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Title: Smoke Analysis

Date: 3rd Nov 17

21ST CENTURY TECHNOLOGIES

HCL

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Objective

To determine the Advanced Smoke analysis is able to capture the violation of Current, Voltage, Temperature and power dissipation for all circuits.

SMOKE ANALYSIS

Smoke analysis is an Advanced analysis in PSPICE, which is technically termed as Stress Analysis and It’s not a worst case analysis.

Smoke warns of component stress due to power dissipation(PDM), increase in junction temperature(Tj), secondary breakdowns(Tb), or violations of voltage / current limits.

Smoke analysis compares the simulation values with the rated values given for the component and if it exceeds the rated value, it will be highlighted in red colour. In case of failures, you need to change the component and Re-run the simulation.

Spreadsheet analysis is a manual stress analysis to calculate Current, Voltage, Power and Temperature of all components.

Advantages and Limitations of Smoke Analysis

Advantages:

- Easy to simulate even complex circuits.
- Manual calculation error can be neglected.
- Overall circuit knowledge is sufficient to run the simulation.
- Derating can be applied to all components parameter as per the requirement and those derating values are not interlinked (i.e., PDM derating is not Interlinked with Tj derating value)
- One time effort itself sufficient for Custom derating, if your are going to use same derating factor.
- By giving extra derating to components, we can overcome the worst case.
- Less time to compute the circuit.
- Smoke capture the Transient peak voltage, current, PD in “PEAK” type and It has the Average and RMS as well.

Limitations:

- Circuit cannot take the Component tolerance for smoke analysis, So it will not able to compute Worst Case.
- “Parts” other than this cannot be covered under smoke Analysis and IC’s Cannot be covered under smoke analysis.
- If Specific Parts PSPICE library file is not available in Website, You need to go for alternative.
- “Smoke parameter” other than this cannot be added.

Case Study1:

- Analog circuit.
- Circuit Contains 34 passive components and 6 active components.
- Out of 6 active component, 4 were readily available in PSPICE Advanced library and 2 downloaded from site.
- Out of 34 passive components, 3 diodes .lib files downloaded from site.
- Comparison of Tool based Advanced smoke analysis and spreadsheet based Manual analysis.

S.no	Advanced Smoke Analysis	Manual Analysis
1	Time Taken for analysis is 8.5hrs	Time Taken for analysis is 2days.
2	Basic knowledge is sufficient to run the simulation.	In depth knowledge of circuit is required to do analysis.
3	Easy to simulate even for complex circuit.	Difficult to calculate for complex circuit.

- Time Taken for the Advanced Smoke analysis is given in below table.

S.no.	Task	Time(hrs)
1	Downloading .lib files	0.5
2	Part Creation	0.5
3	Adding Smoke Paramaters.	2
4	Circuit Creation	3.5
5	Derating Factor Table Creation	1
6	Adding Derate type to the specific Part	0.5
7	Simulating PSPICE and smoke analysis	0.5

Intentionally introduced Fault into the circuit to check whether the tool detects the fault or not:

Before Introducing fault into the Circuit

1. Mosfet(Q4):

Q4	ID	Average	115m	100	115m	2.5615m	3
Q4	PDM	Average	200m	100	200m	350.4019u	1
Q4	TJ	Average	150	100	150	27	19
Q4	VDG	Average	60	100	60	1.1372	2
Q4	VDS	Average	60	100	60	4.8871	9
Q4	VGSF	Average	20	100	20	3.7499	19

2. Resistor(R5):

R5	PDM	Average	250m	84	210.7675m	5.4825m	3
R5	TB	Average	200	100	200	31.3860	16

After Fault

1. Mosfet(Q4):

Q4	ID	Average	115m	100	115m	231.6759m	202
Q4	PDM	Average	200m	100	200m	170.8924m	86
Q4	TJ	Average	150	100	150	27	19
Q4	VDG	Average	60	100	60	1.6149	3
Q4	VDS	Average	60	100	60	5.3666	9
Q4	VGSF	Average	20	100	20	3.7517	19

