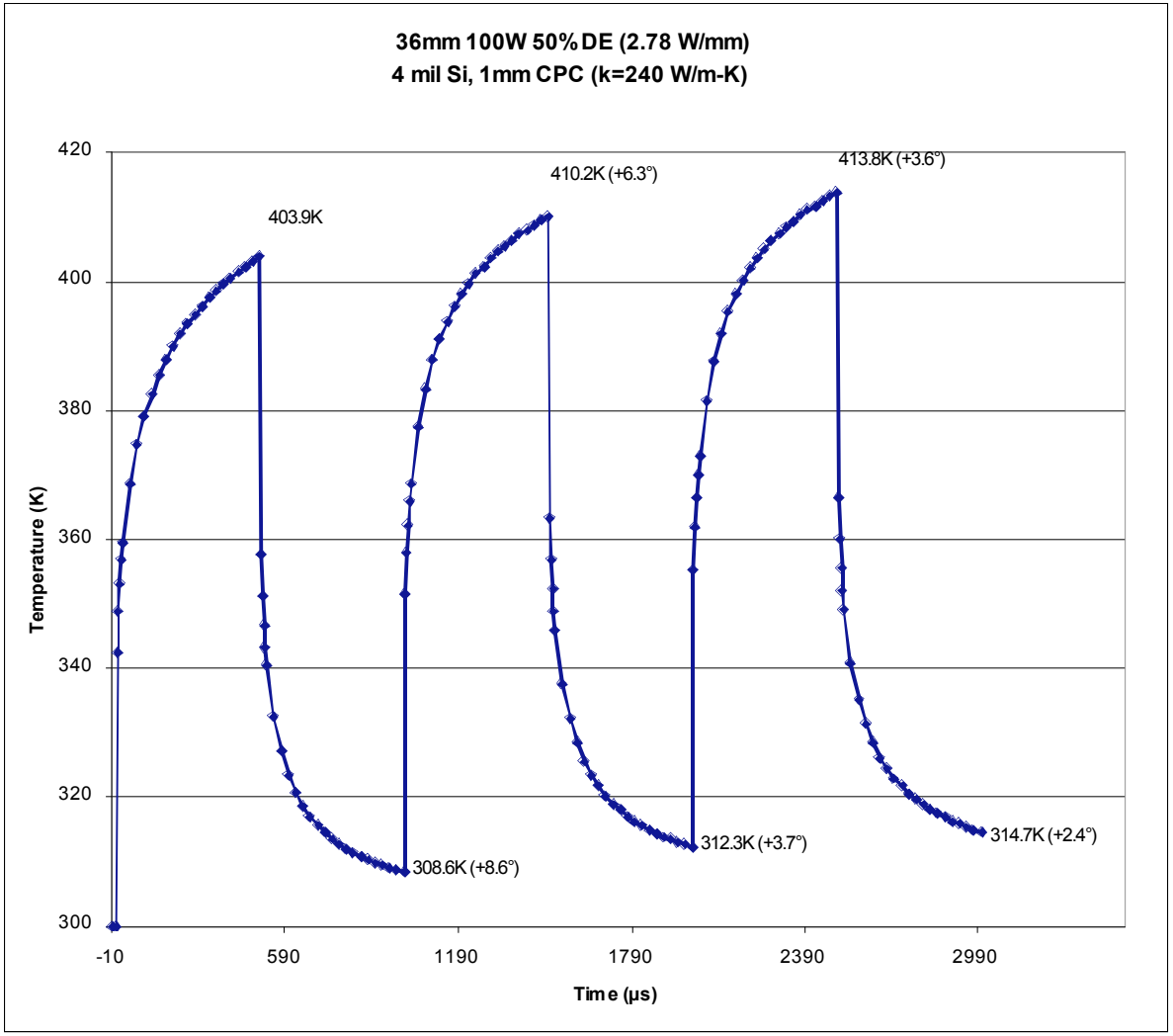
Appendix

- Pulsed Reliability Calculator Explanation

Simulated Pulsed Operation

The pulsed behavior was generated from Finite Element simulation using the full device structure and its relevant thermal environment. The heat flow equation is solved in solids with user defined temperature-dependent thermal conductivity, heat capacity (T-dependent for Si), and density.