2. Resistor(R5):

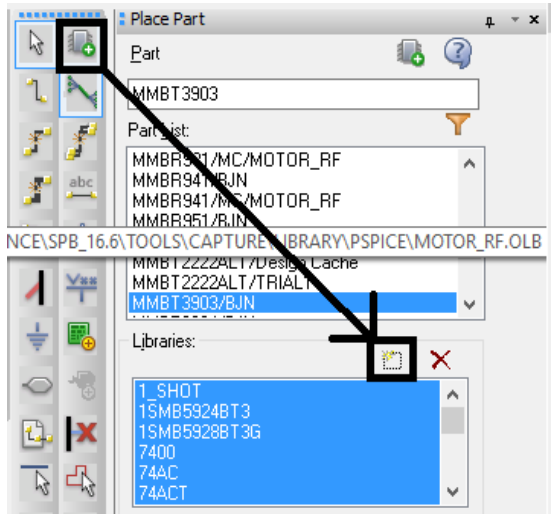
R5	PDM	Average	250m	0	0	1.1249	< MAX >
R5	TB	Average	200	100	200	926.8823	464

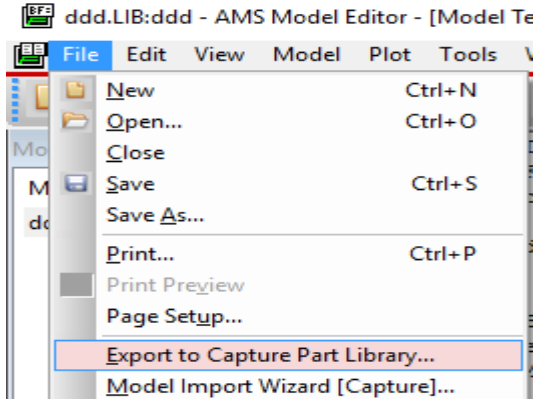
Smoke Analysis Procedure:

1. From your Design Entry CIS, Open your circuit or Create a new one from File menu New -> Project, Select “Analog or Mixed A/D” and Create a Blank Project.

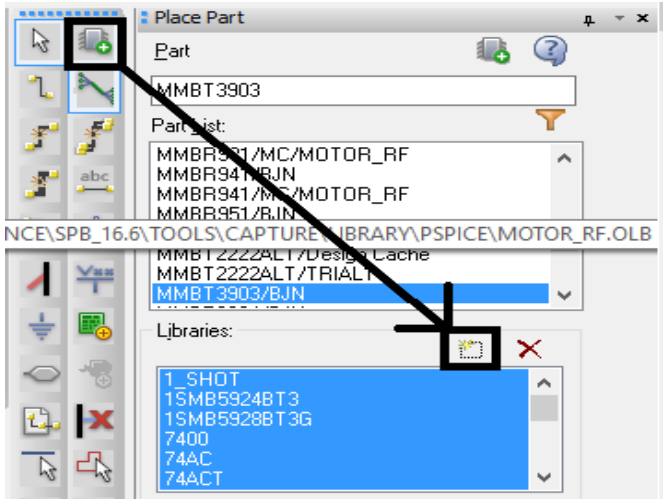
2. Use advanced analysis library (<Target _directory> \ Capture \ Library \ PSpice \ AdvAnls \) Parts for simulating Smoke Analysis and for Source(Vdc, Vac), you can use normal pspice library (<Target_directory> \ Capture \ Library \ PSpice \Source).

3. When you download .lib file from manufacturer site, Use MODEL EDITOR to create a part from .lib file. From File menu, Open the .lib file and click Export to capture library to create the part.