Software used:
ESI Group's CFD-ACE+



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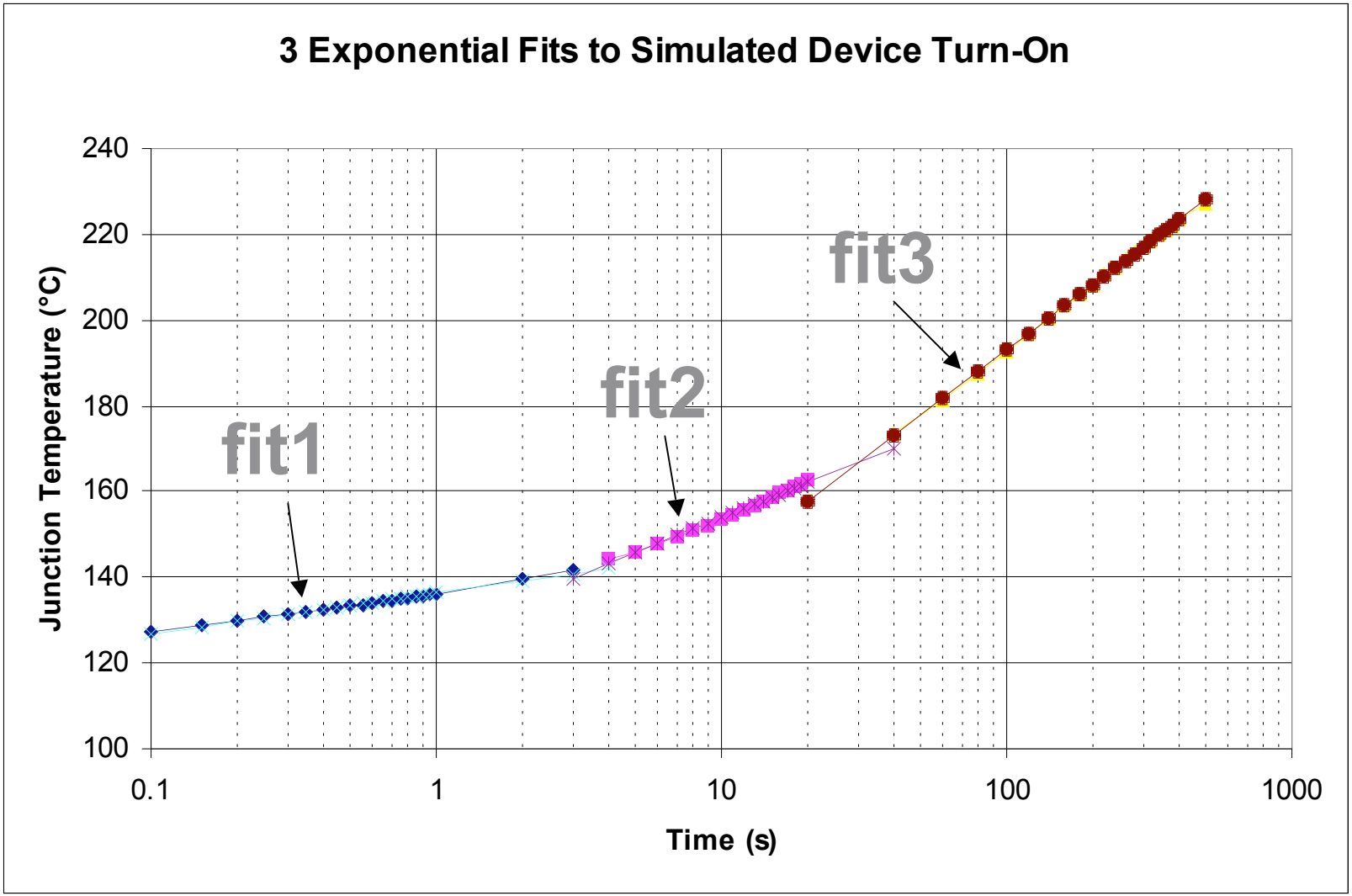
50% DE (25W P_{DIS}) Sim.Turn-on



Fitting

- Divided into three ranges with fits of the form:
  - 0.1 to <3 µs → T_J=4.1568*ln(time)+136.31
  - 3 to 40 µs → T_J=11.777*ln(time)+126.76
  - >40 to 500 µs→ T_J=21.905*ln(time)+92.07
- Repeat procedure for 30%, 40% DE
- Now…fit to the fitting parameters! So we have the fitting parameters as a function of dissipated power.
- 1. Calculate P_{DIS} from user input
- 2. Calculate T_J formula fitting parameters based on P_{DIS}
- 3. Calculate T_J at any time in the turn-on with T_J formula

Pulsed MTTF Calculation Methodology

- Divide the turn-on into 10 slices
- (pulse width-0.1μs)/9
- Calculate T_J and "MTTF based upon that T_J" at each slice (shift by user entered T_F)
- Combine using Matthiessen's rule: $1/MTTF=1/MTTF_1+1/MTTF_2+\ldots 1/MTTF_{10}$
- Divide by duty cycle (10% →10*MTTF)