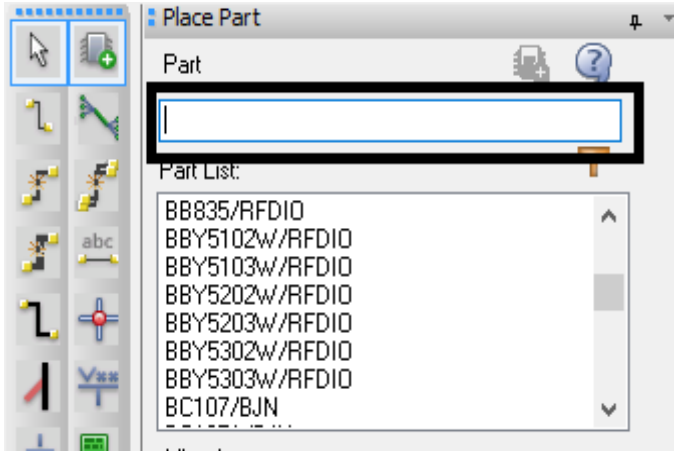




4. Select the Part which you created from .lib file, Place Part -> Add library(Alt+A).

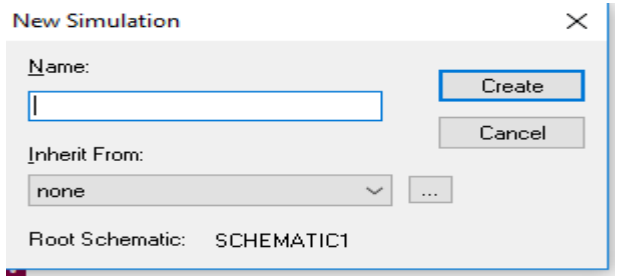


5. Search Parts Under Part Box and add to circuit.

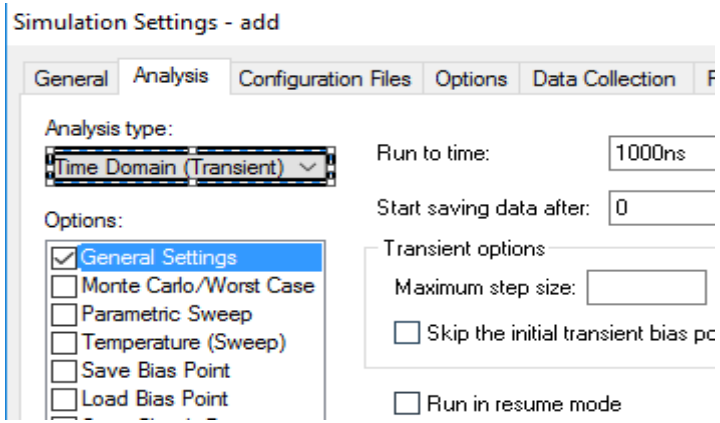


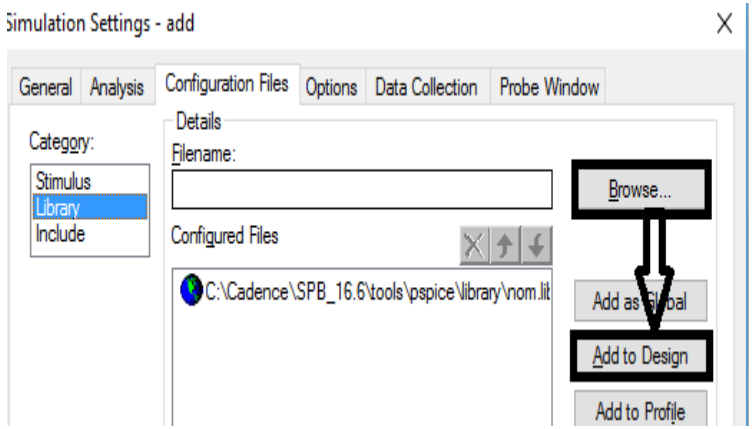
6. Draw Wire(w) using  this symbol, Gnd(g) using  this symbol and rotate parts using “R”.

7. From PSPICE menu, Select New Simulation and Create.

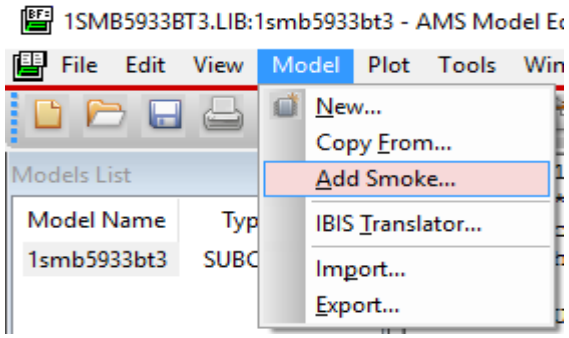


8. Select Transient analysis under Analysis menu. Browse & Add the .lib file to design which you used to create part.

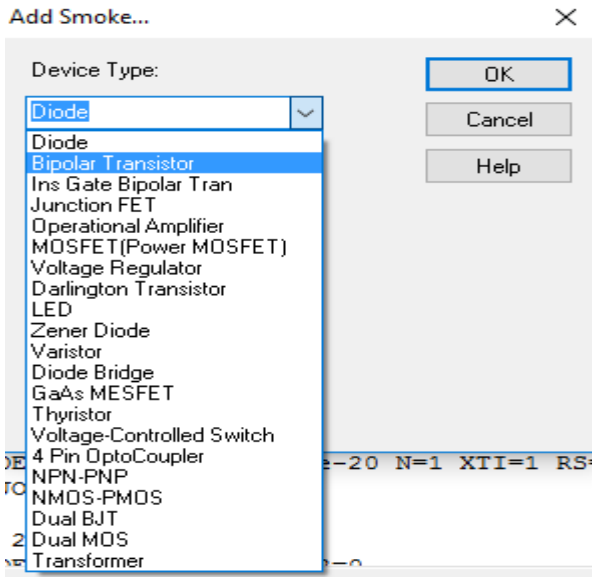




9. Each and Every component in the smoke analysis must have smoke parameter specified, For downloaded components right click -> Edit PSPICE Model -> From MODEL menu select “ADD SMOKE” to the Active Components and for Passive components right click on the component -> Edit Properties. Click “Parameter” to see the default smoke parameters for the Passive Components.



10. Select the Component from Device Type drop down menu.



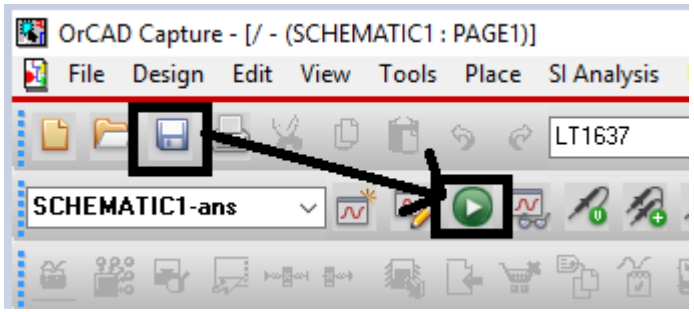
11. Add the Smoke Parameter for the Transistor and save. Similarly add smoke parameter for other components as well. Please click "Smoke Paramater" to see the parameters to be filled for different components and verify the smoke parameters in advanced library with datasheet before proceeding the simulation.

Smoke Parameters

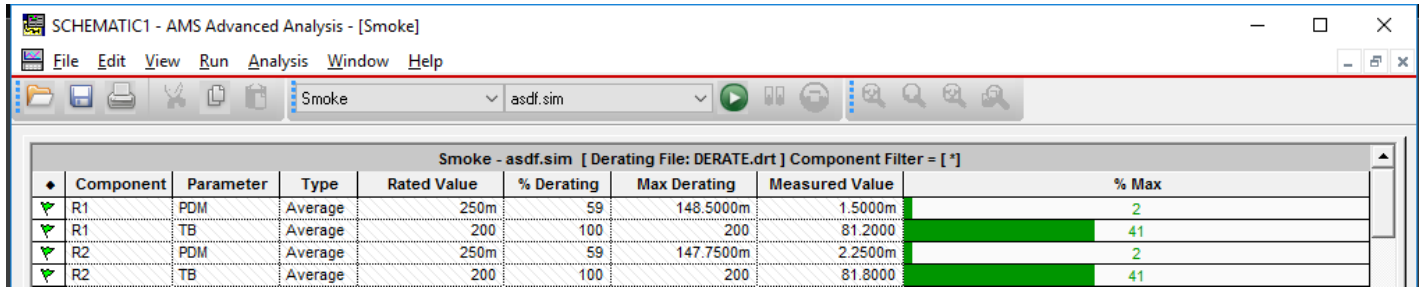
These are Device Maximum Operating condition parameters required for Smoke Analysis

Device Max Ops	Description	Value	Unit
IB	Max base current		A
IC	Max collector current		A
VCB	Max C-B voltage		V
VCE	Max C-E voltage		V
VEB	Max E-B voltage		V
PDM	Max pwr dissipation		W
TJ	Max junction temp		C
RJC	J-C thermal resist		C/W
RCA	C-A thermal resist		C/W
SBSLP	Second brkdown slope		
SBINT	Sec brkdwn intercept		A
SBTSLP	SB temp derate slope		%/C
SBMIN	SB temp derate at TJ		%

12. Run a PSPICE simulation as Time Domain (transient) analysis (Smoke does not work on other types of analyses, such as DC Sweep or AC Sweep/Noise analyses).



13. Run a Smoke analysis from PSPICE -> Advanced Analysis -> Smoke. Smoke Output window displays, how much the component stressed in the circuit.



Smoke - asdf.sim [Derating File: DERATE.drt] Component Filter = [*]

Component	Parameter	Type	Rated Value	% Derating	Max Derating	Measured Value	% Max
R1	PDM	Average	250m	59	148.5000m	1.5000m	2
R1	TB	Average	200	100	200	81.2000	41
R2	PDM	Average	250m	59	147.7500m	2.2500m	2
R2	TB	Average	200	100	200	81.8000	41

14. Green Bars shows that the component are within the safe operating limits, Red bar indicate value that exceeds the safe operating limits and Grey bar indicate limit is not valid for the parameter.

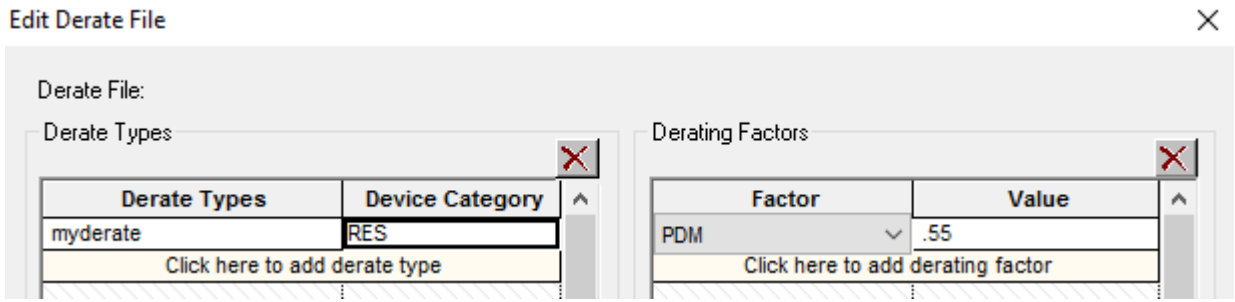
15. Right Click on the smoke analysis window to select type such as Average, Peak and RMS value of each parameter.

16. Right click on the smoke analysis window and select the “DERATING” from the pop-up menu.

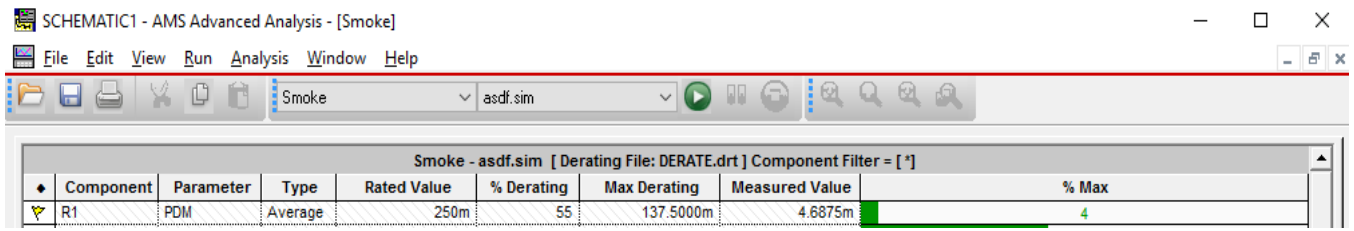
17. Select one of the three from derating options on the pull right menu:
    - No Derating
    - Standard Derating
    - Custom Derating

18. To create a new derate file, Click the custom derating file button.

19. Add the Derate type, category, factor and value in the block and similarly add other derate type as per your requirement and save the file.

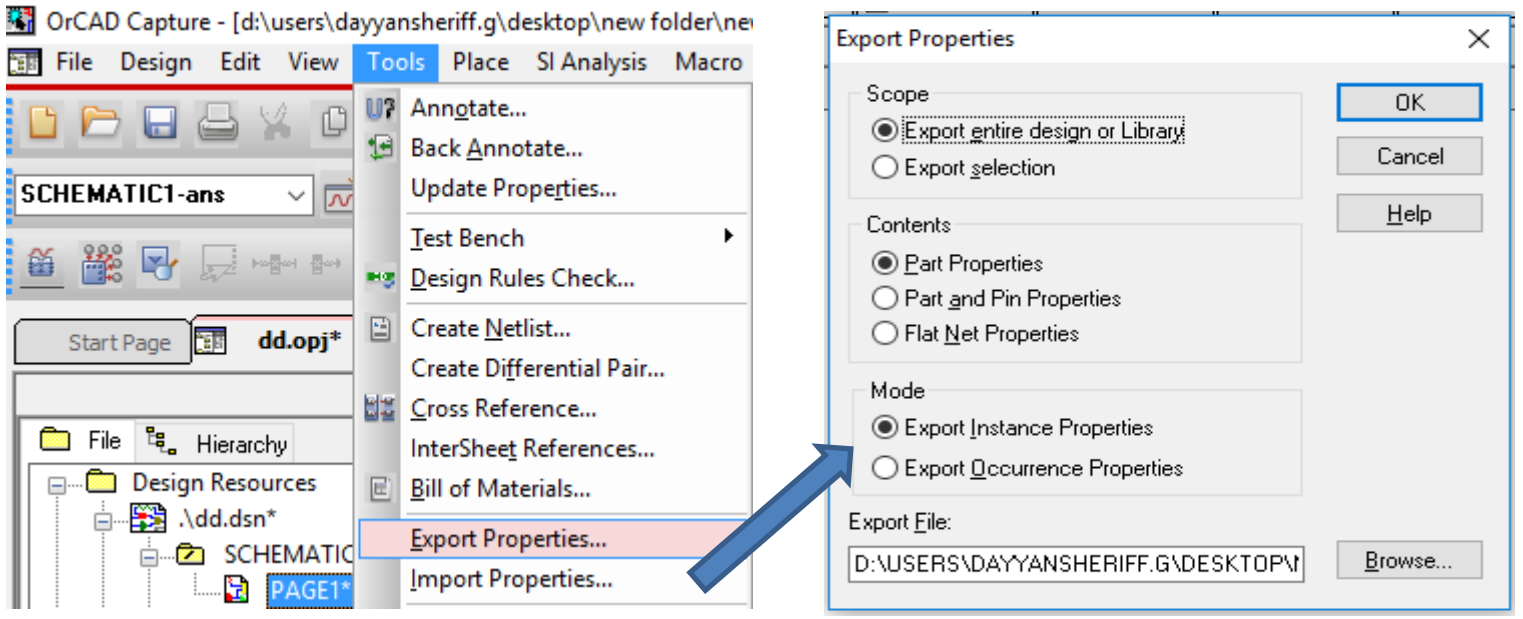


20. To use the custom derate file, In the Property Editor, add a new property for the component with the name DERATE_TYPE and value same as the Derarte Type specified, such as *myderatetype*. Select the corresponding derate file and run smoke.



Alternate method to fill the parameters for Project specific Components

1. Select your Project, From TOOLS menu -> Export Properties and save it.



2. Use Tab as delimiter while opening the .EXP from excel and change the parameters for all components like DERATE_TYPE.
3. Save the file and Import the file into your project using Import Properties from TOOLS menu.

Appendix 1:

Default Smoke Parameter for passive components

Smoke User Interface Parameter Name	Passive Component	Maximum Operating Condition	Symbol Property Name	Symbol Smoke Parameter Name	Variable Table Default Value
CI	Capacitor	Maximum ripple	CURRENT	CIMAX	1A
CV	Capacitor	Voltage rating	VOLTAGE	CMAX	50 V
IV	Current Supply	Supply Max. voltage current source can withstand	VOLTAGE	VMAX	12V
LI	Inductor	Current rating	CURRENT	LMAX	5A
LV	Inductor	Dielectric strength	DIELECTRIC	DSMAX	300V
PDM	Resistor	Maximum power dissipation of resistor	POWER	RMAX	0.25W
RBA* (=1/SLOPE)	Resistor	Slope of power dissipation vs. temperature	SLOPE	RSMAX	0.005W/degC
RV	Resistor	Voltage Rating	VOLTAGE	RVMAX	-
SLP*	Capacitor	Temperature derating slope	SLOPE of volt temperature curve	CSMAX	0.005 V/degC
TBRK*	Capacitor	Breakpoint temperature	KNEE	CBMAX	125 degC
TMAX*	Capacitor	Maximum temperature	MAX_TEMP	CTMAX	125 degC
TMAX, TB	Resistor	Maximum temperature resistor can withstand	MAX_TEMP	RTMAX	200 degC
VI	Voltage Supply	Max. current voltage source can withstand	CURRENT	IMAX	1A

Smoke Parameter Table:

Smoke ParameterName and SymbolProperty Name	Semiconductor Parameter/ OPAMP Parameter	Maximum Operating Condition
IB	BJT	Maximum base current (A)
IC	BJT	Maximum collector current (A)
PDM	BJT	Maximum power dissipation (W)
RCA	BJT	Thermal resistance, Case-to-Ambient(degC/W)
RJC	BJT	Thermal resistance, Junction-to-Case(degC/W)
SBINT	BJT	Secondary breakdown intercept (A)
SBMIN	BJT	Derated percent at TJ (secondary breakdown)
SBSLP	BJT	Secondary breakdown slope
SBTSLP	BJT	Temperature derating slope (secondarybreakdown)
TJ	BJT	Maximum junction temperature (degC)
VCB	BJT	Maximum collector-base voltage (V)
VCE	BJT	Maximum collector-emitter voltage (V)
VEB	BJT	Maximum emitter-base voltage (V)
IF	Diode	Maximum forward current (A)
PDM	Diode	Maximum power dissipation (W)
RCA	Diode	Thermal resistance, Case-to-Ambient(degC/W)
RJC	Diode	Thermal resistance, Junction-to-Case(degC/W)
TJ	Diode	Maximum junction temperature (degC)

Smoke ParameterName and SymbolProperty Name	Semiconductor Parameter/ OPAMP Parameter	Maximum Operating Condition
VR	Diode	Maximum reverse voltage (V)
IC	IGBT	Maximum collector current (A)
IG	IGBT	Maximum gate current (A)
PDM	IGBT	Maximum Power dissipation (W)
RCA	IGBT	Thermal resistance, Case-to-Ambient(degC/W)
RJC	IGBT	Thermal resistance, Junction-to-Case(degC/W)
TJ	IGBT	Maximum junction temperature (degC)
VCE	IGBT	Maximum collector-emitter (V)
VCG	IGBT	Maximum collector-gate voltage (V)
VGEF	IGBT	Maximum forward gate-emitter voltage (V)
VGER	IGBT	Maximum reverse gate-emitter (V)
ID	JFET or MESFET	Maximum drain current (A)
IG	JFET or MESFET	Maximum forward gate current (A)
PDM	JFET or MESFET	Maximum power dissipation (W)
RCA	JFET or MESFET	Thermal resistance, Case-to-Ambient(degC/W)
RJC	JFET or MESFET	Thermal resistance, Junction-to-Case(degC/W)
TJ	JFET or MESFET	Maximum junction temperature (degC)
VDG	JFET or MESFET	Maximum drain-gate voltage (V)

Smoke ParameterName and SymbolProperty Name	Semiconductor Parameter/ OPAMP Parameter	Maximum Operating Condition
VDS	JFET or MESFET	Maximum drain-source voltage (V)
VGS	JFET or MESFET	Maximum gate-source voltage (V)
ID	MOSFET or Power MOSFET	Maximum drain current (A)
IG	MOSFET or Power MOSFET	Maximum forward gate current (A)
PDM	MOSFET or Power MOSFET	Maximum power dissipation (W)
RCA	MOSFET or Power MOSFET	Thermal resistance, Case-to-Ambient(degC/W)
RJC	MOSFET or Power MOSFET	Thermal resistance, Junction-to-Case(degC/W)
TJ	MOSFET or Power MOSFET	Maximum junction temperature (degC)
VDG	MOSFET or Power MOSFET	Maximum drain-gate voltage (V)
VDS	MOSFET or Power MOSFET	Maximum drain-source voltage (V)
VGSF	MOSFET or Power MOSFET	Maximum forward gate-source voltage (V)
VGSR	MOSFET or Power MOSFET	Maximum reverse gate-source voltage (V)
ITM	Varistor	Peak current (A)
RCA	Varistor	Thermal resistance, Case-to-Ambient(degC/W)
RJC	Varistor	Thermal resistance, Junction-to-Case(degC/W)
TJ	Varistor	Maximum junction temperature (degC)
IFS	Zener Diode	Maximum forward current (A)
IRMX	Zener Diode	Maximum reverse current (A)

Smoke ParameterName and SymbolProperty Name	Semiconductor Parameter/ OPAMP Parameter	Maximum Operating Condition
PDM	Zener Diode	Maximum power dissipation (W)
RCA	Zener Diode	Thermal resistance, Case-to-Ambient(degC/W)
RJC	Zener Diode	Thermal resistance, Junction-to-Case(degC/W)
TJ	Zener Diode	Maximum junction temperature (degC)
IPLUS	OpAmp	Non-inverting input current
IMINUS	OpAmp	Inverting input current
IOUT	OpAmp	Output current
VDIFF	OpAmp	Differential input voltage
VSMAX	OpAmp	Supply voltage
VSMIN	OpAmp	Minimum supply voltage
VPMAX	OpAmp	Maximum input voltage (non-inverting)
VPMIN	OpAmp	Minimum input voltage (non-inverting)
VMMAX	OpAmp	Maximum input voltage (inverting)
VMMIN	OpAmp	Minimum input voltage (inverting)

Conclusion

Smoke analysis is a time saving one but it doesn’t take component tolerance so will not be able perform Worst Case analysis.

Cadence Support Team

Tolerance does not have any effect on SMOKE. Smoke is audit of current operating conditions against rated specification under current operating and environmental conditions.
Tolerance parameter places a role in Monte Carlo, Sensitivity analysis.
So, there is no effect of tolerance in SMOKE analysis.

FAQ (Frequently Asked Question)

1. Smoke Parameter other than listed can be added?

Ans: No, Smoke Parameter other than listed in "Table" cannot be added to the Part.

2. IC's can be covered under smoke analysis like Voltage regulator?

Ans: NO, Parts other than listed in "Table" cannot be covered under smoke analysis.

3. What to do, If PSPICE model is not available for the component?

Ans: You need to go for alternative part, If the specific part model is not available.

4. Does the analysis capture the transient peak value and if it does means your result is wrong right?

Ans: YES, But it shows three value PEAK(Transient peak Value), Average and RMS as well

5. Is Tj Derating interlinked with PDM derating?

Ans: NO, Both has separate derating factor.

6. Advanced analysis library smoke parameters need to be verified?

Ans: Yes, Sometimes Parameters would have updated in datasheet.

You’re Done!